NFPA® 25 Handbook: ITM of Water-Based Fire Protection Systems

Sixth Edition

Website:Fire-gas.com

Edited by

Chad R. W. Duffy, P.E.
Principal Engineer, NFPA

Jonathan R. Hart, P.E.
Technical Lead, NFPA

Shawn Mahoney
Engineer, NFPA

Brian O'Connor, P.E.
Engineer, NFPA

Kevin Carr
Specialist, NFPA

With the complete text of the 2020 edition of NFPA® 25,
Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems

NATIONAL FIRE PROTECTION ASSOCIATION
The leading information and knowledge resource on fire, electrical and related hazards

FIRE-GAS

مدرس ، طراح و مشاور سیستم های (آتش نشانی ، تهویه ، اگزاست و فشار مثبت)

دارای صلاحیت سازمان آتش نشانی

اخذ تاییده از سازمان آتش نشانی



اولین هند بوک سیستم اطفاء حریق و مدیریت دود در ایران

Handbook of Smoke Control Engineering

AUTHOR
QUILL PEN



طراحی سیستم های اطفا آبی ، گازی و فوم Sprinkler ,FM200,CO2,Foam

طراحی ، انتخاب ، تست و راه اندازی پمپ های آتش نشانی مطابق NFPA20

طراحی سیستم های اگزاست و تهویه پارکینگ ، فشار مثبت راه پله - آسانسور وآتریوم ها

SOFTWARE

نرم افزار کانتم Contam

نرم افزار پایروسیم و پاس فیدر Pyrosim ,Pathfinder

نرم افزار اتواسپرینک Autosprink

نرم افزار انتخاب فن، دمپرهای دود و آتش Sodeca Quick Fan & RF Damper

برای دریافت اطلاعات بیشتر کد روبرو را اسکن کنید

www.fire-gas.com

Aparat/fire-gas.com

02634411758

00989123280127

البرز گوهردشت خ۱۲ شرقی پ۸ ط اول واحد ۲

instagram/firegascom

t.me/fire_gas

info@fire-gas.com

youtube/firegas2447

Product Management: Debra Rose
Development: Irene Herlihy
Production: Alexandra DeConti
Copyediting: Michela McShane

Cover Design: Twist Creative Group
Interior Design: Cheryl Langway
Composition: Cenveo Publisher Services
Printing/Binding: Webcrafters



Copyright © 2019
National Fire Protection Association®
One Batterymarch Park
Quincy, Massachusetts 02169-7471

All rights reserved.

Important Notices and Disclaimers: Publication of this handbook is for the purpose of circulating information and opinion among those concerned for fire and electrical safety and related subjects. While every effort has been made to achieve a work of high quality, neither the NFPA® nor the contributors to this handbook guarantee or warrantee the accuracy or completeness of or assume any liability in connection with the information and opinions contained in this handbook. The NFPA and the contributors shall in no event be liable for any personal injury, property, or other damages of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, or reliance upon this handbook.

This handbook is published with the understanding that the NFPA and the contributors to this handbook are supplying information and opinion but are not attempting to render engineering or other professional services. If such services are required, the assistance of an appropriate professional should be sought.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems* ("NFPA 25"), is, like all NFPA codes, standards, recommended practices, and guides ("NFPA Standards"), made available for use subject to Important Notices and Legal Disclaimers, which appear at the end of this handbook and can also be viewed at *www.nfpa.org/disclaimers.*

Notice Concerning Code Interpretations: This sixth edition of the *NFPA® 25 Handbook: ITM of Water-Based Fire Protection Systems* is based on the 2020 edition of NFPA 25. All NFPA codes, standards, recommended practices, and guides ("NFPA Standards") are developed in accordance with the published procedures of the NFPA by technical committees comprised of volunteers drawn from a broad array of relevant interests. The handbook contains the complete text of NFPA 25 and any applicable Formal Interpretations issued by the NFPA at the time of publication. This NFPA Standard is accompanied by explanatory commentary and other supplementary materials.

The commentary and supplementary materials in this handbook are not a part of the NFPA Standard and do not constitute Formal Interpretations of the NFPA (which can be obtained only through requests processed by the responsible technical committees in accordance with the published procedures of the NFPA). The commentary and supplementary materials, therefore, solely reflect the personal opinions of the editor or other contributors and do not necessarily represent the official position of the NFPA or its technical committees.

REMINDER: UPDATING OF NFPA STANDARDS

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, like all NFPA codes, standards, recommended practices, and guides ("NFPA Standards"), may be amended from time to time through the issuance of Tentative Interim Amendments or corrected by Errata. An official NFPA Standard at any point in time consists of the current edition of the document together with any Tentative Interim Amendment and any Errata then in effect. In order to determine whether an NFPA Standard has been amended through the issuance of Tentative Interim Amendments or corrected by Errata, visit the "Codes & Standards" section on NFPA's website. There, the document information pages located at the "List of NFPA Codes & Standards" provide up-to-date, document-specific information, including any issued Tentative Interim Amendments and Errata. To view the document information page for a specific NFPA Standard, go to http://www.nfpa.org/docinfo to choose from the list of NFPA Standards, or use the search feature to select the NFPA Standard number (e.g., NFPA 25). The document information page includes postings of all existing Tentative Interim Amendments and Errata. It also includes the option to register for an "Alert" feature to receive an automatic email notification when new updates and other information are posted regarding the document.

The following are registered trademarks of the National Fire Protection Association:

National Fire Protection Association®
NFPA®
NFPA 72®
Life Safety Code® and 101®
National Electrical Code® and NFPA 70®
Standard for Electrical Safety in the Workplace® and NFPA 70E®
Fire Protection Handbook®

NFPA No.: 25HB20
ISBN (book): 978-1-4559-2-2826
ISBN (PDF): 978-1-4559-2-2888
ISSN 2643-8275

Printed in the United States of America
19 20 21 22 23 5 4 3 2 1

CONTENTS

Preface v

About the Editors ix

Tips for Owners Quick Reference Guide xi

NFPA 25 Summary of Technical Changes: 2017 to 2020 T-1

PART ONE

NFPA® 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 2020 Edition, with Commentary 1

1 Administration 3

1.1 Scope 3
1.2 Purpose 9
1.3 Application 10
1.4 Units 11

2 Referenced Publications 13

2.1 General 13
2.2 NFPA Publications 13
2.3 Other Publications 14
2.4 References for Extracts in Mandatory Sections 14

3 Definitions 17

3.1 General 17
3.2 NFPA Official Definitions 17
3.3 General Definitions 19
3.4 Deluge Foam-Water Sprinkler and Foam-Water Spray Systems Definitions 65
3.5 Valve Definitions 65
3.6 Water-Based Fire Protection System Definitions 67
3.7 Inspection, Testing, and Maintenance (ITM) Task Frequencies 78

4 General Requirements 81

4.1 Responsibility of Property Owner or Designated Representative 81
4.2 Manufacturer's Corrective Action 101
4.3 Records 101
4.4 Water Supply Status 102
4.5 Inspection 107
4.6 Testing 107
4.7 Performance-Based Compliance Programs 110
4.8 Maintenance 113
4.9 Safety 114

5 Sprinkler Systems 125

5.1 General 125
5.2 Inspection 127
5.3 Testing 158
5.4 Maintenance 173
5.5 Component Action Requirements 180

6 Standpipe and Hose Systems 185

6.1 General 186
6.2 Inspection 189
6.3 Testing 193
6.4 Maintenance 197
6.5 Component Action Requirements 197

7 Private Fire Service Mains 207

7.1 General 207
7.2 Inspection and Corrective Action 210
7.3 Testing 220
7.4 Maintenance 221
7.5 Component Action Requirements 222

8 Fire Pumps 233

8.1 General 233
8.2 Inspection 255
8.3 Testing 266
8.4 Reports 296
8.5 Maintenance 301
8.6 Component Replacement Testing Requirements 303

9 Water Storage Tanks 327

9.1 General 328
9.2 Inspection 334
9.3 Testing 346
9.4 Maintenance 349
9.5 Automatic Tank Fill Valves 351
9.6 Component Action Requirements 353

10 Water Spray Fixed Systems 363

10.1 General 364
10.2 Inspection and Maintenance Procedures 371
10.3 Operational Tests 378
10.4 Ultra-High-Speed Water Spray System (UHSWSS) Operational Tests 386
10.5 Component Action Requirements 386

11 Foam-Water Sprinkler Systems 391

11.1 General 392
11.2 Inspection 396
11.3 Operational Tests 402
11.4 Maintenance 407
11.5 Component Action Requirements 409

12 Water Mist Systems 421

12.1 General 422
12.2 Inspection 428
12.3 Testing 438
12.4 Maintenance 447
12.5 Training 449

13 Common Components and Valves 455

13.1 General 456
13.2 General Provisions 467
13.3 Control Valves in Water-Based Fire Protection Systems 480
13.4 System Valves 485
13.5 Pressure-Reducing Valves and Relief Valves 502
13.6 Hose Valves 508
13.7 Backflow Prevention Assemblies 510
13.8 Fire Department Connections 512
13.9 Automatic Detection Equipment 516
13.10 Air Compressors and Nitrogen Generators 516
13.11 Component Testing Requirements 517

14 Internal Piping Condition and Obstruction Investigation 541

14.1 General 541
14.2 Assessment of Internal Condition of Piping 541
14.3 Obstruction Investigation and Prevention 554
14.4 Ice Obstruction 558

15 Impairments 559

15.1 General 559
15.2 Impairment Coordinator 560
15.3 Tag Impairment System 560
15.4 Impaired Equipment 562
15.5 Preplanned Impairment Programs 562
15.6 Emergency Impairments 565
15.7 Restoring Systems to Service 567

16 Special Requirements from Other NFPA Documents 569

16.1 General 569
16.2 Small Residential Board and Care Occupancies 570

ANNEXES

A Explanatory Material 573
B Forms and Reports for Inspection, Testing, and Maintenance 575
C Possible Causes of Pump Troubles 579
D Obstruction Investigation 587
E Hazard Evaluation Form 607
F Connectivity and Data Collection 613
G Color-Coded Tagging Program 643
H Informational References 647

PART TWO

Supplements 651

1 Conducting Fire Pump Flow Tests 653
2 ITM Roles and Responsibilities 673
3 Role of the Inspector 683
4 Role of the Owner or Designated Representative 697
5 Role of the Authority Having Jurisdiction 707

Index 723

Important Notices and Legal Disclaimers 734

PREFACE

The amount of data and the number of resources available to sprinkler system designers has never been greater. With the proper application of this information, along with the use of state-of-the-art equipment and system components, water-based fire protection system effectiveness and reliability continues to improve upon what is already considered to be a stellar track record. Even with this data and the latest products on the market, however, a system is only as effective as the inspection, testing, and maintenance (ITM) program that is used to keep it running once a building is occupied. The standard of care for proper water-based fire protection system ITM execution is NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*. This standard is the foundation of *NFPA 25 Handbook: ITM of Water-Based Fire Protection Systems*.

In addition to the requirements of NFPA 25, this handbook contains commentary on why the requirements have been included in the standard and how they can be executed. Dispersed throughout the handbook are several features intended to give the user additional information that will help them properly apply the standard. These recurring features include:

- FAQs
- Tips for Owners
- Historical Notes
- Back to Basics chapter introductions
- ITM Deficiency, Impairment, or Hazard Evaluation examples
- Testing Procedures
- System Tagging case studies

The frequently asked questions, or FAQ, feature is based on the questions most commonly asked of the NFPA 25 staff. Several Case In Point boxes are also included throughout, to expand on material presented in the commentary.

This edition also includes a feature called ITM Deficiency, Impairment, or Hazard Evaluation. This feature provides examples to illustrate the differences between ITM-related field conditions that fall within the scope of NFPA 25 and items that are not considered to be "wear-and-tear" issues. Conditions that require a design evaluation are outside of the scope of the NFPA 25 standard and are not considered part of the NFPA 25 inspector's work. Knowing when something should or should not be covered on an NFPA 25 inspection report can be critical, especially when it comes to liability.

Another feature in this handbook is the addition of testing procedures, which are provided at the end of most chapters, to discuss in detail what steps should be taken in order to properly test systems. These procedures are identified with a brief Testing Procedure Alert box within the chapter, alerting the reader that a more complete list of procedures can be found at the end of the chapter.

While NFPA 25 identifies a myriad of tests that must be conducted in order to gain some assurance of system functionality, the standard does not provide processes and procedures for conducting these tests. This is largely done because in a standard it is not possible to identify a singular approach to testing a system that could have been designed dozens of different ways depending on when it was built. It is also difficult to write a procedure where the resources available to the owner, inspector, and AHJ will vary greatly from facility to facility. As such, NFPA 25 simply identifies the activity that must be performed and the frequency at which it must be performed. This handbook contains a feature to fill in some of the gaps that cannot be addressed within a standard.

These testing procedures outline potential processes and procedures for conducting many of the tests that are mandated by NFPA 25. It is important to note that these processes and procedures are not part of NFPA 25. The actions identified and the steps provided in these procedures represent one approach to conducting a test required by this standard. In some instances, the procedures outlined in this handbook cannot be performed as described or it might not be appropriate to perform them based on the specific equipment that has been installed or the arrangement of the equipment.

A System Tagging feature is also included in this edition of the handbook to help readers identify field conditions that warrant action and determine the criticality of the situation. Assigning criticality to the field conditions that are identified during inspections is a critical part of the ITM process. This feature is intended to help readers understand what goes into the process of classifying deficiencies and impairments. The feature also examines various specific field conditions and explains the process of determining the severity of the condition and whether the condition should be listed as an impairment, a critical deficiency, or a noncritical deficiency.

Other features included in this edition are the Tips for Owners and Historical Notes appearing throughout the commentary. NFPA 25 assigns responsibility for maintaining water-based fire protection systems to the owner or designated representative. While the majority of owners will contract a service for some or all of the ITM, it is important that they have an understanding of the requirements of the standard. The Tips for Owners feature is intended to highlight the most important sections for owners to understand, whether they are performing some of the ITM tasks themselves or if they've contracted the service. New to the 2020 edition, the Tips for Owners have been compiled into a quick-reference table. Also new to the 2020 edition are Back to Basics introductions to the system chapters, followed by charts that display in an easy-to-read format the noncritical deficiencies, critical deficiencies, and impairments for each type of system.

In addition to the commentary and the features that enhance it are five supplements that take a deeper look at specific subjects. The subjects include fire pump testing and analysis (Supplement 1), NFPA 25 roles and responsibilities (Supplement 2), in-depth summaries on the role of the inspector (Supplement 3), the role of the owner (Supplement 4), and the role of the authority having jurisdiction (Supplement 5). These supplements are prepared by industry experts and technical committee members who use their experience and firsthand knowledge of these issues to better explain topics covered in NFPA 25. The handbook also includes a detailed list of the technical/substantive changes from the 2017 edition to the 2020 edition of NFPA 25, located before Part One (NFPA 25).

Acknowledgments

An NFPA Handbook is often a growing body knowledge that builds upon work on previous editions, and for that reason we must acknowledge all of those who have previously contributed or edited this handbook in past editions. For their work in contributing to the 2014 edition, we would like to acknowledge and thank Bob Caputo, Russ Leavitt, Bruce Clarke, Tracey Bellamy, Terry Victor, Gayle Pennel, Rich Ray, John Lake, and Bill Sheppard. We would also like to thank Byron Blake, Bill Koffel, John Munno, George Stanley, Tom Multer, Peter Petrus, Damon Pietraz, Josh Elvove, Cecil Bilbo, David Martinez, and Peter Schwab for sending in their photographs that were used throughout this book. For his work on updating to the 2017 edition, we would like to thank Jason Webb for reviewing the commentary through the entirety of the document: adding information where it lacked, clarifying existing text where needed.

Producing this handbook has taken a tremendous amount of effort on the part of a number of people on the NFPA staff as well. Specifically, we thank Debra Rose, Khela Thorne, Melanie Muto, Irene Herlihy, Alexandra DeConti, and Michela McShane, for their professionalism

and dedication to the project. We must also thank NFPA engineering intern, Zachary Fisher, for his contribution in helping to build the technical/substantive changes table that is included in this handbook.

Last, but certainly not least, we would like to thank our families for giving us the motivation and the support to take on projects like this one.

The Editors

NFPA

ABOUT THE EDITORS



Kevin Carr

Kevin Carr is a Senior Fire Protection Specialist at the National Fire Protection Association (NFPA), where he is a team member of the Building Fire Protection and Life Safety group. He is the staff liaison for several technical committees, including Garages and Parking Structures, Air Conditioning, Construction and Demolition, Manufactured Housing, Building Systems, and Remote Inspections. Prior to his work as a staff liaison, Kevin held various roles within facilities management, with an emphasis on operations and construction.



Chad R. W. Duffy

Chad Duffy is a Principal Engineer at the National Fire Protection Association (NFPA), where he is a team member of the Building Fire Protection and Life Safety group. Chad is responsible for NFPA documents addressing automatic sprinkler systems and inspection, testing, and maintenance of water-based suppression systems. He is a graduate of Seneca College with a degree in fire protection engineering technology and a registered professional engineer in the state of Massachusetts. He is also NICET-certified in water-based layout (CET) and a certified fire protection specialist (CFPS). Chad has extensive experience in water-based suppression systems as a project manager, designer, and estimator for projects throughout the United States and Macau. His project work includes the use of various design software programs for the layout of sprinkler, fire pump, and standpipes systems of high-rise buildings, storage facilities, shopping malls, rail stations, and casinos. Prior to joining NFPA in 2011, Chad owned and operated a sprinkler design and consulting firm as well a sprinkler installation-contracting company.



Jonathan R. Hart

Jon Hart is the Technical Lead for fire protection engineering for the National Fire Protection Association (NFPA). Previously, Jon served as Principal Engineer and as staff liaison for NFPA 99, *Health Care Facilities Code*, dealt extensively with all issues involving fire and life safety of health care facilities. He has developed and delivered numerous training programs and has acted as technical editor for several NFPA handbooks, including the *Health Care Facilities Code Handbook* in addition to the *NFPA 25 Handbook*. Jon has a BS in Mechanical Engineering and an MS in Fire Protection Engineering, both from Worcester Polytechnic Institute. He is a registered professional engineer in the discipline of fire protection.



Shawn Mahoney

Shawn Mahoney is an Engineer in the Technical Services Division at the National Fire Protection Association (NFPA). He is a registered professional engineer who holds a BS in Mechanical Engineering and an MS in Fire Protection Engineering, both from Worcester Polytechnic Institute. Prior to joining NFPA, he held a variety of positions in fire protection engineering, including fire protection consulting and fire protection product design. Shawn contributes to an assortment of projects, including assignments distributed among the Building, Life Safety, and Fire Protection; Public Fire Protection; Electrical; and Industrial and Chemical Engineering Departments at NFPA.



Brian O'Connor

Brian O'Connor is an Engineer at the National Fire Protection Association (NFPA), where he is a team member of the Building Fire Protection and Life Safety group. He is Vice President for the New England Chapter of the Society of Fire Protection Engineers (SFPE). Brian is a professional engineer registered in the states of Texas and Massachusetts. He earned his Bachelor's Degree in Mechanical Engineering and is currently pursuing a Master's Degree in Fire Protection Engineering from the University of Maryland. He is the staff liaison to several technical committees covering topics such as aviation, portable extinguishers, water-based fire protection, energy storage systems, and health care facilities.

TIPS FOR OWNERS QUICK REFERENCE GUIDE

Tips for Owners Quick Reference Table

Tip for Owners	Code/page number
Chapter 1	
It is important to understand that NFPA 25 provides *minimum* requirements for ITM activities. The owner can request that the inspecting contractor perform a higher degree of inspections and testing provided this has been discussed during the contract negotiations with the contractor. An owner can also request ITM frequencies that deviate from those prescribed in the standard based on the results of an engineering analysis. The frequencies identified in the engineering analysis would have to be reviewed and approved by the authority having jurisdiction (AHJ) prior to their implementation.	1.1 Scope p. 3
In order to minimize time and expense, it is advisable to coordinate NFPA 25 ITM activities with the ITM activities required by other NFPA codes and standards, such as NFPA 4, *Standard for Integrated Fire Protection and Life Safety System Testing*, NFPA 92, *Standard for Smoke Control Systems*, and NFPA 72. This will require coordinating a time that works for both the water-based system inspector and all other system inspectors, such as alarm inspectors, so that all inspections can be completed simultaneously. Consult NFPA 4 for further guidance on how full integrated testing programs can be developed for all interconnected fire protection systems.	1.1.1 Coordination with NFPA 72 Testing Requirements. p. 5
Building owners need to be familiar with the fire protection systems in their buildings. If the ITM activities for a building system are not covered by a code or standard, the ITM activities and frequencies should be established by a registered design professional (RDP)—for example, an engineer—for that system, using a performance-based approach and approved by the AHJ.	1.1.2 Types of Systems. p. 5
Because the inspections required by NFPA 25 are not intended to reveal installation flaws or code compliance violations, it should not be the expectation of the owner that the inspector is evaluating the adequacy of the design of the installed system. Instead, NFPA 25 inspections are intended to address the operating condition of a system or system components, not the adequacy of the system design when compared to the applicable design and installation standards.	A.1.1.3.1 p. 6
It is important to disclose any distinct hazard to the ITM contractor during contract negotiations so that the required level of ITM activities can be verified with the AHJ. For example, a warehouse full of hazardous chemicals may require ITM activities beyond the minimum requirements of NFPA 25; whereas for an office building the minimum requirements are acceptable.	1.2* Purpose. p. 9
A performance-based ITM program can be developed and approved by the AHJ to use in lieu of NFPA 25 activities and frequencies. For example, poor water quality may lead to a reduced internal assessment frequency; whereas good water quality may lead to an extended internal assessment frequency of a sprinkler system.	1.3* Application. p. 11
Chapter 2	
Most of the referenced documents in NFPA 25 will only need to be consulted where a system repair constitutes an acceptance test in accordance with the original design and installation standard.	Chapter 2 Referenced Publications p. 13

Tip for Owners	Code/page number
Chapter 3	
Although the fire department is typically associated with the term *authority having jurisdiction (AHJ)*, there are several other entities that may be classified as an AHJ. A building owner may need to submit the inspection reports to more than one AHJ as defined by NFPA 25. For example, in order to maintain current insurance rates, the inspection reports may also need to be provided to the building's insurer.	A.3.2.2 Authority Having Jurisdiction (AHJ). p. 18
Building owners are responsible for the correction of all deficiencies. While some more minor deficiencies could be corrected quickly by the ITM service provider, more complex fixes might require individuals that are qualified in different areas, such as sprinkler system installation. The owner should also clearly understand ahead of time how corrective action is built into the contract with the service provider or how charges for corrective actions will be addressed.	3.3.8* Deficiency p. 20
When contracting ITM services, it is important for owners and contractors to have a clear understanding of the maintenance services that are included in the agreement. For example, the ongoing maintenance to keep dry system or preaction piping free of water is not the responsibility of the service provider unless it is specifically identified in the agreement. However, many owners are not aware of the need to monitor the condition of the piping by the periodic operation of any auxiliary drains (see A.13.4.3.3.3 and A.13.4.5.3.2). Good communication between owners and service providers regarding system maintenance can significantly enhance system reliability and performance.	A.3.3.22 Impairment. p. 44
As mentioned in the commentary for the definition of *authority having jurisdiction (AHJ)*, it is important to note that there may be more than one AHJ. The facility maintenance person could be fully capable of performing certain tasks that are acceptable to one AHJ but that might not meet the requirements of another.	3.3.36 Qualified. p. 53
An NFPA 25 inspector is anyone who is *qualified*, meaning a person who is competent and capable and who has met the requirements and training for a given field acceptable to the AHJ. On-staff personnel may be qualified to perform certain ITM activities as required by NFPA 25.	3.3.36 Qualified. p. 53
It is important to ensure that the drainage in rooms containing RPBAs is maintained free and clear of any obstructions.	3.3.38 Reduced-Pressure Principle Backflow Prevention Assembly (RPBA). p. 54
Chapter 4	
Subsection 4.1.1 sets the tone for the enforcement of the standard by stating that the property owner or designated representative (see A.4.1.1.3) is responsible for maintaining a water-based fire protection system. Maintaining a system includes the ITM tasks, as mandated by the standard. The owner should therefore carefully read and understand all of the requirements in Section 4.1 to have a full understanding of the responsibilities placed on them by NFPA 25.	4.1.1* Responsibility for Inspection, Testing, Maintenance, and Impairment. p. 81
The property owner or the designated representative must maintain access to equipment for ITM purposes. The standard refers to the property owner or designated representative throughout the standard to distinguish between the property owner and the owner of the contracting firm. In addition, when conducting inspections of sprinklered residential-type buildings such as hotels, motels, apartments, and condominiums, gaining access to individual dwelling units can be challenging. NFPA 25 provides no exceptions to the requirement to perform ITM due to limited accessibility. For example, when conducting the annual inspection of sprinklers, performing a "sample" inspection of a few dwelling units does not meet the intent of the standard. Often, solutions to this difficult situation can be found if there is open communication between the owner, the contractor providing the ITM services, and the AHJ.	4.1.2.3 p. 85

Tip for Owners	Code/page number
The requirement of 4.1.2.5 is one of the rare daily frequency inspections required by NFPA 25. Nothing in the standard is meant to prevent facility maintenance personnel from performing this inspection. It is important to note, however, that the documentation requirements in Section 4.3 apply to all inspections, tests, and maintenance required by NFPA 25. In this case, a simple check-off on a clipboard located in the valve enclosure would be sufficient.	4.1.2.5 p. 85
The requirement in 4.1.7.3 for corrections to be approved typically equates to a permit being obtained from the AHJ. Work that is performed without a permit can lead to costly fees or delays to business operations. Even though it is not a requirement, it is a good idea to involve the AHJ any time changes to a system or building are being contemplated.	4.1.7.3 p. 98
Electronic copies of records are often used as an option for long-term record management. However, it is beneficial to have paper copies of recent documents available for quick use, especially in an emergency.	4.3.1.1 p. 102
The requirement in 4.3.1.1 emphasizes that it is the owner's responsibility to maintain the required records; however, it is a good idea for the inspector to keep records as well. It allows the inspector to identify commonalities in deficiencies in a specific property or even a certain type of system. See the commentary following 4.3.1.2 on how the records are permitted to be stored.	4.3.1.2 p. 101
These records are important when extending or modifying the system as well as for routine inspecting, testing, and maintenance. Recreating them when they are needed can be costly and time-consuming. Records are easily misplaced or lost over a period of time, especially when properties are sold or come under different management. Making a conscious effort to comply with this section is often well worth the investment.	4.4 Water Supply Status. p. 102
Compliance with 4.3.5 results in maintaining records for at least 1 year following each successive ITM activity. This requirement for records retention is intended to provide evidence of trending. For example, a main drain test performed on an annual basis should result in a total of three test reports: the original test, results for the current year, and results from the prior year. The record from 2 years ago could be discarded at this time. With this information, fluctuations in the test results are shown and are used for evaluating the operational condition of the system.	4.3.5 p. 102
Chapter 5	
In some cases, actions can be performed by the owner or the owner's representative(s) while the contractor or service provider is present and supervising the activities. Some authorities having jurisdiction (AHJs) or governmental agencies require special licensing of the service provider or individual inspector, so it is recommended to always check with the local fire authority before performing any of the required ITM functions prescribed.	5.1.1.1 p. 125
While the ITM service providers might have their own standard reporting forms, the owner should require and verify that the form will be acceptable to the AHJ(s) they must answer to. In a hospital, for example, the facility can have a number of AHJs, including the local fire department, the state department of health, the Centers for Medicare and Medicaid Services (CMS), and accreditation agencies, all with an interest in confirming that NFPA 25 tasks are completed. Wherever possible, the owner should ensure that a single version of the reports/forms will be acceptable to all AHJs involved.	5.1.4 Impairments. p. 127
Paragraph 5.2.1.1.1 and the explanatory information in A.5.2.1.1.1 are important sections for the owner to understand. Sprinklers that upon inspection show signs that they will not operate correctly are required to be replaced. However, those with light loading can be cleaned with a vacuum or a blast of compressed air. The owner should work with the service provider to determine how such in-stances will be identified and communicated and to clarify who is responsible for cleaning the sprinklers of this light loading.	A.5.2.1.1.1 p. 134

Tip for Owners	Code/page number
When work is performed in concealed areas, it is prudent for the owner to have the sprinklers in these spaces inspected after the other work is completed.	5.2.1.1.4 p. 144
When other work is performed in concealed areas, it is prudent for the owner to have the pipe and fittings in these spaces inspected after the other work is completed.	5.2.2.4 p. 152
The requirement that the hydraulic design information sign be pro-vided means that it must be in place at the time of inspection for compliance with NFPA 25. If it is found to be missing, collecting the in-formation necessary for the sign may be difficult and costly. However, by complying with the record-keeping requirements of 4.3.4 and maintaining the original design information for the life of the system, creating a new or replacement sign is straightforward and simple.	A.5.2.5 p. 156
Chapter 6	
Because hose connections are often located in unsupervised locations (such as stairwells or roofs), they can be subject to vandalism or improper use. It is not unusual to find missing caps, trash, and debris, or damaged threads when inspecting hose connections. Building owners or managers should be especially vigilant about this possibility and might want to consider increasing the frequency of inspections. |This can usually be accomplished by using in-house personnel or by taking other actions, such as installing approved protective devices. The AHJ should be consulted before taking these steps.	6.2.3.2 p. 190
Flow testing of standpipes can release large quantities of water, usually from roof outlets. Ensuring adequate drainage for this water is required by NFPA 25 and is an important consideration for both the owner and the ITM service provider. Roof drains might not have been designed to handle the sudden influx that is produced when standpipes are flow tested. Roof drains and other parts of the drainage system could become plugged or otherwise damaged between flow tests. This may not become apparent until it is too late and damage has already occurred. It is recommended that owners or facility managers have their drainage systems evaluated for this eventuality before testing is conducted.	A.6.3.1.1 p. 194
Chapter 7	
An impairment program is critical for any work associated with a private fire service main, because impairment of these systems often involves shutting water supply control valves to one or more water-based fire protection systems or fire hydrants. Exhibit 7.2 shows one means of identifying hydrants that have been impaired.	7.1.5 Impairments. p. 210
Accessibility is a term that is not defined by this standard. The accessibility of fire hydrants is not necessarily the same as accessibility of some other components. Fire apparatus must be able to get near enough to the hydrant to connect hoses, and fire fighters must be able to make the connections and operate the hydrant. Ensuring this may mean blocking off certain parking spaces or installing protective bollards a certain distance away. Consulting the authority having jurisdiction (AHJ) or the local fire department is recommended. Also see 7.4.2.2 for additional requirements.	7.2.2.3.2 p. 216
The requirement in 7.4.2.2 that hydrants be kept free of snow is sometimes difficult to meet. For example, a hydrant near the street runs the risk of being buried by a snowplow. Where the potential exists for snow burial, extra measures should be taken to ensure that hydrants can be easily located, such as with the use of flags, indicating poles, banners, or other measures, as shown in Exhibit 7.7. Note that in addition to snow, vegetation can also obscure a hydrant location. In that case, the vegetation should be cleared away completely.	7.4.2.2 p. 222

Tip for Owners	Code/page number
Chapter 8	
The manufacturer's maintenance recommendations are important for the long-term care of the various components and should be provided to owners with all new installations by the installing contractor. For new installations, it is important that all manufacturers' manuals and informational material for the pump and the associated equipment remain in the possession of the owner for reference in maintaining the equipment. This material should be kept in a location accessible for regular reference but not where it could be subject to environmental damage or decay, as might be the case in some pump rooms.	8.1.3 Obstruction Investigations. p. 241
The quality and training of attendants at the annunciator location should also be regularly reviewed to verify that they meet the definition of the term *qualified*, in relation to understanding the significance and actions required when various fire pump system signals are received.	8.1.4 p. 246
The information referenced by 8.1.5.2 can be found on the hydraulic design information records. These records must be maintained in accordance with Section 4.3. Maintaining these records can be a daunting task, but recreating them is often a much costlier and burdensome issue.	8.1.6 Energy Source p. 252
The owner should ensure that maintenance personnel or property managers have some input into where test discharge will occur. Those familiar with the property should be able to provide valuable insight to the person conducting the testing as to where discharge flow will drain and what impact that drainage will have on the property and adjacent areas. It may also be necessary for the owner to arrange for areas surrounding the building, including parking lots or other features, to be blocked off for the day of the testing. For more information, see 4.1.1.2.1 and associated commentary.	A.8.3.3.9.1.2 p. 284
If diesel fuel quality is suspect for any reason, steps such as those listed in 8.3.4.2 to remedy the situation should be undertaken as soon as possible. Diesel engine performance can be dramatically reduced when these issues occur. The performance degradation will not be evident until the engine runs, and when that occurs in a fire situation, the results can be disastrous.	A.8.3.4.2 p. 289
NFPA 110, *Standard for Emergency and Standby Power Systems,* requires that emergency generators receive ITM to help ensure that they remain a reliable form of power. Maintenance and testing of these systems require special training and knowledge and must be performed by a "qualified person" as defined in that standard. For more information on the steps necessary to effectively test an emergency generator or standby power system, refer to NFPA 110.	A.8.3.6.1 p. 290
Chapter 9	
The guidance in A.9.2.5.1.1 will help ensure that the interior inspections are performed at the appropriate intervals and can also assist in identifying when a new paint job might be needed.	A.9.2.5.1.1 p. 343
Chapter 10	
The interconnection between the industrial processes being protected and the fire protection system should be considered during the design of the system and the preparation of the facility maintenance plan. When a system is shut down for maintenance or repair, the facility maintenance plan should account for the consequences of the planned system impairment and address the impaired condition.	10.1.6* Impairments. p. 370

Tip for Owners	Code/page number
The owner, or designated representative, is responsible for ensuring ITM happens at the frequencies required by this standard. In some cases, repairs or unscheduled maintenance will necessitate a shutdown, during which ITM activities can be conducted. If ITM activities have not been conducted for almost 18 months because no shutdown has occurred, a shutdown must be scheduled to allow these activities to take place.	10.2 Inspection and Maintenance Procedures. p. 371
Because of the nature of the hazards protected by these systems, the frequency of unsupervised or unlocked valve inspection exceeds that of typical control valves as required in Chapter 13. These daily inspections are normally conducted by trained facility managers or maintenance personnel. It should be noted, however, that the record-keeping requirements in Chapter 4 still apply. A procedure for adequately recording the inspections should be developed, and the documentation maintained in accordance with Section 4.3.	10.3.6.1.2 p. 386
Chapter 11	
The discharge of foam-water sprinkler systems has the potential to damage equipment and/or property. Subsection 11.3.1 requires that precautions be taken to prevent this. The owner should ensure that all exposed equipment or property that could be damaged by the discharge is protected.	11.3.1* Test Preparation. p. 403
Chapter 12	
Relevant plant operations personnel should be informed of any temporary shutdowns. Where such interlocks exist, the owner should ensure that the service contractor is familiar with the entire integrated system and associated interlocks before beginning system testing or maintenance. It should be verified that the temporary shutdown of the water mist system or associated interlocks will not inadvertently interrupt important site operations.	12.1.1 Minimum Requirements. p. 422
The requirements for ITM of water mist systems in NFPA 25 must be supplemented by the specific requirements contained in each design, installation, operation, and maintenance (DIOM) manual. A DIOM manual is required for all listed or approved water mist system equipment and should be readily available for reference.	12.1.1 Minimum Requirements. p. 422
It might be necessary to coordinate the annual ITM tasks for the water mist system with another activity that requires system shutdown, so that access can be gained to protected spaces for inspection of the piping and nozzles. For example, it is not normally possible to enter a turbine enclosure while it is running, but if it is shut down for routine maintenance, an inspection of the water mist system could be scheduled at the same time to minimize disruption.	12.1.1.2 p. 425
The process or equipment being protected can create unsafe conditions for an inspector while the process is active. It might be necessary to coordinate the annual ITM tasks for the water mist system with another activity that requires system shutdown, so that access can be gained to protected spaces for inspection of the piping and nozzles.	12.2.1.1.5 p. 430
It is necessary to maintain a supply of spare automatic water mist nozzles, including all of the types installed in the system, to ensure systems can be returned to service immediately following a fire event or in case a nozzle has been damaged. It is important to verify that the spare nozzles that are provided match the characteristics of the nozzles installed. See 12.4.2 for more details on the required spare nozzles.	12.2.1.2 p. 430

Tip for Owners	Code/page number
At the completion of the system installation, the service provider is required to provide the owner with the as-built installation drawings, as noted in 13.4.2 of NFPA 750. The service provider should review these drawings with the owner and, if necessary, the designated representative, and note any changes in ventilation, compartment size, and obstructions. These changes could significantly alter the ability of the water mist system to achieve its intended performance	12.4.1.2 p. 448
Chapter 13	
The phrase *property owner or designated representative* in 13.2.1 applies to whoever is responsible for the ITM of the equipment (see Section 4.1). Any portion of the ITM — or all it — is permitted to be contracted with an ITM service. However, the ultimate responsibility falls on the building owner unless these responsibilities have been contractually transferred.	A.13.2.2 p. 467
If such a manual is not present, the owner should ask the maintenance contractor to provide one for future reference, complete with a telephone number for emergency service. See NFPA 3, *Recommended Practice for Commissioning of Fire Protection and Life Safety Systems*, for more information and guidance on this topic.	A.13.2.2 p. 468
It is not necessary to notify the AHJ when inspection activities will take place, because alarm initiating devices are not necessarily activated. However, when testing is conducted, alarms typically will be activated and the AHJ should be notified.	13.2.4 p. 468
Section 4.3 states that it is the owner's responsibility for maintaining records. See Section 4.3 and the associated commentary for additional information.	13.3.1 p. 479
In some facilities, conducting a trip test that results in flow could damage equipment or overly impact the process and operations of the facility. The allowance in 13.4.4.2.3.2 allows for trip testing to be conducted in a manner that does not necessitate discharge in the protected area. However, 13.4.4.2.3.2 requires that a full flow system test be conducted at the next system shutdown when this allowance is taken. Either way, 13.4.4.2.3.3 requires the full flow test be conducted within 3 years.	13.4.4.2.3.2 p. 492
If the original design criteria and system hydraulic information are not available, the owner might need to have a hydraulic evaluation of the system completed. This evaluation would be outside of the normal ITM work identified in this standard.	13.4.4.2.7.3 p. 493
Chapter 14	
By requiring an *assessment* rather than an *inspection,* as mandated in previous editions of NFPA 25, the owner now has options available to find the most efficient method for determining the condition of the system piping. The intent of 14.2.1 is to place the smallest burden possible on the property owner by providing these options. For example, if the inspection option is exercised, it can be coordinated with the internal inspection requirement of system valves, such as is required by 13.4.1.2 for alarm valves; it can also be conducted during system renovations or maintenance.	14.2.1 p. 542
The requirements in 14.2.1.1 and 14.2.1.2 address the frequency of the assessment required by 14.2.1. The 5-year minimum frequency is intended to limit the burden placed on the owner by aligning the assessment with the 5-year internal inspection requirement for check valves.	A.14.2.1.2 p. 551
The results of an internal assessment may trigger the need for an internal obstruction investigation. A building's sprinkler system may be compromised by obstructions that were caused by activities on the water supply upstream of the owner's building. This is one of the reasons why regularly scheduled ITM activities in accordance with NFPA 25 are so important.	14.3 Obstruction Investigation and Prevention. p. 554

Tip for Owners	Code/page number
Chapter 15	
The impairment coordinator is usually someone from the building maintenance department. In larger facilities, the coordinator might be a member of the safety or loss control department. The impairment coordinator should be someone who is on site and thoroughly familiar with the building layout, operations, and systems. In addition, he or she should have the authority and means to initiate proper notification when a system impairment is planned. This notification includes, but is not limited to, the fire department, insurance carrier, alarm company, property owner, area supervisors, and tenants.	15.1 General. p. 560
The building owner, through the impairment coordinator or other designated personnel, is responsible for arranging a fire watch. The fire watch is imperative from both a life safety and property protection perspective. It is also important that egress routes and alarm systems be maintained to ensure the safety of the building occupants.	A.15.5.2(4)(b) p. 563
Hot work is a common cause of nonresidential fires and resulting property damage. Should welding or cutting be necessary during system repair, these activities should be carried out in accordance with NFPA 51B. OSHA 29 CFR 1910.252, "Welding, Cutting, and Brazing, General," references NFPA 51B and ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*, so the requirements of those two documents must be followed for OSHA compliance.	A.15.5.2(4)(d) p. 564
Anyone who might be affected by fire protection system testing in a protected premises should be notified that testing will take place. This notification should include, but might not be limited to, the property owner, property manager, switchboard operator, building engineer, building or floor fire wardens, and building maintenance personnel. In addition, the fire department communication center (if required), the alarm supervising station, and building occupants should also be notified. Effective methods of notification for the building occupants include emails, bulletin board postings, public address announcements, and lobby signs.	15.5.2(9) p. 565
Chapter 16	
An owner of a board and care facility needs to refer to NFPA *101* for the ITM requirement of a NFPA 13D sprinkler system. All other NFPA 13D systems are excluded from the scope of NFPA 25.	16.1 General p. 569

NFPA 25 SUMMARY OF TECHNICAL CHANGES: 2017 TO 2020

This table provides an overview of major code changes from the 2017 to the 2020 edition of NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*. Purely editorial and formatting changes are not included. For more information about the reasons for each change, visit www.nfpa.org/25. The first revision (FR) and second revision (SR) numbers are given in the third column for reference to the official documentation of the technical committee's actions.

Section Number	Comments	FR/SR
1.1. 1.1.1.1 1.1.1.2 1.1.1.3	Reorganized to clarify that these sections are not just limited to deluge and preaction systems.	**FR-3**
~~A.1.3.1~~	Deleted Annex A text as it will be replaced by language in the front matter of all NFPA standards going forward.	**FR-45**
CHAPTER 2	Updated references per the NFPA *Manual of Style for Technical Committee Documents.*	**FR-65**
CHAPTER 3		
3.3.3	Added definition of *automated inspection and testing*, which is also included in the most recent editions of NFPA 13, *Standard for the Installation of Sprinkler Systems*; NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*; and NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*.	**FR-5**
3.3.13.2 A.3.3.13.2	Extracted definition of *dry hydrant* from NFPA 1142, *Standard on Water Supplies for Suburban and Rural Fire Fighting*, to clarify the proper application of the scope language of NFPA 25 vs. NFPA 1142 on dry hydrants.	**FR-42**
3.3.16	Updated extracted definition of *hose connection* to match the source document.	**FR-68**
3.3.26 A.3.3.26	Added extracted definition of *lowest permissible suction pressure* because many utilities limit the minimum pressure to 20 psi or higher.	**FR-90**
3.3.42.6	Added definition of *electrically operated sprinklers*, which is a technology now addressed by the standard.	**SR-71**
3.6.2.5	Revised definition of *peak load* to be specific to NFPA 25 as this applies to annual testing and not acceptance testing.	**FR-6**
3.6.2.12	Added definition of *variable speed pump*, which is now used in Chapter 8.	**FR-92**
CHAPTER 4		
4.1.2.2 A.4.1.2.2	Added language to account for situations where water-filled piping was approved for installation in areas where temperatures fall below 40°F.	**FR-7**

Section Number	Comments	FR/SR
4.1.2.5 **4.1.2.5.1** **4.1.2.5.2**	Relocated requirements for the inspection of valve enclosures when subjected to freezing temperatures to Chapter 4 to be in the section on freeze protection for water-filled pipes.	**SR-67**
4.1.5.1.1 **A.4.1.5.1.1** **4.1.5.1.2** **A.4.1.5.1.2**	Added requirements for handling recalled products or components by owner's maintenance personnel, designated representative, or contractors as well as a process for addressing such deficiencies when discovered. Some existing annex material has been paired with the new 4.1.5.1.2 as the most appropriate location.	**FR-112** **SR-14**
4.1.9 **A.4.1.9**	Added annex material to clarify requirements for sprinkler system information signs and general information signs.	**FR-125**
4.3 **4.3.1** **4.3.1.1** **4.3.1.2** **4.3.2** **4.3.3**	Reorganized for ease of use and in accordance with the NFPA *Manual of Style for Technical Committee Documents*.	**FR-8**
4.6.6.4.1	Revised to recognize other technologies besides recirculation.	**SR-6**
4.6.6.7 **A.4.6.6.7**	Added to clarify that many devices and equipment that are used for automated inspection and testing that are not integral to the actual performance of the system do not need to be listed for the purpose.	**FR-19**
4.9.6 **4.9.6.1** **4.9.6.2** **A.4.9.6.2**	Added minimum requirements to utilize the provisions of NFPA *70E®*, *Standard for Electrical Safety in the Workplace®*, as a baseline for protective measures required when working on electric controllers for motor-driven fire pumps. Annex A recognizes alternative approved electrical safety programs to NFPA *70E*.	**FR-20** **SR-25**
CHAPTER 5		
5.1.1.2	Modified Table 5.1.1.2 to align with the requirements of the standard and reorganized alphabetically.	**FR-43** **SR-15**
5.2.1.1 **A.5.2.1.1**	Added annex material to clarify that cover plates do not need to be removed for inspection.	**FR-126**
5.3.1.1.1	Revised to specify that the time starts at installation.	**FR-21**
5.3.1.1.1.3	Revised to specify that the time starts at installation.	**FR-22**
5.3.1.1.1.5	Revised to specify that the time starts at installation.	**FR-23**
5.3.1.1.1.6	Revised to specify that the time starts at installation. The initial inspection for dry sprinkler testing or replacement has been extended from 10 to 15 years.	**FR-24**
5.3.1.1.2 **5.3.1.1.3**	Revised to indicate only sprinklers exposed to these conditions need to be tested. Those that are in such atmospheres but are protected, such as duct sprinklers with baggies, do not need 5-year testing. An exception has been added that allows a 10-year test cycle for listed corrosion-resistant sprinklers as they are tested and listed for harsh environments.	**FR-25** **SR-8**
5.3.1.2	Revised to clarify that the entire subsection applies.	**FR-26**
5.3.2 **5.3.2.1** **5.3.2.2**	Added basic requirements for electrically operated sprinklers, which is a new technology.	**SR-72**

Section Number	Comments	FR/SR
5.3.3.4 **5.3.3.4.1** **5.3.3.4.2**	Revised to ensure that the automated testing device will be listed for the application. This also recognizes other technologies besides recirculation.	**SR-7**
5.4.1.5.2	Revised to match the requirements in NFPA 13 for spare sprinkler cabinet temperature limitations.	**FR-27**
5.4.1.8	Added a mention of maintenance for a new technology now addressed by the standard.	**SR-73**
5.5.1	Modified Table 5.1.1.2 to align with the requirements of this standard and reorganized alphabetically.	**SR-16**
CHAPTER 6		
6.1.1.2	Modified Table 6.1.1.2 to align with the requirements of this standard and reorganized alphabetically.	**FR-116** **SR-17**
6.3.1.1.2 **6.3.1.6.2**	Revised to require that the accuracy for the measuring devices used in the 5-year waterflow test be comparable to that for a fire pump flow test and not just equivalent to the minimum level accepted on a sprinkler system gauge.	**FR-2 (GLOBAL)**
6.5.1	Modified Table 6.5.1 to align with the requirements of this standard and reorganized alphabetically.	**SR-18**
CHAPTER 7		
7.1.1.2	Modified Table 7.1.1.2 to align with the requirements of this standard and reorganized alphabetically.	**SR-19**
7.2.2.4	Modified to require a visual inspection of the hydrant's exterior integrity.	**SR-9**
7.2.2.5	Modified to require a visual inspection of the hydrant's exterior integrity.	**SR-10**
7.2.2.6 to 7.2.2.6.5	Added dry hydrant criteria extracted from NFPA 1142 to this standard.	**SR-1**
7.5.1	Modified Table 7.5.1 to align with the requirements of this standard. Clarifies that underground pipe must be tested as well.	**FR-28** **SR-20**
CHAPTER 8		
8.1.1.2	Modified Table 8.1.1.2 to align with the requirements of this standard and reorganized alphabetically.	**FR-93** **SR-41**
8.1.1.2 to 8.1.1.2.23	Replaced all uses of the term *check* with *inspect* or *test* as applicable. Revised to provide exception to requirements to activities that require access to an energized electric fire pump controller. Clarifies that inspections inside of an electric motor controller should be performed if the controller can be safely isolated with a circuit breaker and isolation switch. Modified Table A.8.1.1.2 to eliminate requirements to tighten electrical connections and check accuracy of voltmeters/ammeters installed on electric fire pump controllers.	**FR-93** **SR-38** **SR-39** **SR-40**
8.1.5.1	Simplified text as new extracted definition of *lowest permissible suction pressure* in Chapter 3 provides additional clarity and eliminates the need for further clarification.	**FR-91** **SR-21**
8.3.2.7	Revised to recognize option for performing automated inspection and testing activities.	**FR-96**

Section Number	Comments	FR/SR
8.3.2.8	Revised to provide exception to requirements to activities that require access to an energized electric fire pump controller.	**FR-98**
8.3.2.10 to 8.3.2.10.4	Added remote monitored automated testing requirements to this standard.	**FR-95**
8.3.3.1 8.3.3.2 A.8.3.3.2 8.3.3.3 8.3.3.4	Added different test procedures for variable speed pumps.	**FR-97 SR-22 SR-11**
8.3.3.5 8.3.3.5.1 8.3.3.5.2 8.3.3.5.3 A.8.3.3.5.3	Revised to no longer require access to an energized electric fire pump controller.	**FR-99 SR-23**
8.3.3.9.1.2	Revised to provide definitive action required.	**FR-102**
8.3.3.10	Revised to no longer require access to an energized electric fire pump controller.	**FR-100**
8.3.3.12	Revised to no longer require access to an energized electric fire pump controller.	**FR-101**
8.3.3.10	Deleted requirements to confirm the operation and confirmation of all remote visual and audible devices.	**FR-103**
8.3.3.13.1 A.8.3.3.13.1	Revised to no longer require access to an energized electric fire pump controller.	**FR-104**
8.3.7.2.3 A.8.3.7.2.3(3)	Revised pump test flow results to evaluate the pump through both the system demand and 100 percent of rated flow.	**FR-106 SR-24**
8.3.7.2.4	Added specific action items to be undertaken upon degraded pump performance.	**FR-107 SR-42**
8.6.1	Modified Table 8.6.1 to align with the requirements of this standard and reorganized alphabetically.	**SR-43**
CHAPTER 9		
9.1.1.2	Modified Table 9.1.1. to align with the requirements of this standard and reorganized in alphabetically.	**FR-117 SR-44**
9.2.1.3 9.2.1.3.1 9.2.1.3.2 A.9.2.1.3.2	Added requirements for visual inspection of water level indicators.	**FR-31 SR-45**
9.5.1.1	Modified Table 9.5.1.1 to align with the requirements of this standard and reorganized alphabetically.	**FR-128 SR-46**
9.6.1	Modified Table 9.6.1 to align with the requirements of this standard and reorganized alphabetically.	**SR-47**
CHAPTER 10		
10.1.1.2	Modified Table 10.1.1.2 to align with the requirements of this standard and reorganized alphabetically.	**FR-118 SR-48**
10.5.1	Modified Table 10.5.1 to align with the requirements of this standard and reorganized alphabetically.	**SR-49**

Section Number	Comments	FR/SR
CHAPTER 11		
11.1.1.2	Modified Table 11.1.1.2 to align with the requirements of this standard and reorganized alphabetically.	**FR-88 SR-50**
11.2.9	Added option to send samples to independent foam testing laboratories.	**FR-32**
11.3.5.4	Revised to match requirement for the acceptance testing from NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*, and NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*. Removes allowance for concentrations below nominal use concentration.	**FR-34 SR-28**
11.4.4.2 11.4.4.2.1 11.4.4.2.2	Added guidance needed to minimize the possibility of damaging the diaphragm.	**FR-36**
11.5.1	Modified Table 11.5.1 to align with the requirements of this standard and reorganized alphabetically.	**FR-37 SR-51**
CHAPTER 12	Revised chapter to align with the format used in the other chapters of NFPA 25.	**FR-44**
12.1.1.2	Modified Table 12.1.1.2 to align with the requirements of this standard and reorganized alphabetically.	**SR-62**
12.1.2	Revised to clarify that in any instance where Chapter 12 conflicts with Chapter 13, the requirements in Chapter 12 take precedence.	**SR-30**
12.2.5.4.1 12.2.5.4.2 12.2.5.4.3	Added to clarify different frequencies for cylinders that are electrically supervised and those that are not.	**SR-52**
12.2.5.8	Added to clarify that only manually operated indicating valves must be inspected on a semiannual basis to ensure they are in the proper position to be operated.	**SR-53**
12.2.6	Added to clarify that the requirement applies to all pneumatically operated valves, not just pneumatically operated cylinder valves.	**SR-54**
12.3.1.5 A.12.3.1.5	Added annex material to clarify allowance for the AHJ to permit additional testing of automatic nozzles.	**SR-55**
12.3.2.2 A.12.3.2.2	Added annex guidance on evaluation and test criteria.	**SR-57**
12.3.2.3	Added requirements for frequency of water mist nozzle testing where annual discharge testing is not feasible.	**SR-56**
12.3.2.5 A.12.3.2.5	Added annex language to clarify allowance for the AHJ to permit additional testing of open nozzles.	**SR-58**
CHAPTER 13		
13.1.1.2	Modified Table 13.1.1.2 to align with the requirements of this standard and reorganized alphabetically.	**FR-89 SR-60**
13.2.4 13.2.4.1 13.2.4.2	Revised criteria to provide pass/fail criteria for waterflow alarm testing. The time frames align with NFPA 13 and *NFPA 72®, National Fire Alarm and Signaling Code®*.	**SR-63**
13.4.3.2.4 A.13.4.3.2.4	Aligned requirements for preaction valves with those for deluge and ensures the full functionality of system is tested.	**FR-41**

Section Number	Comments	FR/SR
13.5.2.3	Specified to only apply to pressure reducing valves.	**FR-63**
13.5.3.3	Specified to only apply to pressure reducing valves.	**FR-64**
13.10 to 13.10.4.2	Added nitrogen generators, an alternate method to air compressors for maintaining system pressure, to the standard.	**FR-111**
13.11.1	Modified Table 13.11.1 to align with the requirements of this standard and reorganized alphabetically.	**FR-120 SR-61**
CHAPTER 14		
14.1	Clarified to address both identification of obstructive materials and identification of potential sources of corrosion.	**SR-31**
CHAPTER 15		
15.1.1.1	Revised to allow extraction to other NFPA documents that need impairment programs not limited to water-based systems.	**FR-62**
CHAPTER 16	No revisions	

PART 1

NFPA® 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 2020 Edition, with Commentary

Part 1 of this handbook includes the complete text of the 2020 edition of NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems,* which consists of 16 mandatory chapters and 8 nonmandatory annexes. Working within the framework of NFPA's consensus-based codes- and standards-making process, the Technical Committee on Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems prepared both the mandatory provisions found in Chapter 1 through Chapter 16 and the nonmandatory material found in the annexes.

The annex material is advisory or informational in nature and is provided to assist users in interpreting the mandatory standard provisions. It is not considered part of the requirements of the standard. An asterisk (*) following a standard paragraph number indicates that advisory material pertaining to that paragraph appears in Annex A. For the reader's convenience, in this handbook, Annex A material appears immediately following the mandatory paragraph to which it relates.

The explanatory commentary in this handbook was prepared by the handbook editors, with the assistance of those persons mentioned in the acknowledgments, and is intended to provide the reader with an understanding of the provisions of the standard and to serve as a resource and reference for implementing the provisions of or enforcing the standard. It is not a substitute for the actual wording of the standard or the text of the many codes and standards that are incorporated by reference. The commentary immediately follows the standard text it discusses and is shaded in blue for easy identification.

This edition of the handbook includes several features to assist the reader in using this handbook. These include the following:

- **Back to Basics.** Basic information on each type of system with helpful illustrations.
- **Frequently Asked Questions (FAQs).** Answers to questions commonly asked of NFPA 25 staff.
- **System Tagging Inspection and Testing Charts.** Charts that display in an easy-to-read format the noncritical deficiencies, critical deficiencies, and impairments for each type of system.
- **Historical Notes.** Additional background information regarding the changes to NFPA 25 over time.
- **Tips for Owners.** Highlighted sections that owners need to understand, whether they are performing some of the ITM tasks themselves or if they've contracted the service.
- **Case in Points.** Boxes that expand on the material in the commentary.
- **ITM vs Hazard Evaluation Examples.** Examples illustrating the differences between ITM-related field conditions that fall within the scope of NFPA 25 and items that are not considered to be "wear-and-tear" issues.
- **Testing Procedures.** Detailed discussions of the steps that should be taken in order to properly test systems.
- **System Tagging Case Studies.** A feature that helps readers understand what goes into the process of classifying deficiencies and impairments.

See the Preface of this handbook and the front and back inside covers for a more detailed explanation of these features.

REVISION SYMBOLS IDENTIFYING CHANGES FROM THE PREVIOUS EDITION

Text revisions are shaded. A Δ before a section number indicates that words within that section were deleted and a Δ to the left of a table or figure number indicates a revision to an existing table or figure. When a chapter was heavily revised, the entire chapter is marked throughout with the Δ symbol. Where one or more sections were deleted, a • is placed between the remaining sections. Chapters, annexes, sections, figures, and tables that are new are indicated with an ***N***.

Note that these indicators are a guide. Rearrangement of sections may not be captured in the markup, but users can view complete revision details in the First and Second Draft Reports located in the archived revision information section of each code at www.nfpa.org/docinfo. Any subsequent changes from the NFPA Technical Meeting, Tentative Interim Amendments, and Errata are also located there.

Shaded text = Revisions Δ = Text deletions and figure/table revisions • = Section deletions ***N*** = New material



1

ADMINISTRATION

Chapter 1 of NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, covers the administrative requirements for the periodic inspection, testing, and maintenance (ITM) of water-based fire protection systems. In addition to the scope and purpose of the standard, Chapter 1 provides guidance on the application of the standard and explains how units of measurement are expressed throughout the document. Understanding the scope of the document is critical to its proper use and application. This chapter establishes that ITM helps ensure operational readiness, while placing clear limits on its purpose, scope, and application.

1.1 Scope.

This document establishes the minimum requirements for the periodic inspection, testing, and maintenance of water-based fire protection systems and the actions to undertake when changes in occupancy, use, process, materials, hazard, or water supply that potentially impact the performance of the water-based system are planned or identified.

The scope of NFPA 25 is intended to help users determine if they are using the correct standard and summarizes what the document addresses.

Several important terms are used in this section. *Minimum requirements* are the basis for the rules that this standard sets forth. However, nothing prohibits the user from exceeding them. *Periodic* establishes that the requirements are performed on a set frequency. Those frequencies are defined in 3.7.1. The phrase *actions to undertake* signifies that further requirements are provided in the document. Lastly, the phrase *planned or identified* implies the following: (1) there are requirements that are meant to be observed as the changes are planned, and (2) these actions are meant to be followed anytime those changes are discovered, even if they were intended to be dealt with beforehand. Primary among these is the requirement that the owner have the system evaluated before making changes to the use, occupancy, hazard, or water supply. See 4.1.6 and 4.1.7 for more detailed information.

The minimum requirements specified in NFPA 25 must be met in order for a system to comply with this standard. Also, Section 4.7 permits alternative means of compliance using a performance-based program that could result in less frequent ITM activities.

Tip for Owners

It is important to understand that NFPA 25 provides *minimum* requirements for ITM activities. The owner can request that the inspecting contractor perform a higher degree of inspections and testing provided this has been discussed during the contract negotiations with the contractor. An owner can also request ITM frequencies that deviate from those prescribed in the standard based on the results of an engineering analysis. The frequencies identified in the engineering analysis would have to be reviewed and approved by the authority having jurisdiction (AHJ) prior to their implementation.

Δ 1.1.1 Coordination with *NFPA 72* Testing Requirements.

Many water-based fire protection systems contain electrical components that are critical to the proper operation of the system (see Exhibit 1.1). Although there may be some common components, NFPA 25 does not address all of the ITM requirements covered by *NFPA 72®*, *National Fire Alarm and Signaling Code®*. For the complete requirements for those systems, refer to *NFPA 72*.

1.1.1.1 The inspection, testing, and maintenance required by this standard and *NFPA 72* shall be coordinated so that the system operates as intended.

The requirements in 1.1.1 and 1.1.1.1 clarify that not all of the ITM requirements for electrical devices that are used with preaction, deluge, and other specialty systems are addressed by NFPA 25. In some cases, it might be necessary to coordinate the ITM of electrical initiating devices and other components with a qualified electrician or fire alarm technician.

1.1.1.2* All inspections, testing, and maintenance required by *NFPA 72* shall conform to *NFPA 72*, and all inspections, testing, and maintenance required by this standard shall conform to this standard.

NFPA 25 and *NFPA 72* address common components such as waterflow indicators. Although the technical committees for each document have worked to coordinate the requirements of the two standards, the frequency and methods for inspecting, testing, and maintaining these components might differ. Paragraphs 1.1.1.2 and A.1.1.1.2 state that devices must be inspected, tested, and maintained in accordance with the requirements of the applicable standard.

Certain inspections, tests, or maintenance may drive other requirements as well. For example, if a valve is closed for part of the valve supervisory switch testing or maintenance, a valve status test, or possibly a main drain test, would now be required by Chapter 13.

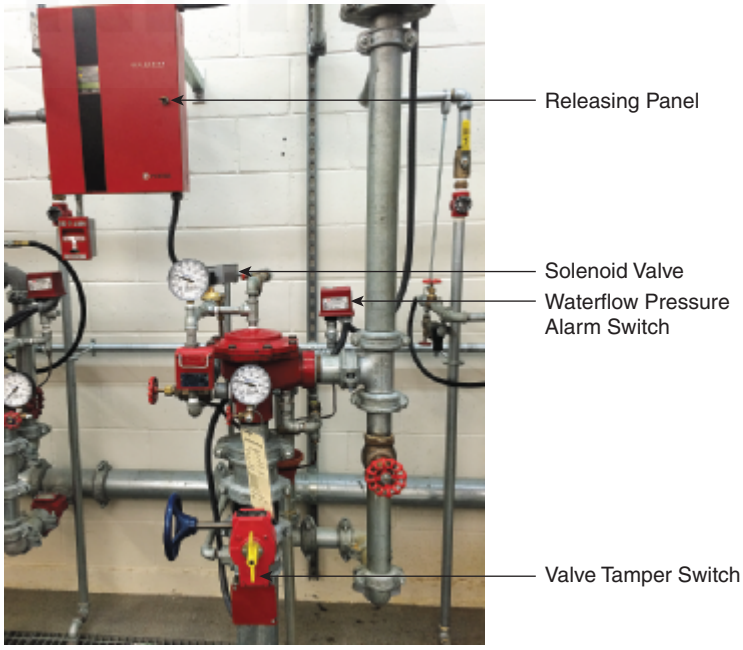


EXHIBIT 1.1 *Deluge Valve with Electrical Components. (Courtesy of Tyco Fire Suppression & Building Products)*

When contemplating the use of a single test to satisfy both NFPA 25 and *NFPA 72*, it is important to investigate the jurisdictional requirements regarding licensing and certification. Some jurisdictions prohibit a single individual from performing tests for both suppression and alarm systems due to licensing restrictions. In the example above, the technician may be permitted to test the valve supervisory switch — but he may not be permitted to perform the valve status or main drain test. However, in many jurisdictions, a single individual could be licensed or certified for multiple competencies.

A.1.1.1.2 This standard does not address all of the inspection, testing, and maintenance requirements of the electrical components of a water-based fire protection system that are addressed by *NFPA 72*. However, there are times when a single inspection or test can meet the requirements of both NFPA 25 and *NFPA 72* (e.g., operation of a tamper switch). This standard does not necessarily require that two separate inspections or tests be conducted on the same component, provided the inspection or test meets the requirements of both standards and the individual performing the inspection or test is qualified to perform the inspection or test required by both standards.

N **1.1.1.3** This standard does not address all of the inspection, testing, and maintenance of the electrical components of the automatic fire detection equipment used to activate preaction and deluge systems that are addressed by *NFPA 72*.

1.1.2 Types of Systems.

1.1.2.1 The types of systems addressed by this standard include, but are not limited to, sprinkler, standpipe and hose, fixed water spray, private fire hydrants, water mist, and foam water.

1.1.2.2 Water supplies that are part of these systems, such as private fire service mains and appurtenances, fire pumps and water storage tanks, and valves that control system flow, are also included in this standard.

1.1.3* This standard addresses the operating condition of fire protection systems as well as impairment handling and reporting and applies to fire protection systems that have been properly installed in accordance with generally accepted practice.

FAQ Do the requirements of NFPA 25, including a service program, inspection, maintenance, tests, and record or document retention, not apply if the system was not originally installed properly? If not, what is the meaning of 1.1.3?

It is the intent of the standard to require ITM of all water-based fire protection systems, regardless of the quality of the design and installation. The phrase *installed in accordance with generally accepted practice* is used so that implementation of the standard is not compromised because of design or installation variances from the applicable installation standard.

Δ **A.1.1.3** Generally accepted NFPA installation practices for water-based fire protection systems relevant to this standard are found in the following:

(1) NFPA 13
(2) NFPA 13R
(3) NFPA 14
(4) NFPA 15
(5) NFPA 16
(6) NFPA 20
(7) NFPA 22
(8) NFPA 24
(9) NFPA 750

Tip for Owners

In order to minimize time and expense, it is advisable to coordinate NFPA 25 ITM activities with the ITM activities required by other NFPA codes and standards, such as NFPA 4, NFPA 92, and *NFPA 72*. This will require coordinating a time that works for both the water-based system inspector and all other system inspectors, such as alarm inspectors, so that all inspections can be completed simultaneously. Consult NFPA 4 for further guidance on how full integrated testing programs can be developed for all interconnected fire protection systems.

Tip for Owners

Building owners need to be familiar with the fire protection systems in their buildings. If the ITM activities for a building system are not covered by a code or standard, the ITM activities and frequencies should be established by a registered design professional (RDP) — for example, an engineer — for that system, using a performance-based approach and approved by the AHJ.

1.1.3.1* This standard does not require the inspector to verify the adequacy of the design of the system.

Δ **A.1.1.3.1** The requirement to evaluate the adequacy of the design of the installed system or the capability of the fire protection system to protect the building or its contents is not a part of the periodic inspection, testing, and maintenance requirements of this standard. Examples of items not covered by this standard include the evaluation of unsprinklered areas and the spacing of sprinklers. However, such evaluation is the responsibility of the property owner or designated representative as indicated in 4.1.6, 4.1.7, and the Hazard Evaluation Form in Annex E.

Tip for Owners

Because the inspections required by NFPA 25 are not intended to reveal installation flaws or code compliance violations, it should not be the expectation of the owner that the inspector is evaluating the adequacy of the design of the installed system. Instead, NFPA 25 inspections are intended to address the operating condition of a system or system components, not the adequacy of the system design when compared to the applicable design and installation standards.

The inspections and tests required by NFPA 25 are developed around the common theme of ensuring operational readiness. Most of those inspection and testing requirements can be found in Chapters 5 through 13. Those chapters dictate specific inspections or tests that must be completed to be in compliance with the standard. For example, 5.2.1.1.1 states:

"Any sprinkler that shows signs of any of the following shall be replaced:
(1) Leakage
(2) Corrosion detrimental to sprinkler performance
(3) Physical damage
(4) Loss of fluid in the glass bulb heat-responsive element
(5) Loading detrimental to sprinkler performance
(6) Paint other than that applied by the sprinkler manufacturer"

However, the standard does not require verification that the installation is in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*.

A requirement to verify compliance with an installation standard is not considered in an NFPA 25 inspection. Verification of the design is challenging since installation standards regularly change with the advancement in sprinkler or other water-based fire suppression technology. Even when the age of the system is known, jurisdictions often do not adopt the most current edition of installation standards, so research would have to be done to determine which edition applies. In addition, local amendments or variances are sometimes in effect, further complicating the issue.

NFPA 25 seeks to balance the cost of inspections and testing with what produces the highest return in system reliability. When determining these requirements, fire loss data, component/system reliability data, and other information are analyzed to determine if the cost associated with the inspection or test, as well as the frequency, is justified. For example, Commentary Table 1.1 indicates that the most common cause of a sprinkler system failing to operate in a fire event is a closed valve. Since the burden on the owner of inspecting a valve on a frequent basis to ensure that it is in the correct position is relatively low, and the chances of a closed valve causing a sprinkler system failure are high, Chapter 13 requires the frequent inspection of control valve position (see 13.3.2).

FAQ Is an NFPA 25 inspection intended to address violations of NFPA 13 and other issues of improper or inadequate installation?

NFPA 25 inspections are intended to address the operating condition of a system or system components, not the adequacy of the system design when compared to the applicable design and installation standards. This is why NFPA 25 is commonly referred to as a "wear and tear" document.

The types of deficiencies that are intended to be identified during an NFPA 25 inspection include system components that are leaking, damaged, corroded, or in disrepair. Exhibit 1.2 shows a section of FDC piping and a coupling that are heavily corroded and need to be replaced. This is not to say that all system components that show signs of wear and tear will need to be immediately replaced. In some instances, there might be some exterior wear and tear or corrosion on a system component, but replacement of the component is not

necessary. Exhibit 1.3 shows a flanged elbow displaying exterior corrosion and rusted bolts. In this instance, the wear and tear on the component might not warrant the replacement of the components, but possibly just some new bolts and some scouring of the rusted exterior surface. The determination of the necessary corrective action is somewhat subjective and might require the input of the municipal AHJ or insurance representative.

It is not the intent of NFPA 25 to place the burden of a complete system evaluation on the inspector. However, nothing in NFPA 25 prohibits an inspector from informing the owner when design deficiencies are found. In reporting alleged design or installation deficiencies to the owner, the inspector must keep in mind that variations from current installation standards are not necessarily deficiencies and could be compliant with the installation standard or equivalency used for the original installation or variances permitted by the AHJ.

Such an evaluation should be conducted only by a qualified contractor, engineer, or design professional, and it is required only when changes are made to the building, its use, or its water supplies. As with most building codes, the requirements in 1.3.4 of *NFPA 5000®*, *Building Construction and Safety Code®*, apply to existing structures when the following situations occur:

- A change of use or occupancy classification
- A repair, renovation, modification, reconstruction, or an addition is made

Case In Point

It is not practical for an inspector to perform an evaluation of the design and installation aspects of a fire protection system because the cost of doing so would be prohibitive. This photo shows a typical warehouse space. To properly evaluate the adequacy of the system in this space, the inspector would need to determine the ceiling height, storage height, ceiling slope, commodity classification, clearance to ceiling, aisle widths, sprinkler design approach, and many other factors that went into the sprinkler system design. It would take an intimate knowledge of the building, its history, and its operation for an inspector to be able to properly evaluate the system. For this reason, it is simply not reasonable to include this level of evaluation as part of an annual inspection of the system.



Typical Large Warehouse Space. (Courtesy of Indonesian Fire & Rescue Foundation)

Similar provisions for existing buildings are found in 10.3.2 of NFPA 1, *Fire Code*:

Existing buildings that are occupied at the time of adoption of this *Code* shall remain in use provided that the following conditions are met:

(1) The occupancy classification remains the same.
(2) No condition deemed hazardous to life or property exists that would constitute an imminent danger.

Note that neither code requires a periodic evaluation of the system or building, but that an evaluation is needed when certain changes occur. This evaluation is covered in detail in Chapter 4 of NFPA 25.

Many owners, insurance providers, and government entities require a periodic evaluation or assessment of their existing systems. In these instances, NFPA 3, *Recommended Practice for Commissioning of Fire Protection and Life Safety Systems*, can be used as a basis for setting up a re-commissioning or retro-commissioning plan for a system or series of systems within a building.



EXHIBIT 1.2 *Corroded FDC Piping. (Courtesy of Byron Blake and SimplexGrinnell)*



EXHIBIT 1.3 *Lightly Corroded Fitting. (Courtesy of Wayne Automatic Fire Sprinklers, Inc.)*



EXHIBIT 1.4 *Improper Corrective Action. (Courtesy of Academy of Sprinkler Technology)*

1.1.4* Corrective action needed to ensure that a system operates in a satisfactory manner shall be in accordance with this standard unless this standard specifically refers to an appropriate installation standard.

While it is not within the scope of NFPA 25 to require the evaluation of a system installation, there are times when an installation standard is used. Such is the case when a corrective action is necessary. For example, if the adjustment, repair, or replacement of pipe and fittings affects more than 20 sprinklers in the system, the provisions of 5.5.1 and Table 5.5.1 require a hydrostatic test on the piping. Table 5.5.1 refers to NFPA 13 for this test.

When corrective action is required for an impaired component, the corrective action must be executed in accordance with the appropriate design and installation standard. For example, when a sprinkler is leaking or the glass bulb has been damaged, stopping the leak or replacing the bulb with a nail, as shown in Exhibit 1.4, is not considered making a corrective action in accordance with the design standard. This sprinkler would need to be replaced, as opposed to the attempted repair work shown in this photo.

A.1.1.4 For systems originally installed in accordance with one of these standards, the repair, replacement, alteration, or extension of such systems should also be performed in accordance with that same standard. When original installations are based on other applicable codes or standards, repair, replacement, alteration, or extension practices should be conducted in accordance with those other applicable codes or standards.

1.1.5 Unless required by Chapter 16, this standard shall not apply to sprinkler systems designed, installed, and maintained in accordance with NFPA 13D.

FAQ Does NFPA 25 apply to sprinkler systems in one- and two-family homes?

Systems installed in accordance with NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes,* are not covered by this standard due to their simplicity, although some of the procedures contained herein can be applied as good practice. Chapter 12 of NFPA 13D provides the ITM requirements for these systems. See A.12.2 of NFPA 13D for a recommended inspection and testing program.

While the scope of NFPA 25 specifically excludes NFPA 13D systems that are installed in one- and two-family homes, NFPA 13D systems are now being installed in some occupancies for which the systems were not originally intended. A primary example of this is in assisted living facilities. NFPA *101®*, *Life Safety Code®*, allows assisted living facilities to employ sprinkler systems designed to NFPA 13D instead of NFPA 13 or NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies.* When this design option is exercised, NFPA *101* requires that certain ITM activities identified in NFPA 25 must be followed even though NFPA 25 specifically excludes NFPA 13D systems from its scope.

To address this situation, the Technical Committee on Inspection, Testing, and Maintenance of Water-Based Systems added Chapter 16 in the 2014 edition of NFPA 25 to formally reference these requirements from NFPA *101*.

1.2* Purpose.

The purpose of NFPA 25 is to ensure that the operational status of a system is maintained. This section also provides the AHJ with the flexibility to deal with extenuating circumstances, such as a product recall or other situations specific to a particular area or project.

A.1.2 History has shown that the performance reliability of a water-based fire protection system under fire-related conditions increases where comprehensive inspection, testing, and maintenance procedures are enforced. Diligence during an inspection is important. The inspection, testing, and maintenance of some items in the standard might not be practical or possible, depending on existing conditions. The inspector should use good judgment when making inspections.

Sprinkler systems have an excellent success record. In those instances when they do fail, the majority of failures can be attributed to closure of control valves or lack of proper maintenance. Commentary Table 1.1 lists some types of failures related to maintaining the operational status of the fire protection system. The failures attributed to manual intervention defeating the equipment occur when equipment is manually shut down after a fire starts but before sprinklers operate. NFPA 25 addresses wholly — or in part — all the issues listed in Commentary Table 1.1.

COMMENTARY TABLE 1.1 *Reasons for Failure to Operate When Fire Was Large Enough to Activate Equipment and Equipment Was Present in Area of Fire*

Cause of Failure	*Percentage of Cases*
Equipment shut off before the fire	59
Manual intervention defeated the equipment	17
Lack of maintenance	10
Damaged component	7

Source: Adapted from Marty Ahrens, "U.S. Experience with Sprinklers," NFPA, July 2017, Figure 13.

Tip for Owners

It is important to disclose any distinct hazard to the ITM contractor during contract negotiations so that the required level of ITM activities can be verified with the AHJ. For example, a warehouse full of hazardous chemicals may require ITM activities beyond the minimum requirements of NFPA 25; whereas, for an office building, the minimum requirements are acceptable.

Historical Note

NFPA 25 was first published as a standard in 1992. The concept of inspection, testing, and maintenance of water-based fire protection systems has a considerably longer history. In 1939, a preliminary progress report of the sprinkler committee was presented during NFPA's 43rd annual meeting. A year later, in 1940, the Association membership officially adopted the first edition of NFPA 13A, *Recommended Practice for the Inspection, Testing, and Maintenance of Sprinkler Systems*, at its annual meeting. Subsequently, NFPA 13A went through 11 revisions, the last of which was published in 1987. The recommended practice was officially withdrawn during the fall 1993 Association meeting to be replaced by the new NFPA 25, which had been adopted the previous year.

During the fall 1988 meeting, the NFPA membership adopted the first edition of NFPA 14A, *Recommended Practice for the Inspection, Testing, and Maintenance of Standpipe and Hose Systems*, presented by the Technical Committee on Standpipes. NFPA 14A was developed from existing industry standards and model building codes. It too was withdrawn when NFPA 25 was first introduced.

Both NFPA 13A and 14A were recommended practices. They contained no mandatory language but offered suggestions for the proper care of sprinkler and standpipe systems. During the development of the final revision of NFPA 13A, several areas needed to be addressed that were outside of the scope of the Technical Committee on Automatic Sprinklers. Discussions on equipment such as underground mains, tanks, and pumps were necessary to provide guidance on the care of these systems. These issues surfaced once again during development of NFPA 14A. As a result, the Correlating Committee on Water Extinguishing Systems recommended that a new document be developed as a standard that contained mandatory language and that included a chapter on each type of basic system under their committee scope. An ad hoc committee was formed in 1989 to develop a committee scope, a document scope and purpose, and an outline draft of each chapter. The NFPA Standards Council approved the proposed project in 1990, a technical committee was appointed, and NFPA 25 was born. Although the standard met some resistance initially because some felt that maintenance of systems should be covered in a recommended practice and not mandated, the standard is now widely accepted.

Prior to the development of NFPA 25, maintenance of systems had been well-documented as a significant contributing factor to the successful operation of a sprinkler system. First published in the *Fire Journal* in 1965 and again in 1970, "Automatic Sprinkler Performance Tables, 1970 Edition," indicated that sprinklers perform exceptionally well. However, when systems do fail, 63 percent of those failures can be directly attributed to lack of proper maintenance. NFPA 25 addresses each of the leading causes of failure, from water control valves being shut off to inadequate water supplies (addressed in Chapter 7), obstruction to water distribution (addressed in Chapters 5 and 14), defective dry pipe valves (addressed in Chapter 13), and frozen systems (addressed in all "systems" chapters).

1.2.1 The purpose of this document is to provide requirements that ensure a reasonable degree of protection for life and property from fire through minimum inspection, testing, and maintenance methods for water-based fire protection systems.

1.2.2 In those cases where it is determined that an existing situation involves a distinct hazard to life or property, the authority having jurisdiction shall be permitted to require inspection, testing, and maintenance methods in excess of those required by the standard.

1.3* Application.

A.1.3 An entire program of quality control includes, but is not limited to, maintenance of equipment, inspection frequency, testing of equipment, on-site fire brigades, loss control provisions, and personnel training. Personnel training can be used as an alternative even if a specific frequency differs from that specified in this standard.

The increasing availability of new products, materials, and technologies, such as ultrasound examination of piping systems, makes the language in Section 1.3 and A.1.3 necessary. Products or methods not specifically addressed in the standard are recognized in Section 1.3, provided that the level of system integrity and performance is not lowered.

FAQ Can the specified frequencies in NFPA 25 be altered?

Increasing frequencies for ITM is generally permitted without restriction since NFPA 25 provides the minimum requirements. However, decreasing frequencies from those specified in NFPA 25 cannot be done unconditionally. The standard allows alternative programs for keeping systems operational, but it must be demonstrated that the programs developed deliver equal system integrity and performance. These alternative programs cannot simply be implemented by the entities that develop them. Rather, they must be reviewed and approved by the AHJ (see 1.3.2). A performance-based option for ITM, provided in Section 4.7, is permitted for establishing alternative methods or frequencies for ITM but must be approved by the AHJ.

1.3.1 It is not the intent of this standard to limit or restrict the use of other inspection, testing, or maintenance programs that provide an equivalent level of system integrity and performance to that detailed in this standard.

1.3.2 The authority having jurisdiction shall be consulted and approval obtained for such alternative programs.

Tip for Owners

A performance-based ITM program can be developed and approved by the AHJ to use in lieu of NFPA 25 activities and frequencies. For example, poor water quality may lead to a reduced internal assessment frequency; whereas good water quality may lead to an extended internal assessment frequency of a sprinkler system.

Recent advancements in automated inspection and testing have been recognized and additional requirements regarding their application are included in 4.6.6. Automated testing and inspection is one example where changes taking place in the field may impact how the standard is applied. It is critical that any variation from the requirements of NFPA 25 be carefully evaluated for performance and that the AHJ be involved.

1.4* Units.

Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI).

A.1.4 The liter and bar units, which are not part of but are recognized by SI, commonly are used in international fire protection. These units are provided in Table A.1.4 with their conversion factors.

Δ ***TABLE A.1.4*** *Metric Conversions*

Name of Unit	*Unit Symbol*	*Conversion Factor*
liter	L	1 gal = 3.785 L
liter per minute per square meter	$L/min \cdot m^2$	1 gpm/ft^2 = 40.746 $L/min \cdot m^2$
cubic decimeter	dm^3	1 gal = 3.785 dm^3
pascal	Pa	1 psi = 6894.757 Pa
bar	bar	1 psi = 0.0689 bar
bar	bar	1 bar = 10^5 Pa

Note: For additional conversions and information, see IEEE/ASTM-SI-10, *American National Standard for Metric Practice*.

1.4.1 If a value for measurement as given in this standard is followed by an equivalent value in other units, the first stated shall be regarded as the requirement. A given equivalent value shall be considered to be approximate.

1.4.2 SI units have been converted by multiplying the quantity by the conversion factor and then rounding the result to the appropriate number of significant digits. Where nominal or trade sizes exist, the nominal dimension has been recognized in each unit.

All units of measure in this standard are direct mathematical conversions, except pipe diameters for which a "soft conversion" is used to recognize trade sizes for metric pipe. Direct mathematical conversions can be problematic because direct conversions are still subject to rounding. It is important to note that the first stated unit is the requirement and the equivalent (second) unit is considered approximate. In NFPA 25, U.S. customary (English) units are listed first, followed by the SI (metric) equivalent.

References Cited in Commentary

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 1, *Fire Code,* 2018 edition.

NFPA 3, *Recommended Practice for Commissioning of Fire Protection and Life Safety Systems,* 2018 edition.

NFPA 4, *Standard for Integrated Fire Protection and Life Safety System Testing*, 2018 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2019 edition.

NFPA 13A, *Recommended Practice for the Inspection, Testing, and Maintenance of Sprinkler Systems,* withdrawn in 1993.

NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes,* 2019 edition.

NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies,* 2019 edition.

NFPA 14A, *Recommended Practice for the Inspection, Testing, and Maintenance of Standpipe and Hose Systems,* withdrawn in 1992.

NFPA 72®, *National Fire Alarm and Signaling Code,* 2019 edition.

NFPA 92, *Standard for Smoke Control Systems*, 2018 edition.

NFPA *101®*, *Life Safety Code®*, 2018 edition.

NFPA 5000®, *Building Construction and Safety Code®*, 2018 edition.

"Automatic Sprinkler Performance Tables, 1970 edition," *Fire Journal,* July 1970, pp. 35–39.

Ahrens, Marty, "U.S. Experience with Sprinklers," July 2017.



2

REFERENCED PUBLICATIONS

Chapter 2 lists publications that contain mandatory references for use with NFPA 25. Annex H lists publications that are nonmandatory informational references. By locating the mandatory referenced publications immediately after Chapter 1, Administration, the user is presented with the complete list of publications needed for effective use of the standard before reading the specific requirements.

The applicable provisions of the publications that are listed in Chapter 2 are considered requirements of NFPA 25. Therefore, whether a requirement resides within NFPA 25 or it is mandatorily referenced in a document from the referenced publications list, the requirement must be met to achieve compliance with NFPA 25. However, the requirements contained in the referenced publications are only applicable to the extent called for in NFPA 25.

FAQ Are the procedures outlined in NFPA 291, *Recommended Practice for Fire Flow Testing and Marking of Hydrants,* required to be followed?

Procedures established in any recommended practice issued by NFPA are, by definition, only recommended. While the practices in NFPA 291 and other similar publications constitute recommended procedures, and in most cases "best practices," they have not been issued as standards and are therefore not mandatory. For this reason, NFPA 291 is included in the list of nonmandatory informational references in Annex H but not Section 2.2 for mandatory referenced publications.

2.1 General.

The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

Tip for Owners

Most of the referenced documents in NFPA 25 will only need to be consulted where a system repair constitutes an acceptance test in accordance with the original design and installation standard.

Δ 2.2 NFPA Publications.

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.
NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam,* 2016 edition.
NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2019 edition.
NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes,* 2019 edition.
NFPA 14, *Standard for the Installation of Standpipe and Hose Systems,* 2019 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection,* 2017 edition.
NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems,* 2019 edition.
NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection,* 2019 edition.
NFPA 22, *Standard for Water Tanks for Private Fire Protection,* 2018 edition.
NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances,* 2019 edition.
NFPA *70E®*, *Standard for Electrical Safety in the Workplace®*, 2018 edition.
NFPA 72®, *National Fire Alarm and Signaling Code®,* 2019 edition.
NFPA *101®*, *Life Safety Code®,* 2018 edition.
NFPA 110, *Standard for Emergency and Standby Power Systems,* 2019 edition.
NFPA 307, *Standard for the Construction and Fire Protection of Marine Terminals, Piers, and Wharves,* 2016 edition.
NFPA 409, *Standard on Aircraft Hangars,* 2016 edition.
NFPA 750, *Standard on Water Mist Fire Protection Systems,* 2019 edition.
NFPA 1962, *Standard for the Care, Use, Inspection, Service Testing, and Replacement of Fire Hose, Couplings, Nozzles, and Fire Hose Appliances,* 2018 edition.

2.3 Other Publications.

2.3.1 ASTM Publications.

ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.
ASTM D975, *Standard Specification for Diesel Fuel Oils*, 2015.
ASTM D3359, *Standard Test Methods for Rating Adhesion by Tape Test*, 2017.
ASTM D6751, *Standard Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels*, 2015ce1.
ASTM D7462, *Standard Test Method for Oxidation Stability of Biodiesel (B100) and Blends of Biodiesel with Middle Distillate Petroleum Fuel (Accelerated Method)*, 2011.

N **2.3.2 CGA Publications.**

Compressed Gas Association, 14501 George Carter Way, Suite 103, Chantilly, VA 20151.
CGA C-6, *Standard for Visual Inspection of Steel Compressed Gas Cylinders,* 2013.

2.3.3 HI Publications.

Hydraulic Institute, 6 Campus Drive, First Floor North, Parsippany, NJ 07054-4405.
HI 3.6, *Rotary Pump Tests*, 2016.

2.3.4 Other Publications.

Merriam-Webster's Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

Δ 2.4 References for Extracts in Mandatory Sections.

NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam,* 2016 edition.
NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2019 edition.
NFPA 14, *Standard for the Installation of Standpipe and Hose Systems,* 2019 edition.
NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection,* 2017 edition.
NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems,* 2019 edition.
NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection,* 2019 edition.
NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances,* 2019 edition.

NFPA 72®, National Fire Alarm and Signaling Code®, 2019 edition.
NFPA 96, *Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations,* 2017 edition.
NFPA 110, *Standard for Emergency and Standby Power Systems,* 2019 edition.
NFPA 750, *Standard on Water Mist Fire Protection Systems,* 2019 edition.
NFPA 820, *Standard for Fire Protection in Wastewater Treatment and Collection Facilities,* 2020 edition.
NFPA 1141, *Standard for Fire Protection Infrastructure for Land Development in Wildland, Rural, and Suburban Areas,* 2017 edition.
NFPA 1142, *Standard on Water Supplies for Suburban and Rural Fire Fighting,* 2017 edition.
NFPA 1911, *Standard for the Inspection, Maintenance, Testing, and Retirement of In-Service Emergency Vehicles,* 2017 edition.

Reference Cited in Commentary

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 291, *Recommended Practice for Fire Flow Testing and Marking of Hydrants,* 2019 edition.

NFPA



3

DEFINITIONS

Chapter 3 of NFPA 25 contains definitions of specialized terms used in the standard and systems descriptions to assist the user. The NFPA official definitions listed in Section 3.2 are used throughout NFPA codes and standards for consistency. Section 3.3 lists general fire protection terms. Some of the definitions in this chapter are extracted from other NFPA standards, and they are identified with the standard and edition year in brackets following the definition.

3.1 General.

The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary*, 11th edition, shall be the source for the ordinarily accepted meaning.

If the stakeholders in the inspection, testing, and maintenance (ITM) process are not familiar with the terms used in NFPA 25, it can result in anything from a minor miscommunication to a significant liability claim or worse. Some terms are used throughout many NFPA documents and have the same meaning; however, there are many terms that have a specific meaning when used in the context of ITM and are therefore defined in this chapter as appropriate.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

A.3.2.1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

The term *approved* is not used often in this standard, because the inspector is not required to verify the use of approved components or installation methods for an inspection or test. However, there are a number of instances where the standard calls for procedures or programs to be approved.

3.2.2* Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

A.3.2.2 Authority Having Jurisdiction (AHJ). The phrase "authority having jurisdiction," or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

Tip for Owners

Although the fire department is typically associated with the term *authority having jurisdiction (AHJ)*, there are several other entities that may be classified as an AHJ. A building owner may need to submit the inspection reports to more than one AHJ as defined by NFPA 25. For example, in order to maintain current insurance rates, the inspection reports may also need to be provided to the building's insurer.

The *authority having jurisdiction* (AHJ) is the person or entity enforcing the standard. In cases where the standard is to be legally enforced, the AHJ is usually a representative of a governmental agency such as a fire marshal or building official. The AHJ can also be an insurance company representative or the property owner. It is common for multiple AHJs to have an interest in the same property.

To comply with NFPA 25, a program for ITM of systems can exceed the NFPA 25 requirements but cannot be less stringent than those specified unless an alternative program provides an equal level of system integrity and performance. Refer to Section 1.3 and Section 4.7 for more information. Supplement 5 in Part 2 of this handbook provides additional information on the role and responsibilities of the AHJ in the ITM process.

3.2.3* Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

A.3.2.3 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

The term *listed* is most often used with installation standards. The term is typically used in NFPA 25 when referring to corrective actions or ITM procedures that are specified with a product's listing. However, it should be kept in mind that listed devices are required or intended for use in conducting certain tests. For example, NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, requires that listed fixed nozzles, hose valves, or flow meters must be installed for fire pump testing. Where listed devices are not installed, steps should be taken to obtain approval from the AHJ for the use of nonlisted test devices as specified in 8.3.3.1, which states that the annual test must be conducted through *approved* test devices.

FAQ Do the terms *classified* and *approved* mean the same as the term *listed*?

When system components or parts are replaced, the related installation standard to be followed identifies the components that are required to be listed. As defined, a listing means that the component has been evaluated under the conditions in which it is expected to perform and that it meets certain product standards. Some testing laboratories refer to "classified" or "approved" components, each of which meets the definition of *listed* in this standard.

3.2.4 Shall. Indicates a mandatory requirement.

The term *shall* indicates a requirement of this standard and mandates that a specific provision of NFPA 25 be followed. Mandatory requirements of NFPA 25 are found in the main body of the standard (Chapter 1 through Chapter 16).

3.2.5 Should. Indicates a recommendation or that which is advised but not required.

The term *should* indicates a recommendation of this standard. It identifies a good idea or a best practice. When the term *should* is used with a provision of the standard, the provision is not meant to be a requirement. Recommended provisions are limited to Annex A through Annex H of NFPA 25. It is important to note, however, that the recommendations in the annexes have, on occasion, been looked at by courts as insight into the intentions of the technical committee that developed the standard. Although it is not intended that the annex material included with any NFPA standard be mandatory, some AHJs could mandate that the annex material be enforceable. In such cases, the annex material should be treated as mandatory.

The user of this handbook is reminded that any section number preceded by a letter (e.g., A.3.5.1) is an annex item. For the reader's convenience, annex material immediately follows the code section it references.

3.2.6 Standard. An NFPA Standard, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and that is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the NFPA Manuals of Style. When used in a generic sense, such as in the phrase "standards development process" or "standards development activities," the term "standards" includes all NFPA Standards, including Codes, Standards, Recommended Practices, and Guides.

3.3 General Definitions.

3.3.1 Adjust. To maintain or regulate, within prescribed limits, by setting the operating characteristics to specified parameters. [**1911,** 2017]

3.3.2* Alarm Receiving Facility. The place where alarm or supervisory signals are received.

A.3.3.2 Alarm Receiving Facility. This can include proprietary supervising stations, central supervising stations, remote supervising stations, or public fire service communications centers.

N **3.3.3 Automated Inspection and Testing.** The performance of inspections and tests at a distant location from the system or component being inspected or tested through the use of electronic devices or equipment installed for the purpose.

3.3.4* Automatic Detection Equipment. Equipment that automatically detects heat, flame, products of combustion, flammable gases, or other conditions likely to produce fire or explosion and cause other automatic actuation of alarm and protection equipment.

A.3.3.4 Automatic Detection Equipment. Water spray systems can use fixed temperature, rate-of-rise, rate-compensation fixed temperature, optical devices, flammable gas detectors, or products of combustion detectors.

The term *automatic detection equipment* is normally used to describe an electronic detection system and should not be confused with a pilot sprinkler system where the sprinkler is used as a fixed temperature heat detector to hydraulically or pneumatically release the system actuation valve.

3.3.5* Automatic Operation. Operation without human intervention.

A.3.3.5 Automatic Operation. This operation includes, but is not limited to, heat, rate of heat rise, smoke, or pressure change.

3.3.6 Automatic Transfer Switch (ATS). Self-acting equipment for transferring the connected load from one power source to another power source. [**110,** 2019]

3.3.7 Clean. To remove dirt, scale, and debris.

3.3.8* Deficiency. For the purposes of inspection, testing, and maintenance of water-based fire protection systems, a condition that will or has the potential to adversely impact the performance of a system or portion thereof but does not rise to the level of an impairment.

A.3.3.8 Deficiency. Depending on the nature and significance of the deficiency, it can result in a system impairment. Critical deficiencies will adversely impact performance but without the need for the implementing impairment procedures. Noncritical deficiencies have the potential to impact performance.

Table A.3.3.8 provides examples for classifying conditions needing repair or correction that are identified during the inspection, testing, and maintenance of water-based suppression systems. The conditions are classified as an impairment, critical deficiency, or noncritical deficiency. The table is not all-inclusive but is included to provide guidance in responding to these conditions. For example, an impairment should be addressed promptly by either immediately correcting the condition or implementing the impairment procedures found in Chapter 15. Critical and noncritical deficiencies should be corrected as soon as practical after considering the nature and severity of the risk. It should be noted that many jurisdictions have requirements for the timely correction of impairments and/or deficiencies.

The table does not take into account every variation of the conditions needing repair or correction. For example, a single lightly painted sprinkler in a large warehouse might be noncritical in its risk while a single painted sprinkler in a battery-charging station might be considered a critical deficiency or perhaps an impairment. In addition, the nature of the hazard or the life safety exposure of the occupancy should be considered when assigning a classification. The table should be used with good judgment and could require input from the authority having jurisdiction.

Tip for Owners

Building owners are responsible for the correction of all deficiencies. While some more minor deficiencies could be corrected quickly by the ITM service provider, more complex fixes might require individuals that are qualified in different areas, such as sprinkler system installation. The owner should also clearly understand ahead of time how corrective action is built into the contract with the service provider or how charges for corrective actions will be addressed.

Δ ***TABLE A.3.3.8*** *Water-Based Fire Protection System Inspection and Testing Findings*

Item	*Finding*	*Reference*	*Impairment*	*Critical Deficiency*	*Noncritical Deficiency*
Chapter 5: Sprinkler Systems—Inspection					
All sprinklers	Leaking—spraying or running water	5.2.1.1.1	X		
All sprinklers	Leaking—dripping water	5.2.1.1.1		X	
All sprinklers	Foreign material attached or suspended from	5.2.1.1.1	X		
All sprinklers	Minimum clearance to storage not maintained	5.2.1.2		X	
All sprinklers	Lightly loaded	5.2.1.1.1			X
Standard-response sprinklers in nonresidential occupancies	One sprinkler and less than 50% of sprinklers in compartment is heavily loaded or corroded; painted operating element, bulb, deflector, or coverplate; improper orientation; glass bulb has lost fluid; damaged	5.2.1.1.1		X	
Standard-response sprinklers in nonresidential occupancies	Two or more sprinklers in compartment are heavily loaded or corroded; painted operating element, bulb, deflector, or coverplate; improper orientation; glass bulb has lost fluid; damaged	5.2.1.1.1	X		
Fast-response element, quick-response, electrically operated, residential sprinklers and standard-response in residential occupancies	One or more sprinklers heavily loaded or corroded; painted operating element, bulb, deflector, or coverplate; improper orientation; glass bulb has lost fluid; damaged	5.2.1.1.1	X		
Coverplates	Concealed sprinkler coverplates caulked or glued to ceiling	5.2.1.1.1	X		
Escutcheons and coverplates	Missing recessed or flush escutcheons, concealed coverplate with deflector and operating element in correct position	5.2.1.1.5			X
Escutcheons and coverplates	Missing recessed or flush escutcheons, concealed coverplate with deflector and operating element not in correct position	5.2.1.1.5	X		
Escutcheons	Recessed or flush escutcheons caulked or glued to ceiling	5.2.1.1.1		X	
Spare sprinkler cabinet	Cabinet missing, temperature, above maximum permitted, not proper number and type, missing wrench for each type	5.2.1.4	Table 5.4.1.5.2		X
Pipe and fittings	Leaking—slowly dripping and/or moisture on surface	5.2.2.1		X	
Pipe and fittings	Leaking—spraying or running water	5.2.2.1	X		
Pipe and fittings	Critical mechanical damage	5.2.2.1		X	
Hangers and seismic braces	Loose	5.2.3.2			X
Hangers and seismic braces	Damaged or unattached	5.2.3.2		X	
Gauges	Not operating or damaged	13.2.5.1.1			X

(continues)

Δ *TABLE A.3.3.8 Continued*

Item	*Finding*	*Reference*	*Impairment*	*Critical Deficiency*	*Noncritical Deficiency*
Gauges	Not showing normal water/air pressure	13.2.5.1.2, 13.7.5.1.3		X	
Gauges	Freezer—system pressure lower than compressor	13.2.5.1.4	X		
Alarm devices	Physical damage	5.2.4			X
Hydraulic design information sign	Not attached properly, illegible or missing	5.2.5			X
Information sign	Not attached, illegible, or missing	5.2.7			X
General information sign	Not attached, illegible, or missing	5.2.8			X
Antifreeze information sign	Not attached, illegible, or missing	5.2.9			X
Heat tape	Not in accordance with manufacturer's instructions	5.2.6		X	
Chapter 5: Sprinkler Systems—Testing					
Gauges	Not replaced or calibrated in 5 years, not accurate within 3% of scale	13.2.5.2/ 13.2.5.3			X
Alarm devices	Water motor and gong not functioning	5.3.3.1		X	
Alarm devices	Pressure-switch- or vane-type switch not functioning or no alarm	5.3.3.2		X	
Antifreeze systems	Mixture and concentration does not meet requirements of 5.3.3.4.1 and 5.3.3(1)(a)	5.3.4		X	
Antifreeze systems	Concentration is inadequate to prevent freezing	Table A.5.3.4.4.1(1), 5.3.4.2.1, and Figure A.5.3.4	X		
Main drain	More than 10% drop in full flow pressure	13.2.3.3		X	
Assessment of internal condition	Assessment revealed presence of MIC, zebra mussels, rust, or scale	14.2.1		X	
Sprinklers	Sprinkler(s) fail laboratory testing	5.3.1	X	X	
Chapter 6: Standpipe and Hose Systems—Inspection					
Pipe and fittings	Leaking—slowly dripping and/or moisture on surface	6.2.4		X	
Pipe and fittings	Leaking—spraying or running water	6.2.4	X		
Pipe and fittings	Critical mechanical damage	6.2.4		X	
Hangers and supports	Damaged or missing	6.2.4		X	
Hose	Cuts, couplings not of compatible threads	6.2.5, NFPA 1962		X	
Hose	Deterioration, no gasket or damaged gaskets	6.2.5, NFPA 1962		X	
Hose	Mildew present, corrosion present, hose not connected	6.2.5, NFPA 1962			X
Hose nozzle	Missing, broken parts or thread gasket damaged	6.2.6, NFPA 1962		X	
Hose storage	Hose not properly racked or rolled, nozzle clip missing, nozzle not contained, damaged, obstructed	6.2.7, NFPA 1962		X	
Cabinet	Corroded or damaged parts, not easy to open, not accessible, not identified, door glazing in poor condition, lock not functioning in break glass type, valve, hose nozzle, fire extinguisher, etc.; not readily accessible	6.2.8, NFPA 1962		X	
Hydraulic design information sign	Missing	6.2.2			X

Δ *TABLE A.3.3.8 Continued*

Item	*Finding*	*Reference*	*Impairment*	*Critical Deficiency*	*Noncritical Deficiency*
Chapter 6: Standpipe and Hose Systems—Testing					
Hose storage device	Rack will not swing out of cabinet at least 90 degrees	6.2.7, NFPA 1962			X
Standpipe system	Test results did not provide design pressure at required flow	6.3.1		X	
Hydrostatic test of manual and semiautomatic dry standpipe systems	Leakage in inside piping	6.3.2.1			X
Main drain	More than 10% drop in full flow pressure	13.2.3.3		X	
Assessment of internal condition	Assessment revealed presence of MIC, zebra mussels, rust, or scale	14.2.1		X	
Chapter 7: Private Fire Service Mains—Inspection					
Exposed piping	Leaking—slowly dripping, and/or moisture on surface	7.2.2.1.2		X	
Exposed piping	Leaking—spraying or running water	7.2.2.1.2	X		
Exposed piping	Mechanical damage, corroded, not properly restrained	7.2.2.1.2		X	
Mainline strainers	Plugged, fouled	7.2.2.3.2	X		
Mainline strainers	Corroded	7.2.2.3.2		X	
Dry barrel, wet barrel, and wall hydrant	Inaccessible, barrel contains ice, cracks in barrel	7.2.2.4, 7.2.2.5	X		
Dry barrel, wet barrel, and wall hydrant	Barrel contains water, improper drainage from barrel, leaks at outlets or top of hydrant	7.2.2.4, 7.2.2.5		X	
Dry barrel, wet barrel, and wall hydrant	Tightness of outlets, worn nozzle threads, worn operating nut, missing wrench	7.2.2.4, 7.2.2.5			X
Monitor nozzles	Damaged, corroded, leaking	7.2.2.7		X	
Hose/hydrant houses	Inaccessible	7.2.2.8	X		
Hose/hydrant houses	Damaged	7.2.2.8		X	
Hose/hydrant houses	Not fully equipped	7.2.2.8			X
Chapter 7: Private Fire Service Mains—Testing					
Underground and exposed piping	Test results show deterioration in water supply when compared to previous results	7.3.1.1		X	
Dry barrel and wall hydrant	Hydrant did not flow clear or did not drain within 60 minutes	7.3.2.1, 7.3.2.4			X
Monitor nozzles	Did not flow acceptable amount of water, did not operate throughout their full range	7.3.3		X	
Chapter 8: Fire Pumps—Inspection					
Pump house/room	Ventilating louvers not free to operate	8.2.2(1)(c)		X	
Pump house/room	Heat not adequate, temperature less than 40°F (4°C)	8.2.2(1)(a)	X		
Pump house/room	Heat not adequate, temperature less than 70°F (21°C) for diesel pumps without engine heaters	8.2.2(1)(b)	X		

(continues)

Δ ***TABLE A.3.3.8*** *Continued*

Item	*Finding*	*Reference*	*Impairment*	*Critical Deficiency*	*Noncritical Deficiency*
Pump house/room	Heat not adequate, temperature less than 40°F (4°C), not as recommended by the engine manufacturer, for diesel pumps with engine heaters	8.2.2(1)(a) and (b)	X		
Pump house/room	Excessive water on floor	8.2.2(1)(d)		X	
Pump house/room	Coupling guard not in place	8.2.2(1)(e)		X	
Pump system	Suction, discharge, or bypass valves not fully open, pipe leaking, suction line and system line pressure not normal, wet pit suction screens obstructed	8.2.2(2)(a–f)	X		
Pump system	Waterflow test valves open, hose connection valve open, test line contains water	8.2.2(2)(g)		X	
Pump system suction	Reservoir empty	8.2.2(2)	X		
Pump system	Suction reservoir does not have required water level, wet pit suction screens missing	8.2.2(2)		X	
Electrical power to pump system	No electrical power—controller pilot light not illuminated, transfer switch pilot light not illuminated, isolating switch not closed, reverse phase alarm pilot light on or normal phase light is off	8.2.2(3)	X		
Electrical power to pump system	Electrical power is provided—controller pilot light not illuminated, transfer switch pilot light not illuminated, reverse phase alarm pilot light on, normal phase light is not illuminated	8.2.2(3)			X
Electric pump system	Oil level in vertical motor sight glass not normal	8.2.2(3)(e)		X	
Pressure maintenance (jockey) pump	No power	8.2.2(3)(f)			X
Diesel engine system	Alarm pilot lights are on	8.2.2(4)(f)		X	
Diesel engine system	Battery charging current not normal	8.2.2(4)(d)		X	
Diesel engine system	Battery failure pilot lights on	8.2.2(4)(e)		X	
Diesel engine system	Battery pilot lights off	8.2.2(4)(e)		X	
Diesel engine system	Battery terminals corroded	8.2.2(4)(l)		X	
Diesel engine system	Battery voltage readings not normal	8.2.2(4)(c)		X	
Diesel engine system	Controller selector switch not in auto position	8.2.2(4)(b)	X		
Diesel engine system	Cooling water level not normal	8.2.2(4)(j)			X
Diesel engine system	Cooling water level not visible	8.2.2(4)(j)		X	
Diesel engine system	Crankcase oil level not normal	8.2.2(4)(i)			X
Diesel engine system	Crankcase oil level below low level	8.2.2(4)(i)	X		
Diesel engine system	Electrolyte level in batteries not normal	8.2.2(4)(k)			X
Diesel engine system	Electrolyte level in batteries below top of battery plates	8.2.2(4)(k)		X	
Diesel engine system	Engine running time meter not reading	8.2.2(4)(g)			X
Diesel engine system	Fuel tank less than two-thirds full	8.2.2(4)(a)		X	
Diesel engine system	Fuel tank empty	8.2.2(4)(a)	X		
Diesel engine system	Water-jacket heater not operating	8.2.2(4)(m)		X	

Δ ***TABLE A.3.3.8*** *Continued*

Item	*Finding*	*Reference*	*Impairment*	*Critical Deficiency*	*Noncritical Deficiency*
Diesel engine system	Oil level in right angle gear drive not normal (not at level mark but visible in sight glass)	8.2.2(4)(h)			X
Diesel engine system	Oil level in right angle gear drive below low level (not visible in sight glass or below one finger knuckle for inspection hole)	8.2.2(4)(h)		X	
Diesel engine system	Battery terminals corroded	8.2.2(4)(l)		X	
Steam system	Steam pressure gauge reading not normal	8.2.2(5)		X	
Chapter 8: Fire Pumps—Testing					
Fire pump test	Pump did not start automatically	8.3.2.2	X		
	Pump failed to run for 10 minutes	8.3.2.3	X		
	Pump failed to run for 30 minutes	8.3.2.4	X		
Fire pump test—pump system	System suction and discharge gauge reading, or pump starting pressure outside the acceptable range	8.3.2.9(1)		X	
Fire pump test—pump system	Pump packing gland discharge not acceptable, unusual noise or vibration, packing boxes, bearings, or pump casing overheating	8.3.2.9(1)		X	
Fire pump test—electrical-motor-driven system	Time for motor to accelerate to full speed, time controller is on first step, or time pump runs after starting not acceptable	8.3.2.9(2)	X		
Fire pump test—diesel-engine-driven system	Time for engine to crank and time for engine to reach running speed not acceptable (engine to reach rated speed within 20 seconds per 11.2.7.1 of NFPA 20, 2019 edition)	8.3.2.9(3)		X	
Fire pump test—diesel-engine-driven system	Low rpm	8.3.2.9(3)	X		
Fire pump test—diesel-engine-driven system	Low oil pressure, high temperature, high cooling water pressure	8.3.2.9(3)		X	
Fire pump test—diesel-engine-driven system	Time for engine to crank and time for engine to reach running speed not acceptable, low rpm, low oil pressure, high temperature, high cooling water pressure	8.3.2		X	
Fire pump test—steam system	Gauge reading and time for turbine to reach running speed not acceptable	8.3.2.9(4)			X
Fire pump annual test	Circulation relief valve and/or pressure relief valve did not work properly at churn condition	8.3.3.10(1)		X	
Fire pump annual test	Pressure relief valve did not work properly at each flow condition	8.3.3.11		X	
Fire pump annual test (with transfer switch)	Overcurrent protective devices opened when simulating a power failure condition at peak load, power not transferred to alternate source, pump did not continue to perform at peak load, pump did not reconnect to normal power after removing power failure condition	8.3.3.12	X		

(continues)

Δ ***TABLE A.3.3.8*** *Continued*

Item	*Finding*	*Reference*	*Impairment*	*Critical Deficiency*	*Noncritical Deficiency*
Fire pump annual test	Alarms did not properly operate	8.3.3.13		X	
Pump house/room	Heating, lighting, ventilating systems did not pass test	8.2.2		X	
Fire pump annual test	Parallel or angular alignment not correct	8.3.6.4		X	
Fire pump annual test	Flow test does not meet most demanding system flow and pressure requirements	8.3.7.2.3(1)	X		
Fire pump annual test	Flow test results not within 5% of acceptance test or nameplate	8.3.7.2.3(2)			X
Fire pump annual test	Voltage readings at motor not within 5% below or 10% above rated (nameplate)	8.3.7.2.9		X	
Diesel fuel annual test	Diesel fuel tested for degradation and failed	8.3.4	X		
Chapter 9: Water Storage Tanks—Inspection					
Water level	Water level and/or condition not correct	9.2.1		X	
Water level	Tank is empty	9.2.1	X		
Heating system	Heating system not operational, water temperature below 40°F (4°C)	9.2.2		X	
Heating system	Water temperature at or below 32°F (0°C)	9.2.2	X		
Exterior	Tank exterior, supporting structure, vents, foundation, catwalks, or ladders where provided damaged	9.2.4.1			X
Exterior	Area around tank has fire exposure hazard in form of combustible storage, trash, debris, brush, or material	9.2.4.2			X
Exterior	Accumulation of material on or near parts that could result in accelerated corrosion or rot	9.2.4.2			X
Exterior	Ice buildup on tank and support	9.2.4.2		X	
Exterior	Erosion exists on exterior sides or top of embankments supporting coated fabric tanks	9.2.4.2			X
Exterior	Expansion joints leaking or cracking	9.2.4.3		X	
Exterior	Hoops and grilles of wooden tanks in poor condition	9.2.4.4			X
Exterior	Exterior painted, coated, or insulated surfaces of tanks or supporting structure degraded	9.2.4.5			X
Interior	Pitting, corrosion, spalling, rot, other forms of deterioration, waste materials exist, aquatic growth, local or general failure of interior coating	9.2.5.3			X
Interior	Voids beneath floor, with sand in middle of tanks on ring-type foundations	9.2.5.5			X
Interior	Heating system components or piping in poor condition but working	9.2.5.6			X
Interior	Heating system components or heating system piping in poor condition and not working	9.2.5.6	X		
Interior	Blockage of antivortex plate	9.2.5.7	X		
Interior	Deterioration of antivortex plate	9.2.5.7		X	

Δ *TABLE A.3.3.8 Continued*

Item	*Finding*	*Reference*	*Impairment*	*Critical Deficiency*	*Noncritical Deficiency*
Chapter 9: Water Storage Tanks—Testing					
Interior testing	Tank coating did not pass adhesion, coating thickness, or wet sponge test	9.2.6			X
Interior testing	Tank walls and bottoms did not pass ultrasonic test	9.2.6			X
Interior testing	Tank bottom seams did not pass vacuum-box test	9.2.6			X
Level indicator	Level indicator lacked freedom of movement, or not accurate	9.3.1		X	
Heating system	Not in working order	9.3.2		X	
Low-temperature alarm	Low-water-temperature alarm did not pass test	9.3.3		X	
High-temperature alarm	High-water-temperature limit switch did not pass test	9.3.4			X
Water level alarm	High- and low-water-level alarms did not pass test	9.3.5		X	
Gauges	Not tested in 5 years, not accurate within 3% of scale	13.2.5.2, 13.2.5.3			X
Chapter 10: Water Spray Fixed Systems—Inspection					
Pipe and fittings	Mechanical damage, missing or damaged paint or coating, rusted or corroded, not properly aligned or trapped sections, low point drains not functioning, improper location of rubber-gasketed fittings	10.2.3.1		X	
Hangers and seismic braces	Damaged or missing, not securely attached to structural or piping, missing or damaged paint or coating, rusted or corroded	10.2.3.2		X	
Water spray nozzles	Discharge devices missing, not properly positioned or pointed in design direction, loaded or corroded	10.2.4.1		X	
Water spray nozzles	Missing caps or plugs if required, or not free to operate as intended	10.2.4.2		X	
Strainers	Strainer plugged or fouled	10.2.6	X		
Strainers	Strainer damaged or corroded	10.2.6			X
Drainage	Trap sumps and drainage trenches blocked, retention embankments or dikes in disrepair	10.2.7			X
Ultra-high-speed	Detectors have physical damage or deposits on lenses of optical detectors	10.4.2		X	
Ultra-high-speed	Controllers found to have faults	10.4.3		X	
Chapter 10: Water Spray Fixed Systems—Testing					
Operational test	Heat detection system did not operate within 40 seconds, flammable gas detection system did not operate within 20 seconds	10.3.3.1	X		
Operational test	Nozzles plugged	10.3.3.3.1	X		
Operational test	Nozzles not correctly positioned	10.3.3.3.1		X	

(continues)

Δ ***TABLE A.3.3.8*** *Continued*

Item	*Finding*	*Reference*	*Impairment*	*Critical Deficiency*	*Noncritical Deficiency*
Operational test	Pressure readings not comparable to original design requirements	10.3.3.4.		X	
Operational test	Manual actuation devices did not work properly	10.3.5	X		
Main drain	More than 10% drop in full flow pressure	13.2.3.3		X	
Ultra-high-speed operational test	Response time was more than 100 milliseconds	10.4.5.2	X		
Assessment of the internal condition	Inspection revealed presence of MIC, zebra mussels, rust, and scale	14.2.1		X	
Chapter 11: Foam-Water Sprinkler Systems—Inspection					
Alarm devices	Physical damage apparent	5.2.4			X
Pipe and fittings	Mechanical damage, missing or damaged paint or coating, rusted or corroded, not properly aligned or trapped sections, low point drains not functioning, improper location or poor condition of rubber-gasketed fittings	11.2.2		X	
Hangers and seismic braces	Damaged or missing, not securely attached to structural or piping, missing or damaged paint or coating, rusted or corroded	11.2.3		X	
Foam-water discharge devices	Discharge devices missing	11.2.4.1	X		
Foam-water discharge devices	Discharge devices not properly positioned or pointed in design direction, loaded or corroded	11.2.4.1		X	
Foam-water discharge devices	Not free to operate as intended	11.2.4.2		X	
Foam-water discharge devices	Missing caps or plugs if required	11.2.4.2		X	
Foam-water discharge devices	Incorrect foam concentrate for application and devices	11.2.4.4		X	
Foam concentrate strainers	Blowdown valve open or not plugged	11.2.6.4		X	
Drainage	Trap sumps and drainage trenches blocked, retention embankments or dikes in disrepair	11.2.7			X
Proportioning systems (all)	Proportioning system valves not in correct open/closed position in accordance with specified operating conditions	11.2.8.3	X		
Proportioning systems (all)	Concentrate tank does not have correct quantity required by original design	11.2.8.4		X	
Proportioning systems (all)	Concentrate tank empty	11.2.8.4	X		
Standard pressure proportioner	Automatic drains (ball drip valves) not free or open, external corrosion on foam concentrate tanks	11.2.8.5.1			X
Bladder tank proportioner	Water control valve to foam concentrate in "closed" position	11.2.8.5.2	X		
Bladder tank proportioner	Foam in water surrounding bladder	11.2.8.5.2	X		
Bladder tank proportioner	External corrosion on foam concentrate tank	11.2.8.5.2			X
Line proportioner	Strainer damaged, corroded, pressure vacuum vent not operating freely	11.2.8.5.3		X	

Δ ***TABLE A.3.3.8*** *Continued*

Item	*Finding*	*Reference*	*Impairment*	*Critical Deficiency*	*Noncritical Deficiency*
Line proportioner	Strainer plugged or fouled	11.2.8.5.3	X		
Line proportioner	External corrosion on foam concentrate tank	11.2.8.5.3			X
Standard balanced pressure proportioner	Sensing line valves not open, no power to foam liquid pump	11.2.8.5.4	X		
Standard balanced pressure proportioner	Strainer damaged, corroded, plugged, or fouled, pressure vacuum vent not operating freely, gauges damaged or not showing proper pressures	11.2.8.5.4		X	
In-line balanced pressure proportioner	Sensing line valves at pump unit or individual proportioner stations not open, no power to foam liquid pump	11.2.8.5.5	X		
In-line balanced pressure proportioner	Strainer damaged, corroded, pressure vacuum vent not operating freely, gauges damaged or not showing proper pressures	11.2.8.5.5		X	
In-line balanced pressure proportioner	Strainer plugged or fouled	11.2.8.5.5	X		
Orifice plate proportioner	No power to foam liquid pump	11.2.8.5.6	X		
Orifice plate proportioner	Strainer damaged, corroded, pressure vacuum vent not operating freely, gauges damaged or not showing proper pressures	11.2.8.5.6		X	
Orifice plate proportioner	Strainer plugged or fouled	11.2.8.5.6	X		
Foam concentrate	Fails quality testing	11.4.2		X	
Chapter 11: Foam-Water Sprinkler Systems—Testing					
Alarm devices	Water motor and gong not functioning	13.2.4.1		X	
Alarm devices	Pressure switch or vane-type switch not functioning or no alarm	13.2.4.2		X	
Operational test	Fire detection system did not operate within requirements of *NFPA 72*	11.3.2.4		X	
Operational test	Nozzles plugged	11.3.2.6.1	X		
Operational test	Nozzles not correctly positioned	11.3.2.6.1		X	
Operational test	Pressure readings not comparable to original design requirements	11.3.2.7		X	
Operational test	Manual actuation devices not working properly	11.3.4	X		
Operational test	Foam sample failed concentration test	11.3.5	X		
Main drain	More than 10% drop in full flow pressure	13.2.3.3		X	
Assessment of internal condition	Inspection revealed presence of MIC, zebra mussels, rust, and scale	14.2.1		X	
Chapter 13: Valves, Valve Components, and Trim—Inspection					
Gauges	Not operating or damaged	13.2.5.1			
Gauges	Not showing normal water/air pressure	13.2.5.1		X	
Control valve	Improper closed position	13.3.2.2	X		
Control valve	Improper open position, leaking	13.3.2.2		X	
Control valve	Not accessible, no appropriate wrench if required, no identification	13.3.2.2			X
Control valve	Not sealed, locked, or supervised	13.3.2.2		X	
Alarm valve	External physical damage, trim valves not in appropriate open or closed position, retard chamber or alarm drain leaking	13.4.1.1		X	

(continues)

Δ *TABLE A.3.3.8 Continued*

Item	*Finding*	*Reference*	*Impairment*	*Critical Deficiency*	*Noncritical Deficiency*
Valve enclosure	Upon visual observation, enclosure not maintaining minimum 40°F (4°C) temperature	4.1.2.5		X	
Valve enclosure	Low-temperature alarms (if installed) are physically damaged	4.1.2.5.1, 4.1.2.5.2		X	
Preaction valve and deluge valve	External physical damage, trim valves not in appropriate open or closed position, valve seat leaking	13.4.3.1.1, 13.4.4.1.1		X	
Preaction valve and deluge valve	Electrical components not in service	13.4.3.1.1, 13.4.4.1.1	X		
Dry pipe valve/quick-opening device	External physical damage, trim valves not in appropriate open or closed position, intermediate chamber leaking	13.4.5.1.2		X	
Sprinkler pressure-reducing control valves	Not in open position	13.5.1.1	X		
Sprinkler pressure-reducing control valves	Not maintaining downstream pressures in accordance with design criteria	13.5.1.1		X	
Sprinkler pressure-reducing control valves	Leaking, valve damaged, hand wheel missing or broken	13.5.1.1		X	
Hose connection pressure-reducing valves	Hand wheel broken or missing, hose threads damaged, leaking, reducer missing	13.5.2.1		X	
Hose connection pressure-reducing valves	Cap missing	13.5.2.1			X
Hose rack assembly pressure-reducing valve	Hand wheel broken or missing, leaking	13.5.3.1		X	
Hose valves	Leaking, visible obstructions, caps, hose threads, valve handle, cap gasket, no restricting device, damaged, or in poor condition	13.6.1		X	
Hose valves	Hose threads not compatible	6.2.5.1	X		
Backflow prevention assemblies	Reduced-pressure assemblies, differential-sensing valve relief port continuously discharging	13.7.1.1		X	
Fire department connection	Not accessible, damaged couplings, or clapper not operating properly or missing	13.8.1	X		
Fire department connection	Couplings and swivels damaged, do not rotate smoothly, check valve leaking, automatic drain not operating properly or missing	13.8.1		X	
Fire department connection	Missing identification sign	13.8.1			X
Chapter 13: Valves, Valve Components, and Trim—Testing					
Main drain	More than 10% drop in full flow pressure	13.2.3.3		X	
Alarm devices	Water motor and gong not functioning	5.3.3.1, 13.2.4.3.2		X	
Alarm devices	Pressure switch or vane-type switch not functioning, no alarm	5.3.3.2, 13.2.4.4.2		X	
Gauges	Not replaced or calibrated in 5 years, not accurate within 3% of scale	13.2.5.2, 13.2.5.3			X
Control valve	Valve not operating through its full range	13.3.3.1		X	

Δ ***TABLE A.3.3.8*** *Continued*

Item	*Finding*	*Reference*	*Impairment*	*Critical Deficiency*	*Noncritical Deficiency*
Control valve	No spring or torsion felt in rod when opening post indicator valve	13.3.3.2	X		
Supervisory switches	No signal from two revolutions of hand-wheel from normal position or when stem has moved one-fifth of distance from normal position, signal restored in position other than normal	13.3.3.5.2		X	
Preaction valve	Priming water level not correct	13.4.3.2.1		X	
Preaction valve	Three-year air leakage test failed	13.4.3.2.6		X	
Deluge valve	Annual full flow trip test revealed plugged nozzles, manual actuation devices did not operate properly	13.4.4.2.4	X		
Deluge valve	Pressure reading at hydraulically most remote nozzle and/or at valve not compatible with original design values	13.4.4.2.7		X	
Preaction valve	Low air pressure switch did not send signal, no alarm	13.4.3.2.11		X	
Preaction and deluge valve	Low-temperature switch did not send signal, no alarm	13.4.3.2.12, 13.4.4.2.14		X	
Preaction valve	Automatic air maintenance device did not pass test	13.4.3.2.13			X
Dry pipe valve	Priming water level not correct	13.4.5.2.1		X	
Dry pipe valve	Does not trip during test	13.4.5.2.2	X		
Dry pipe valve	Test results not comparable with previous results	13.4.5.2.2		X	
Quick-opening device	Quick-opening device did not pass test	13.4.5.2.4		X	
Dry pipe valve	Low air pressure switch did not send signal, no alarm	13.4.5.2.6		X	
Dry pipe valve	Low-temperature switch did not send signal, no alarm	13.4.5.2.7		X	
Dry pipe valve	Automatic air maintenance device did not pass test	13.4.5.2.8		X	
Dry pipe system	Three-year leakage test failed	13.4.5.2.9		X	
Sprinkler pressure-reducing control valves	Test results not comparable to previous results	13.5.1.2		X	
Hose connection pressure-regulating valves	Test results not comparable to previous results	13.5.2.2		X	
Hose rack assembly pressure-regulating valve	Test results not comparable to previous results	13.5.3.2		X	
Hose valves (Class I and Class III standpipe system)	Annual test revealed valve leaking or difficult to operate	13.6.2.1.1		X	
Hose valves (Class II standpipe system)	Test revealed valve leaking or difficult to operate	13.6.2.2.1		X	
Backflow prevention assemblies	Did not pass minimum flow requirement for forward flow test	13.7.2.1	X		
Air compressors and nitrogen generators	Unit does not start at required air pressure, does not restore normal supervisory air pressure in required time frame, unit overheats while operating	13.10.3		X	

Assigning the appropriate deficiency or impairment level to field conditions that are identified while conducting inspections is a critical part of the ITM process. It is also what many believe to be the most difficult part of the process, since it is so subjective. While NFPA 25 does not specifically define a "tagging structure" for identifying these levels, many states have developed a series of color-coded tags that are placed on a system or component to identify the significance of the condition identified. Annex G provides AHJs with some basic guidance regarding a system status tagging program.

Historical Note

In previous editions of NFPA 25, the ITM requirements were presented as pass/fail requirements, because no other options for identifying system status were presented in the standard. In other words, the standard considered problems with a system only in the context of passing or failing a requirement within the standard. In the 2008 edition, tables were added to each chapter to provide guidance on component replacement action, but the standard still did not address when or if a certain violation of a requirement within the standard would result in the system being impaired. As a result, some AHJs treated any and all deficiencies as "impairments" and applied the requirements of Chapter 15, Impairments. For example, some AHJs considered a system "impaired" when minor problems were noted, such as a missing hydraulic nameplate or a missing sprinkler in the spare sprinkler cabinet.

Guidance was needed to determine which deficiency would result in what level of operational problems or potential problems. The solution was to develop sufficient guidance within the standard to clarify which deficiencies result in systems that need to be fixed but are otherwise anticipated to function properly in an emergency and which deficiencies affect system operation or even rise to the level of an impairment.

As a result, in the 2011 edition of NFPA 25, the definition of the term *deficiency* was revised and two new definitions were added—*critical deficiency* and *noncritical deficiency*—with the intent of providing clearer guidance for inspectors and AHJs in determining the severity of violations and the subsequent corrective actions that are necessary. For the 2011 edition, Annex E was developed to provide examples of classifications of some of the needed corrections and repairs that are identified in the system chapters of NFPA 25. While Annex E was not all-inclusive, it helped users determine the potential categories of deficiencies. These categories were strictly advisory and were meant to provide a level of consistency.

In the 2014 edition, Annex E was relocated to Annex A, and it was tied to the definition of *deficiency* and the conditions were further refined. Moving the table into what is considered by many users to be the "main annex" was meant to make it more accessible to those trying to classify deficiencies. Its presence in Annex A does not make it any more or less enforceable than when it was in Annex E, just more accessible.

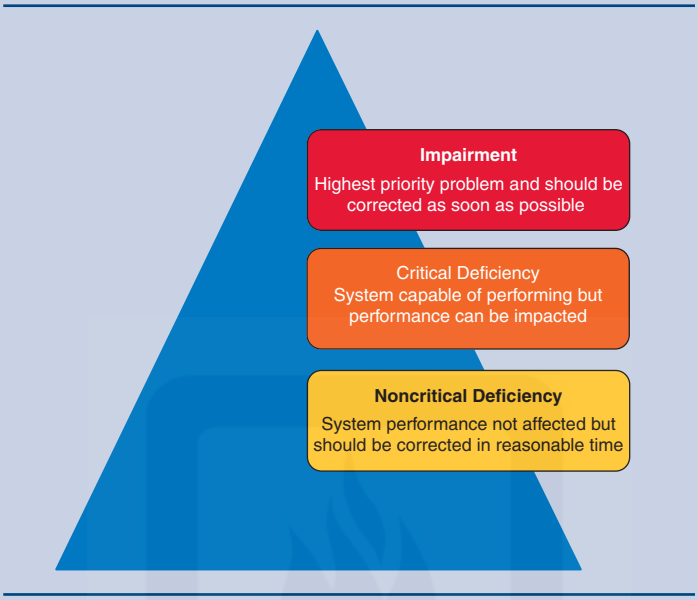
This handbook contains a feature that is intended to help readers learn about what goes into the process of classifying deficiencies and impairments. Using Table A.3.3.8 as a guide, this recurring feature examines dozens of field conditions and provides a glimpse at the thought process behind determining the severity of the condition and, ultimately, whether the condition should be listed as an impairment, critical deficiency, or noncritical deficiency.

To properly classify a deficient condition, the definitions in Chapter 3 become quite important. An *impairment*, as defined in 3.3.22, is a condition that renders a system inoperable or ineffective during a fire event. Many people believe that an impaired system is a system that has been shut off; however, that is only one application of the term. When a sprinkler is leaking, painted, or damaged, that device, and by extension a portion of the system, is impaired. Simply put, if a fire were to occur and a system or a portion of the system did not function as designed, it would qualify as an impairment.

A deficiency that does not leave a system impaired but, if it is not corrected, could lead to an impairment would qualify as a critical deficiency. A pipe that is showing corrosion or a

sprinkler that has loading on the frame arm will likely still function during a fire event; however, if the condition were to get any worse it could lead to an impairment. Finally, *noncritical deficiencies*, as defined by 3.3.8.2, refer to noncompliant conditions that will not impact system functionality, such as missing signs and broken gauges, or that have an unlikely chance of causing a given system to be ineffective during a fire.

Deficiency Levels



While these definitions help the user to classify deficiencies, in many cases the inspector will need to make some judgment calls—for example, assessing the future state of a system on the basis of the current appearance of a single component. In a perfect world, classifying deficiencies would be black and white; most often, however, the answer is some shade of gray.

When looking at these case studies of deficient conditions, there are a few things to keep in mind. First and foremost, there is no "correct" classification for most deficiencies. That is why Table A.3.3.8 resides in the annex as opposed to the body of NFPA 25. Even the technical committee that writes the standard, which is composed of experts on the ITM process, is not in a position to mandate specific levels of criticality for common deficiencies.

The purpose of this feature is not to tell the user exactly how to classify a deficiency if they run into something that looks like a case study in this handbook, but rather to study the thought process associated with applying the appropriate tag. It is important to remember that the photographs used in this feature only provide a snapshot of the field condition found and none of the surrounding facts that might play into the proper classification of a condition. To make good judgments, the inspector needs to be aware of the cumulative effects of the observed combination of conditions for all of the system components and the protected area that might lead to a "likely" adverse impact on the system operation. The dynamic nature of deficient mechanical systems makes it difficult to show the layered impact of multiple conditions in a single photograph; therefore, this feature takes a more static approach and focuses on the likelihood of a condition adversely affecting system operation.

To summarize, photographs seldom tell the whole story. Therefore, the way a condition is classified in this handbook might not always be the appropriate classification for a similar, but not identical, condition identified during an inspection. Another critical concept to keep in mind is that these images assume that the inspector could see the condition being addressed from the floor level. If a condition similar to what is being shown in this feature exists in a building, but it is not something the inspector could see as part of the inspection from floor level, it would not need to be identified in the NFPA 25 inspection report.

This feature uses a series of color-coded tags to represent the level of deficiency. For this handbook, the color scheme outlined in Annex G will be used:

Red tag = impairment
Orange tag = critical deficiency
Yellow tag = noncritical deficiency

System Tagging

The following photos represent the types of case studies that will be reviewed throughout this book. One photo has been provided for each of the three tag conditions that will be considered.

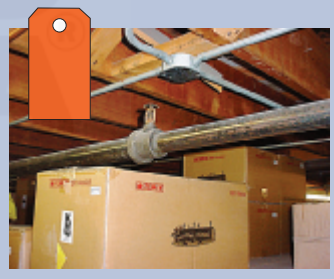
In the photo on the left, the presence of corrosion on the flange bolts in and of itself is not a major concern; however, note that the bolts on the upper flange have already been replaced. Also note that one of the bolts on the lower flange has sheared off. Because some of the bolts on this elbow already needed to be replaced and other bolts are brittle enough to break, these bolts, although not in sufficiently bad shape to cause leaking, should be replaced.

The image on the right shows a single sprinkler with storage located less than 1 ft (0.3 m) immediately below the deflector and more storage located behind the sprinkler that is almost level with the deflector. In many cases, the operations manager is unaware that storing goods within 18 in. (0.46 m) of the deflector is not permitted, and this condition exists over hundreds if not thousands of feet of floor area. These boxes will interrupt spray pattern development and can lead to large unprotected areas of stored goods. This condition can lead to system ineffectiveness and must be considered a critical deficiency. In situations where there are one or two boxes obstructing a single sprinkler in a large room, the inspector might consider looking at it as a noncritical deficiency and providing recommendations for the facility operations and maintenance manual.

A single residential sprinkler that is painted, like the one in the photo on the bottom, or one that is heavily loaded would need to be considered an impairment. Table A.3.3.8 makes a distinction between classifications in residential and nonresidential occupancies, highlighting the importance of not just looking at a single component, but getting the complete picture of the facility and the impact of the observed condition in that facility.

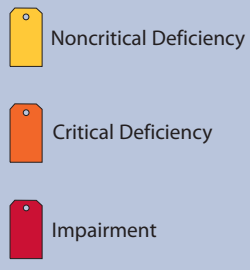


(Courtesy of Byron Blake and SimplexGrinnell)





(Courtesy of Byron Blake and SimplexGrinnell)



At present, there are several different tagging programs that are observed by various state, local, and private jurisdictions. These tagging programs use anywhere from two to five tags, with varying color schemes. For example, in the state of Florida, green tags are used to represent systems that are in compliance with the applicable provisions, and red tags represent systems that contain deficiencies or impairments. The system used in this handbook is not intended to replicate one of these systems but rather to be used in the absence of a universally accepted tagging program.

3.3.8.1 Critical Deficiency. A deficiency that, if not corrected, can have a material effect on the ability of the fire protection system or unit to function as intended in a fire event.

3.3.8.2 Noncritical Deficiency. A deficiency that does not have a material effect on the ability of the fire protection system or unit to function in a fire event, but correction is needed to meet the requirements of this standard or for the proper inspection, testing, and maintenance of the system or unit.

One of the more difficult tasks associated with NFPA 25 is determining how to treat the various deficiencies that are found while conducting inspections and tests. While it is clear in the standard that all deficiencies are required to be corrected, NFPA 25 recognizes that all deficiencies do not have the same impact on a system's ability to provide a reasonable degree of protection. So although it might be desirable to treat the correction of all deficiencies the same, it is not practical.

In deference to the concept of reasonableness, the standard recognizes that judgment should be used when determining how to address the corrective actions for deficiencies. To assist with this, the standard separates deficiencies into three basic categories: impairment, critical deficiency, and noncritical deficiency. An impairment, which is defined as a condition where a system or a portion of a system might not function in a fire event, requires immediate action by either correcting the deficiency or implementing the impairment procedures found in Chapter 15.

A system with critical and noncritical deficiencies will still operate, but its performance might be impacted negatively in some manner. The term *material effect* is used in both definitions to provide separation between these deficiencies. There is no way for judgment to be excluded with the classification of deficiencies. Table A.3.3.8 provides guidance, but even with the inclusion of this information, it is impossible to classify every situation that might be encountered. Some inspectors classify deficiencies, but the most common industry practice is to have the inspector record all observed deficiencies, followed by a subsequent classification conducted by a qualified individual or team. However, if the inspector identifies any severe impairments, such as a shut water control valve or an inoperable fire pump, those deficiencies must be reported immediately.

FAQ Must all deficiencies be treated equally with regard to reporting and corrective action?

Many jurisdictions have enacted differing reporting procedures, depending on the type or severity of the deficiency. Other jurisdictions treat all deficiencies with equal measure without regard to the type or severity. It is the intent of the Technical Committee on Inspection, Testing, and Maintenance of Water-Based Systems to define the differing levels of deficiencies to provide better consistency in interpretation and enforcement. Examples of critical deficiencies include a painted or damaged sprinkler, a faulty pressure-reducing hose valve, or an inaccessible fire hydrant. Noncritical deficiencies include missing signs, a broken handle on an inspector's test valve, or an inadequate number of spare sprinklers. Thus, a large number of painted sprinklers in a warehouse typically would be of more concern than a single painted sprinkler, and damaged threads on a hose connection might require a more immediate response than a missing sign on a control valve. While all deficiencies must be corrected, it is expected that the type of deficiency will dictate the appropriate level of response.

The correction of some deficiencies might require the system or a portion of it to be taken out of service. Such an action would be considered a preplanned impairment. Chapter 15 of the standard addresses the actions needed for preplanned impairments. Information in Annex A provides guidance for determining what level of corrective action should take place to bring the system back on line. It is not the intent of the standard that noncritical and critical deficiencies require impairment procedures such as fire watches, building evacuation, or standby fire protection during the time that the deficiency is being corrected, unless the corrective action requires impairment of the system, such as shutting off the water supply to replace a sprinkler.

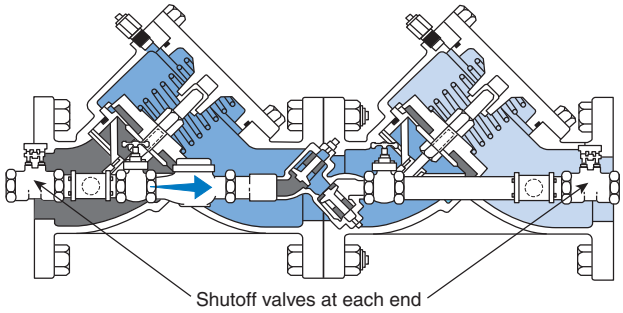
3.3.9 Discharge Device. A device designed to discharge water or foam-water solution in a predetermined, fixed, or adjustable pattern. Examples include, but are not limited to, sprinklers, spray nozzles, and hose nozzles. [**16,** 2019]

3.3.10 Double Check Valve Assembly (DCVA). This assembly consists of two internally loaded check valves, either spring-loaded or internally weighted, installed as a unit between two tightly closing resilient-seated shutoff valves as an assembly, and fittings with properly located resilient-seated test cocks.

The double check valve assembly (DCVA) is also referred to as a double check detector assembly (DCDA). The two differ slightly, but the purpose of both is to protect the potable water supply line from possible contamination or pollution from the fire system, back-pressure from fire line booster pumps, or stagnant "black water" that sits in fire lines over extended periods of time. The DCDA contains a bypass assembly with a water meter along with the double check valve and two tightly closing control valves or gate valves. Exhibit 3.1 shows both a DCVA and the interior of a DCDA.

EXHIBIT 3.1 *Double Check Valve Assembly (top) and Interior of a Double Check Detector Assembly (bottom). (Courtesy of CRD Water Services, Canada)*





3.3.11 Drain.

3.3.11.1 Main Drain. The primary drain connection located on the system riser.

Main drains are used as a test connection (see 13.2.3). Although flow can be estimated from a main drain connection, the main drain test is not intended to evaluate a water supply for hydraulic purposes. The purpose of the main drain test is to verify that water supply valves are open and to reveal any changes in the condition of the water supply by comparing results to those of previous tests. A main drain test on a system with large supply piping might not indicate a drop in pressure, even though the water supply might have deteriorated. For systems with large supply piping, additional flow testing outside of what is required by NFPA 25 might need to be conducted to ascertain a more thorough understanding of the condition of the water supply.

See Chapter 13 for additional details of main drains and their use and purpose.

3.3.11.2* Sectional Drain. A drain located beyond a sectional control valve that drains only a portion of the system.

A.3.3.11.2 Sectional Drain. An example of a sectional drain is a drain located beyond a floor control valve on a multistory building.

Sectional drains are not the same as "auxiliary drains." Auxiliary drains are required for trapped sections of piping that cannot be drained using the main or sectional drain valves. Auxiliary drains for a wet sprinkler system can consist of a fitting with a plug, or they can be complete with a valve, nipple, and cap. The size and configuration of the auxiliary drain depend on the type of system and the capacity of the trapped section of the system. Exhibit 3.2 illustrates an auxiliary drain for a dry pipe system where the volume of trapped water is 5 gal (18.9 L) or more.



EXHIBIT 3.2 *Dry System Auxiliary Drain.*

3.3.12 Fire Department Connection. A connection through which the fire department can pump supplemental water into the sprinkler system, standpipe, or other system furnishing water for fire extinguishment to supplement existing water supplies.

Fire department connections (FDCs) are an integral part of a fire protection system because they provide supplemental flow and pressure to the sprinkler and standpipe systems. Because of their location on the outside of the building, FDCs are prone to failure due to tampering or the exterior environment. Besides ensuring that the FDC is undamaged and unobstructed, access becomes a critical issue. If the fire department cannot access the FDC, it is of little value. See Section 13.8. Exhibit 3.3 through Exhibit 3.5 show FDCs that have been compromised for a multitude of reasons.

3.3.13* Fire Hydrant. A valved connection on a water supply system having one or more outlets and that is used to supply hose and fire department pumpers with water. [**1141,** 2017]

As specified in 1.1.2, the requirements of NFPA 25 apply only to private fire hydrants. ITM of fire hydrants located on public water mains under the control of a water authority is outside the scope of this standard unless required by the AHJ.

A.3.3.13 Fire Hydrant. See Figure A.3.3.13(a) and Figure A.3.3.13(b).



EXHIBIT 3.3 *Bird's Nest in FDC. (Courtesy of Wayne Automatic Fire Sprinklers, Inc.)*



EXHIBIT 3.4 *Inaccessible FDC. (Courtesy of Wayne Automatic Fire Sprinklers, Inc.)*

EXHIBIT 3.5 *Trash-Filled FDC.*



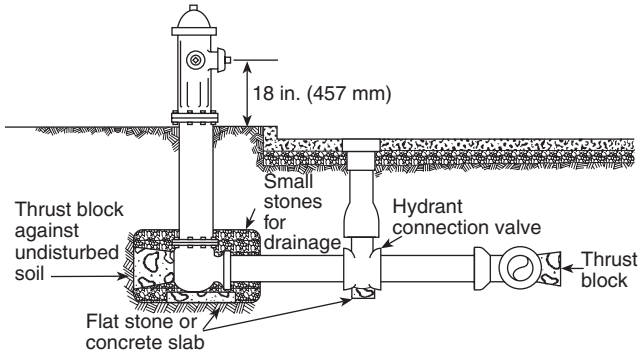


FIGURE A.3.3.13(a) *Typical Fire Hydrant Connection.*

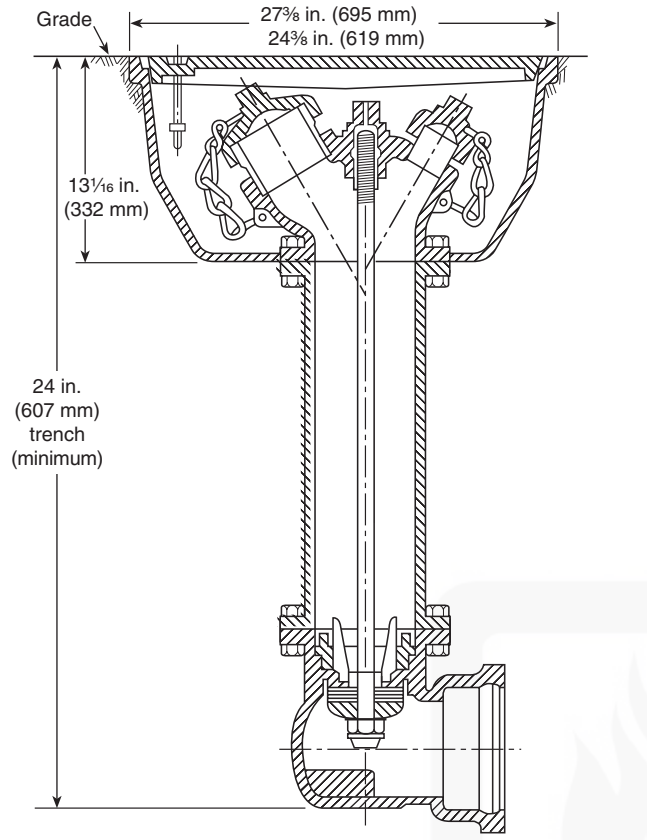


FIGURE A.3.3.13(b) *Flush-Type Hydrant.*

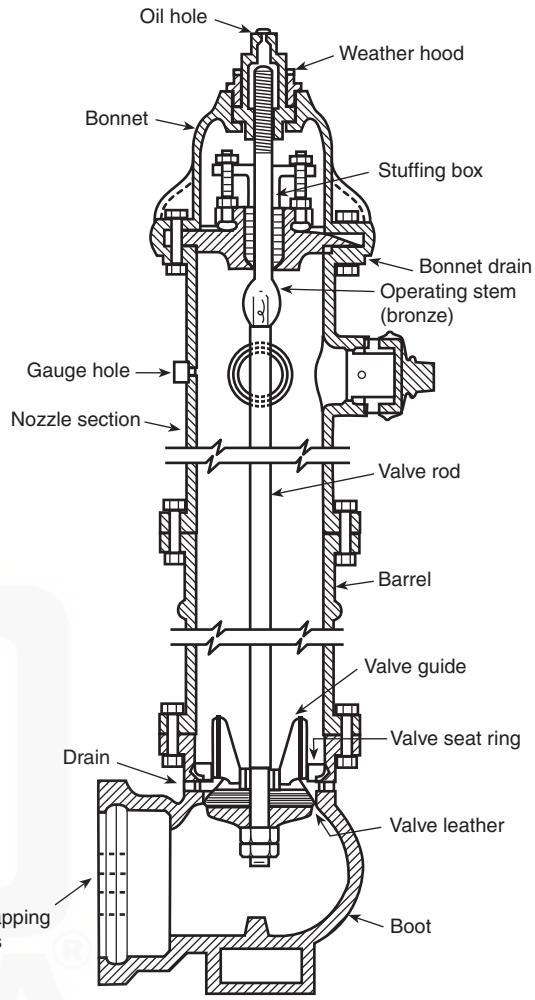


FIGURE A.3.3.13.1 *Dry Barrel Hydrant.*

3.3.13.1* Dry Barrel Hydrant (Frostproof Hydrant). A type of hydrant with the main control valve below the frost line between the footpiece and the barrel.

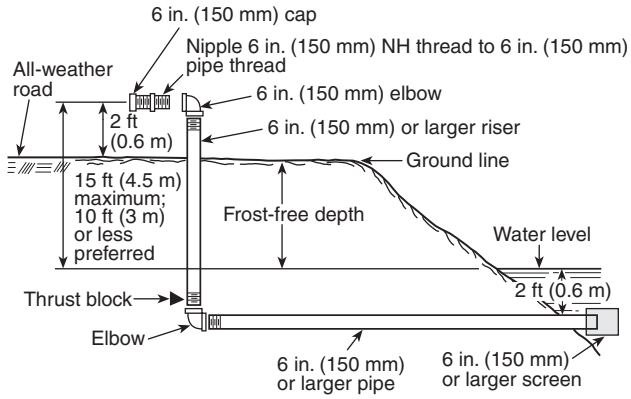
A.3.3.13.1 Dry Barrel Hydrant (Frostproof Hydrant). A drain is located at the bottom of the barrel above the control valve seat for proper drainage after operation to prevent freezing. See Figure A.3.3.13.1.

N **3.3.13.2* Dry Hydrant.** An arrangement of pipe permanently connected to a water source other than a piped, pressurized water supply system that provides a ready means of water supply for fire-fighting purposes and that utilizes the drafting (suction) capability of a fire department pump. [**1142,** 2017]

N **A.3.3.13.2 Dry Hydrant.** See Figure A.3.3.13.2. [**1142,** 2017]

3.3.13.3* Monitor Nozzle Hydrant. A hydrant equipped with a monitor nozzle capable of delivering more than 250 gpm (946 L/min).

A.3.3.13.3 Monitor Nozzle Hydrant. See Figure A.3.3.13.3.



N ***FIGURE A.3.3.13.2*** *Exploded View of Dry Hydrant Construction. [1142:Figure A.8.3.2(b)]*

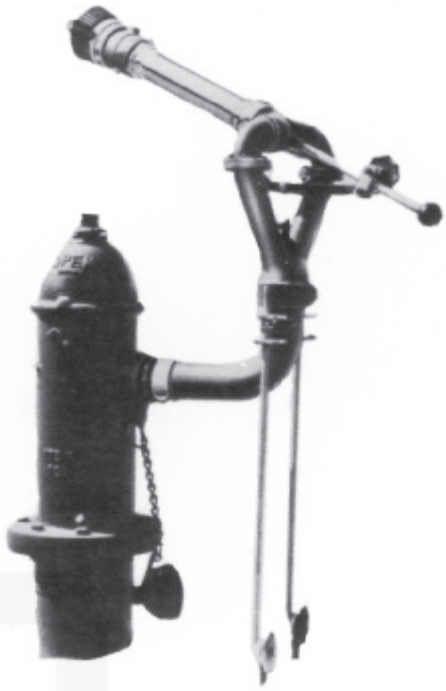


FIGURE A.3.3.13.3 *Hydrant with Monitor Nozzle.*



EXHIBIT 3.6 *Hose Connection. (Courtesy of Byron Blake and SimplexGrinnell)*

3.3.13.4* Wall Hydrant. A hydrant mounted on the outside of a wall of a building, fed from interior piping, and equipped with control valves located inside the building that normally are key-operated from the building's exterior.

A.3.3.13.4 Wall Hydrant. See Figure A.3.3.13.4.

3.3.13.5* Wet Barrel Hydrant. A type of hydrant that is intended for use where there is no danger of freezing weather and where each outlet is provided with a valve and an outlet. [**24,** 2019]

A.3.3.13.5 Wet Barrel Hydrant. See Figure A.3.3.13.5.

3.3.14* Foam Concentrate. A concentrated liquid foaming agent as received from the manufacturer. [**11,** 2016]

A.3.3.14 Foam Concentrate. For the purpose of this document, foam *concentrate* and *concentrate* are used interchangeably.

3.3.15 [Foam] Discharge Device. A device designed to discharge water or foam-water solution in a predetermined, fixed, or adjustable pattern. Examples include, but are not limited to, sprinklers, spray nozzles, and hose nozzles. [**16,** 2019]

3.3.16 Hose Connection. The outlet of a hose valve installed on a standpipe system for connection of fire hose. [**14,** 2019]

An example of a hose connection is shown in Exhibit 3.6.

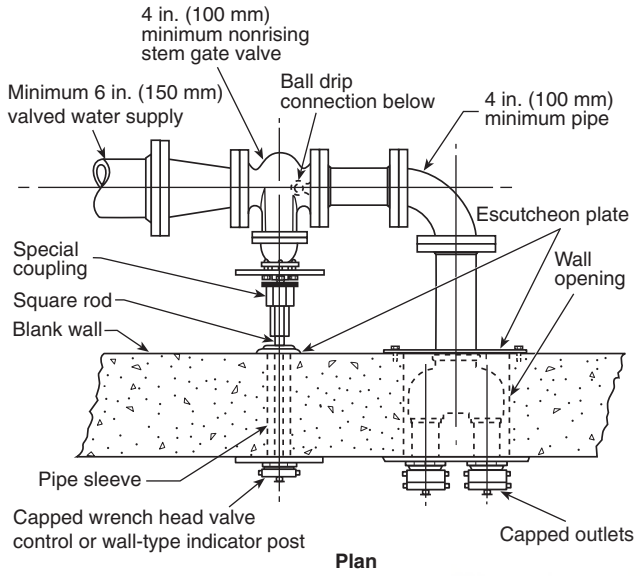


FIGURE A.3.3.13.4 *Wall Hydrant.*

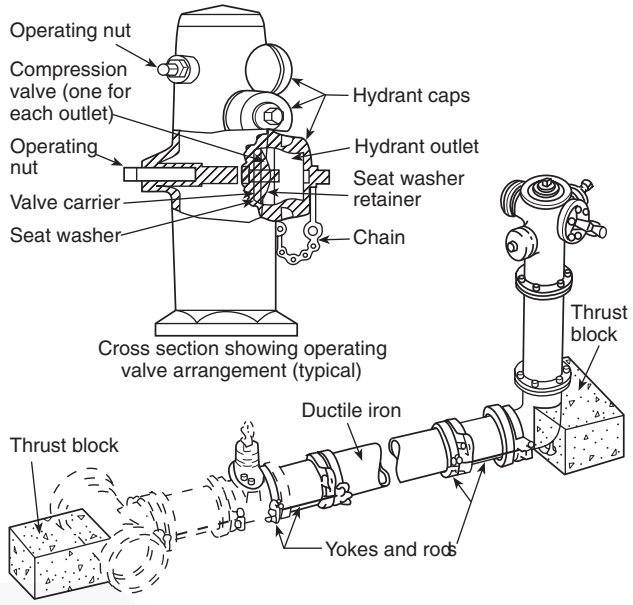


FIGURE A.3.3.13.5 *Wet Barrel Hydrant. (Courtesy of the Los Angeles Department of Water and Power.)*

3.3.17* Hose House. An enclosure located over or adjacent to a hydrant or other water supply designed to contain the necessary hose nozzles, hose wrenches, gaskets, and spanners to be used in fire fighting in conjunction with and to provide aid to the local fire department.

A.3.3.17 Hose House. See Figure A.3.3.17(a) through Figure A.3.3.17(c).

3.3.18 Hose Nozzle. A device intended for discharging water for manual suppression or extinguishment of a fire.

3.3.19 Hose Station. A combination of a hose rack or reel, hose nozzle, hose, and hose connection. [**14,** 2019]

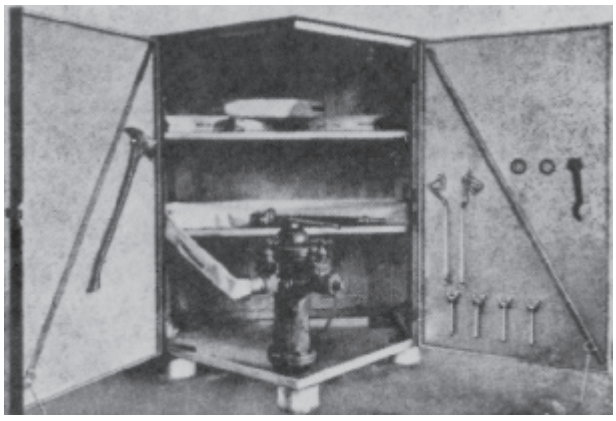


FIGURE A.3.3.17(a) *Hose House of Five-Sided Design for Installation over Private Hydrant.*



FIGURE A.3.3.17(b) *Steel Hose House of Compact Dimensions for Installation over Private Hydrant. House is shown closed; top lifts up, and doors on front side open for complete accessibility.*

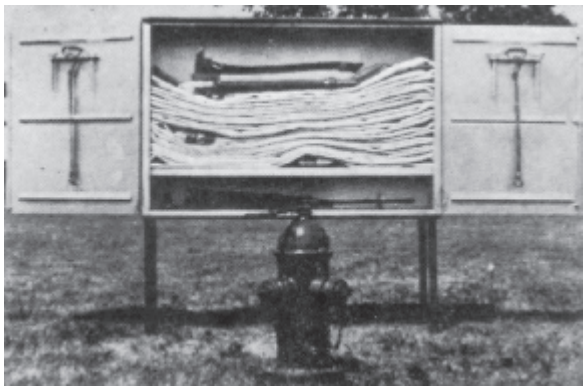


FIGURE A.3.3.17(c) *Hose House That Can Be Installed on Legs, As Pictured, or on Wall Near, but Not Directly over, Private Hydrant.*

EXHIBIT 3.7 *Hose Station. (Courtesy of Byron Blake and SimplexGrinnell)*



An example of a hose station is shown in Exhibit 3.7.

3.3.20 Hose Storage Devices.

3.3.20.1* Conventional Pin Rack. A hose rack where the hose is folded vertically and attached over the pins.

A.3.3.20.1 Conventional Pin Rack. See Figure A.3.3.20.1.

3.3.20.2* Horizontal Rack. A hose rack where the hose is connected to the valve, then stack-folded horizontally to the top of the rack.

A.3.3.20.2 Horizontal Rack. See Figure A.3.3.20.2.

3.3.20.3* Hose Reel. A circular device used to store hose.

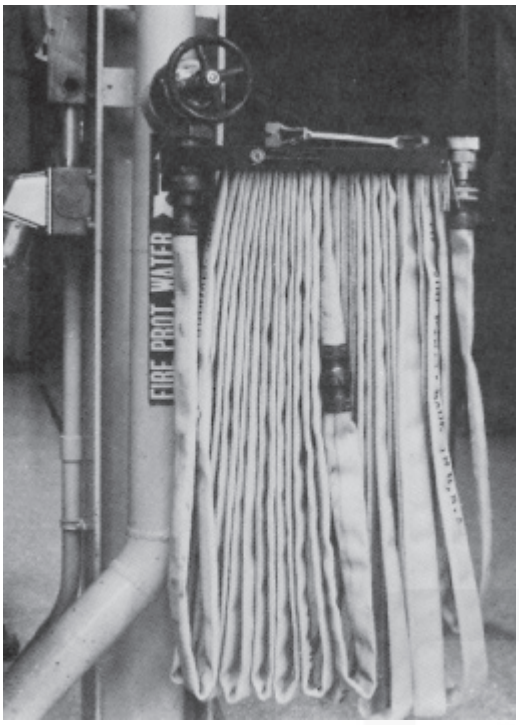


FIGURE A.3.3.20.1 Conventional Pin Rack.

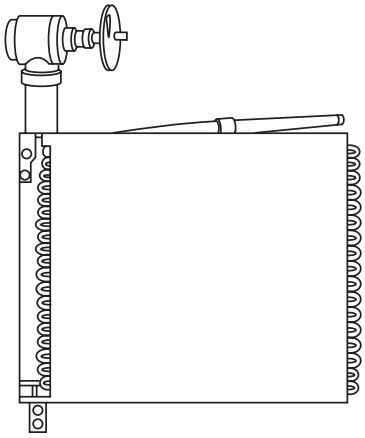


FIGURE A.3.3.20.2 Horizontal Rack.

A.3.3.20.3 Hose Reel. See Figure A.3.3.20.3.

3.3.20.4* Semiautomatic Hose Rack Assembly. The same as a "conventional" pin rack or hose reel except that, after the valve is opened, a retaining device holds the hose and water until the last few feet are removed.

A.3.3.20.4 Semiautomatic Hose Rack Assembly. See Figure A.3.3.20.4.

3.3.21 Hydrostatic Test. A test of a closed piping system and its attached appurtenances consisting of subjecting the piping to an increased internal pressure for a specified duration to verify system integrity and system leakage rates. [**24,** 2019]

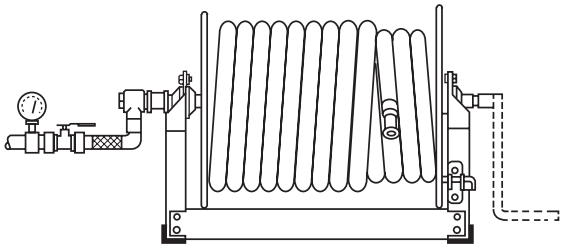


FIGURE A.3.3.20.3 Constant Flow Hose Reel.



FIGURE A.3.3.20.4 Semiautomatic Hose Rack Assembly.

Tip for Owners

When contracting ITM services, it is important for owners and contractors to have a clear understanding of the maintenance services that are included in the agreement. For example, the ongoing maintenance to keep dry system or preaction piping free of water is not the responsibility of the service provider unless it is specifically identified in the agreement. However, many owners are not aware of the need to monitor the condition of the piping by the periodic operation of any auxiliary drains (see A.13.4.3.3.3 and A.13.4.5.3.2). Good communication between owners and service providers regarding system maintenance can significantly enhance system reliability and performance.

3.3.22* Impairment. A condition where a fire protection system or unit or portion thereof is out of order, and the condition can result in the fire protection system or unit not functioning in a fire event.

A.3.3.22 Impairment. The use of the phrase fire *protection system or unit is* a broad reference to those terms used in titles of Chapters 5 through 12. Some fire protection features are referred to as systems in the installation standards (e.g., sprinkler, standpipe, water spray, foam-water, and water mist), or are referred to as units (e.g., fire pumps), and others use neither term (e.g., private service fire mains and water tanks). For the purpose of this standard, the term *unit* refers to a fire pump and its connections required by NFPA 20, or a water storage tank and its connections required by NFPA 22, or a private service fire main and its connections required by NFPA 24. The use of the term *unit* in the definitions of impairment, deficiency, critical deficiency, and noncritical deficiency is not referring to an individual component such as a sprinkler, valve, fitting, switch, piece of pipe, and so forth.

Temporarily shutting down a system as part of performing the routine inspection, testing, and maintenance on that system while under constant attendance by qualified personnel, and where the system can be restored to service quickly, should not be considered an impairment. Good judgment should be considered for the hazards presented.

Because of the comprehensive nature of building and fire codes, buildings are designed and constructed with the expectation that fire protection systems will operate when needed. When an impairment occurs for any reason, the building and its occupants are at increased risk. The term *impairment* is meant to be used for specific circumstances and must trigger immediate action on the part of the impairment coordinator. For more information, see Chapter 15.

3.3.22.1* Emergency Impairment. A condition where a water-based fire protection system or portion thereof is out of order due to an unplanned occurrence, or the impairment is found while performing inspection testing or maintenance activities.

FAQ What precautions can be taken to prepare for an emergency impairment?

An emergency impairment can be difficult to plan for or predict. However, some precautions can be taken to minimize system "downtime." These precautions include providing ready access to as-built plans, original test results, manufacturers' data sheets, and other "closeout" system documents, which can greatly aid in the timely correction of impairments (see 4.3.4). In addition, following the requirements for the on-site maintenance of spare sprinklers or nozzles, including pilot sprinklers, and repair kits for all valves, including alarm, dry pipe, deluge, preaction, and backflow prevention devices, can eliminate the need for ordering replacement equipment or special materials. (See the commentary in Chapter 15 for more information on impairments.) For example, the practice of maintaining a reserve supply of foam concentrate is essential to the timely re-commissioning of a foam-water sprinkler or foam-water spray system.

A.3.3.22.1 Emergency Impairment. Examples of emergency impairments might include a ruptured pipe, an operated sprinkler, or an interruption of the water supply to the system.

3.3.22.2 Preplanned Impairment. A condition where a water-based fire protection system or a portion thereof is out of service due to work planned in advance, such as revisions to the water supply or sprinkler system piping.

Any system impairment can lead to the danger of a shut valve. Of system failures noted in Commentary Table 1.1 that were attributed to shut valves, it was not apparent whether the valve was shut due to maintenance (preplanned or emergency impairment) or from willful or unintentional neglect. Either way, during an impairment, it is essential to ensure that impairment procedures are in place and that valves are left opened completely after the system corrections are completed. A programmed approach to monitoring system valves through a lockout/tagout program can ensure that no valve is left completely or partially closed. See the commentary in Chapter 15 for more information on impairments. Also, see Article 120 of *NFPA 70E®*, *Standard for Electrical Safety in the Workplace®*, for further information regarding lockout/tagout procedures.

3.3.23 Inspect. See 3.3.24, Inspection.

3.3.24 Inspection. A visual examination of a system or portion thereof to verify that it appears to be in operating condition and is free of physical damage. [**820,** 2020]

3.3.25* Inspection, Testing, and Maintenance Service. A service program provided by a qualified contractor or qualified property owner's representative in which all components unique to the property's systems are inspected and tested at the required times and necessary maintenance is provided.

Maintenance includes not only the required functions in the standard, but also practices and procedures recommended by the manufacturer.

A.3.3.25 Inspection, Testing, and Maintenance Service. This program includes logging and retention of relevant records. Any portion or all of the inspection, testing, and maintenance can be contracted with an inspection, testing, and maintenance service. Similarly, any portion or all of the inspection, testing, and maintenance can be performed by qualified personnel employed by the property owner or designated representative.

Inspection, testing, and *maintenance service* should not be confused with the term *service,* which is not defined by NFPA 25. For water-based fire protection systems, service can take on many meanings, but the tasks required by this standard are specific and include only inspections (see 3.3.24), testing (see 3.3.48), and maintenance (see 3.3.27).

N **3.3.26* Lowest Permissible Suction Pressure.** The lowest suction pressure permitted by this standard and the authority having jurisdiction. [**20,** 2019]

N **A.3.3.26 Lowest Permissible Suction Pressure.** The lowest pressure permitted by the authority having jurisdiction will likely be upstream of the backflow prevention device or at the connection to the water utility main. The permissible pressure at the pump suction could be lower than the limit stated by the authority having jurisdiction and could be determined by adding the friction loss and pressure elevation change between the cited location and the fire pump suction. [**20**, 2019]

3.3.27* Maintenance. In water-based fire protection systems, work performed to keep equipment operable.

A.3.3.27 Maintenance. As used in this standard, the term *maintenance* does not include repair activities. Such activities are expressly identified by the term *repair.*

3.3.28 Manual Operation. Operation of a system or its components through human action.

3.3.29 Nozzle.

3.3.29.1* Monitor Nozzle. A permanently mounted device specifically designed with a high flow rate to provide a far-reaching stream for locations where large amounts of water need to be available without the delay of laying hose lines.

A.3.3.29.1 Monitor Nozzle. Monitor nozzles can be used to protect large amounts of combustible materials, aircraft, tank farms, and any other special hazard. See Figure A.3.3.29.1(a) and Figure A.3.3.29.1(b).

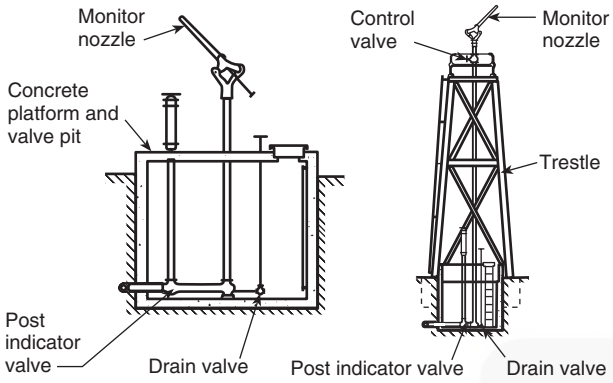


FIGURE A.3.3.29.1(a) *Standard Monitor Nozzles; Gear Control Nozzles Also Are Permitted.*

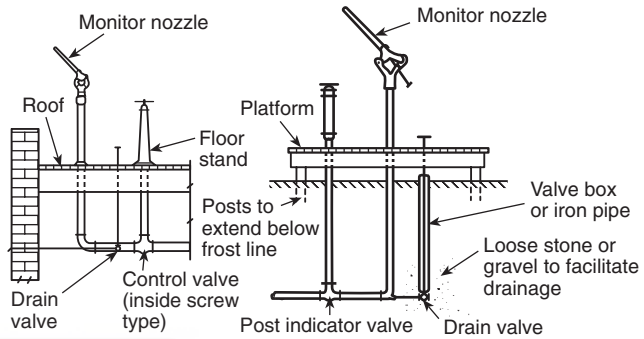


FIGURE A.3.3.29.1(b) *Alternative Arrangement of Standard Monitor Nozzles.*

3.3.29.2* Water Spray Nozzle. An open or automatic water discharge device that, when discharging water under pressure, will distribute the water in a specific, directional pattern.

A.3.3.29.2 Water Spray Nozzle. The selection of the type and size of spray nozzles should have been made with proper consideration given to factors such as physical character of the hazard involved, draft or wind conditions, material likely to be burning, and the general purpose of the system.

High velocity spray nozzles, generally used in piped installations, discharge in the form of a spray-filled cone. Low velocity spray nozzles usually deliver a much finer spray in the form of either a spray-filled spheroid or cone. Due to differences in the size of orifices or waterways in the various nozzles and the range of water particle sizes produced by each type, nozzles of one type cannot ordinarily be substituted for those of another type in an individual installation without seriously affecting fire extinguishment. In general, the higher the velocity and the coarser the size of the water droplets, the greater the effective "reach" or range of the spray.

Another type of water spray nozzle uses the deflector principle of the standard sprinkler. The angle of the spray discharge cones is governed by the design of the deflector. Some manufacturers make spray nozzles of this type individually automatic by constructing them with heat-responsive elements as used in standard automatic sprinklers.

Exhibit 3.8 illustrates directional, non-automatic water spray nozzles. These nozzles are available with a variety of spray patterns ranging from 30° to 180°. They can also be used in an automatic configuration with a fusible link, with temperature ratings comparable to those of a standard spray sprinkler.

3.3.30 Orifice Plate Proportioning. This system utilizes an orifice plate(s) through which passes a specific amount of foam concentrate at a specific pressure drop across the orifice plate(s).

This type of system depends on a properly sized orifice plate to control the amount of foam concentrate from a foam concentrate pump.

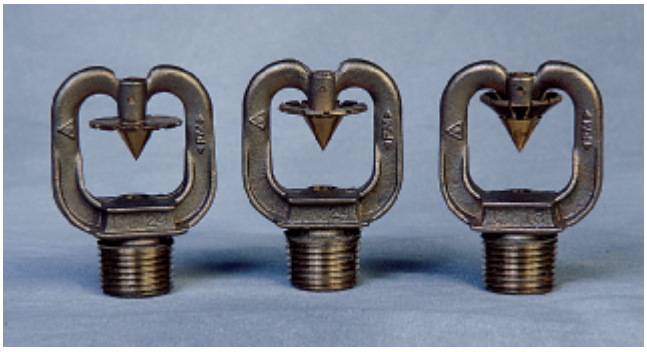


EXHIBIT 3.8 *Directional, Non-Automatic Water Spray Nozzles.*

3.3.31 Performance-Based Program. Methods and frequencies that have been demonstrated to deliver equivalent or superior levels of performance through quantitative performance-based analysis.

3.3.32* Pressure-Regulating Device. A device designed for the purpose of reducing, regulating, controlling, or restricting water pressure. [**14,** 2019]

A.3.3.32 Pressure-Regulating Device. Examples include pressure-reducing valves, pressure control valves, and pressure-restricting devices.

3.3.33 Pressure-Restricting Device. A valve or device designed for the purpose of reducing the downstream water pressure under flowing (residual) conditions only. [**14,** 2019]

A pressure-restricting device (see Exhibit 3.9) is typically found on standpipe systems where flowing pressures exceed 100 psi (6.9 bar) for 1½ in. (40 mm) hose connections or 175 psi (12.1 bar) for 2½ in. (65 mm) hose connections.

3.3.34* Pressure Vacuum Vent. A venting device mounted on atmospheric foam concentrate storage vessels to allow for concentrate expansion and contraction and for tank breathing during concentrate discharge or filling.

A.3.3.34 Pressure Vacuum Vent. At rest (static condition), this device is closed to prevent free breathing of the foam concentrate storage tank. See Figure A.3.3.34.

Exhibit 3.10 shows a pressure vacuum vent on a foam concentrate storage tank dome.

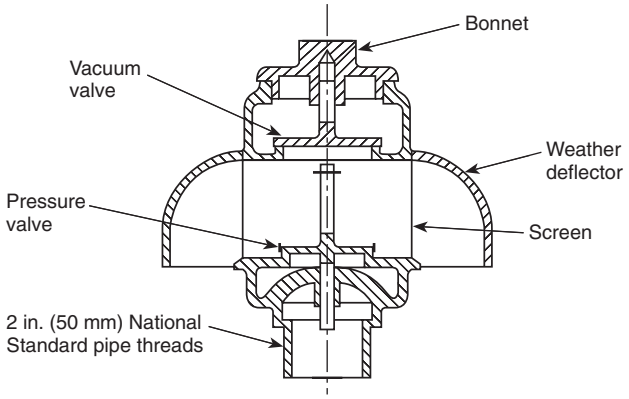


FIGURE A.3.3.34 *Pressure Vacuum Vent.*

EXHIBIT 3.9 *Pressure-Restricting Device. (Source: Fire Protection Handbook, 2008, Figure 16.10.9)*

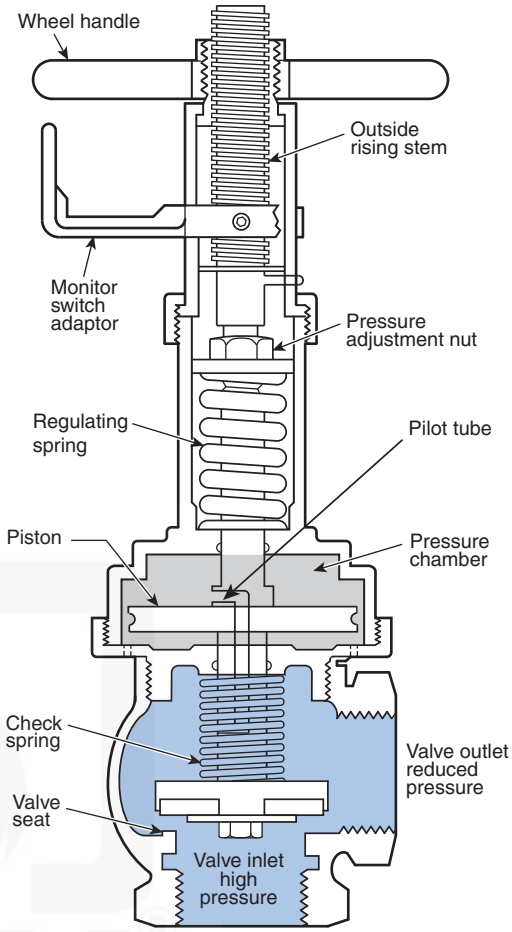
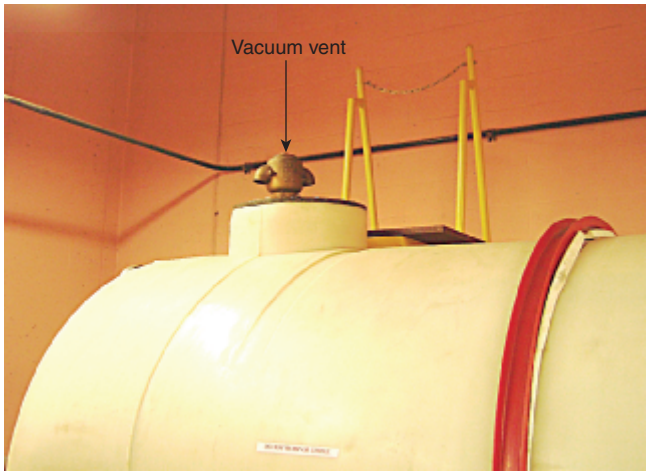


EXHIBIT 3.10 *Pressure Vacuum Vent.*



3.3.35* Proportioner.

A.3.3.35 Proportioner. See Figure A.3.3.35.

3.3.35.1* Bladder Tank Proportioner. A system that is similar to a standard pressure proportioner, except the foam concentrate is contained inside a diaphragm bag that is contained inside a pressure vessel.

A.3.3.35.1 Bladder Tank Proportioner. Operation is the same as a standard pressure proportioner, except that, because of the separation of the foam concentrate and water, this system can be used with all foam concentrates, regardless of specific gravity. See Figure A.3.3.35.1.

The bladder tank proportioner relies on water pressure externally applied to a bladder installed inside the tank as the means of expelling the foam concentrate. This arrangement allows relatively accurate proportioning over a wide range of flow. It is also economical, since external power is not required; however, there are limitations on the maximum size of the tank. Exhibit 3.11 shows a bladder tank proportioning system.

3.3.35.2* In-Line Balanced Pressure Proportioner. A system that is similar to a standard balanced pressure system, except the pumped concentrate pressure is maintained at a fixed preset value.

A.3.3.35.2 In-Line Balanced Pressure Proportioner. Balancing of water and liquid takes place at individual proportioners located in the system riser or in segments of multiple systems. See Figure A.3.3.35.2.

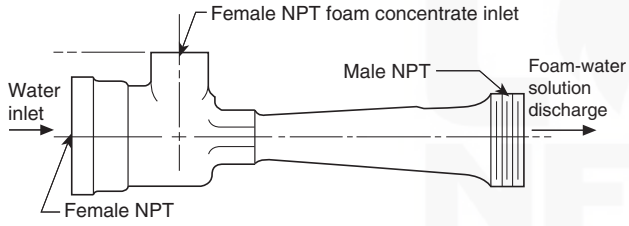
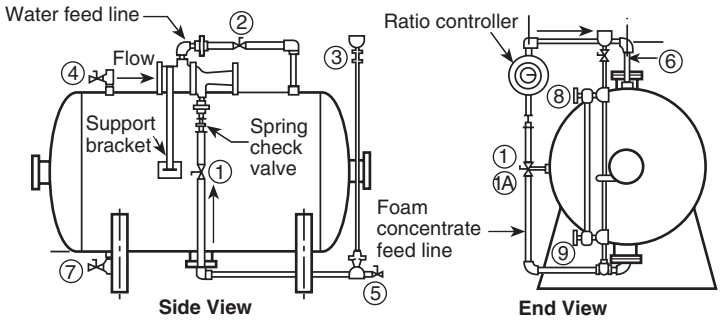


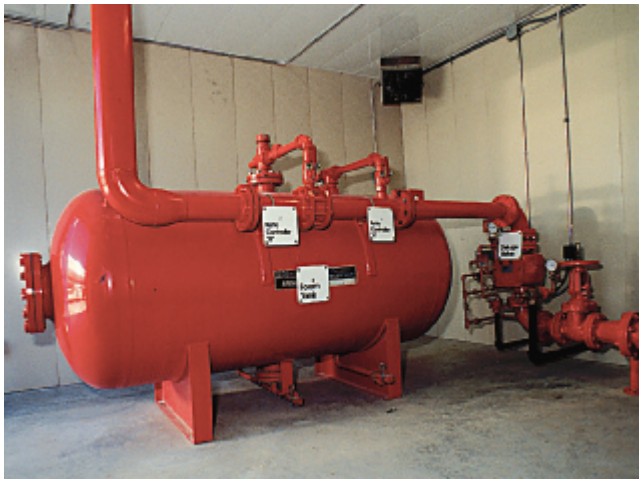
FIGURE A.3.3.35 *Proportioner.*



Valve description		Normal position	
Valve no.	Description	Manual system	Auto system
1	Concentrate shutoff	Closed	Closed
1A	Auto. conc. shutoff	N/A	Closed
2	Water pres. shutoff	Open	Open
3	Fill cup shutoff	Closed	Closed
4	Tank water vent	Closed	Closed
5	Diaph. conc. vent	Closed	Closed
6	Water fill	Closed	Closed
7	Concentrate drain/fill	Closed	Closed
8	Upr. sight gauge (opt.)	Closed	Closed
9	Lwr. sight gauge (opt.)	Closed	Closed

FIGURE A.3.3.35.1 *Bladder Tank Proportioner.*

EXHIBIT 3.11 *Bladder Tank Proportioning System. (Courtesy of Tyco Fire Suppression & Building Products)*



3.3.35.3* Line Proportioner. A system that uses a venturi pickup-type device where water passing through the unit creates a vacuum, thereby allowing foam concentrate to be picked up from an atmospheric storage container.

A.3.3.35.3 Line Proportioner. See Figure A.3.3.35.3.

The line proportioner relies on venturi action. In other words, foam concentrate is drawn into the water stream as water flows through the pipe, drafting the foam concentrate from a tank. Foam proportioning is sensitive to fluctuations in flow and pressure, and variations in flow and pressure will result in incorrect concentrations of foam concentrate.

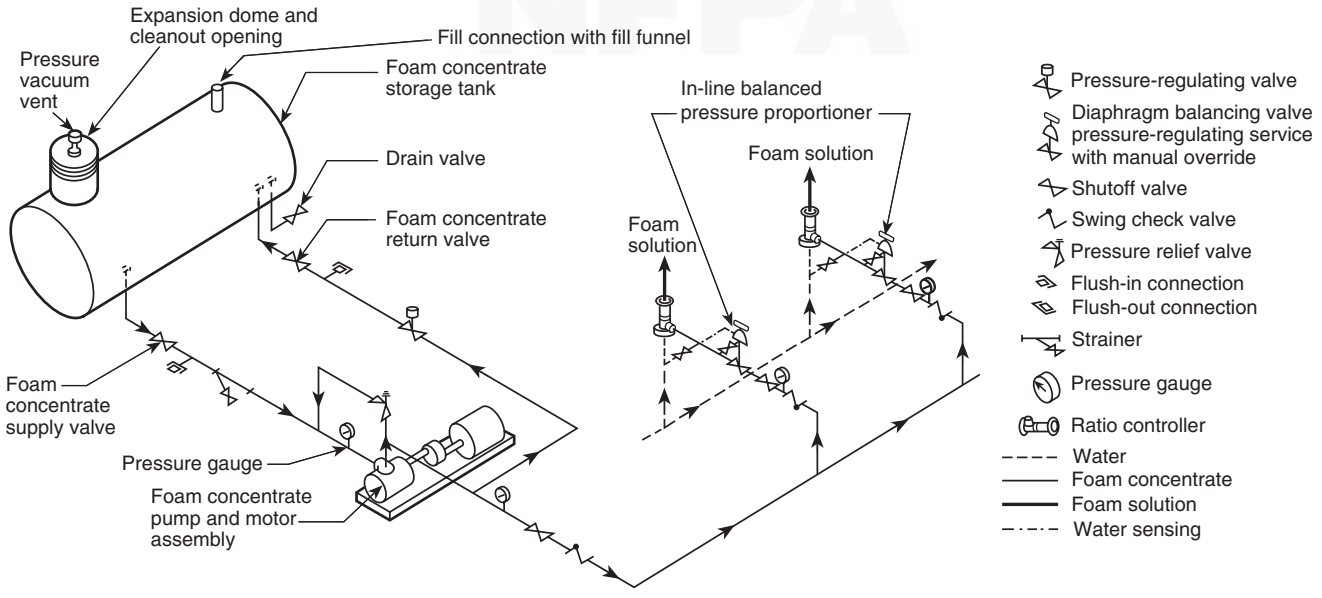


FIGURE A.3.3.35.2 *In-Line Balanced Pressure Proportioner.*

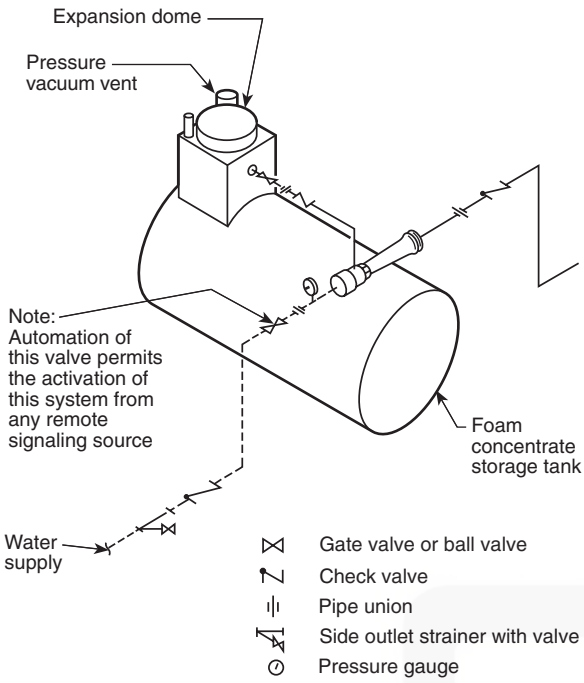


FIGURE A.3.3.35.3 *Line Proportioner.*

3.3.35.4* Standard Balanced Pressure Proportioner. A system that utilizes a foam concentrate pump where foam concentrate is drawn from an atmospheric storage tank, is pressurized by the pump, and passes back through a diaphragm balancing valve to the storage tank.

A.3.3.35.4 Standard Balanced Pressure Proportioner. Water and foam concentrate-sensing lines are directed to the balancing valve and maintain the foam liquid at a pressure equal to that of the water pressure. The two equal pressures are fed to the proportioner proper and are mixed at a predetermined rate. See Figure A.3.3.35.4.

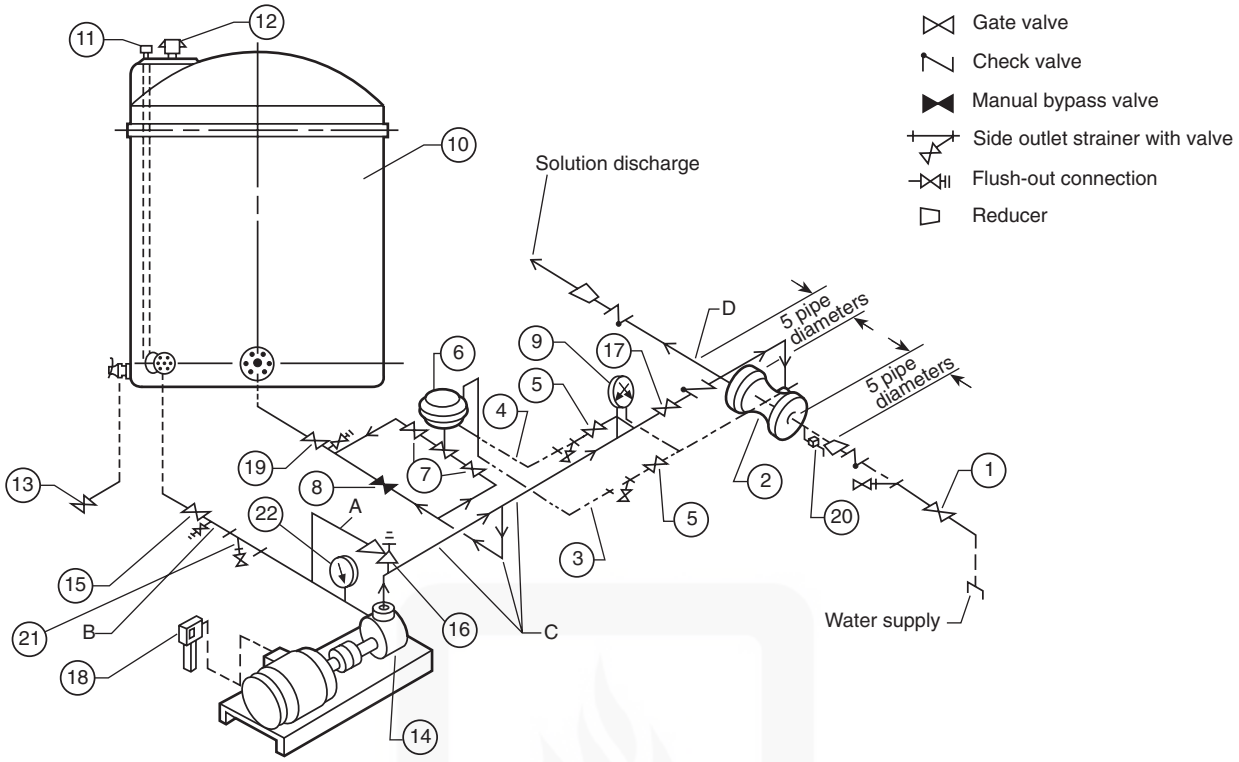
Balanced pressure proportioning relies on the use of a separate pump for pressurizing foam concentrate. This system can be used across a wide range of flow rates.

3.3.35.5* Standard Pressure Proportioner. A system that uses a pressure vessel containing foam concentrate where water is supplied to the proportioner, which directs an amount of the supply downward onto the contained concentrate, thereby pressurizing the tank.

A.3.3.35.5 Standard Pressure Proportioner. Pressurized concentrate then is forced through an orifice back into the flowing water stream. This type of system is applicable for use with foam concentrates having a specific gravity substantially higher than water. It is not applicable for use with foam concentrates with a specific gravity at or near that of water. See Figure A.3.3.35.5.

Similar to the bladder tank proportioner, the standard pressure proportioner relies on a viscosity of the foam concentrate that is higher than water. Water pressure is used to move the foam concentrate through a proportioner and mix it with the water stream.

3.3.36 Qualified. A competent and capable person who has met the requirements and training for a given field acceptable to the AHJ. [**96,** 2017]



Legend:

1 Water supply valve (normally closed)
2 Ratio controller
3 Water balance line — minimum 3/16 in. (5 mm) I.D. pipe or tubing recommended
4 Concentrate balance line — minimum 3/16 in. (5 mm) I.D. pipe or tubing recommended
5 Sensing line valves (normally open)
6 Diaphragm control valve — automatic pressure balance — must be in vertical position
7 Block valves (normally open)
8 Manual bypass valve (normally open)
9 Water and concentrate pressure gauge (duplex)
10 Foam concentrate storage tank
11 Concentrate storage tank fill connection
12 Pressure vacuum vent
13 Concentrate storage tank drain valve (normally closed)
14 Foam concentrate pump and motor
15 Concentrate pump supply valve (normally open)
16 Pressure relief valve (setting as required by system)
17 Concentrate pump discharge valve (normally open)
18 Electric motor starter and switch
19 Concentrate return line valve (normally open)
20 Ball drip valve — ¾ in. (20 mm) (install in horizontal position)
21 Strainer with valved side outlet
22 Compound gauge

Operation:
Start concentrate pump (18). Open water supply valve (1). Open concentrate pump discharge valve (17). Equal gauge readings then maintained at (9) by the automatic valve (6). For manual operation, valves (7) can be closed and equal gauge readings maintained by regulating valve (8) manually.

System Automation:
By automating certain valves, the balanced pressure proportioning system can be activated from any remote signaling source.

- Water supply valve (1), normally closed, to be automatically operated;
- Concentrate pump discharge valve (17), normally closed, to be automatically operated;
- Electric motor starter switch (18) to be automatically operated.

FIGURE A.3.3.35.4 *Standard Balanced Pressure Proportioner.*

The use of the term *qualified* in the standard is intended to be general in nature. The intent of NFPA 25 is that the owner or the owner's designated representative(s) perform many of the required inspections. For example, the owner or the owner's representative could be trained to a level acceptable to the AHJ, and therefore, be *qualified* to perform the monthly inspection to verify that the system control valve(s) are open. A facility maintenance person could be trained to inspect pressure gauges, exterior conditions of water storage tanks, accessibility of fire hydrants, and so forth.

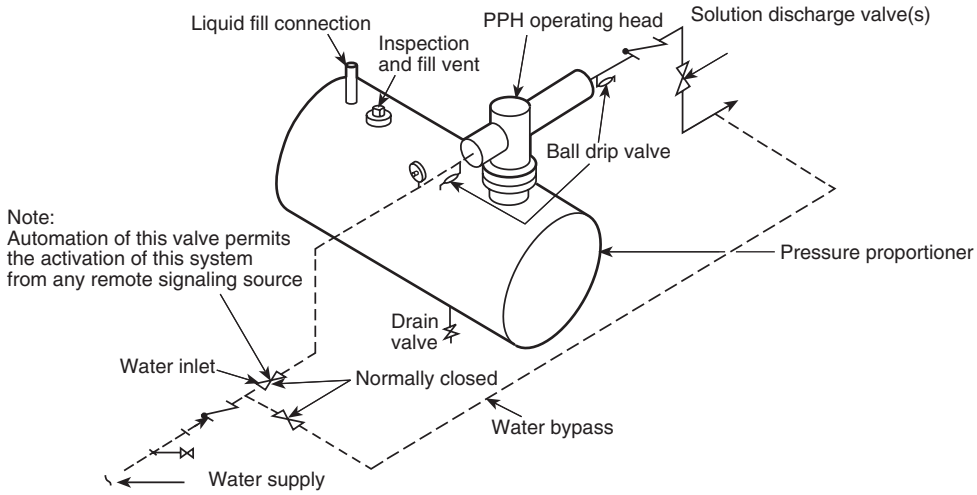


FIGURE A.3.3.35.5 *Standard Pressure Proportioner.*

FAQ Does NFPA 25 require an inspector or service company to be licensed?

NFPA 25 does not require licensing of the individual or company performing the work, because many jurisdictions do not require licensing and because licensing laws vary considerably from one jurisdiction to the next. As a result, NFPA 25 requires an inspector or service provider simply to possess the appropriate knowledge and experience needed to perform the work specified therein. It is important to note that many licensing laws specifically require that an individual who is "engaged in the business of providing this service for a fee" must be licensed. This stipulation means that for properties that have a *qualified* maintenance staff, licensing is not necessarily needed for work that is done in house. Before performing any ITM work, any individual or business entity should contact the appropriate jurisdiction, such as the local or state fire marshal's office or the state contractor's licensing board, for any licensing requirements.

Tip for Owners

As mentioned in the commentary for the definition of *authority having jurisdiction (AHJ)*, it is important to note that there may be more than one AHJ. The facility maintenance person could be fully capable of performing certain tasks that are acceptable to one AHJ but that might not meet the requirements of another.

3.3.37 Rebuild. To restore working condition by replacement or repair of worn or damaged parts.

3.3.38 Reduced-Pressure Principle Backflow Prevention Assembly (RPBA). Two independently acting check valves together with a hydraulically operating, mechanically independent pressure differential relief valve located between the check valves, along with two resilient-seated shutoff valves, all as an assembly, and equipped with properly located test cocks.

In a normal flowing condition, both check valves of the reduced-pressure principle backflow prevention assembly (RPBA) will be open to meet the demand, and the relief valve will remain closed. Should a back-pressure condition occur, both check valves will close. The section between the two check valves provides additional security should the second check valve fail or leak. In such a case the back pressure would flow into the middle zone, causing an increase in pressure to the point that the differential relief valve will open, discharging water to the atmosphere. This could result in a considerable amount of water being discharged in the valve room. Exhibit 3.12 shows an example of a typical RPBA.

Tip for Owners

An NFPA 25 inspector is anyone who is *qualified*, meaning a person who is competent and capable and who has met the requirements and training for a given field acceptable to the AHJ. On-staff personnel may be qualified to perform certain ITM activities as required by NFPA 25.

Tip for Owners

It is important to ensure that the drainage in rooms containing RPBAs is maintained so it is free and clear of any obstructions.

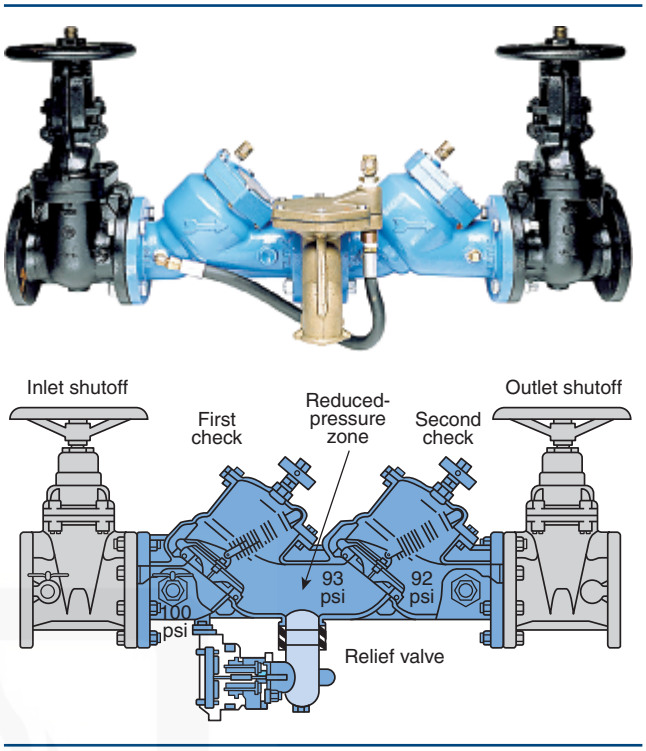


EXHIBIT 3.12 *Reduced-Pressure Principle Backflow Prevention Assembly (top) (Courtesy of Watts Regulator Co.) and Interior View of the Valve (bottom).*

3.3.39 Remove. To physically take away or eliminate.

3.3.40 Repair. Restore to sound working condition or to fix damage.

3.3.41 Replace. To remove a component and install a new or equivalent component.

3.3.42 Sprinkler.

3.3.42.1 Installation Orientation. The following sprinklers are defined according to orientation.

The sprinklers described in 3.3.42.1 are based on the geometry of the sprinkler installation. Representative discharge patterns for these devices allow them to be categorized as concealed, flush, pendent, and recessed sprinklers, all of which have similar discharge patterns and are mounted to the bottom of a branch line or pipe drop. Sidewall sprinklers are typically installed along a wall or lintel and discharge water away from the wall into the room or space. Sidewall sprinklers can be mounted on the side, bottom, or top of a branch line, as specified in their listings. Upright sprinklers have a spray pattern that appears similar to that of a pendent sprinkler. The difference is that upright sprinklers are mounted to the top of branch lines or sprigs.

3.3.42.1.1 Concealed Sprinkler. A recessed sprinkler with cover plate. [**13,** 2019]

Exhibit 3.13 shows a photo of an assembled concealed sprinkler as well as a diagram showing the various components of the device. As shown in the diagram, the cover plate drops away when exposed to a certain amount of heat. The fusible elements holding the cover plate are designed to operate prior to the activation of the sprinkler's thermal element. The cover plate is included as part of the listed sprinkler assembly.

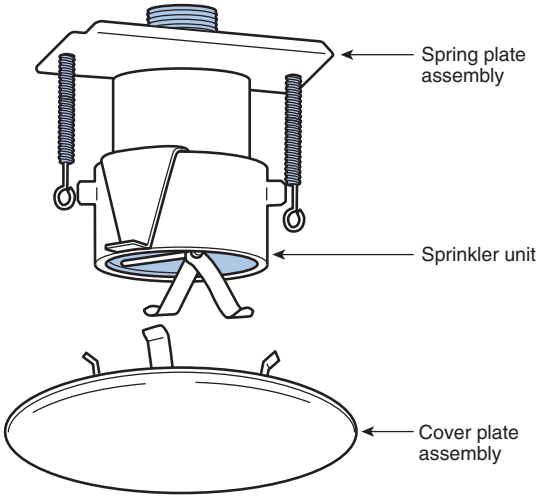




EXHIBIT 3.13 *Standard Model G Concealed Ceiling Sprinkler (left) Diagram of Unit Components, (right) Photo of Typical Unit. (Courtesy of Reliable Automatic Sprinkler Company, Inc.)*

3.3.42.1.2 Flush Sprinkler. A sprinkler in which all or part of the body, including the shank thread, is mounted above the lower plane of the ceiling. [**13,** 2019]

Exhibit 3.14 illustrates a flush sprinkler.

3.3.42.1.3 Pendent Sprinkler. A sprinkler designed to be installed in such a way that the water stream is directed downward against the deflector. [**13,** 2019]

Exhibit 3.15 shows a pendent sprinkler. The flat profile of the deflector is the most obvious characteristic of this type of sprinkler and is usually noticeable even when viewing from floor level.

3.3.42.1.4 Recessed Sprinkler. A sprinkler in which all or part of the body, other than the shank thread, is mounted within a recessed housing. [**13,** 2019]

Exhibit 3.16 shows a recessed sprinkler.

3.3.42.1.5 Sidewall Sprinkler. A sprinkler having special deflectors that are designed to discharge most of the water away from the nearby wall in a pattern resembling one-quarter of a sphere, with a small portion of the discharge directed at the wall behind the sprinkler. [**13,** 2019]

Exhibit 3.17 illustrates a horizontal sidewall sprinkler.

3.3.42.1.6 Upright Sprinkler. A sprinkler designed to be installed in such a way that the water spray is directed upwards against the deflector. [**13,** 2019]

Exhibit 3.18 shows several standard spray upright sprinklers. The most noticeable characteristics of upright sprinklers are a larger deflector than the pendent sprinkler and the downturned prongs at the deflector edge. As with the pendent sprinkler, upright sprinklers typically can be identified from floor level.



EXHIBIT 3.14 *Viking Model H Standard Spray Pendent Flush-Mount Sprinkler. (Courtesy of Viking®)*



EXHIBIT 3.15 *Standard Spray Pendent Sprinkler. (Courtesy of Reliable Automatic Sprinkler Company, Inc.)*



EXHIBIT 3.16 *Recessed Sprinkler. (Courtesy of Reliable Automatic Sprinkler Company, Inc.)*

EXHIBIT 3.17 *Horizontal Sidewall Sprinkler. (Courtesy of Reliable Automatic Sprinkler Company, Inc.)*



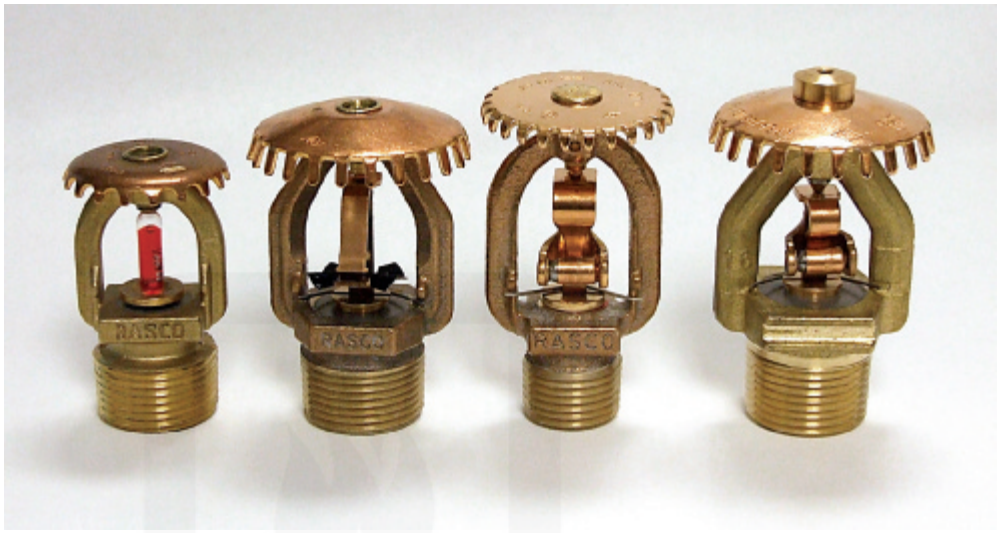


EXHIBIT 3.18 *Upright Sprinklers. (Courtesy of Reliable Automatic Sprinkler Company, Inc.)*

3.3.42.2* Control Mode Specific Application (CMSA) Sprinkler. A type of spray sprinkler that is capable of producing characteristic large water droplets and that is listed for its capability to provide fire control of specific high-challenge fire hazards. [**13,** 2019]

A.3.3.42.2 Control Mode Specific Application (CMSA) Sprinkler. A large drop sprinkler is a type of CMSA sprinkler that is capable of producing characteristic large water droplets and that is listed for its capability to provide fire control of specific high-challenge fire hazards. [**13**, 2019]

Control mode specific application (CMSA) sprinklers incorporate a wide variety of sprinklers that are capable of fire control in high-challenge fire scenarios. The large-drop sprinkler, which was defined in previous editions of the standard, is now included within this category. Exhibit 3.19 shows a CMSA sprinkler. Note that it has a similar appearance to the early suppression fast-response (ESFR) sprinkler, which is covered in 3.3.42.5, but it has a control mode objective rather than a suppression objective.



EXHIBIT 3.19 *Control Mode Specific Application (CMSA) Sprinkler. (Courtesy of Victaulic®)*

3.3.42.3 Corrosion-Resistant Sprinkler. A sprinkler fabricated with corrosion-resistant material, or with special coatings or platings, to be used in an atmosphere that would normally corrode sprinklers. [**13,** 2019]

A corrosion-resistant sprinkler is usually a standard sprinkler to which a corrosion-resistant coating, such as wax or lead, has been applied. Any coating of this type can be applied only by the manufacturer. Exhibit 3.20 shows a typical corrosion-resistant sprinkler.

3.3.42.4 Dry Sprinkler. A sprinkler secured in an extension nipple that has a seal at the inlet end to prevent water from entering the nipple until the sprinkler operates. [**13,** 2019]

Exhibit 3.21 shows an example of one type of dry sprinkler. Dry sprinklers are available as upright, pendent, or sidewall types.

3.3.42.5 Early Suppression Fast-Response (ESFR) Sprinkler. A type of fast-response sprinkler that has a thermal element with an RTI of 50 (meters-seconds)$^{1/2}$ or less and is listed for its capability to provide fire suppression of specific high-challenge fire hazards. [**13,** 2019]

The early suppression fast-response (ESFR) sprinkler evolved by examining the combined effects of sprinkler sensitivity and water distribution characteristics to achieve early fire suppression. The ESFR concept is to apply a sufficient amount of water to the burning fuel during the early phases of a fire and penetrate the developing fire plume to achieve fire suppression. If the fire plume reaches velocities that prevent the water droplets from reaching the burning fuel, the likelihood of suppression is greatly reduced. ESFR sprinklers, in contrast to standard sprinklers, operate earlier in the fire and provide adequate discharge to suppress the fire before a severe fire plume develops. Exhibit 3.22 and Exhibit 3.23 show examples of ESFR sprinklers.

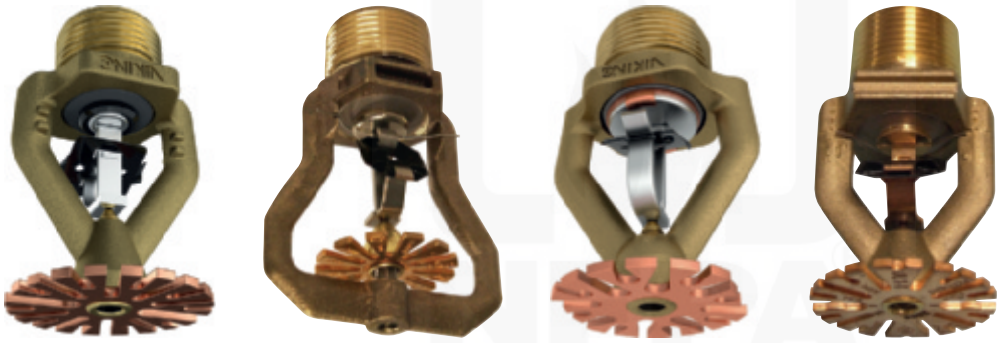


EXHIBIT 3.22 *Examples of Various ESFR Pendent Sprinklers. (Courtesy of Viking® and Reliable Automatic Sprinkler Company, Inc.)*

N **3.3.42.6 Electrically Operated Sprinklers.** A sprinkler that is equipped with an integral means of activation using electricity.

Electrically operated sprinklers differ from traditional sprinklers in that they are operated by a detection system and not a thermal-responsive glass bulb or solder link. Each sprinkler is equipped with an addressable heat detector and electrically operated actuator, which release the sprinkler mechanism when directed by the addressable fire control panel. The control panel determines the location and number of sprinklers to operate around a fire event. See Exhibit 3.24 for an example of an electrically operated sprinkler.

3.3.42.7 Extended Coverage Sprinkler. A type of spray sprinkler with maximum coverage areas as specified in Sections 11.2 and 11.3 of NFPA 13. [**13,** 2019]

The extended coverage (EC) sprinkler is available in pendent, upright, and sidewall configurations. Some examples are shown in Exhibit 3.25 and Exhibit 3.26. The advantage of EC sprinklers is that their areas of coverage are greater than those established for standard spray and sidewall sprinklers.



EXHIBIT 3.20 *Corrosion-Resistant Sprinkler. (Courtesy of American Fire Sprinkler Association)*



EXHIBIT 3.21 *Dry Sprinkler. (Courtesy of Viking®)*



EXHIBIT 3.23 *Upright-Type ESFR Sprinkler. (Courtesy of Viking®)*

EXHIBIT 3.24 *Electrically Operated Sprinkler. (Used with Permission of Johnson Controls)*



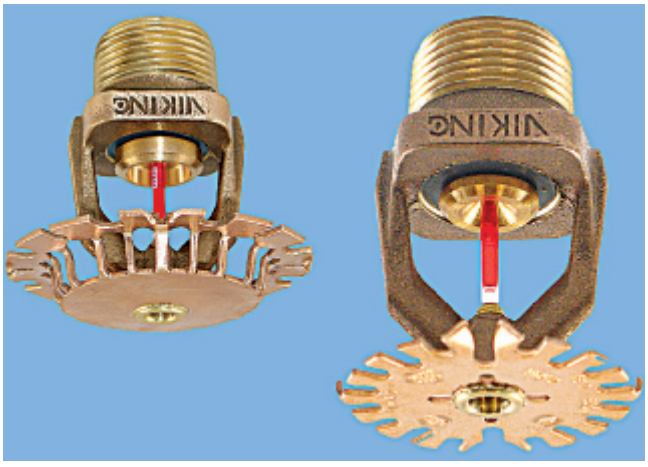


EXHIBIT 3.25 *Examples of EC Sprinklers. (Courtesy of Viking®)*

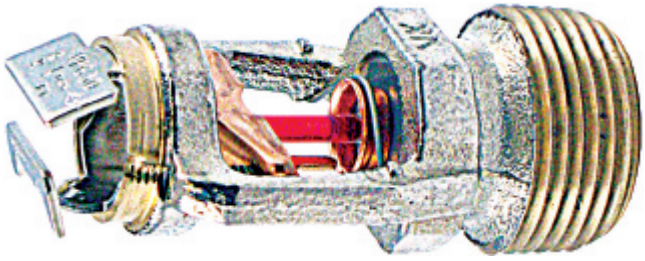


EXHIBIT 3.26 *Example of Sidewall-Type EC Sprinkler. (Courtesy of Viking®)*

3.3.42.8 Nozzle. A device for use in applications requiring special water discharge patterns, directional spray, or other unusual discharge characteristics. [**13,** 2019]

Nozzles, such as those shown in Exhibit 3.8, are special application devices that have unique characteristics designed to meet specific needs. These devices might be equipped with heat-responsive elements or might be open to the atmosphere, and they are designed to spray water in a specific direction. NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection,* provides more information on nozzles.

3.3.42.9 Old-Style/Conventional Sprinkler. A sprinkler that directs from 40 percent to 60 percent of the total water initially in a downward direction and that is designed to be installed with the deflector either upright or pendent. [**13,** 2019]

Old-style/conventional sprinklers were predominantly used in North America prior to the development of spray sprinklers. The major difference between old-style/conventional and standard spray sprinklers is the design of their deflectors. Old-style/conventional sprinklers, whether upright or pendent, direct at least 40 percent of their water discharge up against the ceiling, with the remaining discharge directed downward. Spray sprinklers direct 100 percent of their water discharge downward.

Old-style/conventional sprinklers are still available and are used in Europe. These sprinklers are also used in North America for special applications in which an upward sprinkler discharge is desired, such as for fur storage vaults and for pier and wharf protection.

3.3.42.10 Open Sprinkler. A sprinkler that does not have actuators or heat-responsive elements. [**13,** 2019]

3.3.42.11 Ornamental/Decorative Sprinkler. A sprinkler that has been painted or plated by the manufacturer. [**13,** 2019]

Sometimes an ornamental sprinkler is nothing more than a corrosion-resistant sprinkler with a special coating similar in color to that of the interior building finish. The same holds true for the covers of concealed sprinklers.

It is important to remember that any coating for decorative or protective purposes must be applied only by the sprinkler manufacturer.

3.3.42.12 Quick-Response Early Suppression (QRES) Sprinkler. A type of quick-response sprinkler that has a thermal element with an RTI of 50 (meter-seconds)$^{1/2}$ or less and is listed for its capability to provide fire suppression of specific fire hazards. [**13,** 2019]

3.3.42.13 Quick-Response Extended Coverage Sprinkler. A type of quick-response sprinkler that has a thermal element with an RTI of 50 (meter-seconds)$^{1/2}$ or less and complies with the extended protection areas defined in Chapter 8 of NFPA 13. [**13,** 2019]

3.3.42.14 Quick-Response (QR) Sprinkler. A type of spray sprinkler that has a thermal element with an RTI of 50 (meter-seconds)$^{1/2}$ or less and is listed as a quick-response sprinkler for its intended use. [**13,** 2019]

Exhibit 3.27 shows a quick-response (QR) sprinkler. Note the smaller diameter of the glass bulb as compared to that of the standard-response upright sprinklers shown in Exhibit 3.18.

Δ **3.3.42.15 Residential Sprinkler.** A type of fast-response sprinkler having a thermal element with an RTI of 50 (meters-seconds)$^{1/2}$ or less that has been specifically investigated for its ability to enhance survivability in the room of fire origin and that is listed for use in the protection of dwelling units. [**13,** 2019]



EXHIBIT 3.27 *Quick-Response Sprinkler. (Courtesy of Viking®)*

3.3.42.16 Special Sprinkler. A sprinkler that has been tested and listed as prescribed in Section 15.2 of NFPA 13. [**13,** 2019]

NFPA 13, *Standard for the Installation of Sprinkler Systems,* provides detailed information for special sprinklers. This type of sprinkler does not fall into the other categories, as it is usually intended to protect specific hazards or construction features. Special sprinklers must be evaluated and listed for their intended purpose.

3.3.42.17 Spray Sprinkler. A type of sprinkler listed for its capability to provide fire control for a wide range of fire hazards. [**13,** 2019]

3.3.42.18 Standard Spray Sprinkler. A spray sprinkler with maximum coverage areas as specified in Sections 10.2 and 10.3 of NFPA 13. [**13,** 2019]

The standard spray sprinkler is installed in accordance with the coverage area limitations in Chapter 10 of NFPA 13 and is available in pendent, upright, and sidewall configurations. The standard spray sprinkler has proven to be effective for a broad range of hazards and applications by adjusting the water discharge density; it is very popular and, to a certain degree, serves as the benchmark for sprinkler criteria and performance. Exhibit 3.28 illustrates a standard spray pendent sprinkler and a standard spray upright sprinkler.

3.3.43* Standpipe System. An arrangement of piping, valves, hose connections, and associated equipment installed in a building or structure, with the hose connections located in such a manner that water can be discharged in streams or spray patterns through attached hose and nozzles, for the purpose of extinguishing a fire, thereby protecting a building or structure and its contents in addition to protecting the occupants. [**14,** 2019]

Manual and automatic standpipe systems can be dry or wet. A manual standpipe requires the fire department to supply the volume and pressure required to meet the system design criteria. An automatic standpipe supplies both the required volume and pressure automatically. Manual standpipes are traditionally dry, but there are many situations where the standpipe is connected to a water supply and filled with water. For example, where buildings are retrofitted with fire sprinklers, it is common to have the existing manual dry standpipe connected to

EXHIBIT 3.28 *Examples of Standard Spray Sprinklers: Pendent Sprinkler (left) and Upright Sprinkler (right). (Courtesy of Reliable Automatic Sprinkler Company, Inc.)*



the water supply and used to supply the water for the sprinkler system. The standpipe is still manual by design criteria but is designated as a wet standpipe because of its connection to the water supply.

Automatic standpipe systems are typically wet, but where they are subject to freezing, a dry pipe valve can be added to the system and the piping filled with air pressure much like a dry sprinkler system. An automatic dry system is installed only where there is a need for freeze protection.

A.3.3.43 Standpipe System. This is accomplished by means of connections to water supply systems or by means of pumps, tanks, and other equipment necessary to provide an adequate supply of water to the hose connections.

Standpipe systems differ substantially from the hose connections required by NFPA 13 for sprinkler systems. Standpipe systems are fire-extinguishing systems and, as a result, require much higher flows and pressures for trained fire professionals to use them effectively. Therefore, standpipe systems require specific ITM procedures, as referenced in Chapter 6.

Sometimes it is expedient to combine the standpipe piping and sprinkler piping into one system. Exhibit 3.29 illustrates a combined sprinkler/standpipe system. The standpipe system shown is a single-zone type. The detail views illustrate arrangements for the piping on each floor of a building protected by a combined sprinkler/standpipe system.

3.3.43.1 Automatic Standpipe System. A standpipe system that is attached to a water supply capable of supplying the system demand and that requires no action other than opening a hose valve to provide water at hose connections.

3.3.43.2 Dry Standpipe. A standpipe system designed to have piping contain water only when the system is being utilized.

3.3.43.3 Manual Standpipe. Standpipe system that relies exclusively on the fire department connection to supply the system demand.

3.3.43.4 Semiautomatic Dry Standpipe System. A standpipe system permanently attached to a water supply that is capable of supplying the system demand at all times arranged through the use of a device such as a deluge valve and that requires activation of a remote control device to provide water at hose connections. [**14,** 2019]

3.3.43.5 Wet Standpipe System. A standpipe system having piping containing water at all times. [1**4,** 2019]

3.3.44 Standpipe System Classes.

3.3.44.1 Class I System. A system that provides 2½ in. (65 mm) hose connections to supply water for use by fire departments. [**14**, 2019]

3.3.44.2 Class II System. A system that provides 1½ in. (40 mm) hose stations to supply water for use primarily by trained personnel or by the fire department during initial response. [**14**, 2019]

3.3.44.3 Class III System. A system that provides 1½ in. (40 mm) hose stations to supply water for use by trained personnel and 2½ in. (65 mm) hose connections to supply a larger volume of water for use by fire departments. [**14,** 2019]

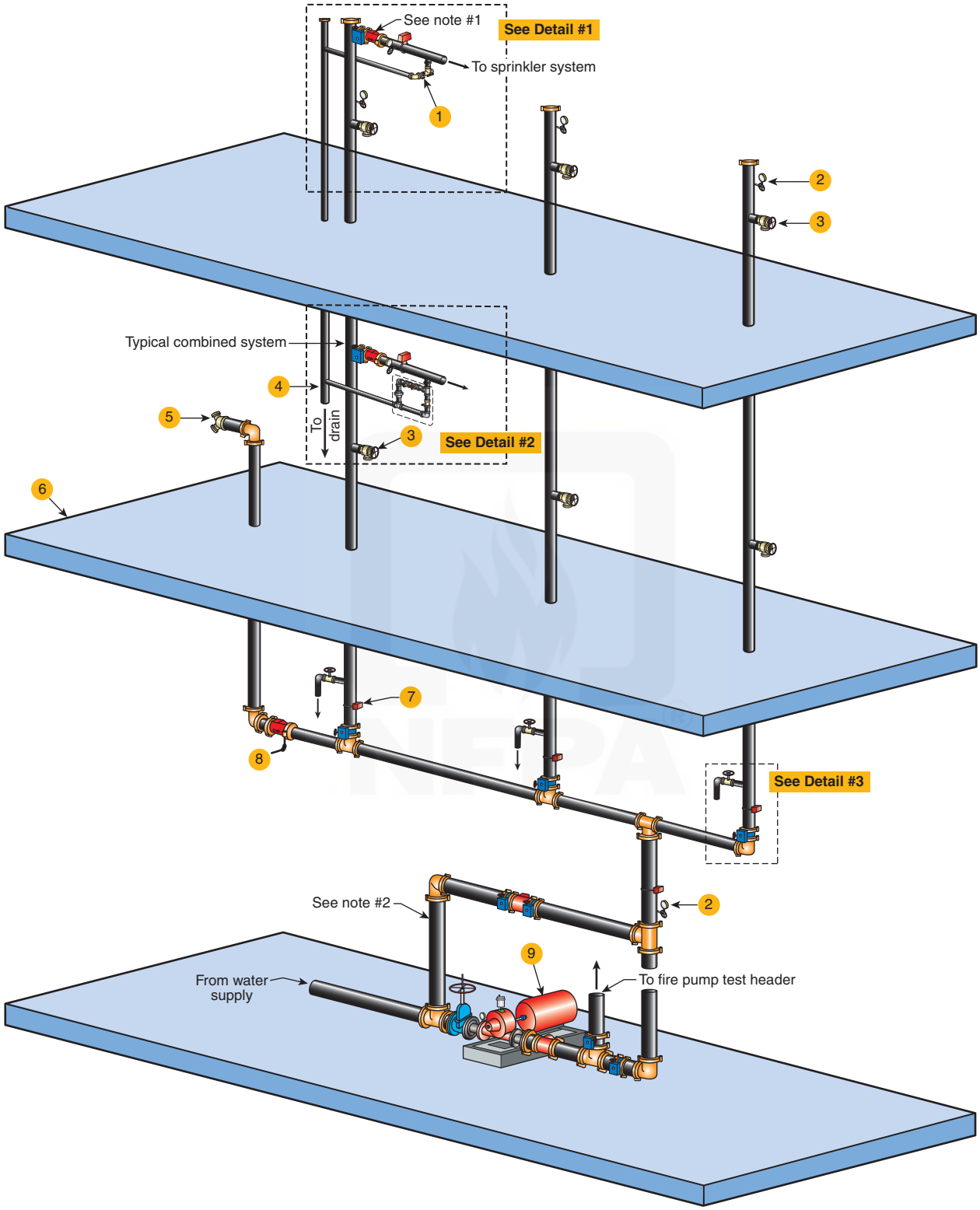
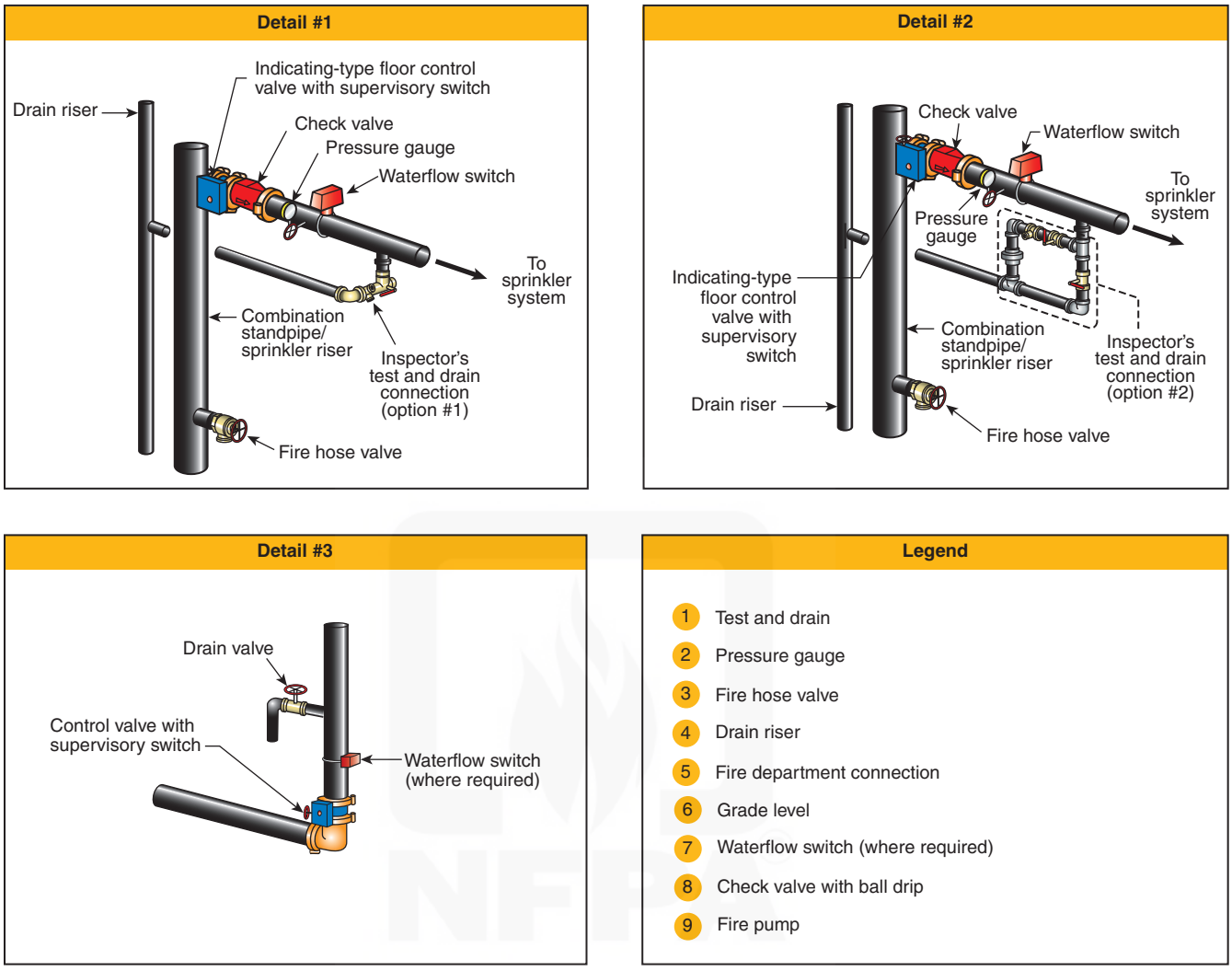


EXHIBIT 3.29 *Combination Sprinkler/Standpipe System with Acceptable Piping Arrangements. (Courtesy of Stephan Laforest)*



Notes:
1. Sprinkler floor assembly in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems.*
2. Bypass in accordance with NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection.*

EXHIBIT 3.29 *Continued*

FAQ Is hose required to be installed in a Class III standpipe system?

Hose is permitted but not required to be installed in a Class III standpipe system. NFPA 14, *Standard for the Installation of Standpipe and Hose Systems,* allows Class III systems in a fully sprinklered building to be equipped with a 2½ in. (65 mm) hose valve and a 2½ in. × 1½ in. (65 mm × 40 mm) reducer, cap, and chain, and no hose. Hose is being installed in fewer and fewer sprinklered buildings. Fire departments will not use fire hose that they do not maintain, and the consensus of most industry experts is that building occupants should not use fire hose unless they are properly trained and equipped with the required protective gear and breathing apparatus. NFPA 25 allows existing hose to be removed where approved by the AHJ (see 6.1.6). However, where hose is provided, it must be inspected, tested, and maintained in accordance with the requirements of Chapter 6.

3.3.45* Strainer. A device capable of removing from the water all solids of sufficient size that are obstructing water spray nozzles.

A.3.3.45 Strainer. There are two types of strainers. Pipeline strainers are used in water supply connections. These are capable of removing from the water all solids of sufficient size to obstruct the spray nozzles [⅛ in. (3.2 mm) perforations usually are suitable]. Pipeline strainer designs should incorporate a flushout connection or should be capable of flushing through the main drain.

Individual strainers for spray nozzles, where needed, are capable of removing from the water all solids of sufficient size to obstruct the spray nozzle that they serve.

3.3.46 Supervision. In water-based fire protection systems, a means of monitoring system status and indicating abnormal conditions.

3.3.47 Test. The operation of a device to verify that it is functioning correctly, or the measurement of a system characteristic to determine if it meets requirements.

3.3.48* Testing. A procedure used to determine the operational status of a component or system by conducting periodic physical checks, such as waterflow tests, fire pump tests, alarm tests, and trip tests of dry pipe, deluge, or preaction valves.

A.3.3.48 Testing. These tests follow up on the original acceptance test at intervals specified in the appropriate chapter of this standard.

Unlike inspections, which can often be simple visual observations of system components, many tests require the analysis of results to determine adequate performance. Some tests — for example, a fire pump test that indicates degradation of more than 5 percent but still produces more than the required flow rate — may indicate that the component or system is still capable of performing at an acceptable level but could pose problems in the future.

3.3.49 Valve Status Test. Flowing water to verify that valves for a portion of the system are not closed.

The valve status test ensures that the valve is in the proper position based on its desired function. One of the leading causes of fires overwhelming sprinklered buildings is that the water could not reach the sprinklers or hose outlets due to partially or fully closed valves. This test is intended to cut down on the number of times a valve is inadvertently left closed or partially closed.

3.3.50* Valve Status Test Connection. A point in the system where water is discharged for purposes of performing a valve status test.

A.3.3.50 Valve Status Test Connection. These connections can include the main drain, fire pump test header, backflow preventer forward flow test connection, fire hydrant, and other similar locations. In the absence of the aforementioned devices, an inspector's test connection might be used.

Consideration should be given to the size and location of the valve status test connection being used. For example, flowing a small amount of water through an inspector's test connection located a long distance from the valve that was closed and reopened may not be adequate. In that scenario, sufficient water should be discharged to ensure the valve is in fact reopened.

3.3.51* Water Spray. Water in a form having a predetermined pattern, particle size, velocity, and density discharge from specially designed nozzles or devices. [**15,** 2017]

A.3.3.51 Water Spray. Water spray fixed systems are usually applied to special fire protection problems, since the protection can be specifically designed to provide for fire control,

extinguishment, or exposure protection. Water spray fixed systems are permitted to be independent of, or supplementary to, other forms of protection.

3.3.52 Water Supply. A source of water that provides the flows [gal/min (L/min)] and pressures [psi (bar)] required by the water-based fire protection system.

FAQ What are examples of acceptable water supplies for use in fire protection systems?

Some examples of water supplies that are acceptable for use in fire protection systems include the following:

- Connections to water works systems
- Fire pumps installed in accordance with NFPA 20
- Pressure and gravity tanks

Other sources of water can be used for fire protection systems, subject to the approval of the AHJ. Ponds, reservoirs, lakes, rivers, and other sources can be acceptable provided the year-round availability of a sufficient volume can be confirmed. All of these sources will be used typically in conjunction with a fire pump. An important function of the standard is to verify that water supplies are in operating condition.

3.3.53 Waterflow Alarm Device. An attachment to a water-based fire protection system that detects and signals a predetermined waterflow.

3.4 Deluge Foam-Water Sprinkler and Foam-Water Spray Systems Definitions.

3.4.1 Foam-Water Spray System. A foam-water sprinkler system designed to use nozzles rather than sprinklers. [**16,** 2019]

Foam-water spray systems are almost identical to water spray fixed systems; however, foam systems have foam-generating equipment attached to the feed main piping. The discharge device or nozzle must be listed for use with foam concentrate.

3.4.2 Foam-Water Sprinkler System. A piping network employing automatic sprinklers, nozzles or other discharge devices, connected to a source of foam concentrate and to a water supply. [**16,** 2019]

Foam-water sprinkler systems and deluge systems are almost identical; they differ in that foam-water sprinkler systems have foam-generating equipment attached to the feed main piping. Like foam-water spray systems, foam-water sprinkler systems must employ discharge devices or sprinklers that are listed for use with foam concentrate. See the commentary in Chapter 11 for more information on foam-water sprinkler systems.

3.5 Valve Definitions.

3.5.1* Control Valve. A valve controlling flow to water-based fire protection systems.

A.3.5.1 Control Valve. Experience has shown that closed valves are the primary cause of failure of water-based fire protection systems in protected occupancies. Control valves do not include hose valves, inspector's test valves, drain valves, trim valves for dry pipe, preaction and deluge valves, check valves, or relief valves.

Shut or partially shut control valves account for the majority of all sprinkler system failures. Therefore, the control valve requires vigorous inspection and monitoring. Control valves require close scrutiny, particularly when there are no mechanical monitoring systems (e.g., chains with locks) or electronic monitoring systems (e.g., tamper switches). When valves are provided with only a seal, the inspection frequency is weekly. Beginning with the 2017 edition, the requirement to inspect valves that are electronically supervised was relaxed to quarterly.

Further, whenever a control valve at the system riser is operated, a valve status test must be performed to verify that the valve has been opened fully. See the commentary in Chapter 13 for more information on valves and valve components.

3.5.2* Deluge Valve. A water supply control valve intended to be operated by actuation of an automatic detection system that is installed in the same area as the discharge devices.

A.3.5.2 Deluge Valve. Each deluge valve is intended to be capable of automatic and manual operation.

3.5.3 Hose Valve. The valve to an individual hose connection with an outlet for attaching a fire hose. [**14,** 2019]

3.5.4 Pressure Control Valve. A pilot-operated pressure-reducing valve designed for the purpose of reducing the downstream water pressure to a specific value under both flowing (residual) and nonflowing (static) conditions. [**14,** 2019]

3.5.5 Pressure-Reducing Valve. A valve designed for the purpose of reducing the downstream water pressure under both flowing (residual) and nonflowing (static) conditions. [**14,** 2019]

Typically, pressure control and pressure-reducing valves are found on systems that are subjected to high pressures, usually in excess of 175 psi (12.1 bar). These valves are intended to protect system components from failure due to high pressure. They must be tested periodically to verify that they are functioning correctly, since failure of the valve can damage system components and could present a danger to personnel.

A typical application for these valves is in a high-rise building where high pressures are needed to move water to the upper floors. They can be used to control pressures for entire sprinkler or standpipe systems or individual fire department hose connections. In the case of valves controlling pressure to individual fire department valves, pressures might be either preset at the factory or adjustable in the field.

Exhibit 3.30 shows an example of both types of pressure-reducing valves.

3.5.5.1* Master Pressure-Reducing Valve. A pressure-reducing valve installed to regulate pressures in an entire fire protection system and/or standpipe system zone.

A.3.5.5.1 Master Pressure-Reducing Valve. Master pressure-reducing valves are typically found downstream of a fire pump's discharge.

A master pressure-reducing valve is used to control pressure to an entire sprinkler or standpipe system. This valve controls water pressure to the entire system, so it must be tested more frequently than other valves in the system to verify that it is functioning properly. For more information regarding the ITM of this valve, see Chapter 13. See Exhibit 3.31 for a typical master pressure-reducing valve.

3.5.6 [Pressure] Relief Valve. A device that allows the diversion of liquid to limit excess pressure in a system. [**20,** 2019]

3.5.6.1 Circulation Relief Valve. A valve used to cool a pump by discharging a small quantity of water. This valve is separate from and independent of the main relief valve. [**20,** 2019]

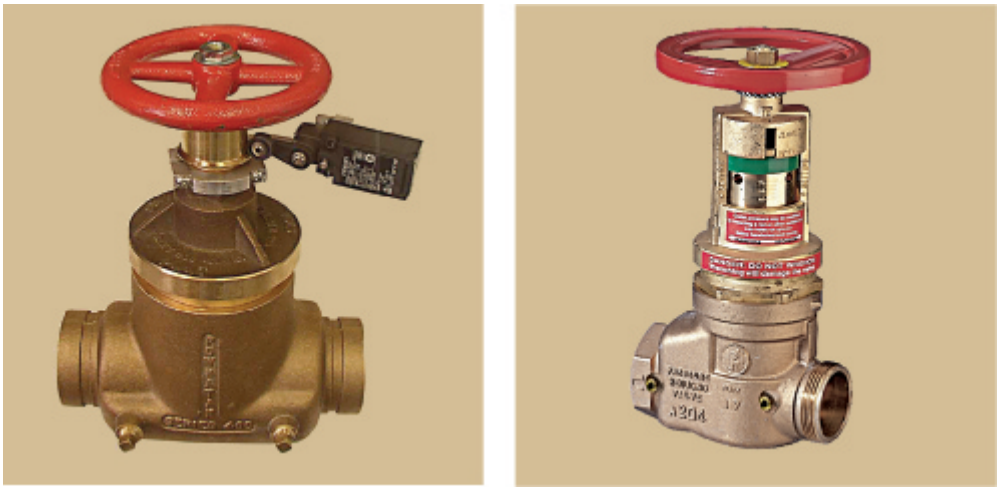


EXHIBIT 3.30 *Pressure-Reducing Valves: Factory Set (left) and Field Set (right). (Courtesy of Fire-End & Croker Corp.)*



EXHIBIT 3.31 *Master Pressure-Reducing Valve. (Courtesy of CLA-VAL)*

3.6 Water-Based Fire Protection System Definitions.

3.6.1 Combined Standpipe and Sprinkler System. A system where the water piping services both 2½ in. (65 mm) outlets for fire department use and outlets for automatic sprinklers.

A combined standpipe and sprinkler system, such as the one shown in Exhibit 3.29, has common piping through the feed main and riser portion of the system. A sprinkler system and a standpipe system that share a common supply header at the water service entrance to the building do not constitute a "combined system." With combined systems, the sprinkler system is designed and installed in such a way that it is isolated from the standpipe system, usually by means of floor control assemblies. Isolating the sprinkler system(s) for the standpipe system allows manual fire fighting to continue even after a sprinkler system is shut off.

3.6.2 Fire Pump Definitions.

Whether taking suction from a natural body of water, a storage tank, or a reliable water works, the presence of a fire pump, such as the one shown in Exhibit 3.32, indicates that the primary water source lacks sufficient pressure to meet the fire protection system demand. The fire pump must be properly maintained to be able to function in the event of a fire. Failure of the fire pump will result in inadequate pressure to meet the demands of the fire protection system. Therefore, frequent operation of the pump and an annual evaluation of performance are necessary. See the commentary in Chapter 8 for more information on fire pumps.

EXHIBIT 3.32 *Horizontal Fire Pump Installation.*



3.6.2.1 Churn. See 3.6.2.4, No Flow (Churn, Shutoff)

3.6.2.2 Discharge Pressure. See 3.6.2.6.1.

3.6.2.2.1 Net Pressure (Differential Pressure). See 3.6.2.6.2.

3.6.2.3 Fire Pump. A pump that is a provider of liquid flow and pressure dedicated to fire protection. [**20,** 2019]

3.6.2.4* No Flow (Churn, Shutoff). The condition of zero flow when the fire pump is running but the only water passing through the pump is a small flow that is discharged through the pump circulation relief valve or supplies the cooling for a diesel engine driver. [**20,** 2019]

A.3.6.2.4 No Flow (Churn, Shutoff). A small discharge of water is required to prevent the pump from overheating when operating under no flow (churn) conditions. [**20,** 2019]

Δ **3.6.2.5* Peak Load.** As pertains to annual testing in this standard, the maximum power required to drive the pump at any flow rate up to 150 percent of rated capacity (flow).

A.3.6.2.5 Peak Load. The maximum power requirements for a centrifugal pump typically occur when the pump is operating between 130 percent and 150 percent of the rated flow. The required power could continue to increase beyond 150 percent of rated flow, but NFPA 20 does not require testing beyond 150 percent of rated flow. The peak load can be determined by looking at the horsepower curve on the fire pump curve supplied by the pump manufacturer. [**20,** 2019]

3.6.2.6 Pressure.

3.6.2.6.1 Discharge Pressure. The total pressure available at the fire pump discharge flange. [**20,** 2019]

3.6.2.6.2* Net Pressure (Differential Pressure). For vertical turbine fire pumps, the total pressure at the fire pump discharge flange plus the total suction lift. For other fire pumps, the total pressure at the fire pump discharge flange minus the total pressure at the fire pump suction flange. [**20,** 2019]

A.3.6.2.6.2 Net Pressure (Differential Pressure). The net pressure (differential pressure) includes the difference in velocity head correction (pressure) from the pump discharge to the pump suction. In many cases, the difference in suction and discharge velocity head correction (pressure) is small and can be ignored without adversely affecting the evaluation of the pump performance. [**20,** 2019]

3.6.2.6.3 Rated Pressure. The net pressure (differential pressure) at rated flow and rated speed as marked on the manufacturer's nameplate. [**20,** 2019]

3.6.2.6.4 Suction Pressure. The total pressure available at the fire pump suction flange. [**20,** 2019]

3.6.2.7 Rated Flow. The capacity of the pump at rated speed and rated pressure as marked on the manufacturer's nameplate. [**20,** 2019]

3.6.2.8 Rated Pressure. See 3.6.2.6.3.

3.6.2.9 Shutoff (No Flow, Churn). See 3.6.2.4, No Flow.

3.6.2.10 Suction Pressure. See 3.6.2.6.4.

3.6.2.11 Unadjusted Field Test Curve. A fire pump discharge curve including churn, 100 percent rate flow, and maximum flow up to 150 percent of rated flow, based on discharge gauge readings without speed or velocity pressure adjustments.

N **3.6.2.12 Variable Speed Pump.** A fire pump with variable speed pressure limiting control or self-regulating variable speed fire pump unit. [**20,** 2019]

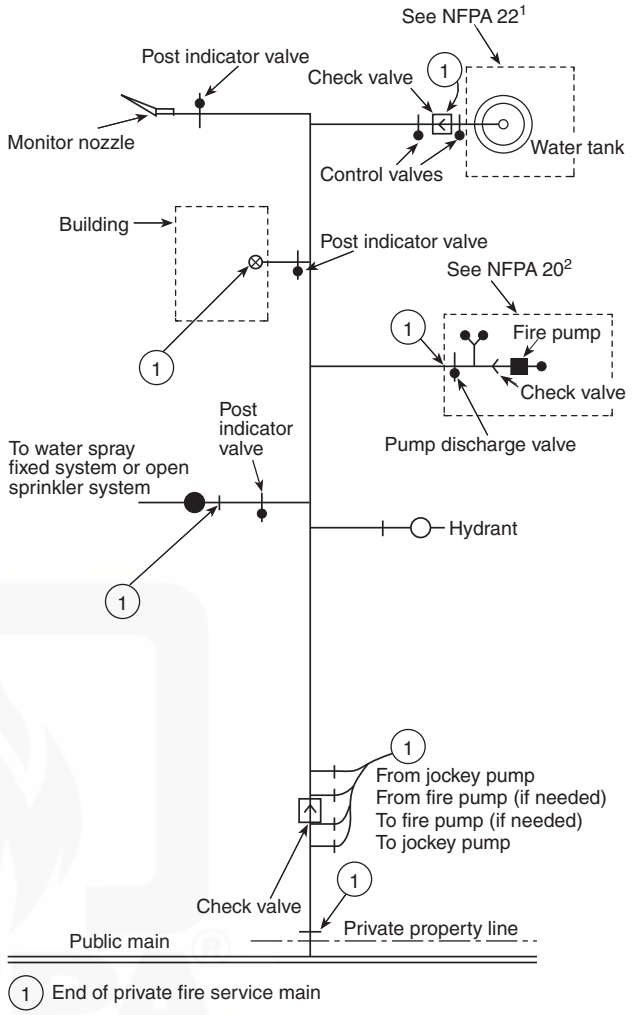
3.6.3* Private Fire Service Main. A private fire service main, as used in this standard, is that pipe and its appurtenances on private property that is between a source of water and the base of the system riser for water-based fire protection systems; between a source of water and inlets to foam-making systems; between a source of water and the base elbow of private hydrants or monitor nozzles; and used as fire pump suction and discharge piping, beginning at the inlet side of the check valve on a gravity or pressure tank. [**24,** 2019]

See the commentary in Chapter 7 for more information on private fire service mains.

A.3.6.3 Private Fire Service Main. See Figure A.3.6.3.

Δ **3.6.4* Sprinkler System.** A system, commonly activated by heat from a fire and discharges water over the fire area, that consists of an integrated network of piping designed in accordance with fire protection engineering standards that includes a water supply source, a water control valve, a waterflow alarm, and a drain. The portion of the sprinkler system above ground is a network of specifically sized or hydraulically designed piping installed in a building, structure, or area, generally overhead, and to which sprinklers are attached in a systematic pattern. [**13,** 2019]

The definition of *sprinkler system* is important to the requirements of NFPA 25. For example, Chapter 14 allows for the assessment of internal condition of pipe to be conducted on alternate wet pipe systems. In a multistory building, where each floor meets the definition of a system, this can have a dramatic effect on the cost of inspections.



Note: The piping (aboveground or buried) shown is specific as to the end of the private fire service main, and this schematic is only for illustrative purposes beyond the end of the fire service main. Details of valves and their location requirements are covered in the specific standard involved.

1. See NFPA 22, *Standard for Water Tanks for Private Fire Protection.*
2. See NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection.*

Δ ***FIGURE A.3.6.3*** *Typical Private Fire Service Main. [24:Figure A.3.3.13]*

A.3.6.4 Sprinkler System. As applied to the definition of a sprinkler system, each system riser serving a portion of a single floor of a facility or where individual floor control valves are used in a multistory building should be considered a separate sprinkler system. Multiple sprinkler systems can be supplied by a common supply main. [**13,** 2019]

3.6.4.1 Antifreeze Sprinkler System. A wet pipe system using automatic sprinklers that contains a liquid solution to prevent freezing of the system, intended to discharge the solution upon sprinkler operation, followed immediately by water from a water supply. [**13,** 2019]

The use of new antifreeze systems and the ITM of existing antifreeze systems have undergone significant changes. For example, antifreeze solutions used in new systems must be listed, and existing systems must have testing conducted to determine the type and concentration of antifreeze solution. Such maintenance requirements vary depending on a number of conditions; see Chapter 5 for the requirements. Exhibit 3.33 shows one of three arrangements of supply piping and valves for an antifreeze system that are permitted by NFPA 13.

3.6.4.1.1 Premixed Antifreeze Solution. A mixture of an antifreeze material with water that is prepared and factory-mixed by the manufacturer with a quality control procedure in place that ensures that the antifreeze solution remains homogeneous and that the concentration is as specified. [**13,** 2019]

The term *premixed* should not be confused with *listed*. NFPA 25 permits existing antifreeze systems to remain in service as long as they meet the requirements of 5.3.4. Whenever new antifreeze is added to an existing system, it must be factory premixed, but there is no requirement for it to be listed. Although it is permitted to be used by NFPA 25 in this form, new antifreeze systems installed in accordance with NFPA 13 must use listed antifreeze.

3.6.4.2 Deluge Sprinkler System. A sprinkler system employing open sprinklers or nozzles that are attached to a piping system that is connected to a water supply through a valve that is opened by the operation of a detection system installed in the same areas as the sprinklers or

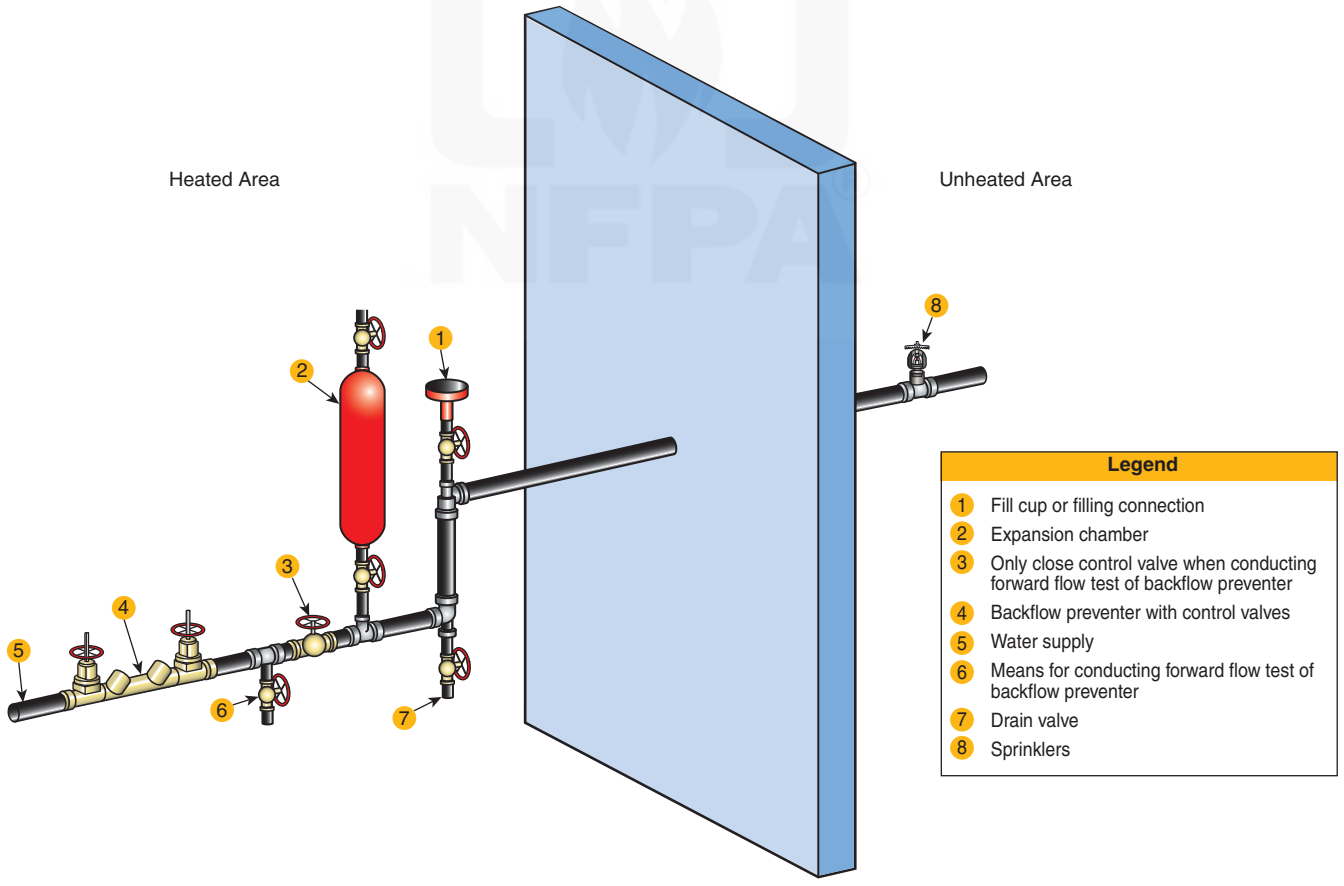


EXHIBIT 3.33 *Valve Arrangement for an Antifreeze System Loop. (Courtesy of Stephan Laforest)*

the nozzles. When this valve opens, water flows into the piping system and discharges from all sprinklers or nozzles attached thereto. [**13,** 2019]

Deluge sprinkler systems are typically used in high-challenge fire areas where water is required for the entire area. Deluge systems are used to extinguish or control a fire, and they are also installed to provide exposure protection to areas adjacent to a fire. Since the deluge piping contains no water and is exposed to the atmosphere, the pipe is subject to the effects of corrosion resulting from condensation or improper draining of the system.

Deluge systems, such as the one shown in Exhibit 3.34, are more complicated and might require more attention than wet pipe systems, due to the actuation systems used. These actuation systems can be in the form of electrical detection systems or wet or dry pilot sprinklers.

3.6.4.3 Dry Pipe Sprinkler System. A sprinkler system employing automatic sprinklers that are attached to a piping system containing air or nitrogen under pressure, the release of which (as from the opening of a sprinkler) permits the water pressure to open a valve known as a dry pipe valve, and the water then flows into the piping system and out the opened sprinklers. [**13,** 2019]

A dry pipe sprinkler system is typically installed where water-filled piping is subject to freezing. (See Exhibit 3.35.) A dry pipe system requires an extensive ITM process because of the need to keep the piping free of water, the requirement for constant pressurized air, and a complicated valve arrangement.

Exposure to fluctuating temperatures and corrosive environments in a dry pipe system can accelerate the corrosion of pipe, fittings, hangers, and sprinklers. The corrosion of the inner surfaces of the piping system is of particular concern because it can lead to the presence of obstructions in the form of rust or scale. Careful observation of water discharge during testing of dry pipe systems is essential to detect this obstructing material.

The dry pipe valve is a differential type valve, meaning that very little air pressure can hold back significantly greater water pressure, usually around 1 psi (0.07 bar) of air pressure to 5 psi or 6 psi (0.34 bar or 0.41 bar) of water pressure. Since a dry pipe system is prone to the formation of internal rust and scale, particular attention to the dry pipe valve is necessary to prevent the accumulation of this material in the valve seat. Accumulated rust and scale can prevent the clapper from sealing properly and result in malfunction of the dry pipe valve, which would necessitate an internal inspection.

The principle of a dry pipe valve is illustrated in Exhibit 3.36. Compressed air in the sprinkler system holds the dry pipe valve closed, preventing water from entering the sprinkler piping until a sprinkler opens and releases air and the air pressure has dropped below a predetermined point.

3.6.4.4 Marine System. A sprinkler system installed on a ship, boat, or other floating structure that takes its supply from the water on which the vessel floats.

3.6.4.5 Preaction Sprinkler System. A sprinkler system employing automatic sprinklers that are attached to a piping system that contains air that might or might not be under pressure, with a supplemental detection system installed in the same areas as the sprinklers. [**13,** 2019]

Several types of preaction systems can be found in use, including the following:

- *Single interlock systems,* which allow water to enter the piping only upon the operation of detection devices
- *Non-interlock systems,* which allow water to enter the piping system upon activation of either detection devices or automatic sprinklers
- *Double interlock systems,* which allow water to enter the piping system only upon operation of both detection devices and automatic sprinklers

A typical preaction sprinkler system is shown in Exhibit 3.37.

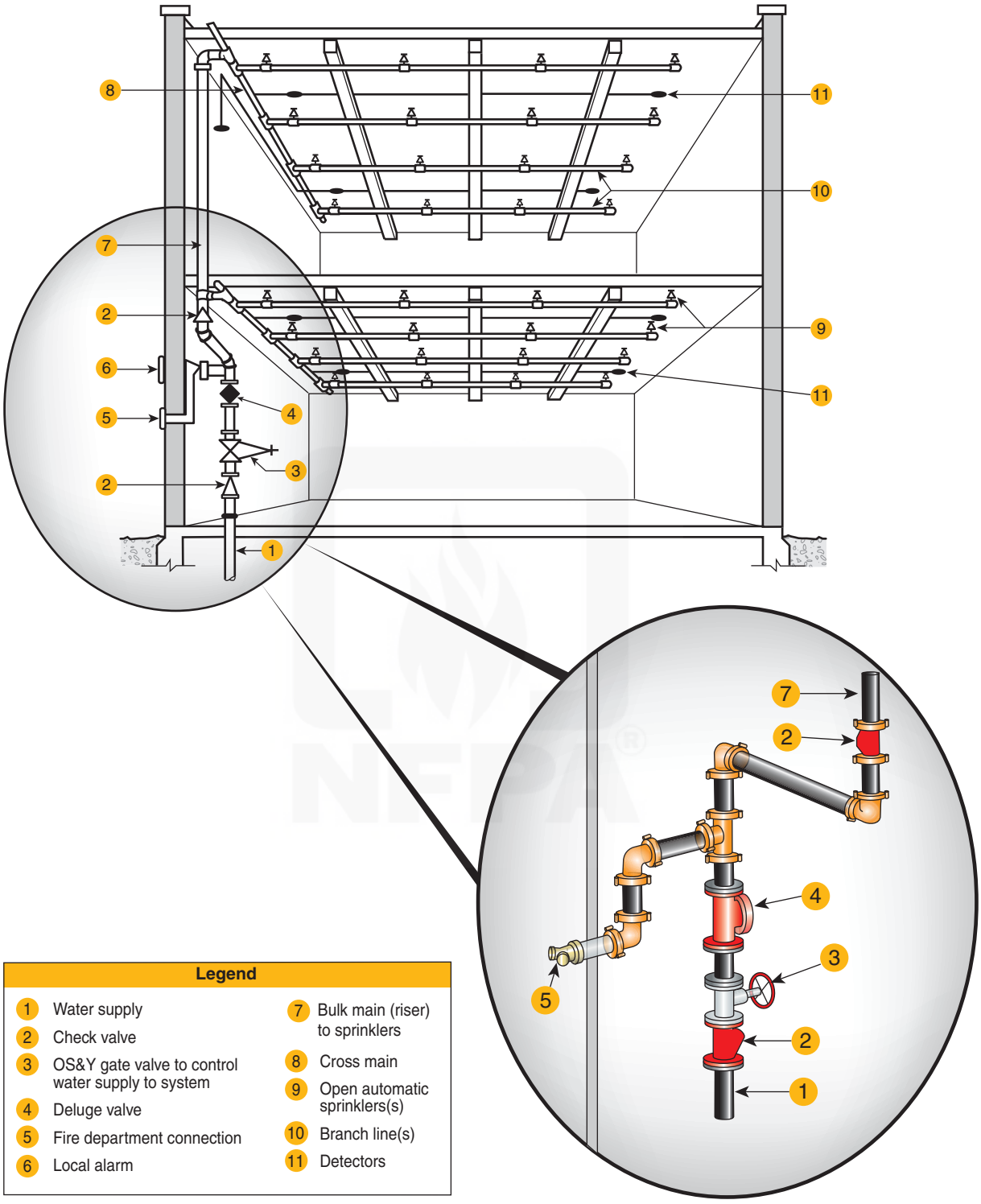


EXHIBIT 3.34 *Deluge System. (Courtesy of Stephan Laforest)*

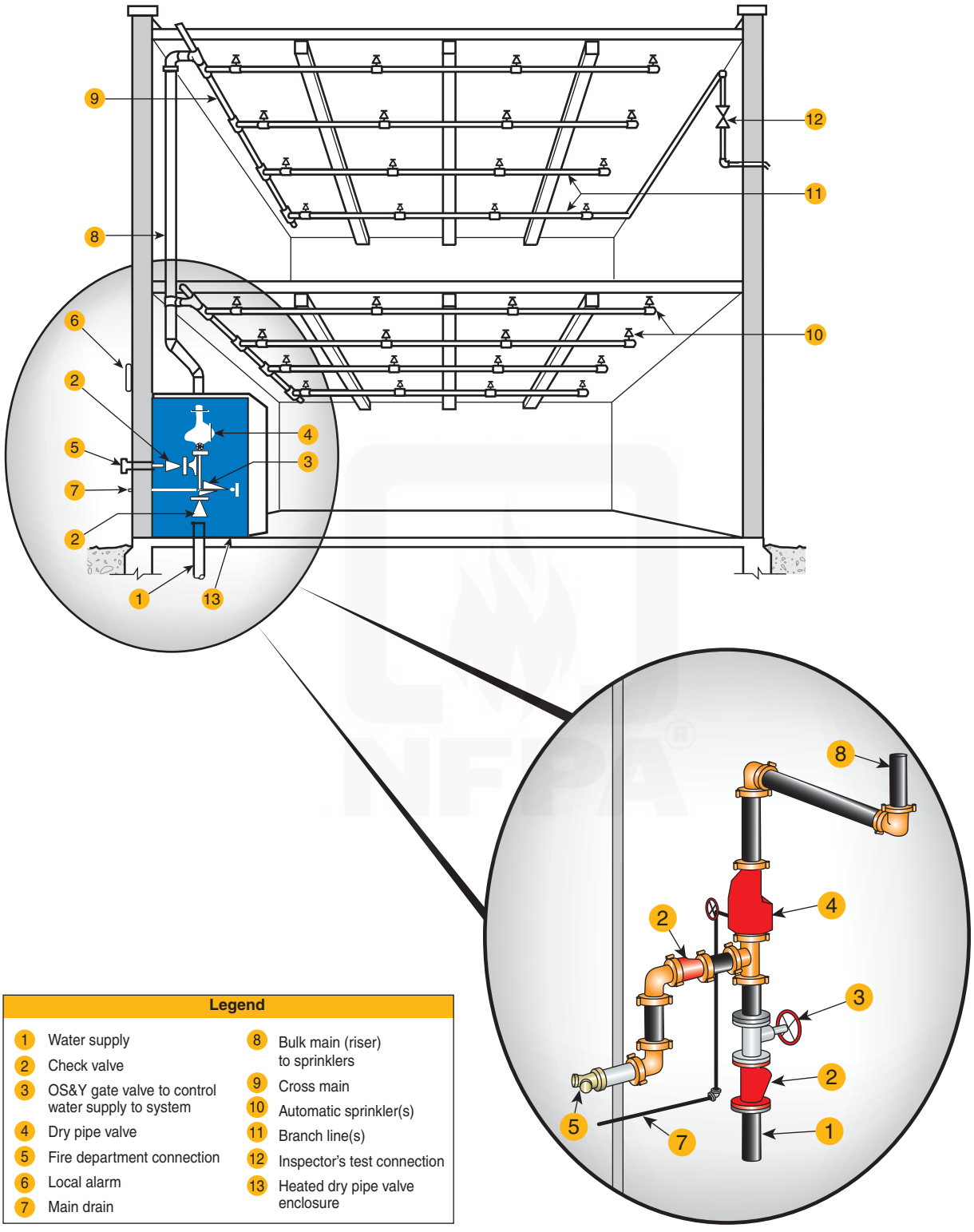


EXHIBIT 3.35 *Dry-Pipe System for Unheated Properties. (Courtesy of Stephan Laforest)*

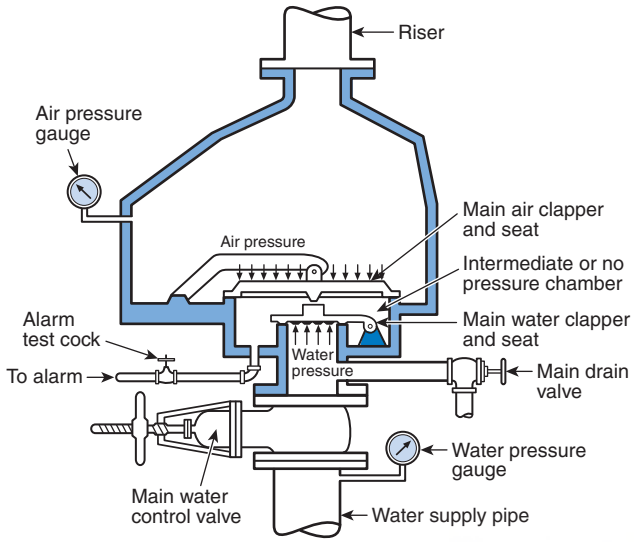


EXHIBIT 3.36 *Dry Pipe Valve. (Source: Fire Protection Handbook, 2008, Figure 16.3.9)*

3.6.4.6* Wet Pipe Sprinkler System. A sprinkler system employing automatic sprinklers attached to a piping system containing water and connected to a water supply so that water discharges immediately from sprinklers opened by heat from a fire. [**13,** 2019]

A.3.6.4.6 Wet Pipe Sprinkler System. Hose connections [1½ in. (40 mm) hose, valves, and nozzles] supplied by sprinkler system piping are considered components of the sprinkler system.

The wet pipe system (see Exhibit 3.38) is the most common of all sprinkler systems and the simplest to maintain. This system is filled with water under pressure at all times so that water is discharged immediately upon activation of a sprinkler. The alarm valve shown in Exhibit 3.38 causes a warning signal to sound when water flows through the system. However, it must be noted here that sprinklers operate independently of each other; in many cases, fire is controlled by a single sprinkler. One of the few limitations of a wet pipe system is that it must be protected from freezing.

3.6.5 Water Mist System. A distribution system connected to a water supply or water and atomizing media supplies that is equipped with one or more nozzles capable of delivering water mist intended to control, suppress, or extinguish fires and that has been demonstrated to meet the performance requirements of its listing and [the applicable] standard. [**750,** 2019]

Water spray fixed systems are usually controlled by a deluge valve supplying water to open or non-automatic discharge devices. For automatic systems, the actuating mechanism might be in the form of an electrical detection system or a system of hydraulic or pneumatic pilot sprinklers. These systems are usually more complex than either wet or dry pipe sprinkler systems. See the commentary in Chapter 10 for more information on water spray fixed systems.

3.6.6* Water Spray System. An automatic or manually actuated fixed pipe system connected to a water supply and equipped with water spray nozzles designed to provide a specific water discharge and distribution over the protected surfaces or area. [**15,** 2017]

A.3.6.6 Water Spray System. Automatic systems can be actuated by separate detection equipment installed in the same area as the water spray nozzles or by the water spray nozzles

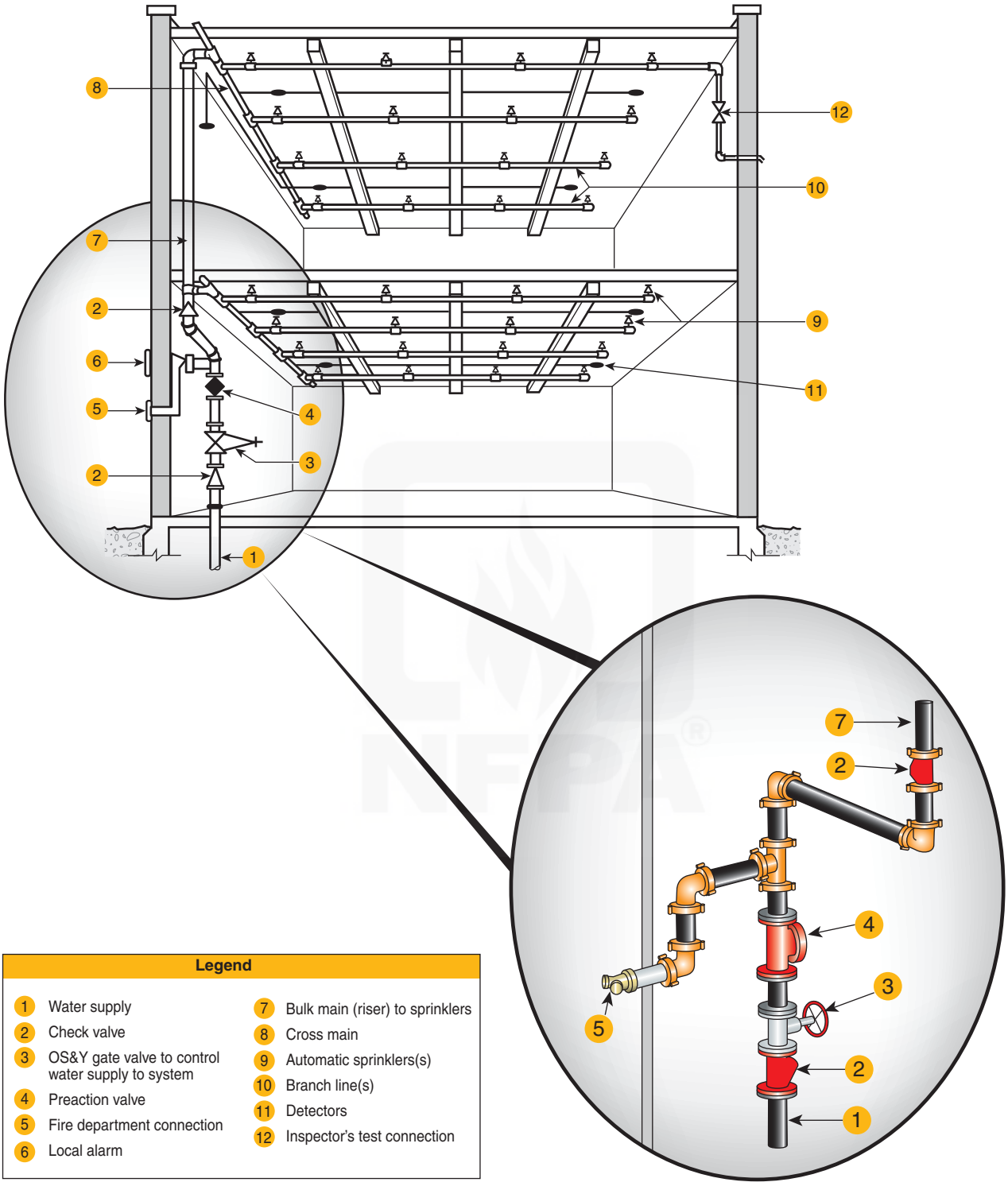


EXHIBIT 3.37 *Typical Preaction Sprinkler System. (Courtesy of Stephan Laforest)*

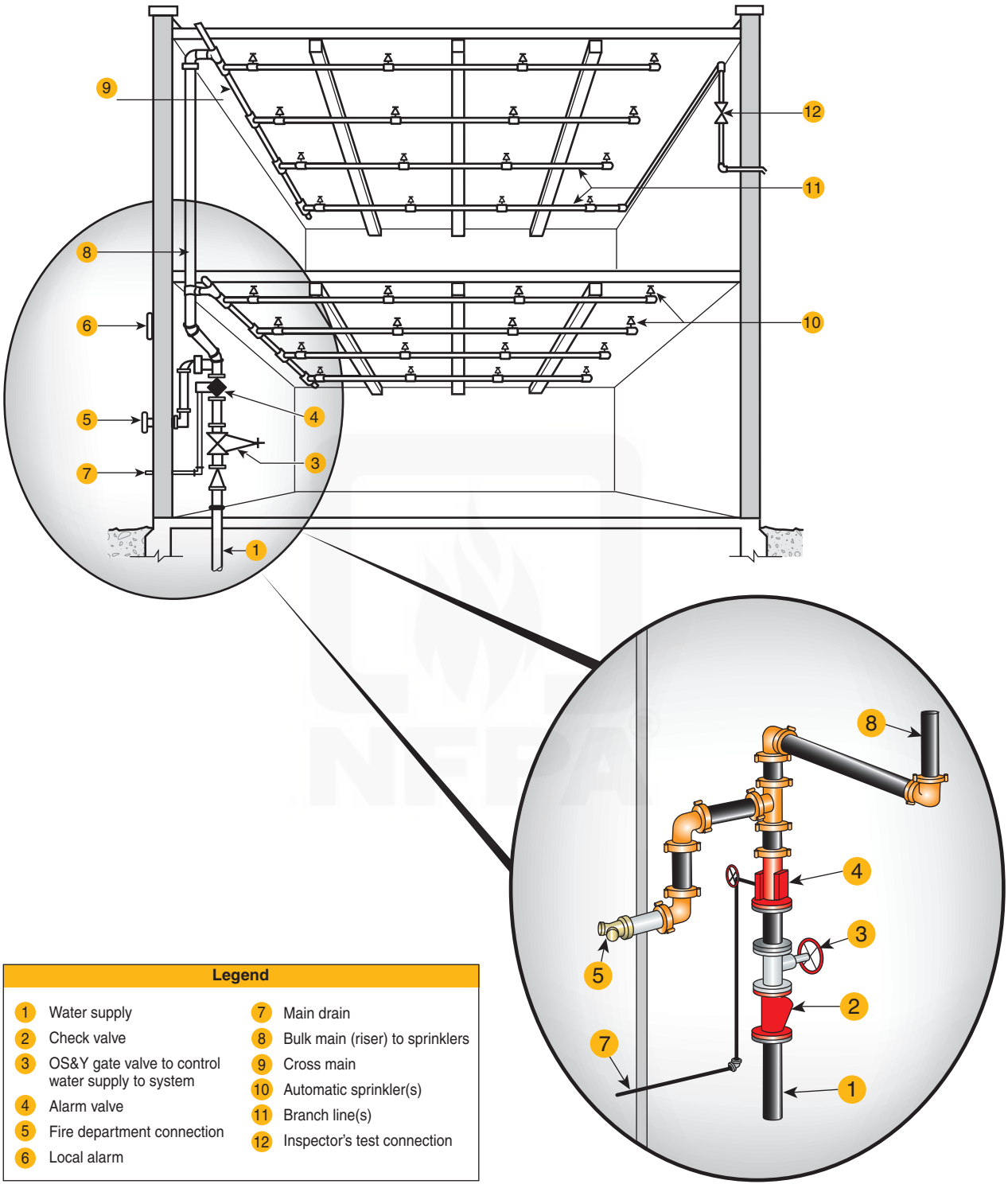


EXHIBIT 3.38 *Wet Pipe Sprinkler System. (Courtesy of Stephan Laforest)*

using an operating element. In some cases, the automatic detector can also be located in another area. [**15,** 2017]

3.6.6.1 Ultra High-Speed Water Spray System. A type of automatic water spray system where water spray is rapidly applied to protect specific hazards where deflagrations are anticipated. [**15,** 2017]

3.6.7 Water Tank. A tank supplying water for water-based fire protection systems.

A water tank is used primarily when there is an insufficient water supply. Ground-mounted suction tanks and embankment-supported coated fabric suction tanks are always used in conjunction with a fire pump. Pressure tanks and elevated tanks provide pressure in addition to the water. Water tanks are also utilized with high-value or high-risk properties as a redundant or back-up water supply, but in most cases, the tanks are the only source of water for a fire protection system and must be cared for to maintain system reliability. Water storage tanks are usually designed and installed in accordance with NFPA 22, *Standard for Water Tanks for Private Fire Protection*. See the commentary in Chapter 9 for more information on water tanks.

3.7 Inspection, Testing, and Maintenance (ITM) Task Frequencies.

3.7.1* Frequency. Minimum and maximum time between events.

A.3.7.1 Frequency. The frequencies in NFPA 25 are intended to establish an optimal time between tasks that are required by this document. When scheduling conflicts or other conditions do not allow the tasks to be performed on a strict calendar schedule, it is important that the required task frequencies be identified and complied with according to the variances described in the frequency definitions. When the required task frequencies have not been followed, it should be noted on the inspection report, the task should be performed, and the task frequencies should be followed for all future tasks. The variances should not be used to "skip" tasks or to perform fewer tasks than called for in this document.

All the inspections, tests, and maintenance required by NFPA 25 are frequency-based. The term *frequency* was added beginning with the 2014 edition to clarify that frequency represents an elapsed time, not a definition of a task. For example, when referring to the inspections that are due to occur on a yearly basis, it would be appropriate to refer to them as annual frequency inspections as opposed to annual inspections. Inspections, tests, and maintenance that are more frequent than annual (weekly, monthly, etc.) should be repeated during the annual frequency event. In other words, an annual frequency inspection should include the 52nd weekly, the 12th monthly, the 4th quarterly, and the 2nd semi-annual frequency tasks.

3.7.1.1 Daily Frequency. Occurring every day.

3.7.1.2 Weekly Frequency. Occurring once per calendar week.

3.7.1.3 Monthly Frequency. Occurring once per calendar month.

3.7.1.4 Quarterly Frequency. Occurring four times per year with a minimum of 2 months and a maximum of 4 months.

3.7.1.5 Semiannual Frequency. Occurring twice per year with a minimum of 4 months and a maximum of 8 months.

3.7.1.6 Annual Frequency. Occurring once per year with a minimum of 9 months and a maximum of 15 months.

3.7.1.7 Three Years Frequency. Occurring once every 36 months with a minimum of 30 months and a maximum of 40 months.

3.7.1.8 Five Years Frequency. Occurring once every 60 months with a minimum of 54 months and a maximum of 66 months.

FAQ Do annual frequency inspections, tests, and maintenance have to occur on the same date each year to comply with NFPA 25?

The definitions in 3.7.1.1 through 3.7.1.8 create "frequency windows" that permit the reasonable application of the standard while maintaining the optimal time between events. As long as the tasks occur within the elapsed times defined is these sections, compliance will be achieved.

References Cited in Commentary

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

Cote, A. E., ed., *Fire Protection Handbook®*, 20th edition, 2008.

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2019 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems,* 2019 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection,* 2017 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, 2019 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection,* 2018 edition.

NFPA 70E®, *Standard for Electrical Safety in the Workplace®*, 2018 edition.

NFPA



4

GENERAL REQUIREMENTS

Chapter 4 of NFPA 25 contains general requirements for the different types of systems covered under the scope of the standard. This chapter outlines the administrative guidelines for compliance with the standard, which include such topics as changes in building use or occupancy, impairments, corrective action, record keeping, and essential safety requirements for those performing the work specified in Chapter 5 through Chapter 16. The primary focus of this chapter is on the property owner or designated representative. The standard aims to clearly identify that the owner or the owner's designated representative is responsible for all aspects of maintaining the systems addressed by the standard. These responsibilities include changes to building contents, changes to building use, or renovations to interior building arrangement that can hinder the efficacy of the fire protection systems operation.

4.1 Responsibility of Property Owner or Designated Representative.

Note that the owner or designated representative is the only person to whom specific responsibility is assigned by this standard. Although *authority having jurisdiction (AHJ)* is defined in Chapter 3, and several sections require the involvement of the AHJ, it is only in the context of the owner seeking AHJ approval or consultation. Likewise, while the qualified person conducting inspections and tests is often a contractor, the responsibility for all tasks in NFPA 25 is that of the owner or designated representative.

4.1.1* Responsibility for Inspection, Testing, Maintenance, and Impairment. The property owner or designated representative shall be responsible for properly maintaining a water-based fire protection system.

In many jurisdictions, NFPA 25 is adopted through a model code or state law. However, due to a lack of manpower, AHJs often cannot actively enforce the standard in those jurisdictions. Even if the AHJ is not banging on the door looking for an ITM inspection report, the owner still must follow the inspection, testing, and maintenance (ITM) program outlined by NFPA 25.

A.4.1.1 Any portion or all of the inspection, testing, and maintenance can be permitted to be contracted with an inspection, testing, and maintenance service. When an inspection, testing, and maintenance service company agrees to perform inspections and tests at a specific frequency required by this standard, the inspection, testing, and maintenance service company should perform all inspections and tests that are required more frequently than the specified frequency. For example, the ITM service provider agrees to perform required inspections and

Tip for Owners

Subsection 4.1.1 sets the tone for the enforcement of the standard by stating that the property owner or designated representative (see A.4.1.1.3) is responsible for maintaining a water-based fire protection system. Maintaining a system includes the ITM tasks, as mandated by the standard. The owner should therefore carefully read and understand all of the requirements in Section 4.1 to have a full understanding of the responsibilities placed on them by NFPA 25.

tests on an annual basis. Those inspections and tests required on a daily, weekly, quarterly, and semiannual frequency should also be performed during the annual inspections and tests.

Most owners contract a service for at least some of the ITM requirements of NFPA 25. Many misunderstandings concerning the expectations of the owner and the contracted service provider can be eliminated with well-written agreements that include detailed scopes of work, any exclusions, schedule constraints, and terms and conditions. When contracting services, owners should require verification that the service provider and personnel are qualified and, where required, properly licensed to perform the contracted tasks.

4.1.1.1 Inspection, testing, maintenance, and impairment procedures shall be implemented in accordance with those established in this document and in accordance with the manufacturer's instructions.

As stated in Chapter 1, the requirements found in NFPA 25 are minimum requirements. Along with those minimum requirements, as indicated in this section, ITM requirements found in manufacturer's instructions must be followed as well.

4.1.1.2 Inspection, testing, and maintenance shall be performed by qualified personnel.

The term *qualified* is defined in 3.3.36 and should not be confused with *licensed*. Qualification is the minimum level of training and expertise that this standard requires, whereas licensing is a governmental function. Regardless of whether the jurisdiction requires a license to perform ITM work, the person doing the work must be qualified. There are many levels of qualification as defined by NFPA 25. For example, building maintenance personnel may be qualified to inspect valves to ensure they remain in the correct position but may not be qualified to perform an internal inspection of some valves as required by Chapter 13.

FAQ Is the property owner required to hire a contractor to perform the activities required by this standard, or can the in-house maintenance staff perform these functions?

Although all ITM functions require at least some training, many of the individual tasks can be performed with minimal training and experience. Looking at a gauge to determine that it is still indicating normal pressure, for example, might be something that a trained building maintenance person can do.

As indicated earlier in this section, NFPA 25 assigns all of the ITM responsibilities to the owner. The owner may contract some or all of these functions out to a qualified contractor. Nothing in the standard is meant to prevent the owner from performing the tasks as long as the owner is qualified to do so. One important fact to keep in mind, however, is that the determination of qualification ultimately rests with the AHJ. The owner should verify any jurisdictional requirements before embarking on an in-house ITM program of any sort.

4.1.1.2.1* The owner shall coordinate with the entity conducting the inspection, testing, and maintenance activities to minimize any water damage caused by the discharge of water.

A.4.1.1.2.1 Water-based systems rely on the adequacy and ongoing maintenance of drainage systems such as roof drains storm drains and floor drains, during flowing water as part of testing systems. These systems are often used for other purposes than fire system testing and are not part of the fire protection system. They are often designed and maintained as part of building plumbing systems.

Anytime water is released, consideration must be given to where that water may ultimately end up. This is not only the responsibility of the person performing the ITM, but it must also involve the owner or designated representative. The owner or designated representative, such as maintenance personnel, is often more familiar with the condition of the plumbing system or the drainage characteristics of the surrounding area.

4.1.1.3* Where the property owner or designated representative is not the occupant, the property owner or designated representative shall be permitted to delegate the authority for inspecting, testing, maintenance, and the managing of impairments of the fire protection system to a designated representative.

A.4.1.1.3 Examples of designated representatives can include the occupant, management firm, or managing individual through specific provisions in the lease, written use agreement, or management contract.

4.1.1.4 Where a designated representative has received the authority for inspecting, testing, maintenance, and the managing of impairments, the designated representative shall comply with the requirements identified for the property owner or designated representative throughout this standard.

FAQ Is the contractor hired to perform ITM ever considered a designated representative?

One of the key factors in determining who should be considered a designated representative is the ability to authorize expenditures. Although some ITM contracts may preauthorize minor repairs or replacement, NFPA 25 requires that all deficiencies or impairments be corrected or repaired by the owner or designated representative in 4.1.5.1.

Case In Point

Sometimes, testing reveals a component that has outlived its useful life span and needs replacement or significant repair. Because 4.1.1.4 requires that the designated representative comply with all of the requirements of the standard — including 4.1.5.1, which mandates corrections or repair — the designated representative would be responsible for any costs involved. When the component is a simple gauge or switch, the cost may be nominal. However, if the component is costlier, such as a fire pump replacement or major work to a storage tank, a lack of clarity about who is in fact the designated representative and therefore responsible for the repair or replacement can be troublesome.

Lease agreements, ITM service contracts, and other arrangements should clearly spell out who is, and who is not, the designated representative with regard to the requirements of NFPA 25. Any delays in correction and repair, including those caused by confusion about who is responsible, can lead to increased safety risks.

4.1.2* Freeze Protection. The property owner or designated representative shall ensure that water-filled piping is maintained at a minimum temperature of 40°F (4°C) unless an approved antifreeze solution is utilized.

Sprinkler system freeze-ups are a matter of simple physics. When untreated water reaches a temperature of 32°F (0°C) it begins to freeze. This is not a "failure" of the sprinkler system, but a matter of not preventing the system from being exposed to freezing temperatures. Section 1.1 states that the scope of NFPA 25 is to establish the ITM of water-based fire protection systems. Verifying the condition of the heating system in the building or identifying holes in walls that may let in cold weather is not part of the requirements of the standard.

When a sprinkler system does freeze, however, it often requires expensive repairs to the system and to the building if water is discharged through broken pipe, fittings, or sprinklers. In addition, the sprinkler system is impaired, which creates a heightened risk of loss from a fire event. For this reason, the standard establishes the requirement for maintaining building temperature and places the responsibility for this important task on the owner.

This subsection specifically refers to an "approved" antifreeze solution.

Historical Note

The requirements for antifreeze systems have changed drastically since the 2011 edition of NFPA 25 was published. As outlined in Chapter 5, an acceptable antifreeze solution would be a solution with 30 percent propylene glycol or less, or a solution with 38 percent glycerine or less. These solutions have been deemed acceptable for existing systems based on test data that have shown that solutions with this concentration of antifreeze did not increase the heat release rate of a fire when the solution was discharged.

Another design approach that might be acceptable would be an antifreeze solution that has been approved by the AHJ as described in a deterministic risk assessment. Refer to 5.3.4.4.1 for more information on deterministic risk assessments for antifreeze systems.

A.4.1.2 In areas that have the potential for freezing temperatures below the level that can be adequately protected by an allowable antifreeze solution, supplemental heat can be provided when temperatures fall below the level of the antifreeze solution. Other means of freeze protection for water-filled piping, including heated valve enclosures, heat tracing, insulation, or other methods, are allowed by the applicable installation standard. Installation standards require heat tracing protecting fire protection piping against freezing to be supervised.

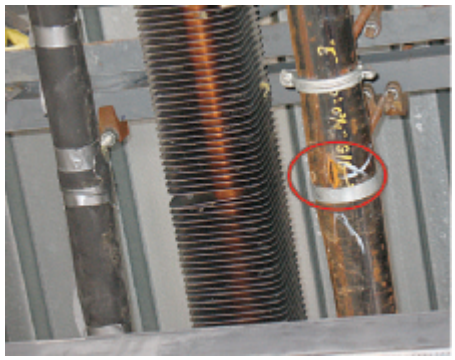
4.1.2.1* All areas of the building containing water-filled piping that does not have another means of freeze protection shall be maintained at a minimum temperature of 40°F (4°C).

Case In Point

When owners find a frozen pipe or frozen system component in a building, they often look to their NFPA 25 inspection provider to find out why the potential freezing condition was not noted in the previous annual system inspection report. However, instances in which the ambient condition has not been properly maintained above a freezing temperature are not considered by NFPA 25 as information that should be recorded during an inspection. This is largely because the ambient temperature in a given room or space varies from day to day. If an inspector recorded a temperature of 75°F (21.1°C) during an annual inspection of a building in July, it probably would not be reflective of the temperature found during an inspection of the building in January. For this reason, frozen system components, such as the valve and the pipe shown in the accompanying photos, cannot be predicted by an inspector during an inspection.



Valve Rupture Due to Freezing. (Courtesy of Byron Blake and SimplexGrinnell)



Pipe Split Due to Freezing. (Courtesy of Byron Blake and SimplexGrinnell)

A.4.1.2.1 In order to ensure compliance, the owner should verify that windows, skylights, doors, ventilators, other openings and closures, concealed spaces, unused attics, stair towers, roof houses, and low spaces under buildings do not expose water-filled piping to freezing. This should occur prior to the onset of cold weather and periodically thereafter.

N **4.1.2.2*** The requirements of 4.1.2 shall not apply where water-filled piping is located in unconditioned building spaces or areas outside the building envelope and are not subject to freezing.

N **A.4.1.2.2** There are locations where water-filled piping was approved for installation and temperatures cannot be maintained at 40° F (4°C). For example, NFPA 13 permits water-filled piping in areas where temperatures are less than 40°F (4°C) and heat loss calculations verify that the system will not freeze.

4.1.2.3 Aboveground water-filled pipes that pass through open areas, cold rooms, passageways, or other areas exposed to temperatures below 40°F (4°C), protected against freezing by insulating coverings, frostproof casings, listed heat tracing systems, or other reliable means, shall be maintained at temperatures between 40°F (4°C) and 120°F (48.9°C).

This paragraph clarifies that when means other than running water-filled piping through heated areas are utilized, these means become an important part of the reliability of the fire protection system and must be maintained accordingly.

4.1.2.4 Where other approved means of freeze protection for water-filled piping as described in 4.1.2.3 are utilized, they shall be inspected, tested, and maintained in accordance with this standard.

N **4.1.2.5** Valve enclosures for preaction valves, deluge valves, and dry pipe valves subject to freezing shall be inspected daily during cold weather to verify a minimum temperature of 40°F (4°C).

N **4.1.2.5.1** Valve enclosures equipped with low-temperature alarms shall be allowed to be inspected weekly.

N **4.1.2.5.2** Low-temperature alarms, if installed in valve enclosures, shall be inspected annually at the beginning of the heating season to verify that they are free of physical damage.

4.1.3* Accessibility. The property owner or designated representative shall provide ready accessibility to components of water-based fire protection systems that require inspection, testing, and maintenance.

A.4.1.3 The components are not required to be open or exposed. Doors, removable panels, or valve pits can be permitted to satisfy the need for accessibility. Such equipment should not be obstructed by features such as walls, ducts, columns, direct burial, or stock storage.

The requirement in 4.1.3 for accessibility is intended to address the all-too-common practice of placing objects — such as file cabinets or stock — in front of sprinkler risers and other control equipment. This requirement is not limited to the interior of the building. Exterior components of the system must be kept accessible as well. Exhibit 4.1 shows a fire department connection (FDC) that has been obstructed by shrubbery. Exterior components such as post indicator valves and FDCs might also be blocked by dumpsters and outdoor storage, as shown in Exhibit 4.2, and even snow piles as a result of plowing and shoveling, as shown in Exhibit 4.3.

FAQ Does a locked door satisfy the requirement for accessibility?

Tip for Owners

The requirement of 4.1.2.5 is one of the rare daily frequency inspections required by NFPA 25. Nothing in the standard is meant to prevent facility maintenance personnel from performing this inspection. It is important to note, however, that the documentation requirements in Section 4.3 apply to all inspections, tests, and maintenance required by NFPA 25. In this case, a simple check-off on a clipboard located in the valve enclosure would be sufficient.

Tip for Owners

The property owner or the designated representative must maintain access to equipment for ITM purposes. The standard refers to the *property owner* or *designated representative* throughout the standard to distinguish between the property owner and the owner of the contracting firm. In addition, when conducting inspections of sprinklered residential-type buildings such as hotels, motels, apartments, and condominiums, gaining access to individual dwelling units can be challenging. NFPA 25 provides no exceptions to the requirement to perform ITM due to limited accessibility. For example, when conducting the annual inspection of sprinklers, performing a "sample" inspection of a few dwelling units does not meet the intent of the standard. Often, solutions to this difficult situation can be found if there is open communication between the owner, the contractor providing the ITM services, and the AHJ.

As indicated in A.4.1.3, the accessibility requirement is satisfied when components are behind doors. The same holds true if these doors are locked to prevent unauthorized access. However, keys or access codes that permit entry into the room or area housing the equipment should be available.

EXHIBIT 4.1 *FDC Obstructed by Shrubbery.*





EXHIBIT 4.2 *FDC Obstructed and Inaccessible Due to Exterior Storage. (Courtesy of Byron Blake and SimplexGrinnell)*



EXHIBIT 4.3 *FDC Obstructed by Snow. (Courtesy of Byron Blake and SimplexGrinnell)*

4.1.4 Notification of System Shutdown or Testing. The property owner or designated representative shall notify the authority having jurisdiction, the fire department, if required, and the alarm-receiving facility before testing or shutting down a system or its supply.

Subsection 4.1.4 establishes the requirement for notification when systems are removed from service. Testing a system without proper notification might—and often does—result in a false alarm. False alarms must be avoided, since they remove emergency services personnel from service at a time when their services might be needed for an actual emergency. In many jurisdictions, repeated false alarms can result in a fine or other penalty for property

owners. When flowing an inspector's test connection, it may be obvious that an alarm is intended to sound upon waterflow and that the supervisory service must be notified as prescribed by 4.1.4. Perhaps not so obvious is the fact that other tests, such as a fire pump test, hydrant test, or main drain test, can also lead to the tripping of a waterflow switch, which will sound an alarm and, potentially, send a signal to the fire department. At the conclusion of such tests, the alarm-receiving facility should be notified that any alarms received from that point on are not test-generated and should be responded to appropriately.

Case In Point

While A.4.1.3 states that the components are not required to be exposed and that access panels are permitted for aesthetic reasons, the access panel and signage cannot be intentionally obscured. The accompanying photos show an access panel and inspector test connection (ITC) sign that are blocked by a clock. An inspector will not necessarily remember year to year that the clock needs to be taken down in order to access the valve. Furthermore, if there is turnover within the facilities management personnel, it is possible for the owner and the in-house team to be unaware of system components that are hidden behind decorative items.



ITC Hidden by Clock. (Photo Courtesy of Byron Blake and SimplexGrinnell)



ITC Sign and Access Panel. (Photo Courtesy of Byron Blake and SimplexGrinnell)



ITC Accessible with Panel Removed. (Photo Courtesy of Byron Blake and SimplexGrinnell)

4.1.4.1 The notification of system shutdown or test shall include the purpose for the shutdown or test, the system or component involved, the estimated time of shutdown or test, and the expected duration of the shutdown or test.

4.1.4.2 The authority having jurisdiction, the fire department, and the alarm-receiving facility shall be notified when the system, supply, or component is returned to service or when the test is complete.

The requirement in 4.1.4.2 assists the AHJ or alarm company in establishing a follow-up program to ensure that systems are properly returned to service.

4.1.5* Corrections and Repairs.

Δ **A.4.1.5** Needed corrections and repairs should be classified as an impairment, critical deficiency, or noncritical deficiency according to the effect on the fire protection system and the nature of the hazard protected.

Impairments are the highest priority problem found during inspection, testing, and maintenance and should be corrected as soon as possible. The fire protection system cannot provide an adequate response to a fire, and implementation of impairment procedures outlined in Chapter 15 is required until the impairment is corrected.

Critical deficiencies need to be corrected in a timely fashion. The fire protection system is still capable of performing, but its performance can be impacted and the implementation of impairment procedures might not be needed. However, special consideration must be given to the hazard in the determination of the classification. A deficiency that is critical for one hazard might be an impairment in another.

Noncritical deficiencies do not affect the performance of the fire protection system but should be corrected in a reasonable time period so that the system can be properly inspected, tested, and maintained.

Assembly occupancies, health care facilities, prisons, high-rise buildings, other occupancies where the life safety exposure is significant, or facilities that cannot be evacuated in a timely manner require special consideration. As an example, a nonfunctioning waterflow alarm might be considered a critical deficiency in a storage warehouse but an impairment in a hospital.

High-hazard occupancies where early response to a fire is critical also require special consideration. A small number of painted sprinklers could be considered an impairment for a system protecting a high-hazard occupancy but might be considered a critical deficiency in a metal working shop.

Classifications of needed corrections and repairs are shown in Table A.3.3.8.

One of the most common misapplications of NFPA 25 comes from not understanding the document scope completely. NFPA 25 is intended to confirm the functionality of the system components that are installed, not to ensure that the designer has designed the system correctly and observed the rules of the design and installation standard.

This misapplication of scope can often lead to arguments between owners, inspectors, and AHJs when certain conditions are present in a building. In some cases, the owner has the expectation that the hired inspector is not only looking for "wear and tear" items associated with the water-based systems but also giving the system a clean bill of health from a design perspective as well. The level of effort to produce this clean bill of health is significantly more than what the standard intends and requires an inspector to deliver.

Simply put, if a condition that is found in the field does not comply with the design standard, but the components observed are in good working condition, it would not be considered a deficiency or impairment per NFPA 25.

In an attempt to provide some examples of where the difference between a hazard evaluation and an ITM-related deficiency exists, this handbook contains a recurring feature (see below) that provides examples of the types of situations that are within the scope of the standard and those that are not.

ITM Deficiency, Impairment, or Hazard Evaluation?

ANSWER: Hazard Evaluation

Recalled sprinklers — or other recalled components — should be replaced or addressed by other remedies, as described by the recall. However, the specific knowledge needed to identify the recalled products makes it next to impossible to include a requirement in NFPA 25 that could be reasonably complied with and enforced. If an inspector does have specific knowledge about a recalled product, such as this Omega sprinkler, it should be reported to the owner as a recommendation to have the entire building inspected for other recalled sprinklers, including those in concealed spaces.



(Courtesy of Byron Blake and SimplexGrinnell)

4.1.5.1* The property owner or designated representative shall correct or repair deficiencies or impairments.

As noted in Chapter 1, corrective action to remediate deficiencies and impairments must be done in accordance with the applicable design and installation standard. Exhibit 4.4 shows a leaking fitting that was simply wrapped with a cloth. Wrapping any absorbent material around a leaking fitting can actually create a worse condition, as the absorbent material becomes drenched and allows water to be in constant contact with a larger surface area of the pipe and/or fitting. This could then lead to more rapid corrosion and system impairment.



EXHIBIT 4.4 *Corrective Action Not Executed per Installation Standard. (Courtesy of Byron Blake and SimplexGrinnell)*

A.4.1.5.1 System deficiencies not explained by normal wear and tear, such as hydraulic shock, can often be indicators of system problems and should be investigated and evaluated by a qualified person or engineer. Failure to address these issues could lead to catastrophic failure. Examples of deficiencies that can be caused by issues beyond normal wear and tear are as follows:

(1) Pressure gauge deficiencies as follows:
   (a) Gauge not returning to zero
   (b) Gauge off scale
   (c) Gauge with bent needle
(2) Support devices deficiencies as follows:
   (a) Bent hangers and/or rods
   (b) Hangers pulled out/off structure
   (c) Indication of pipe or hanger movement such as the following:
      i. Hanger scrape marks on pipe, exposed pipe surface where pipe and hangers are painted
      ii. Firestop material damaged at pipe penetration of fire-rated assembly
(3) Unexplained system damage as follows:
   (a) Unexplained system damage beyond normal wear and tear
   (b) Bent or broken shafts on valves
   (c) Bent or broken valve clappers
   (d) Unexplained leakage at branch lines, cross main, or feed main piping
   (e) Unexplained leakage at closed nipples
   (f) Loose bolts on flanges and couplings

(4) Fire pump deficiencies as follows:
   (a) Fire pump driver out of alignment
   (b) Vibration of fire pump and/or driver
   (c) Unusual sprinkler system piping noises (sharp report, loud bang)

While NFPA 25 focuses on the specific requirements for ITM of water-based fire protection systems, the ultimate goal of such a program is to maintain the operational status of a system. Paragraph 4.1.5.1 provides the enforcement tool to initiate corrective action to ensure that systems are functioning at all times. However, the standard does not provide specific timelines on how quickly corrections or repairs must be completed.

N **4.1.5.1.1*** Upon discovery of any component and equipment under recall or replacement programs by the owner's maintenance personnel, designated representative, or contractor, the owner shall be notified in writing.

Paragraph 4.1.5.1.1 was added in the 2020 edition to bring awareness to the importance of handling recalled products or components if identified. This requirement does not necessitate that the owner's maintenance personnel, designated representative, or contractor have specific knowledge of recalled products or components. However, if they do have knowledge and identify recalled items installed in a system, they must notify the owner so the owner can take corrective action.

N **A.4.1.5.1.1** For an example of a reference source containing a list of links to manufacturers' information regarding components that are recalled or part of a replacement program, see www.nfsa.org.

N **4.1.5.1.2*** The property owner or designated representative shall correct, remedy, repair, or replace components and equipment under recall or replacement program.

N **A.4.1.5.1.2** Remedies for equipment under recall include entrance into a program for scheduled replacement. Such replacement or remedial product should be installed in accordance with the manufacturer's instructions and the appropriate NFPA installation standards. A recalled product is a product subject to a statute or administrative regulation specifically requiring the manufacturer, importer, distributor, wholesaler, or retailer of a product, or any combination of such entities, to recall the product, or a product voluntarily recalled by a combination of such entities.

4.1.5.2 Corrections and repairs shall be performed by qualified maintenance personnel or a qualified contractor.

It should be noted that many jurisdictions regulate who can perform corrections and repairs, along with regulating specific licensing or certification requirements. See the commentary following 3.3.36 and 4.1.1.2. In the case of corrections that do not involve the fire protection contractor, special attention should be paid to how these corrections are documented.

Case In Point

When bushes or shrubbery block access to a fire department connection, the correction is often to trim the plants back. That work will likely be performed by a building maintenance person or landscape contractor. The original deficiency would likely be reported on an ITM report as required by Section 4.3; however, the correction might not.

4.1.6* Changes in Occupancy, Use, Process, or Materials. The property owner or designated representative shall not make changes in the occupancy, the use or process, or the materials used or stored in the building without evaluation of the fire protection system(s) for its capability to protect the new occupancy, use, or materials.

A.4.1.6 The inspections and tests specified in this standard do not address the adequacy of design criteria or the capability of the fire protection system to protect the building or its contents. It is assumed that the original system design and installation were appropriate for the occupancy and use of the building and were approved by all applicable authorities having jurisdiction. If no changes to the water supply or to the building or its use have transpired since it was originally occupied, no evaluation is required. If changes are contemplated, it is the owner's responsibility to arrange for the evaluation of the fire protection system(s). In such a case, Figure A.4.1.6 provides an example of a questionnaire that the owner could use. Where the inspections and tests specified in the standard have been contracted to a qualified inspection provider or contractor, it is not the role of the inspector or contractor to determine if any changes have been made or the subsequent evaluation of the fire protection system. The evaluation of any building changes should be conducted before any proposed change is incorporated and should utilize the appropriate installation standard and input from applicable authorities having jurisdiction.

Fire protection systems should not be removed from service when the building is not in use; however, where a system that has been out of service for a prolonged period (such as in the case of idle or vacant properties) is returned to service, it is recommended

Owner's Questionnaire

A. Is the building occupied?	❑ Yes	❑ No
B. Has the occupancy and hazard of contents remained the same since the last inspection?	❑ Yes	❑ No
C. Are all fire protection systems in service?	❑ Yes	❑ No
D. Has the system remained in service without modification since the last inspection?	❑ Yes	❑ No
E. Was the system free of actuation of devices or alarms since the last inspection?	❑ Yes	❑ No

Explain any "no" answers:

_____

_____

_____

_____

_____

_____ _____

Owner or Designated Representative (print) Signature and Date

© 2019 National Fire Protection Association NFPA 25

N ***FIGURE A.4.1.6*** *Owner's Questionnaire.*

that a responsible and experienced contractor be retained to perform all inspections and tests.

Note that in the fire protection and life safety field, there are different uses of the term *occupancy*. NFPA 13, *Standard for the Installation of Sprinkler Systems*, bases its design/density criteria for sprinkler systems on occupancy classifications based on the quantity and/or combustibility of contents expected within that space. NFPA *101®*, *Life Safety Code®*, on the other hand, bases the application of that code on occupancy classification defined by the purpose for which a building, structure, or part thereof is intended to be used. Either one of these occupancy types can change while the other remains the same, or a change can result in both types falling under different definitions.

Changes to the occupancy that affect the definition from a NFPA *101* perspective are much more likely to call for building permits and require evaluation of the fire protection systems. Changes to the use of individual spaces or contents within an area are less likely to draw such a stringent review but can change the occupancy classification from an NFPA 13 perspective and drastically limit the effectiveness of a system. Regardless of which occupancy classification is affected, 4.1.6 requires an evaluation of the fire protection system for its capability to protect the new occupancy.

Many owners are not aware of the impact that operational and physical changes can have on fire protection systems. Since management of change is the responsibility of the owner and not the service provider, it is not uncommon for these changes to go unrecorded. Some of the most common changes include raising the storage height, changing the storage method arrangement such as adding racks, installing solid shelves in rack structures, or decreasing the aisle widths between racks. Changes in product packaging with the use of foam inserts, bubble wrap, or other plastics or encapsulated storage can significantly increase the fire hazard. Changing from wood pallets to plastic pallets, converting to the use of plastic bin boxes, or revising or adding material handling systems — such as conveyors — may severely impact the effectiveness of the fire protection systems.

The questionnaire is designed to assist the owner in identifying whether any changes have occurred that may impact the capability of the fire protection system to control a fire. This questionnaire could be given to owners by insurance representatives or ITM service providers at annual inspections as a tool to assist the owner in maintaining the effectiveness of their systems.

4.1.6.1 The evaluation required by 4.1.6 shall not be considered part of the normal inspection, testing, and maintenance required by this standard.

It is a common misconception that NFPA 25 does not address changes. As outlined in Chapter 1, the scope of NFPA 25 does not require the inspector to evaluate the design and layout of the systems covered in the standard. The standard presupposes that the system, as designed and installed, complies with the applicable standards at the time of construction and at the points where changes were made to the building that would necessitate system modifications. However, the requirements in 4.1.6 address this concept by identifying that it is the owner's responsibility to understand the impact of changes in occupancy, use, process, or material and take certain steps before they are made. In the event that changes are made to the building and this evaluation does not take place, any noncompliant conditions created by the changes are not the responsibility of the inspector to identify.

NFPA 25 – Owner's Questionnaire

Property Name: _____

Address: _____

Name of Person Completing Questionnaire: _____

Has any part of the building been remodeled or added within the past 12 months?	[Y]	[N]
Have any building modifications or additions resulted in areas that are not protected with sprinklers?	[Y]	[N]
Have you changed the use of function of any areas/rooms/spaces within your building in the past 12 months? (e.g., office space now used for storage)	[Y]	[N]
Have you changed the makeup of the products stored or the packaging materials used with your products? (i.e., paper to plastic)	[Y]	[N]
Have you increased the height of the stored materials in your warehouse area?	[Y]	[N]
Have you revised the storage arrangement in your warehouse? (i.e., added pallet racks, shelves, changed aisle widths or changed from wood to plastic pallets)	[Y]	[N]
Have you removed heating systems from any areas of your building within the past 12 months?	[Y]	[N]
Have you changed or increased the amounts or types of chemicals stored or used within the facility within the past 12 months?	[Y]	[N]

Additional Comments: _____

Signature of Respondent:_____Date: _____/_____/_____

- Any "Yes" answers may necessitate an evaluation of the system adequacy.

Case In Point

In some cases, a condition that does not comply with the design standard is relatively easy to identify. It can be identified from the floor level without the need of a lift, ladder, tape measure, or any other equipment. The first photo shows a sprinkler that is several feet below the ceiling. In this instance, a drop ceiling was removed and the sprinkler was not relocated to within 12 in. (305 mm) of the ceiling as required by NFPA 13. A similar case would be a sprinkler located too close to a hot air diffuser, as shown in the second photo. Although the sprinkler shown is too close to the hot air diffuser per the spacing rules of NFPA 13, this is not a deficiency per NFPA 25 and should not be called out in an NFPA 25 inspection report.

That is not to say that inspectors cannot inform building owners that there might be an issue with a system as it relates to a design standard such as NFPA 13. The problem with providing a client with more information, though, is that it can open the inspector to liability. If an inspector is identifying some, but not all, design deficiencies on an NFPA 25 inspection report, the line can become blurred as to the depth of the review and the inspector's contractual obligation to the owner. Many owners believe that NFPA 25 requires the inspector to conduct a hazard evaluation, so when an inspector includes a few design deficiencies with legitimate NFPA 25 deficiencies, it can further muddy the waters.

Many inspectors feel that they have a moral and ethical obligation, as members of the fire protection and life safety community, to inform their clients of all potential concerns. One way to comply with the requirements of NFPA 25 while still satisfying that moral obligation is to

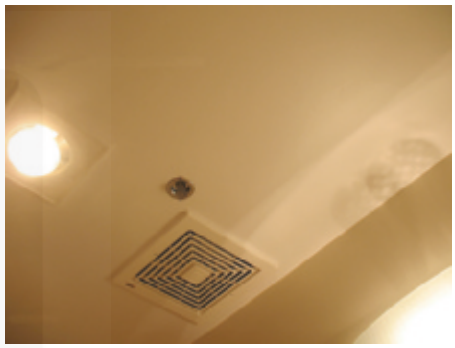
(*continues*)

Case In Point

keep two deficiency reports: one dealing with NFPA 25 issues and another that could be called the "good Samaritan" list. The NFPA 25 report would catalog wear-and-tear issues while clearly identifying the scope of NFPA 25. The "good Samaritan" report would list all other items that are beyond the scope of NFPA 25, along with a disclaimer stating that these items are not considered part of an NFPA 25 inspection program. This way, the scope of NFPA 25 is acknowledged, as are any and all problems observed during the inspection.



No Drop Ceiling. (Courtesy of Byron Blake and SimplexGrinnell)



Heat Source. (Courtesy of Byron Blake and SimplexGrinnell)

The requirement in 4.1.6.1 states that the inspections and tests found in NFPA 25 do not include an evaluation of the capability of the system to adequately protect the property or its contents. The owner or designated representative is responsible for an evaluation of the adequacy (i.e., design criteria) of the fire protection systems when changes are proposed to the building or its use. However, most owners do not understand the significance of this requirement, nor do they know how to have the evaluation conducted. In addition, many users of the standard assume that the inspections and tests specified in the standard include an evaluation of the adequacy of the system to protect the hazard presented by the building, its use, and contents. This assumption is incorrect. For example, an evaluation of the system design criteria would include an examination of the area of coverage and spacing of the sprinklers; these tasks are not part of the annual inspection required in the standard.

To further clarify this point, Exhibit 4.5 shows a retrofitted cross-corridor door. Prior to the retrofit, the sprinklers in the corridor were spaced from each other according to the requirements of NFPA 13. However, after the retrofit, the sprinkler in the foreground must be evaluated against different criteria for spacing from a wall. In this case, the sprinkler is too far from the wall. This evaluation is required by 4.1.6.2, but the criteria for the evaluation are not within the scope of the inspections required by NFPA 25. The criteria for the evaluation of a sprinkler system are found in installation requirements specified by NFPA 13. This is an example of how the scopes of the two standards are interrelated — this is clarified further in 4.1.7.

As stated in Chapter 1, the purpose of the inspections and tests required by this standard is to maintain the operational status of the system(s). Most inspectors are not trained to evaluate the design criteria of a system, and they should not attempt to do so. It is important that contractors or inspection providers are clear in explaining to the owner the scope of the work that they have been contracted to do. An owner might want to have the system evaluated for its adequacy — and it is certainly appropriate for the contractor or inspection provider to conduct the evaluation if qualified to do so — but this evaluation is separate from the inspection and testing activities specified by this standard.



EXHIBIT 4.5 *Retrofitted Cross-Corridor Door Impacts Sprinkler Spacing.*

4.1.6.2* The evaluation shall consider factors that include, but are not limited to, the following:
(1) Occupancy changes such as converting office or production space into warehousing
(2) Process or material changes such as metal stamping to molded plastics
(3) Building revisions such as relocated walls, added mezzanines, and ceilings added below sprinklers
(4) Removal of heating systems in spaces with piping subject to freezing
(5) Changes to the storage method, arrangement, height or commodities
(6) Changes in water supplies

Occupancy changes usually involve a building permit and the subsequent review process by the AHJ. Yet, the more subtle changes listed in 4.1.6.2, items 3 and 4, might not always be reported. Moving walls and adding mezzanines and ceilings can severely affect the spray pattern of sprinklers. Sprinkler protection in unheated spaces frequently causes damage to systems and water damage to buildings and their contents. By monitoring building alterations and performing inspections, costly damage to buildings and contents can be avoided.

In recent years, a growing number of installations have included sprinklers attached to flexible sprinkler hose fittings. As a result, the relocation of sprinklers attached to flexible hose fittings, and who should perform the work, is an area of concern.

Flexible sprinkler hose fittings are recognized in NFPA 13. However, due to growing concern regarding the ability to move sprinklers without proper evaluation, NFPA 13 contains the following language in Chapter 17:

> **17.4.1.3.3.4*** *Where flexible sprinkler hose fittings are used to connect sprinklers to branch lines in suspended ceilings, a label limiting relocation of the sprinkler shall be provided on the anchoring component.*

The annex material for this requirement in NFPA 13 provides suggested language for the label as follows:

CAUTION: DO NOT REMOVE THIS LABEL.

Relocation of this device should only be performed by qualified and/or licensed individuals that are aware of the original system design criteria, hydraulic criteria, sprinkler head listing parameters, and knowledge of the state and local codes including NFPA 13 installation standards. Relocation of the device without this knowledge could adversely affect the performance of this fire protection and life safety system.

Where flexible sprinkler hose fittings allow sprinklers to be adjusted and relocated, adjustments and relocations made by unqualified individuals could violate requirements, such as those for maximum or minimum sprinkler spacing or obstruction avoidance. For this reason, the committee has added a requirement for a label warning against relocation. To further discourage relocation, the length of flexible drops should be kept to the minimum required for adequate installation and proper performance.

Exhibit 4.6 shows a flexible sprinkler hose fitting along with its mounting and a warning label.



EXHIBIT 4.6 *Flexible Sprinkler Hose Fitting (left) and Warning Label (right). (Courtesy of FlexHead Industries)*

Δ **A.4.1.6.2** Fire protection systems are designed and installed based on a specific set of circumstances and building uses. For example, the volume of water needed for a sprinkler system to control a fire in the built environment is based upon the intended use of the facility known at the time the sprinkler system was designed and installed. Revisions to properties used for storage represent one of the most common scenarios that impact the ability of systems to provide adequate protection. Some of the most common changes include raising the storage height, changing the storage method arrangement such as adding racks, installing solid shelves in rack structures or decreasing the aisle widths between racks. Changes in product packaging with the use of foam inserts, bubble wrap, or other plastics or encapsulated storage can significantly increase the fire hazard. Changing from wood pallets to plastic pallets, converting to the use of plastic bin boxes, or revising or adding material

ITM Deficiency, Impairment, or Hazard Evaluation?

ANSWER: Hazard Evaluation

This combustible concealed space was discovered by an inspector. Perhaps a new room or area was added in the building, or perhaps a ceiling was added and the sprinklers that previously protected the combustible construction were turned pendent and extended through the ceiling. It is even possible that the system was installed this way and a variance was provided by the AHJ that allowed sprinklers to be omitted from this space. Under any of these circumstances, this finding warrants a hazard evaluation as required by 4.1.7.1, "Where changes in the occupancy, hazard, water supply, storage commodity, storage arrangement, building modification, or other condition that affects the installation criteria of the system are identified . . ."

The NFPA 25 inspector is not required to know the installation standard requirements. However, it is generally known that combustible concealed spaces in most occupancies require sprinkler protection. While NFPA 25 does not require the inspector to look or inspect above a ceiling when performing an annual visual inspection, this condition could have been discovered while investigating a visible leak or while checking for adequate heat as required by 4.1.2.1.



(Courtesy of Byron Blake and SimplexGrinnell)

handling systems such as conveyors could severely impact the effectiveness of the fire protection systems.

4.1.7* Addressing Changes in Hazard.

Δ **A.4.1.7** Annex E for an example of a hazard evaluation form. A hazard evaluation is not part of a system inspection.

In addition to Annex E, another tool for evaluating an existing system is NFPA 3, *Recommended Practice for Commissioning of Fire Protection and Life Safety Systems*. NFPA 3 provides guidance on the retro-commissioning of individual systems or integrated systems. The purpose of NFPA 3 is to provide a structure and reporting mechanism for the design and operation of a system. Properly documenting a system and its design at the same time as design decisions are being made and put on paper, which is what commissioning is intended to do, makes future assessments and evaluations easier and more cost-effective to conduct.

4.1.7.1 Where changes in the occupancy, hazard, water supply, storage commodity, storage arrangement, building modification, or other condition that affects the installation criteria of the system are identified, the property owner or designated representative shall promptly take steps to evaluate the adequacy of the installed system in order to protect the building or hazard in question.

Management of change has become a critical concept for property owners, manufacturers, and just about any other business trying to keep its head above water. In tough economic times, some companies shy away from constructing new, customized storage facilities, instead choosing to "recycle" old warehouse spaces to fit their needs. Other companies are manufacturing, storing, or selling different products to remain viable, which can create a change in hazard within the building. If these changes in business structure, philosophy, and operation that result in a change in hazard are not properly evaluated, they can have a major impact on the effectiveness of fire protection systems.

Case In Point

Storage facilities are a great example as to why management of change is so critical. If a company changes a product that they store from a Class IV commodity to a Group A plastic, the sprinkler system could be grossly inadequate for the fire that would result from the new commodity. This is why a review of the sprinkler system for effectiveness must be conducted wherever there is a change in one or more of the critical characteristics that drive sprinkler system design for storage areas. These changes include, but are not limited to, change in commodity classification; change in storage height; change in clearance to ceiling; change in packaging, such as encapsulated to exposed; the addition of solid shelving; change in storage type, such as from shelf storage to rack storage; and change in pallet type.

4.1.7.2 Where the evaluation reveals that the installed system is inadequate to protect the building or hazard in question, the property owner or designated representative shall make the required corrections.

4.1.7.3 Corrections shall be approved.

Tip for Owners

The requirement in 4.1.7.3 for corrections to be approved typically equates to a permit being obtained from the AHJ. Work that is performed without a permit can lead to costly fees or delays to business operations. Even though it is not a requirement, it is a good idea to involve the AHJ any time changes to a system or building are being contemplated.

The requirement in 4.1.7.3 clarifies the role of the AHJ in the evaluation of the adequacy of the system(s) when changes in the hazard are identified. The owner is not required to include the AHJ in evaluation of the buildings and its systems, but where a system is determined to be inadequate, the corrections must be acceptable to the AHJ. Annex E includes a sample evaluation form. It is critical that whoever conducts the evaluation is qualified to do so.

4.1.8 Valve Location. The location of shutoff valves shall be identified at the system riser or other approved locations.

4.1.9* Information Sign.

The requirements in 4.1.8 and 4.1.9 state the importance of clearly identifying and marking the location of shutoff valves. In many cases, time is wasted after a system begins to discharge water while the building occupants search for the location of the shutoff valve. This search results in additional water damage that could have been avoided.

Case In Point

A furniture store in the Midwest suffered major water damage after a leak occurred for unknown reasons prior to the store opening for business one morning. No alarm was activated, which would have reduced the damage. Once the flowing water was discovered, building management made several trips back and forth to the riser attempting to stop the flow of water. After numerous attempts, responding fire crews who had arrived on the scene after being called by the store personnel went with the building manager and discovered he had been opening and closing the main drain with each trip to the riser. No valves were marked as to their function.

N **A.4.1.9** Systems installed in accordance with the 2007 and subsequent editions of NFPA 13 should have a general information sign. It is not the intent of the committee for a system to have both the information sign required by NFPA 25 and the general information sign required by NFPA 13. The information sign required by this standard is intended to be provided for systems installed prior to the 2007 edition of NFPA 13. Systems installed under the 2007 and subsequent editions of NFPA 13 should have a general information sign.

4.1.9.1 A permanently marked metal or rigid plastic information sign shall be placed at the system control riser supplying an antifreeze loop, dry system, preaction system, or auxiliary system control valve.

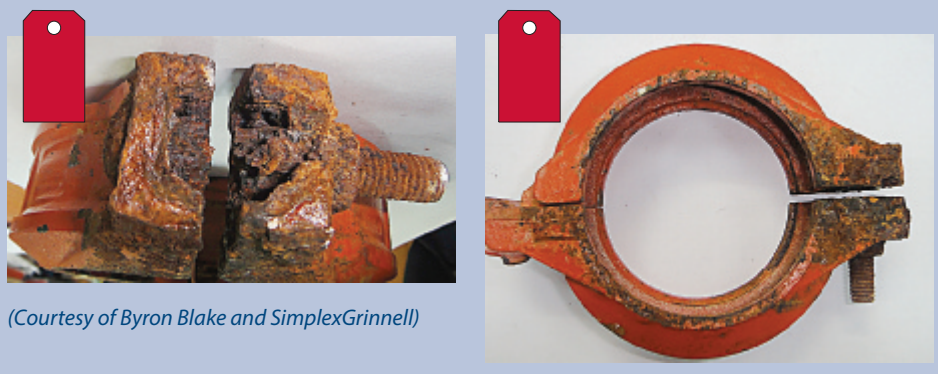
4.1.9.2 Each sign shall be secured with a corrosion-resistant wire, chain, or other approved means and shall indicate at least the following information:

(1) Location of the area served by the system
(2) Location of auxiliary drains and low-point drains for dry pipe and preaction systems
(3) Presence and location of antifreeze or other auxiliary systems
(4) Presence and location(s) of heat tape

The sign required in 4.1.9 is needed to provide vital information that might not otherwise be readily known to anyone maintaining a system. The sign is particularly useful in addressing freeze threats by identifying any locations with heat tape and acknowledging that auxiliary and low-point drains are installed on the system along with their number and location. If this information is not known, the system can be damaged due to freezing of water in the trapped sections of pipe. It is important to recognize that 4.1.9.2 is a retroactive requirement. For example, system information signs were not required by NFPA 13 prior to the 2007 edition, so many systems might not have them. This information is critical to the assessment of a building while conducting certain ITM tasks, as evidenced by NFPA 13 requiring it in the last three editions of the standard. If this sign is not present, contractors and inspection providers should alert the owner to the need for this sign and the importance of the information. The required information could come from the building records, which include the as-built sprinkler system drawing(s), the Contractor's Material and Test Certificate, or other documents. If these are not available, the owner might need to ask the contractor or other qualified entity or individual to survey the system and provide the information needed for the sign.

System Tagging

A coupling that has corroded to the point where the head of the bolt has separated from its body would typically cause significant leaking and would render a system impaired. It is important to keep in mind that if the coupling were somehow not leaking and the corroded side of the coupling were up against a wall or in a location that could not be seen from the floor level, it might not be noticed during an inspection.



(Courtesy of Byron Blake and SimplexGrinnell)

Noncritical Deficiency Critical Deficiency Impairment

4.1.10 Antifreeze Information Sign.

An antifreeze information sign shall be placed on the antifreeze system main valve, which indicates the manufacture type and brand of the antifreeze solution, the concentration by volume of the antifreeze solution used, and the volume of the antifreeze solution used in the system.

4.1.11 Impairments.

4.1.11.1 Where an impairment to a water-based fire protection system occurs or is identified during inspection, testing, or maintenance activities, the procedures outlined in Chapter 15 shall be followed, including the attachment of a tag to the impaired system.

This paragraph clarifies that the requirements in Chapter 15 are to be implemented by the owner in the event that the system is impaired. Chapter 15 outlines the specific steps that must be taken. It is notable that although 3.3.22.1 and 3.3.22.2 define emergency and preplanned impairments separately, the actions that the owner must undertake are the same once the impairment occurs.

Exhibit 4.7 shows an impaired system that has been identified with an impairment tag by the AHJ. NFPA 25 does not mandate a certain style or color for the impairment tag; however, many states have their own tagging system that should be consulted. Where a system impairment occurs in a location that is remote from the system control valve, the inspector will often provide a tag both at the system riser and at the impaired component. For instance, if a system has to be shut down due to a failed coupling in a section of feed main piping outside the sprinkler control room, it makes sense to tag both the coupling and the closed control valve. The tag on the control valve should note where the impairment is, leading the AHJ, owner, or inspector to the other tag.



EXHIBIT 4.7 *Example of an Impaired System Tag. (Courtesy of Byron Blake and SimplexGrinnell)*

4.1.11.2 Where a water-based fire protection system is returned to service following an impairment, the system shall be verified to be working properly by means of an appropriate inspection or test as described in the table "Summary of Component Replacement [Action] Requirements" in the applicable chapters of this document.

Component replacement and testing tables are included in NFPA 25 for each system type to assist the user in determining the type and extent of actions that are needed following a repair or adjustment. See the appropriate systems chapter for the pertinent component replacement and testing table. There are times when these actions are in accordance with the requirements of the appropriate installation standard. For example, the tests needed when replacing an air maintenance device in a dry pipe sprinkler system would be performed in accordance with NFPA 13.

4.2 Manufacturer's Corrective Action.

Manufacturers shall be permitted to make modifications to their own listed product in the field with listed devices that restore the original performance as intended by the listing, where acceptable to the authority having jurisdiction.

4.3 Records.

Δ **4.3.1*** Records shall be made for all inspections, tests, and maintenance of the system and its components.

Although many local and some state jurisdictions require it, NFPA 25 does not mandate the transmittal of records to the AHJ. Some jurisdictions require that all ITM records be immediately sent to the AHJ upon completion of the inspection, test, or maintenance. Other jurisdictions only require that certain records, such as those indicating impairments, be forwarded. Still other jurisdictions only want the records maintained on site for review by fire inspectors or others, such as insurance companies. It is important that all stakeholders in the process are aware of any requirements to forward records to anyone other than the owner.

Δ **A.4.3.1** Typical records include, but are not limited to, valve inspections; flow, drain, and pump tests; and trip tests of dry pipe, deluge, and preaction valves.

Acceptance test records should be retained for the life of the system or its special components. Subsequent test records should be retained for a period of 1 year after the next test. The comparison determines deterioration of system performance or condition and the need for further testing or maintenance.

N **4.3.1.1** Records shall be maintained by the property owner.

4.3.1.2* Records shall be permitted to be stored and accessed electronically.

A.4.3.1.2 Computer programs that file inspection and test results should provide a means of comparing current and past results and should indicate the need for corrective maintenance or further testing.

The ITM records referred to in Section 4.3 provide written documentation of compliance with NFPA 25. These records also offer a service history of the installed systems by indicating their performance during testing and/or maintenance. The advances in electronic database software allow for complete and highly detailed histories of system maintenance. Many AHJs allow owners to use their own central database or that of a service provider to electronically file and maintain records, rather than to store traditional paper records on site. In some jurisdictions, the AHJ has contracted with a third-party records maintenance provider. These programs typically involve the ITM provider submitting the reports required by this chapter directly to the third party in addition to providing them to the owner. There may be a cost involved with these programs, so it is important that the owner and ITM service provider both be familiar with the local requirements.

Tip for Owners

The requirement in 4.3.1.1 emphasizes that it is the owner's responsibility to maintain the required records; however, it is a good idea for the inspector to keep records as well. It allows the inspector to identify commonalities in deficiencies in a specific property or even a certain type of system. See the commentary following 4.3.1.2 on how the records are permitted to be stored.

4.3.2 Records shall indicate the following:

(1) The procedure/activity performed (e.g., inspection, test, or maintenance)
(2) The organization that performed the activity
(3) The required frequency of the activity
(4) The results and date of the activity
(5) The name and contact information of the qualified contractor or owner, including lead person for activity

Any form, whether produced commercially or developed independently, can be used to document ITM activities, provided it details the activity sufficiently to verify compliance with NFPA 25. Many people assume that NFPA 25 requires a specific series of forms that need to be filled out; however, in reviewing the standard, it is completely devoid of forms. This absence of forms in the standard is not intended to lessen the importance of recording ITM data, but rather it allows the owners and inspectors the flexibility to use their own project management programs, software, and ITM forms to track their ITM work. NFPA has developed a series of electronic forms specific to the ITM requirements throughout NFPA 25. These completely customizable forms are available at www.nfpa.org. This handbook contains several examples of forms that can be used for recording system information or documenting an ITM task that has been completed. See Exhibit 4.8.

One of the main concerns of property owners and facility managers who own or manage multiple properties is the many different ITM forms they receive. The same holds true for AHJs. For this reason, in the 2017 edition, annex guidance was expanded regarding recommended minimum information for ITM reports. Although not required, the annex provides a framework for consistency for those who choose to follow it. For more information, see Section B.4 in Annex B.

4.3.3* Records shall be made available to the authority having jurisdiction upon request.

A.4.3.3 See Section B.3 for information regarding sample forms.

4.3.4 As-built system installation drawings, hydraulic calculations, original acceptance test records, and device manufacturer's data sheets shall be retained for the life of the system.

4.3.5 Subsequent records shall be retained for a period of 1 year after the next inspection, test, or maintenance of that type required by the standard.

Tip for Owners

Electronic copies of records are often used as an option for long-term record management. However, it is beneficial to have paper copies of recent documents available for quick use, especially in an emergency.

Tip for Owners

These records are important when extending or modifying the system as well as for routine inspecting, testing, and maintenance. Recreating them when they are needed can be costly and time-consuming. Records are easily misplaced or lost over a period of time, especially when properties are sold or come under different management. Making a conscious effort to comply with this section is often well worth the investment.

Tip for Owners

Compliance with 4.3.5 results in maintaining records for at least 1 year following each successive ITM activity. This requirement for records retention is intended to provide evidence of trending. For example, a main drain test performed on an annual basis should result in a total of three test reports: the original test, results for the current year, and results from the prior year. The record from 2 years ago could be discarded at this time. With this information, fluctuations in the test results are shown and are used for evaluating the operational condition of the system.

4.4 Water Supply Status.

During inspection, testing, and maintenance, water supplies, including fire pumps, shall remain in service unless under constant attendance by qualified personnel or unless impairment procedures in Chapter 15 are followed.

The requirement in Section 4.4 is intended to avoid unnecessary system impairment procedures for any water supply that is turned off for a length of time. Provided that water supplies, including fire pumps, are constantly attended, impairment procedures are not needed for valves that are closed for short periods for testing. An example of such a situation would be closing the discharge isolation valve of a fire pump for the annual flow test. It is also important to keep in mind that for consistency and accuracy in reporting test results, it is necessary for subsequent tests to be performed with the water supply status the same as during the previous tests.

FIRE SPRINKLER SYSTEM HAZARD EVALUATION

Changes in building occupancy, use, or process, or material used or stored, create the need for evaluation of the installed fire protection systems. This form is intended to identify and evaluate such changes and should be completed only by an individual properly qualified in the area of system design.

Owner:_____ Owner's address: _____

Property being evaluated: _____

Property address: _____

Date of work: _____

(All responses refer to the current hazard evaluation performed on this date.)

Section 1. Identification of Sprinklered Occupancy and Storage Hazards
(Use additional pages as needed.)

Area of Property (List nonsprinklered areas separately in Section 3.)	Type of System and Sprinklers	Design Capability of System	Hazard Protected (Uses or storage arrangements, including commodity)	Improvements Needed to Address Hazard
1.				
2.				
3.				
4.				
5.				

NFPA 25 Handbook (p. 1 of 4)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT 4.8 *Sample Fire Sprinkler Hazard Evaluation Form.*

FIRE SPRINKLER SYSTEM HAZARD EVALUATION (Continued)

Section 2. Evaluation of Protection

For each area of the property evaluated in Section 1, please answer the following questions with a "yes," "no," "N/A," or "?" and explain all "no" and "?" responses below by row and column identification:

Answer the following for each identified property area:	1	2	3	4	5
a. Are all sprinklers the correct type for their application?					
b. Are the obstructions to sprinklers in all areas within acceptable limits for the specific types of sprinklers used?					
c. Are hazards associated with all occupancy areas consistent with hazards typical for that occupancy hazard classification?					
d. Are stockpiles of combustibles located within occupancy areas limited to appropriate heights?					
e. Are miscellaneous and dedicated storage areas properly identified and managed?					
f. Are all dedicated storage areas protected in accordance with the proper storage configuration and commodity classification?					
g. Is the storage or use of flammable liquids, combustible liquids, or aerosol products in any area properly addressed?					
h. Is all idle pallet storage properly protected?					
i. Is there any presence of nitrate film, pyroxylin plastic, compressed or liquefied gas cylinders, liquid or solid oxidizers, or organic peroxide formulations except where specifically addressed by appropriate protection measures?					
j. Are all sprinklers spaced appropriately for the hazard and the type of sprinkler?					
k. Do the available sources of heat and cooling appear adequate for the type of system and temperature rating of sprinklers?					

Explanation of "no" and "?" answers:

Examples:
b2 — no — Obstructions to ESFR sprinklers exceed currently accepted standards.
e3 — ? — Owner must provide information on type of plastic involved in product before evaluation can be finalized.

NFPA 25 Handbook (p. 2 of 4)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT 4.8 *Continued*

FIRE SPRINKLER SYSTEM HAZARD EVALUATION (Continued)

Section 3. Evaluation of Unsprinklered Areas

Area of Property for Which Protection Is Not Provided	Basis of Lack of Protection (if known)	Basis for Omission Under Current Codes/Standards
1.		
2.		
3.		
4.		
5.		

Section 4. Water Supply Evaluation

If this hazard evaluation is the result of a reduction in the residual pressure during routine inspections, explain the results of the investigation made to determine the reasons for this change:

Explain the basis of continued acceptability of the water supply or proposed improvements:

NFPA 25 Handbook (p. 3 of 4)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT 4.8 *Continued*

FIRE SPRINKLER SYSTEM HAZARD EVALUATION (Continued)

Section 5. Hazard Evaluator's Information and Certification

Evaluator:

Company:

Company address:

I state that the information on this form is correct at the time and place of my review of my evaluation.

Is this hazard evaluation completed? (Note: All "?" must be resolved.) ❑ Yes ❑ No

Explain if answer is not "yes":

Have deficiencies in protection been identified that should be improved or corrected? ❑ Yes ❑ No

Summarize improvements of corrections needed:

Signature of Evaluator: _____ Date: _____

License or Certification Number (if applicable): _____

NFPA 25 Handbook (p. 4 of 4)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT 4.8 *Continued*

4.5* Inspection.

System components shall be inspected at intervals specified in the appropriate chapters.

A.4.5 Inspection and periodic testing determine what, if any, maintenance actions are required to maintain the operability of a water-based fire protection system. The standard establishes minimum inspection/testing frequencies, responsibilities, test routines, and reporting procedures but does not define precise limits of anomalies where maintenance actions are required.

Substandard conditions, such as a closed valve, subnormal water pressure, loss of building heat or power, or obstruction of sprinklers, nozzles, detectors, or hose stations, can delay or prevent system actuation and impede manual fire-fighting operations.

Section 4.5 refers to inspection intervals for specific system components that can be found in subsequent chapters of NFPA 25. Those chapters are as follows:

Chapter 5—Sprinkler Systems
Chapter 6—Standpipe and Hose Systems
Chapter 7—Private Fire Service Mains
Chapter 8—Fire Pumps
Chapter 9—Water Storage Tanks
Chapter 10—Water Spray Fixed Systems
Chapter 11—Foam-Water Sprinkler Systems
Chapter 12—Water Mist Systems
Chapter 13—Common Components and Valves
Chapter 14—Internal Piping Condition and Obstruction Investigation
Chapter 16 —Special Requirements from Other NFPA Documents

The ITM frequencies established in the standard vary from daily, weekly, monthly, quarterly, semiannually, annually, to every 5 years. Each chapter provides a summary table at the beginning that lays out all of the inspection tasks for each system and system component, along with the required frequency for each inspection. In the 2014 edition, Chapter 3 first provided ranges for the minimum and maximum elapsed time between these inspections.

4.6 Testing.

4.6.1 All components and systems shall be tested to verify that they function as intended.

4.6.1.1 When automated testing in accordance with 4.6.6 is being utilized, the testing shall be observed at a minimum frequency of once every 3 years.

While automated testing is an acceptable method of compliance with the requirements of this standard, it is still required that the actual test be observed occasionally. This is to verify that the test is still being conducted as required and that the automated testing mechanism still operates as intended.

4.6.1.2 Where the automated testing cannot be visually observed, the testing shall be conducted manually at a minimum frequency of once every 3 years.

4.6.2 The frequency of tests shall be in accordance with this standard.

FAQ Must a monthly test be conducted on the exact date each month, or can frequency be varied as long as the test is on or about the same day each month?

It is impractical to require an inspection or test to be performed on the exact date for each subsequent interval. See the commentary following Section 4.5 and the definitions in Chapter 3 for more information on the acceptable ranges to conduct an ITM task. Allowances might be needed for unexpected weather conditions or other uncontrolled factors that impact the scheduled activity.

4.6.3 Fire protection system components shall be restored to full operational condition following testing, including reinstallation of plugs and caps for auxiliary drains and test valves.

4.6.4* Test results shall be compared with those of the original acceptance test (if available) and with the most recent test results.

This requirement highlights the reason why inspectors should keep their own copies of test and inspection reports. While owners are required to maintain these records, if inspectors keep their own records, they can make better comparisons to past testing and essentially create a building or system history. See A.3.3.48.

A.4.6.4 The types of tests required for each protection system and its components, and the specialized equipment required for testing, are detailed in the appropriate chapter.

As referred to in 4.3.4, original records should include, at a minimum, the contractor's material and test certificate, "as-built" drawings and calculations, and any other required or pertinent test reports. These documents establish the conditions under which the systems were first installed and offer some insight to the design intent, installation standards used, and water supply present at the time of installation. Original records are instrumental in determining any subsequent changes or modifications to the buildings or system.

4.6.5* When a component or subsystem is adjusted, repaired, reconditioned, or replaced, it shall be tested in accordance with the original acceptance test required for that subsystem or the requirements where specified by the standard.

The individual system chapters of NFPA 25 contain corrective action tables at the end of the chapter that provide references to many of these required tests. These tests are not intended to create an additional burden; they are simply there to ensure that the functionality of the repaired or replaced components can be confirmed as it would be for a component in a new system.

Δ **A.4.6.5** Examples of subsystems or components include fire pumps, drivers or controllers, pressure-regulating devices, detection systems and controls, alarm check, and dry pipe, deluge, and preaction valves. The required tests for components are contained in the corresponding chapter in tables titled "Summary of [Component] Inspection, Testing, and Maintenance."

4.6.6* Automated Inspection and Testing.

A.4.6.6 Some devices, such as waterflow alarm devices, can be tested automatically. Some things to consider include the following:

(1) Not all tests required by NFPA 25 are suitable for automatic testing.
(2) Periodic visual inspection, including the use of video, should be performed.

Automated inspection and testing is being utilized more often with advancements in technology. The overall concept behind these inspections and testing methods is that they mimic the formerly manual process and produce the same outcome. For example, a sensor on a fire pump housing that records the temperature during testing can replicate the same outcome as a person measuring the temperature manually. However, some inspections and tests require the presence of a qualified person and cannot be performed automatically.

4.6.6.1 Automated inspection and testing procedures performed in accordance with the requirements in this standard shall be permitted to be used.

4.6.6.2* Automated inspection equipment that meets the intent of a required visual inspection shall be permitted to replace the visual inspection.

There might be times when automated inspections are preferred for safety reasons. A camera focused on a gauge or valve in a hazardous location that sends a signal to a monitor outside of the hazardous area is more likely to be inspected for compliance with NFPA 25 than one that requires the technician to don special equipment or shutdown equipment.

Δ **A.4.6.6.2** Transducers, temperature sensors, automatic and remotely operated valves, including motorized valves, and solenoids are examples of some of the equipment that could be used in an automated inspection. The list of items above is a partial list and should not be considered an exclusive list of equipment and methodologies.

4.6.6.3 Automated testing equipment shall produce the same action required by this standard to test a device.

4.6.6.4 The testing shall discharge water where required in this standard.

One example of where water must be discharged is the testing of waterflow alarm devices. However, there are waterflow alarm devices with automated features that can perform this test without flowing water. Where these devices are used, it is acceptable to discharge water only once every 3 years, visually verifying the test. See 5.3.3 for additional information on waterflow alarm device testing.

Δ **4.6.6.4.1** Automated testing equipment that does not discharge water for a test shall be permitted except as required in 4.6.6.4.2.

4.6.6.4.2* The discharge shall be visually observed at a minimum frequency of once every 3 years.

A.4.6.6.4.2 The visual observation should be coordinated with the automatic testing. Appropriate remote visual observation might satisfy this requirement.

Although automated testing is an acceptable and reliable method of compliance with this standard, a visual check is required on a 3-year basis by 4.6.6.4.2. This permits the qualified person overseeing the process to verify that the automated components are still operating as intended; they can also check for other situations, like unexpected water damage from the discharge. Minimizing water damage is a requirement of both this chapter and Chapter 13.

4.6.6.5 Where required in this standard, personnel shall observe the testing and intervene in the testing procedures when necessary to prevent injury or property damage.

4.6.6.6 Automated test devices and equipment shall be listed for the purpose of the test being conducted.

N **4.6.6.7*** Devices and equipment utilized to perform automated inspection and testing procedures that are not subjected to system pressure or are not integral to the operation of the system during a fire event shall not be required to be listed.

N **A.4.6.6.7** Certain devices, meters, and equipment that can be used to perform inspection and testing procedures from a distant location are not integral to the system and don't affect system performance. Automated inspection and testing devices and equipment, such as a digital camera, can be in the riser room or attached to the system externally but are not an integral part of the system. Such devices do not need to be listed.

4.6.6.8 Failure of the testing equipment shall not impair the operation of the system unless indicated by a supervisory signal in accordance with *NFPA 72*.

4.6.6.9 Failure of a component or system to pass an automated test shall result in an audible supervisory signal.

4.6.6.10 Failure of automated inspection and testing equipment shall result in a trouble signal in accordance with *NFPA 72*.

4.6.6.11 Failure of a component or system that impairs the system shall require that impairment procedures be followed.

If the automated equipment used to inspect or test a system or component addressed by NFPA 25 fails to operate as intended, it does not relieve the owner of the need to comply with the inspection and testing frequencies in this standard. In addition, some failures of inspection or testing equipment may require immediate action. For example, if the temperature sensor used as an example in the commentary for A.4.6.6 were to fail for any reason, it would become necessary for a qualified person to immediately check for overheating during fire pump testing as required by Chapter 8.

4.6.6.12 The testing frequencies of this standard shall be maintained regardless of the functionality of the automated testing equipment.

4.6.6.13 A record of all inspections and testing shall be maintained in accordance with 4.3.2.

4.7* Performance-Based Compliance Programs.

Components and systems shall be permitted to be inspected, tested, and maintained under an approved performance-based program.

Section 4.7 provides a detailed procedure for determining an alternative inspection/testing frequency for fire protection systems and equipment. Since its inception, NFPA 25 has included a provision allowing an alternative method of performing ITM (see Section 1.3). However, this provision does not detail exactly how such an alternative method should be implemented.

Section 4.7 explains, in detail, how to implement such a program. It is important to note that the performance-based option requires due diligence in conducting inspections and testing and demands a consistent approach to reporting and record-keeping. The challenge in developing a performance-based program is determining an acceptable failure rate.

There is a wide difference of opinions on establishing an acceptable failure rate, according to a recent study on fire pump performance by the NFPA Research Foundation,

"Fire Pump Field Data Collection and Analysis." The challenge entails pinning down the break point of a cost benefit analysis. Is it worth conducting a weekly test if it makes a system or system component 1 percent or 2 percent more reliable than a system or component that is tested monthly? The cost of running 52 tests instead of 12 is significant to the owner, and it is difficult to quantify the amount of additional reliability that is necessary to justify spending that money. It ends up being determined on a case-by-case basis; it is based on the liability that the owner carries and the specifics of the building and fire protection system.

Performance-based options cannot be implemented without approval by the AHJ. The documentation submitted to the AHJ for review must be complete and sufficiently detailed to clearly justify the deviation in inspection and test frequencies from those specified in NFPA 25.

A.4.7 Section 4.7 provides the option to adopt a performance-based test and inspection method as an alternative means of compliance with 4.6.2. The prescriptive test and requirements contained in this standard are essentially qualitative. In addition, this standard is applied equally to systems where a system failure might be acceptable and to systems where preventing system failure is an extremely high priority. It is appropriate to adjust reliability requirements in performance-based ITM accordingly. One suggested means to complete a performance-based program can be found in the second edition (2007) of *SFPE Engineering Guide to Performance-Based Fire Protection*.

4.7.1* Performance-based programs shall have clearly identifiable goals and clearly define how the program meets those goals.

Δ **A.4.7.1** As noted in A.4.7, this standard is applied equally to systems where a system failure might be acceptable and to systems where preventing system failure is an extremely high priority. Goals should be adjusted accordingly.

Sprinkler systems can be used as an example for establishing a baseline. The overall performance of sprinkler systems is documented and can be used as a starting point to establish a baseline for reliability. However, the performance level of sprinkler systems maintained in accordance with this standard is not currently well documented, and the reliability baseline should be adjusted upward using an adjustment factor agreeable to the approving authority.

Once a baseline for reliability is established, it should be adjusted upward or downward based on, as a minimum, the following issues:

(1) Building criticality
(2) System/component preventive maintenance programs
(3) Consequences of system maloperation such as the following:
    (a) Immediate loss of and/or damage to facilities, equipment, and contents
    (b) Business interruption
    (c) Increased hazard to fire fighters
    (d) Impact on adjacent facilities
    (e) Economic impact on community
(4) System/component repair history
(5) Building/service conditions

Once a baseline acceptable to the approving authority has been determined, equivalent or superior levels of performance can be demonstrated through qualitative and/or quantitative performance-based analyses. This section provides a basis for implementing and monitoring a quantitative performance-based program acceptable under this option (providing approval is obtained from the authority having jurisdiction).

The concept of a quantitative performance-based testing and inspection program is to establish the requirements and frequencies at which inspection and testing must be performed

to achieve an acceptable level of operational reliability. The goal is to balance the inspection/test frequency with the reliability of the system or component. Ideally, a quantitative performance-based inspection program will adjust test/inspection frequencies commensurate with historical documented equipment performance and desired reliability. Frequencies of test/inspection under a quantitative performance-based program can be extended or reduced from the prescriptive test requirements contained in this standard when continued testing has been documented indicating a higher or lower degree of reliability compared to the authority having jurisdiction's expectations of performance. Additional program attributes that should be considered when adjusting test/inspection frequencies include the following:

(1) System/component preventive maintenance programs
(2) Consequences of system maloperation
(3) System/component repair history
(4) Building/service conditions

Fundamental to implementing a quantitative performance-based program is that adjusted test and inspection frequencies must be technically defensible to the authority having jurisdiction and supported by evidence of higher or lower reliability. Data collection and retention must be established so that the data utilized to alter frequencies are representative, statistically valid, and evaluated against firm criteria. Frequencies should not be arbitrarily extended or reduced without a suitable basis and rationale. It must be noted that transitioning to a quantitative performance-based program might require additional expenditures of resources in order to collect and analyze failure data, coordinate review efforts, replace program documents, and seek approval from the authority having jurisdiction. Information on how to estimate the reliability of fire protection systems can be found in Chapter 74, "Reliability, Availability, and Maintainability," of the fifth edition (2016) of the *SFPE Handbook of Fire Protection Engineering*.

Failure Rate Calculation. A quantitative performance-based program requires that a maximum allowable failure rate be established and approved by the authority having jurisdiction in advance of implementation. The use of historical system/component fire system inspection records can be utilized to determine failure rates. One method of calculating the failure rate of a fire system is based on the following equation:

$$FSFR\ (t) = \frac{NF}{(NC)(t)} \qquad \textbf{[A.4.7.1a]}$$

where:

$FSFR$ = fire system failure rate (failures per year)
t = time interval of review (years)
NF = number of failures
NC = total number of fire systems inspected or tested

Example. Data are collected for 50 fire pump weekly tests over a 5-year period. The testing is conducted, as described in 8.3.1. A review of the data has identified five failures:

Total components: 280

Data collection period: 5 years

Total failures: 5

$$FSFR = \frac{5}{280 \times 5} = 0.003/\text{year} \qquad \textbf{[A.4.7.1b]}$$

A fundamental requirement of a quantitative performance-based program is the continual monitoring of fire system/component failure rates and determining whether they exceed the maximum allowable failure rates as agreed upon with the authority having jurisdiction. The process used to complete this review should be documented and repeatable.

Coupled with this ongoing review is a requirement for a formalized method of increasing or decreasing the frequency of testing/inspection when systems exhibit either a higher than expected failure rate or an increase in reliability as a result of a decrease in failures, or both. A formal process for reviewing the failure rates and increasing or decreasing the frequency of testing must be well documented.

Concurrence of the authority having jurisdiction on the process used to determine test frequencies should be obtained in advance of any alterations to the test program. The frequency required for future tests might be reduced to the next inspection frequency and maintained there for a period equaling the initial data review or until the ongoing review indicates that the failure rate is no longer being exceeded—for example, going from annual to semiannual testing when the failure rate exceeds the authority having jurisdiction's expectations or from annual to every 18 months when the failure trend indicates an increase in reliability.

References

Edward K. Budnick, P.E., "Automatic Sprinkler System Reliability," *Fire Protection Engineering*, Society of Fire Protection Engineers, SFPE Winter 2001.

Fire Protection Equipment Surveillance Optimization and Maintenance Guide, Electric Power Research Institute, July 2003.

Kenneth W. Dungan, P.E., "Performance-Based Inspection, Testing, and Maintenance," *Fire Protection Engineering*, SFPE, Quarter 4, 2016.

William E. Koffel, P.E., *Reliability of Automatic Sprinkler Systems, Alliance for Fire Safety*.

NFPA's Future in Performance Based Codes and Standards, July 1995.

NFPA Performance Based Codes and Standards Primer, December 1999.

4.7.2 Compliance with an approved performance-based program shall be deemed as compliance with this standard.

4.7.3 The goals and goal achievement obtained with the approved performance-based program shall be reviewed a minimum of every 3 years and inspection, testing, and maintenance frequencies adjusted to reflect current conditions and the historical record.

4.7.4 The historical record shall be available for review by the authority having jurisdiction.

Some AHJs may not be comfortable reviewing and approving alternative frequencies and ITM programs. In these instances, it might be prudent for an independent third party (e.g., a registered engineer) to review the historical records and assess the proposed alternative frequency or performance-based program.

4.8 Maintenance.

Maintenance shall be performed to keep the system equipment operable.

In addition to the maintenance requirements of NFPA 25, it is important to review the preventive maintenance information provided by the manufacturer. The requirements in the manufacturer's literature are often tied to the warranty, and the argument that the NFPA 25 maintenance schedule was followed will not hold water if the frequencies do not match up.

4.9 Safety.

4.9.1 General.

Inspection, testing, and maintenance activities shall be conducted in accordance with applicable safety regulations.

4.9.2 Confined Spaces.

Legally required precautions shall be taken prior to entering confined spaces such as tanks, valve pits, or trenches.

Subsection 4.9.2 addresses precautions to be taken when working in confined spaces. A confined space is any space that is large enough for a person to enter and perform work and that has limited or restricted access, such as a water storage tank. At times, an inspector will find it necessary to enter a confined space, such as a valve pit, water storage tank, or trench.

Confined space entry is regulated by the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA), in 29 CFR 1910.146, "Permit-Required Confined Spaces." That standard establishes the requirement for a permit-required confined space entry program to protect employees from confined space hazards and to regulate entry into these spaces. In areas not subject to OSHA regulations, such as those outside the United States, other government regulations might apply. Exhibit 4.9 illustrates a warning sign identifying a confined space as part of a permit-required confined space entry program.

Before a confined space can be entered, the internal atmosphere must be tested for oxygen content, flammable gases and vapors, and potential toxic air contaminants. The space must also be ventilated to eliminate or control any hazardous atmosphere.

Access to any confined space must be coordinated with the property owner, contractor, or host employer. (A host employer is the customer of the contractor or inspector.) Controlled access to a confined space might be managed through the use of a permit. The permit should indicate that atmospheric testing has been completed and that proper safety equipment (such as ventilation, communications, personal protective equipment, lighting, ladders, and rescue and emergency equipment) is in place. The permit should also address any other requirements as established in the host employer's confined space entry program. Exhibit 4.10 illustrates a sample confined space entry permit.

Ongoing testing or monitoring of the confined space atmosphere is necessary to ensure that safe conditions are maintained for the duration of entry operations.

EXHIBIT 4.9 *Sample Confined Space Entry Sign.*



Confined Space Entry Permit

Date and Time Issued: _____ Date and Time Expires: _____
Job Site/Space I.D.: _____ Job Supervisor: _____
Equipment to be worked on: _____ Work to be performed: _____

Stand-by personnel: _____

1. Atmospheric checks: Time _____
   Oxygen _____ %
   Explosive _____ % L • F • L •
   Toxic _____ PPM

2. Tester's signature: _____

3. Source isolation (No Entry):

	N/A	Yes	No
Pumps or lines blinded,	( )	( )	( )
disconnected, or blocked	( )	( )	( )

4. Ventilation modification:

	N/A	Yes	No
Mechanical	( )	( )	( )
Natural ventilation only	( )	( )	( )

5. Atmospheric check after isolation and ventilation:

Oxygen _____ %	>	19.5	%
Explosive _____ % L • F • L •	<	10	%
Toxic _____ PPM	<	10	PPM H(2)S

   Time _____
   Testers signature: _____

6. Communication procedures: _____

7. Rescue procedures: _____

8. Entry, standby, and backup persons:

	Yes	No
Successfully completed required training?		
Is it current?	( )	( )

9. Equipment:

	N/A	Yes	No
Direct reading gas monitor - tested	( )	( )	( )
Safety harnesses and lifelines for entry and standby persons	( )	( )	( )
Hoisting equipment	( )	( )	( )
Powered communications	( )	( )	( )
SCBA's for entry and standby persons	( )	( )	( )
Protective Clothing	( )	( )	( )
All electric equipment listed Class I, Division I, Group D and Non-sparking tools	( )	( )	( )

10. Periodic atmospheric tests:

Oxygen	_____ %	Time	_____	Oxygen	_____ %	Time	_____
Oxygen	_____ %	Time	_____	Oxygen	_____ %	Time	_____
Explosive	_____ %	Time	_____	Explosive	_____ %	Time	_____
Explosive	_____ %	Time	_____	Explosive	_____ %	Time	_____
Toxic	_____ %	Time	_____	Toxic	_____ %	Time	_____
Toxic	_____ %	Time	_____	Toxic	_____ %	Time	_____

We have reviewed the work authorized by this permit and the information contained here-in. Written instructions and safety procedures have been received and are understood. Entry cannot be approved if any squares are marked in the "No" column. This permit is not valid unless all appropriate items are completed.

Permit Prepared By: (Supervisor) _____
Approved By: (Unit Supervisor) _____
Reviewed By (Cs Operations Personnel):

_____ _____
(printed name) (signature)

This permit to be kept at job site. Return job site copy to Safety Office following job completion.

EXHIBIT 4.10 *Sample Confined Space Entry Permit. (Source: OSHA, 29 CFR 1910.146, Appendix D)*

During confined space entry, at least one attendant trained in summoning rescue and emergency services, rescuing entrants from the space, and providing emergency services to rescued employees must remain outside of the permit space.

It is important for anyone involved in the ITM of systems to recognize a confined space and be prepared to follow the host employer's confined space entry program. Subsection 4.9.2 is not intended to outline a comprehensive confined space entry program.

4.9.3 Fall Protection.

Legally required equipment shall be worn or used to prevent injury from falls to personnel.

Fall protection, as referred to in 4.9.3, can include wearing safety harnesses, as well as the proper use of ladders, staging, and powered lifts. The inspector should be familiar with any regulations in effect governing this type of equipment.

4.9.4 Hazards.

Precautions shall be taken to address any hazards, such as protection against drowning where working on the top of a filled embankment or a supported, rubberized fabric tank, or over open water or other liquids.

4.9.5* Hazardous Materials.

The hazardous materials referenced in 4.9.5 can be any material capable of causing harm or bodily injury. These materials can include cleaning agents, solvents, paint, adhesives, or other chemicals used for a variety of purposes. It is important that inspectors and service personnel be able to both recognize the presence of a hazardous material and identify and classify the material to prevent accident, injury, or fire.

In 1983, OSHA established the Hazard Communication Standard, 29 CFR 1910, Subpart Z, "Toxic and Hazardous Substances." In 2012, the standard was revised and requires that the chemical manufacturer, distributor, or importer provide safety data sheets (SDSs) (formerly MSDSs or material safety data sheets) for each hazardous chemical to downstream users to communicate information on these hazards. Visit osha.gov/Publications/OSHA3514.html for a detailed description of the 16-section format required for an SDS.

A completed SDS provides chemical and toxicological data regarding hazardous materials and the need for any personal protective equipment. Prior to entering an area containing hazardous materials, an inspector or service personnel should request a copy of the SDS for all substances in the area. The owner is required per 4.9.5.2 to notify the inspector of the hazardous materials stored on the property. The owner should have a catalog of SDSs on site that can be used by the inspector as a quick reference guide while the inspection is conducted.

A.4.9.5 Most places using or storing hazardous materials have stations set up for employees where material safety data sheets (MSDSs) are stored. The inspector should be familiar with the types of materials present and the appropriate actions to take in an emergency.

4.9.5.1 Legally required equipment shall be used where working in an environment with hazardous materials present.

4.9.5.2 The property owner or designated representative shall advise anyone performing inspection, testing, and maintenance on any system under the scope of this document, with regard to hazardous materials stored on the premises.

4.9.6* Electrical Safety.

The owner is not responsible for providing personal protective equipment (PPE) to the service providers working in the building. The service providers are responsible for their own equipment.

Δ **A.4.9.6 WARNING:** NFPA 20 includes electrical requirements that discourage the installation of a disconnect means in the power supply to electric motor-driven fire pumps. This is intended to ensure the availability of power to the fire pumps. Where equipment connected to those circuits is serviced or maintained, the service person could be subject to unusual exposure to electrical and other hazards. It could be necessary to establish special safe work practices and to use safeguards or personal protective clothing, or both. See also NFPA *70E* for additional safety guidance.

4.9.6.1 Legally required precautions shall be taken when testing or maintaining electric controllers for motor-driven fire pumps.

Δ **4.9.6.2*** At a minimum, the provisions of NFPA *70E* or an approved equivalent shall be applied.

N **A.4.9.6.2** NFPA *70E* helps establish an overall electrical safety program. It is not the intent of 4.9.6.2 to restrict the use of other electrical safety programs that are recognized and established by a jurisdiction. For jurisdictions that do not recognize the provisions of NFPA *70E*, other approved electrical safety programs could be acceptable. The acceptance of an equivalent standard or program to NFPA *70E* must be approved by the authority having jurisdiction.

Safety-related work practices and procedures for persons who work on energized electrical equipment should be in place prior to engaging in such activity. As a minimum, procedures should be in accordance with 29 CFR 1926, "Safety and Health Regulations for Construction," and *NFPA 70E®*, *Standard for Electrical Safety in the Workplace®* or the equivalent for the country in which you reside. A fire pump controller is classified by *NFPA 70E* as a 600 V Class Motor Control Center. Commentary Table 4.1, excerpted from *NFPA 70E*, defines the arc flash PPE category and arc flash boundary for work specifically involving fire pump controllers.

Once the arc flash PPE category for testing and maintenance of fire pump controllers has been determined from Commentary Table 4.1, the need for and type of protective clothing and personal protective equipment can be determined from Commentary Table 4.2, which is also excerpted from *NFPA 70E*.

Exhibit 4.11 illustrates the necessary personal protective equipment needed for service and maintenance of fire pump controllers.

COMMENTARY TABLE 4.1 *Arc Flash PPE Categories for Alternating Current (ac) Systems*

Equipment	*Arc Flash PPE Category*	*Arc Flash Boundary*
Panelboards or other equipment rated 240 volts and below	1	485 mm
Parameters: Maximum of 25 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)		(19 in.)
Panelboards or other equipment rated greater than 240 volts and up to 600 volts	2	900 mm
Parameters: Maximum of 25 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)		(3 ft)
600-volt class motor control centers (MCCs)	2	1.5 m

(*continues*)

COMMENTARY TABLE 4.1 *Continued*

Equipment	*Arc Flash PPE Category*	*Arc Flash Boundary*
Parameters: Maximum of 65 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)		(5 ft)
600-volt class MCCs	4	4.3 m
Parameters: Maximum of 42 kA available fault current; maximum of 0.33 sec (20 cycles) fault clearing time; minimum working distance 455 mm (18 in.)		(14 ft)
600-volt class switchgear (with power circuit breakers or fused switches) and 600-volt class switchboards	4	6 m
Parameters: Maximum of 35 kA available fault current; maximum of up to 0.5 sec (30 cycles) fault clearing time; minimum working distance 455 mm (18 in.)		(20 ft)
Other 600-volt class (277 volts through 600 volts, nominal) equipment	2	1.5 m
Parameters: Maximum of 65 kA available fault current; maximum of 0.03 sec (2 cycles) fault clearing time; minimum working distance 455 mm (18 in.)		(5 ft)
NEMA E2 (fused contactor) motor starters, 2.3 kV through 7.2 kV	4	12 m
Parameters: Maximum of 35 kA available fault current; maximum of up to 0.24 sec (15 cycles) fault clearing time; minimum working distance 910 mm (36 in.)		(40 ft)
Metal-clad switchgear, 1 kV through 15 kV	4	12 m
Parameters: Maximum of 35 kA available fault current; maximum of up to 0.24 sec (15 cycles) fault clearing time; minimum working distance 910 mm (36 in.)		(40 ft)
Metal enclosed interrupter switchgear, fused or unfused type construction, 1 kV through 15 kV	4	12 m (40 ft)
Parameters: Maximum of 35 kA available fault current; maximum of 0.24 sec (15 cycles) fault clearing time; minimum working distance 910 mm (36 in.)		
Other equipment 1 kV through 15 kV		
Parameters: Maximum of 35 kA available fault current; maximum of up to 0.24 sec (15 cycles) fault clearing time; minimum working distance 910 mm (36 in.)	4	12 m (40 ft)
Arc-resistant equipment up to 600-volt class		
Parameters: DOORS CLOSED and SECURED; with an available fault current and a fault clearing time that does not exceed the arc-resistant rating of the equipment*	N/A	N/A
Arc-resistant equipment 1 kV through 15 kV		
Parameters: DOORS CLOSED and SECURED; with an available fault current and a fault clearing time that does not exceed the arc-resistant rating of the equipment*	N/A	N/A

N/A: Not applicable

Note: For equipment rated 600 volts and below and protected by upstream current-limiting fuses or current-limiting molded case circuit breakers sized at 200 amperes or less, the arc flash PPE category can be reduced by one number but not below arc flash PPE category 1.

*For DOORS OPEN refer to the corresponding non-arc-resistant equipment section of this table.

Source: NFPA 70E, 2018, Table 130.7(C)(15)(a)(b)

COMMENTARY TABLE 4.2 *Personal Protective Equipment (PPE)*

Arc-Flash PPE Category	*PPE*
1	**Arc-Rated Clothing, Minimum Arc Rating of 4 cal/cm² (16.75 J/cm²)[a]**
	Arc-rated long-sleeve shirt and pants or arc-rated coverall
	Arc-rated face shield[b] or arc flash suit hood
	Arc-rated jacket, parka, high-visibility apparel, rainwear, or hard hat liner (AN)
	Protective Equipment
	Hard hat
	Safety glasses or safety goggles (SR)
	Hearing protection (ear canal inserts)[c]
	Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with leather protectors (SR)[d]
	Leather footwear[e] (AN)
2	**Arc-Rated Clothing, Minimum Arc Rating of 8 cal/cm² (33.5 J/cm²)[a]**
	Arc-rated long-sleeve shirt and pants or arc-rated coverall
	Arc-rated flash suit hood or arc-rated face shield[b] and arc-rated balaclava
	Arc-rated jacket, parka, high-visibility apparel, rainwear, or hard hat liner (AN)
	Protective Equipment
	Hard hat
	Safety glasses or safety goggles (SR)
	Hearing protection (ear canal inserts)[c]
	Heavy-duty leather gloves, arc-rated gloves, or rubber insulating gloves with leather protectors (SR)[d]
	Leather footwear[e]
3	**Arc-Rated Clothing Selected so That the System Arc Rating Meets the Required Minimum Arc Rating of 25 cal/cm² (104.7 J/cm²)[a]**
	Arc-rated long-sleeve shirt (AR)
	Arc-rated pants (AR)
	Arc-rated coverall (AR)
	Arc-rated arc flash suit jacket (AR)
	Arc-rated arc flash suit pants (AR)
	Arc-rated arc flash suit hood
	Arc-rated gloves or rubber insulating gloves with leather protectors (SR)[d]
	Arc-rated jacket, parka, high-visibility apparel, rainwear, or hard hat liner (AN)
	Protective Equipment
	Hard hat
	Safety glasses or safety goggles (SR)
	Hearing protection (ear canal inserts)[c]
	Leather footwear[e]

(*continues*)

COMMENTARY TABLE 4.2 *(Continued)*

Arc-Flash PPE Category	*PPE*
4	**Arc-Rated Clothing Selected so That the System Arc Rating Meets the Required Minimum Arc Rating of 40 cal/cm² (167.5 J/cm²)[a]**
	Arc-rated long-sleeve shirt (AR)
	Arc-rated pants (AR)
	Arc-rated coverall (AR)
	Arc-rated arc flash suit jacket (AR)
	Arc-rated arc flash suit pants (AR)
	Arc-rated arc flash suit hood
	Arc-rated gloves or rubber insulating gloves with leather protectors (SR)[d]
	Arc-rated jacket, parka, high-visibility apparel, rainwear, or hard hat liner (AN)
	Protective Equipment
	Hard hat
	Safety glasses or safety goggles (SR)
	Hearing protection (ear canal inserts)[c]
	Leather footwear[e]

AN: As needed (optional). AR: As required. SR: Selection required.
[a]*Arc rating* is defined in Article 100.
[b]Face shields are to have wrap-around guarding to protect not only the face but also the forehead, ears, and neck, or, alternatively, an arc-rated arc flash suit hood is required to be worn.
[c]Other types of hearing protection are permitted to be used in lieu of or in addition to ear canal inserts provided they are worn under an arc-rated arc flash suit hood.
[d]Rubber insulating gloves with leather protectors provide arc flash protection in addition to shock protection. Higher class rubber insulating gloves with leather protectors, due to their increased material thickness, provide increased arc flash protection.
[e]Footwear other than leather or dielectric shall be permitted to be used provided it has been tested to demonstrate no ignition, melting or dripping at the minimum arc rating for the respective arc flash PPE category.

Source: NFPA 70E, 2018, Table 130.7(C)(15)(c).

In addition to electrical safety requirements and procedures, other precautions such as lock-out/tagout procedures should be exercised to prevent injury from the accidental starting of mechanical equipment, such as motors and pumping equipment.



EXHIBIT 4.11 *Personal Protective Equipment.*

References Cited in Commentary

Fire Protection Research Foundation, 1 Batterymarch Park, Quincy, MA 02169-7471.

"Fire Pump Field Data Collection and Analysis," Gayle Pennel, Aon Risk Solutions, January 2012.

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 3, *Recommended Practice for Commissioning of Fire Protection and Life Safety Systems,* 2018 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2019 edition.

NFPA 70E®, Standard for Electrical Safety in the Workplace®, 2018 edition.

NFPA 101®, Life Safety Code®, 2018 edition.

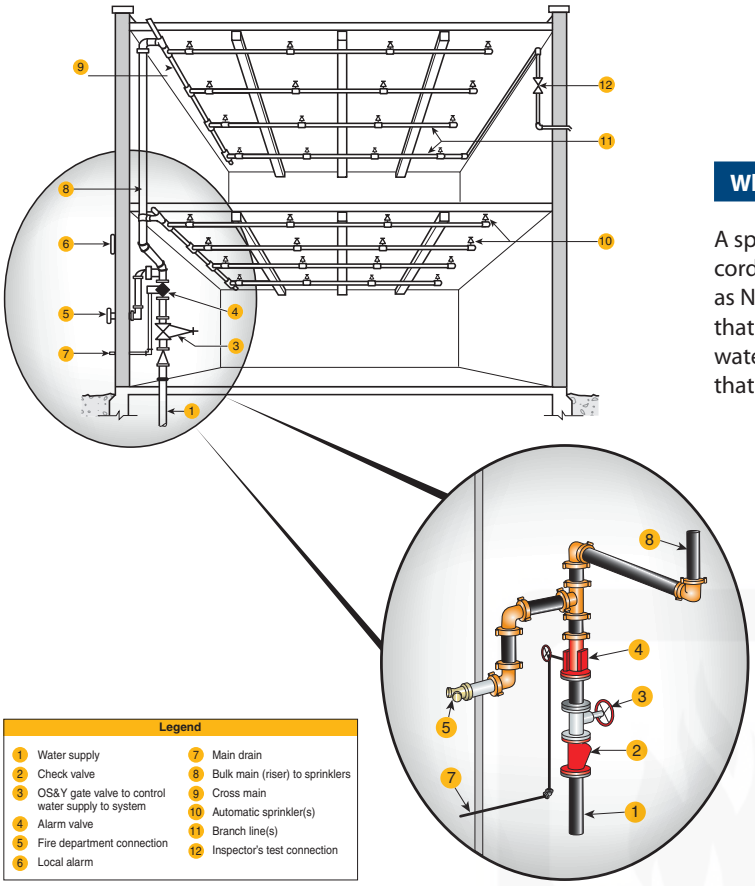
U.S. Government Publishing Office, 732 North Capitol Street, NW, Washington, DC 20401-0001.

Title 29, Code of Federal Regulations, Part 1910.146, "Permit-Required Confined Spaces."

Title 29, Code of Federal Regulations, Part 1910, Subpart Z, "Toxic and Hazardous Substances."

Title 29, Code of Federal Regulations, Part 1926, "Safety and Health Regulations for Construction."

Title 29, Code of Federal Regulations, Part 1910.1200.



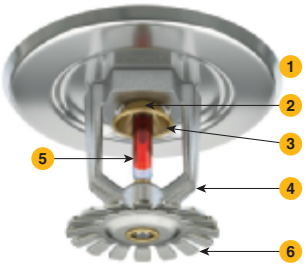
Courtesy of Stephan Laforest

What Is a Sprinkler System?

A sprinkler system is a network of piping designed in accordance with fire protection engineering standards (such as NFPA 13, *Standard for the Installation of Sprinkler Systems*) that includes a water supply source, a water control valve, a waterflow alarm, and a drain that provides water to sprinklers that are located throughout a building.

What Is a Sprinkler?

A sprinkler is a device designed to distribute water in order to either control (stop the growth) or suppress (reduce the size of) a fire.



Automatic Sprinkler



Open Sprinkler

Legend
1 Escutcheon
2 Orifice seat
3 Orifice cap
4 Frame arms
5 Fusible element
6 Deflector

Automatic

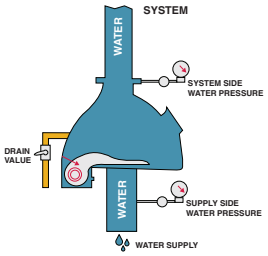
Automatic sprinklers operate or open automatically when a heat-activated element holding a plug that holds the water back breaks. In a system with automatic sprinklers, only the sprinklers closest to the fire will activate from the heat of the fire. Automatic sprinklers are the most common type of sprinklers.

Open

Open sprinklers are similar to automatic sprinklers, but they do not have actuators or heat responsive elements holding back the water. When the sprinkler system with open sprinklers activates, all of the sprinklers discharge water.

What Are the Types of Sprinkler Systems?

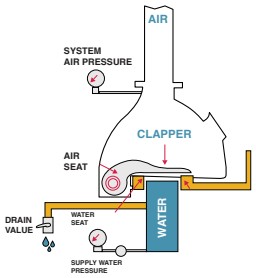
There are four main types of fire sprinkler systems that all operate differently, each with its own specific use. The main difference with these systems is the valve used to hold back the water from the system and the type of sprinklers used.



WET PIPE SYSTEM

Wet Pipe Sprinkler System

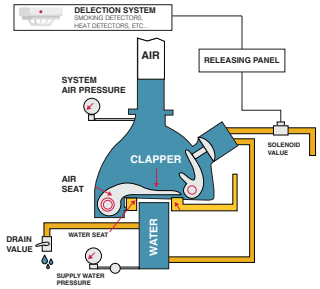
A wet pipe sprinkler system utilizes automatic sprinklers attached to piping that contains water and is connected to a water supply. Water is discharged immediately from the automatic sprinklers once they activate. Wet pipe sprinkler systems are the most common type of sprinkler systems.



DRY PIPE SYSTEM

Dry Pipe Sprinkler System

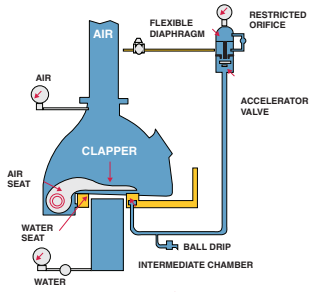
A dry pipe system utilizes automatic sprinklers attached to piping containing air or nitrogen under pressure. Upon activation of the automatic sprinkler, the release of the air or nitrogen from the piping will open a valve and permit the piping to be filled with water and discharge from the opened sprinklers. Dry pipe systems are used in areas where the system is subject to freezing temperatures below 40° F (4° C) (parking garages, unheated warehouses, etc).



PRE-ACTION SYSTEM

Pre-Action Sprinkler System

A pre-action system utilizes automatic sprinklers attached to piping containing air or nitrogen that may or may not be under pressure. Water is only permitted to be released into the piping after a combination of automatic sprinkler activation and the activation of a detection system. Pre-action systems are used in areas where protection from accidental activation is required (data centers, museums, etc.).



DELUGE

Deluge Sprinkler System

A deluge sprinkler system utilizes open sprinklers attached to piping that does not contain any water with water held back by a valve. The valve, which is opened by the activation of a detection system, will allow water to discharge from all of the open sprinklers in the system. Deluge systems are used to protect against fires that spread quickly or for exposure protection.

ITM

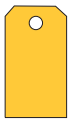
Unlike the plumbing system, the flow within a sprinkler system is static and not constantly flowing; because of this, sprinkler systems require periodic inspection, testing, and maintenance (ITM) to ensure that they will remain operational. Major considerations in the ITM program include ensuring all valves are open, the water supply remains adequate, and the system is not damaged or obstructed in a manner that would prevent water from reaching a fire.

For more information refer to NFPA 13, *Standard for the Installation of Sprinkler Systems*.

Sprinkler Systems Inspection and Testing



NO DEFICIENCIES OR IMPAIRMENTS



NONCRITICAL DEFICIENCIES

- Lightly loaded sprinklers
- Missing escutcheons
- Concealed coverplate with deflector and operating element in correct position
- Sprinkler cabinet missing
- Sprinkler cabinet above maximum permitted temperature
- Sprinkler cabinet — not proper number or type
- Sprinkler cabinet — missing wrench for each type
- Loose hangers and seismic braces
- Gauges not operating or damaged
- Alarm devices physically damaged
- Hydraulic design information sign not attached properly, illegible, or missing
- Information sign not attached, illegible, or missing
- Gauges not replaced or calibrated in 5 years
- Gauges not accurate within 3% of scale
- General information sign not attached, illegible or missing
- Antifreeze information sign not attached, illegible or missing



CRITICAL DEFICIENCIES

- Leaking sprinkler — dripping water
- Minimum clearance to storage not maintained
- SR sprinklers (nonresidential) — one sprinkler heavily loaded or corroded; painted operating element; improper orientation, glass bulb lost fluid; damaged
- Escutcheons caulked or glued to ceiling
- Pipe and fittings leaking — slowly dripping and/or moisture on the surface
- Pipe and fittings with critical mechanical damage
- Hangers and seismic braces unattached or damaged
- Gauges not showing normal water/air pressure
- Heat tape not in accordance with manufacturer's instructions
- Pressure switch or vane-type switch not functioning properly
- Antifreeze mixture and concentrations not appropriate
- Main drain test shows more than 10% drop in full pressure
- Internal assessment reveals presence of MIC, zebra mussels, rust, and scale
- Water motor and gong not functioning
- Sprinklers fail laboratory testing



IMPAIRMENTS

- Leaking sprinkler — spraying or running water
- Sprinkler with foreign material attached or suspended from
- SR sprinklers (nonresidential) — 2+ sprinklers heavily loaded or corroded; painted operating element; improper orientation; glass bulb lost fluid; damaged
- Fast-response sprinklers — one or more sprinklers heavily loaded or corroded; painted operating element; improper orientation; glass bulb lost fluid, damaged
- Coverplates caulked or glued to ceiling
- Missing recessed or flush escutcheons, concealed coverplate with deflector and operating element not in correct position
- Pipe and fittings leaking — spraying or running water
- Gauges (freezer) — system pressure lower than compressor
- Antifreeze concentration inadequate to prevent freezing

Source: Table A.3.3.8



5

SPRINKLER SYSTEMS

Chapter 5 provides requirements for the inspection, testing, and maintenance (ITM) of fire sprinkler systems, the most common type of fire protection systems installed in the built environment. Sprinkler systems are exceptionally reliable, but like any mechanical system, they require attention to remain operational. Unlike other types of building systems, such as plumbing or HVAC, sprinkler systems are relatively static in that they are normally not flowing water. Periodic ITM is necessary to ensure that the system and its components will function as intended in the event of a fire emergency.

5.1 General.

5.1.1 Minimum Requirements.

5.1.1.1 This chapter shall provide the minimum requirements for the routine inspection, testing, and maintenance of sprinkler systems.

As indicated, the ITM tasks and frequencies outlined in this chapter represent "minimum requirements" and, as such, can be exceeded when necessary. For example, if previous inspections routinely revealed storage being placed in a way that violates 5.2.1.2, consideration may be given to increasing the frequency of inspecting the sprinklers in these areas for obstructions to spray patterns.

5.1.1.2 Table 5.1.1.2 shall be used to determine the minimum required frequencies for inspection, testing, and maintenance.

Some of the inspection activities listed in Table 5.1.1.2 can be performed by property owners, their designated representatives, or property maintenance personnel, with a minimal amount of training. For example, the weekly/monthly inspection of gauges and control valves can be performed with some basic training, and the quarterly inspection for the hydraulic nameplate is intended simply to verify that it is attached to the system riser and is legible. The more technical inspection tasks and the testing and maintenance activities required by Table 5.1.1.2 should be performed by a qualified contractor, service provider, or facilities personnel, since these activities require specialized training. (See 3.3.36 for the definition of the term *qualified* and related commentary.)

Tip for Owners

In some cases, actions can be performed by the owner or the owner's representative(s) while the contractor or service provider is present and supervising the activities. Some authorities having jurisdiction (AHJs) or governmental agencies require special licensing of the service provider or individual inspector, so it is recommended to always check with the local fire authority before performing any of the required ITM functions prescribed.

Δ ***TABLE 5.1.1.2*** *Summary of Sprinkler System Inspection, Testing, and Maintenance*

Item	*Frequency*	*Reference*
Inspection		
Assessment of the internal piping condition		Chapter 14
Control valves		Chapter 13
Fire department connections		Chapter 13
Gauges (wet and deluge systems)		Chapter 13
Gauges (dry and preaction systems)		Chapter 13
Hanger/braces/supports	Annually	5.2.3
Heat tracing	Per manufacturer's requirements	5.2.6
Hydraulic design information sign	Annually	5.2.5
Information signs	Annually	5.2.7, 5.2.8, 5.2.9
Pipe and fittings	Annually	5.2.2
Sprinklers	Annually	5.2.1
Sprinklers (spare)	Annually	5.2.1.4
Supervisory signal devices (except valve supervisory switches)		5.2.4, Chapter 13
System valves		Chapter 13
Valve supervisory signal devices		5.2.4, Chapter 13
Waterflow alarm devices	Quarterly	5.2.4
Test		
Antifreeze solution	Annually	5.3.4
Control valves		Chapter 13
Gauges		Chapter 13
Main drain		Chapter 13
Sprinklers	At 50 years and every 10 years thereafter	5.3.1.1.1, 5.3.1.1.1.1, 5.3.1.1.1.2
Sprinklers	At 75 years and every 5 years thereafter	5.3.1.1.1.5
Sprinklers (dry)	15 years and every 10 years thereafter	5.3.1.1.1.6
Sprinklers (extra-high or greater temperature solder type)	5 years	5.3.1.1.1.4
Sprinklers (fast-response)	At 20 years and every 10 years thereafter	5.3.1.1.1.3
Sprinklers (harsh environments)	5 years	5.3.1.1.2
Supervisory signal devices (except valve supervisory switches)		Chapter 13
System valves		Chapter 13
Valve supervisory signal devices		Chapter 13
Waterflow alarm devices (mechanical)	Quarterly	5.3.3.1
Waterflow alarm devices (vane and pressure switch type)	Semiannually	5.3.3.2
Maintenance		
Low-point drains (dry pipe and preaction systems)		Chapter 13
Sprinklers and automatic spray nozzles protecting commercial cooking equipment and ventilation systems	Annually	5.4.1.7
Replacement of sprinklers	Removed for any reason	5.4.1.1
Valves (all types)		Chapter 13
Investigation		
Obstruction		Chapter 14

In addition to the requirements of this chapter, many of the requirements of Chapter 13, Common Components and Valves; Chapter 14, Internal Piping Condition and Obstruction Investigation; and Chapter 15, Impairments, apply to a sprinkler system. Table 5.1.1.2 summarizes the specific minimum requirements of sprinkler system ITM. Note that the "Reference" column contains pointers to sections of the standard. It is important that users of this table refer to those sections for complete information on the task in question. This table, and similar tables in other chapters, are meant to be just what they are titled, a "summary" and not the complete information needed to use, apply, or enforce the standard.

5.1.2 Common Components and Valves. Common components and valves shall be inspected, tested, and maintained in accordance with Chapter 13.

5.1.3 Obstruction Investigations. The procedures outlined in Chapter 14 shall be followed where there is a need to conduct an obstruction investigation.

5.1.4 Impairments. The procedures outlined in Chapter 15 shall be followed where an impairment to protection occurs.

Impairments represent a serious situation and must be dealt with immediately (see the commentary for A.3.3.22). Negative results from some inspections and tests do not necessarily trigger the impairment procedures detailed in Chapter 15. The definitions of the terms *deficiency* (3.3.8), *critical deficiency* (3.3.8.1), and *noncritical deficiency* (3.3.8.2) provide guidance to differentiate between items requiring more immediate attention and those that can be repaired within a reasonable timeframe.

One example of a noncritical deficiency would be a missing hydraulic calculations placard on a hydraulically calculated sprinkler system, which is required by 5.2.5 to be verified annually. Missing this required inspection would not affect the mechanical function of the sprinkler system; therefore, this would be considered a noncritical deficiency. Where there is uncertainty as to whether a deficient item should be considered critical or noncritical, it would be prudent to discuss such items with the local AHJ, the owner, and the insurance provider.

5.1.5 Hose Connections. Hose connections shall be inspected, tested, and maintained in accordance with Chapters 6 and 13.

5.2* Inspection.

A.5.2 The provisions of the standard are intended to apply to routine inspections. In the event of a fire, a post-fire inspection should be made of all sprinklers within the fire area. In situations where the fire was quickly controlled or extinguished by one or two sprinklers, it might be necessary only to replace the activated sprinklers. Care should be taken that the replacement sprinklers are of the same make and model or that they have compatible performance characteristics (*see 5.4.1.2*). Soot-covered sprinklers should be replaced because deposits can result in corrosion of operating parts. In the event of a substantial fire, special consideration should be given to replacing the first ring of sprinklers surrounding the operated sprinklers because of the potential for excessive thermal exposure, which could weaken the response mechanisms.

Chapter 5 includes inspection requirements of varying frequencies, such as weekly, quarterly, or annually, for system components such as sprinklers, piping, gauges, and hangers. Keeping

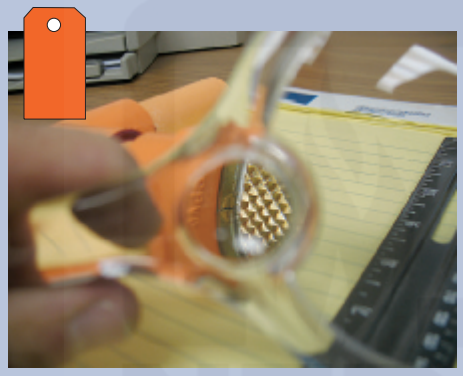
Tip for Owners

While the ITM service providers might have their own standard reporting forms, the owner should require and verify that the form will be acceptable to the AHJ(s) they must answer to. In a hospital, for example, the facility can have a number of AHJs, including the local fire department, the state department of health, the Centers for Medicare and Medicaid Services (CMS), and accreditation agencies, all with an interest in confirming that NFPA 25 tasks are completed. Wherever possible, the owner should ensure that a single version of the reports/forms will be acceptable to all AHJs involved.

track of which of these inspections have been conducted and what deficiencies were noted is critical to maintaining a system in good working order. While NFPA 25 does not contain a specific form that must be filled out, having a form or series of forms that can be used to record the information obtained while conducting an inspection is important. Exhibit 5.1 is an example of a generic form that can be used to record a sprinkler inspection task required by Chapter 5. The form can be used to record the frequency and the information associated with the inspection for any inspection task in Table 5.1.1.2. NFPA has developed a series of electronic forms specific to the ITM requirements throughout NFPA 25. These completely customizable forms are available at www.nfpa.org.

System Tagging

The following photos show a cracked adapter for a nonmetallic piping system. The crack is only noticeable with the aid of a magnifying glass. An inspector would not be expected to see this damaged adapter from the floor level, so it must be assumed that this condition was identified because of a leak or dripping caused by the damage. This would be considered a critical deficiency.





(Courtesy of Byron Blake and SimplexGrinnell)

 Noncritical Deficiency

 Critical Deficiency

 Impairment

5.2.1 Sprinklers.

5.2.1.1* Sprinklers shall be inspected from the floor level annually.

N **A.5.2.1.1** The coverplates of concealed sprinklers do not need to be removed for inspection. Where the inspection of coverplates for concealed sprinklers reveals possible signs of leakage, damage, corrosion, or other adverse conditions, those coverplates should be removed to facilitate a closer inspection of the concealed sprinkler.

5.2.1.1.1* Any sprinkler that shows signs of any of the following shall be replaced:

(1) Leakage
(2) Corrosion detrimental to sprinkler performance
(3) Physical damage
(4) Loss of fluid in the glass bulb heat-responsive element
(5) Loading detrimental to sprinkler performance
(6) Paint other than that applied by the sprinkler manufacturer

WET PIPE SPRINKLER SYSTEMS INSPECTION, TESTING, AND MAINTENANCE

Property Name: _____ **Inspector:** _____

Property Address: _____ **Contract No.:** _____

Property Phone Number: _____ **Date:** _____

Inspection Frequency: ❑ Daily ❑ Weekly ❑ Monthly ❑ Quarterly ❑ Annually ❑ Five Years

Inspections: Daily

❑ Yes	❑ No	❑ N/A	**Valve (Cold Weather/Heating Season Only)**
			Enclosure, not equipped with a low temperature alarm, is inspected during cold weather to verify a minimum temperature of 40°F (4°C)

Inspections: Weekly

			Backflow
❑ Yes	❑ No	❑ N/A	Isolation valves are in open position and locked or supervised
❑ Yes	❑ No	❑ N/A	RPA and RPDA — differential-sensing relief valve operating correctly
			Master Pressure-Regulating Device
❑ Yes	❑ No	❑ N/A	Downstream pressures are in accordance with design criteria _____ psi
❑ Yes	❑ No	❑ N/A	Supply pressure is in accordance with design criteria _____ psi
❑ Yes	❑ No	❑ N/A	Free of damage or leaks
❑ Yes	❑ No	❑ N/A	Trim in good operating condition
			Control Valves
❑ Yes	❑ No	❑ N/A	In the correct (open or closed) position
❑ Yes	❑ No	❑ N/A	Sealed
❑ Yes	❑ No	❑ N/A	Accessible
❑ Yes	❑ No	❑ N/A	Post Indicator Valves (PIVs) are provided with correct wrenches
❑ Yes	❑ No	❑ N/A	Free from damage or leaks
❑ Yes	❑ No	❑ N/A	Proper signage

Inspections: Monthly

❑ Yes	❑ No	❑ N/A	Gauges are in good operating condition
❑ Yes	❑ No	❑ N/A	Gauges — normal unsupervised air and nitrogen pressure maintained _____ psi
			Control Valves (Locked or Supervised)
❑ Yes	❑ No	❑ N/A	In the correct (open or closed) position
❑ Yes	❑ No	❑ N/A	Locked or supervised
❑ Yes	❑ No	❑ N/A	Post Indicator Valves (PIVs) are provided with correct wrenches
❑ Yes	❑ No	❑ N/A	Accessible
❑ Yes	❑ No	❑ N/A	Free from damage or leaks
❑ Yes	❑ No	❑ N/A	Proper signage

NFPA 25 Handbook (p. 1 of 5)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT 5.1 *Sample Form for Automatic Sprinkler Systems: Inspection of Wet Pipe Sprinkler Systems.*

WET PIPE SPRINKLER SYSTEMS INSPECTION, TESTING, AND MAINTENANCE (Continued)

Inspections: Quarterly

❑ Yes	❑ No	❑ N/A	Waterflow alarm and supervisory devices are free of damage
❑ Yes	❑ No	❑ N/A	Gauges — normal air and nitrogen pressure that is supervised by a constantly attended location is maintained _____ psi
❑ Yes	❑ No	❑ N/A	Gauges — normal water pressure is maintained _____ psi
			Alarm Valves/Riser Check
❑ Yes	❑ No	❑ N/A	Gauges — normal water pressure maintained
❑ Yes	❑ No	❑ N/A	Free of damage
❑ Yes	❑ No	❑ N/A	In appropriate open or closed position
❑ Yes	❑ No	❑ N/A	Retard chamber/alarm drains not leaking
			Control Valves (Electronically Supervised)
❑ Yes	❑ No	❑ N/A	In the correct (open or closed) position
❑ Yes	❑ No	❑ N/A	Electronically supervised
❑ Yes	❑ No	❑ N/A	Accessible
❑ Yes	❑ No	❑ N/A	Post Indicator Valves (PIVs) are provided with correct wrenches
❑ Yes	❑ No	❑ N/A	Free from damage or leaks
❑ Yes	❑ No	❑ N/A	Proper signage
			Fire Department Connections
❑ Yes	❑ No	❑ N/A	Visible and accessible
❑ Yes	❑ No	❑ N/A	Coupling/swivels operate correctly
❑ Yes	❑ No	❑ N/A	Plugs/caps are in place
❑ Yes	❑ No	❑ N/A	Gaskets are not damaged
❑ Yes	❑ No	❑ N/A	Automatic Drain Valve in place and operating properly
❑ Yes	❑ No	❑ N/A	Identification signs are in place
❑ Yes	❑ No	❑ N/A	Interior is clear of obstructions (unless locked)
❑ Yes	❑ No	❑ N/A	Clapper(s) operates correctly
❑ Yes	❑ No	❑ N/A	Check valve is not leaking
❑ Yes	❑ No	❑ N/A	Visible piping supplying the fire department connection is undamaged
			Pressure-Reducing Valve
❑ Yes	❑ No	❑ N/A	In the open position and not leaking
❑ Yes	❑ No	❑ N/A	Maintaining downstream pressure
❑ Yes	❑ No	❑ N/A	In good condition, with hand wheel installed and unbroken

Inspections: Annual

❑ Yes	❑ No	❑ N/A	Hydraulic design information sign is securely attached to riser and legible

NFPA 25 Handbook (p. 2 of 5)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT 5.1 *Continued*

WET PIPE SPRINKLER SYSTEMS INSPECTION, TESTING, AND MAINTENANCE (Continued)

Inspections: Annual			**Sprinklers (visible)**
❑ Yes	❑ No	❑ N/A	No damage or leaks
❑ Yes	❑ No	❑ N/A	Free of corrosion, foreign material, or paint
❑ Yes	❑ No	❑ N/A	Installed in proper orientation
❑ Yes	❑ No	❑ N/A	Fluid in glass bulbs
❑ Yes	❑ No	❑ N/A	Spare sprinklers — proper number and type, including installation wrench
❑ Yes	❑ No	❑ N/A	No paint or coating other than that applied by the manufacturer
❑ Yes	❑ No	❑ N/A	Loading — sprinklers are free of dust
❑ Yes	❑ No	❑ N/A	Escutcheons/cover plates are present and installed correctly
❑ Yes	❑ No	❑ N/A	Minimum clearance between sprinklers and storage
			Hangers/Seismic Bracing
❑ Yes	❑ No	❑ N/A	Not damaged or loose
			Pipes and Fittings (visible)
❑ Yes	❑ No	❑ N/A	In good condition and no external corrosion
❑ Yes	❑ No	❑ N/A	No leaks or mechanical damage
❑ Yes	❑ No	❑ N/A	Correct alignment — no external loads
❑ Yes	❑ No	❑ N/A	Heat trace per manufacturer's requirements
			Building
❑ Yes	❑ No	❑ N/A	Wet piping not exposed to freezing temperatures
			Fire Department Connections
❑ Yes	❑ No	❑ N/A	Interior of connection with locked plugs or caps is free of obstructions
Inspections: Five Years			
❑ Yes	❑ No	❑ N/A	Alarm valve interior including strainers, filters, and restriction orifice
❑ Yes	❑ No	❑ N/A	Check valve — internal moves freely and in good condition
❑ Yes	❑ No	❑ N/A	Obstruction inspection — no foreign or obstructing material found
❑ Yes	❑ No	❑ N/A	Backflow — internal inspection
Test: Quarterly			
❑ Yes	❑ No	❑ N/A	Alarm devices — water motor gong
❑ Yes	❑ No	❑ N/A	Main drain test — if the sole supply is through a backflow preventer or pressure-reducing valve Static psi _____ Residual psi _____
❑ Yes	❑ No	❑ N/A	Do main drain test results differ more than 10% from previous test?
			Master Pressure-Regulating Device
❑ Yes	❑ No	❑ N/A	Partial flow test performed to exercise valve
Test: Semiannual			
❑ Yes	❑ No	❑ N/A	Alarm device (vane, paddle, and pressure switch type) — inspector's test or bypass opened and observed flow
❑ Yes	❑ No	❑ N/A	Valve supervisory switch(es) function

NFPA 25 Handbook (p. 3 of 5)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT 5.1 *Continued*

WET PIPE SPRINKLER SYSTEMS INSPECTION, TESTING, AND MAINTENANCE (Continued)

Test: Annual

❑ Yes	❑ No	❑ N/A	All control valves operated through full range of motion and returned to normal position
❑ Yes	❑ No	❑ N/A	Backflow — forward flow test at a minimum flow rate of the system demand
❑ Yes	❑ No	❑ N/A	Valve status test performed
❑ Yes	❑ No	❑ N/A	Antifreeze solution has been tested
❑ Yes	❑ No	❑ N/A	Sprinkler pressure-reducing valve — partial flow test
❑ Yes	❑ No	❑ N/A	Supervisory switch(es) function
			Main Drain Test
			Static psi _____ Residual psi _____
❑ Yes	❑ No	❑ N/A	Do main drain test results differ more than 10% from previous test?
			Master Pressure-Regulating Device
❑ Yes	❑ No	❑ N/A	Full flow test compared to previous test results

Test: Five Years

❑ Yes	❑ No	❑ N/A	Gauges tested or replaced
❑ Yes	❑ No	❑ N/A	Sprinkler pressure-reducing valve — full flow test compared to previous test results
			Fire Department Connections
❑ Yes	❑ No	❑ N/A	Piping from fire department connection to fire department connection check valve has been hydrostatically tested at 150 psi (10 bar) for at least 2 hours

Routine Maintenance

❑ Yes	❑ No	❑ N/A	Sprinklers tested or replaced per appropriate testing schedule
❑ Yes	❑ No	❑ N/A	OS&Y — stems lubricated annually

Comments

Signature: _____ Date: _____

Contractor Name: _____

Contractor Address: _____

License/Certification No.: _____

NFPA 25 Handbook (p. 4 of 5)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT 5.1 *Continued*

WET PIPE SPRINKLER SYSTEMS INSPECTION, TESTING, AND MAINTENANCE (Continued)

This form covers a 6-month period.

Year: **System:**

Location:

General
1. If valves are sealed, note "yes" in this block. If any are not sealed, reseal and note "resealed" in this block.
2. Gauges for dry, preaction, and deluge systems must be inspected for normal air and water pressures.
3–6. Record pressure readings in psi (bar). A loss of more than 10% should be investigated.
7. Record any notes about the system that the inspector believes to be significant. Place a number in the box and corresponding note in space provided below.

Date	Inspector	Valves Sealed (1)	Gauges (2)	Alarm Valve OK (3)	Dry Pipe Valve (4)		Preaction Valve (5)		Deluge Valve Water Pressure (6)	Notes (7)
					Air Static Press.	Water Static Press.	Air Static Press.	Water Static Press.		

Notes:

NFPA 25 Handbook (p. 5 of 5)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT 5.1 *Continued*

Tip for Owners

Paragraph 5.2.1.1.1 and the explanatory information in A.5.2.1.1.1 are important sections for the owner to understand. Sprinklers that, upon inspection, show signs that they will not operate correctly are required to be replaced. However, those with light loading can be cleaned with a vacuum or a blast of compressed air. The owner should work with the service provider to determine how such instances will be identified and communicated and to clarify who is responsible for cleaning the sprinklers of this light loading.

A.5.2.1.1.1 The conditions described in this section can have a detrimental effect on the performance of sprinklers by adversely impacting water distribution patterns, insulating thermal elements delaying operation, or otherwise rendering the sprinkler inoperable or ineffectual.

Severely corroded or loaded sprinklers should be reported as a deficiency or impairment as part of the visual inspection and designated to be replaced. Such sprinklers could be affected in their distribution or other performance characteristics not addressed by routine sample testing.

FAQ How do I inspect sprinklers that are located in a warehouse with high ceilings where it is difficult to determine their condition?

Paragraph 5.2.1.1 requires a visual inspection of sprinklers to reveal obvious signs of damage, leakage, loading, or corrosion. Inspections are conducted from the floor level, because it is usually impractical to get closer to the sprinklers for a more in-depth inspection, and the use of ladders is of limited benefit when compared to the cost. In buildings with high ceilings, a flashlight or binoculars can assist in the inspection of sprinklers, piping, hangers, and other components. When other work is being done at the ceiling level using ladders or lifts, personnel could take advantage of the opportunity of being closer to the sprinklers to inspect the system.

Inspectors who use a flashlight or binoculars must be careful about false positive results, which can occur when the light reflects off the white printing on glass bulb sprinklers. This is also a point of contention with some building owners who mistakenly see the use of additional resources not mandated by the standard, such as a flashlight or binoculars, as an effort to generate service work, as opposed to an effort to ensure a properly working sprinkler system. As with most issues, a little communication goes a long way in helping the owner understand why it is so important to look closely at the sprinklers.

FAQ How much corrosion or loading is acceptable for sprinklers?

In past editions of NFPA 25, the sprinkler inspection criteria in Chapter 5 were designed as pass/fail. For example, sprinklers with corrosion were required to be replaced with no room for judgment. Now, the criteria for sprinkler replacement depend on whether the corrosion or loading is detrimental to sprinkler performance. This introduces a certain level of subjectivity into the inspection of sprinklers and further explains the necessity of those conducting the inspection to be qualified as defined in 3.3.36. Paragraph A.5.2.1.1.1 gives general guidance for how to apply these requirements. Whenever there is a question about how much is too much, testing representative samples in accordance with 5.3.1 is a viable option.

Corrosion found on the seat, or built up on the deflector that could affect the spray pattern, or a buildup on the operating elements that could affect the operation can have a detrimental effect on the performance of the sprinkler. Sprinklers having limited corrosion or loading that does not impact the water distribution characteristics can continue to be used if the samples are selected for testing in accordance with 5.3.1 based on worst-case conditions and if the samples successfully pass the tests. Surface discoloration that does not impact the performance of the sprinkler should not warrant replacement or testing.

Multiple sprinkler operations within a facility without a fire might be a sign of exposure to excessive temperatures, sprinkler damage, or excessive corrosion of similar sprinklers installed in that facility. Consideration should be given to replacing sprinklers that are considered representative of the operated sprinklers.

Glass bulbs in sprinklers exposed to sunlight or installed in cold environments such as walk-in coolers and freezers might lose or change their temperature classification color due to

the environment. This loss of color should not be confused with loss of fluid in the glass bulb. Tests have shown that this loss or change of color in the bulb does not affect the operation or any other performance characteristics of the sprinkler, and these sprinklers can be allowed to remain in service. The tests also showed that when sprinklers installed in cold environments were subjected to temperatures above 60°F (15.5°C), the fluid color returned.

In lieu of replacing sprinklers that are loaded with a coating of dust, it is permitted to clean sprinklers with compressed air or a vacuum, provided that the equipment does not touch the sprinkler.

FAQ Are there situations in which sprinklers can be cleaned of foreign material instead of being replaced?

Sprinklers that have a light coating of dust or dirt can be cleaned with a vacuum or a blast of compressed air; they can also remain in place, provided the sprinklers are not touched or agitated in the process. Exhibit 5.2 shows a sprinkler covered with some dust and cobwebs that could be cleaned with a vacuum or compressed air. However, if the vacuum or compressed air does not clear the debris, the sprinkler would need to be replaced. Under no circumstances should sprinklers be cleaned with bleach, ammonia, or any other household cleaner. Furthermore, attempting to remove paint with a razor blade or utility knife can further compromise the device and is not permitted.

Sprinklers that are heavily loaded with any contaminant such as dirt, dust, grease, or paint must be replaced. Painted sprinklers are never permitted to be cleaned and/or reinstalled, because the potential of damaging the assembly is too great. A "light" overspray or loading can be tolerated when a representative sample is tested to verify that the sprinklers will operate as intended (see A.5.2.1.1.1).

FAQ Is paint permitted on a sprinkler?

NFPA 25 does not permit paint on a sprinkler. This requirement is further clarified in 7.2.5.2 of NFPA 13, *Standard for the Installation of Sprinkler Systems*, which stipulates that sprinklers can be painted only by the manufacturer and that any other painted sprinklers must be replaced. In addition, 5.2.1.1.1(6) stipulates that a sprinkler must be free of paint other than that applied by the manufacturer. The only painting that is permitted is on the coverplate of concealed sprinklers and the frame of fusible link–type sprinklers as indicated in the listing for the sprinkler. It is important to inspect sprinklers from opposing vantage points. Often sprinklers are painted only on the side that faced the painter as the ceiling or structure was sprayed.

Sprinklers that are leaking or that have been damaged must be replaced without testing. Dissolved minerals and other residues in the water can solidify as the sprinkler leaks, hampering the operation of the sprinkler by changing internal clearances or acting like an adhesive, preventing parts from moving as intended. If corrosion is a significant problem, special corrosion-resistant sprinklers can be used.

Exhibit 5.3 through Exhibit 5.9 provide examples of sprinklers that require replacement. In Exhibit 5.3, the sprinkler is clearly corroded; this is an indicator that the other sprinklers in this space should also be carefully examined even if they do not appear initially to have any damage.

Exhibit 5.4 shows a sprinkler with a damaged deflector. Damaged deflectors should not be overlooked, although they can be difficult to detect from the floor level. What might appear to be only slight damage to the deflector can have a drastic impact on the distribution of the spray pattern and the density of the water that is delivered.

Exhibit 5.5 shows a coverplate that has been cut, which is a clear violation of the listing of a concealed sprinkler. In this case, a privacy curtain track was installed retroactively around the sprinkler. Apparently, the track could not be moved and the sprinkler was in the way.



EXHIBIT 5.2 *Light Sprinkler Loading that Can Be Cleaned with Compressed Air. (Courtesy of Byron Blake and SimplexGrinnell)*



EXHIBIT 5.4 *Damaged Sprinkler Deflector. (Courtesy of Wiginton Fire Systems)*



EXHIBIT 5.3 *Corroded Sprinkler. (Courtesy of Wiginton Fire Systems)*



EXHIBIT 5.5 *Damaged Concealed Sprinkler.*

Glass bulb sprinklers operate when the liquid inside the bulb expands until the internal pressure is sufficient to break the glass. Missing liquid or a crack in the bulb will prevent the buildup of pressure inside the bulb and prevent the sprinkler from operating.

In some cases, rough handling of glass bulb sprinklers during shipment or installation can cause minute fractures in the bulb, allowing the fluid to leak out. Exhibit 5.6 shows a glass bulb sprinkler that contains no liquid inside the glass bulb. In this case, the sprinkler will not operate until the glass melts. Care should be taken, however, to verify whether the fluid is in fact gone or has simply lost its color. There have been reports of the fluid becoming clear or pale colored in some situations, particularly in cold environments. Testing has

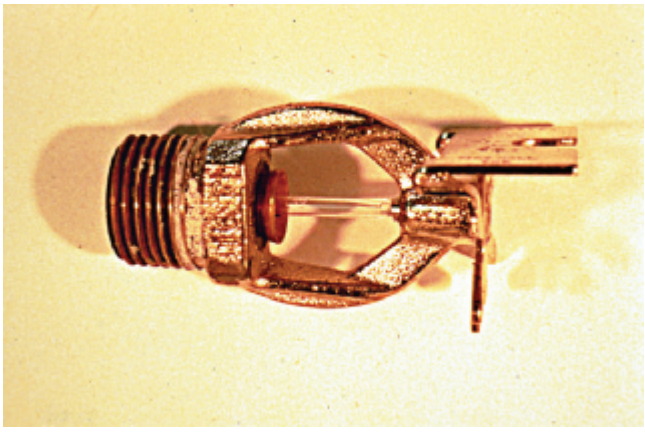


EXHIBIT 5.6 *Glass Bulb Sprinkler Without Fluid. (Courtesy of National Fire Sprinkler Association)*

revealed that these sprinklers operate as designed and do not warrant replacement. If the inspector is unable to determine whether the fluid has leaked out of the bulb or simply lost its color, the sprinkler should be replaced. Annex text in A.5.2.1.1.1 provides information and guidance regarding the potential loss of color in glass bulb heat-responsive elements in field installation environments.

Paint overspray is a common sprinkler problem. Exhibit 5.7 shows a sprinkler that has been hit by overspray from a careless or uninformed painter. Paint spray on the fusible link will inhibit the reaction of the link to heat and slow the operation of the sprinkler. Paint globs in the deflector could impact the spray pattern.

Exhibit 5.8 and Exhibit 5.9 show a loaded sprinkler. In this case, the sprinkler was not covered during a spray-on application process. As a result, the sprinkler deflector has been fouled, which will affect water distribution, and the glass bulb has been coated, which will delay operation.

Exhibit 5.10 shows a leaky sprinkler that was "repaired" and reinstalled in a sprinkler system. The machine bolt is not a fusible element, and this sprinkler will not operate in a fire emergency. Sprinklers should never be repaired; they must be replaced instead.



EXHIBIT 5.7 *Paint Overspray on a Sprinkler.*



EXHIBIT 5.8 *Loaded Sprinkler. (Courtesy of Wiginton Fire Systems)*

Exhibit 5.11 shows a sprinkler that is leaking in a freezer environment. The leak has caused ice to build up and form all around the sprinkler. The sprinkler either has a defect or has been damaged in some way to cause the leak, and it must be replaced.

The requirement in 5.4.1.1 states that when any sprinkler has been removed for any reason, it cannot be reinstalled. This rule applies to any sprinkler of any age that is removed for any purpose.



EXHIBIT 5.9 *Close-Up of Loaded Sprinkler. (Courtesy of Wiginton Fire Systems)*

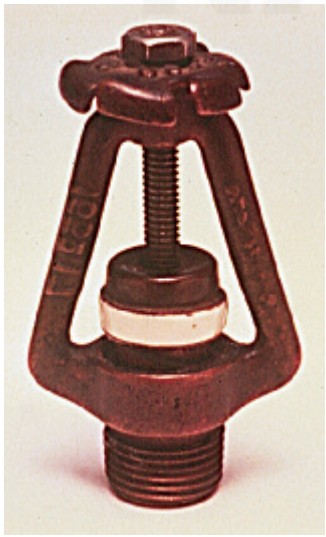


EXHIBIT 5.10 *Sprinkler Leak Stopped and Sprinkler Returned to Service.*



EXHIBIT 5.11 *Frozen Sprinkler. (Courtesy of Shaun K. Wrightson, Koffel Associates, Inc.)*

System Tagging

Loaded and painted heads can be tagged several ways in accordance with Table A.3.3.8. A single standard spray sprinkler in a nonresidential area will commonly be classified as a critical deficiency. However, this rule is not hard and fast, as a further consideration of the occupancy that might be necessary.

A single painted sprinkler in a school or daycare facility, while not classified as residential, might necessitate an impairment tag based on the nature of the occupants. A condition where multiple sprinklers in the same compartment are painted or heavily loaded, such as the ones found in the bucket in this photo, would be considered an impairment.



(Photos courtesy of Byron Blake and SimplexGrinnell)

Noncritical Deficiency Critical Deficiency Impairment

System Tagging

A single residential sprinkler that is painted or heavily loaded would be considered an impairment. Table A.3.3.8 makes a distinction between classifications in residential and nonresidential occupancies, highlighting the importance of not just looking at a single component but getting the complete picture of the facility and the impact of the observed condition in that particular facility.

Noncritical Deficiency Critical Deficiency

Impairment



(Courtesy of Byron Blake and SimplexGrinnell)

The presence of paint or corrosion on a sprinkler can impact not only the activation characteristics of the devices but also the spray pattern development. Exhibit 5.12 shows a severely corroded sprinkler, while Exhibit 5.13 shows a sprinkler with a painted bulb. Exhibit 5.14 shows a sprinkler that has been covered with a spray-applied foam insulation product. All three sprinklers should be replaced immediately, without any attempt to remove the corrosion, paint, or foam.



EXHIBIT 5.12 *Severely Corroded Sprinkler. (Courtesy of Wayne Automatic Fire Sprinklers, Inc.)*



EXHIBIT 5.13 *Painted Sprinkler. (Courtesy of Josh Elvove)*

A common deficiency involving concealed sprinklers is the application of caulking or glue to affix the concealer plate to the underside of the ceiling. The 2013 edition of NFPA 13 was modified to explicitly state that no glues, caulking compounds, or epoxies be used on concealer plates. It is not always easy to identify this condition from the floor level; however, telltale signs include discoloration around the concealer plate or any foreign material that appears to be adjoining the concealer plate and the ceiling, as shown in Exhibit 5.15.



EXHIBIT 5.14 *Sprinkler Encased in Foam Insulation. (Courtesy of Reliable Automatic Sprinkler Company, Inc.)*



EXHIBIT 5.15 *Glued Concealer Plate. (Courtesy of Josh Elvove)*

ITM Deficiency, Impairment, or Hazard Evaluation?

ANSWER: Hazard Evaluation

While performing the annual visual inspection of sprinklers required by 5.2.1.1, an inspector observes several overhead doors without sprinkler protection below them. The inspector has specific knowledge that NFPA 13 requires sprinklers under overhead doors when they create an obstruction more than 4 ft (1.2 m) wide. When open, these doors will extend more than 4 ft (1.2 m) from the walls, and therefore, they should have sprinklers under them.

While the NFPA 25 inspector is required to inspect the system and identify any issues that would impair the system from functioning properly, the inspector is not required to verify the adequacy of the design of the system, as stated in 1.1.3.1. It is unusual for an NFPA document to state that the inspector is required to test the system but does not need to fully understand all aspects of the system, such as the system's design. However, some users of this document believe inspectors should know the design and installation requirements for every system covered by NFPA 25 as well. The NFPA 25 technical committee recognizes that no one person can possibly know all the design and installation requirements in all the different editions of all the water-based fire protection system installation documents. However, if the inspector has specific knowledge of the design and installation requirements and identifies what could be an incorrect installation or an area lacking sprinkler protection, a recommendation for a hazard evaluation should be made to the property owner or the owner's authorized representative.



(Courtesy of Byron Blake and SimplexGrinnell)

System Tagging

A sprinkler that is leaking to this degree must be considered an impairment. In Table A.3.3.8, a distinction is made between "spraying or running" water and "dripping" water. Spraying water, which is what is shown in this photo, would be considered an impairment. A simple drip or a bead of water seeping out of the sprinkler might be considered a critical deficiency. The sprinkler could be damaged and might not activate as it is intended to. This condition would require immediate action because the functionality of the device is in question.



(Courtesy of Byron Blake and SimplexGrinnell)

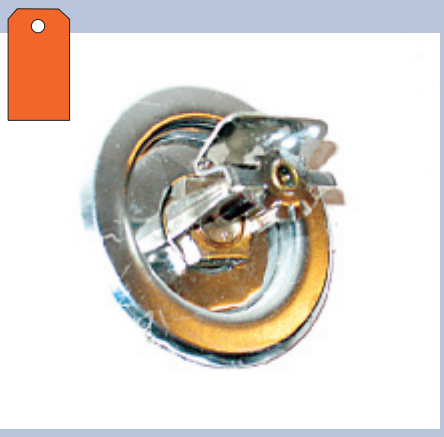
Noncritical Deficiency

Critical Deficiency

Impairment

System Tagging

NFPA 25 requires, as part of the sprinkler inspection, a review for the proper orientation of sprinklers. In this case, the deflector of a horizontal sidewall sprinkler is not parallel to the ceiling. The inspector must use some judgment as to whether or not the degree of misalignment would result in ineffective system operation. A sprinkler that is misaligned will typically leave an excessive shadow area, which is why this is often considered a critical deficiency. However, where the misalignment is negligible, an inspector might consider this a noncritical deficiency.



(Courtesy of Byron Blake and SimplexGrinnell)

Noncritical Deficiency

Impairment

Critical Deficiency

5.2.1.1.2 Any sprinkler that has been installed in the incorrect orientation shall be corrected by repositioning the branchline, drop, or sprig, or shall be replaced.

Exhibit 5.16 through Exhibit 5.18 show examples of sprinklers installed in the incorrect orientation.



EXHIBIT 5.16 *Upright Sprinkler Incorrectly Installed in the Pendent Position.*

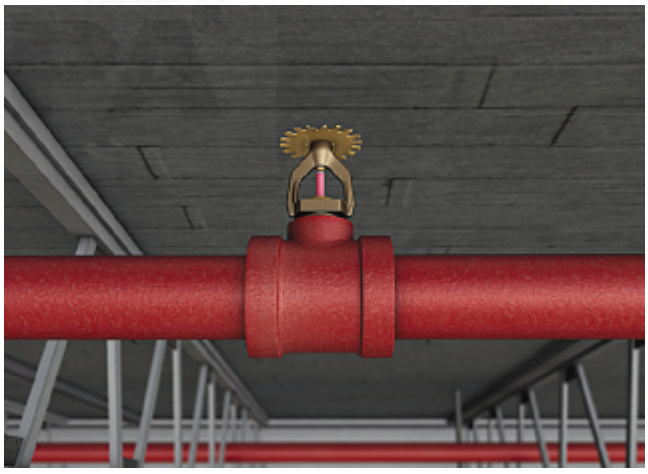


EXHIBIT 5.17 *Pendent Sprinkler Incorrectly Installed in the Upright Position.*

Exhibit 5.19 shows a sidewall sprinkler that is now in open space in an office area. In this instance, a wall had been removed, and rather than replacing the sprinkler with a pendent, the sprinkler was left as previously installed in the wall, which is incorrect. This sprinkler should be replaced in accordance with NFPA 13, taking into consideration the spacing

requirements and the adjacent sprinkler. This is an example of the type of issue that should be addressed when making modifications to the building compartmentation scheme, as noted in 4.1.5 and 4.1.6.

The requirement in 5.2.1.1.2 would not apply where a sprinkler has been intentionally installed in a position other than its listing, such as a pendent sprinkler in the upright position pointed up into the fan motor of a cooling tower.



EXHIBIT 5.18 *Sidewall Sprinkler Incorrectly Installed Upside Down.*



EXHIBIT 5.19 *Sidewall Sprinkler in the Middle of the Room. (Courtesy of M. Steven Welsh, Koffel Associates, Inc.)*

System Tagging

This heavily corroded fitting and section of pipe would be considered a noncritical deficiency. This portion of the system is not actively leaking, which is what drives its classification. However, if there was a significant leak, the condition could be considered critical or even an impairment.



Noncritical Deficiency



Critical Deficiency



Impairment



(Courtesy of Byron Blake and SimplexGrinnell)

ITM Deficiency, Impairment, or Hazard Evaluation?



(Courtesy of Josh Elvove)

ANSWER: Hazard Evaluation

This photo shows a flexible fitting connecting from a branch line outlet to the suspended ceiling below. The listings for flexible fittings limit the number of allowable turns in the fitting as well as the radius of such turns. Excessive bending and looping of the flexible piping will cause the friction losses to skyrocket, which makes the assembly hydraulically inefficient and prevents the correct flow and pressure combination from being discharged during a fire event. That being said, this condition would not be noted on an NFPA 25 inspection form because inspections above the ceiling are outside of the scope of the standard. This is the type of item that, if identified, could be brought to the attention of the owner on a separate list of hazard or hazard evaluation issues that might require an additional inspection beyond the scope of NFPA 25, as noted in the commentary in Chapter 4.

5.2.1.1.3* Sprinklers installed in concealed spaces such as above suspended ceilings shall not require inspection.

A.5.2.1.1.3 Examples include spaces above ceilings, whether the ceilings are lay-in tile or gypsum board, areas under theater stages, pipe chases, and other inaccessible areas, even if access panels or hatches are provided into the areas.

Where temporary listed membrane ceilings are installed, NFPA 13 allows sprinkler protection to be omitted below the "drop out" membrane ceiling. These areas should be inspected during periods when the membrane ceiling is not present.

The requirement in 5.2.1.1.3 provides an exemption from the inspection requirements for sprinklers in concealed spaces on the basis of the two factors that follow:

1. It is extremely costly and impractical to inspect sprinklers in these spaces.
2. The sprinklers are in an inaccessible location, which means that they are less likely to be damaged, painted, or loaded than those in an open space.

Where finished ceiling areas around installed pendent sprinklers show signs of water damage, further investigation should be conducted and the building owner or representative should be notified.

5.2.1.1.4 Sprinklers installed in areas that are inaccessible for safety considerations due to process operations shall be inspected during each scheduled shutdown.

An example of these areas might be sprinklers protecting a conveyor belt system in a manufacturing plant. If the routine inspection happens to fall during a period when the belt is in operation preventing the safe inspection from the floor, coordination of the inspection with a regularly scheduled shutdown of the conveyor system should take place. This section does not, however, eliminate the requirement for annual frequency inspection as required by 5.2.1.1.

Tip for Owners

When work is performed in concealed areas, it is prudent for the owner to have the sprinklers in these spaces inspected after the other work is completed.

5.2.1.1.5 Escutcheons and coverplates for recessed, flush, and concealed sprinklers shall be replaced with their listed escutcheon or coverplate if found missing during the inspection.

5.2.1.1.5.1 Where the listed escutcheon or coverplate from a listed assembly is missing and is no longer commercially available, the sprinkler shall be replaced.

Sprinklers with missing escutcheons and coverplates must be replaced with their listed escutcheon or coverplate, or the entire sprinkler must be replaced. Many times a generic escutcheon or coverplate is installed. This is improper and is addressed by 5.2.1.1.5. Sprinklers do not need to be replaced unless the missing and unavailable coverplate is part of a listed assembly. The focus should be on the "listed assembly" as opposed to the listed coverplate.

5.2.1.1.6 Escutcheons for pendent sprinklers that are not recessed, flush, or concealed shall not be required to be replaced if found missing during the inspection.

Paragraphs 5.2.1.1.5 through 5.2.1.1.6 generate many questions during the inspection process. Many recessed, flush, and concealed sprinklers are listed as part of an assembly with their escutcheons or coverplates. When these pieces are missing, the sprinkler may not perform as designed and must be replaced. For more information, refer to the definition of *deficiency* in 3.3.8. Missing standard escutcheons (sometimes called *beauty rings*) do not affect the performance of the sprinkler system and, therefore, do not meet the definition of a deficiency. Exhibit 5.20 shows a sprinkler with an incomplete escutcheon assembly.



EXHIBIT 5.20 *Sprinkler with Missing Escutcheon.*

5.2.1.2* The minimum clearance to storage as described in 5.2.1.2.1 through 5.2.1.2.6 shall be maintained below all sprinkler deflectors.

Obstructions to sprinkler distribution patterns, such as those referred to in 5.2.1.2, can hamper the effectiveness of sprinklers. Obstructions that are closer than 18 in. (457 mm) below the sprinkler have a greater impact on distribution patterns than do obstructions located further away. NFPA 13 provides guidance on these types of obstructions.

Exhibit 5.21 shows storage piled too close to the sprinklers, which is a common obstruction for sprinklers.

EXHIBIT 5.21 *Typical Obstruction: Storage.*



A.5.2.1.2 NFPA 13 in the storage definitions defines clearance as the distance from the top of storage to the ceiling sprinkler deflectors. Other obstruction rules are impractical to enforce under this standard. However, if obstructions that might cause a concern are present, the owner is advised to have an engineering evaluation performed.

5.2.1.2.1* Unless greater distances are required by 5.2.1.2.2, 5.2.1.2.3, or 5.2.1.2.4, or lesser distances are permitted by 5.2.1.2.6, clearance between the deflector and the top of storage shall be 18 in. (457 mm) or greater.

A.5.2.1.2.1 The 18 in. (457 mm) clearance rule generally applies to standard pendent, upright and sidewall spray sprinklers, extended coverage upright and pendent sprinklers, and residential sprinklers.

5.2.1.2.2 Where standards other than NFPA 13 specify greater clearance to storage minimums, they shall be followed.

5.2.1.2.3* Clearance between the deflector and the top of storage shall be 36 in. (914 mm) or greater for special sprinklers.

A.5.2.1.2.3 The special sprinklers that the minimum 36 in. (915 mm) clearance rule generally applies to includes large drop sprinklers, CMSA sprinklers, and early suppression fast-response (ESFR) sprinklers.

5.2.1.2.4 Clearance from the top of storage to sprinkler deflectors shall be 36 in. (914 mm) or greater where rubber tires are stored.

5.2.1.2.5 In-rack sprinklers shall not be required to meet the obstruction criteria and clearance from storage requirements.

5.2.1.2.6* Clearance between the deflector and the top of storage shall be permitted to be less than 18 in. (457 mm) where shown to be permitted by the installation standard.

An example is described in A.5.2.1.2.6. NFPA 13 permits clearance less than 18 in. (457 mm) where proven by successful full-scale fire tests for the particular hazard. This is a general allowance for all sprinklers. Specific for standard pendent and upright sprinklers, NFPA 13 allows distances less than 18 in. (457 mm) when storage is on shelving on a wall or against a wall and is not directly located below a sprinkler.

A.5.2.1.2.6 The purpose of maintaining a minimum clearance is to ensure water discharge is not obstructed. There are certain installations where this can be achieved by other means. Examples include library stacks, record storage, and where sprinklers are installed in aisles in between storage shelving. Clearance is also not needed for shelving along perimeter walls since this does not cause an obstruction. NFPA 13 allows a clearance less than 18 in. (457 mm) where full-scale fire tests demonstrate an acceptable sprinkler discharge pattern. Also, where sufficient shielding of the sprinkler spray pattern has resulted in an increase in the hazard classification to Extra Hazard Group 2, a clearance less than 18 in. (457 mm) might be acceptable.

5.2.1.3* Storage closer to the sprinkler deflector than permitted by the clearance rules of the installation standard described in 5.2.1.2.1 through 5.2.1.2.4 shall be corrected.

A.5.2.1.3 Sprinkler spray patterns should not be obstructed by temporary or nonpermanent obstructions such as signs, banners, or decorations. While it is impractical for an inspector to know all of the various obstruction rules for all the different types of sprinklers, the inspector can observe when temporary or nonpermanent obstructions have been installed that could block or obstruct a sprinkler's spray pattern. Temporary or nonpermanent obstructions that appear to be obstructions to sprinkler spray patterns should be removed or repositioned so they are not an obstruction.

The 2014 edition of NFPA 25 took a broader look at the storage requirements from NFPA 13 and how they should be reviewed as part of a sprinkler inspection. The requirements in 5.2.1.2 and all of its subsections, along with 5.2.1.3, provide a comprehensive look at the various storage requirements and how they should be treated.

ITM Deficiency, Impairment, or Hazard Evaluation?

ANSWER: Hazard Evaluation

Obstructions to sprinkler discharge are some of the most difficult observations to deal with in NFPA 25. While it appears that there is no wear and tear on the sprinkler, what is not certain is whether or not there is a violation of the NFPA 13 obstruction and spacing rules. Is the obstruction a permanent architectural or structural feature, or is it a mechanical or electrical component that was added after the sprinkler system was installed? Is the obstruction temporary and easily removed or moved away from the sprinkler?

While the proximity of the insulation to the sprinkler shown in this photo is an obvious problem, it is not specifically addressed in NFPA 25, and therefore, this situation should be reported as a recommendation for a hazard evaluation.



(Courtesy of M. Steven Welsh, Koffel Associates, Inc.)

5.2.1.4 The supply of spare sprinklers shall be inspected annually for the following:

(1) The correct number and type of sprinklers as required by 5.4.1.5
(2) A sprinkler wrench for each type of sprinkler as required by 5.4.1.5.5
(3) The list of spare sprinklers as required by 5.4.1.5.6

It is necessary to maintain a supply of spare sprinklers, including all of the types and temperature ratings installed in the system (except for dry sprinklers, as covered in 5.4.1.5.3), to ensure systems can be returned to service immediately following a fire event or where a sprinkler has been damaged. It is important to verify that the spare sprinklers that are provided match the characteristics of the sprinklers installed and that the manufacturer's recommended wrenches that are appropriate for these sprinklers are also provided. For remote locations, it might be prudent to provide more spare sprinklers than those prescribed. A pipe or crescent wrench should never be used to install sprinklers, as these can stress the sprinkler frame and cause the sprinkler to leak. Exhibit 5.22 shows a spare sprinkler cabinet complete with two of each type of installed sprinkler and a sprinkler wrench in the lower cabinet.

EXHIBIT 5.22 *Spare Sprinkler Cabinet.*



5.2.2* Pipe and Fittings. Sprinkler pipe and fittings shall be inspected annually from the floor level.

A.5.2.2 The conditions described in 5.2.2 can have a detrimental effect on the performance and life of pipe by affecting corrosion rates or pipe integrity or otherwise rendering the pipe ineffectual.

The inspection required by 5.2.2 includes checking for the conditions described in 5.2.2.1 and 5.2.2.2. These conditions are identified by a visual inspection from the floor level, because it is usually impractical to get closer to the piping for a more detailed inspection. The use of ladders or lifts is of limited benefit when compared to the cost. As noted with the inspection of sprinklers, a flashlight or binoculars can assist in the inspection of piping in buildings with high ceilings. Where problems are suspected, such as those indicated by a wet spot on the floor, or when other work is being done at the ceiling level using ladders or lifts, the inspector could take advantage of the opportunity of being closer to the piping to inspect the system.

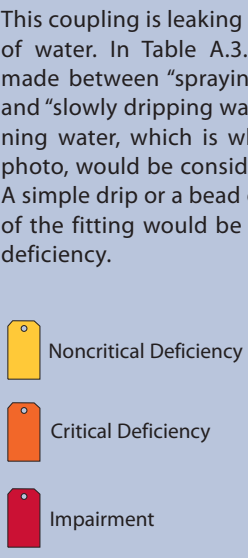
5.2.2.1* Pipe and fittings shall be free of mechanical damage, leakage, and corrosion.

FAQ Is the inspector required to verify piping pitch during the annual inspection?

It can be difficult sometimes to determine the condition of piping corrosion, and mechanical damage might not be evident from the floor level. However, Exhibit 5.23 provides an example of a more obvious problem with corrosion and the need for repair.

System Tagging

This coupling is leaking a significant amount of water. In Table A.3.3.8, a distinction is made between "spraying or running water" and "slowly dripping water." Spraying or running water, which is what is shown in this photo, would be considered an impairment. A simple drip or a bead of water seeping out of the fitting would be considered a critical deficiency.





(Courtesy of Byron Blake and SimplexGrinnell)



EXHIBIT 5.23 *Sprinkler Pipe with Obvious Corrosion and Leaking. (Courtesy of Wiginton Fire Systems)*

It should be noted that installation issues such as piping pitch, pipe size, and type of pipe and fittings are not covered by the annual inspection required by 5.2.2. Where conditions indicate a potential problem, such as level or trapped sections of piping observed while making repairs to a system or section of a system, the owner should be advised that

further investigation might be needed to avoid further problems related to this condition. Exhibit 5.24 features an elbow that shows signs of leakage and corrosion. If not corrected, this condition could worsen and lead to a system impairment.

It is important to remember that the external condition of the pipe is not an indicator of the internal condition of the pipe. Many owners or their designated representatives will not conduct the internal assessment of sprinkler piping that is required by Chapter 14 because there were no pipe segments reported to show external corrosion during the annual inspection. Exhibit 5.25 features piping with no signs of exterior corrosion, but the pipe interior is showing significant corrosion. The absence of exterior corrosion is not a valid reason for not conducting an internal assessment of the piping.



EXHIBIT 5.24 *Elbow with Leakage and Corrosion. (Courtesy of Josh Elvove)*

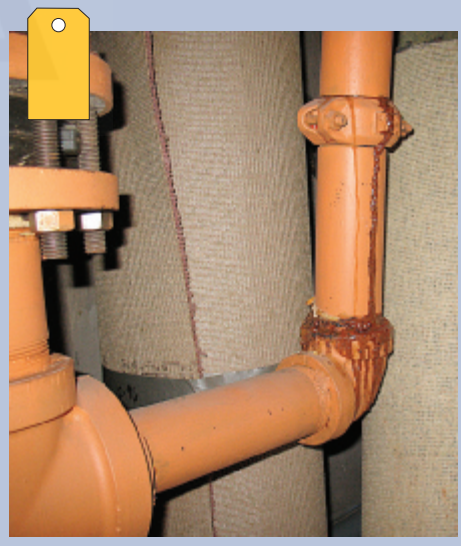


EXHIBIT 5.25 *Piping with Interior Corrosion. (Courtesy of Wiginton Fire Systems)*

System Tagging

This pipe and its multiple fittings are showing signs of corrosion, most likely caused by a coupling that was leaking at some point. The condition as shown is not actively leaking, and therefore, it would be considered a noncritical deficiency.





(Courtesy of Byron Blake and SimplexGrinnell)

A.5.2.2.1 Surface corrosion not impacting the integrity of the piping strength or raising concern of potential leakage should not warrant the replacement of piping. A degree of judgment should be exercised in the determination of the extent of corrosion that would necessitate replacement.

Exhibit 5.26 shows a coupling with a significant amount of rust and corrosion due to a constant leak. Even though the two pieces of pipe that are connected by the coupling show a small amount of surface corrosion, it is not necessary to replace them. The coupling is most likely the culprit and should be replaced and the pipe simply scrubbed clean.

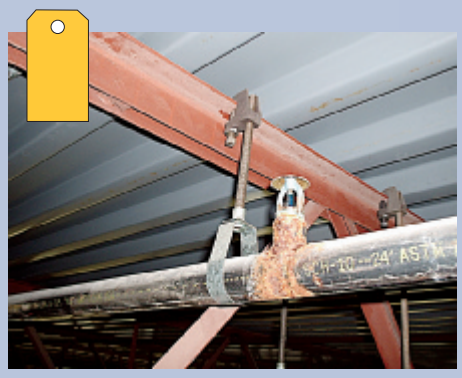


EXHIBIT 5.26 *Coupling Corrosion Caused by Leak. (Courtesy of M. Steven Welsh, Koffel Associates, Inc.)*

5.2.2.2 Sprinkler piping shall not be subjected to external loads by materials either resting on the pipe or hung from the pipe.

System Tagging

In this case, the sprinkler remains intact despite the massive amount of corrosion on the welded outlet. Because the sprinkler does not appear to be of such a condition that activation would be delayed, this would be considered a noncritical deficiency. If the sprinkler itself is corroded and it appears that activation time or spray pattern development might be affected, this would become a critical deficiency.



(Courtesy of Byron Blake and SimplexGrinnell)


Noncritical Deficiency


Critical Deficiency


Impairment

FAQ Is it permissible for small coaxial cable to be wrapped around sprinkler pipe?

Small coaxial cable is not permitted to be wrapped around sprinkler pipe. While the weight of the cable might be negligible, anything that is not a part of the sprinkler system should not be attached to piping. The design of sprinkler piping, fittings, and their supports takes into account the weight of the pipe and water and the normal forces anticipated during sprinkler operation. Although there are safety factors included in the design, the additional weight from other loads is not considered in the design of the system. To be certain that the sprinkler piping is not subjected to undue stress, the standard has adopted a zero-tolerance stance in regard to materials that are not a part of the system. Therefore, equipment, signs, decorations, or other materials should not be hung from, or otherwise supported by, the sprinkler piping. In addition to the potential for failure from the added load, attachments to sprinkler piping can also obstruct sprinklers or hinder their operation. There are exceptions, such as listed linear wire detection systems; they are commonly used for activation of preaction or deluge systems, and can be attached to sprinkler piping where listed for such use. Exhibit 5.27 provides an example of cable wrapped around sprinkler piping, which is not permitted. Exhibit 5.28 shows clothing hanging from a sprinkler guard, which places additional loading on the sprinkler piping, the guard, and the fitting and is also not permitted.



EXHIBIT 5.27 *Cabling Not Permitted to Be Wrapped Around Sprinkler Piping.*

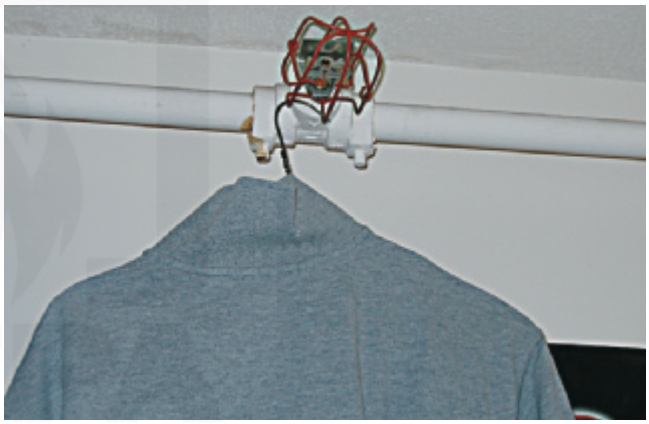


EXHIBIT 5.28 *Overloaded Sprinkler Piping. (Courtesy of Josh Elvove)*

5.2.2.3* Pipe and fittings installed in concealed spaces such as above suspended ceilings shall not require inspection.

A.5.2.2.3 Examples include some floor/ceiling or roof/ceiling assemblies, areas under theater stages, pipe chases, and other inaccessible areas.

The requirement in 5.2.2.3 provides an exemption from the inspection requirements for pipe and fittings in concealed spaces on the basis of the two factors that follow:

1. It is costly and impractical to inspect piping in these spaces.
2. The inaccessibility of such piping means it is less likely to be damaged or otherwise affected than piping in an open space.

Tip for Owners

When other work is performed in concealed areas, it is prudent for the owner to have the pipe and fittings in these spaces inspected after the other work is completed.

5.2.2.4 Pipe and fittings installed in areas that are inaccessible for safety considerations due to process operations shall be inspected during each scheduled shutdown.

See the commentary for 5.2.1.1.4.

5.2.3* Hangers, Braces, and Supports. Sprinkler pipe hangers, braces, and supports shall be inspected annually from the floor level.

The visual inspection of hangers and seismic braces is conducted from the floor level, as specified in 5.2.3, because it is usually impractical to get closer to the hangers and braces for a more detailed inspection. The use of ladders or lifts is of limited benefit when compared to the cost. A flashlight or binoculars can assist in the inspection of hangers and braces in buildings with high ceilings.

Where problems are suspected, or when other work is being done at the ceiling level using ladders or lifts, the inspector might take advantage of the opportunity of being closer to the hangers and braces to inspect the system. However, similar to inspecting piping, it is not always necessary to get close to the hanger or bracing to identify problems. Exhibit 5.29 through Exhibit 5.31 show examples of clear violations of the requirements for hangers. Exhibit 5.29 shows a hanger that has come loose from its connection to the structure. Exhibit 5.30 shows piping being supported by a closet rod hanger that has been used to replace the missing pipe hanger, and Exhibit 5.31 shows a piece of wood that has been used to replace a hanger.



EXHIBIT 5.29 *Hanger Rod Detached from the Ceiling Anchor.*



EXHIBIT 5.30 *Improper Use of a Closet Coat Rod Hanger to Support Pipe.*



EXHIBIT 5.31 *Improper Use of a Board to Support Pipe.*

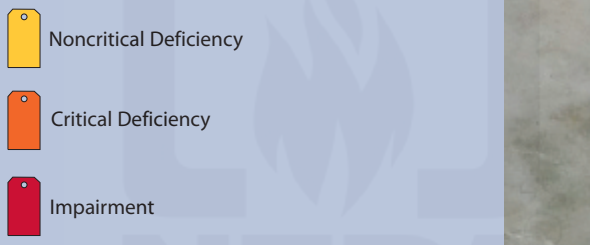
A.5.2.3 The conditions described in this section can have a detrimental effect on the performance of hangers and braces by allowing failures if the components become loose.

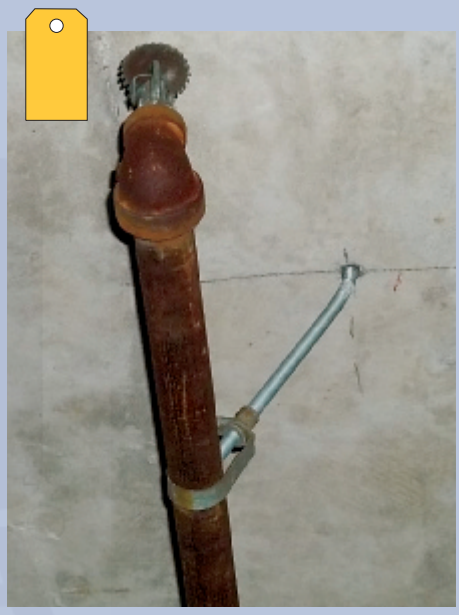
5.2.3.1 Hangers, braces, and supports shall not be damaged, loose, or unattached.

The requirement in 5.2.3.1 is another example of the standard limiting the scope of the inspection to the functionality of the component. Issues such as the spacing, sizing, or type of hanger or seismic brace are not included in the inspection required by 5.2.3. This requirement does not impose the need to physically check that the seismic brace is tight, since the inspection is conducted from the floor per 5.2.3.

System Tagging

A bent hanger rod will not usually have an impact on the functionality of the system, which is why it would typically be considered a noncritical deficiency. If several consecutive hangers are damaged or have failed, it might increase the likelihood for system failure and it would be a different classification.





(Courtesy of Byron Blake and SimplexGrinnell)

ITM Deficiency, Impairment, or Hazard Evaluation?



(Courtesy of Byron Blake and SimplexGrinnell)

ANSWER: Hazard Evaluation

A missing hanger for a sprinkler system is not something that an inspector conducting an annual inspection would be looking for. The spacing of hanging and bracing system components would be considered part of a hazard evaluation.

If, during an inspection, an inspector sees a hanger that has been pulled from the ceiling as evidenced by the hanger ring and threaded rod dangling from the piping, this would be considered a noncritical deficiency. In extreme instances, where the deflection is to the point where it looks like couplings or fittings could fail or are showing signs of leaking, it could be upgraded to a critical deficiency.

5.2.3.2 Hangers, braces, and supports that are damaged, loose, or unattached shall be replaced or refastened.

When hangers or seismic braces are loose, other hangers or braces must support the load. If enough supports need repair, overloading and failure of other hangers or braces can occur. Damaged hangers or braces can also fail. When such conditions are found, the damaged or loose supports must be replaced or refastened as appropriate.

5.2.3.3* Hangers, braces, and supports installed in concealed spaces such as above suspended ceilings shall not require inspection.

Paragraph 5.2.3.3 provides an exemption from the inspection requirements for hangers and seismic braces in concealed spaces on the basis of the two factors that follow:

1. It is costly and impractical to inspect the hangers and braces in these spaces.
2. The inaccessibility of such hangers and braces means they are less likely to be damaged or otherwise affected than hangers and braces in open spaces.

However, when other work is performed in concealed areas, it is a good idea for the owner to have the hangers and braces in these spaces inspected after the other work is completed.

A.5.2.3.3 Examples of hangers and seismic braces installed in concealed areas include some floor/ceiling or roof/ceiling assemblies, areas under theater stages, pipe chases, and other inaccessible areas.

5.2.3.4 Hangers, braces, and supports installed in areas that are inaccessible for safety considerations due to process operations shall be inspected during each scheduled shutdown.

5.2.4 Waterflow Alarm and Supervisory Signal Initiating Device. Waterflow alarm and supervisory signal initiating devices shall be inspected quarterly to verify that they are free of physical damage.

5.2.5* Hydraulic Design Information Sign. The hydraulic design information sign shall be inspected annually to verify that it is provided, attached securely to the sprinkler riser, and is legible.

A.5.2.5 The hydraulic design information sign should be secured to the riser with durable wire, chain, or equivalent. *(See Figure A.5.2.5.)*

This system as shown on _____ company
print no. _____ dated _____
for _____
at _____ contract no. _____
is designed to discharge at a rate of _____
gpm per ft^2 (L/min per m^2) of floor area over a maximum
area of _____ ft^2 (m^2) when supplied
with water at a rate of _____ gpm (L/min)
at _____ psi (bar) at the base of the riser.
Hose stream allowance of _____
gpm (L/min) is included in the above.

FIGURE A.5.2.5 *Sample Hydraulic Design Information Sign.*

Tip for Owners

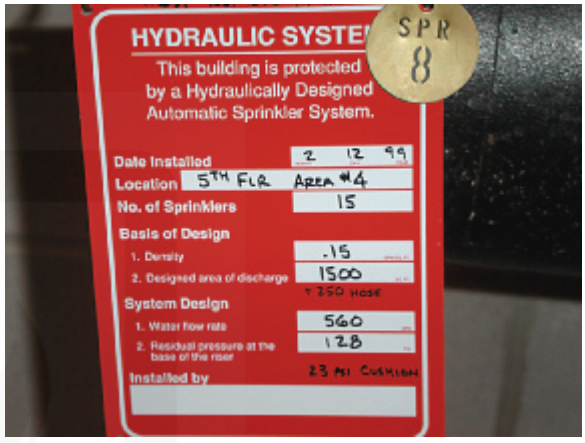
The requirement that the hydraulic design information sign be provided means that it must be in place at the time of inspection for compliance with NFPA 25. If it is found to be missing, collecting the information necessary for the sign may be difficult and costly. However, by complying with the record-keeping requirements of 4.3.4 and maintaining the original design information for the life of the system, creating a new or replacement sign is straightforward and simple.

Subsection 5.2.5 requires that the hydraulic design information sign (also called a nameplate or placard) be inspected on an annual basis. NFPA 13 requires a hydraulic design information sign on hydraulically designed systems so that the design criteria and system demand can be readily determined.

A hydraulic design information sign that is securely fastened to the riser can provide the details when these other data are missing (see Exhibit 5.32). If the sign becomes loose or is difficult to read, it must be repaired or replaced.

A hydraulic design information sign will not be present on systems where the piping diameter was determined by the pipe schedule method. To avoid confusion as to whether the sign is missing or simply not required, NFPA 25 requires pipe schedule systems to be provided with a sign indicating this basis of design.

EXHIBIT 5.32 *Hydraulic Design Information Sign.*



ITM Deficiency, Impairment, or Hazard Evaluation?



(Courtesy of Byron Blake and SimplexGrinnell)

ANSWER: ITM Deficiency

At first glance, this hydraulic design information sign might appear to meet the requirements of 5.2.5 because it is provided and it is securely attached to the riser. It is the final requirement of this section that causes this to be a deficiency. Yes, the preprinted lettering on this sign is legible, but the hydraulic information that is required to be filled in on the sign is not legible because it does not exist.

Although this is considered a noncritical deficiency because it does not hinder the ability of the fire protection system to function in a fire event, the information on this sign is important for hazard and water supply evaluations. The most recent set of working drawings, the hydraulic calculations, and/or other installation documents required by NFPA 13 will need to be reviewed to obtain the needed information. In the absence of the latest installation documents, a hazard evaluation might have to be performed and the required documentation recreated. Once the hydraulic design information has been determined, a new sign should be provided or this sign filled in using a permanent marker.

5.2.5.1 A hydraulic design information sign that is missing or illegible shall be replaced.

5.2.5.2 A pipe schedule system shall have a hydraulic design information sign that reads "Pipe Schedule System."

5.2.6 Heat Tracing. Heat tracing shall be inspected and maintained in accordance with manufacturer's requirements.

5.2.7 Information Sign. The information sign required by 4.1.9 shall be inspected annually to verify that it is provided, securely attached, and legible.

The information sign required by 4.1.9 is in fact required to be added or replaced where missing. It is a rare retrofit requirement to the extent that at a minimum, information related to the four specific items noted in 4.1.9.2 must be provided on system risers so that the owner, owner's representative, or service provider is aware of the presence of these system attachments.

5.2.8* General Information Sign. The general information sign required by NFPA 13 shall be inspected annually to verify that it is provided, securely attached, and legible.

Δ **A.5.2.8** The sign referenced in 5.2.8 should satisfy the requirements of 4.1.9 and 5.2.7. See Figure A.5.2.8.

SPRINKLER SYSTEM — GENERAL INFORMATION

for

_____

_____

_____

Pipe schedule system ❑ Yes ❑ No
High-piled storage ❑ Yes ❑ No
Rack storage: ❑ Yes ❑ No
Commodity class: _____
Max. storage height _____ ft m
Aisle width (min.) _____ ft m
Encapsulation ❑ Yes ❑ No
Solid shelving: ❑ Yes ❑ No
Flammable/ combustible liquids: ❑ Yes ❑ No
Other storage: ❑ Yes ❑ No
_____
Hazardous materials: ❑ Yes ❑ No
Idle pallets: ❑ Yes ❑ No
Antifreeze systems ❑ Yes ❑ No
Location: _____
Dry or aux systems ❑ Yes ❑ No
Location: _____

Date: _____
Flow test data:
Static: _____ psi bar
Resid: _____ psi bar
Flow: _____ gpm lpm
Pitot: _____ psi bar
Date: _____
Location: _____
_____
Location of aux/low point drains:
_____
_____
_____
Dry pipe/double interlock preaction valve test results
_____
Original main drain test results:
Static: _____ psi bar
Residual: _____ psi bar
Venting valve location: _____

Where injection systems are used to treat MIC or corrosion:
Type of chemical: _____ Concentration: _____ For proper disposal, see:
_____
Name of contractor or designer: _____
Address: _____
Phone: _____

N ***FIGURE A.5.2.8*** *Sprinkler System General Information. [**13**:Figure A.28.6]*

Historical Note

The general information sign required by 5.2.8 of NFPA 25 and Section 28.6 of NFPA 13 was introduced in the 2007 edition of NFPA 13 and, as such, should not be expected to be present on systems installed prior. Where the information is known, it is prudent to provide the sign for older systems so that future parties evaluating the system might have easy access to the data provided.

5.2.9 Antifreeze Information Sign. The antifreeze information sign required by 4.1.10 shall be inspected annually to verify that it is present, securely attached, and legible.

With the concern about the hazard introduced by high concentrations of antifreeze solution, it is critical that the details of the antifreeze solution be posted at the antifreeze loop, so that all parties will be aware of what is on hand within a system.

5.3 Testing.

5.3.1* Sprinklers.

A.5.3.1 The sprinkler performance testing described in this section is considered routine testing to determine if the installed sprinklers have maintained a level of sensitivity that would allow them to operate as expected during a fire event. Nonroutine testing should be conducted to address unusual conditions not associated with the routine test cycles mandated within this standard. Due to the nature of nonroutine testing, specific tests cannot be identified in this standard. The type of tests to be conducted and the number and location of samples to be submitted should be appropriate to the problem discovered or being investigated and based on consultation with the manufacturer, listing agency, and the authority having jurisdiction.

Examples of documents that can be used to determine the installation date include the Contractor's Material and Test Certificate for Aboveground Piping or the Certificate of Occupancy. Where documentation of the installation date is not available, the start date for the in-service performance testing interval should be based upon the sprinkler's manufacture date.

The sprinkler testing provisions in NFPA 25, like most of its requirements, are frequency based. For this concept to work, there has to be a starting point. For each of the frequencies in this section, the basis for this starting point is the date of installation. This information can be found in many places — for example, acceptance or commissioning documents, contractor's material and test certificates, and so forth. As a last resort, the sprinkler manufacture date can be used, but it is important to keep in mind that sprinklers may not be installed in the same year in which they are manufactured.

5.3.1.1* Where required by this section, sample sprinklers shall be submitted to a recognized testing laboratory acceptable to the authority having jurisdiction for field service testing.

Sprinklers are extremely reliable and can last as long as the building in which they are installed. However, unlike plumbing, electrical, and HVAC systems, sprinkler systems sit idle for years if no fire emergency occurs. As a result of this idleness, sprinkler system operation and the operation of the sprinkler itself cannot be verified without proper testing.

Paragraph 5.3.1.1 specifies that routine testing is needed to identify potential problems that would otherwise go unnoticed. Sprinklers that have visible signs of damage, that are

leaking, or that are loaded, corroded, or painted are required to be replaced without testing. The test frequency varies based on the sprinkler type or its use.

As sprinklers age, the frequency with which they must be tested increases. For example, standard-response sprinklers are required to be tested after 50 years of service. They must then be retested every 10 years, and after 75 years the testing frequency increases to every 5 years.

FAQ What is the basis for determining whether sprinklers should be tested or simply replaced?

As sprinklers age, they may fail more frequently. As stated in 5.3.1.3, where one sprinkler fails the test, all sprinklers represented by that sample must be replaced. With the improvements being made in sprinkler technology, it might be desirable to replace the aging sprinklers rather than continue testing. In addition, if the sample area is small, it might be most cost-efficient to replace the sprinklers. A cost-benefit analysis is necessary to determine if replacement is the best strategy.

The sprinklers being tested undergo a procedure known as a plunge test. The sprinkler is inserted (or plunged) into a device known as a plunge test apparatus where it is exposed to an airflow that has a controlled velocity and temperature (see Exhibit 5.33, top). The temperature in the device is considerably higher than the operating temperature of the sprinkler. The sprinkler is pressurized with 7 psi (0.5 bar) of air pressure. The amount of time taken for the fusible element or glass bulb to activate is measured. If the sprinkler fails to operate in the specified amount of time, the sprinkler fails the test and all sprinklers represented by the test sprinkler (see Exhibit 5.33, bottom) must be replaced.

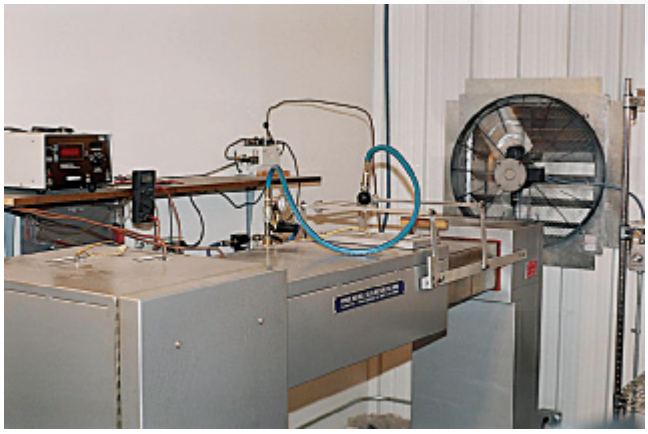




EXHIBIT 5.33 *Plunge Test Apparatus (top) and Test Sprinkler (bottom).*

Δ **A.5.3.1.1** Sprinklers should be first given a visual inspection in accordance with 5.2.1.1.1 to determine if replacement is required. Sprinklers that have passed the visual inspection should then be laboratory tested for sensitivity and functionality. The waterway should clear when sensitivity/functionality tested at 7 psi (0.5 bar) or the minimum listed operating pressure for dry sprinklers.

The thermal sensitivity should be such that the RTI does not exceed 350 (meters-seconds)$^{1/2}$ for standard-response sprinklers, 65 (meters-seconds)$^{1/2}$ for quick-response and residential sprinklers and 50 (meters-seconds)$^{1/2}$ for ESFR sprinklers.

Sprinklers that have been installed for a number of years should not be expected to have all of the performance qualities of a new sprinkler. However, if there is any question about their continued satisfactory performance, the sprinklers should be replaced.

5.3.1.1.1 Where sprinklers have been installed for 50 years, they shall be replaced or representative samples from one or more sample areas shall be tested.

FAQ Where are the requirements found for testing 1 percent of piping and sprinklers when they reach 50 years old?

Paragraph 5.3.1.1.1 addresses the removal and testing of standard spray sprinklers after a service period of 50 years. Piping is not involved in this particular test. The correct quantity of sprinklers based on the total from 5.3.1.2 is removed and sent to an approved testing lab for evaluation of the response time index (RTI). The subsections of 5.3.1 should be reviewed carefully, because the test frequency varies based on the sprinkler type and use. Paragraph 5.3.1.2 addresses the number of sprinklers that must be removed for testing.

5.3.1.1.1.1 Test procedures shall be repeated at 10-year intervals.

5.3.1.1.1.2 Sprinklers manufactured prior to 1920 shall be replaced.

5.3.1.1.1.3* Sprinklers manufactured using fast-response elements that have been installed for 20 years shall be replaced or representative samples shall be tested and then retested at 10-year intervals.

Quick-response sprinklers, as defined in 3.3.42.14, are a relatively recent advancement in sprinkler technology, appearing in the industry in the early 1980s. The 20-year (rather than the typical 50-year) testing frequency requirement in 5.3.1.1.1.3 is included in the standard because the long-term performance of these relatively new sprinklers is not yet known. The reduced frequency is intended to identify potential problems early in the life cycle of quick-response sprinklers, rather than waiting for the 50-year test required of sprinklers whose performance is well known. As more quick-response sprinklers are tested over the next few years, the Committee on Inspection, Testing, and Maintenance of Water-Based Systems intends to monitor their performance and adjust the test frequency requirement if no significant problems are identified.

To determine the age of sprinklers in a system, the inspector often examines the sprinklers in the spare sprinkler cabinet. However, if a building has undergone renovations or if the spare sprinklers have been replaced over the years, they might not be the same age as those in the system. In addition, the age of the sprinklers might not be the same as the sprinklers' years in service. In some cases, sprinklers could be a couple of years old before they are actually installed in a system. Therefore, the inspector should not rely exclusively on examining the spare sprinklers to determine the age of the sprinklers in the system, but rather, they should review the building completion documents or other data to determine when the system went into service.

FAQ Are glass bulb sprinklers an exception to the requirement in 5.3.1.1.1.3?

Although glass bulb sprinklers have a different operating mechanism and other types of failure for these sprinklers are possible, such as corrosion around the seat, contamination, and loading, there is no exception for testing glass bulb–type sprinklers at any other testing frequency.

A.5.3.1.1.1.3 Sprinklers defined as fast response have a thermal element with an RTI of 50 (meters-seconds)$^{1/2}$ or less. A quick-response sprinkler, residential sprinkler, and early suppression fast-response (ESFR) sprinklers are examples of fast-response sprinklers.

5.3.1.1.1.4* Representative samples of solder-type sprinklers with a temperature classification of extra high [325°F (163°C)] or greater that are exposed to semicontinuous to continuous maximum allowable ambient temperature conditions shall be tested at 5-year intervals.

A.5.3.1.1.1.4 Due to solder migration caused by the high temperatures to which these devices are exposed, it is important to test them every 5 years. Because of this phenomenon, the operating temperature can vary over a wide range.

5.3.1.1.1.5 Where sprinklers have been installed for 75 years, they shall be replaced or representative samples from one or more sample areas shall be submitted to a recognized testing laboratory acceptable to the authority having jurisdiction for field service testing and repeated at 5-year intervals.

5.3.1.1.1.6* Dry sprinklers that have been installed for 15 years shall be replaced or representative samples shall be tested and then retested at 10-year intervals.

FAQ Do dry sprinklers have to be tested, or can they be replaced?

Replacing all the dry-type sprinklers in a sample area, rather than testing them, is always an option. Experience with dry-type sprinklers has indicated a much higher failure rate than with standard sprinklers and a greater susceptibility to corrosion both internally, when moisture condenses inside the device, and externally.

FAQ Does 5.3.1.1.1.6 apply to listed dry sprinklers, or does it apply to all sprinklers installed in a dry pipe system?

Paragraph 5.3.1.1.1.6 refers to the listed dry-type sprinkler. The requirement does not apply to standard spray sprinklers installed on a dry pipe system.

Historical Note

Prior to the 2020 edition, NFPA 25 had a 10-year threshold requirement that was added to the 2002 edition. At the time, not all of the conditions that cause failures were well understood, and the frequency of failures was higher for sprinklers that had been in service for more than 10 years. Design changes have been made to dry sprinklers where dynamic O-ring seals are no longer used. As a result, dry sprinklers are performing quite well and thus the requirement has been modified from the initial 10-year requirement to 15 years.

A.5.3.1.1.1.6 See 3.3.42.4.

5.3.1.1.2* Sprinklers exposed to harsh environments, including corrosive atmospheres, shall be one of the following:

(1) Replaced
(2) Tested via representative sprinkler on a 5-year basis

Δ **A.5.3.1.1.2** Examples of these environments are paper mills, packing houses, tanneries, alkali plants, organic fertilizer plants, foundries, forge shops, fumigation areas, pickle and vinegar works, stables, storage battery rooms, electroplating rooms, galvanizing rooms, steam rooms of all descriptions including moist vapor dry kilns, salt storage rooms, locomotive sheds or houses, driveways, areas exposed to outside weather, around bleaching equipment in flour mills, and portions of any area where corrosive vapors prevail.

N **5.3.1.1.3** Listed corrosion-resistant sprinklers installed in harsh environments shall be permitted to be tested on a 10-year basis.

Paragraph 5.3.1.1.3 is new to the 2020 edition of NFPA 25 and provides a specific test requirement for corrosion-resistant sprinklers of 10 years, which differs from other sprinklers that are installed in harsh environments as identified in 5.3.1.1.2. This is because corrosion-resistant sprinklers are specifically tested and listed for use in harsh environments.

5.3.1.1.4 Where historical data indicate, longer intervals between testing shall be permitted.

5.3.1.2* A representative sample of sprinklers for testing per 5.3.1.1 shall consist of a minimum of not less than four sprinklers or 1 percent of the number of sprinklers per individual sprinkler sample, whichever is greater.

The requirement in 5.3.1.2 for a minimum sample of four sprinklers or 1 percent of the total number of sprinklers installed is intended to balance the cost of testing with the likelihood of identifying a possible problem. The sample should be somewhat random and should be representative of the sprinklers installed in the system. For example, sprinklers should be selected from different floors or areas of the building and not selected simply because they are more accessible than other sprinklers. In addition, the selection should take into consideration the age and types of sprinklers as well as the environmental conditions to which they are subjected.

The inspector and/or the owner can determine which groups of sprinklers the sprinkler sample represents. Keep in mind that if a single sprinkler from the sample fails the plunge test, all the sprinklers that the sample represents must be replaced. The sample can represent an entire system or one floor of a multi-story building.

FAQ Can the sprinklers in the spare sprinkler cabinet be used to comply with 5.3.1.2?

Note that only sprinklers that have been exposed to service conditions must be tested. The sprinklers in the spare sprinkler cabinet, for example, have not been exposed to service conditions and might not reveal any deficiencies.

A.5.3.1.2 Within an environment, similar sidewall, upright, and pendent sprinklers produced by the same manufacturer could be considered part of the same sample, but additional sprinklers would be included within the sample if produced by a different manufacturer.

The sample sprinklers sent for testing can represent any group of sprinklers that is practical, keeping in mind that if one sprinkler in the sample set fails, then all sprinklers that the sample represents should be replaced. The following is an example of sample sprinklers chosen for testing:

Example:
A warehouse has five overhead systems with 300 sprinklers per system, and an office area with 200 sprinklers. The warehouse sprinklers are all subject to the same ambient environment and all of the office area sprinklers are subjected to the same ambient environment.

Sample Option #1: All warehouse sprinklers as one sample set (1% of 1500 = 15 sprinklers).
All office sprinklers as one sample set (1% of 200 = 2, but a minimum of 4 sprinklers must be tested).
Total of 19 sprinklers tested.

Sample Option #2: Each warehouse system sample set (1% of 300 = 3, but a minimum of 4 sprinklers must be tested, 4 × 5 = 20 sprinklers).
All office sprinklers as one sample set (1% of 200 = 2, but a minimum of 4 sprinklers must be tested).
Total of 24 sprinklers tested.

As shown, the number of sprinklers to be tested would be different depending on the sample chosen.

5.3.1.3 Where one sprinkler within a representative sample fails to meet the test requirement, all sprinklers within the area represented by that sample shall be replaced.

The number of sprinklers selected for testing as specified in 5.3.1.2 is a minimum and will not guarantee that all problems will be discovered. As a result, when a single sprinkler fails, there is a high probability that other sprinklers will also fail. Therefore, 5.3.1.3 requires that all of the sprinklers represented by the sample be replaced.

5.3.1.3.1 Manufacturers shall be permitted to make modifications to their own sprinklers in the field with listed devices that restore the original performance as intended by the listing, where acceptable to the authority having jurisdiction.

N **5.3.2 Electrically Operated Sprinklers.**

N **5.3.2.1** Electrically operated sprinklers shall be tested in accordance with the manufacturer's requirements.

N **5.3.2.2** The testing of the electronic actuation and supervision shall be in accordance with the manufacturer's requirements and *NFPA 72* or the local fire alarm code.

5.3.3 Waterflow Alarm Devices.

See 13.2.6 for the recommended operational procedure.

5.3.3.1 Mechanical waterflow alarm devices including, but not limited to, water motor gongs, shall be tested quarterly.

5.3.3.2* Vane-type and pressure switch–type waterflow alarm devices shall be tested semiannually.

A.5.3.3.2 Data concerning reliability of electrical waterflow switches indicate no appreciable change in failure rates for those tested quarterly and those tested semiannually. Mechanical motor gongs, however, have additional mechanical and environmental failure modes and need to be tested more often.

The waterflow alarm is a key part of the sprinkler system and must be tested. Paragraphs 5.3.3.1 and 5.3.3.2 take into account that each type of waterflow alarm has its own failure modes and that some are more susceptible than others to environmental conditions. For example, water motor gongs (see Exhibit 5.34, top) might be affected more by

environmental conditions, such as bird or wasp nests or freezing (see Exhibit 5.34, bottom), than would be an electric alarm initiating device such as a pressure switch or vane-type flow switch. For more information on alarm devices, see the commentary following 13.2.6.



EXHIBIT 5.34 *Water Motor Alarm Gong (top) and Water Motor Gong with Wasp Nests (bottom).*

5.3.3.3 Testing of pressure switch–type waterflow alarm devices on wet pipe systems shall be accomplished by opening the inspector's test connection.

5.3.3.3.1 Where freezing weather conditions or other circumstances prohibit use of the inspector's test connection, the bypass connection shall be permitted to be used.

The inspector's test connection should be arranged to facilitate testing. The valve should be readily accessible and the discharge should be directed so that the flow of water does not cause damage or unsafe conditions. If an inspector's test valve cannot be accessed, or if there are conditions where the flow discharges to a location that does not allow testing, the situation should be corrected. Care should always be taken prior to discharging water to ensure proper drainage to an acceptable location where no property will be damaged.

5.3.3.4 Except as permitted in 5.3.3.4.1, testing of vane-type waterflow alarm devices on wet pipe systems shall be accomplished by a flow of water equivalent to the flow out of the smallest single k-factor sprinkler (or smaller) past the flow switch.

N **5.3.3.4.1** A vane-type waterflow alarm device listed with an integral automated test feature that is capable of verifying the presence of water at the location of the water flow alarm device and function of the water flow device and alarm shall be permitted to be used.

5.3.3.4.2 Vane-type waterflow alarm devices tested semiannually using circulated water or as described in 5.3.3.4.1 shall be tested by opening the inspector's test connection at a minimum frequency of once every 3 years.

The use of water-saving methods and automated testing practices continues to grow and be recognized by the NFPA 25 technical committee. The requirement to physically perform and witness these tests on an occasional basis is part of the transition toward these concepts. As they become more commonplace and their reliability can be verified, it might not be unusual for requirements such as 5.3.3.4.2 to eventually be removed.

5.3.3.5 Fire pumps shall not be taken out of service during testing unless constantly attended by qualified personnel or all impairment procedures contained in Chapter 15 are followed.

It is vital that water supplies remain in service during testing for the following reasons:

1. Turning off fire pumps creates an impairment.
2. Sprinkler systems designed to be supplied by a fire pump might not perform properly without the flow and pressure the pump provides.
3. Testing the waterflow device with the fire pump in service simulates the conditions in which it is expected to operate.

Testing with the fire pump turned on exercises the pump and ensures that adequate water will be available should a fire occur during the test. It is required that an attendant be present in the pump room during operation. When it is necessary to shut down water supplies during testing, extra care and coordination are required to ensure that the pump or other water supply can be promptly returned to operation in case of emergency. It will also be necessary to apply all of the requirements in Chapter 15 of NFPA 25 whenever a pump is taken out of service. See NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, for more information on fire pump operation.

5.3.4* Antifreeze Systems. Annually, before the onset of freezing weather, the antifreeze solution shall be tested using the following procedure:

(1) Using the antifreeze information sign required by 4.1.10, installation records, maintenance records, information from the owner, chemical tests, or other reliable sources of information, the type of antifreeze in the system shall be determined and (a) or (b) implemented if necessary:
   (a) If the antifreeze is found to be a type that is no longer permitted, the system shall be drained completely and the antifreeze replaced with an acceptable solution.
   (b) If the type of antifreeze cannot be reliably determined, the system shall be drained completely and the antifreeze replaced with an acceptable solution in accordance with 5.3.4.4.

(2) If the antifreeze is not replaced in accordance with 5.3.4(1)(a) and 5.3.4(1)(b), test samples shall be taken at the top of each system and at the bottom of each system as follows:
   (a) If the most remote portion of the system is not near the top or the bottom of the system, an additional sample shall be taken at the most remote portion.
   (b) If the connection to the water supply piping is not near the top or the bottom of the system, an additional sample shall be taken at the connection to the water supply.
(3) The specific gravity of each solution shall be checked using a hydrometer with a suitable scale or a refractometer having a scale calibrated for the antifreeze solution.
(4) If any of the samples exhibits a concentration in excess of what is permitted by 5.3.4.4, the system shall be emptied and refilled with a new acceptable solution.
(5) If a concentration greater than what is currently permitted by 5.3.4.4 was necessary to keep the fluid from freezing, alternative methods for preventing the pipe from freezing shall be employed.

Testing Procedure Alert

In recent years, the sprinkler industry found out how dangerous antifreeze can be in a sprinkler system when concentrations of the solution are too high. It is imperative that the exact type of solution and the concentration of the solution are known before considering leaving an antifreeze solution in a system. All antifreeze solutions in existing systems must comply with 5.3.4.4.1. See the Case In Point on p. 169 for additional information. For more information about testing antifreeze systems, please refer to the detailed testing procedure at the end of this chapter.

Δ **A.5.3.4** Sampling from the top and bottom of the system helps to determine if the solution has settled. Antifreeze solutions are heavier than water. If the antifreeze compound is separating from the water due to poor mixing, it will exhibit a higher concentration in the lower portion of the system than in the upper portion of the system. If the concentration is acceptable near the top, but too low near the water connection, it might mean that the system is becoming diluted near the water supply. If the concentration is either too high or too low in both the samples, it might mean that the wrong concentration was added to the system.

Two or three times during the freezing season, test samples can be drawn from test valve B as shown in Figure 8.6.3.1 of NFPA 13, especially if the water portion of the system has been drained for maintenance or repairs. A small hydrometer can be used so that a small sample is sufficient. Where water appears at valve B, or where the sample indicates that the solution has become weakened, the entire system should be emptied and refilled with acceptable solution as previously described.

See Figure A.5.3.4 for expected minimum air temperatures in 48 of the United States and parts of Canada where the lowest one-day mean temperature can be used as one method of determining the minimum reasonable air temperature. In situations where the piping containing the antifreeze solution is protected in some way from exposure to the outside air, higher minimum temperatures can be anticipated.

Where systems are drained in order to be refilled, it is not typically necessary to drain drops. Most systems with drops have insufficient volume to cause a problem, even if slightly higher concentration solutions collect in the drops. For drops in excess of 36 in. (915 mm), consideration should be given to draining drops if there is evidence that unacceptably high concentrations of antifreeze have collected in these long drops.

When emptying and refilling antifreeze solutions, every attempt should be made to recycle the old solution with the antifreeze manufacturer rather than discard it.

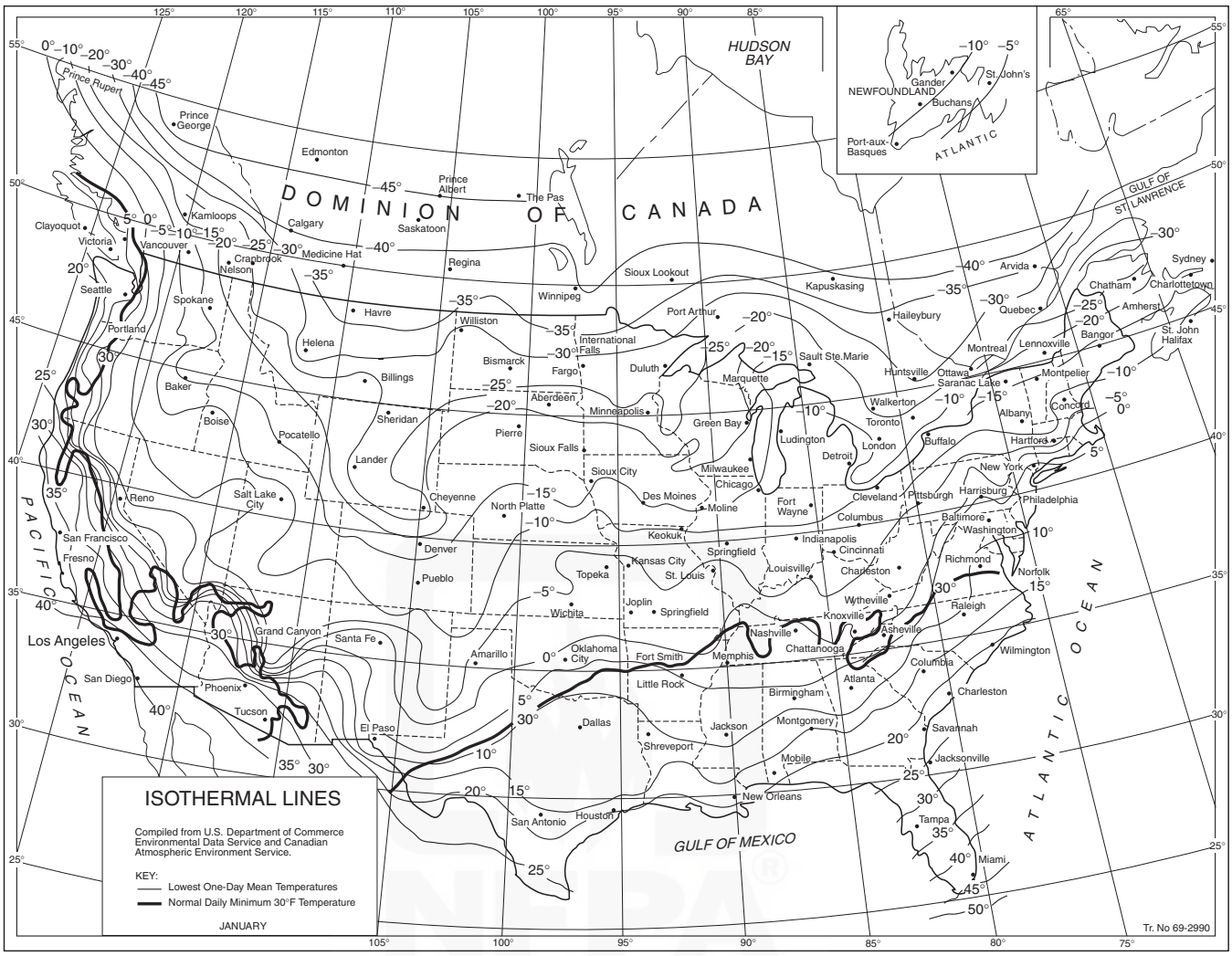


FIGURE A.5.3.4 *Isothermal Lines — Lowest One-Day Mean Temperature (°F). [**24**:Figure A.10.5.1]*

Historical Note

After a series of fires where the presence of antifreeze in the system negatively contributed to the fire, the NFPA sprinkler committees responsible for NFPA 13 and NFPA 25 prepared a series of Tentative Interim Amendments (TIAs) to the standards to reflect the most up-to-date information on antifreeze.

This included a series of TIAs that were approved by the NFPA Standards Council following the printing of the 2011 edition of NFPA 25. These TIAs were written to the 2011 edition of the standard, but the content provided in them was also picked up by the NFPA 25 technical committee in the 2014 revision cycle.

The revisions to the testing section for antifreeze systems require that a sample of the antifreeze solution be tested every year before the onset of freezing weather.

5.3.4.1 The antifreeze solution shall be tested at its most remote portion and where it interfaces with the wet pipe system.

5.3.4.2 Where antifreeze systems have a capacity larger than 150 gal (568 L), tests at one additional point for every 100 gal (379 L) shall be made.

Case In Point

The first photo shows an antifreeze solution test outlet and a test sample being collected and analyzed. Another photo shows an antifreeze loop with a test outlet and an expansion tank. With the use of a refractometer, such as the one shown in the final photo, the percentage of water and antifreeze in a given solution can be determined. The importance of this test cannot be understated, because it provides the owner and inspector with the concentration of the solution in the system. Certain concentrations of antifreeze have been proven in full-scale testing to significantly increase the heat release rate of a fire.







Antifreeze Testing. Obtaining an Antifreeze Sample by Draining a Small Quantity of Antifreeze from the Antifreeze System (top). Applying the Antifreeze Test Sample to a Refractometer (middle). Reading the Refractometric Index of the Antifreeze Sample by Holding the Refractometer Up to a Natural Light Source (bottom).



Antifreeze Loop. (Courtesy of Josh Elvove)



Digital Refractometer. (Courtesy of MISCO Refractometer, Cleveland, OH)

Beginning with the 2013 editions of NFPA 13 and NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies,* only listed antifreeze solutions are permitted. This is due to the unpredictability of traditional antifreeze solutions, as identified in the full-scale testing presented in "Antifreeze Solutions Supplied through Spray Sprinklers: Final Report," from the Fire Protection Research Foundation (FPRF). NFPA 25 also adopted this philosophy as a baseline requirement, but it contains several exceptions for existing systems, as identified in 5.3.4.4.1.

5.3.4.2.1 If the results indicate an incorrect freeze point at any point in the system, the system shall be drained and refilled with new premixed antifreeze.

5.3.4.2.2 For premixed solutions, the manufacturer's instructions shall be permitted to be used with regard to the number of test points and the refill procedure.

5.3.4.3 The use of antifreeze solutions shall be in conformity with state and local health regulations.

5.3.4.3.1* Listed CPVC sprinkler pipe and fittings shall be protected from freezing with glycerine only.

A.5.3.4.3.1 Where inspecting antifreeze systems employing listed CPVC piping, the solution should be verified to be glycerine based.

5.3.4.3.1.1 The use of diethylene, ethylene, or propylene glycols shall be specifically prohibited.

Case In Point

As mentioned in the commentary associated with 5.3.4 and A.5.3.4, ascertaining the correct antifreeze concentration through a test sample is critical, as 5.3.4.4.1 provides several thresholds based on the determined concentration.

First, this requirement identifies that solutions with concentrations of antifreeze in excess of 40 percent propylene glycol and 50 percent glycerine should never be permitted in a sprinkler system. This concept is supported by full-scale testing using both residential and standard spray sprinklers where it was found that concentrations in excess of these values were prone to large-scale ignition under certain conditions, such as pressure, ceiling height, or K-factor.

Secondly, antifreeze solutions at or below 30 percent propylene glycol and 38 percent glycerine are permitted to remain in the system, as testing summarized in an FM Technical Report, "K-25 Suppression Mode Sprinkler Protection for Areas Subject to Freezing," shows that these solutions are diluted to the point where no increase in heat release rate was noted when the solution was discharged onto a fire.

These two thresholds leave a gray area between 30 percent and 40 percent propylene glycol and 38 percent and 50 percent glycerine where in some cases these solutions might be acceptable and in others they might not be. The determination of whether or not a particular solution within these ranges is acceptable would be made by the AHJ, based on the data provided in a deterministic risk. The term *deterministic* is important because it requires the individual preparing the assessment to assume there is a fire. If a risk assessment was conducted in which the author stated that, "There won't be a fire, so I don't have to worry about the concentration of the antifreeze solution," then it would not be considered a deterministic approach and, therefore, would not be valid.

Also note that the technical committee has approved language that would phase out traditional antifreeze solutions by 2022. This allows combustible solutions to be used in the interim but recognizes that using a combustible liquid in a life safety system is not ideal. This time allotment gives property owners time to budget for system modifications that consider alternative methods of freeze protection; it also allowed manufacturers time to develop listed noncombustible solutions. Currently, a listed solution is available.

5.3.4.4 Except as permitted by 5.3.4.4.1 and 5.3.4.4.3, all antifreeze systems shall utilize listed antifreeze solutions.

5.3.4.4.1* For systems installed prior to September 30, 2012, listed antifreeze solutions shall not be required until September 30, 2022, where one of the following conditions is met:

(1)* The concentration of the antifreeze solution shall be limited to 30 percent propylene glycol by volume or 38 percent glycerine by volume.

A.5.3.4.4.1(1) The use of factory premixed solutions is required because solutions that are not mixed properly have a possibility of separating from the water, allowing the pure concentrate (which is heavier than water) to drop out of solution and collect in drops or low points of the system. Such concentrations are combustible and could present problems during fires. The properties of glycerine are shown in Table A.5.3.4.4.1(1).

The freeze points provided in Table A.5.3.4.4.1(1) might not be appropriate for all manufactured solutions at the concentrations noted. The installer should confirm the amount of freeze protection that the selected solution provides and not simply assume that it will line up with the values in these tables.

(2)* Antifreeze systems with concentrations in excess of 30 percent but not more than 40 percent propylene glycol by volume and 38 percent but not more than 50 percent glycerine by volume shall be permitted based upon an approved deterministic risk assessment prepared by a qualified person approved by the authority having jurisdiction.

A.5.3.4.4.1(2) Antifreeze solutions with a maximum concentration of 38 percent glycerine or 30 percent propylene glycol do not require a deterministic hazard analysis. The risk

TABLE A.5.3.4.4.1(1) *Properties of Glycerine and Propylene Glycol*

Material	*Solution (% by Volume)*	*Specific Gravity at 77°F (25°C)*	*Freezing Point*	
			°F	*°C*
Glycerine (C.P. or U.S.P. grade)	0	1.000	32	0
	5	1.014	31	–0.5
	10	1.029	28	–2.2
	15	1.043	25	–3.9
	20	1.059	20	–6.7
	25	1.071	16	–8.9
	30	1.087	10	–12
	35	1.100	4	–15.5
	40	1.114	–2	–19
	45	1.130	–11	–24
	50	1.141	–19	–28
Propylene glycol	0	1.000	32	0
	5	1.004	26	–3
	10	1.008	25	–4
	15	1.012	22	–6
	20	1.016	19	–7
	25	1.020	15	–10
	30	1.024	11	–12
	35	1.028	2	–17
	40	1.032	–6	–21

assessment should be prepared by individual(s) who can demonstrate an ability to prepare a risk assessment by education and experience and who can demonstrate an understanding of the issues associated with antifreeze sprinkler systems, including the available related fire tests. For additional information regarding the risk assessment process, documentation to be submitted, and the AHJ's role, refer to NFPA 551 and the SFPE *Engineering Guide: Fire Risk Assessment*.

Propylene glycol and glycerine antifreeze solutions discharged from sprinklers have the potential to ignite under certain conditions. Research testing has indicated that several variables might influence the potential for large-scale ignition of the antifreeze solution discharged from a sprinkler. These variables include, but are not limited to, the concentration of antifreeze solution, sprinkler discharge characteristics, inlet pressure at the sprinkler, ceiling height, and size of fire at the time of sprinkler discharge. All relevant data and information should be carefully reviewed and considered in the deterministic risk assessment. As appropriate, the risk assessment should consider factors such as the following:

(1) Occupancy use group per NFPA 13
(2) Ceiling height
(3) Antifreeze solution concentration and type
(4) Maximum system pressure (normal static pressures)
(5) Sprinkler type, including K-factor
(6) Potential and actual fuel load (Christmas trees)
(7) Type of structure (construction types)
(8) Size of structure
(9) Ability of the sprinkler system to control the fire
(10) Occupied spaces versus unoccupied spaces such as trash enclosures and dust collectors as follows:
    (a) Adjacent occupancies (spaces adjacent to the area protected by antifreeze systems)
    (b) Separation between areas protected with an antifreeze system and other areas
    (c) Ventilation of areas protected with an antifreeze system to prevent damage to adjacent areas
    (d) Duration of antifreeze discharge

Tests summarized in Table A.5.3.4.4.1(2) show that large-scale ignition of the sprinkler spray did not occur in tests with 50 percent glycerine and 40 percent propylene glycol antifreeze solutions discharging onto a fire having a nominal heat release rate (HRR) of 1.4 MW. A deterministic risk assessment that demonstrates that the heat release rate for reasonably credible fire scenarios will be less than 1.4 MW at the time of sprinkler activation should be acceptable. The risk assessment should also address issues associated with management of change, such as change in occupancy and temporary fuel loads. A natural Christmas tree can result in an HRR well above 1.4 MW at the time of sprinkler activation. In addition to the variables identified previously, the deterministic risk assessment should include occupancy, quantity of solution, impact on life safety, and potential increase in heat release rate.

The following is a list of research reports that have been issued by the Fire Protection Research Foundation (FPRF) related to the use of antifreeze in sprinkler systems that should be considered in the development of the deterministic risk assessment:

(1) *Antifreeze Systems in Home Fire Sprinkler Systems—Literature Review and Research Plan*, Fire Protection Research Foundation, June 2010.
(2) *Antifreeze Systems in Home Fire Sprinkler Systems—Phase II Final Report*, Fire Protection Research Foundation, December 2010.
(3) *Antifreeze Solutions Supplied through Spray Sprinklers—Interim Report*, Fire Protection Research Foundation, February 2012.

Table A.5.3.4.4.1(2) provides an overview of the testing conducted by the FPRF.

TABLE A.5.3.4.4.1(2) *FPRF Testing Summary*

Topic	*Information*
Scope of sprinklers tested	The following sprinklers were used during the residential sprinkler research program described in the report dated December 2010: (1) Residential pendent style having nominal K-factors of 3.1, 4.9, and 7.4 gpm/psi$^{1/2}$ (2) Residential concealed pendent style having a nominal K-factor of 4.9 gpm/psi$^{1/2}$ (3) Residential sidewall style having nominal K-factors of 4.2 and 5.5 gpm/psi$^{1/2}$ The following sprinklers were used during the spray sprinkler research program described in the report dated February 2012: (1) Residential pendent style having a nominal K-factor of 3.1 gpm/psi$^{1/2}$ (2) Standard spray pendent style having nominal K-factors of 2.8, 4.2, 5.6, and 8.0 gpm/psi$^{1/2}$ (3) Standard spray concealed pendent style having a nominal K-factor of 5.6 gpm/psi$^{1/2}$ (4) Standard spray upright style having a nominal K-factor of 5.6 gpm/psi$^{1/2}$ (5) Standard spray extended coverage pendent style having a nominal K-factor of 5.6 gpm/psi$^{1/2}$
Antifreeze solution concentration	<50% glycerine and <40% propylene glycol antifreeze solutions — solutions were not tested. 50% glycerine and 40% propylene glycol antifreeze solutions — large-scale ignition of the sprinkler spray did not occur in tests with sprinkler discharge onto a fire having a nominal heat release rate (HRR) of 1.4 MW. Large-scale ignition of the sprinkler spray occurred in multiple tests with sprinkler discharge onto a fire having a nominal HRR of 3.0 MW. 55% glycerine and 45% propylene glycol antifreeze solutions — large-scale ignition of the sprinkler spray occurred in tests with sprinkler discharge onto a fire having a nominal HRR of 1.4 MW. >55% glycerine and >45% propylene glycol antifreeze solutions — large-scale ignition of the sprinkler spray occurred in tests with sprinkler discharge onto a fire having an HRR of less than 500 kW. 70% glycerine and 60% propylene glycol antifreeze solutions — maximum antifreeze solution concentrations tested.
Sprinkler inlet pressure	Large-scale ignition of the sprinkler discharge spray was not observed when the sprinkler inlet pressure was 50 psi or less for tests using 50% glycerine or 40% propylene glycol.
Ceiling height	When discharging 50% glycerine and 40% propylene glycol antifreeze solutions onto fires having an HRR of 1.4 MW, no large-scale ignition of the sprinkler spray was observed with ceiling heights up to 20 ft. When discharging 50% glycerine and 40% propylene glycol antifreeze solutions onto fires having an HRR of 3.0 MW, large-scale ignition of the sprinkler spray was observed at a ceiling height of 20 ft.
Fire control	The test results described in the test reports of December 2010 and February 2012 indicated that discharging glycerine and propylene glycol antifreeze solutions onto a fire can temporarily increase the fire size until water is discharged. As a part of the residential sprinkler research described in report dated December 2010, tests were conducted to evaluate the effectiveness of residential sprinklers to control fires involving furniture and simulated furniture. The results of these tests indicated that 50% glycerine and 40% propylene glycol antifreeze solutions demonstrated the ability to control the furniture-type fires in a manner similar to water. For standard spray–type sprinklers, no tests were conducted to investigate the ability of these sprinklers to control the types and sizes of fires that these sprinklers are intended to protect.

The deterministic risk assessment should address, at a minimum, the items listed in A.5.3.4.4.1(2). The results of the testing conducted by the FPRF should be reviewed in preparing and reviewing the deterministic risk assessments. These reports provide a plethora of information on how antifreeze solutions can contribute to a fire under certain combinations of variables.

A.5.3.4.4.1 All antifreeze systems installed after September 30, 2012, are assumed to meet the minimum requirements of NFPA 13, 2013 edition. For systems installed after September 30, 2012, that do not meet the requirements of the 2013 edition of NFPA 13, consideration should be given to applying 5.3.4.4.1.

5.3.4.4.2 Newly introduced solutions shall be factory premixed antifreeze solutions (chemically pure or United States Pharmacopeia 96.5 percent).

5.3.4.4.3 Premixed antifreeze solutions of propylene glycol exceeding 30 percent concentration by volume shall be permitted for use with ESFR sprinklers where the ESFR sprinklers are listed for such use in a specific application.

5.4 Maintenance.

5.4.1 Sprinklers.

5.4.1.1 Where a sprinkler has been removed for any reason, it shall not be reinstalled.

5.4.1.2* Replacement sprinklers shall have the proper characteristics for the application intended, which include the following:

(1) Style
(2) Orifice size and K-factor
(3) Temperature rating
(4) Coating, if any
(5) Deflector type (e.g., upright, pendent, sidewall)
(6) Design requirements

There are many types of sprinklers, a number of which have a similar appearance yet have different performance characteristics. Paragraph 5.4.1.2 identifies sprinkler characteristics that must be matched to the application.

Care must be taken to ensure that replacement sprinklers have the same characteristics as those they are replacing so that the design performance of the system is maintained. This is especially important for special sprinklers, as noted in 5.4.1.4. When the same make and model of a special sprinkler is no longer manufactured, persons with appropriate expertise and knowledge should be consulted when selecting a replacement sprinkler.

While replacement sprinklers must have the same characteristics, nothing in NFPA 25 or NFPA 13 requires that the replacement sprinkler be the same make and model. Sprinkler manufacturers may update or discontinue a particular model, but sprinklers with the same operating characteristics are almost always available.

FAQ Must a sprinkler be replaced with a sprinkler having the exact temperature rating?

The replacement sprinkler is not required to have the exact temperature rating of the sprinkler being replaced, but it should be of the temperature range appropriate for the environment installed, based on Table 5.4.1.5.2 .

A.5.4.1.2 To help in the replacement of like sprinklers, unique sprinkler identification numbers (SINs) are provided on all sprinklers manufactured after January 1, 2001. The SIN accounts for differences in orifice size, deflector characteristics, pressure rating, and thermal sensitivity.

5.4.1.2.1* Spray sprinklers shall be permitted to replace old-style sprinklers.

A.5.4.1.2.1 Old-style sprinklers are permitted to replace existing old-style sprinklers. Old-style sprinklers should not be used to replace standard sprinklers without a complete engineering review of the system. The old-style sprinkler is the type manufactured before 1953. It discharges approximately 40 percent of the water upward to the ceiling, and it can be installed in either the upright or pendent position.

5.4.1.2.2* Where replacing residential sprinklers manufactured prior to 2003 that are no longer available from the manufacturer and are installed using a design density less than 0.05 gpm/ft^2 (204 mm/min), a residential sprinkler with an equivalent K-factor (± 5 percent) shall be permitted to be used provided the currently listed coverage area for the replacement sprinkler is not exceeded.

A.5.4.1.2.2 It is recognized that the flow and pressure available to the replacement sprinkler might be less than its current flow and pressure requirement.

This paragraph was first introduced in the 2017 edition of NFPA 25 and was added to correlate with NFPA 13 and NFPA 13R. Minimum design density requirements were added to the 2002 edition of NFPA 13. Since that change, many sprinkler manufacturers stopped making residential sprinklers listed for densities less than 0.05 gpm/ft^2 (204 mm/min). This section gives owners NFPA 25–compliant options for replacing sprinklers installed prior to this change when sprinklers matching the exact characteristics are not available.

5.4.1.2.3 Replacement sprinklers for piers and wharves shall comply with NFPA 307.

5.4.1.3 Only new, listed sprinklers shall be used to replace existing sprinklers.

5.4.1.4* Special and quick-response sprinklers as defined by NFPA 13 shall be replaced with sprinklers of the same orifice, size, temperature range and thermal response characteristics, and K-factor.

A.5.4.1.4 It is imperative that any replacement sprinkler have the same characteristics as the sprinkler being replaced. If the same temperature range, response characteristics, spacing requirements, flow rates, and K-factors cannot be obtained, a sprinkler with similar characteristics should be used, and the system should be evaluated to verify the sprinkler is appropriate for the intended use. With regard to response characteristics, matching identical response time index (RTI) and conductivity factors are not necessary unless special design considerations are given for those specific values.

Historical Note

Prior to the 2008 edition of NFPA 25, the standard required that sprinklers be replaced by a sprinkler of the exact make and model, in addition to having the same performance characteristics. This is impractical, so the standard now simply requires that sprinklers be replaced with types having equal performance characteristics, such as orifice size, K-factor, temperature rating, and thermal response.

5.4.1.5* A supply of at least six spare sprinklers shall be maintained on the premises so that any sprinklers that have operated or been damaged in any way can be promptly replaced.

A.5.4.1.5 A minimum of two sprinklers of each type and temperature rating installed should be provided.

Following an incident where a sprinkler has operated, either due to a fire or mechanical damage, it is important to minimize system impairments. Thus, 5.4.1.5 specifies that a supply of spare sprinklers must be available so that sprinklers can be replaced quickly following a small fire or accidental discharge. Note that the supply must be "on the premises" but need not be in each building of a complex or specifically at the sprinkler system riser. For example, a supply of spare sprinklers for a complex can be stored in a central location, provided that the supply is accessible and does not substantially delay the replacement of sprinklers following an incident. A sprinkler cabinet with spare sprinklers is shown in Exhibit 5.22.

ITM Deficiency, Impairment, or Hazard Evaluation?

ANSWER: ITM Deficiency

The spare sprinkler cabinet shown in this photo is required to be inspected annually in accordance with 5.2.1.4. In this case, the cabinet is missing almost all the spare parts required by 5.4.1.5, 5.4.1.5.5, and 5.4.1.5.6. A spare stock of sprinklers must include a minimum of six sprinklers for any protected facility, and at least two of each type and temperature rating is to be provided. A proper sprinkler wrench is also required, as well as a list of the sprinklers installed in the property.

The spare sprinkler requirements in the 2014 edition of NFPA 25 were correlated with the spare sprinkler requirements in the 2013 editions of NFPA 13 and NFPA 13R. Now all three documents have the same requirements.

This cabinet is missing the list of sprinklers installed in the property, so the most recent set of working drawings required by NFPA 13 will need to be reviewed to determine how many of each type of sprinkler is installed in the building or facility. In the absence of adequate working drawings, a complete visual examination of all the sprinklers installed in the property should be performed, including those in concealed spaces and above ceilings.



(Courtesy of Byron Blake and SimplexGrinnell)

5.4.1.5.1 The sprinklers shall correspond to the types and temperature ratings of the sprinklers in the property.

5.4.1.5.2 The stock of spare sprinklers shall be kept in a cabinet located where the temperature to which they are subjected will at no time exceed the maximum ceiling temperatures specified in Table 5.4.1.5.2 for each of the sprinklers within the cabinet.

Spare sprinklers must be maintained at normal temperatures to prevent their operation and also to prevent the phenomenon of "cold flow," which can result in premature operation. Exhibit 5.35 shows a series of well-maintained spare sprinkler cabinets with hydraulic information signs posted above.

N ***TABLE 5.4.1.5.2*** *Temperature Ratings, Classifications, and Color Codings*

Maximum Ceiling Temperature		*Temperature Rating*				
°F	*°C*	*°F*	*°C*	*Temperature Classification*	*Color Code*	*Glass Bulb Colors*
100	38	135–170	57–77	Ordinary	Uncolored or black	Orange or red
150	66	175–225	79–107	Intermediate	White	Yellow or green
225	107	250–300	121–149	High	Blue	Blue
300	149	325–375	163–191	Extra high	Red	Purple
375	191	400–475	204–246	Very extra high	Green	Black
475	246	500–575	260–302	Ultra high	Orange	Black
625	329	650	343	Ultra high	Orange	Black

[**13:**Table 7.2.4.1]

EXHIBIT 5.35 *Sprinkler Cabinet with Hydraulic Information Signs. (Courtesy of Wayne Automatic Fire Sprinklers, Inc.)*



5.4.1.5.3 Where dry sprinklers of different lengths are installed, spare dry sprinklers shall not be required, provided that a means of returning the system to service is furnished.

Dry sprinklers are manufactured to specific lengths. Due to the pitching of pipe or various ceiling heights, the dry sprinklers on a system are often of varying lengths, so it is impractical to have spare sprinklers for each specific length. However, if all the dry sprinklers on a system are the same length, spare dry sprinklers should be kept in the cabinet. For example, freezer boxes with dry sprinklers supplied by a wet system can all be the same length, and it is practical and reasonable to provide the spare dry sprinklers.

5.4.1.5.4 The stock of spare sprinklers shall include all types and ratings installed and shall be as follows:

(1) For protected facilities having under 300 sprinklers—no fewer than 6 sprinklers
(2) For protected facilities having 300 to 1000 sprinklers—no fewer than 12 sprinklers
(3) For protected facilities having over 1000 sprinklers—no fewer than 24 sprinklers

5.4.1.5.5* One sprinkler wrench as specified by the sprinkler manufacturer shall be provided in the cabinet for each type of sprinkler installed to be used for the removal and installation of sprinklers in the system.

Special wrenches as prescribed by the manufacturer must be kept in the sprinkler cabinet so that sprinklers can be properly replaced following an incident or in the event that inspection or testing indicates damage. There should be an appropriate wrench provided for each sprinkler type installed in the system.

A.5.4.1.5.5 One sprinkler wrench design can be appropriate for many types of sprinklers, and multiple wrenches of the same design should not be required.

5.4.1.5.6 A list of the sprinklers installed in the property shall be posted in the sprinkler cabinet.

5.4.1.5.6.1* The list shall include the following:

(1) Sprinkler identification number (SIN) if equipped; or the manufacturer, model, orifice, deflector type, thermal sensitivity, and pressure rating
(2) General description
(3) Quantity of each type to be contained in the cabinet
(4) Issue or revision date of the list

Historical Note

Starting with the 2007 edition, NFPA 13 has required a list of the sprinklers installed on the premises to be posted in the sprinkler cabinet. The list is required to include the Sprinkler Identification Number (SIN), a general description, the quantity of each sprinkler to be maintained in the cabinet, and the date of the list.

It would be prudent for an owner to provide this list for projects completed under earlier editions of NFPA 13. The information can be found on the Contractor's Material Test Certificate or the as-built drawings that are part of the original records. If these records are not available, a survey of the installed sprinklers could be conducted by a qualified individual.

A.5.4.1.5.6.1 The minimum information in the list contained in the spare sprinkler cabinet should be marked with the following:

(1) General description of the sprinkler, including upright, pendent, residential, ESFR, and so forth
(2) Quantity of sprinklers to be maintained in the spare sprinkler cabinet

An example of the list is shown in Figure A.5.4.1.5.6.1.

5.4.1.6* Sprinklers shall not be altered in any respect or have any type of ornamentation, paint, or coatings applied after shipment from the place of manufacture.

As noted in the commentary following the last paragraph of A.5.2.1.1.1, paint or overspray can prevent the proper operation of sprinklers. Paragraph 5.4.1.6 requires sprinklers to be protected from such overspray.

A.5.4.1.6 Corrosion-resistant or specially coated sprinklers should be installed in locations where chemicals, moisture, or other corrosive vapors exist.

Sprinklers Contained in this Cabinet			
Sprinkler Identification, SIN	**General Description**	**Temperature Rating, °F**	**Sprinkler Quantity Maintained**
TY9128	Extended Coverage, K-25, upright	165	6
VK494	Residential concealed pendent	155	6
Issued: 8/31/19	Revised:		

Δ ***FIGURE A.5.4.1.5.6.1*** *Sample List. [**13**:Figure A.16.2.7.7.1]*

5.4.1.7 Sprinklers and automatic spray nozzles used for protecting commercial-type cooking equipment and ventilating systems shall be replaced annually.

5.4.1.7.1 Where automatic bulb-type sprinklers or spray nozzles are used and annual examination shows no buildup of grease or other material on the sprinklers or spray nozzles, such sprinklers and spray nozzles shall not be required to be replaced.

N **5.4.1.8** Electrically operated sprinklers shall be maintained in accordance with the manufacturer's requirements.

5.4.1.9 Protective Coverings.

5.4.1.9.1* Sprinklers protecting spray areas and mixing rooms in resin application areas installed with protective coverings shall continue to be protected against overspray residue so that they will operate in the event of fire.

A.5.4.1.9.1 Typical sandwich bags purchased in a grocery store are generally plastic, not cellophane. Plastic bags have a tendency to shrink and adhere to the sprinkler prior to sprinkler activation, creating the potential for disruption of sprinkler spray patterns. Bags placed over sprinklers need to be true cellophane or paper.

5.4.1.9.2 Sprinklers installed as described in 5.4.1.9.1 shall be protected using cellophane bags having a thickness of 0.003 in. (0.076 mm) or less or thin paper bags.

Testing has shown that lightweight cellophane or paper bags will not adversely affect the operation of the sprinkler. However, sprinklers protected by lightweight cellophane or paper bags might require more frequent inspection than the annual inspection outlined in 5.2.1.1, to prevent excessive buildup on the bags. Depending on the use of the spray coating area, the inspection and subsequent replacement of the bags might need to be done daily. The use of plastic bags is not permitted due to concerns for the potential of a plastic bag to shrink prior to sprinkler activation and disrupt the discharge pattern. Exhibit 5.36 illustrates a sprinkler protected from overspray by a cellophane bag.

5.4.1.9.3 Coverings shall be replaced periodically so that heavy deposits of residue do not accumulate.



EXHIBIT 5.36 *Sprinkler Protected from Overspray with a Cellophane Bag.*

5.4.2* Dry Pipe Systems. Dry pipe systems shall be kept dry at all times.

A ruptured dry system, the result of water accumulating or left in the system, is one of the most frequent and expensive consequences of an owner failing to enact a regular maintenance program. NFPA 25 addresses this with guidance on the use and frequency of operating dry auxiliary drains (see A.13.4.5.3.2).

A.5.4.2 Conversion of dry pipe systems to wet pipe systems on a seasonal basis causes corrosion and accumulation of foreign matter in the pipe system and loss of alarm service.

Moisture is one of the main causes of corrosion in sprinkler piping. Alternating from a dry system to a wet system allows moisture to enter the system and can accelerate corrosion rates. In addition, the waterflow alarm on most dry systems will need to be removed from service if the system is left wet. To minimize corrosion and prevent freezing of sprinkler piping, it is required that these systems always remain dry, and it is recommended that they be reset and drained following operation to minimize moisture inside the system. Exhibit 5.37 shows rust and scale removed from a dry pipe system.

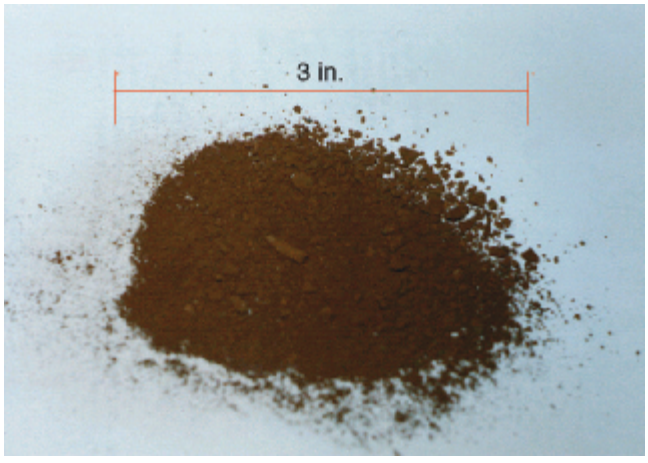


EXHIBIT 5.37 *Rust and Scale Removed from Dry Pipe System.*

5.4.2.1 During nonfreezing weather, a dry pipe system shall be permitted to be left wet if the only other option is to remove the system from service while waiting for parts or during repair activities.

5.4.2.2 Refrigerated spaces or other areas within the building interior where temperatures are maintained at or below 40°F (4°C) shall not be permitted to be left wet.

5.4.2.3 Air driers shall be maintained in accordance with the manufacturer's instructions.

5.4.2.4 Compressors used in conjunction with dry pipe sprinkler systems shall be inspected, tested, and maintained in accordance with Chapter 13 and the manufacturer's instructions.

5.4.3* Marine Systems. Sprinkler systems that are normally maintained using fresh water as a source shall be drained and refilled, then drained and refilled again with fresh water following the introduction of raw water into the system.

A.5.4.3 Certain sprinkler systems, such as those installed aboard ships, are maintained under pressure by a small freshwater supply but are supplied by a raw water source following system activation. In these systems, the effects of raw water are minimized by draining and refilling with freshwater. For systems on ships, flushing within 45 days or the vessel's next port of call, whichever is longer, is considered acceptable.

5.5 Component Action Requirements.

Component replacement tables offer guidance when system components are adjusted, repaired, rebuilt, or replaced. It is not necessary in each case to require a complete acceptance test for each component when maintenance is performed.

5.5.1 Whenever a component in a sprinkler system is adjusted, repaired, reconditioned, or replaced, the actions required in Table 5.5.1 shall be performed.

Δ ***TABLE 5.5.1*** *Summary of Component Action Requirements*

Component	*Adjust*	*Repair/ Recondition*	*Replace*	*Required Action*
Water Delivery Components				
Antifreeze solution	X		X	Inspect freezing point of solution Inspect for leaks at system working pressure
Fire department connections	X	X	X	See Chapter 13
Pipe and fittings affecting not more than 20 sprinklers	X	X	X	Inspect for leaks at system working pressure
Pipe and fittings affecting more than 20 sprinklers	X	X	X	Hydrostatic test in conformance with NFPA 13
Sprinklers, regardless of number	X		X	Inspect for leaks at system working pressure
Alarm and Supervisory Components				
Detection system (for deluge or preaction system)	X	X	X	Operational test for conformance with NFPA 13 and/or *NFPA 72*
High– and low– air pressure switch	X	X	X	Operational test of high and low settings

Δ ***TABLE 5.5.1*** *(Continued)*

Component	*Adjust*	*Repair/ Recondition*	*Replace*	*Required Action*
Pressure switch–type waterflow	X	X	X	Operational test using the inspector's test connection or alarm bypass test valve
Valve supervisory signal initiating device	X	X	X	Test for conformance with NFPA 13 and/or *NFPA 72*
Vane-type waterflow	X	X	X	Operational test using inspector's test connection
Water motor gong	X	X	X	Operational test using inspector's test connection
Testing and Maintenance Components				
Air compressor	X	X	X	Operational test for conformance with NFPA 13
Automatic air maintenance device	X	X	X	Operational test for conformance with NFPA 13
Auxiliary drains	X	X	X	Inspect for leaks at system working pressure; main drain test
Gauges	X		X	Verify at 0 bar (0 psi) and system working pressure
Inspector's test connection	X	X	X	Inspect for leaks at system working pressure; main drain test
Main drain	X	X	X	Main drain test
Structural Components				
Hanger/seismic bracing	X	X	X	Inspect for conformance with NFPA 13
Pipe stands	X	X	X	Inspect for conformance with NFPA 13
Informational Components				
Antifreeze information sign	X	X	X	Inspect for conformance with this standard
General information sign	X	X	X	Inspect for conformance with this standard
Hydraulic design information sign	X	X	X	Inspect for conformance with NFPA 13 and this standard
Identification sign	X	X	X	Inspect for conformance with NFPA 13 and this standard
Information sign	X	X	X	Inspect for conformance with this standard

5.5.2 Where the original installation standard is different from the cited standard, the use of the appropriate installing standard shall be permitted.

5.5.3 These actions shall not require a design review, which is outside the scope of this standard.

References Cited in Commentary

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2019 edition.

NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*, 2019 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, 2019 edition.

Fire Protection Research Foundation, 1 Batterymarch Park, Quincy, MA 02169-7471.

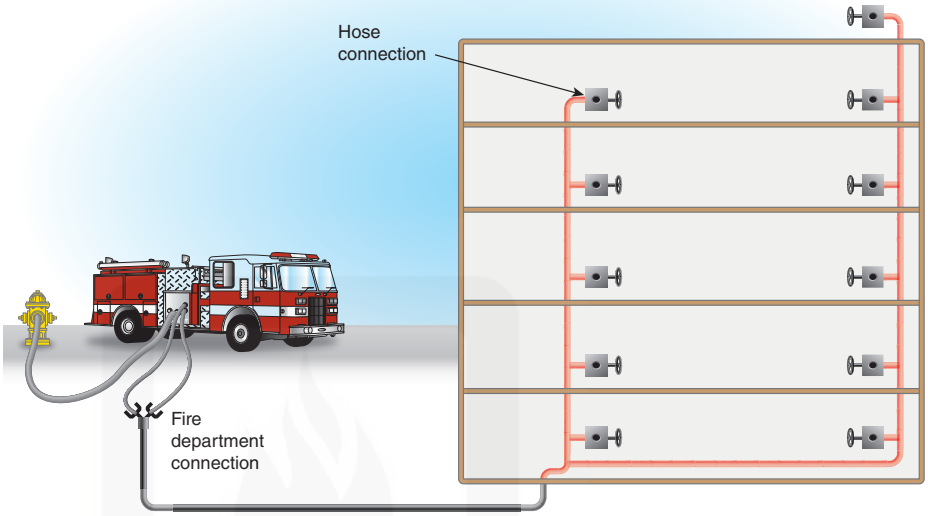
"Antifreeze Solutions Supplied through Spray Sprinklers: Final Report," February 2012.

FM Global, 270 Central Avenue, P.O. Box 7500, Johnston, RI 02919.

"K-25 Suppression Mode Sprinkler Protection for Areas Subject to Freezing," FM Technical Report J.L. 0003004619, 2010.

What Are Standpipe and Hose Systems?

A standpipe system is a fixed piping system used to deliver water for manual fire fighting. Standpipe systems can significantly improve the efficiency of manual fire-fighting operations by eliminating the need for long and cumbersome hose lays from the fire apparatus.

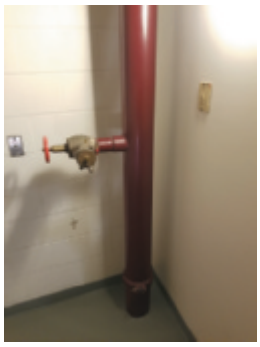


Where Are Standpipe and Hose Systems Installed?

These systems are typically installed in tall and large-area buildings due to the increased travel distance for fire fighters. The requirement for installing a standpipe system in a building is located in codes such as NFPA *101®*, *Life Safety Code*; NFPA 1, *Fire Code*; and the model building codes.

What Class and Type of Standpipe Systems Are There?

Standpipe systems are designated as Class I, Class II, and Class III. Some refer to a fourth class called a "combined system," but a combined system is just a Class I or Class III system that supplies a sprinkler system. Note that a sprinkler system with hose connections is not necessarily considered a standpipe system.



Class I System

Class I systems are used for full-scale fire fighting and provide 2½ in. (65 mm) hose connections at designated locations for use by the fire department. The most typical location for these is within the stairwell of a building.



Class II Systems

Class II systems are intended to be used by trained personnel or the fire department during initial response and consist of 1½ in. (40 mm) hose connections, hose, nozzle, and hose rack or reel at designated locations.





Courtesy of Potter Roemer/Fire Pro

Class III Systems

Class III systems are used for both full-scale fire fighting and first-aid fire fighting. In order to achieve this, the hose connections are typically a 2½ in. (65 mm) hose valve with a removable 2½ in. to 1½ in. (65 to 40 mm) adapter or equipped with both a 2½ in. (65 mm) hose valve and a 1½ in. (40 mm) hose valve either with or without a hose, nozzle, and hose rack or reel.

Types

The different classes of standpipe systems are also further broken down into different types of systems to delineate whether the piping is full of water (wet) or not (dry) and whether the water supplied for fire fighting is automatically provided by a water supply such as a city main or a tank and fire pump (automatic or semiautomatic), or needs to be provided by a fire department pumper (manual).

ITM

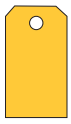
Standpipe and hose systems are crucial when conducting fire fighting operations on large or tall buildings. Inspection, testing, and maintenance (ITM) must be completed on these systems so they do not catastrophically fail when needed by first responders.

For more information refer to NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*.

Standpipe and Hose Systems Inspection and Testing



NO DEFICIENCIES OR IMPAIRMENTS



NONCRITICAL DEFICIENCIES

- Mildew or corrosion present on hose, hose not connected
- Missing hydraulic design information sign
- Hose storage device rack will not swing out of cabinet at least 90 degrees
- Hydrostatic test of standpipe system shows leakage inside piping



CRITICAL DEFICIENCIES

- Leaking pipe and fittings — slowly dripping, and/or moisture on surface
- Critical mechanical damage to pipe and fittings
- Cuts in hose, couplings not of compatible threads
- Deteriorated hose, no gasket or damaged gaskets
- Missing hose nozzle, broken parts or thread gasket damaged
- Hose not properly racked or rolled, nozzle clip missing, nozzle not contained, damaged, obstructed
- Cabinet
  - Corroded or damaged parts
  - Not easy to open
  - Not accessible
  - Not identified
  - Door glazing in poor condition
  - Lock not functioning in break glass type
  - Valve, hose nozzle, fire extinguisher, etc., not readily accessible
- Standpipe system test results do not provide design pressure at required flow
- More than 10% drop in full pressure flow of main drain
- Presence of MIC, zebra muscles, rust, and scale internally
- Damaged or missing hangers



IMPAIRMENTS

- Leaking pipe and fittings — spraying or running water

Source: Table A.3.3.8



6

STANDPIPE AND HOSE SYSTEMS

Chapter 6 of NFPA 25 covers the inspection, testing, and maintenance (ITM) of standpipe systems. The operating condition of standpipe systems is important because standpipe systems are critical equipment in buildings where fire-fighting operations must be conducted internally due to the size or height of the building. A standpipe failure can have catastrophic consequences to both building occupants and first responders who rely on the system for their safety.

Standpipe systems may or may not be equipped with hose and nozzles. When hose and nozzles are part of the system, they must be tested and maintained as required by NFPA 1962, *Standard for the Care, Use, Inspection, Service Testing, and Replacement of Fire Hose, Couplings, Nozzles, and Fire Hose Appliances,* along with Chapter 6 and Chapter 13 of this standard.

Exhibit 6.1 shows a properly racked hose and nozzle. This installation demonstrates a properly maintained standpipe system hose rack assembly.



EXHIBIT 6.1 *Hose Rack Assembly in Proper Condition. (Courtesy of Josh Elvove)*

6.1 General.

Some of the fire protection systems inspections listed in Table 6.1.1.2 can be performed by someone with minimal training; in many cases, these inspections can be conducted by the property owner or the owner's representative. These inspections could include items such as the operating position of the control valve, or obvious signs of pipe damage or leaking.

However, for work beyond simple and basic inspections, a qualified inspection service or contractor should perform all testing and maintenance activities listed in Table 6.1.1.2. Before any decision is made about who may or may not perform inspections and testing, however, the authority having jurisdiction (AHJ) should be consulted and any licensing requirements of the jurisdiction confirmed.

6.1.1 Minimum Requirements.

6.1.1.1 This chapter shall provide the minimum requirements for the routine inspection, testing, and maintenance of standpipe and hose systems.

6.1.1.2 Table 6.1.1.2 shall be used to determine the minimum required frequencies for inspection, testing, and maintenance.

Δ ***TABLE 6.1.1.2*** *Summary of Standpipe and Hose Systems Inspection, Testing, and Maintenance*

Item	*Frequency*	*Reference*
Inspection		
Cabinet	Annually	6.2.8
Control valves		Chapter 13
Gauges		Chapter 13
Hose	Annually	6.2.5
Hose connection	Annually	6.2.3
Hose nozzle	Annually and after each use	6.2.6
Hose storage device	Annually	6.2.7
Hydraulic design information sign	Annually	6.2.2
Hose valves		Chapter 13
Piping	Annually	6.2.4
Pressure-regulating devices		Chapter 13
Supervisory devices (except valve supervisory devices)		Chapter 13
Valve supervisory devices		Chapter 13
Test		
Control valves		Chapter 13
System valves		Chapter 13
Flow test	5 years	6.3.1
Hose		NFPA 1962
Hose connection pressure regulating devices		Chapter 13
Hose valves		Chapter 13
Hydrostatic test	5 years	6.3.2
Main drain test		Chapter 13
Pressure control valve		Chapter 13

(Continues)

TABLE 6.1.1.2 (Continued)

Item	*Frequency*	*Reference*
Pressure-reducing valve		Chapter 13
Supervisory signal devices (except valve supervisory switches)		Chapter 13
Valve status test		Chapter 13
Valve supervisory devices		Chapter 13
Waterflow alarm devices		Chapter 13
Maintenance		
Hose valves		Chapter 13
Pressure gauges		Chapter 13
Valves (all types)	Annually/as needed	Chapter 13

NFPA 1962, which is referenced in Table 6.1.1.2, provides the requirements for fire hose and must be used where standpipe systems contain hose. For example, small hose must be stored unracked, unreeled, or unrolled and inspected annually. In addition, the hose must be removed and service tested 5 years from the date it was manufactured and every 3 years thereafter. The inspection provider should have a copy of NFPA 1962 to be certain that the requirements are met.

6.1.2 Inspection, testing, and maintenance activities required by this chapter shall be followed to determine that components are free of corrosion, foreign material, physical damage, tampering, or other conditions that adversely affect system operation.

6.1.3 Common components and valves shall be inspected, tested, and maintained in accordance with Chapter 13.

Because the main purpose of standpipe systems is to provide fire-fighting water to locations throughout a building, they rely heavily on the use of valves and pressure-regulating devices for proper operation. The ITM requirements for those components are found in Chapter 13; these requirements are critical for ensuring the operational reliability of these systems.

6.1.4 The procedures outlined in Chapter 14 shall be followed where there is a need to conduct an obstruction investigation.

6.1.5 Where the inspection, testing, and maintenance of standpipe and hose systems results or involves a system that is out of service, the impairment procedures outlined in Chapter 15 shall be followed.

6.1.6 Where approved by the authority having jurisdiction, existing hose shall be permitted to be removed and shall not be recorded as a deficiency.

Guidance on the installation and use of small hose in buildings has evolved over recent years. Fire department personnel are normally trained not to use the fire hose that is supplied in a building or as part of a standpipe, due to a lack of verified maintenance or testing of the appliances provided. As a result, most fire departments bring their own hose into a building and connect it to the standpipe hose valves. In addition, the universal guidance is for untrained building occupants not to use hose and nozzles in fire-fighting activities. As a result, it is left to the fire department to determine the disposition of existing hose, and many fire departments are requiring or approving the removal of small hose from standpipe systems.

ITM Deficiency, Impairment, or Hazard Evaluation?



(Courtesy of Byron Blake and SimplexGrinnell)

ANSWER: ITM Deficiency

There are several problems with the 2½ in. (65 mm) hose valve shown in this picture, and two of them are NFPA 25 deficiencies. The missing handle on the hose valve is a deficiency and must be replaced. The pile of boxes in front of the hose valve is creating an obstruction and needs to be removed. All versions of NFPA 25 require that standpipe hoses be inspected and tested in accordance with NFPA 1962. If the hose is missing from a hose rack as is shown here, the inspector should report the missing hose as a deficiency.

Historical Note

In the 2011 edition of NFPA 25 a new subsection, 6.1.7, was added. This subsection allows hoses to be permanently removed where approved by the AHJ, and the absence of the hose would not be reported as a deficiency.

System Tagging

Exterior corrosion can be seen on the hose outlet threading and welded outlet. Most facility managers would simply clean the threading and joint with a wire brush and apply a fresh coat of paint. For inspectors who have no maintenance responsibilities, they might call this a noncritical deficiency due to the light corrosion and recommend a remediation plan.

Noncritical Deficiency

Critical Deficiency

Impairment



(Courtesy of Byron Blake and SimplexGrinnell)

6.2 Inspection.

6.2.1 Components. Components of standpipe and hose systems shall be visually inspected annually or as specified in Table 6.1.1.2.

Historical Note

Inspection frequencies of piping and hose connections were changed from quarterly to annually in the 2008 edition, because the committee determined that this equipment does not require such rigorous inspections. The inspection frequencies for pressure-regulating devices and alarms, addressed in Chapter 13, were not changed because those devices require different inspection frequencies. Pressure-regulating devices are constantly working to assure that the inactive system components are not subject to conditions outside of the parameters of their design. For this reason, more frequent inspections are required for those system components as the impact of those inspections carry over to other system components.

6.2.2* Hydraulic Design Information Sign. The hydraulic design information sign for standpipe systems shall be inspected annually to verify that it is provided, attached securely, and legible.

A hydraulic information sign is required by NFPA 14, *Standard for the Installation of Standpipe and Hose Systems,* regardless of whether the standpipe system piping is sized by hydraulic calculations or pipe schedule. This is not the case for sprinkler systems that are designed in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*. The sign is required by NFPA 14 to be placed at the water control valve for automatic and semiautomatic systems or at an approved location for manual systems. Section 6.7 and 6.5.4.2.2 of NFPA 14 also require that the following signs related to the system hydraulics be posted:

- A sign at the fire department connection indicating the pressure required at the inlets to deliver the system demand
- Where a fire pump is provided, a sign in the vicinity of the pump indicating the minimum pressure and flow required at the pump discharge flange to meet the system demand

The signs should be legible and securely attached.

A.6.2.2 The design information sign should be secured with durable wire, chain, or equivalent to the water supply control valve for automatic or semiautomatic standpipe systems and at an approved location for manual systems. See Figure A.6.2.2 for sample hydraulic information sign.

6.2.2.1 A hydraulic design information sign that is missing or illegible shall be replaced.

6.2.2.2 A standpipe system that was not sized by hydraulic design shall have a hydraulic design information sign that reads "Pipe Schedule System."

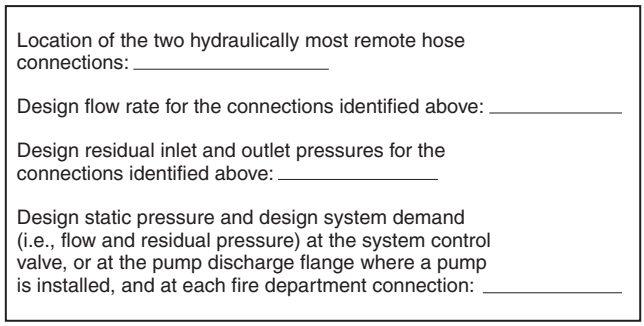


FIGURE A.6.2.2 *Sample Hydraulic Sign. [**14**:Figure A.6.8]*

6.2.3 Hose Connections.

6.2.3.1 Hose connections shall be inspected annually for the following conditions:

(1) Valve cap(s) missing or damaged
(2) Fire hose connection damaged
(3) Valve handles missing or damaged
(4) Cap gaskets missing or deteriorated
(5) Valve leaking
(6) Visible and physical obstructions to hose connections
(7) Pressure restricting device missing
(8) Manual, semiautomatic, or dry standpipe valve does not operate smoothly
(9) Valve threads damaged

6.2.3.2 Where any deficiency is noted, the appropriate corrective action shall be taken.

Whenever corrections or repairs have been made to a standpipe system or component, the requirements of Table 6.5.1 must be followed. Often these corrections and repairs lead to performing others tests, such as main drain tests or valve status tests. Many of the component action requirements called for in Table 6.5.1 reference Chapter 13, further clarifying the close ties between these two chapters.

6.2.4 Piping.

In editions prior to the 2017 edition of NFPA 25, many of the individual components and conditions that needed to be inspected were found in a table at the beginning of the chapter. Beginning in the 2017 edition of the standard, the requirements were broken out of the table and placed in the body of the standard to be consistent with the other chapters in NFPA 25. See 6.2.3 through 6.2.8 for these components and conditions.

6.2.4.1 Piping shall be inspected annually for the following conditions:

(1) Damaged piping
(2) Damaged control valves
(3) Missing or damaged pipe support device (i.e., missing or damaged hanger or seismic brace)
(4) Damaged supervisory signal initiating device

Tip for Owners

Because hose connections are often located in unsupervised locations (such as stairwells or roofs), they can be subject to vandalism or improper use. It is not unusual to find missing caps, trash, and debris, or damaged threads when inspecting hose connections. Building owners or managers should be especially vigilant about this possibility and might want to consider increasing the frequency of inspections. This can usually be accomplished by using in-house personnel or by taking other actions, such as installing approved protective devices. The AHJ should be consulted before taking these steps.

Case In Point

The piping shown in the first photo is severely corroded and could fail if pressurized. Such a failure under pressure could present a safety hazard to the end user or to nearby building occupants. A simple visual observation of this system should reveal to the inspector that it has not been examined for some time.

Even minor corrosion, which is caused by the interaction between dissimilar metals as shown in the second photo, should be noted when conducting an inspection, since this equipment is vital to fire department operations.



Severely Corroded Manual Dry Standpipe.



Fire Hose Valve with Dissimilar Metals. (Courtesy of M. Steven Welsh, Koffel Associates, Inc.)

ITM Deficiency, Impairment, or Hazard Evaluation?

ANSWER: ITM Deficiency

Table 6.1.1.2 does not include any reference for inspecting waterflow alarm devices. However, 6.2.1 requires all components of a standpipe system to be inspected annually. During the annual inspection, this waterflow switch was found without a cover; the wiring was disconnected, the terminal block was removed, and there was significant corrosion in the switch. The purpose of an inspection is to verify that the items being inspected appear to be in operating condition and are free of physical damage. In this case, the switch is missing the cover, as well as other internal components. It is not in operating condition. This condition should be considered a critical deficiency.



(Courtesy of Byron Blake and SimplexGrinnell)

6.2.4.2 Where any deficiency is noted, the appropriate corrective action shall be taken.

6.2.5 Hose.

6.2.5.1 Hose shall be inspected annually for the following conditions as required by NFPA 1962:

(1) Mildew, cuts, abrasions, and deterioration
(2) Couplings hose threads damaged
(3) Gaskets missing or deteriorated
(4) Incompatible threads on coupling
(5) Hose not connected to hose rack nipple or valve
(6) Hose test outdated

6.2.5.2 Where any deficiency is noted, the appropriate corrective action shall be taken.

6.2.6 Hose Nozzle.

6.2.6.1 Hose nozzles shall be inspected annually for the following conditions:

(1) Hose nozzle missing
(2) Gasket missing or deteriorated
(3) Obstructions
(4) Does not operate smoothly

6.2.6.2 Where any deficiency is noted, the appropriate corrective action shall be taken.

6.2.7 Hose Storage Device.

6.2.7.1 Hose storage devices shall be inspected annually for the following conditions:

(1) Difficult to operate
(2) Damaged
(3) Visible or physical obstruction
(4) Hose improperly racked or rolled
(5) Nozzle clip not in place and nozzle not correctly contained
(6) Hose rack enclosed in cabinet not swinging out at least 90 degrees

6.2.7.2 Where any deficiency is noted, the appropriate corrective action shall be taken.

6.2.8 Cabinet.

6.2.8.1 Cabinets shall be inspected annually for the following conditions:

(1) Overall for corroded or damaged parts
(2) Difficult to open
(3) Cabinet door not opening fully
(4) Door glazing cracked or broken
(5) Lock on break glass–type cabinet not functioning properly
(6) Glass break device missing or not attached
(7) Not properly identified as containing fire equipment
(8) Visible or physical obstructions
(9) All valves, hose, nozzles, fire extinguishers, and so forth, easily accessible

6.2.8.2 Where any deficiency is noted, the appropriate corrective action shall be taken.

6.3 Testing.

Where water damage is a possibility, an air test shall be conducted on the system at 25 psi (1.7 bar) prior to introducing water to the system.

Extreme care should be taken when testing with pressurized air because the greater amount of energy stored in compressed air can be released if a portion of the system fails catastrophically. Pressures in excess of the 25 psi (1.7 bar) recommended should therefore be avoided for safety concerns. This section relates to standpipe systems that are normally dry, such as manual dry or semiautomatic dry standpipe systems. Operationally, manual systems rely on the fire pump provided by a fire engine or truck, with the fire fighter on the hose nozzle communicating with the engineer at the engine controls for the proper level of pressure regulation and flow during fire-fighting operations.

Since an automatic dry system is already pressurized with air, additional periodic air testing is not prescribed. Similarly, wet systems of all types do not require an air test, because leaks will be readily apparent in those systems.

Testing Procedure Alert

The purpose of conducting a flow test for the standpipe system is to ensure the adequacy of the water supply as well as the capability of the system to meet the original design flow and pressure criteria for the performance of the system. The design criteria to which the test data must be compared will vary depending on which edition of NFPA 14 the system was designed to; therefore, a preliminary assessment of the system is necessary. For more information on conducting the standpipe flow test, see the detailed testing procedure at the end of this chapter.

6.3.1 Flow Tests.

6.3.1.1* A flow test shall be conducted every 5 years on all automatic standpipe systems to verify that the required flow and pressure are available at the hydraulically most remote hose valve outlet(s) while flowing the standpipe system demand.

In the 2014 edition of the standard, changes were made to standpipe systems' testing requirements. These changes resulted in the elimination of testing for Class II standpipe systems. The 2017 edition reinstated the requirement for flow testing Class II standpipes, and they remain in the 2020 edition. Additionally, the requirements have been modified to specify that this requirement addresses automatic standpipe systems and excludes manual standpipes.

A.6.3.1.1 The hydraulically most remote hose connections in a building are generally at a roof manifold, if provided, or at the top of a stair leading to the roof. In a multizone system, the testing means is generally at a test header at grade or at a suction tank on higher floors.

NFPA 25 limits the 5-year flow test to automatic systems. This flow test is conducted to verify that the water supply for the system is still available and that all of the devices that could restrict flow in the standpipe are operating properly. These devices can include improperly installed or repaired check valves, gate valves, and pressure-regulating fire hose valves, or physical failures in the pipe network that might render the supply unavailable.

Tip for Owners

Flow testing of standpipes can release large quantities of water, usually from roof outlets. Ensuring adequate drainage for this water is required by NFPA 25 and is an important consideration for both the owner and the ITM service provider. Roof drains might not have been designed to handle the sudden influx that is produced when standpipes are flow tested. Roof drains and other parts of the drainage system could become plugged or otherwise damaged between flow tests. This may not become apparent until it is too late and damage has already occurred. It is recommended that owners or facility managers have their drainage systems evaluated for this eventuality before testing is conducted.

The test is intended to verify the design flow rate and pressure under functional flow conditions. Design pressure varies depending on the age of the system. For example, systems installed prior to 1993 should be tested to verify 65 psi (4.5 bar) at the topmost outlet. Systems installed after 1993 should be tested to verify 100 psi (6.9 bar) at the topmost outlet. It might be necessary to confirm the age of the system and what edition of NFPA 14 was in effect at the time of the original installation. Regardless of the pressure requirement, the test flow is based on a flow of 500 gpm (1892 L/min) for the most demanding riser and 250 gpm (946 L/min) for each additional riser up to a maximum of 1250 gpm (4731 L/min) for buildings that are partially or nonsprinklered and 1000 gpm (3785 L/min) for buildings that are fully sprinklered.

Note that NFPA 14 requires an additional outlet at the top of the most demanding standpipe for testing purposes. This requirement is intended to facilitate testing of the standpipe system at the design flow of 500 gpm (1892 L/min) [250 gpm × 2 = 500 gpm (946 L/min × 2 = 1892 L/min)]. The total required flow rate is required to be provided simultaneously for this test.

FAQ Why does the requirement for flow testing only apply to automatic standpipe systems?

The water supply for manual standpipe systems typically comes from a fire department pumper. It is not the intent of NFPA 25 to test the pumping capacity of the fire department or its apparatus.

Case In Point

Usually, the most remote hose connections, as referred to in 6.3.1.1, are located on the roof or upper floors. Testing hose connections in such locations requires coordination to conduct the test safely, prevent water damage, and ensure proper water disposal. In some cases, special drain risers might be needed to remove the water generated by the test. If the test cannot be conducted at the most remote outlet, other arrangements can be made where acceptable to the AHJ. In cases where the drain riser provided is undersized to accept the full flow rates required, hoses can be run between two standpipes and arranged so that opposing standpipes can be used as the drain riser for the first. Where fire pumps are provided as a water supply for standpipes, the annual fire pump test required by Chapter 8 can often be accomplished at the same time as the standpipe's 5-year flow test.

It should be noted that special equipment might be required to measure both the flow rate (gpm or L/min) and the residual pressure (psi or bar) concurrently, especially where adjustments are needed for field adjustable pressure-regulating fire hose valves.

6.3.1.1.1 Where a flow test of the hydraulically most remote outlet(s) is not practical, the authority having jurisdiction shall be consulted for the appropriate location for the test.

6.3.1.1.2 Pressure gauges maintained in accordance with 8.3.3.5.2 shall be provided for the test.

6.3.1.2* Class I and Class III standpipe system demand shall include 500 gpm (1892 L/min) for the most remote standpipe and 250 gpm (946 L/min) for each additional standpipe until the total system demand is simultaneously flowing.

A.6.3.1.2 When the standpipe system was accepted, NFPA 14 required that each additional standpipe be flowed to simulate the hydraulic calculations. Typically, the lowest hose valve was used to create this simultaneous flow so hoses wouldn't have to be run all the way down each standpipe.

6.3.1.2.1* The 250 gpm (946 L/min) required from each additional Class I and Class III standpipe shall be allowed to be flowed from the most convenient hose valve on that standpipe.

A.6.3.1.2.1 Since the pressures at each standpipe aren't required to be balanced by NFPA 14 or this standard, any hose valve on the standpipe can be flowed to achieve the additional 250 gpm (950 L/min) needed. It might be more convenient to use a hose valve on an upper level rather than the lowest one on the standpipe.

6.3.1.2.2* Where the 250 gpm (946 L/min) cannot be flowed from each additional Class I and Class III standpipe, the authority having jurisdiction shall determine where the additional flow can be taken.

A.6.3.1.2.2 In some instances it isn't reasonable to attach a hose to a standpipe to provide this additional flow point. The authority having jurisdiction can allow the additional flow be made at other outlets on the standpipe system, such as from another standpipe, or from the fire pump test header. Although the results of having the flow points somewhere else in the standpipe system won't match the hydraulic calculations, the test will still prove that the most remote standpipe can provide the necessary flow and pressure required for fire department use while simultaneously flowing the full system demand.

6.3.1.3 Class II standpipe system demand shall include 100 gpm (379 L/min) for the most remote standpipe connection.

6.3.1.4 The standpipe system demand shall be based on the design criteria in effect at the time of the installation.

FAQ What are some of the possible design pressures based on the date of installation?

The requirement in 6.3.1.3 requires the system to be flow tested and pressure tested according to the design criteria used for the standpipe system design. Depending on the edition of NFPA 14 the system was designed to, the hydraulic demand and permissible system pressures can vary greatly. Testing the system to the wrong demand and pressure could provide inaccurate results or damage the system. In order to test to the proper pressure, the testing agent should remember these pressure differences to determine the date of installation of the standpipe system and, if possible, which edition of NFPA 14 was used in the design. Obviously, a standpipe system that was designed to operate at 65 psi (4.5 bar) will — most likely — not flow water at 100 psi (6.9 bar).

Historical Note

In the 1950s, standpipe systems were designed to flow water at a pressure of 50 psi (3.5 bar). The 65 psi (4.5 bar) pressure requirement was introduced into NFPA 14 in the early 1970s and was later revised to the current pressure of 100 psi (6.9 bar).

6.3.1.4.1 Where the standpipe system demand cannot be determined, the authority having jurisdiction shall determine the standpipe system demand.

6.3.1.4.2 The actual test method(s) and performance criteria shall be discussed in advance with the authority having jurisdiction.

6.3.1.5 Standpipes, sprinkler connections to standpipes, or hose stations equipped with pressure-reducing valves or pressure-regulating valves shall have these valves inspected, tested, and maintained in accordance with the requirements of Chapter 13.

6.3.1.6 A main drain test shall be performed on all standpipe systems with automatic water supplies in accordance with the requirements of Chapter 13.

6.3.1.6.1 The test shall be performed at the low point drain for each standpipe or the main drain test connection where the supply main enters the building (when provided).

6.3.1.6.2 Pressure gauges maintained in accordance with Chapter 13 shall be provided for the test.

6.3.2 Hydrostatic Tests.

6.3.2.1* Hydrostatic tests of not less than 200 psi (13.8 bar) pressure for 2 hours, or at 50 psi (3.4 bar) in excess of the maximum pressure, where maximum pressure is in excess of 150 psi (10.3 bar), shall be conducted every 5 years on manual standpipe systems and semiautomatic dry standpipe systems, including piping in the fire department connection.

Historical Note

The 2011 edition of the standard eliminated the requirement for a hydrostatic test on automatic dry systems. Automatic dry systems are supervised under constant air pressure and the dry valve is subject to annual trip testing. However, semiautomatic dry systems use a deluge valve and are not supervised; thus, the need for the hydrostatic test remains.

FAQ Why is a hydrostatic test required for a manual dry standpipe system?

The requirement in 6.3.2.1 requires a hydrostatic test every 5 years for manual standpipe systems and semiautomatic dry standpipe systems to ensure the structural integrity of the system and to detect potential failures before they are discovered during an actual emergency. Problems associated with piping integrity in wet systems are usually detected by leaks. Similarly, leaks in automatic dry systems are detected by the loss of air pressure and are subject to the 3-year test for air leakage, as required by the standard (see 13.4.5.2.9). Pneumatic testing is required to detect leakage within manual dry and semiautomatic standpipe systems, which are more susceptible to corrosion due to the combination of air and moisture in the system. Undetected leaks can lead to failures when the dry standpipe is pressurized.

A.6.3.2.1 The intent of 6.3.2.1 is to ascertain whether the system retains its integrity under fire conditions. Minimum leakage existing only under test pressure is not cause for repair.

6.3.2.1.1 Manual wet standpipes that are part of a combined sprinkler/standpipe system shall not be required to be tested in accordance with 6.3.2.1.

It is not the intent of NFPA 25 to require a hydrostatic test on manual wet standpipes that are part of a combined system, since leaks in this type of system are usually detected immediately.

6.3.2.2 The hydrostatic test pressure shall be measured at the low elevation point of the individual system or zone being tested.

6.3.2.2.1 The inside standpipe piping shall show no leakage.

6.3.3 Waterflow Alarm and Supervisory Alarm Devices.

See 13.2.6 for the recommended operational procedure.

6.3.3.1 Where provided, waterflow alarm and supervisory alarm devices shall be tested in accordance with 13.2.4 and 13.3.3.5.

6.3.3.2 Where freezing conditions necessitate a delay in testing, tests shall be performed as soon as weather allows.

6.4 Maintenance.

Δ **6.4.1** Maintenance and repairs shall be in accordance with 6.1.3 and Table 6.1.1.2.

6.4.2 Equipment that does not pass the inspection or testing requirements shall be repaired and tested again or replaced.

6.5 Component Action Requirements.

Component replacement tables provide guidance when system components are adjusted, repaired, rebuilt, or replaced. It is not necessary in each case to require a complete acceptance test for each component when maintenance is performed. It is important to keep in mind that corrective action must be completed in accordance with the applicable design standard. Quick fixes to undesirable field conditions, such as the duct tape provided in lieu of a cap as shown in Exhibit 6.2, are not appropriate, because they might only cause further deficiencies or potential impairments down the line.

6.5.1 Whenever components in standpipe and hose systems are adjusted, repaired, reconditioned, or replaced, the actions required in Table 6.5.1 shall be performed.



EXHIBIT 6.2 *Fire Hose Valve Connection with Duct Tape. (Courtesy of M. Steven Welsh, Koffel Associates, Inc.)*

Δ ***TABLE 6.5.1*** *Summary of Component Action Requirements*

Component	*Adjust*	*Repair*	*Replace*	*Required Action*
Water Delivery Components				
Backflow prevention device	X	X	X	See Chapter 13
Control valves	X	X	X	See Chapter 13
Fire department connections	X	X	X	See Chapter 13
Fire hose			X	No action required
Fire hose		X		Perform hydrostatic test in accordance with NFPA 1962
Hose valve	X	X	X	See Chapter 13
Hose valve pressure-regulating devices	X	X	X	See Chapter 13
Piping	X	X	X	Hydrostatic test in conformance with NFPA 14
System pressure-regulating devices	X	X	X	See Chapter 13
Alarm and Supervisory Components				
Pressure switch–type waterflow	X	X	X	Operational test using inspector's test connection
Valve supervisory device	X	X	X	Operational test for receipt of alarms and verification of conformance with NFPA 14 and/or *NFPA 72*
Vane-type waterflow	X	X	X	Operational test using inspector's test connection
Water motor gong	X	X	X	Operational test using inspector's test connection
Status-Indicating Components				
Gauges	X		X	Verify at 0 psi (0 bar) and system working pressure
System Housing and Protection Components				
Cabinet	X	X	X	Verify conformance with NFPA 14
Hose storage rack	X	X	X	Verify conformance with NFPA 14
Testing and Maintenance Components				
Auxiliary drains	X	X	X	Inspect for leaks at system working pressure
Drain riser	X	X	X	Inspect for leaks while flowing from connection above the repair
Main drain	X	X	X	Inspect for leaks and residual pressure during main drain test
Structural Components				
Hanger/seismic bracing	X	X	X	Verify conformance with NFPA 14
Pipe stands	X	X	X	Verify conformance with NFPA 14
Informational Components				
Hydraulic design information sign	X	X	X	Verify conformance with NFPA 14
Identification signs	X	X	X	Verify conformance with NFPA 14

6.5.2 Where the original installation standard is different from the cited standard, the use of the appropriate installing standard shall be permitted.

6.5.3 These actions shall not require a design review, which is outside the scope of this standard.

References Cited in Commentary

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2019 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems,* 2019 edition.

NFPA 1962, *Standard for the Care, Use, Inspection, Service Testing, and Replacement of Fire Hose, Couplings, Nozzles, and Fire Hose Appliances*, 2018 edition.

Class I and Class III (Single Zone) Standpipe Flow

Purpose

The purpose of conducting a flow test for the standpipe system is to ensure the adequacy of the water supply as well as the capability of the system to meet the original design flow and pressure criteria for the system performance. The specific required design criteria for standpipe systems has changed through the various editions of NFPA 14, as well as for the specific type of installed standpipe. Therefore, a determination of the original design criteria as well as the type of standpipe must be established as a baseline against which the test results can be assessed. The types of systems include automatic wet, automatic dry, semiautomatic dry, manual wet, and manual dry. Definitions for each of these standpipe system types are provided by 3.3.20 of NFPA 14 and can be used in making a determination of the type of installed standpipe. The flow testing requirements for standpipes have changed in the last few editions of NFPA 25 based on the class of standpipe that is installed. Previous editions of NFPA 25 exempted Class II standpipes from the flow testing requirement; however, this edition requires all automatic standpipes to be tested.

The specified minimum design pressure at the hydraulically most remote outlet for Class I and Class III standpipe systems was typically 65 psi (4.5 bar) for systems installed prior to 1993 and 100 psi (6.9 bar) for systems installed thereafter; however, the specific edition of NFPA 14 under which the system was installed and the required pressures mandated by the original should be confirmed. This information regarding the system type and specific design criteria might be directly obtained from a variety of sources, including, but not limited to: the signage provided at the system riser, original installation records, maintenance records, information provided by the owner, and information provided by the AHJ.

Tools/Equipment

1. Sufficient hose lengths with the appropriate thread connection to allow for the discharge of the standpipe design flow to an appropriate location from the standpipe connections being tested is required. Typically, 2½ in. (65 mm) hose with a coupling having a thread pattern matching that of the hose outlet are used for this purpose. The number and length(s) of hose will depend on the specific location and the distance from the tested outlet to a suitable location, as well as the number of outlets being tested.
2. A sufficient number of test nozzles to permit flow from the number of standpipe outlets to be tested simultaneously is required. Test nozzles can include UL play pipes or other approved test nozzles. The flow characteristics of the test nozzles must be known.
3. A pitot tube, together with a test-pressure gauge[1] that is suitable for the pressures to be expected, is required. [Usually, a 60 psi (4 bar) gauge is satisfactory.]
   - A pitot-tube-and-gauge assembly is indispensable for conducting flow tests from nozzles. The small opening at the end of the tube — not more than 1/16 in. (1.6 mm) in diameter — is inserted in the center of the stream in a direct line with the flow, at a distance in front of the opening equal to one-half the opening diameter. Velocity pressure is registered on the gauge attached to the tube.
   - Some available test nozzles include an integral pitot tube or pitotless flow measuring feature with an attached test gauge[1]; this allows for direct measurement of flows without the use of a separate pitot tube.
4. A means to measure the operating pressure at the hydraulically most remote hose connections under flow conditions is required. Typically, a pressure gauge installed at the top of the standpipe or at the flowing outlet is used.
5. For automatic dry pipe standpipe systems, a timing device is needed to measure the duration between the opening of the most remote hose valve connection and water delivery.
6. Various wrenches and tools needed to facilitate the necessary connections are required.

Procedure Steps

Automatic Wet / Automatic Dry / Semiautomatic Dry Standpipe

1. Prior to any testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is going to be conducted. An approval of the test method and performance criteria must be established with the AHJ prior to conduct of the test.
2. Ensure that the system is in the normal operating position.

1. Test-quality gauges should be used in accordance with ASME B40.100, *Pressure Gauges and Gauge Attachments,* having an accuracy of ±1%. The use of quality test gauges produces results that are considered reasonably accurate within the scope of the test procedure. Care should be taken to protect the gauges from rough handling.

Gauges should be calibrated at least annually by means of a dead-weight or calibrated tester throughout the range of operation before a test series is begun. Calibration sheets should be kept for each gauge and correction factors affixed to the back of each gauge.

3. For semiautomatic dry standpipe systems, locate or establish a point of connection for the introduction of pressurized air to the standpipe system on the dry side of the deluge valve, and pressurize the system piping to 25 psi (1.7 bar) to verify the integrity of the system piping, including piping leaks and open hose valves. No specific acceptance criteria are prescribed by NFPA 25 as to allowable leakage rate. Judgment should be applied to assess conditions that might be indicative of gross leakage raising concern for system integrity.

4. Set up a flow test connection from the hydraulically most remote standpipe hose valve connection(s). This usually includes the connection and routing of fire hose from the hose valve connection to a proper discharge location, including the connection to a suitable discharge device to allow for measurement of the flow rate. For other than horizontal standpipes, this will require a flow rate of 500 gpm (1893 L/min) from the most remote standpipe. This can be accomplished through the use of a roof manifold or connection to the uppermost connection(s) within the stairway where no roof manifold is provided. For a horizontal standpipe, a flow rate of 250 gpm (946 L/ min) is required from the hydraulically most remote hose connection. A means must be established to measure the pressure at the hydraulically most remote hose connection during the conduct of the flow test. Typical installations include the installation of a pressure gauge at the top of the standpipe riser. However, where no pressure gauge is installed, the use of an adaptor with a pressure gauge or other alternative arrangement at or near the flowing outlet might be used.

5. Set up a flow connection for each of the additional standpipe risers (or hose connections for a horizontal standpipe) needed to achieve the required test flow. This usually includes the connection and routing of fire hose from the hose valve connection to a proper discharge location, including the connection to a suitable discharge device to allow for measurement of the flow rate. This will require the flow rate of an additional 250 gpm (946 L/min) from each additional standpipe riser (or additional hose connection for horizontal standpipes) up to a maximum flow rate of 1000 gpm (3785 L/min) for fully sprinklered buildings, 1250 gpm (4731 L/min) for nonsprinklered or partially sprinklered buildings, and 750 gpm (2840 L/min) for horizontal standpipe systems. The connection locations for these flows can be made at the most convenient point for flow purposes on the additional standpipe (or hose connection for horizontal standpipe) being used. Where the flow from these additional locations cannot be accomplished, other locations can be used as permitted by the AHJ. Such alternative flow locations might include other standpipes or the fire pump test header.

6. Check the area surrounding the discharge point for the connected discharge devices to ensure that there are no obvious conditions that would prevent water from being discharged safely or cause direct damage in the immediate vicinity; take appropriate caution to ensure that personnel and property are protected from the resultant high-pressure hose stream discharge. The use of a flow diffuser can aid in breaking the directed stream and managing resultant energy of the discharge. Where the discharge of water is to an area subject to potential freezing conditions, the facility representative should be advised of the potential for icing conditions.

7. For semiautomatic dry standpipes, initiate the means of manual operation of the deluge valve.

8. Initiate the flow test by slowly opening the hose valve(s) on the hydraulically most remote standpipe connection, allowing for the establishment of the automatic operation of any fire pumps or tripping of the dry pipe valve for automatic dry standpipe systems, followed by simultaneously opening additional hose valve(s) or flow locations as established above. For automatic dry standpipe systems, record the time that the first hose valve is fully opened and the elapsed time for water delivery to this most remote hose connection. The flow rate from each is to be measured and adjusted as required. The flow rate can be adjusted by metering the flow rate at the hose valve to obtain the required flow, with multiple flow points generally requiring multiple passes of adjustment to obtain the required flow rate at each outlet. Record the flow rate from each of the flowing connections.

9. Allow the flow to stabilize, take pressure readings at the hydraulically most remote hose connection, and record the results.

10. Slowly close each of the hose valves to avoid water hammer.

11. Shut down any fire pump(s) that has operated.

12. Remove all attached test equipment.

13. For dry systems, completely drain the system piping.

14. Restore the system to normal operating condition.

15. Upon completion of all testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is complete, and reset the fire alarm system as necessary.

Class I and Class III (Single Zone) Standpipe Flow

Manual Wet / Manual Dry Standpipe

1. Prior to any testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is going to be conducted. An approval of the test method and performance criteria must be established with the AHJ prior to conducting the test.
2. Ensure that the system is in the normal operating position.
3. For manual dry standpipe systems, locate or establish a point of connection for the introduction of pressurized air to the standpipe system, and pressurize the system piping to 25 psi (1.7 bar) to verify the integrity of the system piping, including piping leaks or open hose valves. No specific acceptance criteria are prescribed by NFPA 25 as to allowable leakage rate. Judgment should be applied to assess conditions that might be indicative of gross leakage raising concern for system integrity.
4. Establish a temporary means of supplying pressurized water through the fire department connection. This might be accomplished by means of the fire department pumper truck or a portable pump having a comparable capacity to that of the fire department's pumper truck. This might be supplied with water from a fire hydrant on the municipal system or other alternate water supply. The typical fire department operating procedure is to charge the fire department connection to a pressure of 150 psi (10.3 bar) and maintain that during the flow testing; however, original design criteria might have established alternative pressure requirements.
5. Set up a flow test connection from the hydraulically most remote standpipe hose valve connection(s). This usually includes the connection and routing of fire hose from the hose valve connection to a proper discharge location, including the connection to a suitable discharge device to allow for measurement of the flow rate. For other than horizontal standpipes, this will require a flow rate of 500 gpm (1893 L/min) from the most remote standpipe. This can be accomplished through the use of a roof manifold or connection to the uppermost connection(s) within the stairway where no roof manifold is provided. For a horizontal standpipe, a flow rate of 250 gpm (946 L/min) is required from the hydraulically most remote hose connection. A means must be established to measure the pressure at the hydraulically most remote hose connection during the flow test. Typical installations include the installation of a pressure gauge at the top of the standpipe riser; however, where no pressure gauge is installed, the use of an adaptor with a pressure gauge or other alternative arrangement at or near the flowing outlet might be used.
6. Set up a flow connection for each of the additional standpipe risers (or hose connections for a horizontal standpipe) needed to achieve the required test flow. This usually includes the connection and routing of fire hose from the hose valve connection to a proper discharge location, including the connection to a suitable discharge device to allow for measurement of the flow rate. This will require the flow rate of an additional 250 gpm (946 L/min) from each additional standpipe riser (or additional hose connection for horizontal standpipes) up to a maximum flow rate of 1000 gpm (3785 L/min) for fully sprinklered buildings, 1250 gpm (4731 L/min) for nonsprinklered or partially sprinklered buildings, and 750 gpm (2840 L/min) for horizontal standpipe systems. The connection locations for these flows can be made at the most convenient point for flow purposes on the additional standpipe (or hose connection for horizontal standpipe) being used. Where the flow from these additional locations cannot be accomplished, other locations can be used as permitted by the AHJ. Such alternative flow locations might include other standpipes or the fire pump test header.
7. Check the area surrounding the discharge point for the connected discharge devices to ensure that there are no obvious conditions that would prevent water from being discharged safely or cause direct damage in the immediate vicinity; take appropriate caution to ensure personnel and property are protected from the resultant high-pressure hose stream discharge. Where the discharge of water is to an area subject to potential freezing conditions, the facility representative should be advised of the potential for icing conditions.
8. Establish the fire department operating pressure at the fire department pumper or temporary pump connection to the fire department connection.
9. Initiate the flow test by slowly opening the hose valve(s) on the hydraulically most remote standpipe connection, followed by simultaneously opening additional hose valve(s) or flow locations as established above. The flow rate from each is to be measured and adjusted as required to obtain the required flow rate from each. The flow rate can be adjusted by metering the flow rate at the hose valve to obtain the required flow, with multiple flow points generally requiring multiple passes of adjustment to obtain the required flow rate at each outlet. Additionally, the operating pressure at the fire department pumper or temporary pump connection must be adjusted to maintain the established pressure for the connection. Record the flow rate from each of the flowing connections and the operating pressure at the fire department pumper or temporary pump.
10. Allow the flow to stabilize, take pressure readings at the hydraulically most remote hose connection, and record the results.
11. Slowly close each of the hose valves to avoid water hammer.
12. Shut down the fire department pumper or temporary pump.
13. Remove all attached test equipment.
14. For dry systems, completely drain the system piping.
15. Restore the system to normal operating condition.
16. Upon completion of all testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is complete, and reset the fire alarm system as necessary.

Evaluation of Results

For semiautomatic dry and manual dry standpipe systems that are required to be air pressure tested at 25 psi (1.7 bar), an evaluation of the degree of leakage must be assessed. While no specific acceptance criteria are prescribed by NFPA 25 as to allowable leakage rate, an experienced level of judgment should be applied to assess if gross leakage raising concern for system integrity is evident. Where such conditions exist, the system should be investigated and corrective action taken prior to conducting the flow test of the system.

For automatic dry standpipe systems, the water delivery time to the hydraulically most remote hose valve should be compared with previous tests to reveal substantial delays for the water delivery time of dry pipe systems, since significant differences from one test to another are an indication of possible operational problems with the system. A drastic increase in the water delivery time from one full flow trip test of a dry pipe system to the next is of major concern, because such an increase is most likely due to corrosion of the system piping. Such conditions should be investigated and appropriate corrective action should be taken as necessary. NFPA 25 does not require a specific water delivery time for these systems.

An evaluation of the test results from the flow test must be compared to that established for the original design of the system. This would typically require that the available pressure at the hydraulically most remote hose connection while flowing the full design demand be either 100 psi (6.9 bar) or 65 psi (4.5 bar), depending on the specific edition of NFPA 14 under which the system was designed and installed. System performance falling below these criteria should be investigated and appropriate corrective action should be taken as necessary.

References

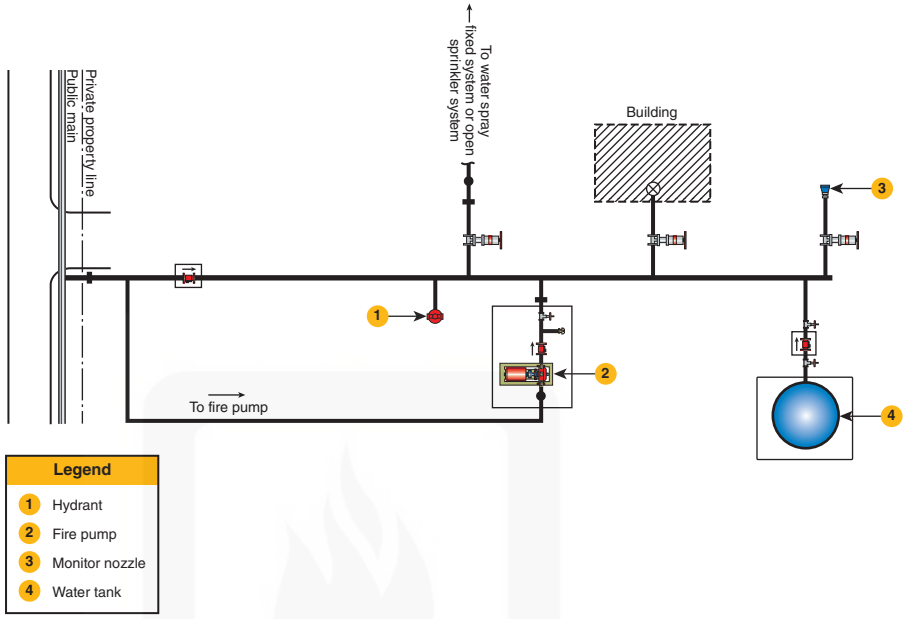
American Society of Mechanical Engineers, Two Park Avenue, New York, NY 10016-5990.

ASME B40.100, *Pressure Gauges and Gauge Attachments*, 2013 edition.

The procedure(s) outlined above is not mandated by NFPA 25 and represents only one approach to conducting this test.

What Are Private Fire Service Mains?

A private fire service main is a system of pipe and components on private property that is supplied by a source of water and used to provide water to a water-based fire protection system, foam-making system, private hydrants and monitor nozzles, and fire pumps. As opposed to a public waterworks system that is maintained by the water purveyor, this system of fire service mains needs to be maintained by the owner.

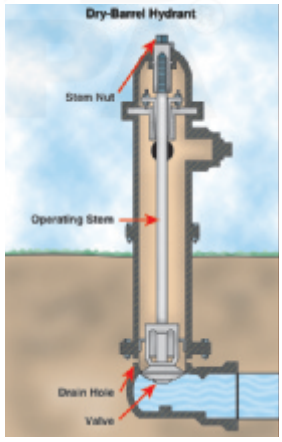


Courtesy of Stephan Laforest.

What Are the Different Types of Hydrants?

Dry Barrel

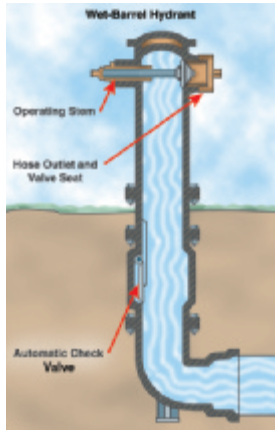
A type of hydrant with the main control valve located below the frost line so it can be used in climates that are subject to freezing temperatures.



Courtesy of IFSTA/Fire Protection Publications

Wet Barrel Hydrant

A type of hydrant that is intended for use in locations where there is no danger of freezing weather that contains valves at the outlets of the hydrant.



Courtesy of IFSTA/Fire Protection Publications

Monitor Nozzle

Monitor nozzles can be provided where a large quantity of combustibles are present that would require large amounts of water quickly in order to control the fire. These nozzles can be stand alone, or can be attached to a hydrant.



Courtesy of Sanco SpA



Courtesy of Akron Brass

Hose House

A hose house is an enclosure that is located near a hydrant or water supply that is designed to contain the necessary hose nozzles, hose wrenches, gaskets, and spanners to be used in fire fighting when the hydrants are intended to be used by plant personnel or a fire brigade.



Courtesy of Potter Roehmer/Fire Pro

ITM

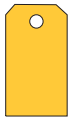
Since the inspection of private fire service mains is not practical, it is important to conduct flow tests at least every 5 years and compare it to previous tests to ensure that the flow and pressure that the system can provide is not deteriorating. Hydrants need to be flushed annually to ensure that nothing is blocking the hydrants and that they operate correctly.

For more information refer to NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances.*

Private Fire Service Mains Inspection and Testing



NO DEFICIENCIES OR IMPAIRMENTS



NONCRITICAL DEFICIENCIES

- Tightness of hydrant outlets
- Worn hydrant nozzle threads
- Worn hydrant operating nut
- Missing hydrant wrench
- Hose/hydrant houses not fully equipped
- Dry barrel or wall hydrant did not flow clear or did not drain within 60 minutes



CRITICAL DEFICIENCIES

- Leaking exposed piping — slowly dripping, and/or moisture on surface
- Mechanical damage to exposed piping
- Corroded exposed piping
- Exposed piping not properly restrained
- Corroded mainline strainers
- Hydrant barrel contains water,
- Improper drainage from hydrant barrel
- Leaks at outlets or top of hydrant
- Damaged, corroded, or leaking monitor nozzles
- Damaged hose/hydrant houses
- Test results show deterioration in water supply when compared to previous results
- Monitor nozzles did not flow acceptable amount of water
- Monitor nozzles did not operate throughout their full range



IMPAIRMENTS

- Leaking exposed piping — spraying or running water
- Plugged or fouled mainline strainers
- Hydrant inaccessible
- Hydrant barrel contains ice
- Cracks in hydrant barrel
- Inaccessible hose/hydrant houses

Source: Table A.3.3.8

7

PRIVATE FIRE SERVICE MAINS

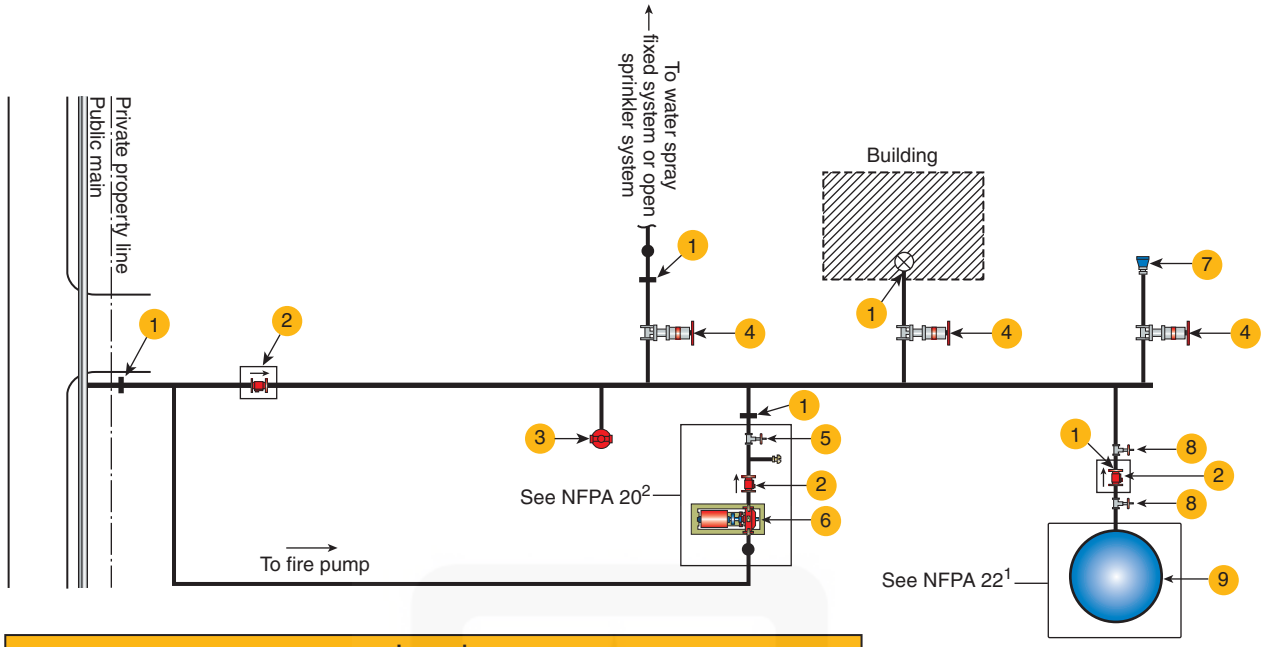
Chapter 7 of NFPA 25 addresses the inspection, testing, and maintenance (ITM) of private underground mains and their appurtenances. The term *private* indicates that the piping and equipment is located on private property and is neither owned by nor maintained by the local municipality, water district, or other water purveyor. The flow testing discussed in this chapter is intended to apply to hydrants located on private property, although the procedures are similar for testing hydrants on public property.

Private firms or individuals are often not permitted to operate equipment owned by the water purveyor, so it is best to contact the owner of the system or equipment before conducting any test or operating valves or hydrants. In regions impacted by the Clean Water Act, it might be necessary to capture or treat the water discharged during hydrant flow tests. This can include de-chlorination or other precautionary measures to avoid washing debris into local storm drain piping. NFPA 291, *Recommended Practice for Fire Flow Testing and Marking of Hydrants,* provides guidance on public and private fire hydrant markings and color codes, which can be helpful in determining if a hydrant is public or private. NFPA 291 also provides guidance on how to conduct hydrant flow tests, in terms of which hydrants to use to read static and residual pressures and which hydrants to flow for the best test results.

Exhibit 7.1 illustrates the boundary between public and private equipment and systems. Generally, when piping enters private property, the property owner is responsible for the inspection, testing, and maintenance (ITM) of piping and related equipment. Generally, the piping and equipment on the public side of the property line are the responsibility of the water purveyor.

7.1 General.

The purpose of Section 7.1 mirrors the basic purpose of the standard — that is, "to provide requirements that ensure a reasonable degree of protection for life and property from fire through minimum inspection, testing, and maintenance methods. . ." It should be recognized that when inspecting equipment such as private fire service mains, a visual examination of the equipment is usually not possible. Much of the inspection, therefore, centers on the ITM of the attached equipment, such as hydrants, hose houses, and monitor nozzles. Testing this equipment is necessary to assess the condition of the underground piping. Camera equipment can be helpful in discovering internal corrosion or obstructive materials. However, observing changes in flow and pressure during testing is the best way to determine whether further investigation is needed.



Legend

1	End of private fire service main	6	Fire pump
2	Check valve	7	Monitor nozzle
3	Hydrant	8	Control valve
4	Post indicating valve	9	Water tank
5	Pump discharge valve		

Notes

The piping (aboveground or buried) shown is specific as to the end of the private fire service main, and this schematic is only for illustrative purposes beyond the end of the fire service main. Details of valves and their location requirements are covered in the specific standard involved.

1. See NFPA 22, *Standard for Water Tanks for Private Fire Protection.*
2. See NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection.*

EXHIBIT 7.1 *Public/Private Equipment Boundary. (Courtesy of Stephan Laforest)*

FAQ Is the intent of NFPA 25 to require that the ITM requirements of fire hydrants apply to both private and public hydrants?

Section 7.1 specifically states that this chapter applies to private fire service mains and appurtenances. The equipment that is covered in this chapter is designed and installed in accordance with NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*. Neither standard is intended to apply to public systems. However, on-site flow testing of hydrants and main drain flow testing of fire sprinkler or standpipe systems can be an indicator of a need to investigate the public water main system valves and piping as well. Where there is degradation in the test results from year to year or where the difference between the test results compared to the original results is significant (i.e., 10 percent or more), further investigation is normally needed.

7.1.1 Minimum Requirements.

7.1.1.1 This chapter shall provide the minimum requirements for the routine inspection, testing, and maintenance of private fire service mains and their appurtenances.

7.1.1.2 Table 7.1.1.2 shall be used to determine the minimum required frequencies for inspection, testing, and maintenance.

Δ ***TABLE 7.1.1.2*** *Summary of Private Fire Service Main Inspection, Testing, and Maintenance*

Item	*Frequency*	*Reference*
Inspection		
Backflow preventer		Chapter 13
Check valve		Chapter 13
Control valve		Chapter 13
Fire department connection		Chapter 13
Hose houses	Quarterly	7.2.2.8
Hydrants (dry barrel and wall)	Annually and after each operation	7.2.2.4
Hydrants (wet barrel)	Annually and after each operation	7.2.2.5
Mainline strainers	Annually and after each significant flow	7.2.2.3
Monitor nozzles	Semiannually	7.2.2.7
Pipe and fittings (exposed)	Annually	7.2.2.1
Valve supervisory devices		Chapter 13
Test		
Backflow preventer		Chapter 13
Control valve		Chapter 13
Hydrants	Flow, annually	7.3.2
Monitor nozzles	Flow, annually (range and operation)	7.3.3
Piping (exposed and underground) (flow test)	5 years	7.3.1
Valve status test		Chapter 13
Valve supervisory devices		Chapter 13
Maintenance		
Backflow preventer		Chapter 13
Check valve		Chapter 13
Control valve		Chapter 13
Hydrants	Annually	7.4.2
Mainline strainers	Annually and after each operation	7.2.2.3
Monitor nozzles	Annually	7.4.3

7.1.2 Common Components and Valves. Common components and valves shall be inspected, tested, and maintained in accordance with Chapter 13.

7.1.3 Obstruction Investigations. The procedures outlined in Chapter 14 shall be followed where there is a need to conduct an obstruction investigation.

One of the conditions identified in 14.3.1 that triggers the requirement to conduct an obstruction investigation is a record of broken public mains in the vicinity. Although not specifically mentioned in this chapter or Chapter 14, broken private fire service mains can introduce obstructive material into the system as well. Anytime private fire service mains

suffer damage or break, consideration should be given to conducting an obstruction investigation to determine if there is cause for concern.

7.1.4 Fire Hose. Fire hose shall be maintained in accordance with NFPA 1962.

7.1.5 Impairments. The procedures outlined in Chapter 15 shall be followed wherever such an impairment to protection occurs.

Impairments such as those referred to in 7.1.5 involve removing a system from service. Impairments can be of an emergency nature, such as a broken fire service main, or they can be preplanned, as in cases of physical modification to the system or routine maintenance of the equipment. In either case, an impairment program must be in place to minimize the length of time the system is impaired and to verify that systems and valves are properly returned to service upon completion of the work.

As mentioned in the commentary on Chapter 1, shut valves are the most common cause of sprinkler system failure (see Commentary Table 1.1).

Tip for Owners

An impairment program is critical for any work associated with a private fire service main, because impairment of these systems often involves shutting water supply control valves to one or more water-based fire protection systems or fire hydrants. Exhibit 7.2 shows one means of identifying hydrants that have been impaired.

EXHIBIT 7.2 *Hydrant with an "Out of Service" Collar Indicating an Impaired Condition.*



7.2 Inspection and Corrective Action.

7.2.1 General. Private fire service mains and their appurtenances shall be inspected at the intervals specified in Table 7.1.1.2.

Generally, inspectors should check each inspection point as listed in Table 7.1.1.2. The intent is to perform a quick visual examination to verify that the system and components appear to be in good working order. As referenced in Chapter 1, it is important to verify that water supply control valves are in the full open position. The findings of the inspections conducted in accordance with Section 7.2 must be recorded and maintained by the owner. Exhibit 7.3 is a sample form that can be used to record not only the inspection-related tasks of Section 7.2, but also the maintenance and testing tasks required by the other sections of Chapter 7.

7.2.2* Procedures. All procedures shall be carried out in accordance with the manufacturer's instructions, where applicable.

A.7.2.2 The requirements in 7.2.2 outline inspection intervals, conditions to be inspected, and corrective actions necessary for private fire service mains and associated equipment.

PRIVATE FIRE SERVICE MAINS INSPECTION, TESTING, AND MAINTENANCE

Name of Property: _____ **Inspector:** _____

Address: _____ **Contract No.:** _____

Property Phone Number: _____ **Date:** _____

Inspection Frequency: ❑ Weekly ❑ Monthly ❑ Quarterly ❑ Semiannual ❑ Annual ❑ Five-Year

Inspections: Weekly			**Control Valves**
❑ Yes	❑ No	❑ N/A	In the correct (open or closed) position
❑ Yes	❑ No	❑ N/A	Sealed
❑ Yes	❑ No	❑ N/A	Accessible
❑ Yes	❑ No	❑ N/A	Post Indicator Valves (PIVs) are provided with correct wrenches
❑ Yes	❑ No	❑ N/A	Free from damage or leaks
❑ Yes	❑ No	❑ N/A	Proper signage
			Backflow
❑ Yes	❑ No	❑ N/A	Isolation valves are in open position and locked or supervised
❑ Yes	❑ No	❑ N/A	RPA and RPDA - differential-sensing relief valve operating correctly
Inspections: Monthly			**Control Valves (Locked or Supervised)**
❑ Yes	❑ No	❑ N/A	In the correct (open or closed) position
❑ Yes	❑ No	❑ N/A	Locked or supervised
❑ Yes	❑ No	❑ N/A	Accessible
❑ Yes	❑ No	❑ N/A	Post Indicator Valves (PIVs) are provided with correct wrenches
❑ Yes	❑ No	❑ N/A	Free from damage or leaks
❑ Yes	❑ No	❑ N/A	Proper signage
Inspections: Quarterly			**Control Valves (Electronically Supervised)**
❑ Yes	❑ No	❑ N/A	In the correct (open or closed) position
❑ Yes	❑ No	❑ N/A	Electronically supervised
❑ Yes	❑ No	❑ N/A	Accessible
❑ Yes	❑ No	❑ N/A	Post Indicator Valves (PIVs) are provided with correct wrenches
❑ Yes	❑ No	❑ N/A	Free from damage or leaks
❑ Yes	❑ No	❑ N/A	Proper signage
			Fire Department Connections
❑ Yes	❑ No	❑ N/A	Visible and accessible
❑ Yes	❑ No	❑ N/A	Coupling/swivels operate correctly
❑ Yes	❑ No	❑ N/A	Plugs/caps are in place

NFPA 25 Handbook (p. 1 of 4)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT 7.3 *Sample Form for Inspection, Testing, and Maintenance of Private Fire Service Mains.*

PRIVATE FIRE SERVICE MAINS INSPECTION, TESTING, AND MAINTENANCE (Continued)

Inspections: Quarterly			**Fire Department Connections**
❑ Yes	❑ No	❑ N/A	Gaskets are not damaged
❑ Yes	❑ No	❑ N/A	Automatic drain valve in place and operating properly
❑ Yes	❑ No	❑ N/A	Identification signs are in place
❑ Yes	❑ No	❑ N/A	Interior is clear of obstructions (unless locked)
❑ Yes	❑ No	❑ N/A	Clapper(s) operates correctly
❑ Yes	❑ No	❑ N/A	Check valve not leaking
❑ Yes	❑ No	❑ N/A	Visible piping supplying the fire department connection is undamaged
			Hose Houses
❑ Yes	❑ No	❑ N/A	Accessible
❑ Yes	❑ No	❑ N/A	Free from damage or leaks
❑ Yes	❑ No	❑ N/A	No missing equipment
			Dry Hydrant
❑ Yes	❑ No	❑ N/A	Water supply is not deteriorated in pond, stream, or cistern.
❑ Yes	❑ No	❑ N/A	Vegetation cleared 3 ft (0.9 m) radius from hydrant
Inspections: Semiannual			**Monitor Nozzles**
❑ Yes	❑ No	❑ N/A	Not leaking
❑ Yes	❑ No	❑ N/A	Free of damage
❑ Yes	❑ No	❑ N/A	Free of corrosion
			Dry Hydrants
❑ Yes	❑ No	❑ N/A	Reflective material marking and signage is in accordance with 8.4.7 of NFPA 1142
Inspections: Annual			**Hydrants (Dry Barrel and Wall Type)**
❑ Yes	❑ No	❑ N/A	Accessible
❑ Yes	❑ No	❑ N/A	Barrel is free of water and ice
❑ Yes	❑ No	❑ N/A	Barrel drains properly
❑ Yes	❑ No	❑ N/A	Not leaking
❑ Yes	❑ No	❑ N/A	Barrel is free of cracks
❑ Yes	❑ No	❑ N/A	Outlets are not excessively tight and lubricated
❑ Yes	❑ No	❑ N/A	Nozzle threads are not worn
❑ Yes	❑ No	❑ N/A	Operating nut is not worn
❑ Yes	❑ No	❑ N/A	Operating wrench is available
❑ Yes	❑ No	❑ N/A	Free of detrimental corrosion

NFPA 25 Handbook (p. 2 of 4)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT 7.3 *Continued.*

PRIVATE FIRE SERVICE MAINS INSPECTION, TESTING, AND MAINTENANCE (Continued)

Inspections: Annual			**Hydrants (Wet Barrel)**
❑ Yes	❑ No	❑ N/A	Accessible
❑ Yes	❑ No	❑ N/A	Not leaking
❑ Yes	❑ No	❑ N/A	Barrel is free of cracks
❑ Yes	❑ No	❑ N/A	Outlets not excessively tight and lubricated
❑ Yes	❑ No	❑ N/A	Nozzle threads are not worn
❑ Yes	❑ No	❑ N/A	Operating nut is not worn
❑ Yes	❑ No	❑ N/A	Operating wrench is available
			Fire Department Connections
❑ Yes	❑ No	❑ N/A	Interior of connection with locked plugs or caps is free of obstructions
			Mainline Strainers
❑ Yes	❑ No	❑ N/A	Not plugged or fouled
❑ Yes	❑ No	❑ N/A	Free of corrosion
❑ Yes	❑ No	❑ N/A	No damaged parts
			Pipe and Fittings (exposed)
❑ Yes	❑ No	❑ N/A	Not leaking
❑ Yes	❑ No	❑ N/A	Free of damage and corrosion
❑ Yes	❑ No	❑ N/A	Hangers intact and not damaged
Inspections: Five Years			
❑ Yes	❑ No	❑ N/A	Backflow - internal inspection
❑ Yes	❑ No	❑ N/A	Check valve - internal moves freely and in good condition
❑ Yes	❑ No	❑ N/A	Backflow - forward flow test at minimum flow rate of the system demand
Test: Annual			**Monitor Nozzles**
❑ Yes	❑ No	❑ N/A	Flow test until all foreign material has cleared (not less than one minute)
❑ Yes	❑ No	❑ N/A	Operated through full range of motion
			Dry Hydrant
❑ Yes	❑ No	❑ N/A	Flow Test
			Hydrants
❑ Yes	❑ No	❑ N/A	Flow test until all foreign material has cleared (not less than one minute)
❑ Yes	❑ No	❑ N/A	Barrel drains within 60 minutes
			Hydrant Isolation Valve
❑ Yes	❑ No	❑ N/A	Operated through full range of motion
❑ Yes	❑ No	❑ N/A	Status test (verify valve is in the open position)

NFPA 25 Handbook (p. 3 of 4)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT 7.3 *Continued.*

PRIVATE FIRE SERVICE MAINS INSPECTION, TESTING, AND MAINTENANCE (Continued)

Test: Five Years

❑ Yes	❑ No	❑ N/A	**Piping (Exposed and Underground)**
❑ Yes	❑ No	❑ N/A	Flow test piping at rate anticipated during a fire
❑ Yes	❑ No	❑ N/A	Flow test results comparable to previous test
			Fire Department Connections
❑ Yes	❑ No	❑ N/A	Piping from fire department connection to fire department connection check valve hydrostatically tested at 150 psi (10 bar) for at least 2 hours

Maintenance: Annual

❑ Yes	❑ No	❑ N/A	**Mainline Strainers**
❑ Yes	❑ No	❑ N/A	Removed, inspected, and cleaned
			Hydrants
❑ Yes	❑ No	❑ N/A	Lubricate stems, caps, plugs, and threads
❑ Yes	❑ No	❑ N/A	Accessible (no snow, ice, or other material)
❑ Yes	❑ No	❑ N/A	Protected from damage
			Monitor Nozzles
❑ Yes	❑ No	❑ N/A	Lubricate per manufacturer's recommendations

Comments

Signature: _____ Date: _____

Contractor Name: _____

Contractor Address: _____

License/Certification No.: _____

NFPA 25 Handbook (p. 4 of 4)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT 7.3 *Continued.*

7.2.2.1 Exposed Piping.

ITM Deficiency, Impairment, or Hazard Evaluation?



(Courtesy of Byron Blake and SimplexGrinnell)

ANSWER: ITM Deficiency

The hydrant shown here has been struck or backed over by a vehicle. Pictures from different angles show no obvious damage to the hydrant itself, although based on the position of the hydrant, the following can be determined:

1. The barrel is cracked or broken below ground level.
2. The shaft is bent and will not operate.

Paragraph 7.2.2.4 indicates that if the hydrant barrel is cracked, it needs to be replaced. It is interesting to note that NFPA 25 does not specifically address situations like this one, where the component is obviously damaged, but the damage is not visible.

7.2.2.1.1 Exposed piping shall be inspected annually.

7.2.2.1.2 Piping shall be inspected for the following conditions:

(1) Leaks
(2 Physical damage
(3) Corrosion
(4) Restraint methods

7.2.2.1.2.1 Where any deficiency is noted, the appropriate corrective action shall be taken.

7.2.2.1.3 Piping installed in areas that are inaccessible for safety considerations due to process operations shall be inspected during each scheduled shutdown.

If the routine inspection falls during a period when a process is in operation that prevents safe inspection, coordination of the inspection with a regularly scheduled shutdown of the process should take place.

7.2.2.2* Underground Piping.

A.7.2.2.2 Generally, underground piping cannot be inspected on a routine basis. However, flow testing can reveal the condition of underground piping and should be conducted in accordance with Section 7.3.

7.2.2.3* Mainline Strainers.

A.7.2.2.3 Any flow in excess of the flow through the main drain connection should be considered significant.

A strainer is installed on a system where foreign material is likely to be present in the water supply and might obstruct an orifice. For example, the presence of rocks, pebbles, leaves, and sediment in a raw water source, such as a pond, would necessitate a strainer.

Strainers must be installed where sprinkler or nozzle orifices are smaller than ⅜ in. (10 mm) in diameter. The concern is increased where higher volumes of water are used for



EXHIBIT 7.4 *Fire Protection Mainline Strainer. (Courtesy of Watts Water Technologies)*

fire protection purposes, as opposed to volumes typically encountered in a plumbing system. In fire pump installations, the velocity of the water could be sufficient to dislodge and carry material to an orifice. In this case, the strainer serves to "filter" the water. During inspection, the strainer flushing valve should be opened and allowed to flow until the water is clear. In cases of severe sediment, the strainer basket should be removed and cleaned. Exhibit 7.4 shows a typical fire protection system strainer.

7.2.2.3.1 Mainline strainers shall be inspected and cleaned after each system flow exceeding that of a nominal 2 in. (50 mm) orifice.

7.2.2.3.2 Mainline strainers shall be removed and inspected annually for plugging, fouling, and damaged and corroded parts.

As a matter of good practice, the best time to remove the strainer for inspection and maintenance is after any testing of downstream appurtenances has been completed. Paragraph 7.2.2.3.1 permits system flow through an orifice of up to 2 in. (50 mm) without triggering the need for inspection of the strainer, but any routine downstream testing can draw unwanted material into the strainer.

7.2.2.4 Dry Barrel and Wall Hydrants. Dry barrel and wall hydrants shall be inspected annually and after each operation for the following conditions:

(1) Inaccessibility
(2) Presence of water or ice in barrel, which could indicate a faulty drain, a leaky hydrant valve, or high groundwater table)
(3) Improper drainage from barrel
(4) Leaks in outlets or at top of hydrant
(5) Cracks in hydrant barrel
(6) Tightness of outlet caps
(7) Worn outlet threads
(8) Worn hydrant operating nut
(9) Availability of operating wrench
(10) Corrosion detrimental to hydrant integrity

Tip for Owners

Accessibility is a term that is not defined by this standard. The accessibility of fire hydrants is not necessarily the same as accessibility of some other components. Fire apparatus must be able to get near enough to the hydrant to connect hoses, and fire fighters must be able to make the connections and operate the hydrant. Ensuring this may mean blocking off certain parking spaces or installing protective bollards a certain distance away. Consulting the authority having jurisdiction (AHJ) or the local fire department is recommended. Also, see 7.4.2.2 for additional requirements.

The dry barrel hydrants (see Figure A.3.3.13.1) are also known as frost-proof hydrants. These hydrants are used where there is a chance that temperatures will drop below freezing. The valve controlling the water is located below the frost line between the foot piece and barrel of the hydrant. The barrel of the hydrant is dry, and water is admitted upon opening the operating nut. A drain valve at the base of the barrel is open when the main valve is closed, allowing residual water in the barrel to drain out. A common sign that the hydrant needs maintenance is when water remains in the hydrant after the valve is shut, indicating that this drain is plugged. Failure to address this issue can lead to the hydrant freezing and breaking, making the repair much costlier. See the commentary for 7.3.2.3 for more information.

7.2.2.4.1 Where any deficiency is noted, the appropriate corrective action shall be taken.

7.2.2.5 Wet Barrel Hydrants. Wet barrel hydrants shall be inspected annually and after each operation for the following conditions:

(1) Inaccessibility

See Tip for Owner related to 7.2.2.4(1).

(2) Leaks in outlets or at top of hydrant
(3) Cracks in hydrant barrel
(4) Tightness of outlet caps
(5) Worn outlet threads
(6) Worn hydrant operating nut
(7) Availability of operating wrench
(8) Corrosion detrimental to hydrant integrity

System Tagging

The hydrant shown in this photo has had the cap removed or stolen, and it was not replaced. This hydrant was exposed to harsh conditions for several seasons, and threading has deteriorated to the point where a hose line could not be attached. In this instance, the hydrant can no longer accept a hose, and therefore, it would not be considered functional during a fire. This condition should be considered an impairment of that hydrant.

Furthermore, this hydrant is not labeled with an out-of-service tag; therefore, when responding personnel arrive on scene, they would have a false indication of a potential manual source of fire suppression. This can be problematic as it can require responding personnel to modify operational tactics on the fly, costing them several minutes in response time.



(Courtesy of Byron Blake and SimplexGrinnell)

Noncritical Deficiency Critical Deficiency Impairment

ITM Deficiency, Impairment, or Hazard Evaluation?



(Courtesy of Byron Blake and SimplexGrinnell)

ANSWER: ITM Deficiency

The hydrant shown here is — apparently — used frequently, because the operating nut is worn so badly that it is completely round. Hydrants are required in 7.2.2.4 and 7.2.2.5 to be inspected annually and after each operation. Paragraph 7.2.2.4 describes the conditions the inspector is looking for and the corrective action that needs to be taken to fix each specific problem.

In this case, a worn hydrant operating nut is a condition described in each table, and the required corrective action is to repair or replace the operating nut. Although it will be difficult to open this hydrant in a fire event, if an adjustable hydrant wrench or pipe wrench is available, it can be done. Then, the condition should be recorded as a critical deficiency.

ITM Deficiency, Impairment, or Hazard Evaluation?

ANSWER: ITM Deficiency

The hydrant shown here was opened before the annual flow test required by 7.3.2 to perform the inspections required by 7.2.2.4 and 7.2.2.5, which require hydrants to be inspected annually and after each operation. Paragraph 7.2.2.4 describes the conditions the inspector is looking for and the corrective action that needs to be taken to fix each specific problem.

In this case, a hydrant that leaks from the outlets or top is a condition described in 7.2.2.4 or 7.2.2.5. The required corrective action is to repair or replace gaskets, packing, or parts as necessary. Although it leaks, this hydrant can still be used in a fire event, and the condition should be recorded as a critical deficiency.



(Courtesy of Byron Blake and SimplexGrinnell)

Paragraph 7.2.2.5 addresses the inspection of wet barrel hydrants, also known as "California" hydrants, such as the one shown in Exhibit 7.5. These hydrants are sometimes used where the temperature remains above freezing. A wet barrel hydrant usually has a compression valve at each outlet, but it might have another valve in the bonnet that controls the water flow to all outlets. As with any flow testing, the inspector should verify where water will go before any valves or hydrants are opened. Extra care should be used in newly landscaped areas that could be washed out by a normal flow test, because such actions could result in owners or occupants losing the desire to comply with the ITM requirements provided in this standard.



EXHIBIT 7.5 *Wet Barrel Hydrant.*

7.2.2.5.1 Where any deficiency is noted, the appropriate corrective action shall be taken.

N **7.2.2.6* Dry Hydrants.** Dry hydrants shall be inspected at least quarterly and maintained as necessary to keep them in good operating condition. [**1142**, 2017]

N **A.7.2.2.6** There could be a need for more frequent inspections due to freezing and droughts. Particular attention should be given to streams and ponds where frequent removal of debris, dredging or excavation of silt, and protection from erosion might be required. The pond should be maintained as free of aquatic growth as possible. At times it might be necessary to drain the pond to control this growth. Helpful information is available from such sources as the county agricultural extension agent or the U.S. Department of Agriculture. [**1142**, 2017]

N **7.2.2.6.1** Thorough surveys shall be conducted, to reveal any deterioration in the water supply situation in ponds, streams, or cisterns. [**1142**, 2017]

N **7.2.2.6.2** Vegetation shall be cleared for a minimum 3 ft (0.9 m) radius from around hydrants. [**1142**, 2017]

N **7.2.2.6.3** The reflective material marking the hydrant and signage shall be inspected at least annually to verify that it is being maintained in accordance with 8.4.7 of NFPA 1142. [**1142**, 2017]

N **7.2.2.6.4** Hydrant risers shall be protected from ultraviolet (UV) degradation by painting or other measures. [**1142**, 2017]

N **7.2.2.6.5*** The hydrants shall be flow tested at least annually with an approved pump to ensure that the minimum design flow is maintained. [**1142**, 2017]

N **A.7.2.2.6.5** Dry hydrants can be checked and tested by actual drafting as part of the fire department training program. If the tests do not produce the design flow, the fire department should determine what the problem is. It could be necessary to back flush the system to clear leaves and other debris. When a dry hydrant is back flushed, pump pressures should not exceed 20 psi. [**1142**, 2017]

7.2.2.7 Monitor Nozzles. Monitor nozzles shall be inspected semiannually for the following conditions:

(1) Leakage
(2) Physical damage
(3) Corrosion

Monitor nozzles are provided where large amounts of combustible materials, such as log piles, lumber piles, flammable or combustible liquids, or railway cars are stored in yards; it is necessary to provide a means of quickly delivering large volumes of water to control fires. See Exhibit 7.6 for an example of a monitor nozzle.

EXHIBIT 7.6 *Monitor Nozzle.*



7.2.2.7.1 Where any deficiency is noted, the appropriate corrective action shall be taken.

7.2.2.8 Hose Houses. Hose houses shall be inspected quarterly for the following conditions:

(1) Inaccessibility
(2) Physical damage
(3) Missing equipment

A hose house is typically located in an industrial environment to provide manual fire-fighting equipment outside to protect buildings, exposures, or process equipment that might be exposed to a fire hazard. Such equipment generally includes hose, nozzles, wrenches, gated wyes, and hose couplings.

7.2.2.8.1 Where any deficiency is noted, the appropriate corrective action shall be taken.

7.3 Testing.

7.3.1* Underground and Exposed Piping Flow Tests. Underground and exposed piping shall be flow tested at minimum 5-year intervals.

Prior to the 2017 edition, this subsection only applied to piping that serves hydrants. There was no requirement to flow any other systems such as those that only serve individual sprinkler systems, standpipe systems, and so on. Therefore, the subsection has been revised to apply to all private fire service mains.

Testing Procedure Alert

It is not uncommon for underground piping and other appurtenances associated with private service mains to become damaged due to the environment where the equipment is located. This can lead to a degradation in the water supply that is delivered to the systems downstream. The underground flow test is intended to identify reductions in flow, among other things. For a procedure for conducting this test, please refer to the detailed testing procedure at the end of this chapter.

Δ **A.7.3.1** Full flow tests of underground piping can be accomplished by methods including, but not limited to, flow through yard hydrants, fire department connections once the check valve has been removed, main drain connections, and hose connections. The flow test should be conducted in accordance with NFPA 291.

A hydrant flow test, which helps determine the internal condition of piping, should be compared to the most recent test conducted, as well as to the original test. If deterioration is noted, additional testing, such as a hydraulic gradient analysis, should be conducted. All data gathered during either test should be recorded on report forms.

7.3.1.1 Any flow test results that indicate deterioration of available waterflow and pressure shall be investigated to the complete satisfaction of the authority having jurisdiction to ensure that the required flow and pressure are available for fire protection.

7.3.1.2 Where underground piping supplies individual fire sprinkler, standpipe, water spray, or foam-water sprinkler systems and there are no means to conduct full flow tests, tests generating the maximum available flows shall be permitted.

Case In Point

The flows expected during a fire are not just those used by automatic suppression systems, such as sprinklers. Many jurisdictions use fire flows from the adopted fire code, which could include much higher flows that take into consideration manual fire-fighting tactics. It might be necessary to consult the fire department to ascertain what amount of flow was accounted for in the design of the system. This is particularly important if the private fire service main(s) supplies only has manual fire-fighting equipment, such as hydrants. If the flow test required by 7.3.1.1 indicates a potential problem, additional information can be obtained by conducting an engineering analysis or hydraulic gradient analysis. For further information on how to conduct a hydraulic gradient analysis, see Section 15 in the 20th edition of the *Fire Protection Handbook*.

7.3.2 Hydrants. Hydrants shall be tested annually to ensure proper functioning.

Testing Procedure Alert

The purpose of completing a hydrant test is to exercise the hydrant valves through the full range of operation, to clear the hydrant of any built-up debris, and to ensure proper operation of the barrel drainage for dry barrel and wall hydrants. It should be noted that although hydrant tests are conducted by flowing water, the flow is not measured by any means, such as a pitot tube. Hydrant operation is often critical for manual fire-fighting operations, and this test provides a level of assuredness that the hydrants will be available for fire department use. For a process for conducting the test required by 7.3.2, please refer to the detailed testing procedure at the end of this chapter.

7.3.2.1 Each hydrant shall be opened fully and water flowed until all foreign material has cleared.

7.3.2.2 Flow shall be maintained for not less than 1 minute.

With the exception of annual fire pump tests (see 8.3.3), few tests required by NFPA 25 result in as much water being discharged as does the testing required by 7.3.2. Because of this, it is necessary to be vigilant about where this water may ultimately end up. It is also necessary to ensure that the proper procedures to mitigate water damage are observed. For more information, see the commentary following 4.1.1.2.1.

7.3.2.3 After operation, dry barrel and wall hydrants shall be observed for proper drainage from the barrel.

The dry barrel hydrant is often used in areas where there are concerns about freezing temperatures. Proper drainage is important, because if the water does not drain out of the barrel promptly, the potential for freezing increases. (See the commentary following 7.2.2.4 for more information.) One common cause of drainage failure or slow drainage is plugged weep holes; they are easily repaired by excavating around the hydrant and cleaning out the drainage holes.

7.3.2.4 Full drainage shall take no longer than 60 minutes.

7.3.2.5 Where soil conditions or other factors are such that the hydrant barrel does not drain within 60 minutes, or where the groundwater level is above that of the hydrant drain, the hydrant drain shall be plugged and the water in the barrel shall be pumped out.

7.3.2.6 Dry barrel hydrants that are located in areas subject to freezing weather and that have plugged drains shall be identified clearly as needing pumping after operation.

7.3.3 Monitor Nozzles.

7.3.3.1 Monitor nozzles that are mounted on hydrants shall be tested as specified in 7.3.2.

7.3.3.2 All monitor nozzles shall be oscillated and moved throughout their full range annually to ensure proper operability.

A monitor nozzle can be a fixed-position device or a directional device capable of being manually or automatically rotated either from side to side or up and down. The requirement in 7.3.3.2 addresses the necessity of ensuring the device maintains full movement in all directions. (See the commentary following 7.2.2.7 for more explanation of monitor nozzles and their use.)

7.4 Maintenance.

7.4.1 General. All equipment shall be maintained in proper working condition, consistent with the manufacturer's recommendations.

Tip for Owners

The requirement in 7.4.2.2 that hydrants be kept free of snow is sometimes difficult to meet. For example, a hydrant near the street runs the risk of being buried by a snowplow. Where the potential exists for snow burial, extra measures should be taken to ensure that hydrants can be easily located, such as with the use of flags, indicating poles, banners, or other measures, as shown in Exhibit 7.7. Note that in addition to snow, vegetation can also obscure a hydrant location. In that case, the vegetation should be cleared away completely.

7.4.2 Hydrants.

7.4.2.1 Hydrants shall be lubricated annually to ensure that all stems, caps, plugs, and threads are in proper operating condition.

7.4.2.2* Hydrants shall be kept free of snow, ice, or other materials and protected against mechanical damage so that free access is ensured.

A.7.4.2.2 The intent of 7.4.2.2 is to maintain adequate space for use of hydrants during a fire emergency. The amount of space needed depends on the configuration as well as the type and size of accessory equipment, such as hose, wrenches, and other devices that could be used.

EXHIBIT 7.7 *Hydrant with Indicating Pole.*



7.4.3 Monitor Nozzles. Monitor nozzles shall be lubricated annually to ensure proper operating condition.

7.5 Component Action Requirements.

Component replacement tables offer the user guidance of the standard when system components are adjusted, repaired, rebuilt, or replaced. It is not necessary in each case to require a complete acceptance test for each component when maintenance is performed.

7.5.1 Whenever a component in a private fire service system is adjusted, repaired, reconditioned, or replaced, the action required in Table 7.5.1 shall be performed.

7.5.2 Where the original installation standard is different from the cited standard, the use of the appropriate installing standard shall be permitted.

7.5.3* Where a main drain is not provided, other equivalent means of flow testing shall be permitted.

A.7.5.3 Private fire service mains might not include a main drain connection; therefore, other equivalent means of flow such as an installed fire hydrant can be used.

7.5.4 The actions of 7.5.1 shall not require a design review, which is outside the scope of this standard.

Δ ***TABLE 7.5.1*** *Summary of Component Action Requirements*

Component	*Adjust*	*Repair/ Recondition*	*Replace*	*Test Criteria*
Water Delivery Components				
Pipe and fittings (exposed and underground)	X	X	X	Hydrostatic test in conformance with NFPA 24
				Flush in conformance with NFPA 24 or NFPA 20, as appropriate
Hydrants	X	X	X	Hydrostatic test in conformance with NFPA 24
				Waterflow in conformance with NFPA 24
				Inspect for proper drainage
Monitor nozzles	X	X	X	Flow test to confirm required coverage
Mainline strainers	X	X	X	Flow test downstream of strainer
Fire department connection	X	X	X	See Chapter 13
Alarm and Supervisory Components				
Valve supervisory device	X	X	X	Operational test for conformance with NFPA 24 and/or *NFPA 72*
System-Indicating Components				
Gauges			X	Verify at 0 psi (0 bar) and system working pressure
System Housing and Protection Components				
Hose houses	X	X	X	Verify integrity of hose house and hose house components
Hose		X		Repair and test hose in accordance with NFPA 1962
Hose			X	No action required
Structural Components				
Thrust blocks	X	X	X	Test at system working pressure
Tie rods	X	X	X	Test at system working pressure
Retainer glands	X	X	X	Test at system working pressure
Informational Components				
Identification signs	X	X	X	Verify conformance with NFPA 24

References Cited in Commentary

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

Cote, A. E. ed., *Fire Protection Handbook®*, 20th edition, 2008.

Cote, A. E. ed., *Fire Protection Handbook®*, 19th edition, 2003.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection,* 2019 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection,* 2018 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, 2019 edition.

NFPA 291, *Recommended Practice for Fire Flow Testing and Marking of Hydrants*, 2019 edition.

U.S. Government Printing Office, Washington, DC 20402.

P.L. 92-500, Federal Water Pollution Control Amendments of 1972, Clean Water Act, October 18, 1972.

Underground Flow Test

Purpose

The purpose of completing a test of the underground piping is to assess the adequacy of the connected water supply and to detect significant reductions that might adversely impact the system operation. This assessment is accomplished by comparing the results of the current test to previous baseline test data, as well as to the system demands supplied by the underground piping.

Tools/Equipment

1. A ruler with 1/16 in. (1.6 mm) divisions is required. [A minimum 6 in. (50 mm) rule is recommended.]
2. A pitot tube (see Testing Exhibit 7.1), together with a test-pressure gauge, suitable for the pressures to be expected is required. [Usually, a 60 psi (4 bar) gauge is satisfactory.]

   A pitot-tube-and-gauge assembly, such as the one shown in Testing Exhibit 7.1, is indispensable for conducting flow tests from hydrants and nozzles. The small opening at the end of the tube — not more than 1/16 in. (1.6 mm) in diameter — is inserted in the center of the stream in a direct line with the flow, at a distance in front of the opening equal to one-half the opening diameter. Velocity pressure is registered on the gauge attached to the tube.



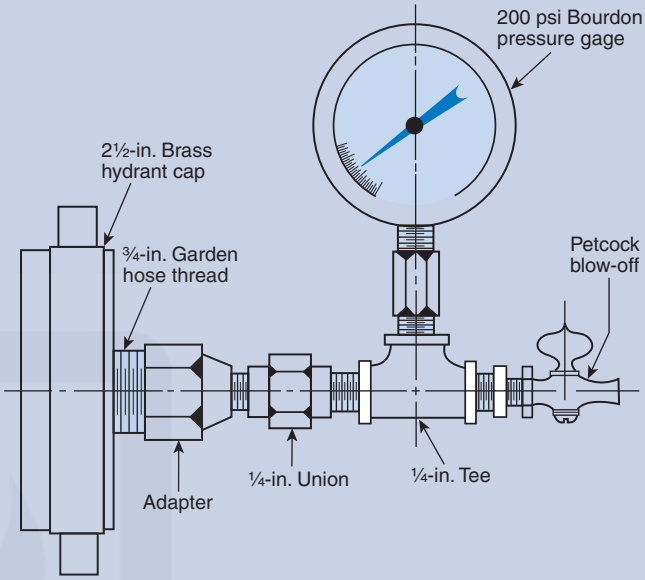
TESTING EXHIBIT 7.1 *Typical Pitot Tube Assembly.*

Some available test nozzles include an integral pitot tube or pitotless flow-measuring feature with an attached test gauge[1] allowing for direct measurement of flows without the use of a separate pitot tube. Where used, a sufficient number of test nozzles are needed to achieve the desired flow rate.

1. Test-quality gauges should be used in accordance with ASME B40.100, *Pressure Gauges and Gauge Attachments,* having an accuracy of ±1%. The use of quality test gauges produces results that are considered reasonably accurate within the scope of the test procedure. Care should be taken to protect the gauges from rough handling.

   Gauges should be calibrated at least annually by means of a dead-weight or calibrated tester throughout the range of operation before a test series is begun. Calibration sheets should be kept for each gauge and correction factors affixed to the back of each gauge.

3. A 2½ in. (65 mm) hydrant gauge cap with fittings (see Testing Exhibit 7.2) [assuming 2½ in. (65 mm) outlets], together with a test-pressure gauge[1] suitable for the pressures to be expected, with 1 psi (0.07 bar) graduations is required. [Usually, a 200 psi (13.8 bar) gauge is satisfactory.]



TESTING EXHIBIT 7.2 *Typical Hydrant Cap and Gauge. (Source: NFPA Fire Protection Handbook® 2003, Figure 10.6.2.)*

In Testing Exhibit 7.2, note the petcock blow-off. Its operation permits air from the hydrant barrel to be vented when the hydrant is opened and air to re-enter when the hydrant is closed. Failure to open the petcock during hydrant closing might subject the pressure gauge to a partial vacuum, which could introduce errors in future gauge readings.

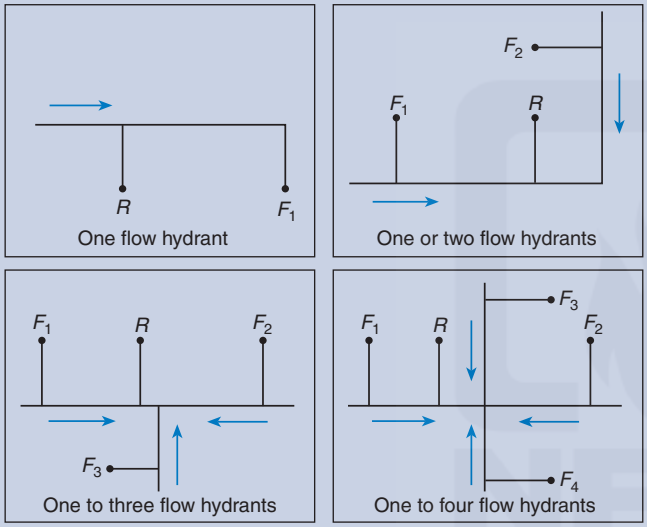
4. A hydrant wrench compatible with the operating nut of the hydrants being tested is required. Adjustable wrenches, pipe wrenches, and parrot wrenches should not be used, because these could damage the operating nut.
5. A form for recording test data, including a sketch of the test location showing hydrants and any other salient features, is required. All test data should be recorded in a neat, systematic fashion, along with any system operating conditions that might affect the test results.

Procedure Steps

1. Prior to any testing, notify the water department, the fire department and/or the alarm monitoring company (if needed), and the facility representatives that testing is going to be conducted.
2. Establish a test plan with the AHJs and obtain required approvals.

3. Identify the test hydrants (non-flowing and flowing). In a single-direction feed water supply, the test hydrant should be the one nearest the source. In a gridded-type system where the water flow comes from multiple directions, the location of the test and flow hydrants is not as critical. In any case, the test should be conducted in the vicinity of the required point of connection.

   Based on the underground piping configuration, Testing Exhibit 7.3 provides the recommended arrangement of flow (*F*) and residual (*R*) hydrants. The hydrants used to measure flow and pressure vary, based on the directional flow of the water in relation to the hydrants being tested, along with the piping configuration.



Arrows indicate direction of flow: *R* = residual hydrant; *F* = flow hydrant

TESTING EXHIBIT 7.3 *Suggested Flow Test Arrangements. (Source: NFPA 291, 2016, Figure 4.3.4.)*

4. Check the area surrounding the flow (*F*) hydrant(s) to ensure that there are no obvious conditions that would prevent water from being discharged safely or cause direct damage in the immediate vicinity. Take appropriate caution to ensure personnel and property are protected from the resultant high-pressure hose stream discharge. The use of a flow diffuser can aid in breaking the directed stream, managing resultant energy of the discharge, and directing the flow in a specific direction. Where the discharge of water is to an area subject to potential freezing conditions, the facility representative should be advised of the potential for icing conditions.

5. Remove the residual hydrant (*R*) cap and flush. Flushing the hydrant reduces the possibility of damage to the test equipment or the tester. Once a clean, steady stream of water is observed, the hydrant valve should be slowly closed. Note that the flow of fire hydrants supplied by a fire pump will result in the operation of the fire pump.

6. Install the hydrant gauge cap and pressure gauge on the residual hydrant (*R*) with the petcock open (see Testing Exhibit 7.2). Ensure that the non-gauged caps on the residual hydrant (*R*) are secured and tight.

7. Open the residual hydrant (*R*), obtain a flow from the petcock, then close the petcock.

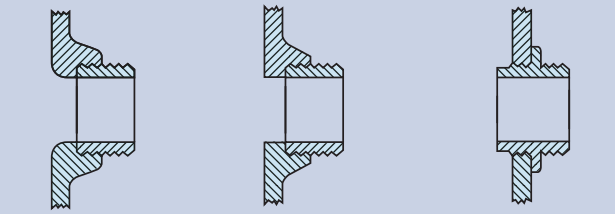
8. Record the static pressure (i.e., no other hydrants flowing) from the pressure gauge on the residual hydrant (*R*).

9. Remove the cap(s) from the flow hydrant(s) (*F*) and measure the diameter of the opening. Then, determine the hydrant coefficient (see Testing Exhibit 7.4).



TESTING EXHIBIT 7.4 *Verifying Hydrant Outlet Coefficient.*

The hydrant coefficient can be determined by inserting one hand into the hydrant opening and comparing the shape of the outlet to the shapes shown in Testing Exhibit 7.5.



TESTING EXHIBIT 7.5 *Three General Types of Hydrant Outlets and Their Coefficients of Discharge. (Source: NFPA 291, 2016, Figure 4.7.1.)*

The use of a test nozzle and/or diffuser can also be used to provide an accurate coefficient for use in determining the flow rate. Where used, these devices should be installed on the flow outlets for the hydrant. Ensure that the non-flowing caps on the flow hydrant (*F*) are secured and tight.

Underground Flow Test *(Continued)*

10. Fully open the flow hydrant(s) (*F*) and wait for a steady stream of water and stabilized pressure reading at the residual hydrant (*R*).

11. Measure flowing pressure at each flowing outlet by inserting a pitot tube and gauge assembly (see Testing Exhibit 7.1) into the center of the stream at a distance of one-half the opening diameter out from the face of the hydrant outlet, while holding the center line of the pitot orifice at a right angle to the face of the hydrant outlet. The air chamber of the pitot tube should be kept elevated.

    Where a test nozzle is attached that includes an integral pitot tube or pitotless flow-measuring feature, the flowing pressures can be read directly from the pressure gauge on the attached device.

12. Record the pitot gauge reading(s) while the pressure reading at the residual hydrant (*R*) is recorded simultaneously.

    The pressure recorded by the pitot tube assembly is the velocity pressure, which is used to calculate flow. Converting the pitot pressure to flow can be accomplished by using the flow listed in the flow tables in NFPA 291. Alternatively, the flow can be calculated by inserting the outlet coefficient (*c*), outlet diameter (*d*), and velocity pressure (*p*) into the following formula:

$$Q = 29.84cd^2\sqrt{p}$$

    where:
    Q = flow in gpm
    c = coefficient of discharge
    d = diameter of outlet (in.)
    p = flowing pressure (psi)

    In metric units, the formula is as follows:

$$Q = 0.0666cd^2\sqrt{p}$$

    where:
    Q = flow in L/min
    c = coefficient of discharge
    d = diameter of outlet (mm)
    p = flowing pressure (bar)

    To obtain satisfactory test results, sufficient discharge should be achieved to cause a drop in pressure at the test hydrant of at least 25 percent of static pressure or to flow the total system demand. Should additional flow rates be desired, additional outlets or hydrants can be opened and pressures measured accordingly.

    Pitot readings of less than 10 psi (0.7 bar) or over 30 psi (2.1 bar) at any open hydrant should be avoided. To keep within these pressure limits, the rate of flow can be controlled by throttling the hydrant, opening a second outlet, or both. However, the flow hydrants should be opened sufficiently so that hydrant drains are closed. Water continuously discharged through the drains tends to erode the soil from the base of the hydrant.

    The use of the larger pumper connection on a hydrant for testing should be avoided unless flow and pressure are strong enough to produce a full stream. When pumper outlets are used, a proper coefficient of discharge must be determined, based on the extent to which the orifice is completely filled with water. This is accomplished by applying an additional correction factor to the calculated flow rate using the proper pumper outlet coefficient from Table 4.8.2 from NFPA 291. See Commentary Table 7.1. This coefficient is applied in addition to the coefficient applied in the equation above.

COMMENTARY TABLE 7.1 *Pumper Outlet Coefficients*

Pitot Pressure (Velocity Head)		
psi	***bar***	***Coefficient***
2	0.14	0.97
3	0.21	0.92
4	0.28	0.89
5	0.35	0.86
6	0.41	0.84
7 and over	0.48 and over	0.83

Source: NFPA 291, 2016, Table 4.8.2.

13. Slowly close the flow hydrant(s) (*F*) one at a time to avoid water hammer until all hydrant flow is ceased.

14. Record the return static pressure on the residual hydrant (*R*).

15. Allow any fire pumps that might have automatically operated to run for 10 minutes, for an electric fire pump, or 30 minutes, for a diesel fire pump. Follow this with a shutdown of the fire pump and restoration of automatic operating condition.

16. Remove any installed test nozzles and/or diffusers.

17. Check the flow hydrant(s) (*F*) barrel for proper drainage.

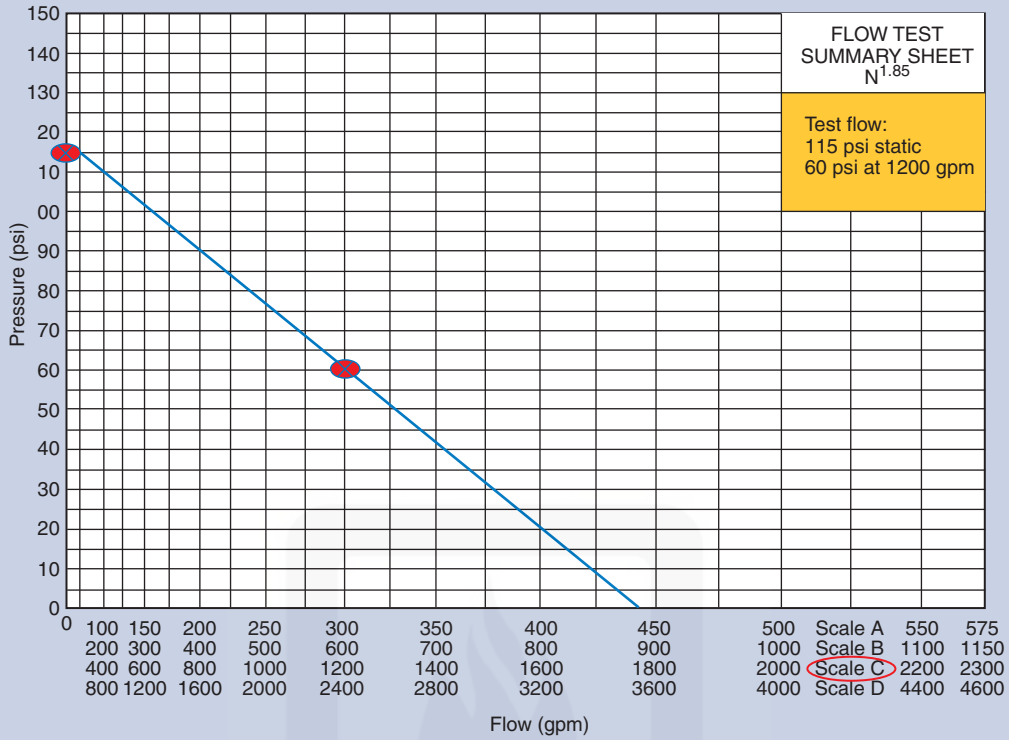
18. Replace the hydrant cap(s) on the flow hydrant(s) (*F*).

19. Close the residual hydrant (*R*) and open the petcock on the hydrant gauge cap. The petcock should be opened prior to complete closure to avoid the development of a vacuum.

20. Remove the hydrant gauge cap from the residual hydrant (*R*) and check the barrel for proper drainage.

21. Replace the hydrant cap on the residual hydrant (*R*).

22. Upon completion of all testing, notify the water department, fire department and/or the alarm monitoring company (as needed), and the facility representatives that testing is complete, and reset the fire alarm system as necessary.



TESTING EXHIBIT 7.6 *Water Supply Test Plotted on $N^{1.85}$ Graph Paper.*

Evaluation of Results

The test data should be plotted on $N^{1.85}$ graph paper. See Testing Exhibit 7.6. The data is plotted by drawing a line between the two points represented by the recorded static pressure along the vertical axis at 0 flow on the horizontal axis and the recorded residual pressure along the vertical axis at the recorded total flow rate of all flowing outlets.

A comparative evaluation should be made against the original test data, if available, or previous test data. A significant degradation in performance should warrant further investigation, such as a hydraulic gradient analysis, to determine the source of the reduced system capacity. For further information regarding the conduct of a hydraulic gradient analysis, see Section 15 in the 20th edition of the *Fire Protection Handbook*. Additionally, the supplied system demands, such as the fire sprinkler, standpipe, or hydrants that are connected to the underground piping and are being tested, should be plotted on $N^{1.85}$ graph paper. Where those demands fall above the plotted water supply curve, an unacceptable condition is represented requiring further investigation, and corrective action should be taken as necessary.

The procedure(s) outlined above is not mandated by NFPA 25 and represents only one approach to conducting this test.

Hydrant Test

Purpose

The purpose of completing a hydrant test is to exercise the hydrant valves through the full range of operation, clear the hydrant of any built-up debris, and to ensure proper operation of the barrel drainage for dry barrel and wall hydrants. Additionally, the test verifies operation, addresses repair issues, and verifies reliability of the hydrant with a reasonable assurance that the water supply is connected and available for use.

Tools/Equipment

1. A hydrant wrench compatible with the operating nut of the hydrants being tested is required.
2. A timing device to measure the drainage time for dry barrel or wall hydrants is required.

Procedure Steps

1. Prior to any testing, notify the water department, the fire department and/or the alarm monitoring company (if needed), and the facility representatives that testing is going to be conducted.
2. Check the area surrounding the hydrant to ensure that there are no obvious conditions that would prevent water from being discharged safely or cause direct damage in the immediate vicinity. Take appropriate caution to ensure personnel and property are protected from the resultant high-pressure hose stream discharge. The use of a flow diffuser can aid in breaking the directed stream and managing resultant energy of the discharge. Where the discharge of water is to an area subject to potential freezing conditions, the facility representative should be advised of the potential for icing conditions.
3. Remove a hydrant cap from the hydrant. Ensure the non-flowing caps are secured and tight.
4. Open the hydrant fully and allow the flow to continue until all foreign material has cleared, with a minimum flow period of 1 minute. Note that the flow of fire hydrants supplied by a fire pump will result in the operation of the fire pump.
5. Slowly close the hydrant to avoid water hammer.
6. Allow any fire pumps that might have automatically operated to run for 10 minutes, for an electric fire pump, or 30 minutes, for a diesel fire pump. Follow this with a shutdown of the fire pump and restoration of automatic operating condition.
7. For dry barrel or wall hydrants, check the barrel for proper drainage, noting the time required for full drainage.
8. Dry barrel or wall hydrants that fail to drain within 60 minutes must be pumped out.
9. Replace the hydrant cap on the hydrant.
10. Upon completion of all testing, notify the water department, fire department and/or the alarm monitoring company (as needed), and the facility representatives that testing is complete, and reset the fire alarm system as necessary.

Evaluation of Results

The hydrant should cycle through the full range of operation without excessive operating force or disengagement and should fully stop the hydrant flow upon closure.

Dry barrel and wall hydrants must fully drain within a period of not more than 60 minutes. Hydrants that do not properly drain must be pumped out to ensure protection of the hydrant against freeze-up.

The hydrant should produce a substantial water flow when fully open. Obvious degradation in the flow capacity of the hydrant should be investigated, and corrective action should be taken as necessary.

References

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

Cote, A. E. ed., *Fire Protection Handbook®*, 20th edition, 2008.

NFPA 291, *Recommended Practice for Fire Flow Testing and Marking of Hydrants*, 2019 edition.

American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990.

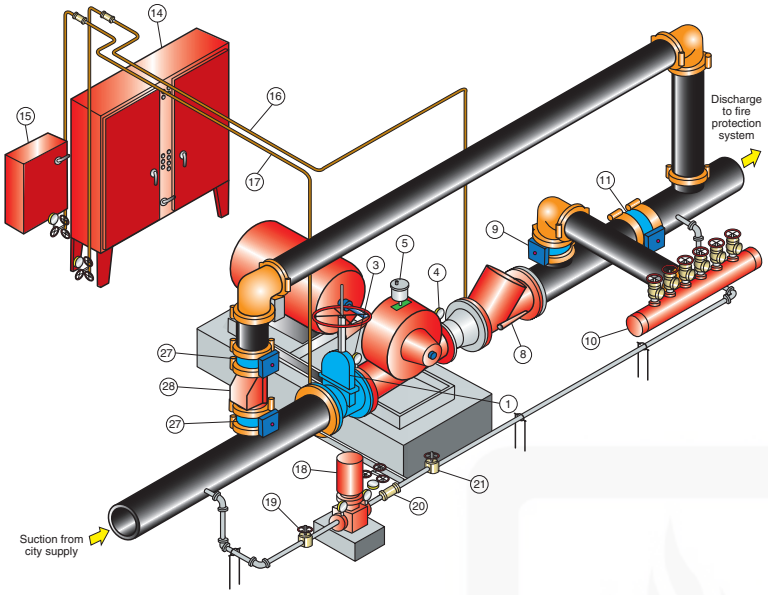
ASME B40.100, *Pressure Gauges and Gauge Attachments*, 2013 edition.

The procedure(s) outlined above is not mandated by NFPA 25 and represents only one approach to conducting this test.

NFPA

What Is a Fire Pump?

Fire pumps are used to increase the water supply pressure available from public mains, gravity tanks, reservoirs, or other sources. An entire fire assembly consists of a fire pump, driver, controller, and accessories.



Legend	
1	OS&Y Gate Valve (Suction Control Valve)
3	Suction Pressure Gauge
4	Discharge Pressure Gauge
8	Check Valve (Pump Discharge)
9	Indicating Gate Valve or Butterfly Valve (Test Header)
10	Test Header
11	Indicating Gate Valve or Butterfly Valve (Discharge Control Valve)
14	Fire Pump Controller
15	Pressure Maintenance Pump Controller (Jockey Pump)
16	Pressure Sensing Line (Fire Pump)
17	Pressure Sensing Line (Jockey Pump)
18	Pressure Maintenance Pump (Jockey Pump)
19	Isolation Valve (Jockey Pump Suction)
20	Check Valve (Jockey Pump Discharge)
21	Isolation Valve (Jockey Pump Discharge)

What Are the Types of Fire Pumps?

The fire pump itself is just the provider of water flow and pressure; the driver (diesel engine or electric motor) provides the energy needed for the pump to spin and move the water. There are many different types of fire pumps that can be used.

Centrifugal Pump

A centrifugal pump creates pressure by using centrifugal force (outward force created from rotating an object) to increase the velocity of the water through the rotation of the impeller.



Courtesy of Xylem – AC Fire Pump



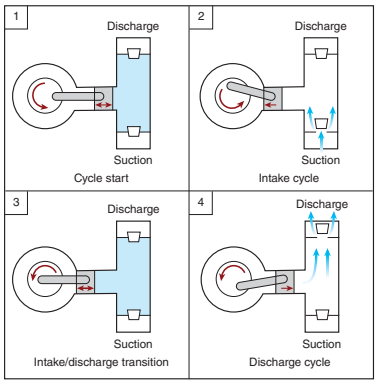
Courtesy of Grundfos

Vertical Shaft Turbine-Type Pump

A vertical turbine pump is designed to pump water out of a static source of water (such as a well or an underground tank). This is the only pump that doesn't require the source of water have some pressure coming into the pump, known as suction pressure.

Positive Displacement Pump

A positive displacement pump creates pressure by filling a cavity with water and then pushing it out; these types of pumps can create higher pressures than a centrifugal pump. Positive displacement pumps are generally found as part of water mist and foam-based fire protection systems because of these attributes.



What Are the Types of Fire Pump Drivers?

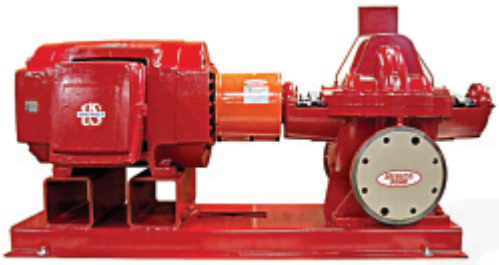
Power for driving fire pumps is selected on the basis of reliability, adequacy, safety, and economy.

Diesel Engine

Diesel engines have proven to be very reliable and effective, and they are currently the only type of internal combustion engine permitted by NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection,* for driving fire pumps. Diesel engines require batteries to power the electric start of the engine and are required to have a fuel storage tank.



Courtesy of Clarke Fire Protection Products, Inc.



Courtesy of Peerless Pump Company

Electric Motor

Electric motors are a reliable, effective means of supplying power to fire pumps. Electric motors need to be supplied by a reliable source of power.

What Is a Fire Pump Controller?

A fire pump controller is a group of devices that serve to control the starting and stopping of the fire pump driver and monitor the signal and status and condition of the fire pump unit.



Steam Turbine

The application of steam as a driver for fire pumps is not as common as that of electric drive or diesel drive, because steam is not as readily available.



Courtesy of Larry Wenzel

ITM

Fire pumps are required to provide water supply pressure or enhance the existing water supply pressure for a fire protection system, such as an automatic sprinkler system. Without a functional pump, the systems will be unable to provide the design pressure and very likely not be able to adequately suppress the fire and because of that, proper Inspection, testing, and maintenance (ITM) is required.

For more information refer to NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection.*

Fire Pump Inspection and Testing

NO DEFICIENCIES OR IMPAIRMENTS

NONCRITICAL DEFICIENCIES

ELECTRICAL POWER TO PUMP SYSTEM

- No power to pressure maintenance pump
- Electrical power is provided — controller pilot light not illuminated, transfer switch pilot light not illuminated, reverse phase alarm pilot light on, normal phase light is not illuminated

STEAM SYSTEM

- Testing — Gauge reading and time for turbine to reach running speed not acceptable

DIESEL ENGINE SYSTEM

- Cooling water level not normal
- Crankcase oil level not normal
- Electrolyte level in batteries not normal
- Engine running time meter not reading
- Oil level in right angle gear drive not normal (not at level mark but visible in sight glass)

CRITICAL DEFICIENCIES

ELECTRIC PUMP SYSTEM

- Oil level in vertical motor sight glass not normal

FIRE PUMP

- Annual test — Circulation relief valve and/or pressure relief valve did not work properly at churn condition
- Annual test — Pressure relief valve did not work properly at each flow condition
- Annual test — Alarms did not properly operate
- Annual test — Parallel or angular alignment not correct
- Annual test — Voltage readings at motor not within 5% below or 10% above rated (nameplate)
- Annual test — Flow test results not within 5% of initial unadjusted acceptance test or nameplate

PUMP HOUSE/ROOM

- Excessive water on floor
- Coupling guard not in place
- Ventilating louvers not free to operate
- Heating, lighting, ventilating systems did not pass test

PUMP SYSTEM

- Waterflow test valves open, hose connection valve open, test line contains water
- Suction reservoir does not have required water level, wet pit suction screens missing
- Testing — System suction and discharge gauge reading, or pump starting pressure outside the acceptable range
- Testing — Pump packing gland discharge not acceptable, unusual noise or vibration, packing boxes, bearings, or pump casing overheating

DIESEL ENGINE SYSTEM

- Battery terminals corroded
- Alarm pilot lights are on
- Battery charging current not normal
- Battery failure pilot lights on
- Battery pilot lights off
- Battery terminals corroded
- Battery voltage readings not normal
- Cooling water level not visible
- Electrolyte level in batteries below top of battery plates
- Fuel tank less than two-thirds full
- Water-jacket heater not operating
- Oil level in right angle gear drive below low level (not visible in sight glass or below one finger knuckle for inspection hole)
- Testing — Time for engine to crank and time for engine to reach running speed not acceptable
- Testing — Low oil pressure, high temperature, high cooling water pressure
- Testing — Time for engine to crank and time for engine to reach running speed not acceptable, low oil pressure, high temperature, high cooling water pressure

STEAM SYSTEM

- Steam pressure gauge reading not normal

IMPAIRMENTS

FIRE PUMP

- Annual Test — Flow test does not meet most demanding system flow and pressure requirements
- Testing — Pump did not start automatically
- Testing — Pump failed to run for 10 minutes
- Testing — Pump failed to run for 30 minutes
- Annual test (with transfer switch) — Overcurrent protective devices opened when simulating a power failure condition at peak load, power not transferred to alternate source, pump did not continue to perform at peak load, pump did not reconnect to normal power after removing power failure condition

PUMP HOUSE/ROOM

- Heat not adequate, temperature less than 40°F
- Heat not adequate, temperature less than 70°F for diesel pumps without engine heaters
- Heat not adequate, temperature less than 40°F, not as recommended by the engine manufacturer, for diesel pumps with engine heaters

PUMP SYSTEM

- Wet pit suction screens obstructed
- Suction reservoir empty
- Suction, discharge, or bypass valves not fully open, major leaking such as spraying or leaking to extent that pump performance might be questioned

ELECTRICAL POWER TO PUMP SYSTEM

- No electrical power — controller pilot light not illuminated, transfer switch pilot light not illuminated, isolating switch not closed, reverse phase alarm pilot light on or normal phase light is off
- Testing — Time for motor to accelerate to full speed, time controller is on first step, or time pump runs after starting not acceptable

DIESEL ENGINE SYSTEM

- Fuel tank empty
- Controller selector switch not in auto position
- Crankcase oil level below low level
- Testing — low rpm
- Diesel fuel annual test — Diesel fuel tested for degradation and failed

Source: Table A.3.3.8



8

FIRE PUMPS

Chapter 8 addresses the inspection, testing, and maintenance (ITM) of fire pumps and related equipment. In most cases where fire pumps are installed, the fire protection systems they connect to would be ineffective in fire control if the pumps and connected drivers were not fully functioning. Therefore, proper maintenance is critical to help ensure constant system readiness at all times.

Fire pumps and their associated equipment also constitute a major investment, ranging in cost from $20,000 to more than $1,000,000 when suction tanks are required.

Fire pumps are typically required for effective fire protection system operations. When pumps that were put in place to protect a facility must be removed from service for repairs, the facility can become unprotected for the duration of the repair. In some of these situations, the protection of property and life is considered impaired, resulting in a shutdown of operations mandated by the authority having jurisdiction (AHJ) until repairs are made. This shutdown could result in major business interruption loss, in addition to costly pump repairs. Thus, the failure to properly maintain fire pumps and related equipment can quickly result in significant direct and indirect costs.

8.1* General.

A.8.1 A fire pump assembly provides waterflow and pressure for private fire protection. The assembly includes the water supply suction and discharge piping and valving; pump; electric, diesel, or steam turbine driver and control; and the auxiliary equipment appurtenant thereto.

Fire pumps and associated piping are installed in accordance with NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*. For more information on the installation and design requirements, refer to that standard.

8.1.1 Minimum Requirements.

8.1.1.1 This chapter shall provide the minimum requirements for the routine inspection, testing, and maintenance of fire pump assemblies.

FAQ What is the testing frequency for a fire pump that only services a standpipe system in a municipal or private office building?

All stationary fire pumps must be tested weekly or monthly, depending on the driver type and a complete annual test per the requirements of Table 8.1.1.2, regardless of the type of system they are connected to or building occupancy they are installed in.

Exhibit 8.1 shows a typical horizontal split-case fire pump installation, and Exhibit 8.2 shows a typical vertical turbine fire pump installation.

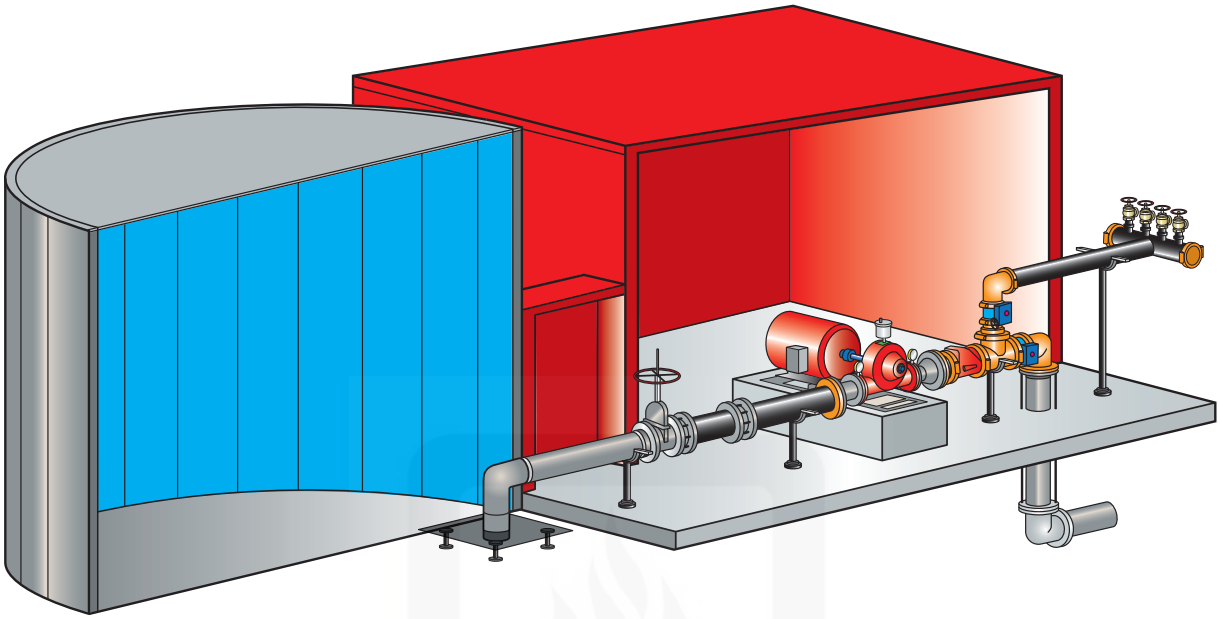
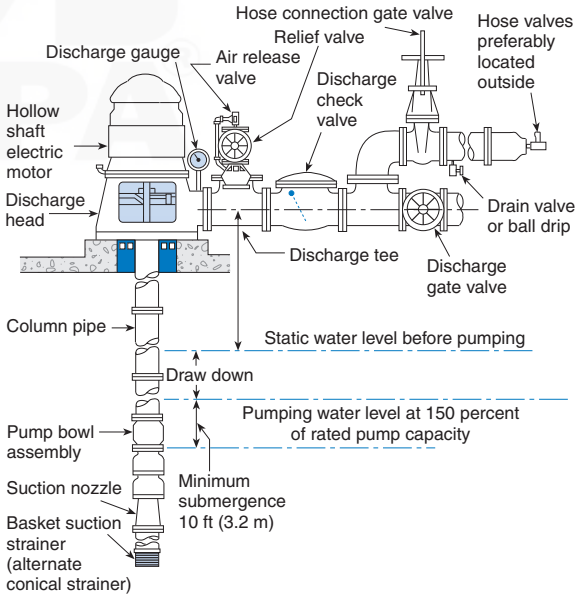


EXHIBIT 8.1 *Horizontal Split-Case Fire Pump Assembly. (Courtesy of Stephan Laforest)*

EXHIBIT 8.2 *Vertical Turbine Fire Pump Assembly. (Source: NFPA 20, 2019, Figure A.7.2.2.1)*



Note: The distance between the bottom of the strainer and the bottom of the wet pit should be one-half of the pump bowl diameter but not less than 12 in. (305 mm).

8.1.1.2* The minimum frequency of inspection, testing, and maintenance shall be in accordance with the manufacturer's recommendations and Table 8.1.1.2.

Δ ***TABLE 8.1.1.2*** *Summary of Fire Pump Inspection, Testing, and Maintenance*

Item	*Frequency*	*Reference*
Inspection		
Alignment	Annually	8.3.6.4
Cable/wire insulation	Annually	8.1.1.2.5
Diesel engine system	Weekly	8.2.2(4)
Electric system	Weekly	8.2.2(3)
Engine crankcase breather	Quarterly	8.1.1.2.12
Exhaust system, drain condensate trap, and silencers	Annually	8.1.1.2.13
Flexible hoses and connections	Annually	8.1.1.2.11
Fuel tank vents and overflow	Annually	8.1.1.2.10
Plumbing parts — inside and outside of panels	Annually	8.1.1.2.6
Printed circuit board (PCB) corrosion	Annually	8.1.1.2.4
Pump	Weekly	8.2.2(2)
Pump house/room	Weekly	8.2.2(1)
Shaft movement or endplay while running	Annually	8.1.1.2.1
Steam pump system	Weekly	8.2.2(5)
Suction screens	Annually	8.3.3.15
Test		
Automatic transfer switch	Annually	8.3.3.12
Automatic transfer switch and emergency/standby generators	Per NFPA 110	8.3.6.1, 8.3.6.2
Diesel engine–driven fire pump (no flow)	Weekly	8.3.1.1
Diesel fuel testing	Annually	8.3.4.1
Electric motor–driven fire pump (no flow)	Weekly/monthly	8.3.1.2
Electronic control module (ECM)	Annually	8.3.3.16
Fire pump alarm signals	Annually	8.3.3.13
Flow meters	Annually	8.3.3.5.3
Fuel tank, float switch, and supervisory signal for interstitial space	Quarterly	8.1.1.2.7
Gauges, transducers, and other devices used for testing	Annually	8.3.3.5.2
Main pressure relief valve	Annually	8.3.3.11, 13.5.6.2.3
Pump house/room environmental conditions		8.3.6.3
Pump operation (no flow)	Weekly/monthly	8.3.2, 8.3.5
Pump performance (flow)	Annually	8.3.3, 8.3.5
Supervisory signal for high cooling water temperature	Annually	8.1.1.2.8
Maintenance		
Batteries	Annually	8.1.1.2.15
Circulating water filter	Annually	8.1.1.2.21
Control and power wiring connections	Annually	8.1.1.2 16
Controller and all other components of the pump assembly	Per manufacturer	8.5
Diesel active fuel maintenance system	Annually or per manufacturer	8.3.4.3
Diesel engine system	Per manufacturer	8.5
Electric motor and power system	Per manufacturer	8.5
Electrical connections	Annually	8.1.1.2.2
Engine lubricating oil	50 operating hours or annually	8.1.1.2.17
Engine oil filter	50 operating hours or annually	8.1.1.2.18
Fuel filter	50 operating hours or annually	8.1.1.2.19
Fuel tank — check for water and foreign materials	Annually	8.1.1.2.9
Measure back pressure on engine turbo	Annually	8.1.1.2.14
Power transmission components with elastomeric materials (including torsional couplings)	5 years or per manufacturer	8.1.1.2.23
Pressure gauges and sensors	Annually	8.1.1.2.22
Pump and motor bearings and coupling	Annually or as required	8.1.1.2.3
Sacrificial anode	Annually	8.1.1.2.20

A.8.1.1.2 Alternative Inspection, Testing, and Maintenance Procedures. In the absence of manufacturer's recommendations for preventive maintenance, Table A.8.1.1.2 can be used for alternative requirements.

Δ ***TABLE A.8.1.1.2*** *Alternative Fire Pump Inspection, Testing, and Maintenance Procedures*

Complete as Applicable	*Visual Inspection*	*Inspect*	*Change*	*Clean*	*Test*	*Frequency*
Pump System						
Pump bearings		X				Annually
Lubricate pump bearings			X			As needed
Inspect pump shaft end play		X				Annually
Inspect accuracy of pressure gauges and sensors		X	X			Annually (replace or recalibrate when 5% out of calibration)
Inspect pump coupling alignment		X				Annually
Wet pit suction screens		X		X		After each pump operation
Mechanical Transmission						
Lubricate coupling/flexible connecting shaft (driveshaft)		X				Annually
Lubricate right-angle gear drive		X				Annually
Electrical System						
Exercise isolating switch and circuit breaker					X	Monthly
Trip circuit breaker (if mechanism provided)					X	Annually
Operate manual starting means (electrical)					X	Semiannually
Inspect and operate emergency manual starting means (without power)	X				X	Annually
Lubricate mechanical moving parts (excluding starters and relays)		X				Annually
Calibrate pressure switch settings*		X				Annually
Grease motor bearings		X				Annually
			X			Annually or as needed
Any corrosion on printed circuit boards (PCBs)*	X					Annually
Any cracked cable/wire insulation*	X					Annually
Any leaks in plumbing parts*	X					Annually
Any signs of water on electrical parts*	X					Annually
Diesel Engine System						
Fuel						
Tank level	X	X				Weekly
Tank float switch	X				X	Weekly
Solenoid valve operation	X				X	Weekly
Strainer, filter, or dirt leg, or combination thereof				X		Quarterly
Water and foreign material in tank				X		Annually
Water in system		X		X		Weekly
Flexible hoses and connectors	X					Weekly
Tank vents and overflow piping unobstructed		X			X	Annually
Piping	X					Annually

Δ ***TABLE A.8.1.1.2*** *(Continued)*

Complete as Applicable	*Visual Inspection*	*Inspect*	*Change*	*Clean*	*Test*	*Frequency*
Lubrication system						
Oil level	X	X				Weekly
Oil change			X			50 hours or annually
Oil filter(s)			X			50 hours or annually
Lube oil heater		X				Weekly
Crankcase breather	X		X	X		Quarterly
Cooling system						
Level	X	X				Weekly
Antifreeze protection level					X	Semiannually
Antifreeze		X				Annually
Adequate cooling water to heat exchanger		X				Weekly
Rod out heat exchanger				X		Annually
Water pump(s)	X					Weekly
Condition of flexible hoses and connections	X	X				Weekly
Jacket water heater		X				Weekly
Inspect duct work, clean louvers (combustion air)	X	X	X			Annually
Water strainer				X		Quarterly
Exhaust system						
Leakage	X	X				Weekly
Drain condensate trap		X				Weekly
Insulation and fire hazards	X					Quarterly
Excessive back pressure					X	Annually
Exhaust system hangers and supports	X					Annually
Flexible exhaust section	X					Semiannually
Battery system						
Electrolyte level		X				Weekly
Terminals clean and tight	X	X				Quarterly
Case exterior clean and dry	X	X				Monthly
Specific gravity or state of charge					X	Monthly
Charger and charge rate	X					Monthly
Equalize charge		X				Monthly
Clean terminals				X		Annually
Cranking voltage exceeds 9 volts on a 12 volt system or 18 volts on a 24 volt system		X				Weekly
Electrical system						
General inspection	X					Weekly
Tighten control and power wiring connections		X				Annually
Wire chafing where subject to movement	X	X				Quarterly
Operation of safeties and alarms		X			X	Semiannually
Boxes, panels, and cabinets				X		Semiannually
Circuit breakers or fuses	X	X				Monthly
Circuit breakers or fuses			X			Biennially
Voltmeter and ammeter for accuracy (5%)		X				Annually
Any corrosion on printed circuit boards (PCBs)	X					Annually
Any cracked cable/wire insulation	X					Annually
Any leaks in plumbing parts	X					Annually
Any signs of water on electrical parts	X					Annually

*Required only where the extent of such work can be completed without the opening of energized electric motor-driven fire pump controller.

The purpose of Table A.8.1.1.2 is to provide the owner and fire pump service provider with minimum ITM guidance when information from the manufacturer is not available. When that information is available, however, it should be followed. Manufacturers know their products best and often provide much more detail on how to maintain their products. This table is more "generic" in nature and while it may provide sufficient guidance for basic fire pump ITM, it might not address specific circumstances encountered in the field.

8.1.1.2.1* Shaft movement or end play shall be inspected annually with the pump operating.

A.8.1.1.2.1 Shaft movement should be less than 1/8 in. (3 mm).

Δ **8.1.1.2.2 Electrical Connections.**

The electrical components of fire pump assemblies are a specialty system, and as such, any work on or around them requires special attention both from a technical as well as a safety perspective. For more information on the safety requirements, see 4.9.6 and the associated commentary. NFPA 20 refers to *NFPA 70®*, *National Electrical Code®*, for proper installation of these components. ITM of electrical systems associated with fire pumps must be in accordance with this chapter and *NFPA 70* as required.

N **8.1.1.2.2.1*** Electrical connections shall be inspected annually and repaired as necessary to the extent that such work can be completed without opening an energized electric-motor-driven fire pump controller.

NFPA 25 now restricts the opening of energized electric fire pump controllers in order to limit personnel exposure to arc flash or shock hazards. This change came as a result of TIA 17-2, which was issued on the 2017 edition. It has been determined that the benefits of opening energized controllers to take voltage and ampere readings or to check connections do not outweigh the risks. Other tests that are performed regularly on a fire pump can be used to indicate whether there are electrical issues, such as a variance in voltage or amperes. If it is determined that further investigation is required and an energized electric controller needs to be opened, it should be done by a qualified individual under the guides of NFPA *70E®*, *Standard for Electrical Safety in the Workplace®*, or by another approved safety standard as required by 4.9.6.

N **A.8.1.1.2.2.1** Where available, a disconnect switch upstream of the fire pump controller can be opened and the isolated electrical connections inside the electric-motor-driven controller inspected. In some cases the fire pump controller cannot be isolated without shutting off power to the building, and shutting off power to the building could be impractical.

N **8.1.1.2.2.2*** The isolating switch in the fire pump controller that is located in a separate compartment from the other controller components shall be permitted to be used to meet the requirement of 8.1.1.2.2.1.

An isolating switch that is located in its own rated enclosure as part of a rated fire pump controller enclosure ahead of all the electrical components can be used to de-energize the fire pump controller. This makes it safe for personnel to open the controller and perform ITM activities on electrical connections and components. See Exhibit 8.3 for a fire pump controller with a separate isolation switch enclosure.

N **A.8.1.1.2.2.2** Some manufacturers are including an isolation switch upstream of all controller components in an isolated sub-cabinet as part of the controller. This permits de-energizing the circuit boards and other controller components and allows the controller to be opened for ITM activities.



EXHIBIT 8.3 *Fire Pump Controller with a Separate Isolation Switch Enclosure. (Courtesy of Master Controls Systems)*

8.1.1.2.3 Pump and motor bearings and couplings shall be greased annually or as required.

Δ **8.1.1.2.4 Printed Circuit Boards.**

N **8.1.1.2.4.1** Printed circuit boards (PCBs) shall be inspected annually for corrosion to the extent that such work can be completed without opening an energized electric-motor-driven fire pump controller. *(See A.8.1.1.2.2.2.)*

N **8.1.1.2.4.2** The isolating switch in the fire pump controller that is located in a separate compartment from the other controller components shall be permitted to be used to meet the requirement of 8.1.1.2.4.1. *(See A.8.1.1.2.2.1.)*

Δ **8.1.1.2.5 Cable and Wire Insulation.**

N **8.1.1.2.5.1** Cable and/or wire insulation shall be inspected annually for cracking to the extent that such work can be completed without opening an energized electric-motor-driven fire pump controller. *(See A.8.1.1.2.2.2.)*

N **8.1.1.2.5.2** The isolating switch in the fire pump controller that is located in a separate compartment from the other controller components shall be permitted to be used to meet the requirement of 8.1.1.2.5.1. *(See A.8.1.1.2.2.1.)*

Δ **8.1.1.2.6 Plumbing.**

N **8.1.1.2.6.1** Plumbing parts, both inside and outside of electrical panels, shall be inspected annually for any leaks to the extent that such work can be completed without opening an energized electric-motor-driven fire pump controller. *(See A.8.1.1.2.2.2.)*

N **8.1.1.2.6.2** The isolating switch in the fire pump controller that is located in a separate compartment from the other controller components shall be permitted to be used to meet the requirement of 8.1.1.2.6.1. *(See A.8.1.1.2.2.1.)*

8.1.1.2.7 Fuel tanks, float switches, and supervisory signals for interstitial space shall be tested quarterly for liquid intrusion.

8.1.1.2.8 Supervisory signal circuitry shall be tested annually for high cooling water temperature.

8.1.1.2.9 Fuel tanks shall be tested annually for water and foreign materials.

8.1.1.2.10 Fuel tank vents and overflow piping shall be inspected annually for any obstructions.

8.1.1.2.11 All flexible hoses and connections shall be inspected annually for cracks and leaks.

8.1.1.2.12 Engine crankcase breathers shall be inspected quarterly.

8.1.1.2.13 Exhaust systems, drain condensate traps, and silencers shall be inspected annually.

8.1.1.2.14 Back pressure on the engine turbos shall be measured annually.

Δ **8.1.1.2.15** Batteries shall be checked annually as follows:

(1) Test the specific gravity, state of charge, and charger rates of the batteries
(2) Clean the terminals of any corrosion
(3) Ensure that the cranking voltage exceeds 9 V on a 12 V system or 18 V on a 24 V system
(4) Ensure that only distilled water is used in batteries

Δ **8.1.1.2.16 Inspections of Controls and Power Wire Connections.**

N **8.1.1.2.16.1** All controls and power wiring connections shall be inspected annually and repaired as necessary to the extent that such work can be completed without opening an energized electric-motor-driven fire pump controller. *(See A.8.1.1.2.2.2.)*

N **8.1.1.2.16.2** The isolating switch in the fire pump controller that is located in a separate compartment from the other controller components shall be permitted to be used to meet the requirement of 8.1.1.2.16.1. *(See A.8.1.1.2.2.1.)*

8.1.1.2.17 Lubricating oil in engines shall be changed every 50 hours of operation or annually.

8.1.1.2.18 Lubricating oil filters shall be changed every 50 hours of operation or annually.

N **8.1.1.2.19** Fuel filter(s) shall be changed as needed, but at a minimum every 50 hours of operation or annually.

8.1.1.2.20 The condition of sacrificial anodes shall be inspected annually and replaced as necessary.

8.1.1.2.21 Circulating water filters shall be replaced annually.

8.1.1.2.22 The accuracy of pressure gauges and sensors shall be inspected annually and replaced or recalibrated when more than 5 percent out of calibration to the extent that such work can be completed without opening an energized electric-motor-driven fire pump controller. *(See A.8.1.1.2.2.2.)*

N **8.1.1.2.22.1** The isolating switch in the fire pump controller that is located in a separate compartment from the other controller components shall be permitted to be used to meet the requirement of 8.1.1.2.22. *(See A.8.1.1.2.2.1.)*

N **8.1.1.2.22.2** If replacement or recalibration is required, proper personal protective equipment in accordance with NFPA *70E o*r an approved equivalent shall be used.

N **8.1.1.2.23** Power transmitting components used in pump drives that include elastomeric materials, such as torsional couplings, shall be replaced every 5 years or as required by the component manufacturer for a specific elastomeric material.

8.1.2 Common Components and Valves. Common components and valves shall be inspected, tested, and maintained in accordance with Chapter 13.

8.1.3 Obstruction Investigations. The procedures outlined in Chapter 14 shall be followed where there is a need to conduct an obstruction investigation.

Obstructions and damage related to microbiologically influenced corrosion (MIC) are not typically associated with fire pump installations. However, a number of cases have occurred in which biological activity that was associated with MIC has resulted in obstructive growth and pipe wall damage in piping within several feet of fire pump discharge flange. Contrary to what might be expected, the increased velocity and flow rate at fire pump discharge does not eliminate the risk of system damage from MIC in this area. If questionable flange leaks or reduced fire pump flow performance is detected and not determined to be an impeller or driver issue, the discharge piping on the fire pump should be visually inspected for obstructions per Chapter 14.

8.1.4* Auxiliary Equipment. The pump assembly auxiliary equipment shall include the following:

(1) Pump accessories as follows:
   (a) Pump shaft coupling

A pump shaft coupling, as shown in Exhibit 8.4, is used to connect a driver and a pump shaft together to transmit driver torque and rotation to the pump. These couplings allow for minor angular and parallel driver-to-pump misalignment from baseplate flexibility and temperature changes.

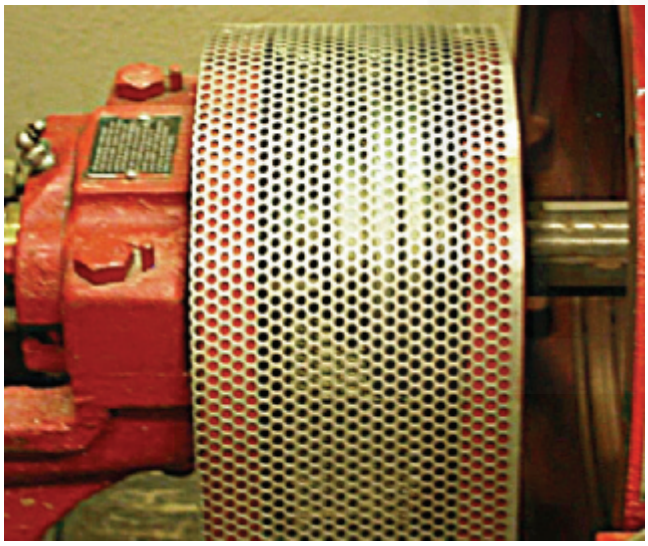


EXHIBIT 8.4 *Pump Shaft Coupling Under a Protective Cage.*

   (b) Automatic air release valve

Automatic float-operated air release valves are required to be located at the high point on centrifugal fire pump casings to remove air that can become trapped inside the pump casing. Trapped air can cause pump cavitation, which can quickly result in permanent impeller damage if not released. On some old installations, the air release valve might be manually operated. Manually operated air release valves are allowed by the current standard but only for manually operated pumps. Exhibit 8.5 shows an air release valve mounted on top of the fire pump casing.

Tip for Owners

The manufacturer's maintenance recommendations are important for the long-term care of the various components and should be provided to owners with all new installations by the installing contractor. For new installations, it is important that all manufacturers' manuals and informational materials for the pump and the associated equipment remain in the possession of the owner for reference in maintaining the equipment. This material should be kept in a location accessible for regular reference but not where it could be subject to environmental damage or decay, as might be the case in some pump rooms.

EXHIBIT 8.5 *Air Release Valve.*

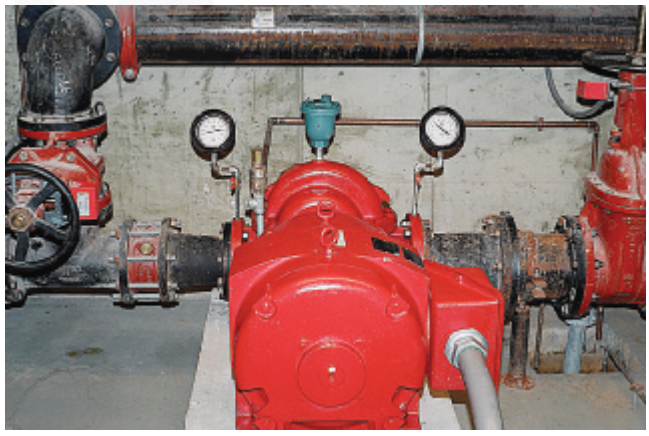


(c) Pressure gauges

Pressure gauges, such as the two shown in Exhibit 8.6, are located on the suction and discharge pipes on a horizontal split case pump. These gauges are required to be located near the pump casing by NFPA 20. There are also specific gauge sizes and gauge pressure ratings that are required based on specific fire system suction pressure and pump working pressures. A pressure gauge is also required as a component of the engine side of a diesel driver heat exchanger to verify cooling water flow and that the water pressure is within the specifications of the driver heat exchanger. See 8.2.2(4)(j) for a more detailed discussion.

Heat exchanger ratings normally range from 30 psi to 60 psi (2.1 bar to 4.1 bar). Because the cooling water is taken off of the pump discharge, it is easy to overpressurize the cooling water heat exchanger — this can result in catastrophic failure.

EXHIBIT 8.6 *Pump Casing with Air Release Valve and Suction and Discharge Pressure Gauges.*



(d) Circulation relief valve (not used in conjunction with diesel engine drive with heat exchanger)

The circulation relief valve, often referred to as the automatic relief valve, is also sometimes confused with the pressure relief valve; the latter is much larger and has a different function.

The circulating relief valve, as the name implies, is designed to open slightly below churn pressure and provide impeller, packing, and bearing cooling by relieving water that is circulating around the pump casing water. This valve opens to relieve some of the water heated in the casing by friction, which then allows a small flow of cooler water to pass from the suction pipe through the casing.

If circulation relief valves are incorrectly set too low or fail to operate, pumps can operate without casing relief. However, within a short time they will overheat from frictional heat. In cases where this has occurred, the steam created raises temperatures to levels that operate pump room sprinklers. At this point, the damage to fire pumps often requires a complete and costly impeller replacement. Adequate flow through the circulating relief valves should be the top priority each time a pump is churned, because these valves are usually spring-operated and they can fail with the slightest bit of foreign material in the water supply or hard water buildup in the valve body. NFPA 20 requires these valves to "discharge to drain," but the intent is that they are piped in such a way to an "open drain" where flow can be verified with each pump churn.

Circulating relief valves are typically only installed on electric-driven pumps, since most diesel-driven pumps have heat exchanger cooling supplied by a water connection to the pump discharge pipe that serves the same purpose as the circulation relief valve. Per NFPA 20, these valves must be sized at 0.75 in. (19 mm) for pump capacities of 2500 gpm (9462 L/min) or less and 1 in. (25 mm) for all larger pump size. Exhibit 8.7 shows a typical circulation relief valve, while Exhibit 8.8 shows a diesel-driven pump with a cooling water line connection.



EXHIBIT 8.7 *Circulation Relief Valve Installed on Electric-Driven Pump.*

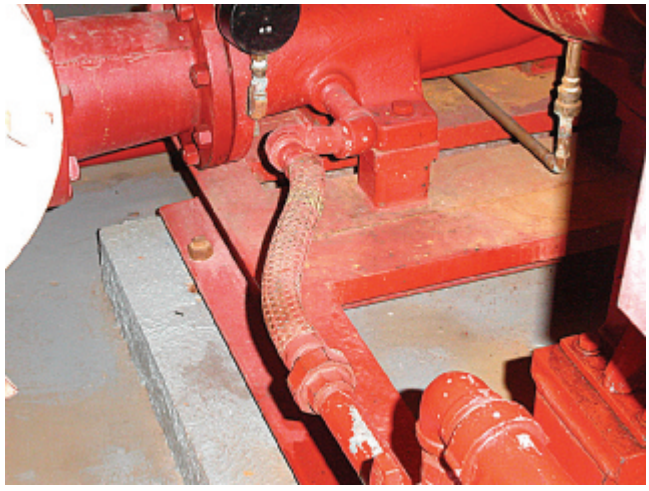


EXHIBIT 8.8 *Cooling Water Line Connection Installed on Diesel-Driven Pump, Negating the Need for a Circulating Relief Valve.*

Case In Point

The purpose of the circulating relief valve is to create enough flow to maintain water temperature in the pump casing. Accordingly, the optimum circulating relief valve setting is based on the maximum temperature that a pump casing should experience, to avoid damage to the packing glands, impeller, and bearings. Because the water in the pump casing should never exceed 140°F (60°C), this valve must be open enough to prevent the pump from reaching this temperature at churn. However, the valve setting is really not determined by pressure but by flow, which is dependent on the brake horsepower (BHP) of the pump running at churn and not on the capacity of the pump. This valve setting can be roughly calculated with assumptions such as the churn BHP of a pump equals approximately 50 percent maximum pump BHP and heat is approximately 80 percent dissipated energy.

Assumptions would also have to be made on the maximum water temperature in order to calculate heat absorption. Going through this exercise, a safe rough estimate would be a minimum flow of about 16 gpm (60 L/min). In fact, neither the calculation nor the valve settings are usually critical since the design standard, NFPA 20, requires a larger relief valve for larger pumps. NFPA 20 requires a ¾ in. (19 mm) casing relief valve for pumps with a capacity up to 2500 gpm (9462 L/min) and a 1 in. (25 mm) valve for larger pumps. A ¾ in. (19 mm) valve set to fully open discharges about 30 gpm (114 L/min), which is easily enough to cool a 100 hp to 200 hp pump. For a 2500 gpm (9462 L/min) pump, this is approximately 1 percent of the rated flow if wide open. Setting a casing relief valve on smaller pumps, such as a 500 gpm (1892 L/min) pump, might take some consideration. A relief valve flowing 30 gpm (114 L/min) could actually relieve a significant portion of the fire pump's capacity. In this case, it would be recommended to set the valve to discharge much less.

(2) Pump test device(s)

As indicated in 8.1.4(2), each pump must have the means to be flow tested annually and after any overhauls or repairs. The most common method to meet this requirement is to install a fire pump test header. Per NFPA 20, test headers, such as the ones shown in Exhibit 8.9, are sized such that there will be at least one hose valve for each 250 gpm (946 L/min) of pump flow capacity.

The second most common method is to install a flowmeter (see Exhibit 8.10). Flowmeters are typically installed on a bypass pipe or test header with discharge back to a water storage tank or reservoir. The benefit of this test method is that it can be completed without the added time or resources that are needed to connect test hoses and play pipes. Tools, such as a pitot tube to measure flow, are not required. With this method, wasting water and risking damage from play pipe discharge to the ground are also avoided.

However, when using such devices in a "closed loop," every third year the annual test must be conducted using hose streams or the flowmeter bypass to discharge into a drain or suction reservoir. See 8.3.3.9(2) for more information.

Flowmeters must be listed, and they often need factory calibration. Stream-straightening devices on test headers, such as play pipes, should also be listed. If a test header or flowmeter cannot be used, a site fire hydrant or standpipe can be used to connect hoses and nozzles to conduct the testing.



EXHIBIT 8.9 *Examples of Fire Pump Test Headers. (Left: Courtesy of John Munno and Arthur J. Gallagher Risk Management Services, Inc.)*

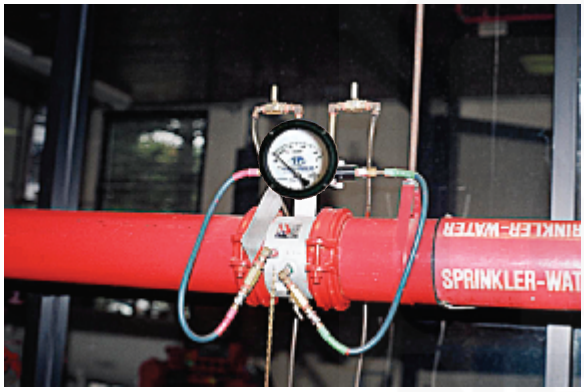


EXHIBIT 8.10 *Fire Pump Flowmeter.*

Case In Point

The need for a main pump relief valve and subsequent required sizing are dictated by NFPA 20. In the 2013 edition, the requirements dictating when a pressure relief valve is required were changed from previous editions. Although they previously were required for all engine-driven fire pumps due to concern over speed governors failing and creating an overspeed (system overpressurization) condition, there have not been any documented cases of this occurring. Thus, they now are only required as follows:

1. For standard diesel engine–driven pumps, where 1.21 × net-rated shutoff (churn) plus elevation-adjusted maximum pump suction supply static pressure exceeds any system component listings' maximum allowable pressure [typically 175 psi (12.1 bar)]
2. For pressure-limiting diesel engine–driven pumps, where elevation-adjusted maximum total discharge churn pressure at rated speed exceeds any system component listings' maximum allowable pressure [typically 175 psi (12.1 bar)]
3. For electric motor–driven pumps with variable speed pressure limiting controllers, where elevation-adjusted maximum total discharge churn pressure at rated speed exceeds any system component listings' maximum allowable pressure [typically 175 psi (12.1 bar)]

(3) Pump relief valve and piping (where maximum pump discharge pressure exceeds the rating of the system components or the driver is of variable speed)

A relief valve, which is sometimes called a main relief valve or pressure relief valve, is designed to open at a predetermined pressure [usually 175 psi (1.2 bar)] to protect the piping and other components in the fire protection system from overpressurization. See Exhibit 13.32 for an illustration of a pressure relief valve. This should not be confused with a pressure reducing valve, which is shown in Exhibit 13.31. Confusion can occur if the abbreviation PRV is used, which typically is used for reducing valves and not relief valves.

(4) Alarm sensors and indicators

The alarm sensors and indicators listed in 8.1.4(4) are the required supervisory signals addressing pump readiness or operation that require immediate attention per NFPA 20 installation requirements. This requirement encompasses not just the fire pump driver and controller but all alarms associated with devices to keep the fire pump fully operational; this includes those for valve tamper switches, controller alarms for the "off" position, failure to start, tanks fuel levels (for diesel drivers), and loss of phase for electric pumps. Per NFPA 20 requirements, these alarms must be of an audible level to be clearly heard in the pump room while the pump is running and in every controller position except "off." In addition, if pump rooms are not constantly attended, the alarms listed in NFPA 20 must also transmit to a constantly attended location and annunciate either with an audible or visible indication. These requirements should guide testing per NFPA 25.

It should be noted that while most remote annunciation signals can be grouped into a common "trouble" signal, the signals for "pump running" and "pump off" must indicate separately from all other signals. A common error in new pump installations and pumps that have been damaged or rewired is the crossing of wires and the poor panel description programming of these signals. One such example illustrating this is when a "pump running" signal appears on a security center screen as a simple "valve trouble alarm," and thus, does not get the immediate action required. For this reason, alarms should be tested from the driver to the remote annunciation location when possible.

Tip for Owners

The quality and training of attendants at the annunciator location should also be regularly reviewed to verify that they meet the definition of the term *qualified*, in relation to understanding the significance and actions required when various fire pump system signals are received.

(5) Right-angle gear sets (for engine-driven vertical shaft turbine pumps)

Right-angle gear drives (see Exhibit 8.11) are built with a cooling oil reservoir. That reservoir must be checked regularly per the manufacturer's requirements to verify that oil levels are acceptable to provide proper cooling and prevent overheating. Oil temperatures should typically be maintained below 200°F (93.3°C) and preferably below 135°F (57°C) to avoid premature breakdown.

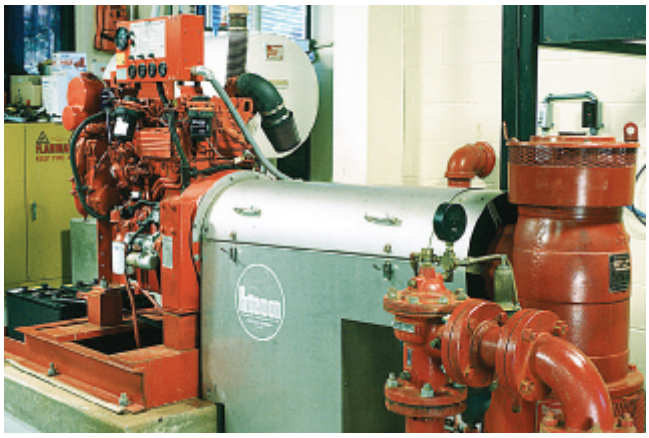


EXHIBIT 8.11 *Right-Angle Gear Drive Attached to a Diesel Engine Driver.*

(6) Pressure maintenance (jockey) pump and accessories

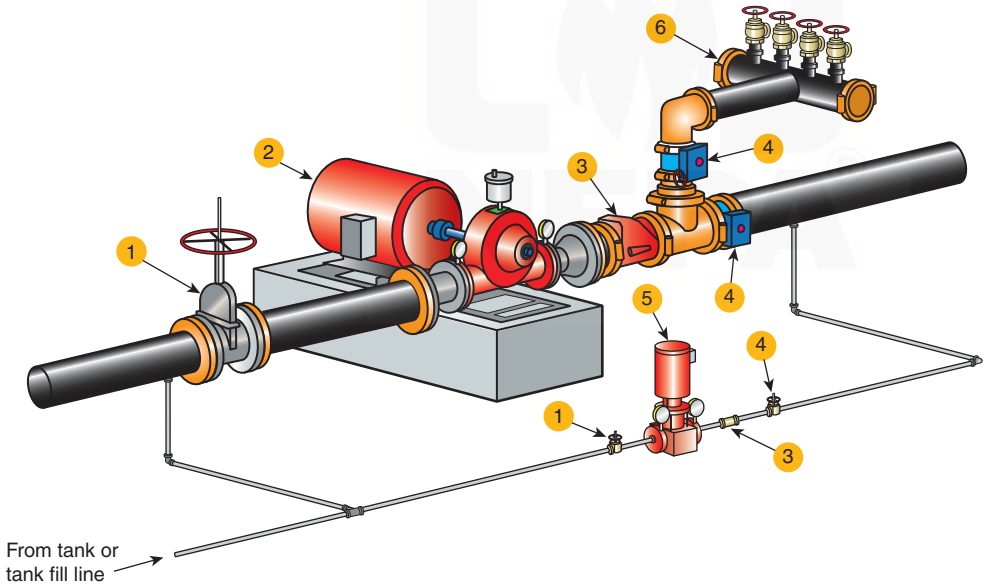
The pressure maintenance pump, or jockey pump, as shown in Exhibit 8.12, is a low-flow, high-pressure pump, installed in parallel with a primary pump on automatic fire pump systems (see Exhibit 8.13). Pressure maintenance pumps are installed to prevent the unplanned operation of primary pumps when system pressures fluctuate or drop slightly, such as from small fitting leaks in large underground water main systems. These pumps typically are rated to slightly exceed system pressure created by the primary pump but with the capability of only providing 40 gpm to 75 gpm (150 L/min to 284 L/min). Thus, the discharge of a pressure maintenance pump is not intended to supply a fire sprinkler system and typically supply a little less than what is required for a single sprinkler.

Pressure maintenance pumps are actuated by dedicated controllers and system pressure-sensing lines, so the system pressure decreases when one or more sprinklers activate. Under these circumstances, as the system pressure drops, the pressure switch (see Exhibit 8.14) in the pressure maintenance pump controller senses the pressure drop and activates the pump. Since the pressure maintenance pump is not designed to keep pace with the flowing sprinkler(s), the system pressure continues to drop.

The pressure switch shown in Exhibit 8.14 is located in the fire pump controller and has high- and low-pressure settings to start and stop the associated pump. The pressure switch is internally mounted in each controller and has specific settings based on the water supply. These can also be fully electronic and part of a controller master display only.



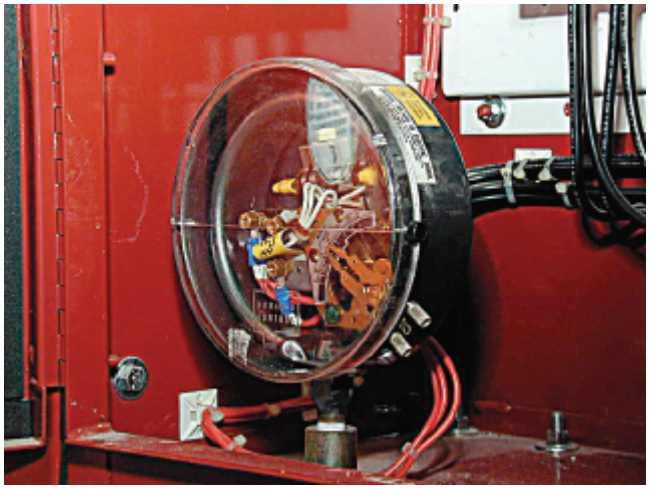
EXHIBIT 8.12 *Pressure Maintenance (Jockey) Pump.*



Legend	
1 OS&Y gate valve	4 OS&Y gate valve or indicating butterfly valve
2 Fire pump	5 Jockey pump
3 Check valve	6 Hose header

EXHIBIT 8.13 *Required Jockey and Fire Pump Installation Arrangement. (Courtesy of Stephan Laforest)*

EXHIBIT 8.14 *Mercoid-Type Pressure Switch.*



The following is an example of recommended pressure switch settings from A.14.2.6(4)(f) of NFPA 20:

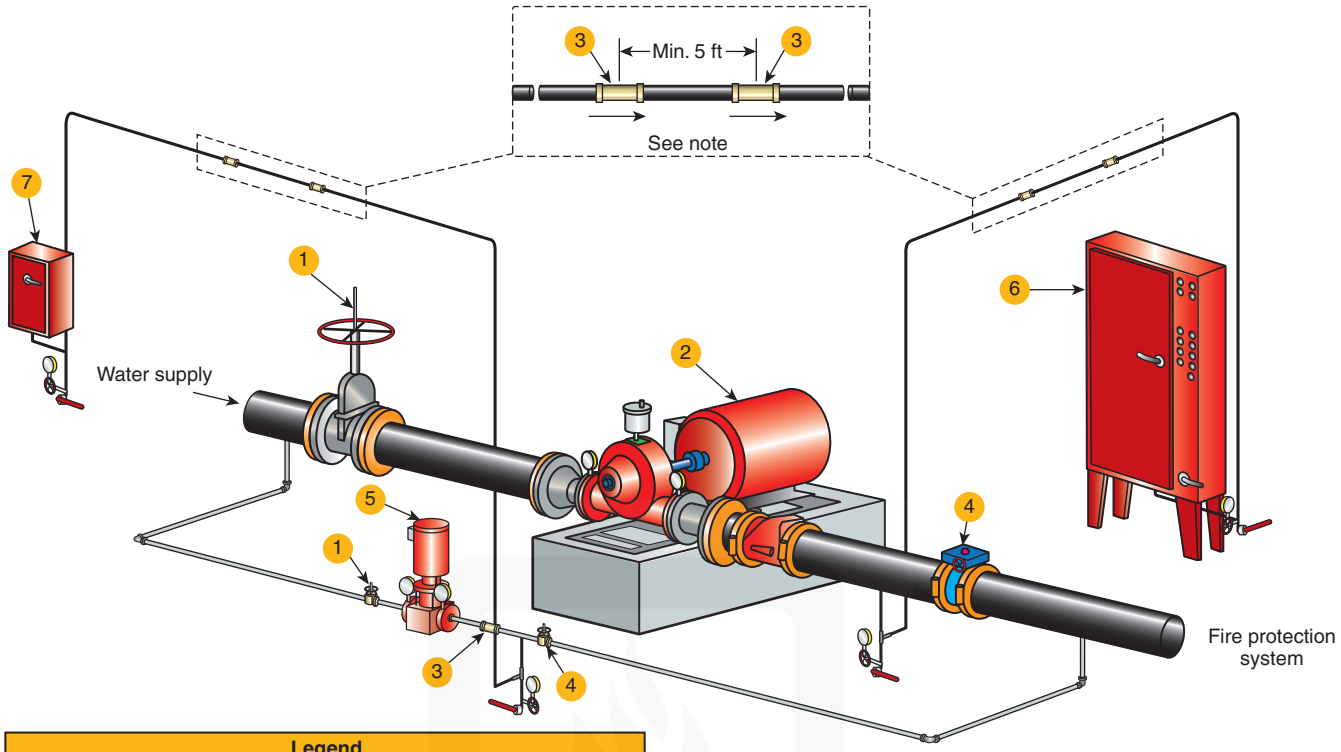
(f) Examples of fire pump settings follow (for SI units, 1 psi = 0.0689 bar):
- i. Pump: 1000 gpm, 100 psi pump with churn pressure of 115 psi
- ii. Suction supply: 50 psi from city — minimum static; 60 psi from city — maximum static
- iii. Jockey pump stop = 115 psi + 50 psi = 165 psi
- iv. Jockey pump start = 165 psi - 10 psi = 155 psi
- v. Fire pump stop = 115 psi + 50 psi = 165 psi
- vi. Fire pump start = 155 psi - 5 psi = 150 psi
- vii. Fire pump maximum churn = 115 psi + 60 psi = 175 psi

There is usually at least a 5 psi (0.4 bar) pressure differential between the pressure maintenance pump and the fire pump start settings. Pressure switch settings less than 5 psi (0.4 bar) can cause unintentional starting of the fire pump.

Some jurisdictions and insurance companies often require that fire pumps only be stopped manually and that the automatic stop relay in the controller be removed or bypassed. This is due to concerns that a fire pump could repeatedly cycle on and off during a fire and eventually not restart from an off sequence. NFPA 20 allows both an automatic and manual fire pump stop setting, except in cases where a pump constitutes a sole site fire protection water source. In these cases, NFPA 20 requires a manual stop only.

The jockey pump should be sized to be able to maintain the system pressure above the starting pressure of the main fire pump, while accounting for small leaks in the system. Such units are not required to be listed for fire service but should be listed as general electrical pump devices. Flow tests of pressure maintenance pumps and controllers are not required in NFPA 25, but they should be started and run through a normal on-off cycle during the annual fire pump test to verify set points. Conditions where a primary pump appears to be running excessively should be investigated. This problem could indicate an incorrect jockey pump setting or service wear that might require replacement.

In addition to dedicated controllers, each pressure maintenance pump and primary pump is required to have independent, dedicated pressure-sensing lines (arranged as shown in Exhibit 8.15). Each sensing line is required to have two check valves or ground-face unions installed, to act as pressure snubbers and limit fire pump start-stop cycles due to momentary pressure surges, as shown in Exhibit 8.16.



Legend	
1	OS&Y gate valve
2	Fire pump
3	Check valve
4	OS&Y gate valve or indicating butterfly valve
5	Jockey pump
6	Fire pump controller
7	Jockey pump controller

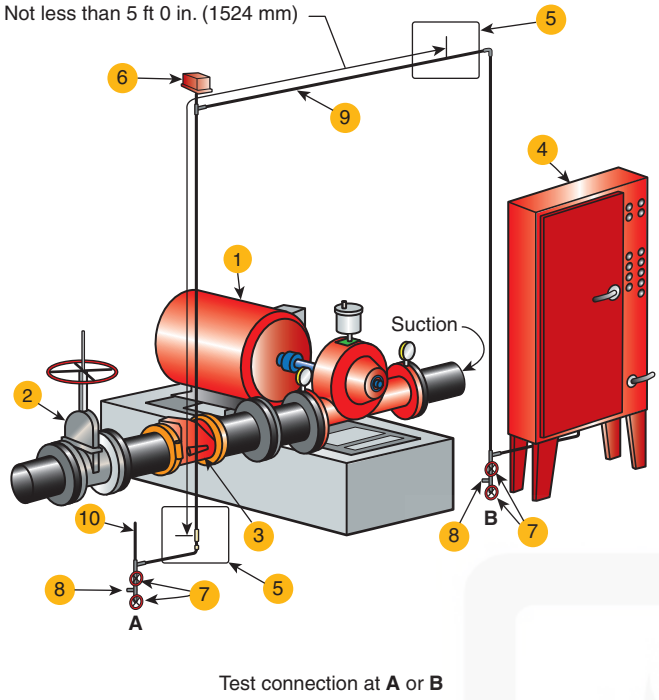
Note

Check valves or ground-face unions complying with 10.5.2.1 (of NFPA 20)

EXHIBIT 8.15 *Required Pressure Maintenance Pump and Fire Pump Arrangement with Dedicated Pressure-Sensing Lines. (Courtesy of Stephan Laforest)*

A.8.1.4 Types of centrifugal fire pumps include single and multistage units of horizontal or vertical shaft design. Listed fire pumps have rated capacities of 25 gpm to 5000 gpm (95 L/min to 18,925 L/min), with a net pressure range from approximately 40 psi to 400 psi (2.75 bar to 27.6 bar).

Multistage pumps have a single shaft and casing but more than one impeller inside the casing. For example, a four-stage pump has four impellers on the same shaft and in the casing that take suction from the same source. Impellers can be installed in both parallel and series arrangements. A parallel multistage arrangement, as shown in Exhibit 8.17, is used to boost flow beyond that of a single-stage (single-impeller) pump. A series multistage arrangement, as shown in Exhibit 8.18, is used to boost pressure beyond that of a single-stage pump.



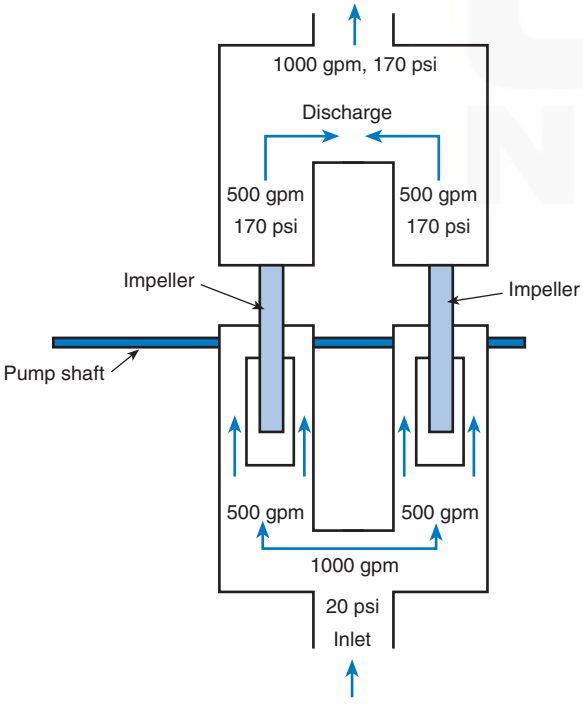
Legend

1. Fire pump
2. Indicating control valve
3. Check valve
4. Control panel (with pressure switch)
5. Bronze check valves with 3⁄32 in. (2 mm) orifice in clapper
6. Supplemental air chamber or pulsation damper—might be needed if water pulsation causes erratic operation of the pressure switch or the recorder
7. ½ in. (15 mm) globe valves
8. ¼ in. (mm) plug
9. Not less than ½ in. (15 mm) brass pipe with brass fittings or equivalent
10. Connect to a tapped boss or other suitable outlet between the indicating control valve and check valve

Notes

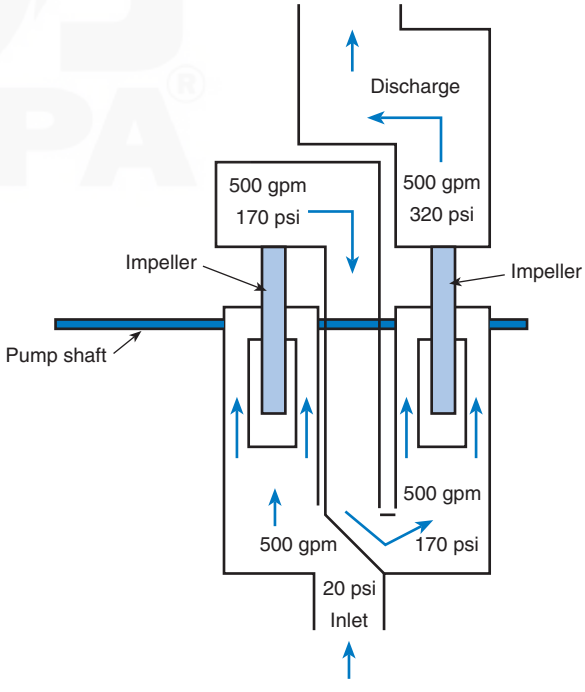
(1) Solenoid drain valve used for engine-driven fire pumps can be at A, B, or inside controller enclosure.
(2) If water is clean, ground-face unions with noncorrosive diaphragms drilled for 3⁄32 in. (2 mm) orifices can be used in place of the check valves.

EXHIBIT 8.16 *Typical Fire Pump Piping Sensing Line Arrangement Showing Snubber Placement. (Courtesy of Stephan Laforest)*



For SI units, 1 psi = 0.0689 bar; 1 gpm = 3.785 L/min

EXHIBIT 8.17 *Two-Stage Pump in Parallel. (Source: Pumps for Fire Protection Systems, 2002, Figure 3.9)*



For SI units, 1 psi = 0.0689 bar; 1 gpm = 3.785 L/min

EXHIBIT 8.18 *Two-Stage Pump in Series. (Source: Pumps for Fire Protection Systems, 2002, Figure 3.10)*

This arrangement is typically seen in high-rise applications. Testing of these types of pumps is typically completed in the same manner as for single-stage pumps. One exception to this is multistage, multi-outlet pumps, where a single casing can have multiple outputs in the casing, each providing an independent discharge. These are being used in Europe where a single fire pump can supply multiple levels of a high-rise structure without pressure zoning. Exhibit 8.19 shows a single-shaft, two-impeller horizontal split case pump.

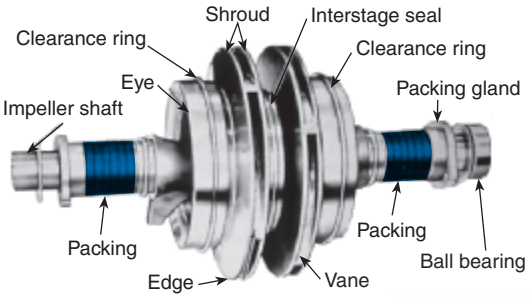


EXHIBIT 8.19 *Two Pump Impellers on a Single Shaft with Shrouds, Vanes, and Eye. (Source: Pumps for Fire Protection Systems, 2002, Figure 3.3)*

(1) *Horizontal Split Case.* This pump has a double suction impeller with an inboard and outboard bearing and is used with a positive suction supply. A variation of this design can be mounted with the shaft in a vertical plane. *[See Figure A.8.1.4(a).]*
(2) *End Suction and Vertical In-Line.* This pump can have either a horizontal or vertical shaft with a single suction impeller and a single bearing at the drive end. *[See Figure A.8.1.4(b).]*
(3) *Vertical Shaft, Turbine Type.* This pump has multiple impellers and is suspended from the pump head by a column pipe that also serves as a support for the shaft and bearings. This pump is necessary where a suction lift is needed, such as from an underground reservoir, well, river, or lake. *[See Figure A.8.1.4(c).]*

NFPA 20 allows positive displacement pumps for water mist and foam system applications. For details on the ITM of these pumps, the pump manufacturer should be contacted.

8.1.5 Water Supply to Pump Suction.

8.1.5.1 The suction supply for the fire pump shall provide the required flow at or above the lowest permissible suction pressure to meet the system demand.

The pressure observed at the suction gauge while the pump is operating should be positive, even when the fire pump is operating at its overload condition. The suction gauge pressure is permitted by NFPA 20 to drop to −3 psi (−0.2 bar) when the supply is a suction tank with its base at or above the same elevation as the pump, provided the lowest water tank level and all maximum fire system demands and durations have been properly supplied. However, it should also be noted that when taking water from a public water system, most municipal water companies limit the residual pressure on the system to 20 psi (1.4 bar) due to concerns of collapsing water mains and drastically increasing water turbidity. But this is generally the minimum required at the city connection. Many times, gauges at the location of a pump test could be 10 psi to 20 psi (0.7 bar to 1.4 bar) above that at the city connection due to pressure losses across backflow apparatus and numerous valves and other reasons. Thus, in

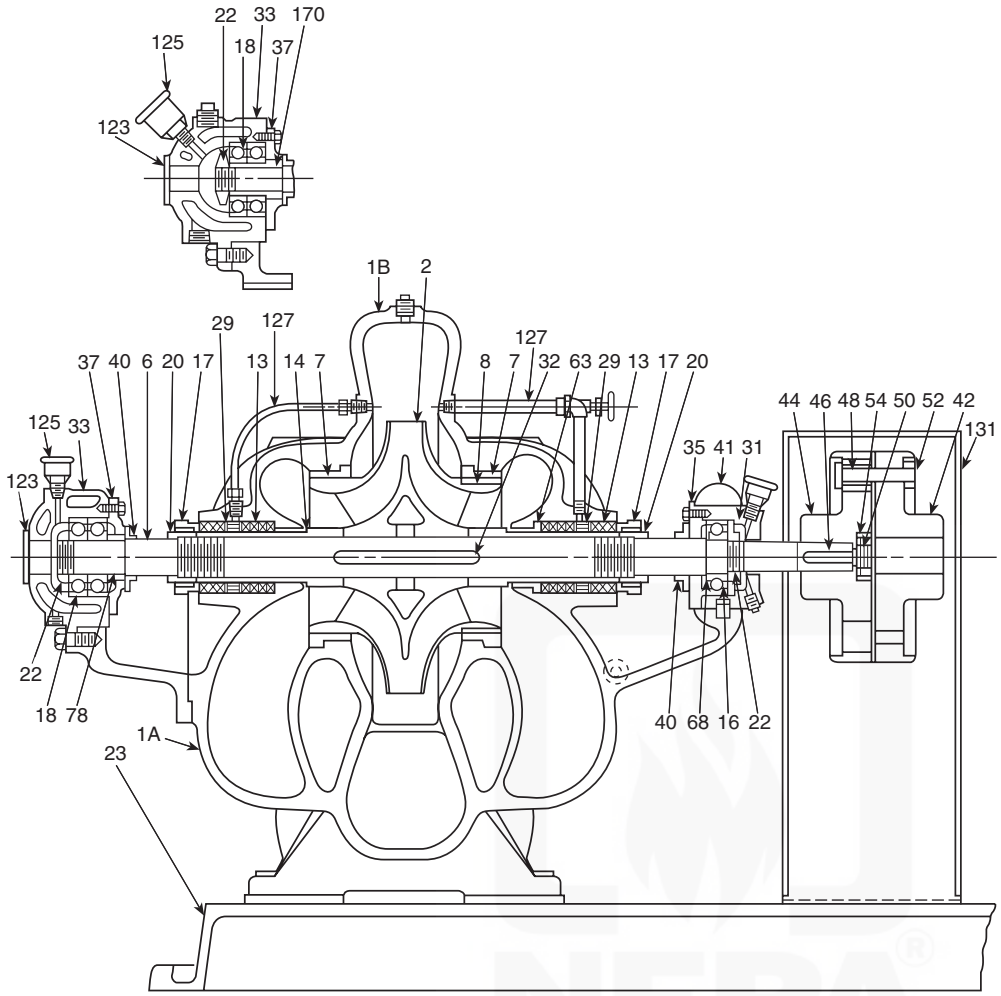


FIGURE A.8.1.4(a) *Impeller Between Bearings, Separately Coupled, Single-Stage Axial (Horizontal) Split Case. (Courtesy of Hydraulic Institute, Parsippany, NJ, www.Pumps.org.)*

these cases, an additional pressure gauge should be attached to a hydrant or the city side of the site backflow apparatus and examined so the accurate public water supply pressure can be monitored for compliance with any minimum amounts stipulated by the municipality. If suction pressures drop below the minimum established by the water purveyor, the test should be suspended and the water purveyor contacted. If previous tests did not indicate this drop, the situation should be investigated to determine what has changed. Often a partially or fully closed valve on the city side of the system is discovered. These can sometimes occur during regular maintenance of public water systems and not be identified until a high-demand occurrence, such as a fire pump test, takes place.

Tip for Owners

The information referenced by 8.1.5.2 can be found on the hydraulic design information records. These records must be maintained in accordance with Section 4.3. Maintaining these records can be a daunting task, but recreating them is often a much costlier and burdensome issue.

8.1.5.2 Those installations for which NFPA 20 permitted negative suction gauge pressures at the time of pump installation, where the system demand still can be met by the pump and water supply, shall be considered to be in compliance with 8.1.5.

8.1.6 Energy Source. The energy sources for the pump driver shall supply the necessary brake horsepower of the driver so that the pump meets system demand.

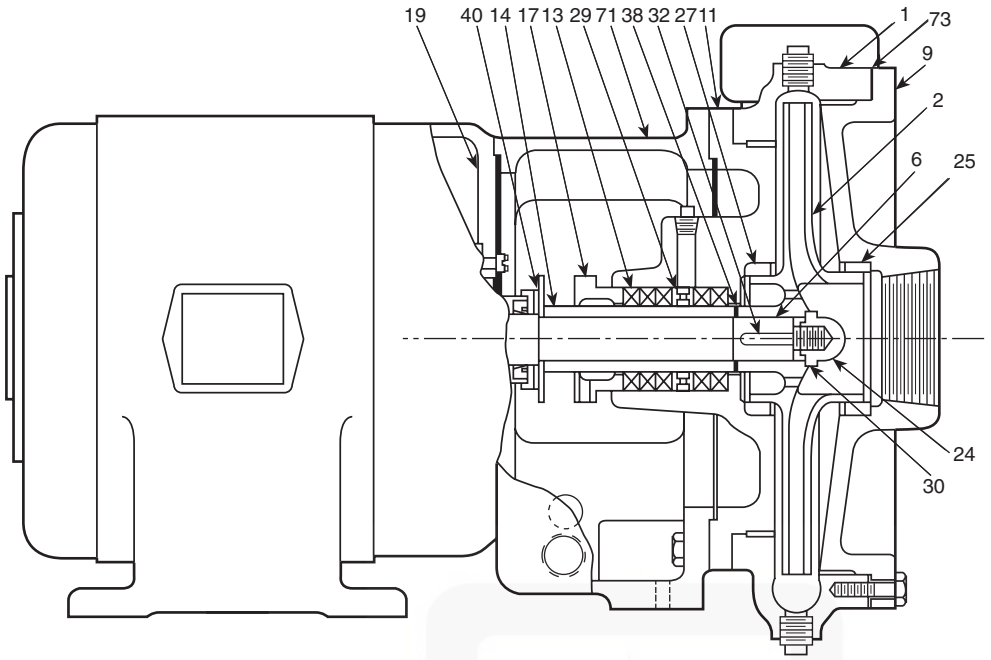


FIGURE A.8.1.4(b) *Overhung Impeller, Close-Coupled, Single-Stage, End Suction. (Courtesy of the Hydraulic Institute, Parsippany, NJ, www.Pumps.org.)*

The energy sources referred to in 8.1.6 are electric power, steam, and diesel fuel. Other fuels currently are not allowed for newly installed fire pump installations.

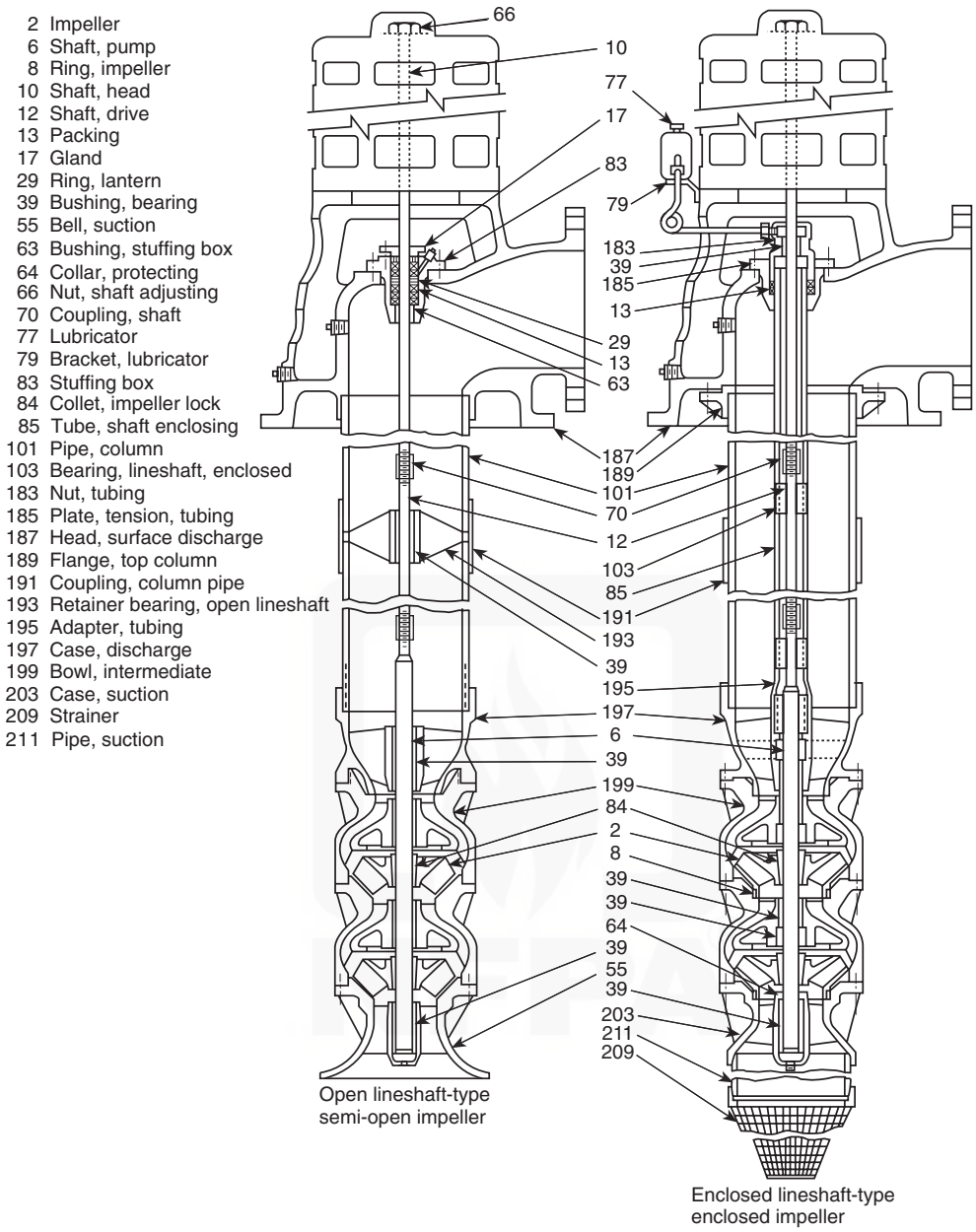
8.1.7 Driver. The pump driver shall not overload beyond its rating (including any service factor allowance) when delivering the necessary brake horsepower.

8.1.8* Controller. Automatic and manual controllers for applying the energy source to the driver shall be capable of providing this operation for the type of pump used.

The two types of controllers approved for electric fire pump service are limited-service and full-service controllers. For installations with across-the-line starting of squirrel-cage type motors 30 hp or less and 600 V or less, limited-service controllers can be used. These controllers are typically less expensive and less complex than standard controllers. They are used in cases where pumps are connected to large, high-capacity water mains with very low pressures. The other type of controller approved for electric fire pump service is a full-service controller, which is seen in most installations.

A.8.1.8 Controllers include air-, hydraulic-, or electric-operated units. These units can take power from the energy source for their operation, or the power can be obtained elsewhere. Controllers used with electric power sources can apply the source to the driver in one (across-the-line) or two (reduced voltage or current) steps. Controllers can be used with automatic and manual transfer switches to select the available electric power source where more than one is provided.

The most common reason for installing multiple electric power supplies, as referred to in A.8.1.8, is in cases where one or more of the supplies do not offer the reliability required



The cross-sectional views illustrate the largest possible number of parts in their proper relationship and some construction modifications but do not necessarily represent recommended design.

FIGURE A.8.1.4(c) *Turbine-Type, Vertical, Multistage, Deep Well. (Courtesy of the Hydraulic Institute, Parsippany, NJ, www.Pumps.org.)*

by NFPA 20. When testing fire pumps, each power source must be tested using the transfer switch to determine its adequacy for supplying the fire pump under full load. Testing each pump on each power supply under full load is critical in determining true reliability and redundancy.

8.1.9 Impairments. The procedures outlined in Chapter 15 shall be followed where an impairment to protection occurs.

8.2 Inspection.

8.2.1 The purpose of inspection shall be to verify that the pump assembly appears to be in operating condition and is free from physical damage.

Exhibit 8.20 shows a pump casing that has been severely damaged. In this instance, the contractor replaced a valve in the suction piping and used a mechanical assist on the piping connected to the fire pump to reconnect the piping to the valve.

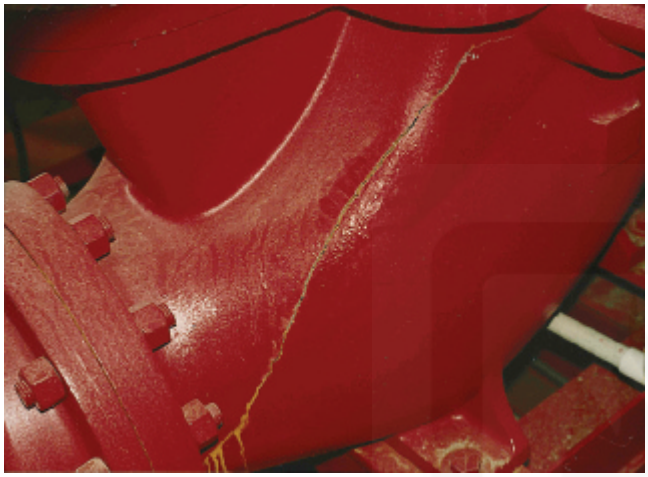


EXHIBIT 8.20 *Crack in Pump Casing. (Courtesy of Damon Pietraz, Underwood Fire Equipment)*

ITM Deficiency, Impairment, or Hazard Evaluation?

ANSWER: ITM Deficiency

This photo shows a serious problem with the fire pump test header. The normal visual inspection probably did not reveal this problem, since the control valve to the test header is in a typical closed position and the hose valves are cracked but not broken apart. However, when the control valve to the test header was opened to begin the annual fire pump flow test, the damaged valves began spraying water. Subsection 8.2.1 requires that the pump assembly be free from physical damage, and as described in 8.1.4(2), the pump test device is part of the pump assembly auxiliary equipment.

While this break is serious, it should not be considered an impairment because the pump assembly itself will function in a fire event. The repairs can be made without affecting the pump when the test header control valve is shut.



(Courtesy of Byron Blake and SimplexGrinnell)

8.2.2* The pertinent visual observations specified in the following checklists shall be performed weekly:

While NFPA 25 does not mandate that a specific inspection form must be used, it is important to document that each item required to be inspected has been addressed at the proper frequency. Exhibit 8.21 is a sample form that could be used to document the items identified in 8.2.2.

(1) Pump house conditions are determined as follows:
   (a) Heat is adequate, not less than 40°F (4°C) for pump room with electric motor or diesel engine–driven pumps with engine heaters.
   (b) Heat is adequate, not less than 70°F (21°C) for pump room with diesel engine–driven pumps without engine heaters.

Water is present in the fire pump piping and sprinkler system that protects the fire pump room, so it is necessary to prevent temperatures that could freeze the water in these systems by providing heat in the pump house.

In the case of diesel engines, it is also necessary to provide a sufficiently cooled environment in summer months for the engine to properly operate. Diesel engines are derated 1 percent for each 10°F (5.6°C) above 77°F (25°C) ambient temperature. Thus, at significantly elevated temperatures, diesel drivers might not be capable of delivering the necessary horsepower to drive a pump at its required speed. High temperatures can also be an issue in electric pump rooms where controllers can be damaged. Many controllers have maximum operating temperatures of 104°F (40°C). Some offer a 122°F (50°C) option but, in either case, fire pump buildings with metal deck roofs in areas subject to high temperatures could quickly see elevated temperatures without air conditioning.

   (c) Ventilating louvers are free to operate.

Paragraph 8.2.2(1)(c) requires a weekly pump house ventilating louver inspection to verify their operational condition. These louvers are needed to maintain fresh air for proper diesel system combustion and room air temperature control. In cold climates, the inlet air might need to be heated to prevent small piping and gauges from freezing. See Exhibit 8.22.

   (d) Excessive water does not collect on the floor.
   (e) Coupling guard is in place.

(2) Pump system conditions are determined as follows:
   (a) Pump suction and discharge and bypass valves are fully open.

NFPA 13, *Standard for the Installation of Sprinkler Systems,* requires that all valves controlling water supplies be supervised. Although Chapter 13 of NFPA 25 indicates that electronically monitored control valves and/or locked valve inspections can be decreased from weekly to monthly inspection frequencies, this section supersedes that requirement for control valves associated with fire pumps. All valves directly associated with the fire pump (i.e., in the pump room) must be part of the weekly visual inspection.

   (b) Piping is free of leaks.

Piping leaks in suction and discharge piping, most frequently found at flanges or couplings as shown in Exhibit 8.23, can be considered impairments or can lead to impaired systems, depending on the severity of the leak.

Frequently, inexperienced personnel might view the water in the drip pocket as a leak. If the packing glands are tightened to the point where no water is allowed to drip, then the

FIRE PUMP WEEKLY INSPECTION

Property Name: _____ **Inspector:** _____

Property Address: _____ **Contract No.:** _____

Property Phone Number: _____ **Date:** _____

Inspections: Weekly			
			Pump House
❑ Yes	❑ No	❑ N/A	Heat in pump room is 40°F (4°C) or higher
❑ Yes	❑ No	❑ N/A	Ventilation louvers are free to operate
❑ Yes	❑ No	❑ N/A	Excessive water does not appear on the floor
❑ Yes	❑ No	❑ N/A	Coupling guard is in place
❑ Yes	❑ No	❑ N/A	Heat in pump room is not less than 70°F (21°C) for diesel engine pump without engine heater
			Pump Systems
❑ Yes	❑ No	❑ N/A	Pump suction, discharge, and bypass valves are open
❑ Yes	❑ No	❑ N/A	No piping or hoses leak
❑ Yes	❑ No	❑ N/A	Fire pump leaking one drop of water per second at seals
❑ Yes	❑ No	❑ N/A	Suction line pressure is within acceptable range
❑ Yes	❑ No	❑ N/A	System line pressure is within acceptable range
❑ Yes	❑ No	❑ N/A	Suction reservoir is full
❑ Yes	❑ No	❑ N/A	Wet pit suction screens are unobstructed and in place
❑ Yes	❑ No	❑ N/A	Waterflow test valves are in closed position, hose connection valve is closed, and the line to test valves is free of water
			Electrical Systems
❑ Yes	❑ No	❑ N/A	Controller pilot light (power on) is illuminated
❑ Yes	❑ No	❑ N/A	Transfer switch normal power light is illuminated
❑ Yes	❑ No	❑ N/A	Isolating switch for standby power is closed
❑ Yes	❑ No	❑ N/A	Reverse-phase alarm light is not illuminated
❑ Yes	❑ No	❑ N/A	Normal-phase rotation light is illuminated
❑ Yes	❑ No	❑ N/A	Oil level in vertical motor sight glass is within acceptable range
❑ Yes	❑ No	❑ N/A	Pressure maintenance (jockey) pump has power
			Diesel Engine Systems
❑ Yes	❑ No	❑ N/A	Diesel fuel tank is at least two-thirds full
❑ Yes	❑ No	❑ N/A	Controller selector switch is in “auto” position
❑ Yes	❑ No	❑ N/A	Voltage readings for batteries (2) are within acceptable range
❑ Yes	❑ No	❑ N/A	Charging current readings are within acceptable range for batteries
❑ Yes	❑ No	❑ N/A	Pilot lights for batteries are “on” or battery failure pilot lights are “off”

NFPA 25 Handbook (p. 1 of 2)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT 8.21 *Sample Form for Fire Pumps Weekly Inspection.*

FIRE PUMP WEEKLY INSPECTION (Continued)

Inspections: Weekly

❑ Yes	❑ No	❑ N/A	All alarm pilot lights are "off"
❑ Yes	❑ No	❑ N/A	Record engine running time from meter
❑ Yes	❑ No	❑ N/A	Oil level is within acceptable range in right angle gear drive pumps
❑ Yes	❑ No	❑ N/A	Crankcase oil level is within acceptable range
❑ Yes	❑ No	❑ N/A	Cooling water level is within acceptable range
❑ Yes	❑ No	❑ N/A	Electrolyte level in batteries is within acceptable range
❑ Yes	❑ No	❑ N/A	Battery terminals are free of corrosion
❑ Yes	❑ No	❑ N/A	Water-jacket heater is operational
❑ Yes	❑ No	❑ N/A	Battery cranking voltage exceeds 9 volts for a 12 volt system and 18 volts for a 24 volt system (Alternative ITM A.8.1.1.2)
❑ Yes	❑ No	❑ N/A	Water pump(s) is not leaking (Alternative ITM A.8.1.1.2)
❑ Yes	❑ No	❑ N/A	Jacket water heater operational (Alternative ITM A.8.1.1.2)
❑ Yes	❑ No	❑ N/A	Flexible hose and connections are in good operating condition (Alternative ITM A.8.1.1.2)
❑ Yes	❑ No	❑ N/A	Check lube oil heater for operation (Alternative ITM A.8.1.1.2)
❑ Yes	❑ No	❑ N/A	Oil lube level is within acceptable range (Alternative ITM A.8.1.1.2)
❑ Yes	❑ No	❑ N/A	Check for water in diesel fuel tank (Alternative ITM A.8.1.1.2)
			Steam System
❑ Yes	❑ No	❑ N/A	For steam-driven pumps, steam pressure is within acceptable range
			Exhaust System
❑ Yes	❑ No	❑ N/A	Examine exhaust system for leaks (Alternative ITM A.8.1.1.2)
❑ Yes	❑ No	❑ N/A	Drain condensate trap (Alternative ITM A.8.1.1.2)

Comments

Signature: _____ Date: _____

Contractor Name: _____

Contractor Address: _____

License/Certification No.: _____

NFPA 25 Handbook (p. 2 of 2)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT 8.21 *Continued.*

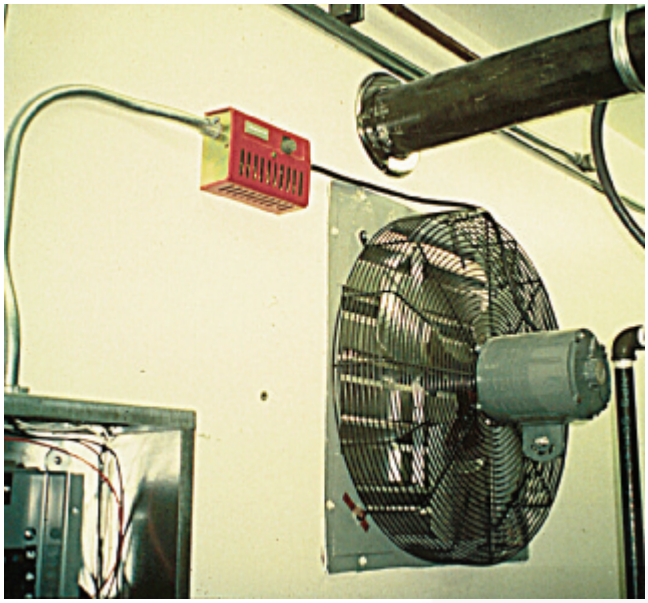


EXHIBIT 8.22 *Ventilation Louvers.*

packing gland will dry out and fail. Exhibit 8.24 illustrates a packing gland that has been properly adjusted, because water can be seen in the drip pocket.

(c) Suction line pressure gauge reading is within acceptable range.

As required by 8.2.2(2)(c), an inspection of pump system conditions includes a check to ensure that the suction line pressure gauge reading is within an acceptable range. Where the water supply is taken from a tank, the gauge should be positive at a pressure approximately equal to the water height in the tank multiplied by 0.433 psi/ft. As an example, a pump attached to a tank that has 20 ft (6.1 m) of water above the point of the pipe connection



EXHIBIT 8.23 *Leaking Coupling in Fire Pump Piping. (Courtesy of Indonesian Fire and Rescue Foundation)*

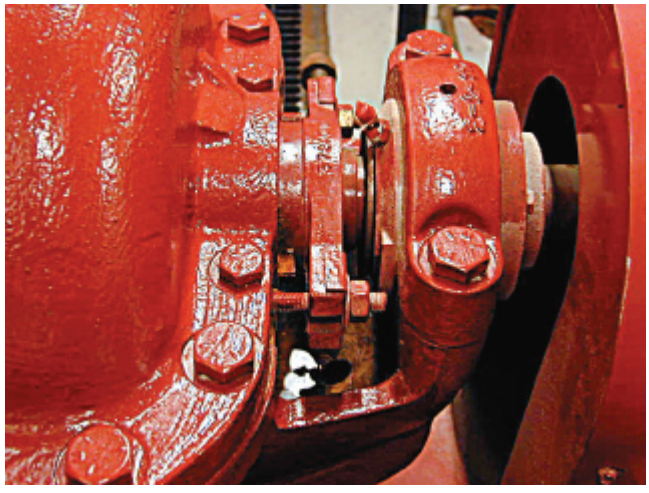


EXHIBIT 8.24 *Fire Pump Packing Gland and Drip Pocket.*

should have approximately 8.7 psi (0.6 bar) on the suction gauge [0.433 psi/ft × 20 ft = 8.7 psi (0.6 bar)]. Where the supply is from a public source, the gauge should equal the public water supply pressure, adjusted for elevation changes.

(d) System line pressure gauge reading is within acceptable range.

Fire pumps boost pressure only when they are running. Therefore, when a pump is not running, the pressure on the system line pressure (pump discharge) gauge should be the same as the suction pressure gauge.

(e) Suction reservoir has the required water level.

An altitude float located on the exterior of the tank is usually used to check the pressure in the suction reservoir. These devices should always be moved slightly at inspection to ensure that the sliding gauge has not become stuck in the full position. In some installations, a pressure gauge that reads in feet of water or psi is installed in the pump room. See Chapter 9 for ITM requirements for suction tanks.

In the case of suction from a well or underground reservoir, a different method must be used to check the water level. It involves using an airline that extends below the water surface and a pressure gauge that, when air is blown into the tubing, reads how far below grade the water is. See A.7.3.5.3 and Figure A.7.3.5.3 of NFPA 20, for a detailed description of this method.

(f) Wet pit suction screens are unobstructed and in place.

The size and shape of the wet pit are governed by the Hydraulic Institute standards. The following must be checked during the inspection required by 8.2.2(2)(f):

- Trash rack
- Two sets of screens
- Pump suction strainer at the bottom of the submerged pump assembly

A small amount of debris can negatively affect pump operation by damaging the pump impeller or by causing obstruction of the pump and the piping around the pump.

(g) Waterflow test valves are in the closed position, the hose connection valve is closed, and the line to test valves is free of water.

Subsection 4.18.2 of NFPA 20 requires test header control valves be supervised in the closed position. That requirement is meant to protect against pump operation caused by small header cap leaks or unauthorized use of the header. The test header must be protected from freezing, so water must be fully drained following each use after the control valve is fully closed. Frequently, hose valves are found broken from freezing if they have not been properly drained following their use.

(3) Electrical system conditions are determined as follows:
(a) Controller pilot light (power on) is illuminated.
(b) Transfer switch normal pilot light is illuminated.

Transfer switches are installed only with electric motors that have an alternative electric power supply installed. Exhibit 8.25 through Exhibit 8.27 offer three views of a fire pump controller with an attached power transfer switch.

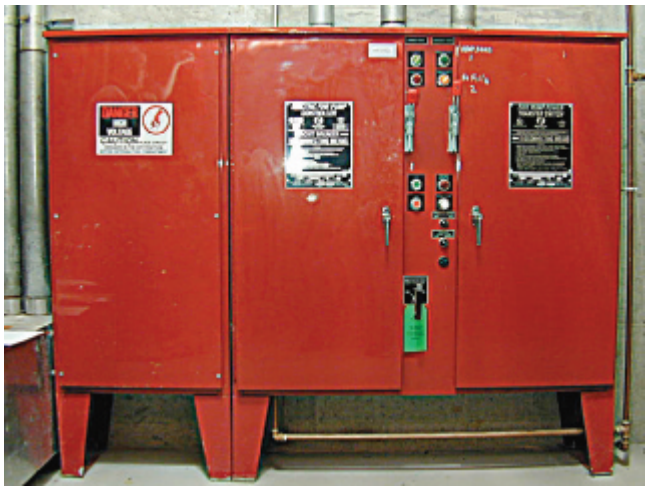


EXHIBIT 8.25 *Fire Pump Controller with Transfer Switch.*



EXHIBIT 8.26 *Close-Up of Controller Indicators.*



EXHIBIT 8.27 *Close-Up of Transfer Switch Indicators.*

(c) Isolating switch is closed — standby (emergency) source.

Isolation switches on each source of power to an electric motor drive must be closed when the pump is in the operating or standby condition.

(d) Reverse phase alarm pilot light is off, or normal phase rotation pilot light is on.

Once the electric motor/controller installation is completed and the phases have been checked, there is little chance that reverse phase will be a problem, unless work is conducted on the electric supply system.

(e) Oil level in vertical motor sight glass is within acceptable range.
(f) Power to pressure maintenance (jockey) pump is provided.

In addition to the items listed in 8.2.2(3)(a) through 8.2.2(3)(f), the general condition of the electrical components should be observed and recorded. Potential problems that can be discovered include rodent nesting, plugged motor vents, broken parts, unlocked controller doors, and improperly labeled electrical panel boards. If the pump room is equipped with electric heat, the thermostat should be checked to determine that it is operating in cold weather and that the temperature is set at a normal room temperature. Any electric controls for ventilation should also be verified as fully operational.

(4) Diesel engine system conditions are determined as follows:
(a) Fuel tank is at least two-thirds full.

The fuel tank is designed to hold an 8-hour supply of fuel for the diesel engine. The quantity of fuel needed is based on a formula of 1 gal per horsepower (5.07 L per kW), plus a 10 percent volume adjustment for expansion and sump. If an engine does not consume this quantity of fuel — and many do not — the fuel storage can be adjusted for the actual demand. Fuel in the tank should be consumed within 1 year. Fuel kept longer than 1 year has an increased risk of becoming contaminated with biological growth and can clog the engine fuel filters, preventing the engine from running.

The bottom 5 percent of a fuel tank is reserved for collecting water or other contaminants. Therefore, this fuel should be removed on an annual basis, as is required by NFPA 25. Also, the bottom of the fuel tank should be observed to make sure that it is above the level of the fuel injectors so that if the fuel pump fails, the engine can still operate. Exhibit 8.28 and Exhibit 8.29 show a diesel fuel tank and fuel gauge.



EXHIBIT 8.28 *Fuel Tank for a Diesel Fire Pump (with Driver Supply Line Installed to Allow a 5 Percent Sump as Required).*



EXHIBIT 8.29 *Fuel Level Indicator for a Diesel Fire Pump.*

(b) Controller selector switch is in auto position.
(c) Batteries' (2) voltage readings are within acceptable range.
(d) Batteries' (2) charging current readings are within acceptable range.
(e) Batteries' (2) pilot lights are on or battery failure (2) pilot lights are off.
(f) All alarm pilot lights are off.
(g) Engine running time meter is reading.
(h) Oil level in right angle gear drive is within acceptable range.
(i) Crankcase oil level is within acceptable range.

A pressure gauge is also required as a component of the engine side of a diesel driver heat exchanger, to verify cooling water flow and that the water pressure is within the specifications of the driver heat exchanger. Engine heat exchanger ratings typically range from 30 psi to 60 psi (2.1 bar to 4.1 bar). Thus cooling water, which comes off of the pump discharge main piping typically at over 125 psi (8.6 bar), could quickly cause permanent damage to the exchanger if not properly regulated or if the regulator fails.

Older fire pumps typically only have one regulator installed on the main line. Thus, during emergency operation where cooling water flows only through the bypass line, pressure regulation must be done manually with the bypass line quarter turn valves and by monitoring the pressure gauge. Exhibit 8.30 through Exhibit 8.32 illustrate common engine driver cooling arrangements.

(j) Cooling water level is within acceptable range.
(k) Electrolyte level in batteries is within acceptable range.

The electrolyte level in a battery is normal when the battery is full of water up to the ring under the cell cap. A lower water level exposes the battery to an accumulation of hydrogen in the cell; this can lead to an explosion when the pump is started and there is a spark in the battery. Proper personal protective equipment (PPE) should be worn when filling batteries with electrolyte. (See Commentary Table 4.2 for PPE selection.)

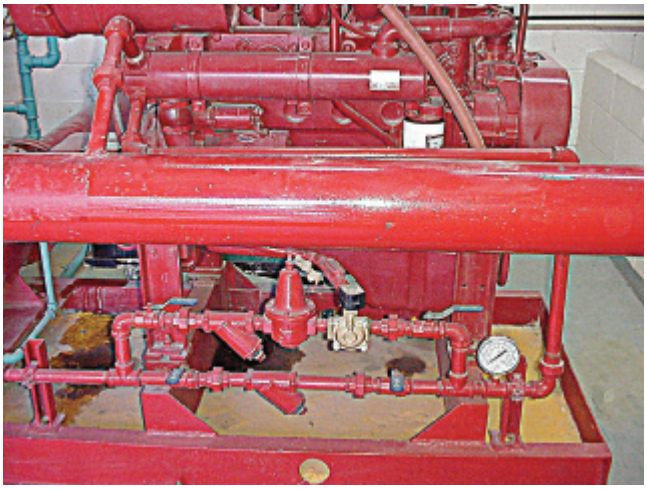


EXHIBIT 8.30 *Close-Up of Fire Pump Cooling Line.*

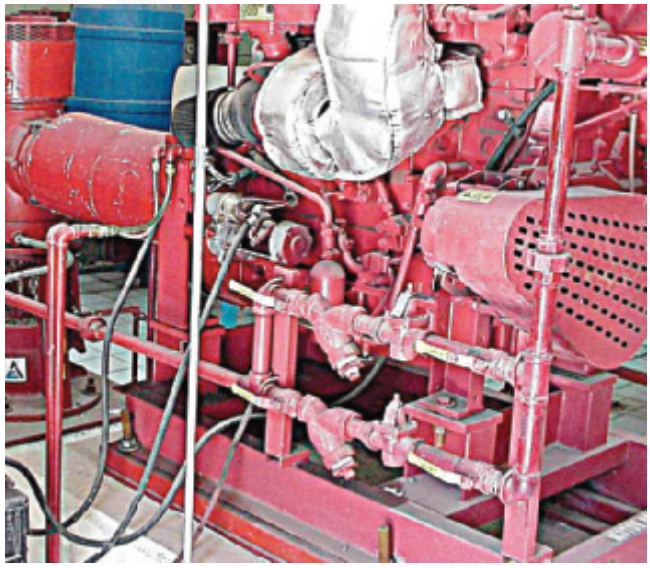


EXHIBIT 8.31 *Typical Engine Driver Cooling Water Pressure Arrangement with Single Regulator.*

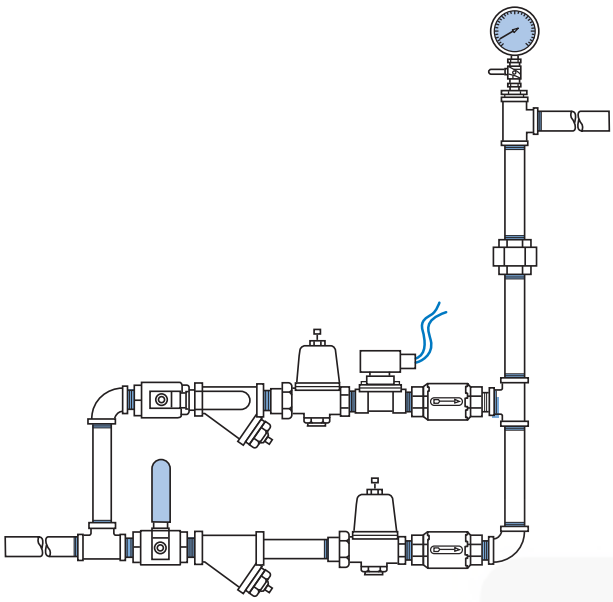


EXHIBIT 8.32 *Spring-Loaded Check Valve Arrangement. [Source: NFPA 20, 2019, Figure A.11.2.8.5.3.8(A)]*

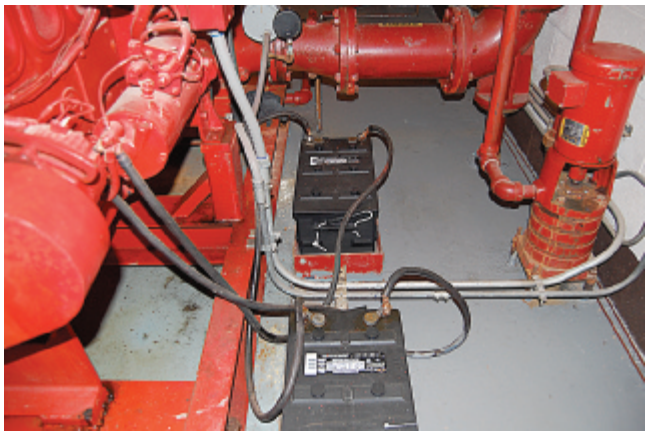


EXHIBIT 8.33 *Diesel Fire Pump Batteries.*

Diesel fire pumps are required by NFPA 20 to have two battery banks. During the cranking cycle, the fire pump controller will alternate cranking from one bank to the other, with a 15-second rest period between attempts until the engine starts or until it has signaled through a 3-minute cycle with six attempts on each battery. Both batteries must be fully charged at all times. Exhibit 8.33 shows the two battery banks for a diesel fire pump.

(l) Battery terminals are free from corrosion.
(m) Water-jacket heater is operating.

(5) *Steam system conditions: Steam pressure gauge reading is within acceptable range.

A.8.2.2 See Table A.8.2.2 and Figure A.8.2.2.

TABLE A.8.2.2 *Observations — Before Pumping*

Item	*Before Pump Is Operated*
Horizontal pumps	1. Inspect drip pockets under packing glands for proper drainage. Standing water in drip pockets is the most common cause of bearing failure. 2. Inspect packing adjustment — approximately one drop per second is necessary to keep packing lubricated. 3. Observe suction and discharge gauges. Readings higher than suction pressure indicate leakage back from system pressure through either the fire pump or jockey pump.

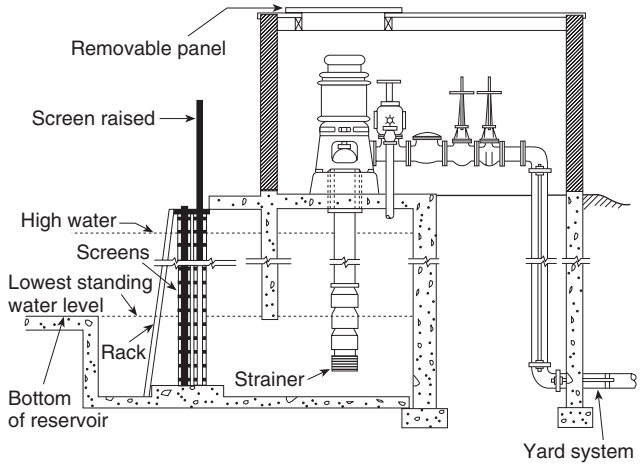
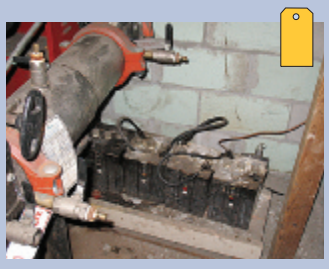


FIGURE A.8.2.2 *Wet Pit Suction Screen Installation.*

System Tagging

The batteries shown in the first photo are showing early signs of corrosion. The batteries are not at the point of failure and not corroded to the point where the system will not work; however, they are in need of some maintenance. In these instances, inspectors might consider this observed condition to be a noncritical deficiency.

The terminal on the battery shown in this next photo is severely corroded, which would be considered a critical deficiency. Many facility managers who conduct inspections would simply clean the terminal when they observed this condition; however, it is important to keep in mind that not all individuals conducting NFPA 25 inspections have the authority to engage in maintenance or to correct any observed conditions. The final photo shows a new battery with clean terminals.







Noncritical Deficiency

Critical Deficiency

Impairment

(Courtesy of Byron Blake and SimplexGrinnell)

ITM Deficiency, Impairment, or Hazard Evaluation?



(Courtesy of Indonesian Fire and Rescue Foundation)

ANSWER: Hazard Evaluation

This photo shows several installation errors on the suction side of this centrifugal fire pump. NFPA 20 has always prohibited the installation of elbows in the horizontal plane this close to the suction flange, and the suction reducer must be an eccentric type to avoid air pockets. Some might also question the installation of a strainer in the suction piping. The current installation as shown could affect the performance of the pump by introducing trapped air into the casing, likely increasing the maintenance required on the pump due to the uneven wear on bearings, sleeves, and other internal parts. However, with all of these apparent problems, these are not NFPA 25 deficiencies or impairments.

While the NFPA 25 inspector is required to inspect the system and identify any issues that would impair the system from functioning properly, the inspector is not required to verify the adequacy of the design of the system, as stated in 1.1.3.1. It is unusual for an NFPA document to state that the inspector is required to test the system but does not need to fully understand all aspects of the system, such as the system's design. However, some users of this document believe inspectors should know the design and installation requirements for every system covered by NFPA 25, as well. The NFPA 25 technical committee recognizes that no one can possibly know all of the design and installation requirements for all of the different editions of all of the water-based fire protection system installation documents.

A.8.2.2(5) Visual indicators other than pilot lights can be used for the same purpose.

8.3* Testing.

A.8.3 The purpose of testing the pump assembly is to ensure automatic or manual operation upon demand and continuous delivery of the required system output. An additional purpose is to detect deficiencies of the pump assembly not evident by inspection.

8.3.1 Frequency.

The weekly testing requirement in 8.3.1 has generated significant discussion in the fire protection industry over the years. Weekly testing of fire pumps can be costly due to the time required. Many owners do not have qualified personnel and must contract the tests to a qualified contractor or service provider, which can cost $5,000 to $10,000 or more annually. Electricity and diesel fuel are expensive and further add to the costs. In addition, it is difficult to apply a one-size-fits-all approach to testing such a critical piece of equipment given all the possible configurations of the equipment and the various controllers. For this reason, the standard permits a performance-based testing schedule beyond the weekly frequency recommended that is subject to approval by the authority having jurisdiction (AHJ). Performance-based testing requires a review of the historical data for the particular system to determine what should be the appropriate performance-based test frequency.

Historical Note

The decision made by the technical committee to reduce the frequency of the no-flow test for electric motor-driven fire pumps from weekly to monthly in the 2011 edition of NFPA 25 came after significant review and discussion of data presented by owners and maintainers of large numbers of fire pumps. The data submitted appeared to indicate that a change to monthly testing from weekly testing of electric motor–driven fire pumps had no significant change in the failure rates with these types of pumps and drivers. However, there was no substantive data to justify reducing the testing frequency for diesel engine–driven pumps.

8.3.1.1* A no-flow test shall be conducted for diesel engine–driven fire pumps on a test frequency in accordance with 8.3.1.1.1 or 8.3.1.1.2.

A.8.3.1.1 Fire pump systems conforming to the 1999 and more recent editions of NFPA 20 should be designed so that the pressure relief valve has a minimum flow (to verify pressure relief valve is properly set and operating) at churn and only allows a larger flow under abnormal conditions (i.e., engine overspeed or failure of a variable speed pressure limiting control). In situations where the discharge from the relief valve is piped back to the pump suction, the fire pump imparts more energy into the water when recirculating the water through the pump than when the pump is operating at churn (no flow). Since the 1999 edition of NFPA 20 a circulation relief valve has been required downstream of the pressure relief valve whenever the pressure relief valve is piped back to the pump suction. Improperly installed and/or operating circulation relief valves can result in unacceptably high water temperature, especially when recirculating the water to the pump suction. High water temperatures can affect the operation of a diesel engine drive. Modern engines, due to EPA requirements, are more sensitive to cooling water temperatures. For fire pump systems conforming to editions of NFPA 20 prior to 1999 that were installed with a pressure relief valve piped back to suction without a circulation relief valve installed downstream of the pressure relief valve, installation of a circulation relief valve is needed. The test can be conducted without a circulation relief valve by taking suction

and discharge pressure gauge readings quickly while there is no flow into the fire protection system, then creating a small flow by opening an inspector's test connection, alarm bypass or main drain downstream of the pump to prevent the pump from overheating during the rest of the test. However, if the first pump starts while it is unattended without water flowing into the fire protection system, it is likely to be damaged.

8.3.1.1.1 Except as permitted in 8.3.1.1.2, a weekly test frequency shall be required.

Exhibit 8.34 shows a nonmandatory sample form that can be used to document the weekly operating test required by 8.3.1.1.1.

8.3.1.1.2* The test frequency shall be permitted to be established by an approved risk analysis.

The data collected as part of the Fire Protection Research Foundation (FPRF) project concluded that diesel pumps were more than 99 percent effective when tested weekly, compared to only 96 percent effective when tested monthly. The data showed that diesel pumps were not quite as effective as electric-driven pumps when tested on a monthly basis; this prompted the technical committee to keep the baseline requirement for operating tests of diesel fire pumps at a weekly frequency. The data reviewed did show that some pumps were still highly effective when tested monthly. As a result, NFPA 25 allows for an approved risk analysis to be used as a mechanism for modifying the frequency to allow for a monthly test or some other frequency supported by the analysis.

A.8.3.1.1.2 The risk analysis should be prepared and reviewed by qualified people. Increased test frequencies might be desirable when high impact losses could result from an uncontrolled fire. Examples where increased fire pump test frequencies can be considered could include high piled storage facilities and buildings where the predominant occupancy is protected by an extra hazard density sprinkler system.

Test frequency has been a heavily discussed and researched topic for several years, and is still continuing to be researched. A set of data was submitted in 2008 by a group of owners and maintainers of large numbers of fire pumps. This data was presented to the committee as indicating a decreased test frequency on electric fire pumps did not "significantly" impact "reliability"; however, "reliability" as used in the discussion of the data presentation was actually the failure rate, and did not take into account the effect of test frequency on the fire pump reliability (i.e., the time between failure and discovery of the failure affects reliability). Subsequently, the NFPA Research Council commissioned research, and the resultant "Fire Pump Field Data Collection and Analysis Report" in 2011 (available for download at www.nfpa.org/Foundation) reported that electric fire pumps tested weekly had a failure rate of approximately 0.64 per year. Assuming a failure rate independent of the test frequency, and assuming that on the average the impairment occurs at the midpoint of the test interval, this failure rate provides approximately 99.4 percent reliability with weekly testing and approximately 97.3 percent reliability with monthly testing. Diesel engine fire pumps tested weekly had a failure rate of approximately 1.02 per year. Assuming a failure rate independent of the test frequency and assuming that on the average the impairment occurs at the midpoint of the test interval, this failure rate provides approximately 99.1 percent reliability with weekly testing and approximately 96.0 percent reliability with monthly testing.

Based on this data, the lower reliability has not been determined to be acceptable for all facilities. Decisions to decrease test frequency must be based on more than cost savings. A reliability/risk analysis to decrease test frequency should take into account the risk associated with life safety, property values, hazards, and business interruption at the protected property. Fire pump redundancy can impact overall fire system reliability and be used in a reliability/risk analysis.

8.3.1.2* A no-flow test shall be conducted for electric motor–driven fire pumps on a test frequency in accordance with 8.3.1.2.1, 8.3.1.2.2, 8.3.1.2.3, or 8.3.1.2.4.

FIRE PUMP WEEKLY OPERATING TESTS

Property Name: _____ **Inspector:** _____

Property Address: _____ **Contract No.:** _____

Property Phone Number: _____ **Date:** _____

Inspections: Weekly

			Pump Systems
❑ Yes	❑ No	❑ N/A	Record pump starting pressure _____ psi
❑ Yes	❑ No	❑ N/A	Operate fire pump for 10 minutes (30 minutes for diesel pump)
❑ Yes	❑ No	❑ N/A	Check packing gland tightness (slight leak at no flow)
❑ Yes	❑ No	❑ N/A	Record suction pressure from gauge in _____ psi
❑ Yes	❑ No	❑ N/A	Record discharge pressure from gauge in _____ psi
❑ Yes	❑ No	❑ N/A	Adjust gland nuts if necessary
❑ Yes	❑ No	❑ N/A	Check for unusual noise or vibration
❑ Yes	❑ No	❑ N/A	Check packing boxes, bearings, or pump casing for overheating
❑ Yes	❑ No	❑ N/A	Record pressure switch or pressure transducer and compare with pump discharge gauge
❑ Yes	❑ No	❑ N/A	Record pumps highest _____ psi and lowest _____ psi pressure on the fire pump control log
❑ Yes	❑ No	❑ N/A	Circulation relief valve functions correctly
❑ Yes	❑ No	❑ N/A	Check fuel system solenoids for proper operation (Alternative ITM A.8.1.1.2)
❑ Yes	❑ No	❑ N/A	Check tank float switch for proper operation (Alternative ITM A.8.1.1.2)
			Electrical Systems
❑ Yes	❑ No	❑ N/A	Record time controller is on first step (for reduced voltage or reduced current starting)
❑ Yes	❑ No	❑ N/A	Observe time for motor to accelerate to full speed
❑ Yes	❑ No	❑ N/A	Record time pump runs after starting for pumps having automatic stop feature
			Diesel Engine Systems
❑ Yes	❑ No	❑ N/A	Record time for diesel engine to crank
❑ Yes	❑ No	❑ N/A	Record time for diesel engine to reach running speed
❑ Yes	❑ No	❑ N/A	Check oil pressure gauge, speed indicator and water and oil temperatures while engine is running
❑ Yes	❑ No	❑ N/A	Check heat exchanger for cooling water flow
❑ Yes	❑ No	❑ N/A	Operate speed governor (internal combustion engine only)
			Steam System
❑ Yes	❑ No	❑ N/A	Observe the time for turbine to reach running speed
❑ Yes	❑ No	❑ N/A	Record steam pressure for steam-operated pumps
❑ Yes	❑ No	❑ N/A	Check steam trap
❑ Yes	❑ No	❑ N/A	Check steam relief valve

Record any notes that the inspector believes to be significant in the corresponding action's comments field.

NFPA 25 Handbook (p. 1 of 2)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT 8.34 *Sample Form for Fire Pumps Weekly Operating Tests.*

FIRE PUMP WEEKLY OPERATING TESTS (Continued)

Comments

Signature: _____ Date: _____

Contractor Name: _____

Contractor Address: _____

License/Certification No.: _____

Controller: Work shall be completed, to the extent that such work can be completed without opening an energized electric motor-driven fire pump controller.

NFPA 25 Handbook (p. 2 of 2)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT 8.34 *Continued.*

A.8.3.1.2 For pressure relief valve operation, see 8.3.1.1.

8.3.1.2.1 Except as permitted in 8.3.1.2.2 and 8.3.1.2.3, a weekly test frequency shall be required for the following electric fire pumps:

(1) Fire pumps that serve fire protection systems in buildings that are beyond the pumping capacity of the fire department
(2) Fire pumps with limited service controllers
(3) Vertical turbine fire pumps
(4) Fire pumps taking suction from ground level tanks or a water source that does not provide sufficient pressure to be of material value without the pump

8.3.1.2.2 A monthly test frequency shall be permitted for electric fire pumps not identified in 8.3.1.2.1.

Historical Note

In the 2014 edition of NFPA 25, the generic monthly testing frequency for electric fire pumps was moved back to weekly testing for certain electric fire pumps. The majority of electric-driven fire pumps are still required to have a monthly operating test, which is consistent with the modification first made in the 2011 edition. This change was based on a review of results from a 2012 report, "Fire Pump Field Data Collection and Analysis," prepared by the Fire Protection Research Foundation (FPRF). This project aimed to identify, collect, and analyze available data to validate, or revalidate, optimum testing frequency for fire pumps.

Several companies that assisted in the project provided a total of 32 data sets with 3396 non-flow tests on 79 fire pumps using pass/fail criteria forms only. A total of 112 failures were reported in these tests. One company provided a total of 6 data sets with 749 non-flow tests on 17 fire pumps using pass/fail/repair forms. A total of 20 pumps needing repairs and 29 failures were reported in these tests. Comments regarding maintenance issues that do not directly affect the fire pump starting and operating were recorded on 122 tests. Additionally, one company provided electronic records in a different format on 983 tests on 41 fire pumps. A total of 103 tests identified repairs were needed, and 11 failures were reported.

The sample size for non-flow weekly testing was deemed adequate to provide a meaningful fire pump failure rate range with 95 percent confidence. For electric motor pumps, there were 19 failures in 1547 tests, for a failure rate of 1.23 percent and a 95 percent confidence in a failure range between 0.67 percent and 1.79 percent. For diesel engine pumps, there were 98 failures in 4855 tests, for a failure rate of 2.02 percent and a 95 percent confidence in a failure range between 1.61 percent and 2.42 percent. When electric motor and diesel engine pump data are combined, there are 117 failures in 6402 tests, for a failure rate of 1.83 percent, a standard deviation of 0.17 percent, and a 95 percent confidence in a failure range between 1.49 percent and 2.16 percent. The sample size for no-flow monthly testing provided a 95 percent confidence failure range of between 0 percent and 7.9 percent for monthly testing, which does not allow meaningful analysis of the monthly test data.

The data solidly justified re-establishing a weekly test requirement for specific electric fire pumps listed in 8.3.1.2.1.

8.3.1.2.3* A monthly test frequency shall be permitted for electric fire pump systems having a redundant fire pump.

A.8.3.1.2.3 For systems where multiple fire pumps are required to meet the system demand, a one-for-one redundancy is not necessary (i.e., one backup pump for two or more primary pumps meets the intent of this section).

8.3.1.2.4* The test frequency shall be permitted to be established by an approved risk analysis.

Not unlike the diesel operating pump test described above, the frequency for an electric-driven pump operating test can also be modified based on a risk analysis.

A.8.3.1.2.4 The risk analysis should be prepared and reviewed by qualified people. Increased test frequencies can be desirable when high impact losses could result from an uncontrolled fire. Examples where increased fire pump test frequencies can be considered could include high piled storage facilities and buildings where the predominant occupancy is protected by an extra hazard density sprinkler system.

Testing Procedure Alert

One of the most controversial topics in the ITM industry over the past few years is determining the appropriate operating test frequency for fire pumps. Irrespective of what the appropriate frequency is, it is important that the building owner, the facility manager, or the inspector understands how to conduct this no-flow test. The testing procedures vary depending on whether the pump is electric driven or diesel driven. Procedures for each of these pump types are provided at the end of this chapter.

8.3.1.3 An annual flow test shall be conducted in accordance with 8.3.3.

8.3.2 No-Flow Test.

8.3.2.1 A no-flow test of fire pump assemblies shall be conducted in accordance with 8.3.2.

FAQ Is it an acceptable procedure to crack open a test header valve to provide enough water flow to keep the pump casing cool?

The reason that 8.3.2.1 references the associated test "without flowing water" is to indicate that it is not the intent of the standard to require a flow test on a weekly basis. Paragraph 8.3.2.1 is intended to verify that the pump will start and will not overheat. Paragraph 8.3.2.5 allows the circulation relief valve to open to flow water as a cooling measure. Allowing additional water flow to prevent overheating is not a requirement of the standard. Flow from the circulation relief valve should be sufficient to prevent overheating of the pump, and the flowing of additional water is a waste and should be avoided.

8.3.2.1.1 Except as permitted in 8.3.2.1.2 and 8.3.2.1.3, a main pressure relief valve (where installed) shall be permitted to weep but not discharge a significant quantity of water.

8.3.2.1.1.1 Except as required in 8.3.2.1.1.2, the circulation relief valve shall discharge a small flow of water.

8.3.2.1.1.2 The circulation relief valve shall not operate when the flow through the main pressure relief valve is greater than weeping.

8.3.2.1.2 For fire pump installations that were installed under a standard (1993 and earlier editions of NFPA 20) that did not prohibit a design that required operation of a pressure relief valve to keep the discharge pressure below the rating of the system components, the pressure relief valve shall be permitted to operate as designed during a no-flow test.

8.3.2.1.2.1* The pressure readings on the discharge and suction gauges shall be recorded, and a pressure difference that is greater than 95 percent of the rated pump pressure shall be investigated and corrected.

A.8.3.2.1.2.1.1 An excessive pressure differential might indicate that the pressure relief valve is wide open and not properly regulating the pressure. Excessively high flow rates through the pressure relief valve can cause failure of the fire protection system and can overload a diesel engine drive and result in destruction of the engine.

8.3.2.1.2.2* The discharge temperature of the water shall be monitored and the pump shut down if necessary to prevent exposing the pump and/or driver to excessive temperatures.

A.8.3.2.1.2.2.2 High water temperatures can cause diesel engines to overheat and fail.

8.3.2.1.3 For positive displacement pumps, the pressure relief valve shall operate during a no-flow test.

8.3.2.1.3.1 Where the pressure relief valve is piped back to suction, the pump circulation relief valve shall not operate.

8.3.2.1.3.2 On electric motor and radiator cooled engine drives, a circulation pressure relief valve located downstream of the main pressure relief valve shall discharge sufficient water to prevent overheating of the pump.

8.3.2.2 The test shall be conducted by starting the pump automatically.

FAQ What is meant by an automatic start?

Paragraph 8.3.2.2 requires that pumps be started automatically, rather than by the use of the "start" button on the front panel of the fire pump controller. The pump must be started by drawing water from the sensing line to simulate a pressure drop in the system. As the pressure drops, the pressure switch (see Exhibit 8.14) will sense this drop in pressure and should start the pump automatically. Using the start button on the fire pump controller does not constitute an automatic start.

Exhibit 8.35 shows a pressure-sensing line connection that can be used to draw water to simulate a pressure drop in the pressure-sensing line. This pressure drop should cause the jockey pump, and ultimately the fire pump, to start automatically.

8.3.2.3 The electric pump shall run a minimum of 10 minutes.

When a pump is started, a great deal of heat is generated in the pump windings from the energy needed to bring the pump up to speed. Paragraph 8.3.2.3 requires that the electric motor run for 10 minutes, which is seen as the minimum time for the motor windings to cool back down after starting. Repeatedly starting and running a motor-driven fire pump for less than 10 minutes each time it is started could significantly shorten the motor's life span.

Another reason for the 10-minute requirement is that it allows time to check the pump packing and bearings to determine if they are overheating or leaking excessively. It is important to inspect the pump bearings, as failed bearings can lead to larger issues. Exhibit 8.36 shows an impeller that was destroyed due to the outboard bearing failing, which caused the impeller to come into contact with the pump casing.

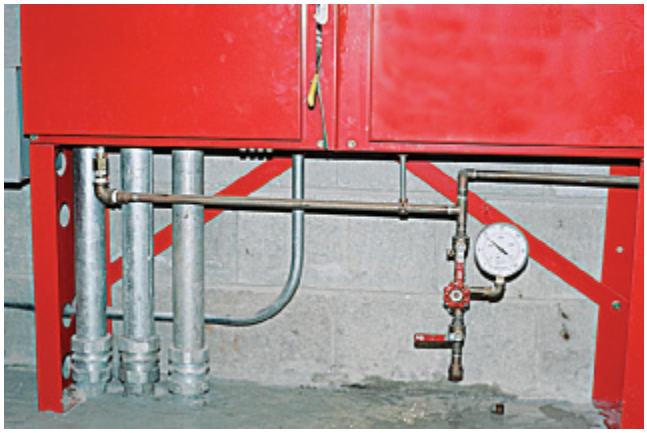


EXHIBIT 8.35 *Pressure-Sensing Line.*



EXHIBIT 8.36 *Impeller Failure Due to Failed Bearing. (Courtesy of Damon Pietraz, Underwood Fire Equipment)*

Exhibit 8.37 shows a stone in the impeller of a fire pump. The stone was revealed by weekly testing.



EXHIBIT 8.37 *Some Faults Found in Testing: Stone in Impeller (left) and Size of Stone (right). (Courtesy of John Jensen)*

8.3.2.4 The diesel pump shall run a minimum of 30 minutes.

FAQ Why does NFPA 25 require the diesel pump to be run at churn for 30 minutes each week?

Paragraph 8.3.2.4 requires that a diesel fire pump operate for 30 minutes each week. This requirement is intended to allow the pump and driver to reach operating temperature, which is the point most experts agree that overheating problems can be detected. The 30-minute operating time is also intended to consume enough fuel to prevent the fuel from stagnating. Running the driver long enough to get up to rated temperature also helps prevent wet stacking. Wet stacking is a condition where unburned fuel residue collects in diesel engine cylinders and exhaust. Over a prolonged period, this buildup can seriously degrade engine performance, increase fuel consumption, and ultimately cause engine failure. Exhibit 8.38 shows a diesel engine that has failed due to excess exhaust pressure.

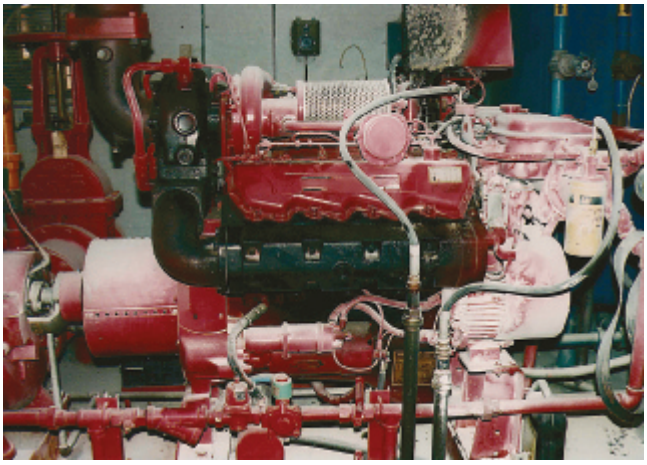


EXHIBIT 8.38 *Engine Failure Due to Excessive Exhaust Pressure. (Courtesy of Damon Pietraz, Underwood Fire Equipment)*

8.3.2.5 A valve installed to open as a safety feature shall be permitted to discharge water.

The following are three types of valves that might be found in a pump room that are designed to open as a safety feature that discharges water:

- Circulating (automatic) relief valve, for cooling electric-driven pump casings
- Pressure relief valve (sometimes called the "main" relief valve), for preventing system overpressurization
- Heat exchanger cooling line automatic valve, on diesel drivers

During a weekly test, all three valves, if installed, must be verified to be operational, but the valve primarily referred to in 8.3.2.5 is the pressure (or "main") relief valve (see Exhibit 13.32). This valve is installed to limit overpressurization on the system downstream of the pump. It is important that this valve be set so that it discharges water only at or above the rating of the piping downstream of the pump. This valve, if present, should cause water to discharge while the pump is operating at churn, meaning that water will be discharging for 30 minutes each week. However, this can be controlled by adjusting valve trim settings to allow only a small flow. A common complaint about 30-minute weekly runs is the amount of water wasted when the valve is open, which if adjusted incorrectly, could total more than 500 gpm (1893 L/min) for the 30-minute weekly run. There are also provisions, which did not exist in previous editions, to allow this valve to be piped back to a suction water source for water conservation.

8.3.2.6 An automatic timer that meets 8.3.2.6.1 through 8.3.2.6.3 shall be permitted to be substituted for the starting procedure.

The requirements in 8.3.2.6 address the acceptable methods used for pump tests. These do not intend to supersede the requirement in 8.3.2.7 that someone must be present and watching the pump system each time it operates.

8.3.2.6.1 A solenoid valve drain on the pressure control line shall be the initiating means for a pressure-actuated controller.

8.3.2.6.2 In a pressure-actuated controller, performance of this program timer shall be recorded as a pressure drop indication on the pressure recorder.

8.3.2.6.3 In a non-pressure-actuated controller, the test shall be permitted to be initiated by means other than a solenoid valve.

8.3.2.7 Qualified personnel shall be in attendance whenever the pump is in operation unless automated inspection and testing is performed in accordance with 8.3.2.10 including the provision for automated engine shutdown indicated in 8.3.2.10.3 for diesel engine drives.

With advancements in technology, the possibility of performing required fire pump testing from a remote location has become much more prevalent. If an issue does arise while performing a remote inspection or test, 8.3.2.7 mandates that the requirements of 8.3.2.10 be in place. Paragraph 8.3.2.10 has been added to the 2020 edition and covers remotely monitored automated testing. The most important requirement of 8.3.2.10 is that if an issue is identified, a qualified person must be able to respond to the fire pump location within 5 minutes.

8.3.2.7.1* The use of the automatic timer allowed in 8.3.2.6 shall not eliminate the requirement of 8.3.2.7 to have qualified personnel present during the test.

The definition of the term *qualified* is a point of debate in the fire protection community (and in most committees tasked with defining the word). There is disagreement because the word could have several meanings depending on where it is used. For example, a professional

qualified to complete a weekly fire pump test might not be qualified to complete an annual flow test, and analyzing the data from an annual flow test might require someone else's qualification and expertise. Qualified personnel are required by 8.3.2.7 to be in attendance whenever a fire pump is operating, unless automated inspection and testing has been approved. The intent is to have a person present that has the qualifications to know if something visually appears wrong with the fire pump system (such as excessive cooling water temperature, overpressurization, or low oil temperature) and both the ability and authority to quickly address the issue. Automated equipment must be able to identify any issues that would be recognized by having qualified personnel in the pump room. It must be capable of recording the issue and sending notification so that someone can respond to the fire pump room within 5 minutes to investigate or address the issue (see 8.3.2.10.4).

Additionally, some jurisdictions require that anyone who performs fire pump testing be licensed, while others have no licensing requirements whatsoever. Other jurisdictions require different levels of licensure for churn tests versus flow tests. Therefore, in some jurisdictions, facility managers may be able to perform the churn tests without needing a contractor's license or technician certification; however, they may not be able to do the flow test. It is important that whoever does the testing be familiar with the licensing requirements in the jurisdiction.

Often, the presence of qualified personnel is thought to affect the decision of using an automatic timer, not only for starting a fire pump but for automatically shutting it down as well.

Some jurisdictions and insurance companies require that fire pumps only be stopped manually and that the automatic stop relay in the controller be removed or bypassed. This is due to concerns that a fire pump could repeatedly cycle on and off in an actual fire and eventually not restart from an "off" sequence. NFPA 20 allows both an automatic and manual fire pump stop setting, except in cases where a pump constitutes a sole site fire protection water source. In these cases, this standard requires a manual stop only.

A.8.3.2.7.1 An automatic timer allows a person who has been instructed on what to watch for and record during this test to monitor the test and request assistance should any issues arise.

Δ **8.3.2.8** The pertinent visual observations or adjustments specified in the following checklists shall be conducted while the pump is idle:

(1) Record the system suction and discharge pressure gauge readings

The system suction and discharge pressure gauge readings are taken both when the pump is running and when the pump is shut off. For diesel engine–driven pumps, it is recommended that the cooling water pressure be recorded to ensure that the heat exchanger is not being overpressurized due to a failed or improperly adjusted cooling water line pressure regulator.

(2) For pumps that use electronic pressure sensors to control the fire pump operation, record the current pressure and the highest and the lowest pressure shown on the fire pump controller event log where such information is available without having to open an energized electric motor–driven fire pump controller
(3) If the highest or lowest pressure is outside of the expected range, record all information from the event log that helps identify the abnormality

8.3.2.9* The pertinent visual observations or adjustments specified in the following checklists shall be conducted while the pump is running:

(1) Pump system procedure is as follows:
    (a) Record the pump starting pressure from the pressure switch or pressure transducer.
    (b) Record the system suction and discharge pressure gauge readings.
    (c) Inspect the pump packing glands for slight discharge.

(d) Adjust gland nuts if necessary.
(e) Inspect for unusual noise or vibration.
(f) Inspect packing boxes, bearings, or pump casing for overheating.
(g) Record pressure switch or pressure transducer reading and compare to the pump discharge gauge.
(h) For pumps that use electronic pressure sensors to control the fire pump operation, record the current pressure and the highest and the lowest pressure shown on the fire pump controller event log.
(i) For electric motor and radiator cooled diesel pumps, check the circulation relief valve for operation to discharge water.

(2) Electrical system procedure is as follows:
(a) Observe the time for motor to accelerate to full speed.
(b) Record the time controller is on first step (for reduced voltage or reduced current starting).
(c) Record the time pump runs after starting (for automatic stop controllers).

(3) Diesel engine system procedure is as follows:
(a) Observe the time for engine to crank.

The engine controller on diesel-driven pump systems will alternate battery supplies with each attempt-to-start sequence. There should be a pilot light on the controller that indicates which bank of batteries is being used for the present start cycle. If the engine is difficult to start, the cause should be investigated; maintenance or repair may be necessary to correct the problem. Excessive cranking time causes the batteries to discharge, and delays in the engine starting sequence can affect the delivery of needed water or liquids to the fire protection system.

(b) Observe the time for engine to reach running speed.



EXHIBIT 8.39 *Handheld Tachometer Used to Measure Motor Speed in rpm. (Courtesy of BC Group International)*

The engine should come up to speed within 10 seconds by NFPA 20 requirements. A tachometer is required instrumentation on a listed diesel fire pump driver, but handheld units, such as the one shown in Exhibit 8.39, are often used as a means for measuring engine running speed and are typically more accurate. The property owner is not required to furnish handheld tachometers to service personnel working in the building.

(c) Observe the engine oil pressure gauge, speed indicator, water, and oil temperature indicators periodically while engine is running.
(d) Record any abnormalities.

Abnormalities that should be recorded include excessively low or high driver speed, low oil pressure, high temperature, high cooling water pressure for diesel engines using discharge water for cooling, leaking hoses, or strange vibrations. The weekly checklist should have a location to record these items and, more importantly, an active management system to note and address discrepancies immediately. Identification of abnormalities can help resolve pump issues at the incipient stages. If these items are not identified early, it could lead to a major failure. This highlights the need to have qualified individuals engaged in the ITM process.

(e) Inspect the heat exchanger for cooling waterflow.

Radiator-cooled fire pump drivers are rarely used, and they are typically used only in locations where water is highly restricted. Such pumps do not have a connection off the pump for a heat exchanger, due to the radiator. (See Exhibit 8.40.)

Heat exchangers typically discharge into an open drain in the pump room or to an outside location, in which case there should also be a sight glass or pressure gauge inside the

pump room so the water flow can be observed directly. There should not be any antifreeze or discoloration in the heat exchanger water discharge when visually observed.



EXHIBIT 8.40 *Fire Pump Driver with Radiator.*

(4) Steam system procedure is as follows:
   (a) Record the steam pressure gauge reading.
   (b) Observe the time for turbine to reach running speed.

A.8.3.2.9 See Table A.8.3.2.9.

TABLE A.8.3.2.9 *Observations — While Pumping*

Item	*While Pump Is Operating*
Horizontal pumps	1. Read suction and discharge gauges — difference between these readings indicates churn pressure, which should match churn pressure as shown on fire pump nameplate. 2. Observe packing glands for proper leakage for cooling of packing. 3. Observe discharge from casing relief valve — adequate flow keeps pump case from overheating.
Vertical pumps	1. Read discharge gauge — add distance to water level in feet (or meters) and divide by 2.31 to compute psi (30.47 to compute bar). This total must match churn pressure as shown on fire pump nameplate. 2. Observe packing glands for proper leakage for cooling of packing. 3. Observe discharge from casing relief valve — adequate flow keeps pump case from overheating.
Diesel engines	1. Observe discharge of cooling water from heat exchanger — if not adequate, inspect strainer in cooling system for obstructions. If still not adequate, adjust pressure-reducing valve for correct flow. 2. Inspect engine instrument panel for correct speed, oil pressure, water temperature, and ammeter charging rate. 3. Inspect battery terminal connections for corrosion and clean if necessary. 4. After pump has stopped running, inspect intake screens, if provided; replace diesel system pressure recorder chart; and rewind if necessary.

While the pump is running, observations that include the items listed in Table A.8.3.2.9 should be made and a record of the test prepared. Exhibit 8.41 shows operating personnel recording test data during the weekly test. The weekly checklist should have a location to record these items and, more importantly, an active management system to note and address discrepancies in a timely manner.

EXHIBIT 8.41 *Weekly Test.*



N **8.3.2.10 Remotely Monitored Automated Testing.** The requirements of 8.3.2.10 are new to the 2020 edition and have been added to specifically address automated testing, as it relates to fire pumps. For the general requirements on automated inspections and testing, see Chapter 4. These requirements ensure that the automated tests provide the same outcome as having a qualified person in the fire pump room performing the tests and recording the information.

N **8.3.2.10.1** Remotely monitored automated testing performed in accordance with 4.6.6 shall be permitted for the no-flow test.

N **8.3.2.10.2** All of the pertinent observations or adjustments specified in the checklists described in 8.3.2.8 and 8.3.2.9 shall be performed.

N **8.3.2.10.2.1** Any abnormalities shall be recorded.

N **8.3.2.10.2.2** If, during the automated test, it becomes apparent that the packing gland nuts need to be adjusted as described in 8.3.2.9(1)(d), the need for adjustment shall be recorded and the necessary adjustment shall be made by qualified personnel.

N **8.3.2.10.3** The controller for a diesel engine–driven fire pump shall be equipped with automatic engine shutdown as referenced in 12.7.2.7 of NFPA 20.

N **8.3.2.10.4** Qualified personnel shall be able to respond to the pump location upon abnormal condition within 5 minutes.

8.3.3 Annual Flow Testing.

8.3.3.1* Except as permitted in 8.3.3.4, an annual test of each constant speed pump assembly shall be conducted by qualified personnel under no-flow (churn), rated flow, and 150 percent of the pump rated capacity flow of the fire pump by controlling the quantity of water discharged through approved test devices.

It is specifically required that the annual flow test be conducted by qualified personnel. The definition of the term *qualified* is a point of debate in the fire protection community (and in most committees tasked with defining the word). There is disagreement because the term could have several meanings depending on where it is used. For example, a professional qualified to complete a weekly fire pump churn test might not be qualified to complete an annual flow test. Additionally, analyzing the data from an annual flow test might require someone else's qualification and expertise. See Supplement 1 for annual pump test requirements and the required analysis.

In most instances, annual testing requires the owner to contract with a service provider or contractor to conduct the test. In some jurisdictions, a licensed contractor is required to conduct the test. The annual flow test generally follows the same procedure as was used for the original acceptance test.

During the flow test, a minimum of the following three points must be measured and plotted on graph paper:

1. *Pump churn.* The no-flow condition, sometimes called shutoff or churn, is the point where water is not flowing through test apparatus of play pipes. The normal water flowing at churn is restricted to diesel engine cooling water, casing relief, and/or the main relief valve.
2. *Rated capacity.* The rated capacity is the volume of water at the pressure indicated on the pump nameplate.
3. *Overload.* The overload test point is where the pump discharge is flowed to 150 percent of rated capacity flow. At this point, pressure is measured and should meet the rated pressure stamped on the pump nameplate or manufacturer's pump curve.

Exhibit 8.42 illustrates the annual test at churn. In this example, calibrated test gauges have been installed. Exhibit 8.43 shows measuring flow at rated capacity. Exhibit 8.44 illustrates the annual test at overload. A difference can be observed in the quantity of water of the annual test at overload versus rated capacity (from Exhibit 8.43).

Testing Procedure Alert

Unlike the no-flow test, there is no controversy associated with the frequency at which the fire pump flow test must be conducted. The annual flow test is an important test because it serves to confirm that the pump's performance has not degraded significantly when compared to the certified shop test curve. For more information on conducting the annual flow test, refer to Supplement 1. It provides an in-depth look at the data analysis associated with determining the pump's performance relative to when it is installed. Also, see the detailed testing procedures at the end of this chapter for guidance on conducting these tests for various arrangements.

A.8.3.3.1 Minimum flow for a pump is the churn pressure.

N **8.3.3.2*** Except as permitted in 8.3.3.4 , an annual test of each variable-speed pump assembly shall be conducted by qualified personnel under variable-speed control under no-flow (churn), 25 percent, 50 percent, 75 percent, 100 percent, 125 percent, and 150 percent of the rated pump capacity flow of the fire pump by controlling the quantity of water discharge through approved test devices.

N **A.8.3.3.2** Unless otherwise specified by the pump manufacturer and the controller manufacturer, two separate tests are required for variable-speed pumps: one test under variable-speed control and one test under constant-speed control. Operation and setting of relief valves that are required for variable-speed pumps should be done in accordance with the requirements of Chapter 13.

N **8.3.3.3** Except as permitted in 8.3.3.4, an annual test of each variable speed pump assembly shall be conducted by qualified personnel under constant speed control under no-flow (churn),

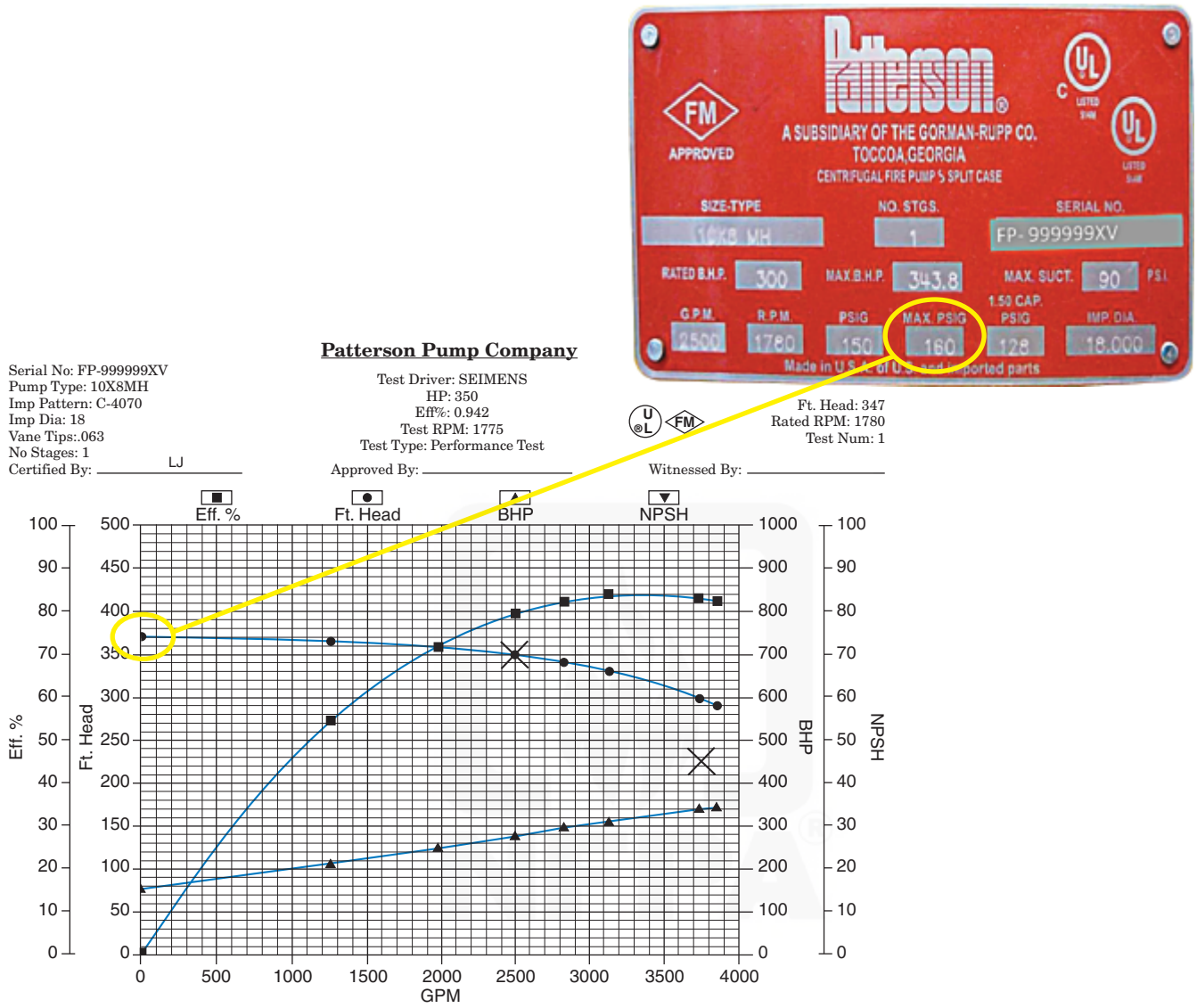


EXHIBIT 8.42 *Annual Test at Churn.*

100 percent rate, and 150 percent of the pump rated capacity flow of the fire pump by controlling the quantity of water discharged through approved test devices.

N **8.3.3.4** If available suction supplies do not allow flowing of 150 percent of the rated pump capacity, the fire pump shall be tested at flow rates at 100 percent of the rated pump flow rate, and at the maximum flow allowed at the lowest permissible suction pressure.

Two reasons a suction supply does not allow for the flow equal to 150 percent of the rated pump capacity are as follows:

1. Drainage in the area around the pump test is not of capacity to allow a continued test.
2. Low fire pump suction pressure drops to a point where discharge flow cannot safely be made to reach 150 percent of rated flow.

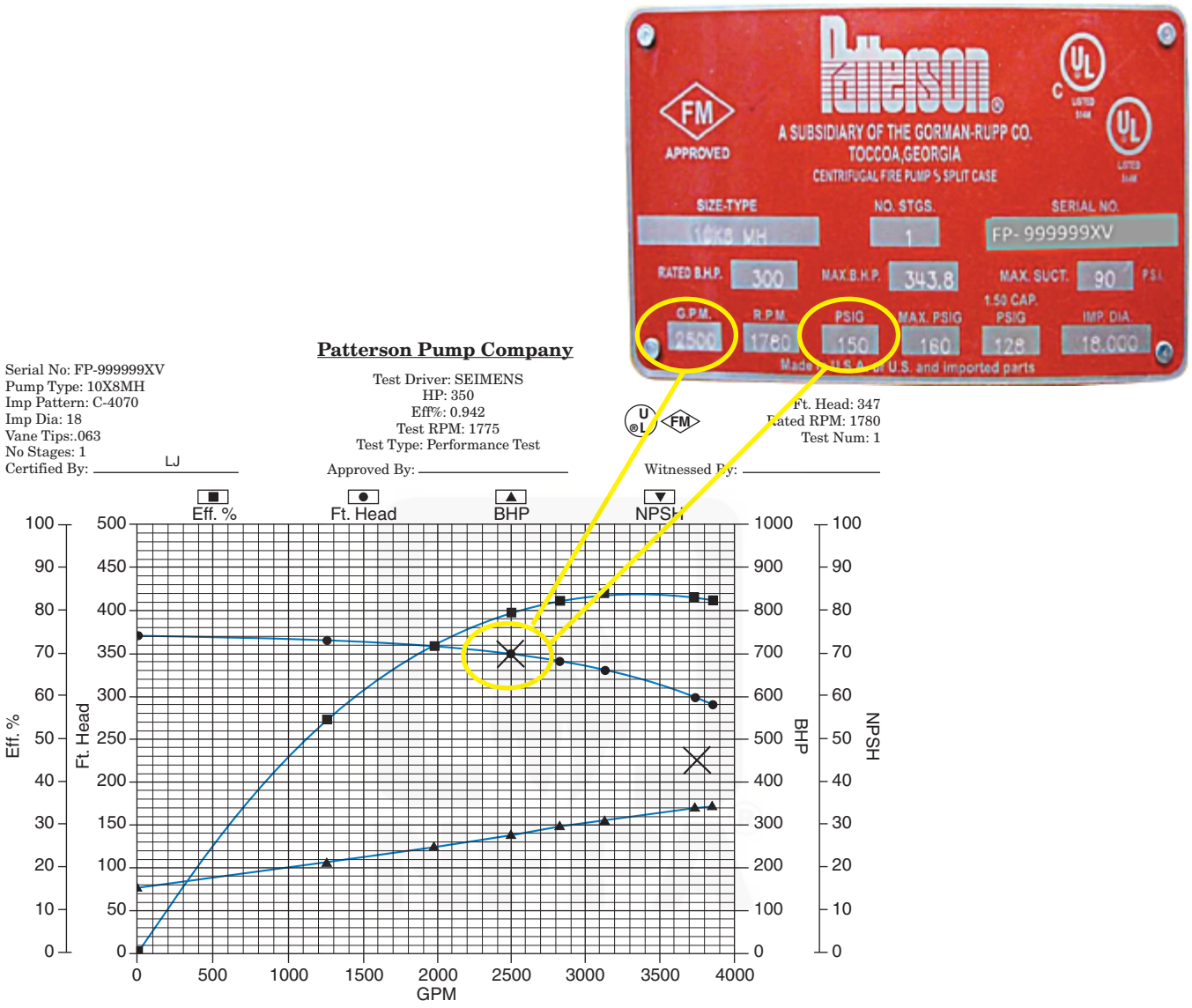


EXHIBIT 8.43 *Discharge from Annual Fire Pump Test at Rated Capacity.*

In case 1, the proper drainage as required by the design standard should be installed, and the test should be completed when the required drainage is in place. Another approach to addressing insufficient drainage is to allow the area to drain between test points, such as testing at the 100 percent point, waiting for water to drain in the area, and then testing at the 150 percent point.

For case 2, when suction pressures drop too low, a test should be stopped and plotted with the data available. In this instance, the points that have been tested (at least three) must be plotted, and some engineering judgment must be used to determine the condition of the pump.

As indicated in 8.1.5, the pressure observed at the suction gauge while the pump is operating should be positive, even when the fire pump is operating at its overload condition. The suction gauge pressure is permitted by NFPA 20 to drop to -3 psi (-0.2 bar) when

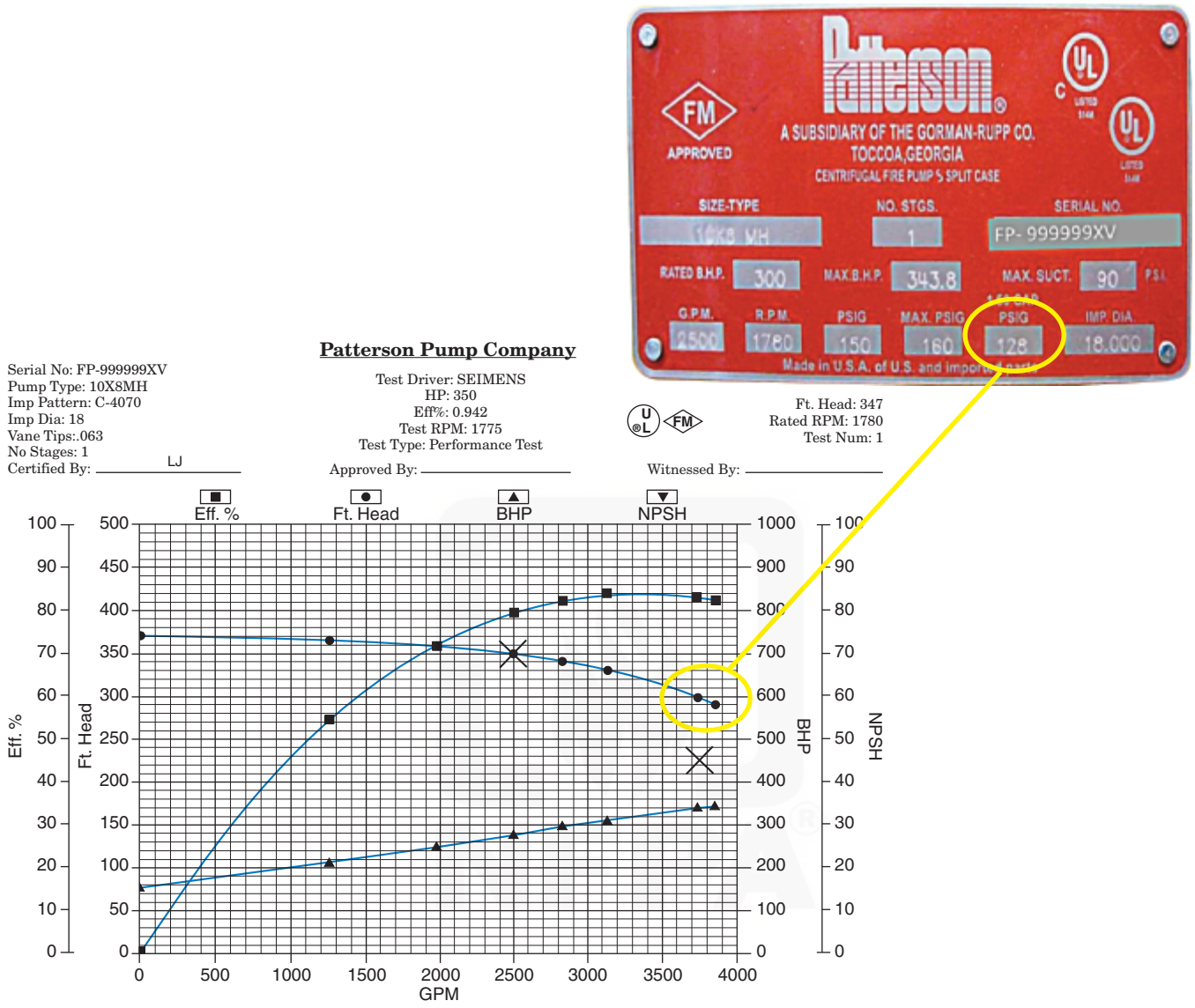


EXHIBIT 8.44 *Discharge from Annual Test at Overload.*

the supply is a suction tank with its base at or above the same elevation as the pump, provided the lowest water tank level and all maximum fire system demands and durations have been acceptably supplied. However, it should also be noted that when taking water from a public water system, most municipal water companies' purveyors limit the residual pressure on the system to 20 psi (1.4 bar) due to concerns of collapsing water mains and drastically increasing water turbidity. But this is generally the minimum required at the city connection. Many times, gauges at the location of a pump test could be 10 psi to 20 psi (0.7 bar to 1.4 bar) above that at the city connection due to such issues as pressure losses across backflow apparatus and numerous valves. Thus, in these cases, an additional pressure gauge should be attached to a hydrant or the city side of the site backflow apparatus and examined so the accurate public water supply pressure can be monitored for compliance with any minimum amounts stipulated by the municipality.

FAQ If a pump test must be stopped early per 8.3.3.4, is it still considered an acceptable test, and can an acceptable annual NFPA 25 test be reported to the local jurisdiction?

To meet the requirements of an acceptable pump test, the criteria in 8.3.7.2.3 must be completed. If a test is stopped early, as allowed per 8.3.3.4, then all that can be determined is how the pump performed along the test curve up to the point that the test was stopped. If the test was stopped close to the 150 percent flow point, engineering judgment — with some extrapolation — could likely be used to indicate if the test was the equivalent of a successful annual test. However, there is a second pump test data analysis requirement in 8.3.7.2.3. The test flow would have to be long enough to allow a complete analysis to confirm there is enough water flow and pressure to supply all connected fire protection systems. If the test could not be made with enough flow to verify that system demands are met, the test cannot be considered complete. A fire pump test report could then only have assumptions based on extrapolations of flow curves and engineering judgment. See Supplement 1 for more information.

8.3.3.5 Test Equipment. Calibrated test equipment shall be provided to determine net pump pressures, rate of flow through the pump, and speed.

Δ **8.3.3.5.1** Gauges, transducers, and other devices used for measurement during the test shall bear a label with the latest date of calibration.

8.3.3.5.2 Gauges, transducers, and other devices, with the exception of flow meters, used for measurement during the test shall be calibrated a minimum of annually to an accuracy level of ±1 percent.

8.3.3.5.3* Flow meters shall be calibrated annually to an accuracy level of ±3 percent.

N **A.8.3.3.5.3** When using a flow meter piped back to suction, the requirement for annual calibration applies to the sensing devices on the flow meter. When the test discharges water downstream of the flow meter, the flow discharge should be measured and used to calibrate the flow meter.

• **8.3.3.6** Discharge and sensing orifices that can be visually observed without disassembling equipment, piping, or valves shall be visually inspected and be free of damage and obstructions that could affect the accuracy of the measurement.

8.3.3.7 The sensing/measuring elements in a flow meter shall be calibrated in accordance with 8.3.3.5.

8.3.3.8 Discharge orifices shall be listed or constructed to a recognized standard with a known discharge coefficient.

8.3.3.9 The annual test shall be conducted as follows:

(1) The arrangement described in 8.3.3.9.1 or 8.3.3.9.2 shall be used at a minimum of every third year.
(2)* The arrangement described in 8.3.3.9.3 shall be permitted to be used 2 out of every 3 years.

A.8.3.3.9(2) The method described in 8.3.3.9.3 is not considered as complete as those in 8.3.3.9.1 and 8.3.3.9.2, because it does not test the adequacy of the water supply for compliance with the requirements of 8.1.6 at the suction flange.

When testing fire pumps, the inspector should closely examine beneath the coupling guard for filings, which can indicate a misaligned coupling. When the pump is running, excessive vibration can also be an indication of coupling misalignment.

Testing Procedure Alert

While fire pumps are operated on a weekly or monthly basis as part of the testing required by 8.3.1, those tests do not require the flow of water and are primarily intended to exercise the pump. The annual flow test required by 8.3.3 provides the current flow characteristics and allows for a comparison to the pump's original capabilities. For more information on conducting a flow test, see the testing procedure at the end of this chapter.

8.3.3.9.1 Use of Pump Discharge via Hose Streams.

8.3.3.9.1.1 Pump suction and discharge pressures and the flow measurements of each hose stream shall determine the total pump output.

8.3.3.9.1.2* Prior to flow testing, the entity performing testing shall make the owner or their representative aware of the location, approximate flow rate, and duration of flow testing.

Δ **A.8.3.3.9.1.2** Whether using a play pipe, water diffuser, or other discharge device, damage can be caused by the water stream, or can be caused by inadequate drainage in the area of the discharge

The impact of the test discharge water on the property will vary, depending on the topography of the property. The owner and the contractor administering the test should have an understanding of where the discharge flow will drain and the potential impact on the property, adjacent property, and roadways.

Tip for Owners

The owner should ensure that maintenance personnel or property managers have some input into where test discharge will occur. Those familiar with the property should be able to provide valuable insight to the person conducting the testing as to where discharge flow will drain and what impact that drainage will have on the property and adjacent areas. It may also be necessary for the owner to arrange for areas surrounding the building, including parking lots or other features, to be blocked off for the day of the testing. For more information, see 4.1.1.2.1 and associated commentary.

8.3.3.9.2 Use of Pump Discharge via Bypass Flowmeter to Drain or Suction Reservoir. Pump suction and discharge pressures and the flowmeter measurements shall determine the total pump output.

8.3.3.9.3 Use of Pump Discharge via Bypass Flowmeter to Pump Suction (Closed-Loop Metering).

8.3.3.9.3.1 Pump suction and discharge pressures and the flowmeter measurements shall determine the total pump output.

8.3.3.9.3.2 When testing includes recirculating water back to the fire pump suction, the temperature of the recirculating water shall be monitored to verify that it remains below temperatures that could result in equipment damage as defined by the pump and engine manufacturers.

8.3.3.9.3.3 If the test results are not consistent with the previous annual test, the test shall be repeated using the test arrangement described in 8.3.3.9.1.

Flowmeters are used only once a year and, as a result, must be adjusted and calibrated prior to conducting the annual flow test. If a test using a flowmeter shows a material deviation from the previous year's test, the pump is required to be retested using hose streams.

8.3.3.9.3.4 If testing in accordance with 8.3.3.9.1 is not possible, a flowmeter calibration shall be performed and the test shall be repeated.

Δ **8.3.3.10** The pertinent visual observations, measurements, and adjustments specified in the following checklists shall be conducted annually while the pump is running and flowing water under the specified output condition:

(1) At no-flow condition (churn), the procedure is as follows:
   (a) Inspect the circulation relief valve for operation to discharge water

The circulation relief valve opens when the pump is running to allow a small amount of water to discharge, usually into a drain box or outside the pump room. The intent is to allow water to enter the pump casing for cooling purposes. Circulation relief valves are usually pressure operated (i.e., spring-loaded) and can fail easily when a small amount of obstructing material or corrosion enters the valve. The circulation relief valve should be set to open at the pump-rated pressure.

(b) Inspect the pressure relief valve (if installed) for proper operation

Under certain installation conditions, a main or pressure relief valve is used to maintain the system pressure below the maximum system rated pressure, which is usually 175 psi (12.1 bar). If a diesel engine reaches a runaway or overspeed condition, this valve is used in case a speed governor fails to control the pressure. The overspeed governor is set at 120 percent of rated engine speed. Using the pump affinity laws, the formula to determine the overspeed governor setting is as follows:

$$H_1 = H_2 \frac{N_1^2}{N_2}$$

where:

H_1 = Head at test speed (ft or m)

H_2 = Head at rated speed (ft or m)

N_1 = Test speed (rpm)

N_2 = Rated speed (rpm)

For example, a rated speed of 1750 rpm, a rated pressure of 125 psi (8.6 bar), and a test speed of 2100 rpm (1750 rpm × 1.2) gives us the following:

$$H_1 = 125 \frac{2100^2}{1750} = 180 \text{ psi (12.4 bar)}$$

A pressure of 180 psi (12.4 bar) is above the system component rating.

The overspeed governor should be tested annually to make sure it will operate in an emergency situation. For system components rated for 175 psi (12.1 bar), the setting of the main relief valve should be no higher than this pressure.

(2) At each flow condition, the procedure is as follows:

(a) Where an external means is provided on the controller, record the electric motor voltage and current (all lines)

An energized controller should not be opened where there is no external means to read the voltage and current. Issues with voltage and current can be identified through the results of other various fire pump tests that have been performed. If it is determined there is a voltage or current issue and an energized controller must be opened, it should only be done so by someone trained and qualified in electrical hazards and equipped with the necessary safety equipment as outlined in NFPA *70E*.

(b) Record the pump speed in rpm

The pump speed should be recorded using a calibrated strobe tachometer or handheld rpm counter placed on the end of the pump shaft. The newer engine electronic tachometers

are as accurate as any portable unit and are considered adequate for fire pump testing purposes. Electric motors run at their synchronous speed and, unlike diesel engines, their speed will not vary drastically with load.

(c) Record the simultaneous (approximate) readings of pump suction and discharge pressures and pump discharge flow

(3)* For electric motor–driven pumps, do not shut down the pump until it has run for 10 minutes

A.8.3.3.10(3) It is not the intent to discharge water for the full 1-hour test duration, provided all flow tests can be conducted in less time and efforts are taken to prevent the pump from overheating.

(4) For diesel motor–driven pumps, do not shut down the pump until it has run for 30 minutes

8.3.3.11* For installations having a pressure relief valve, the operation of the relief valve shall be closely observed during each flow condition to determine whether the pump discharge pressure exceeds the normal operating pressure of the system components.

The pressure setting of the pressure relief valve must be set at the working pressure of the system, which is usually 175 psi (12.1 bar) or less. When the pressure relief valve is set to open just below the rated pressure of the pipe network, it prevents excessive strain on the system by not allowing the system components to experience pressures in excess of the normal operating pressure.

A.8.3.3.11 A pressure relief valve that opens during a flow condition is discharging water that is not measured by the recording device(s). It can be necessary to temporarily close the pressure relief valve to achieve favorable pump test results. At the conclusion of the pump test, the pressure relief valve must be readjusted to relieve pressures in excess of the normal operating pressure of the system components.

If the pressure relief valve is open during the flowing conditions due to the fact that the pressure is too high for the components in the fire protection system, the discharge control valve should be closed prior to closing the pressure relief valve to make sure that the fire protection system is not overpressurized. After the test, the valve must be opened again.

8.3.3.11.1* The pressure relief valve shall also be observed during each flow condition to determine whether the pressure relief valve closes at the proper pressure.

A.8.3.3.11.1 A pressure relief valve that is open during a flow condition will affect test results.

8.3.3.11.2 The pressure relief valve shall be closed during flow conditions if necessary to achieve minimum rated characteristics for the pump and reset to normal position at the conclusion of the pump test.

8.3.3.11.2.1 When it is necessary to close the relief valve to achieve minimum rated characteristics for the pump, the pump discharge control valve shall be closed if the pump churn pressure exceeds the system rated pressure.

8.3.3.11.3 When pressure relief valves are piped back to the fire pump suction, the temperature of the recirculating water shall be monitored to verify that it remains below temperatures that could result in equipment damage as defined by the pump and engine manufacturers.

Δ **8.3.3.12** For installations having an automatic transfer switch, the following test shall be performed to ensure that the overcurrent protective devices (i.e., fuses or circuit breakers) do not open:

(1) Simulate a power failure condition while the pump is operating at peak load
(2) Verify that the transfer switch transfers power to the alternate power source

(3) While the pump is operating at peak load and alternate power, record the following to include in the pump test results:
   (a) The voltage where an external means is provided on the controller
   (b) The amperage where an external means is provided on the controller
   (c) The rpm
   (d) Suction pressure
   (e) Discharge pressure
(4) Verify that the pump continues to perform at peak horsepower load on the alternate power source for a minimum of 2 minutes
(5) Remove the power failure condition and verify that, after a time delay, the pump is reconnected to the normal power source

8.3.3.13* Alarm conditions shall be simulated by activating alarm circuits at alarm sensor locations and confirmed for proper operation.

Fire pump alarm conditions per NFPA 20 will send a supervisory signal to the fire alarm panel as defined in *NFPA 72®, National Fire Alarm and Signaling Code®*. For fire pump alarm conditions required by 8.3.3.10, immediate local attention is required, but fire department response is not required.

A.8.3.3.13 It is not the intent to verify that all the alarm conditions required by NFPA 20 (e.g., low oil pressure, high coolant temperature, failure of engine to start, engine overspeed) transmit individually to a remote location, as long as these alarms, where provided, can be individually verified at the fire pump controller.

It is not the intent of 8.3.3.13 to verify the presence or lack of these alarm devices, just whether or not they operate correctly if installed.

8.3.3.13.1* Alarm sensors located within electric motor–driven fire pump controllers that cannot be accessed without opening an energized electric motor–driven fire pump controller shall be tested at an alternative location outside of the controller.

Working near electric motor–driven pumps requires licensed or qualified personnel using the appropriate safety equipment, such as gloves, protective clothing, and a face shield. The property owner is not responsible for furnishing this equipment to the service providers performing the work. These environments constitute one of the most dangerous that an ITM technician may encounter.

Due to the voltages present in a typical fire pump controller, NFPA *70E* considers it a motor control center (MCC). Therefore, protective equipment in the form of flash protection for the face, rated gloves, and noncombustible shirt and trousers must be worn when opening the controller. (See Exhibit 4.12 for the safety equipment needed to work on a fire pump controller, and see Commentary Table 4.2 for PPE selection.)

A.8.3.3.13.1 Testing at an alternative location can include completion of a test at an external fire alarm monitor module used to monitor the sensors within the fire pump controller.

8.3.3.14 Safety. *(See also A.4.9.6.)*

8.3.3.14.1 Section 4.9 shall be followed for safety requirements while working near electric motor–driven fire pumps.

8.3.3.15* Suction Screens. After the waterflow portions of the annual test or fire protection system activations, the suction screens shall be inspected and cleared of any debris or obstructions.

- **A.8.3.3.15** During periods of unusual water supply conditions such as floods, inspection should be on a daily basis.

The "unusual water supply conditions" mentioned in A.8.3.3.15 include floods and times of low water. In times of low water, the suction supply should be inspected to make sure there is adequate water to cover the pump bowls so that cavitation does not occur.

If the pump takes suction from a well, the water level needs to be checked regularly during times of drought or unusual water demand to make sure there is adequate water available for the pump. If the water level is too low, it might be necessary to extend the well deeper or add additional sections of pipe in the well. In extreme cases, additional bowl sections and a larger pump driver might need to be added.

8.3.3.16* Where engines utilize electronic fuel management control systems, the backup electronic control module (ECM) and the primary and redundant sensors for the ECM shall be tested annually.

A.8.3.3.16 *ECM and Sensor Testing. To v*erify the operation of the alternate ECM with the stop, the ECM selector switch should be moved to the alternate ECM position. Repositioning of this should cause an alarm on the fire pump controller. Then the engine is started; it should operate normally with all functions. Next, the engine is shut down, switched back to the primary ECM, and restarted briefly to verify that correct switchback has been accomplished.

To verify the operation of the redundant sensor, with the engine running, the wires are disconnected from the primary sensor. There should be no change in the engine operation. The wires are then reconnected to the sensor, then disconnected from the redundant sensor. There should be no change in the engine operation. The wires should next be reconnected to the sensor. This process is repeated for all primary and redundant sensors on the engines. It should be noted whether disconnecting and reconnecting of wires to the sensors can be done while the engine is not running, then starting the engine after each disconnecting and reconnecting of the wires to verify engine operation.

8.3.4 Diesel Fuel Testing and Maintenance.

8.3.4.1 Diesel fuel shall be tested for degradation no less than annually.

Most diesel fuels available have a shelf life of about 1 year. Fuel oil stored for more than 1 year can become highly susceptible to oxidation and biological growth. The amount of time that a fuel spends at a fueling dispatch station cannot be controlled, so shelf life of the fuel is a significant problem.

In an effort to address this issue, additives are mixed with fuels to extend the shelf life of the diesel fuel. Trying to predict how long fuel can be stored is a complex problem with many variables, but commercial power plants have experienced satisfactory storage periods of up to 1 year when stability additives were used. Fuel additives are typically either biocides and/or stabilizer additives, and they are used commonly throughout the fuel industry to prevent degradation.

Stabilizers are used to inhibit oxidation of the fuel oil. When diesel fuel oxidizes, it precipitates insoluble particulates and gum, which can clog fuel filters and foul diesel engine injectors. Biocide additives are used to prohibit biological growth in the water/fuel interface.

A consistent fuel draining program as discussed in A.8.5.1, backed by a biocide treatment program, can significantly lower the risk of having fuel oil contaminated with biological growth.

It is important to realize that biocides and stabilizers are not effective in correcting existing fuel contamination problems. Extreme caution should be taken not to treat a tank that is already in service with a known problem. Stabilizers will not reduce the particulates in fuel; it will only prevent more particulate from forming in the fuel. Furthermore, if a diesel fuel tank

has large microbiological colonies, treating the fuel tank with a biocide while it is in service could result in engine failure if the colonies are killed and float to the engine suction line. If a tank is known to have severe to moderate biological growth problems, the tank should be taken out of service and cleaned prior to adding a biocide per 8.3.4.2.

8.3.4.1.1* Fuel degradation testing shall comply with ASTM D975, *Standard Specification for Diesel Fuel Oils,* or ASTM D6751, *Standard Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels,* as approved by the engine manufacturer, using ASTM D7462, *Standard Test Method for Oxidation Stability of Biodiesel (B100) and Blends of Biodiesel with Middle Distillate Petroleum Fuel (Accelerated Method).*

The best maintenance for diesel fuel oil is consumption of the fuel. It is extremely advantageous to establish a driver test schedule that will "turn over" the fuel tank's full contents at least once a year. With a 30-minute weekly run required, fuel in diesel driver tanks should be fully consumed annually. Commercial distillate fuels, including diesel fuel, are subject to various degrees of degradation. Beginning with the 2014 edition of NFPA 25, diesel fuel is required to be analyzed annually to ensure that fuel supplying diesel fire pump drivers will not cause engine failure.

A.8.3.4.1.1 Commercial distillate fuel oils used in modern diesel engines are subject to various detrimental effects from storage. The origin of the crude oil, refinement processing techniques, time of year, and geographical consumption location all influence the determination of fuel blend formulas. Naturally occurring gums, waxes, soluble metallic soaps, water, dirt, blends, and temperature all contribute to the degradation of the fuel as it is handled and stored. These effects begin at the time of fuel refinement and continue until consumption. Proper maintenance of stored distillate fuel is critical for engine operation, efficiency, and longevity.

Storage tanks should be kept water-free. Water contributes to steel tank corrosion and the development of microbiological growth where fuel and water interface. This and the metals of the system provide elements that react with fuel to form certain gels or organic acids, resulting in clogging of filters and system corrosion. Scheduled fuel maintenance helps to reduce fuel degradation. Fuel maintenance filtration can remove contaminants and water and maintain fuel conditions to provide reliability and efficiency for standby fire pump engines. Fuel maintenance and testing should begin the day of installation and first fill.

8.3.4.2* If diesel fuel is found to be deficient in the testing required in 8.3.4.1.1, the fuel shall be reconditioned or replaced, the supply tank shall be cleaned internally, and the engine fuel filter(s) shall be changed.

A.8.3.4.2 Where environmental or fuel quality conditions result in degradation of the fuel while stored in the supply tank, from items such as water, micro-organisms and particulates, or destabilization, active fuel maintenance systems permanently installed on the fuel storage tanks have proven to be successful at maintaining fuel quality. An active fuel maintenance system will maintain the fuel quality in the tank, therefore preventing the fuel from going through possible cycles of degradation, risking engine reliability, and then requiring reconditioning.

8.3.4.2.1 After the restoration of the fuel and tank in 8.3.4.2, the fuel shall be retested every 6 months until experience indicates the fuel can be stored for a minimum of 1 year without degradation beyond that allowed in 8.3.4.1.1.

8.3.4.3 When provided, active fuel maintenance systems shall be listed for fire pump service.

8.3.4.3.1 Maintenance of active fuel maintenance systems shall be in accordance with the manufacturer's recommendations.

8.3.4.3.2 Maintenance of active fuel maintenance systems shall be performed at a minimum annual frequency for any portion of the system that the manufacturer does not provide a recommended maintenance frequency.

Tip for Owners

If diesel fuel quality is suspect for any reason, steps such as those listed in 8.3.4.2 to remedy the situation should be undertaken as soon as possible. Diesel engine performance can be dramatically reduced when these issues occur. The performance degradation will not be evident until the engine runs, and when that occurs in a fire situation, the results can be disastrous.

8.3.4.3.3 Where utilized, fuel additives shall be used and maintained in accordance with the active fuel maintenance system manufacturer's recommendations.

8.3.5 Positive Displacement Pumps. [20:14.2.6.4.3]

8.3.5.1 Except as provided in 8.3.5.1 through 8.3.5.7, positive displacement pumps shall be tested in accordance with 8.3.1 through 8.3.3.

8.3.5.2 The pump flow for positive displacement pumps shall be tested and determined to meet the specified rated performance criteria where only one performance point is required to establish positive displacement pump acceptability. [**20:**14.2.6.4.3.1]

8.3.5.3 The pump flow test for positive displacement pumps shall be accomplished using a flowmeter or orifice plate installed in a test loop back to the supply tank, to the inlet side of a positive displacement water pump, or to drain. [**20:**14.2.6.4.3.2]

8.3.5.4 The flowmeter reading or discharge pressure shall be recorded and shall be in accordance with the pump manufacturer's flow performance data. [**20:**14.2.6.4.3.3]

8.3.5.5 If orifice plates are used, the orifice size and corresponding discharge pressure to be maintained on the upstream side of the orifice plate shall be made available to the authority having jurisdiction. [**20:**14.2.6.4.3.4]

8.3.5.6 Flow rates shall be as specified while operating at the system design pressure. Tests shall be performed in accordance with HI 3.6, *Rotary Pump Tests.* [**20:**14.2.6.4.3.5]

8.3.5.7 Positive displacement pumps intended to pump liquids other than water shall be permitted to be tested with water; however, the pump performance will be affected, and manufacturer's calculations shall be provided showing the difference in viscosity between water and the system liquid. [**20:**14.2.6.4.3.6]

8.3.6 Other Tests.

8.3.6.1* Engine generator sets supplying emergency or standby power to fire pump assemblies shall be tested routinely in accordance with NFPA 110.

A.8.3.6.1 Routine tests required by NFPA 110 and conducted in accordance with NFPA 110 should be performed to utilize the generator for standby power for a fire pump. During the annual fire pump test, a generator test is required by 8.3.3.9 of this standard. Except for 8.3.3.9, the testing requirements for the standby generator reside in NFPA 110.

8.3.6.2 Automatic transfer switches shall be tested routinely and exercised in accordance with NFPA 110.

8.3.6.3 Tests of appropriate environmental pump room space conditions (e.g., heating, ventilation, illumination) shall be made to ensure proper manual or automatic operation of the associated equipment.

8.3.6.4* Parallel and angular alignment of the pump and driver shall be inspected during the annual test, and any misalignment shall be corrected.

Tip for Owners

NFPA 110, *Standard for Emergency and Standby Power Systems,* requires that emergency generators receive ITM to help ensure that they remain a reliable form of power. Maintenance and testing of these systems require special training and knowledge and must be performed by a "qualified person" as defined in that standard. For more information on the steps necessary to effectively test an emergency generator or standby power system, refer to NFPA 110.

Historical Note

Couplings are required to be listed by NFPA 20 due to several past catastrophic failures of several types of elastomeric and polymeric couplings. This listing requirement was added to the 1996 edition of NFPA 20, but approved models did not become available by manufacturers until several years later. Thus, pumps installed in the early 1990s to meet NFPA 20 requirements might not have been installed with approved couplings, although they were required by the standard. Speed, torque, and specific load ratings are part of the individual listings for these products.

When inspecting and testing fire pumps, the inspector should closely examine beneath the coupling guard for filings, which can indicate a misaligned coupling. When the pump is running, excessive vibration can also be an indication of coupling misalignment. Exhibit 8.45 shows a pump shaft that failed at the internal bearing. The cause of the failure was determined to be due to misalignment.

Pump shaft couplings are typically protected by a cage or cover that meets the requirements of ANSI B11.19, *Performance Requirements for Safeguarding*, as required by 4.14.8 of NFPA 20 and as shown in Exhibit 8.4.

Pump alignment is required to be checked annually per 8.3.6.4. Coupling alignment requirements are dictated by both the pump and coupling manufacturer specifications. The allowable amount of misalignment can vary by type of pump, driver, coupling, model, and size. Irrespective of which type of coupling is used, proper maintenance is imperative, because a failed coupling can lead to an impaired pump. Exhibit 8.46 shows a shaft that failed due to misalignment where a metallic coupling was used. Exhibit 8.47 shows a failed elastopolymer coupling that sheared in half due to misalignment.

Most couplings now come almost fully enclosed, and thus, guards must be removed for inspection. The important things to look for to ensure a pump is aligned and to minimize chances of failure are as follows:

- *Flatness of the foundation and base plate.* If the base is not leveled and properly grouted, the pump will lose alignment over time.
- *Pipe strain.* If the pump is aligned but the pump flanges are being pulled in different directions, the pump will lose alignment. The best way to check this is to remove the bolts from the pump flanges to see if the piping needs to be pulled over to get the bolts back in.
- *Misinstalled set screws.* Incorrectly installed set screws are not limited to pumps already in service. There have been instances in which pumps have been shipped directly from the manufacturer with the set screws incorrectly installed.



EXHIBIT 8.45 *Broken Shaft Due to Misalignment. (Courtesy of Damon Pietraz, Underwood Fire Equipment)*

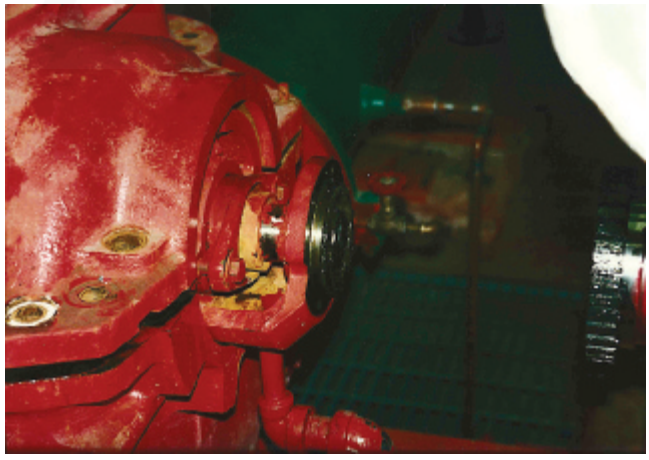


EXHIBIT 8.46 *Misalignment Caused Broken Shaft (with Metallic Coupling). (Courtesy of Damon Pietraz, Underwood Fire Equipment)*

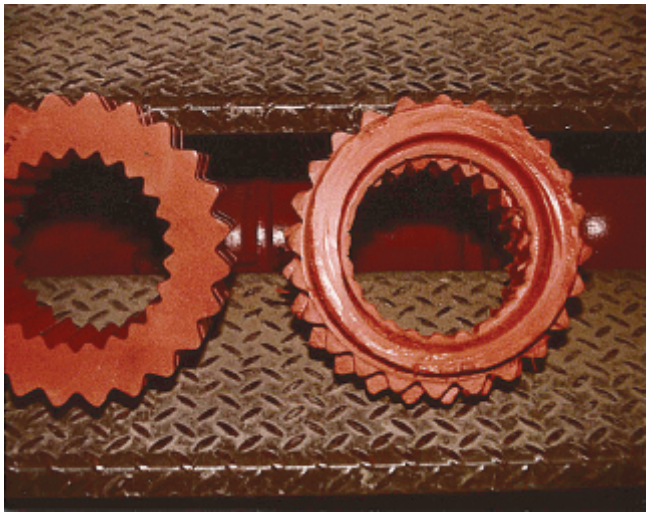


EXHIBIT 8.47 *Coupling Sheared in Half Due to Misalignment. (Courtesy of Damon Pietraz, Underwood Fire Equipment)*

Δ **A.8.3.6.4** A pump and driver shipped from the factory with both machines mounted on a common baseplate, are accurately aligned before shipment. All baseplates are flexible to some extent and, therefore, should not be relied upon to maintain the factory alignment. Realignment is necessary after the complete unit has been leveled on the foundation and again after the grout has set and foundation bolts have been tightened. The alignment should be checked after the unit is piped and rechecked periodically. To facilitate accurate field alignment, most manufacturers either do not dowel the pumps or drivers on the baseplates before shipment or, at most, dowel the pump only.

After the pump and driver unit has been placed on the foundation, the coupling halves should be disconnected. The coupling should not be reconnected until the alignment operations have been completed.

The purpose of the flexible coupling is to compensate for temperature changes and to permit end movement of the shafts without interference with each other while transmitting power from the driver to the pump.

There are two forms of misalignment between the pump shaft and the driver shaft are as follows:

(1) *Angular misalignment.* Shafts with axes concentric but not parallel
(2) *Parallel misalignment.* Shafts with axes parallel but not concentric

The faces of the coupling halves should be spaced within the manufacturer's recommendations and far enough apart so that they cannot strike each other when the driver rotor is moved hard over toward the pump. Due allowance should be made for wear of the thrust bearings. The necessary tools for an approximate check of the alignment of a flexible coupling are a straight edge and a taper gauge or a set of feeler gauges.

A check for angular alignment is made by inserting the taper gauge or feelers at four points between the coupling faces and comparing the distance between the faces at four points spaced at 90 degree intervals around the coupling *[see Figure A.8.3.6.4(a)].* The unit will be in angular alignment when the measurements show that the coupling faces are the same distance apart at all points.

A check for parallel alignment is made by placing a straight edge across both coupling rims at the top, bottom, and at both sides *[see Figure A.8.3.6.4(b)].* The unit will be in parallel alignment when the straight edge rests evenly on the coupling rim at all positions. Allowance might be necessary for temperature changes and for coupling halves that are not of the same outside diameter. Care must be taken to have the straight edge parallel to the axes of the shafts.

Angular and parallel misalignment are corrected by means of shims under the motor mounting feet. After each change, it is necessary to recheck the alignment of the coupling

halves. Adjustment in one direction can disturb adjustments already made in another direction. It should not be necessary to adjust the shims under the pump.

The permissible amount of misalignment will vary with the type of pump and driver; and coupling manufacturer, model, and size. [**20:** A.6.5]

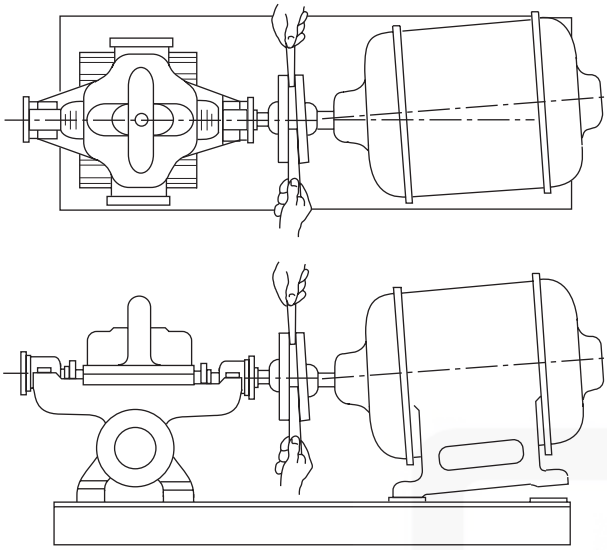


FIGURE A.8.3.6.4(a) *Checking Angular Alignment. (Courtesy of the Hydraulic Institute, Parsippany, NJ, www.Pumps.org.)*

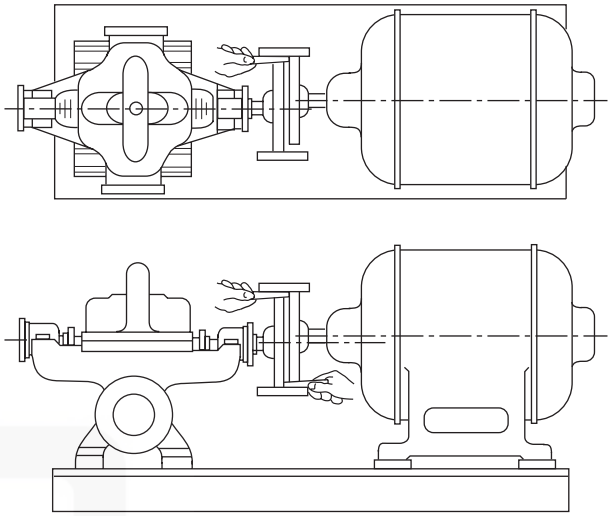


FIGURE A.8.3.6.4(b) *Checking Parallel Alignment. (Courtesy of the Hydraulic Institute, Parsippany, NJ, www.Pumps.org.)*

8.3.7 Test Results and Evaluation.

8.3.7.1* Data Interpretation.

A.8.3.7.1 Where the information is available, the test plot should be compared with the original acceptance test plot. It should be recognized that the acceptance test plot could exceed the minimum acceptable pump requirements as indicated by the rated characteristics for the pump. While a reduction in output is a matter of concern, this condition should be evaluated in light of meeting the rated characteristics for the pump. *[See Figure A.8.3.7.2.3(2)(a).]*

The test equipment should be of high quality and accuracy. All equipment should have been calibrated within the last 12 months by an approved calibration facility. Where possible, the calibration facility should provide documentation indicating the instrument reading against the calibrated reading. Instruments that pass the calibration test should be labeled by the calibration facility with the name of the facility and the date of the test.

Pressure gauges should have an accuracy not greater than 1 percent of full scale. To prevent damage to a pressure gauge utilizing a Bourdon tube mechanism, it should not be used where the expected test pressure is greater than 75 percent of the test gauge scale. Some digital gauges can be subjected to twice the full scale pressure without damage. The manufacturer's recommendations should be consulted for the proper use of the gauge. To be able to easily read an analog gauge, the diameter of the face of the analog gauge should be greater than 3 in. (76 mm). Pressure snubbers should be used for all gauges to minimize needle fluctuation. All gauges used in the test should be such that a gauge with the lowest full scale pressure is used. For example, a 300 psi (20.7 bar) gauge should not be used to measure a 20 psi (1.4 bar) pitot pressure.

Equipment other than pressure gauges, such as volt/ammeters, tachometers, and flowmeters, should be calibrated to the manufacturer's specifications. The readings from equipment with this level of accuracy and calibration can be used without adjustment for accuracy.

8.3.7.1.1 The interpretation of the flow test performance relative to the manufacturer's performance shall be the basis for determining performance of the pump assembly.

8.3.7.1.2 Qualified individuals shall interpret the test results.

8.3.7.1.3 Where applicable, speed and velocity pressure adjustments shall be applied to the net pressure and flow data obtained to determine compliance with 8.3.7.2.3(2).

Abnormal performance of a pump can be caused by the pump operating at speeds other than its rated speed. NFPA 25 requires the use of affinity laws to correct the rated pump speed. This correction is needed as the pump ratings were established under ideal factory conditions, and most pump performance will vary from the factory ratings under field conditions. This correction identifies if abnormal performance is due to a change in pump speed or a result of physical wear of the pump. The uncorrected pump performance must be sufficient to supply the required system demand as required in 8.3.7.2.3, to ensure that the active systems are properly supported with appropriate pressure and flow.

8.3.7.2 Evaluation of Fire Pump Test Results.

8.3.7.2.1 The fire pump test results shall be evaluated in accordance with 8.3.7.2.2 through 8.3.7.2.9.

8.3.7.2.2 Increasing the engine speed beyond the rated speed of the pump shall not be permitted as a method for meeting the rated pump performance.

Δ **8.3.7.2.3** The fire pump test results shall be considered acceptable if all of the following conditions are satisfied:

(1) Fire pump meets the flow and pressure requirements of the most demanding system(s) being supplied by the fire pump based on owner-provided system design information

(2)* Fire pump supplies 100 percent of rated flow

The annual fire pump test is intended to evaluate the net fire pump performance. This net performance includes flow and pressure. Figure A.8.3.7.2.3(2)(a) illustrates that the pump is evaluated based on discharge minus suction pressure. Variations of more than 5 percent must be investigated as to the cause.

A.8.3.7.2.3(2) Figure A.8.3.7.2.3(2)(a) shows a pump test result plotted on linear graph paper adjusted to rated speed and compared to an original pump performance test and the manufacturer's test curve. Suction pressure and discharge pressure are also plotted, which when compared to previous results can aid in determining if a degraded pump discharge is the result of a decreased water supply. Also note that adjusted results of this test closely overlap, which is a good indication that the internal parts of the pump are functioning well (i.e., the pump is performing at or above 95 percent of the original design specifications per the manufacturer's performance curve).

Figure A.8.3.7.2.3(2)(b) shows an unadjusted pump test result plotted on linear graph paper and compared (plotted) with fire system demands. This is the actual tested performance and shows how the pump will perform in an emergency. This curve clearly shows whether the actual pump discharge can meet fire system demands. Suction pressure and discharge pressure are also plotted. The suction curve can be compared to previous results to aid in determining if a degraded pump discharge is the result of a decreased water supply.

(3)* The net pressure at each flow point is at least 95 percent of one of the following:
- (a) Original manufacturer's pump curve
- (b) Original unadjusted field test curve
- (c) Test curve generated from the fire pump nameplate

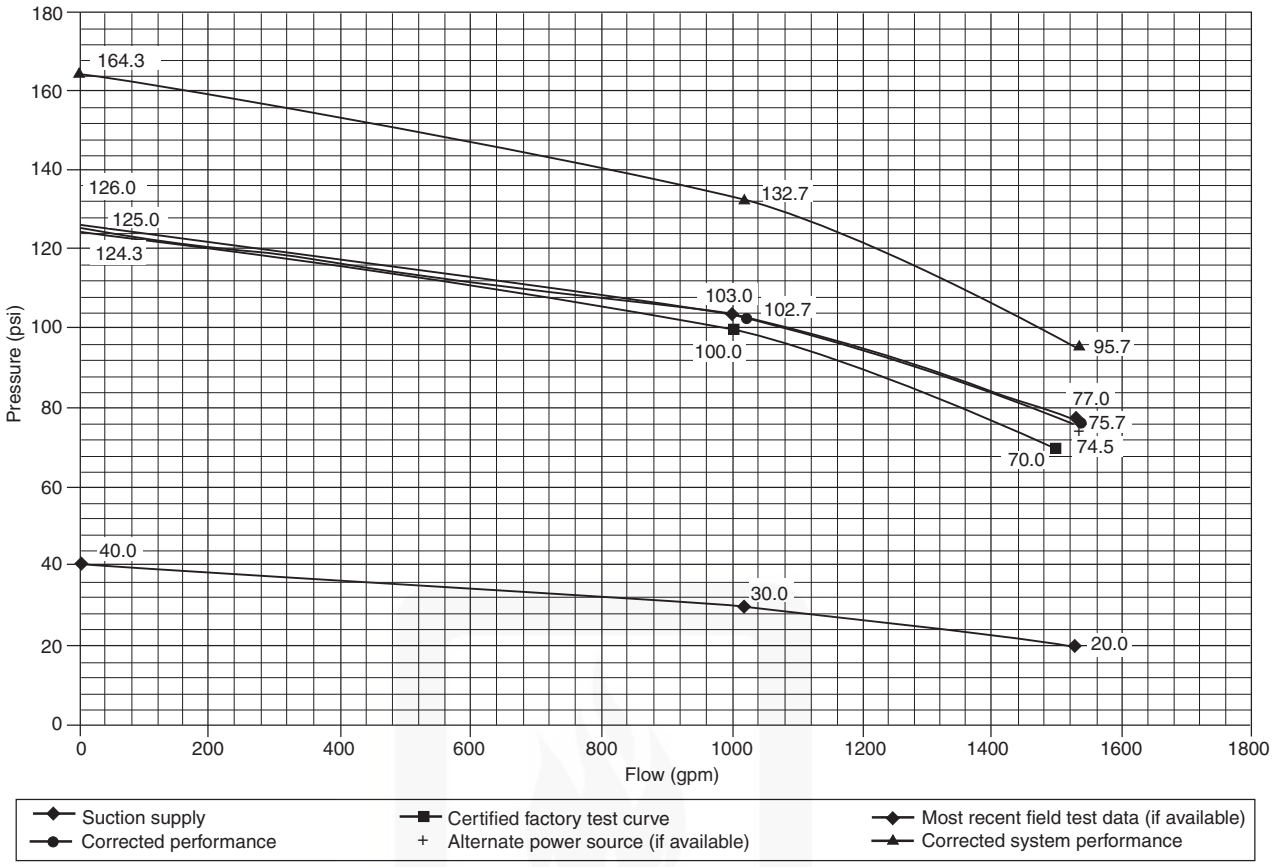


FIGURE A.8.3.7.2.3(2)(a) *Fire Pump Performance Curve — Corrected Data.*

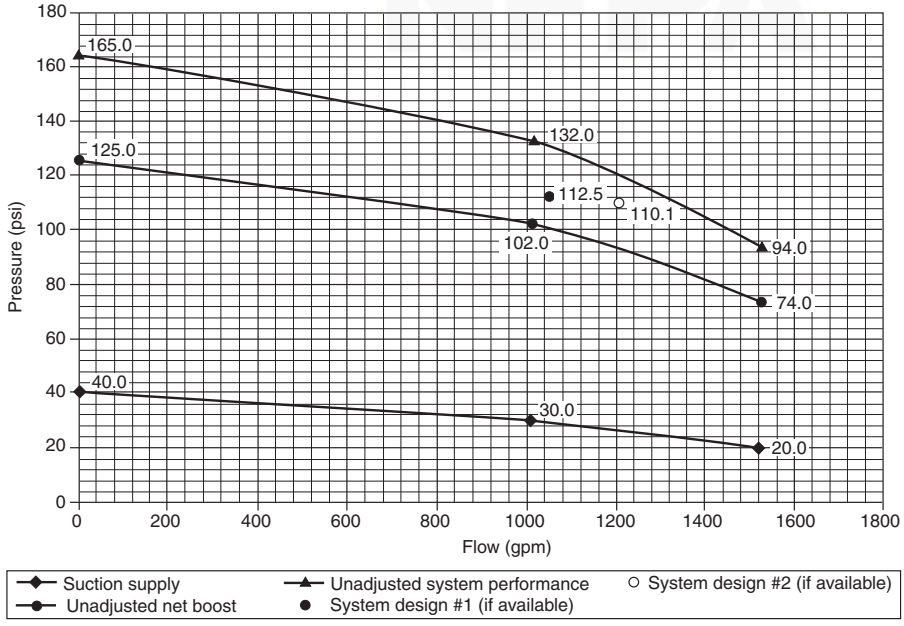


FIGURE A.8.3.7.2.3(2)(b) *Fire Pump Performance Curve — Unadjusted Data.*

N **A.8.3.7.2.3(3)** While pressures that exceed the original unadjusted field test curve or fire pump nameplate are considered acceptable, the test could be flawed and should be thoroughly reviewed by a qualified person.

Δ **8.3.7.2.4*** The following actions shall be required upon failure to meet the criteria in 8.3.7.2.3:

(1) The owner shall be notified in writing of the unacceptable test results.
(2) An investigation shall be conducted into the cause of the unacceptable test results.
(3) Failure to provide the maximum system demand shall be deemed an impairment.

If the pump pressure falls more than 5 percent below that shown on the nameplate or the initial pump acceptance test, an investigation must be undertaken. History shows that the most common cause of degraded pump performance is the presence of a shut or partially shut control valve in the water supply. Booster pumps taking water from a looped or gridded network can be affected by sectional valves that were left closed after repairs or by modifications that were made by the water purveyor. In high-growth areas, water supplies can deteriorate over time from more user demand; this can impact pump performance at rated or peak capacity. If water supplies appear to be normal, the cause might rest within the pump itself, and the pump should be evaluated by qualified personnel.

(4) Excessive vibration and/or excessively worn or loose components shall be deemed a deficiency.
(5) Degraded performance that still provides the maximum system demand shall be deemed a noncritical deficiency.
(6) The owner shall be notified in writing of corrections completed.

A.8.3.7.2.4 See Annex C.

Δ **8.3.7.2.5** For electric motor–driven fire pumps operating at constant speed, the current at each flow rate test point and at each phase shall not exceed the product of the electric motor service factor and the full-load amperage rating of the motor.

Δ **8.3.7.2.6** Where the current at each flow rate test point and at each phase exceeds the product of the electric motor service factor and the full-load amperage rating of the motor, the source of the problem shall be identified and corrected.

Δ **8.3.7.2.7** For electric motor–driven fire pumps operating at varying voltage, the product of the test voltage and the current at each test point and on each phase shall not exceed the product of the voltage and the full-load current times the motor service factor.

Δ **8.3.7.2.8** Where the product of the test voltage and the current at each test point and on each phase exceeds the product of the voltage and the full-load current times the motor service factor, the source of the problem shall be identified and corrected.

8.3.7.2.9 Voltage readings at the motor within 5 percent below or 10 percent above the rated (i.e., nameplate) voltage shall be considered acceptable.

8.3.7.2.10 A written or electronic record of the results of the investigation and the corrective action shall be prepared and maintained by the owner.

8.4 Reports.

8.4.1* A complete written report of the fire pump test results shall be prepared for and retained by the owner.

A.8.4.1 For a sample pump test form, see Figure A.8.4.1.

Sample Centrifugal Fire Pump Annual Test Form

Information on this form covers the minimum requirements of NFPA 25, 2020 edition, for performing an annual test on centrifugal fire pumps with electric motor or diesel engine drivers. A separate form is required for each pump operating simultaneously. This form does not cover other periodic inspections, testing, and maintenance required by NFPA 25.

Owner: _____

Owner's address: _____

_____

Pump location: _____

Property address: _____

_____

Date of test: _____

Maximum demand(s) of fire protection system(s) _____ gpm at _____ psi for _____ minutes at fire pump discharge

System demand information supplied by: _____

Pump type: Horizontal ❑ Vertical ❑ Inline ❑ Other (specify) _____

Manufacturer: _____ Model or type: _____ Shop/serial number _____

Pump rated for _____ gpm at _____ psi at _____ RPM, net discharge pressure _____ psi at 150% _____ psi at churn

Pump suction size _____ in. Discharge size _____ in. Suction from _____

If suction from tank, tank diameter _____ ft, height _____ ft, net capacity _____ gpm

Driver: _____ Electric motor _____ Diesel engine _____ Steam turbine

Manufacturer: _____ Shop/serial number: _____ Model or type: _____

Rated horsepower: _____ Rated speed: _____ If electric motor, rated voltage _____ Operating voltage _____

Rated amps _____ Phase cycles _____ Service factor _____

Controller manufacturer: _____

Shop/serial number: _____ Model or type: _____

Controller rated _____ HP _____ VAC

Does controller rated HP & VAC match motor? ❑ Yes ❑ No

Transfer switch? ❑ Yes ❑ No

Transfer switch rated _____ HP _____ VAC

Does controller rate HP & VAC match motor? ❑ Yes ❑ No ❑ N/A

Pressure maintenance (jockey) pump on system? ❑ Yes ❑ No ❑ Manual ❑ Automatic

Manufacturer: _____ Shop/serial number: _____

Model or type: _____ ❑ Centrifugal or ❑ Positive displacement?

Pressure relief valve provided on jockey pump discharge? ❑ Yes ❑ No ❑ N/A

Jockey pump rated for _____ gpm at _____ psi at _____ RPM _____ HP

Jockey pump suction size _____ in. Discharge size _____ in.

Jockey pump controller manufacturer: _____

Shop/serial number: _____ Model or type: _____

Jockey pump controller rated _____ HP _____ VAC

Does jockey pump controller rated HP & VAC match motor? ❑ Yes ❑ No

Note: All blanks are to be filled in. All questions are to be answered Yes, No, or Not Applicable. All "No" answers are to be explained in the comments portion of this form.

I. People Present

A. Owner or owner's representative? ❑ Yes ❑ No

B. Other attendees? ❑ Yes ❑ No

II. Electric Wiring

A. Was any defect noted in the electric wiring? ❑ Yes ❑ No ❑ N/A

III. Annual Flow Test

A. Is a copy of the manufacturer's certified pump test curve attached? ❑ Yes ❑ No

B. Test results compared to the following: 1. The manufacturer's certified pump test curve? ❑ Yes ❑ No

2. The nameplate? ❑ Yes ❑ No

C. Gauges and other test equipment calibrated? ❑ Yes ❑ No

D. No vibrations that could potentially damage any fire pump component? ❑ Yes ❑ No ❑ N/A

E. The fire pump performed at all conditions without objectionable overheating of any component? ❑ Yes ❑ No ❑ N/A

© 2019 National Fire Protection Association (NFPA 25, p. 1 of 4)

Δ ***FIGURE A.8.4.1*** *Sample Annual Centrifugal Pump Test Form.*

F. For each test, record the required information for each load condition using the following formulas (or other acceptable methods) and tables:

$$P_{Net} = P_{Discharge} - P_{Suction}$$

$$Q = 29.83\ cd^2p^{0.5}$$

$$Pv = 0.43352V^2/(2g) = (Q^2)/(890.47D^4)$$

where

P_{Net} = Net pump pressure (psi)
$P_{Discharge}$ = Total pressure at the pump discharge (psi)
$P_{Suction}$ = Total pressure at the pump suction (psi)
Q = Flow through a circular orifice (gpm)
c = Nozzle discharge coefficient
d = Nozzle orifice diameter (in.)
P = Pressure measured on gauge (pitot)
Pv = Velocity pressure (psi)
V = Velocity of liquid (ft/sec)
g = Gravitational constant (32.174 ft/sec)
D = Internal pipe diameter (in.)

Test	Pump speed (rpm)	Suction pressure (psi)	Discharge pressure (psi)	Nozzle size (in.)_____ Nozzle coef. _____ Pitot readings (psi) 1	2	3	4	5	6	Flow (gpm)	Net pressure (psi)	RPM adjusted net pressure	RPM adjusted flow (psi)	Suction velocity pressure (psi)[1]	Discharge velocity pressure (psi)[1]	Velocity adjusted pressure (psi)[1]	Oil pressure (psi)[2]	Exhaust back pressure (in. Hg)[2]	Diesel water temperature[2]	Cooling loop pressure (psi)[2]
0%																				
25%																				
50%																				
75%																				
100%																				
125%																				
150%																				
0%																				
100%																				
150%																				

Pump is ❑ constant speed ❑ variable speed

Notes:
(1) Velocity pressure adjustments provide a more accurate analysis in most cases and as a minimum should be included whenever the pump suction and discharge diameters are different and the pump fails by a narrow margin. The actual internal diameter of the pump suction and discharge should be obtained from the manufacturer.
(2) These readings are applicable to diesel engine pumps only. Recording these readings is not specifically required in Chapter 14.

For electric motor–driven pumps also record the following:

Test	Voltage			Amperes		
	L1-L2	L2-L3	L1-L3	L1	L2	L3
0%						
25%						
50%						
75%						
100%						
125%						
150%						
0%						
100%						
150%						

G. For electric motors operating at rated voltage and frequency, is the ampere demand less than or equal to the product of the full load ampere rating times the allowable service factor as stamped on the motor nameplate? ..... ❑ Yes ❑ No ❑ N/A

H. For electric motors operating under varying voltage, determine the following:
1. Was the product of the actual voltage and current demand less than or equal to the product of the rated full load current times the rated voltage times the allowable service factor? ..... ❑ Yes ❑ No ❑ N/A
2. Was the voltage always less than 5 percent above the rated voltage during the test? ..... ❑ Yes ❑ No ❑ N/A
3. Was the voltage always less than 10 percent above the rated voltage during the test? ..... ❑ Yes ❑ No ❑ N/A

I. Did engine-driven units operate without any signs of overload or stress? ..... ❑ Yes ❑ No ❑ N/A

J. Was the engine overspeed emergency shutdown tested? ..... ❑ Yes ❑ No ❑ N/A

K. Was the governor set to properly regulate the engine speed at rated pump speed? ..... ❑ Yes ❑ No ❑ N/A

© 2019 National Fire Protection Association

Δ ***FIGURE A.8.4.1*** *Sample Annual Centrifugal Pump Test Form (continued).*

L. Did the gear drive assembly operate without excessive objectionable noise, vibration, or heating? ❑ Yes ❑ No ❑ N/A
M. Was the fire pump unit started and brought up to rated speed without interruption under the conditions of a discharge equal to peak load? ❑ Yes ❑ No ❑ N/A
N. Did the fire pump performance equal a minimum of 95 percent of the manufacturer's factory curve within the accuracy limits of the test equipment? ❑ Yes ❑ No ❑ N/A
O. Did the electric motor pumps pass phase reversal test on normal and alternate (if provided) power? ❑ Yes ❑ No ❑ N/A

IV. Multiple Pump Operation

A. _____ fire pumps are required to operate ❑ in series ❑ in parallel ❑ N/A to meet the maximum fire protection demand.
B. Record the following information for each of the _____ pumps operating simultaneously.

Test	Pump speed (rpm)	Suction pressure (psi)	Discharge pressure (psi)	Nozzle size (in.)_____ Nozzle coef. _____ Pitot readings (psi) 1	2	3	4	5	6	7	8	9	10	11	12	Oil pressure (psi)	Total flow (gpm)	Flow through net pressure	RPM adjusted flow (psi)	RPM adjusted flow (psi)	Suction velocity pressure (psi)	Suction velocity pressure (psi)	Velocity adjusted net pressure (psi)
0%																							
25%																							
50%																							
75%																							
100%																							
125%																							
150%																							
0%																							
100%																							
150%																							
Pump is ❑ constant speed ❑ variable speed																							

C. Did the fire pump performance equal a minimum of 95 percent of the manufacturer's factory curve within the accuracy limits of the test equipment during the multiple test? ❑ Yes ❑ No ❑ N/A

V. Main Pressure Relief Valve

A. Is a main pressure relief valve installed on the fire pump discharge? ❑ Yes ❑ No
B. During variable speed performance testing, what was the flow rate through the main pressure relief valve at churn?
❑ No flow ❑ Weeping flow ❑ More than weeping flow ❑ Substantial flow ❑ N/A
C. During variable speed performance testing, what was the flow rate though the main pressure relief valve at rated flow?
❑ No flow ❑ Weeping flow ❑ More than weeping flow ❑ Substantial flow ❑ N/A
D. During constant speed performance testing, what was the flow rate though the main pressure relief valve at rated churn?
❑ No flow ❑ Weeping flow ❑ More than weeping flow ❑ Substantial flow ❑ N/A
E. During constant speed performance testing, what was the flow rate though the main pressure relief valve at rated flow?
❑ No flow ❑ Weeping flow ❑ More than weeping flow ❑ Substantial flow ❑ N/A
F. After resetting the pressure relief valve after performance testing, under variable speed operation, what was the flow rate through the main pressure relief valve at churn? ❑ No flow ❑ Weeping flow ❑ More than weeping flow ❑ Substantial flow ❑ N/A
G. After resetting the pressure relief valve after performance testing, under constant speed operation, what was the flow rate through the main pressure relief valve at churn? ❑ No flow ❑ Weeping flow ❑ More than weeping flow ❑ Substantial flow ❑ N/A
What was the fire pump discharge pressure? _____ psi.
H. After resetting the pressure relief valve after performance testing, under constant speed operation, at what flow rate did the pressure relief valve substantially close? _____ gpm. What was the fire pump discharge pressure when the pressure relief valve was substantially closed? _____ psi.
I. Is the maximum discharge pressure adjusted for elevation, and with the pressure relief operational, less than the pressure rating of the system components for elevation? ❑ Yes ❑ No ❑ N/A

VI. Controller Test

A. Did the pump start from automatic sources? ❑ Yes ❑ No ❑ N/A
B. Was each automatic starting feature tested at least once? ❑ Yes ❑ No ❑ N/A
C. Did the pump start manually? ❑ Yes ❑ No ❑ N/A
D. Was the pump run for at least 5 minutes during each of the operations in Parts A, B, and C above? ❑ Yes ❑ No ❑ N/A
(Note: An engine driver is not required to run for 5 minutes at full speed between successive starts until the cumulative cranking time of successive starts reaches 45 seconds.)
E. Were the starting operations divided between both sets of batteries for engine-driven controllers? ❑ Yes ❑ No ❑ N/A
F. Were both ECMs tested if supported? ❑ Yes ❑ No ❑ N/A
G. Was the engine tested and RPM set on both ECMs at rated flow and full load? ❑ Yes ❑ No ❑ N/A
H. Were all alarm functions, including ECM alarms for fuel injection failure, low fuel pressure, and any primary sensor failure, tested at the engine? ❑ Yes ❑ No ❑ N/A

© 2019 National Fire Protection Association (NFPA 25, p. 3 of 4)

Δ ***FIGURE A.8.4.1*** *Sample Annual Centrifugal Pump Test Form (continued).*

I. Electric Driven Pump Controllers
1. Did all overcurrent protective devices (including the controller circuit breaker) hold during the tests? ..... ❑ Yes ❑ No ❑ N/A
2. Was the fire pump started at least once from each power service and run for at least 5 minutes? ..... ❑ Yes ❑ No ❑ N/A
3. Upon simulation of a power failure, while the pump is operating at peak load, did the transfer switch transfer from the normal to the emergency source without opening overcurrent protection devices on either line? ..... ❑ Yes ❑ No ❑ N/A
4. When normal power was restored, did retransfer from emergency to normal power occur without overcurrent protection devices opening on either line? ..... ❑ Yes ❑ No ❑ N/A
5. Were at least 1 automatic and 1 manual starts performed with the pump connected to the alternate source? ..... ❑ Yes ❑ No ❑ N/A

J. Were all signal conditions simulated demonstrating satisfactory operation? ..... ❑ Yes ❑ No ❑ N/A

K. Did the pump run for at least the minimum time required by this standard? ..... ❑ Yes ❑ No ❑ N/A
NOTE: Run time includes all time the driver was turning the impeller, i.e., no-flow and flow conditions.

VII. Water Storage Tank ❑ Yes ❑ No

A. Tank capacity _____ gallons, height _____ ft, diameter _____ ft

B. Break tank ❑ Yes ❑ No ❑ N/A Required break tank fill rate _____ gpm ❑ N/A

C. Did refill rate maintain tank level when flowing 150 percent of rated capacity? ❑ Yes ❑ No ❑ N/A

D. A water refill rate of _____ gpm was ❑ field verified by flowing _____ gpm through the fire pump with a starting water level of _____ ft _____ in. and an ending water level of _____ ft _____ in. after flowing for _____ minutes, ❑ field verified by raising the water level from _____ ft _____ in. to _____ ft _____ in. in minutes, ❑ field verified by other means (specify) _____

E. Was the automatic refill assembly operated? ..... ❑ Yes ❑ No ❑ N/A

VIII. Test Evaluation

A. Did the pump performance equal that indicated on the manufacturer's certified shop test under all load conditions? ..... ❑ Yes ❑ No

B. Did the pump discharge equal or exceed the maximum fire protection system demand? ..... ❑ Yes ❑ No

C. Did the pump performance meet the requirements of NFPA 25?..... ❑ Yes ❑ No

IX. Tester Information

Tester: _____

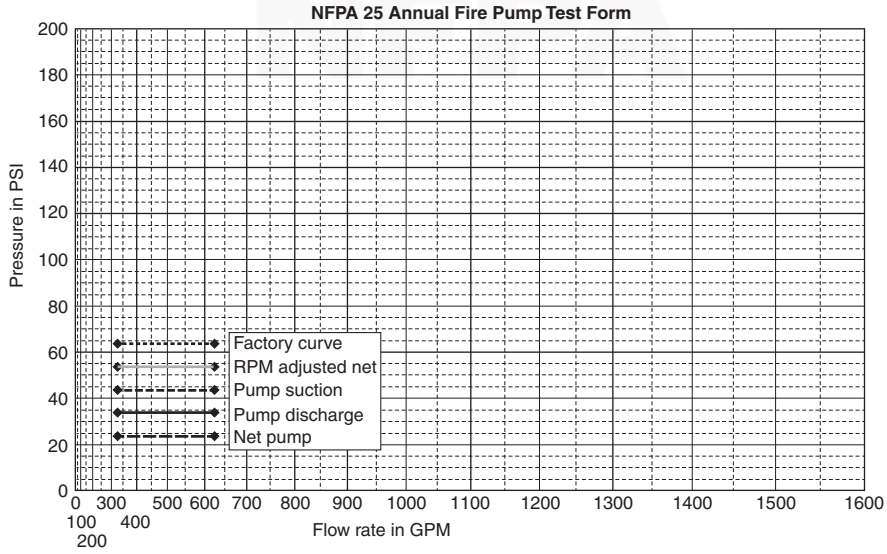
Company: _____

Company address: _____

I state that the information on this form is correct at the time and place of my test, and that all equipment tested was left in operational condition upon completion of this test except as noted in the comments section below.

Signature of tester: _____ Date: _____ License or certification number if applicable: _____

X. Comments *(Any "No" answers, test failures, or other problems must be explained — use additional sheets if necessary.*



© 2019 National Fire Protection Association

Δ ***FIGURE A.8.4.1*** *Sample Annual Centrifugal Pump Test Form (continued).*

8.4.1.1 At a minimum, the report shall contain the following information:

(1) All raw data necessary for a complete evaluation of the fire pump performance, including suction and discharge pressures, voltage and amperage readings, and pump speed at each flow rate tested
(2) The fire protection system demand as furnished by the owner
(3) Pump performance, whether satisfactory or unsatisfactory
(4) Deficiencies noted during the testing and identified during analysis, with recommendations to address deficiencies as appropriate
(5) Manufacturer's performance data, actual performance, and the available pump discharge curves required by this standard
(6) Time delay intervals associated with the pump's starting, stopping, and energy source transfer
(7) Where applicable, comparison with previous test results

Although no formal recording process is mandated by the standard, there are several key pieces of information that should be recorded so that the pump efficiency and performance can be plotted if needed. This information includes the percent of rated pump discharge, suction and discharge pressure, flow, and pump operating speed. Supplement 4 contains sample forms that provide a means for recording this information.

8.5 Maintenance.

8.5.1* A preventive maintenance program shall be established on all components of the pump assembly in accordance with the manufacturer's recommendations or an approved alternative maintenance plan.

A.8.5.1 Where the manufacturer's preventive maintenance requirements are not provided, refer to Table A.8.1.1.2.

It is important to provide proper bearing lubrication and to keep bearings clean. Some bearings are the sealed type and need no relubrication. Couplings with rubber drive parts do not need lubrication; other types generally do. The following practices are recommended:

(1) Lubricant fittings should be cleaned before relubricating with grease.
(2) The proper amount of lubricant should be used. Too much lubricant results in churning, causing excessive power loss and overheating.
(3) The correct lubricant should be used.

Engine Maintenance. Engines should be kept clean, dry, and well lubricated. The proper oil level in the crankcase should be maintained.

Battery Maintenance. Only distilled water should be used in battery cells. Plates should be kept submerged at all times. An automatic battery charger is not a substitute for proper maintenance of the battery and charger. Periodic inspection ensures that the charger is operating correctly, the water level in the battery is adequate, and the battery is holding its proper charge.

An adequate water level in battery cells is established when the water level reaches the ring at the bottom of the cell fill connection. The use of distilled water in battery cells is also critical. Exhibit 8.48 shows a battery that was not properly maintained because the battery cells were refilled with tap water. Tap water contains impurities, which bridged the gap between the lead cells, causing the battery to fail. If there is any space in the top of the cell, hydrogen can accumulate in that space. If that occurs, an explosion could result when the pump starts.

It is important to make sure that the proper amount and type of lubricants are used to maintain bearings. Exhibit 8.49 shows a broken drive shaft that was caused by seized outboard bearings, while Exhibit 8.50 shows an over-greased outboard bearing.



EXHIBIT 8.48 *Battery Failure Due to Improper Maintenance. (Courtesy of Damon Pietraz, Underwood Fire Equipment)*

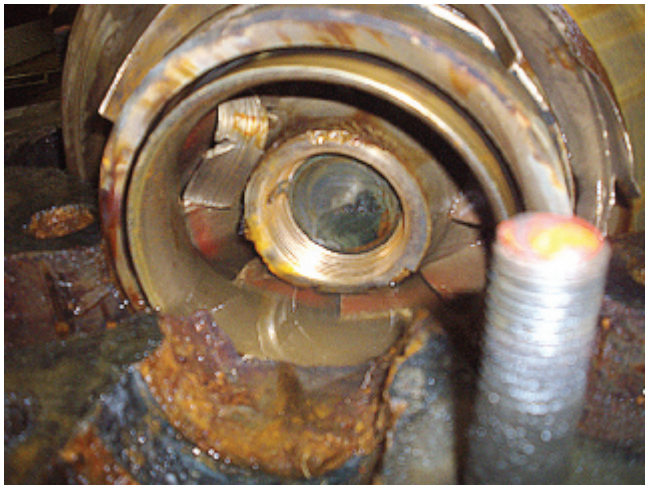
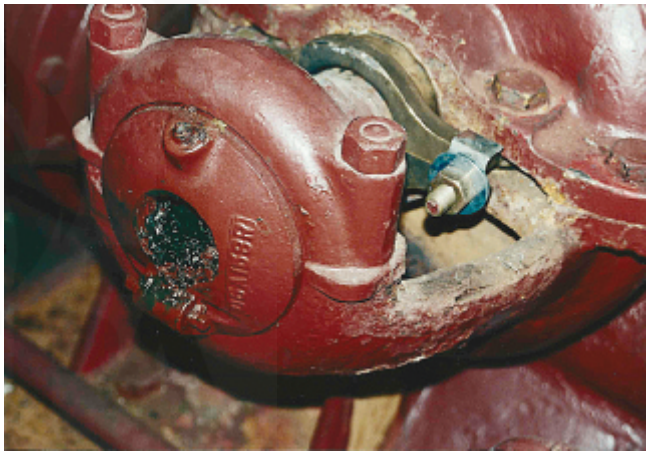


EXHIBIT 8.49 *Broken Pump Shaft Due to Seized Bearings. (Courtesy of Damon Pietraz, Underwood Fire Equipment)*

EXHIBIT 8.50 *Over-Greased Outboard Bearing. (Courtesy of Damon Pietraz, Underwood Fire Equipment)*



Fuel Supply Maintenance. The fuel storage tank should be kept at least two-thirds full. Fuel should be maintained free of water and foreign material by draining water and foreign material from the tank sump annually. This necessitates draining approximately 5 gal (19 L).

Fuel that is kept for longer than 1 year could contain biological growth that can clog the engine fuel filters. Therefore, fuel should be rotated or filtered annually and new biological inhibitors added. For more information on testing of diesel fuel, see the commentary following 8.3.4.1.1.

Temperature Maintenance. The temperature of the pump room, pump house, or area where engines are installed should never be less than the minimum recommended by the engine manufacturer. The manufacturer's temperature recommendations for water and oil heaters should be followed.

8.5.2 Records shall be maintained on all work performed on the pump, driver, controller, and auxiliary equipment.

8.5.3 The preventive maintenance program shall be initiated immediately after the pump assembly has passed acceptance tests.

As with every installation standard, once commissioning activity has been completed, the scope of the installation standard is no longer applicable and the scope (and frequencies) of the maintenance standard begins.

8.6 Component Replacement Testing Requirements.

Component replacement tables provide guidance to the user of the standard when system components are adjusted, repaired, rebuilt, or replaced. It is not necessary in each case to require a complete acceptance test for each component when maintenance is performed.

8.6.1 Whenever a component in a fire pump is adjusted, repaired, rebuilt, or replaced, the tests required to restore the system to service shall be performed in accordance with Table 8.6.1.

Δ ***TABLE 8.6.1*** *Summary of Component Action Requirements*

Component	*Adjust*	*Repair*	*Rebuild*	*Replace*	*Test Criteria*
Fire Pump System					
Entire pump assembly				X	Perform acceptance test in accordance with NFPA 20
Impeller/rotating assembly		X		X	Perform acceptance test in accordance with NFPA 20
Casing		X		X	Perform acceptance test in accordance with NFPA 20 with alignment inspection
Bearings				X	Perform annual test in accordance with 8.3.3
Sleeves				X	Perform annual test in accordance with 8.3.3
Wear rings				X	Perform annual test in accordance with 8.3.3
Main shaft		X		X	Perform annual test in accordance with 8.3.3
Packing	X			X	Perform test in accordance with 8.3.2
Mechanical Transmission					
Gear right-angle drives		X	X	X	Perform acceptance test in accordance with NFPA 20
Drive coupling	X	X	X	X	Perform test in accordance with 8.3.3 with alignment inspection
Electrical System/Controller					
Entire controller				X	Perform acceptance test in accordance with NFPA 20
Electronic component or module that can prevent the controller from starting or running			X	X	Perform acceptance test in accordance with NFPA 20
Electronic component or module that will not prevent the controller from starting or running			X	X	Perform weekly test in accordance with 8.3.2
Plumbing part				X	Perform weekly test in accordance with 8.3.2
Isolating switch				X	Perform test in accordance with 8.3.2 and exercise six times
Circuit breaker	X				Perform six momentary starts in accordance with NFPA 20
Circuit breaker				X	Test in accordance with 8.3.3, including six starts at peak load and operate pump for a minimum of 1 hour

(continues)

Δ ***TABLE 8.6.1*** *Continued*

Component	*Adjust*	*Repair*	*Rebuild*	*Replace*	*Test Criteria*
Electrical connections	X				Perform test in accordance with 8.3.2
Main contactor		X		X	Perform test in accordance with 8.3.3 with six starts
Power monitor				X	Perform six operations of the circuit breaker/isolation switch disconnect (cycle the power on/off)
Start relay				X	Perform test in accordance with 8.3.2 with six starts
Pressure switch	X			X	Perform test in accordance with 8.3.2 and exercise six times automatically
Pressure transducer	X			X	Perform six automatic no-load starts
Manual start or stop switch				X	Perform six operations under load
Transfer switch — load-carrying parts		X	X	X	Test in accordance with 8.3.3, including six starts at peak horsepower load, operate pump for a minimum of 1 hour, and transfer from normal power to emergency power and back one time
Transfer switch — no-load parts		X	X	X	Perform six no-load operations of transfer of power
Electric Motor Driver					
Electric motor		X	X	X	Perform acceptance test in accordance with NFPA 20 with alignment inspection
Motor bearings				X	Perform annual test in accordance with 8.3.3
Incoming power conductors				X	Test in accordance with 8.3.3 and operate pump for a minimum of 1 hour, including six starts at peak load
Diesel Engine Driver					
Entire engine			X	X	Perform acceptance test in accordance with NFPA 20 with alignment inspection
Fuel transfer pump	X		X	X	Perform test in accordance with 8.3.2
Fuel injector pump or ECM	X			X	Perform test in accordance with 8.3.3
Fuel system filter		X		X	Perform test in accordance with 8.3.2
Combustion air intake system		X		X	Perform test in accordance with 8.3.2
Fuel tank		X		X	Perform test in accordance with 8.3.2
Cooling system		X	X	X	Perform test in accordance with 8.3.3
Batteries				X	Perform start/stop sequence from replaced battery in accordance with 8.3.2
Battery charger		X		X	Perform test in accordance with 8.3.2
Electric system		X		X	Perform test in accordance with 8.3.2
Lubrication filter/oil service		X		X	Perform test in accordance with 8.3.2
Steam Turbines					
Steam turbine		X		X	Perform acceptance test in accordance with NFPA 20
Steam regulator or source upgrade		X		X	Perform acceptance test in accordance with NFPA 20
Positive Displacement Pumps					
Entire pump				X	Perform acceptance test in accordance with NFPA 20
Rotors				X	Perform annual test in accordance with 8.3.3
Plungers				X	Perform annual test in accordance with 8.3.3
Shaft				X	Perform annual test in accordance with 8.3.3
Driver		X	X	X	Perform acceptance test in accordance with NFPA 20
Bearings				X	Perform annual test in accordance with 8.3.3
Seals				X	Perform test in accordance with 8.3.2

Δ ***TABLE 8.6.1*** *Continued*

Component	*Adjust*	*Repair*	*Rebuild*	*Replace*	*Test Criteria*
Pump House and Miscellaneous Components					
Baseplate		X			Perform test in accordance with 8.3.2 with alignment inspection
Baseplate				X	Perform test in accordance with 8.3.3 with alignment inspection
Foundation		X	X	X	Perform test in accordance with 8.3.2 with alignment inspection
Suction/discharge pipe		X		X	Perform visual inspection in accordance with 8.2.2(2)
Suction/discharge fittings		X		X	Perform visual inspection in accordance with 8.2.2(2)
Suction/discharge valves		X	X	X	Perform operational test in accordance with 13.3.3.1

Table 8.6.1 is intended to be used only in the absence of the pump manufacturer's recommendations for maintenance. It is best to obtain the manufacturer's operations and maintenance manuals for a fire pump, because some manufacturers might have special requirements particular to their equipment. Failure to follow such requirements could result in damage to the pump or its components and could void any warranties.

8.6.2 NFPA 20 shall be consulted for the minimum requirements for design, installation, and acceptance testing.

8.6.3 Replacement parts shall be provided that will maintain the listing for the fire pump component assembly whenever possible.

8.6.3.1 If the part is no longer available from the original equipment manufacturer, then an approved like part shall be permitted to be used.

References Cited in Commentary

ANSI Publications. American National Standards Institute, Inc., 25 West 43rd Street, 4th Floor, New York, NY 10036.

ANSI B11.19, *Performance Requirements for Safeguarding*, 2010.

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2019 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, 2019 edition.

NFPA 70®, *National Electrical Code®*, 2017 edition.

NFPA *70E®*, *Standard for Electrical Safety in the Workplace®*, 2018 edition.

NFPA 72®, *National Fire Alarm and Signaling Code®*, 2019 edition.

NFPA 110, *Standard for Emergency and Standby Power Systems,* 2016 edition.

Isman, K. E. and M.T. Puchovsky, *Pumps for Fire Protection Systems,* 2002 edition.

Fire Protection Research Foundation, 1 Batterymarch Park, Quincy, MA 02169-7471.

"Fire Pump Field Data Collection and Analysis," April 2012.

No-Flow Condition Fire Pump (Non-Variable Speed) Test

Purpose

The purpose of completing a no-flow condition test of a fire pump is to verify that the fire pump will start under automatic conditions and run without overheating or developing unacceptable operating conditions. In meeting this objective, a variety of normal operating conditions are to be observed during the test.

Tools/Equipment

1. A handheld tachometer is required to measure the operating speed of the fire pump.
2. The various wrenches and tools necessary to facilitate any required adjustments during the test are required.
3. A timing device is needed to measure the fire pump run time duration.
4. A form for recording test data is required.

Procedure Steps

Electric-Driven Fire Pump

1. Prior to any testing, notify the fire department and/or the alarm monitoring company (as needed), as well as the facility representatives, that testing is going to be conducted.
2. The inspection activities required by Section 8.2 should be completed prior to any testing of the fire pump to ensure its readiness for testing.
3. Review the fire pump assembly nameplates noting the voltage rating, rated speed, and churn pressure for the unit.
4. Prior to operation of the fire pump, record the suction and discharge pressures. For fire pump controllers that use electronic pressure sensors, record the current pressure reading as well as the highest and lowest pressures indicated on the fire pump controller event log. Where these values are outside the expected range, a record of the entire event log must be made and further investigation of the condition conducted. Appropriate corrective action should be taken prior to conducting the no-flow condition test.
5. Check the area surrounding any relief valve or cooling water discharge outlets to ensure that there are no obvious conditions that would prevent water from being discharged safely or cause direct damage in the immediate vicinity. Where the discharge of water is to an area subject to potential freezing conditions, the facility representative should be advised of the potential for icing conditions.
6. Consider closing the fire pump discharge control valve prior to conducting the test. This can be done to limit the exposure of the connected systems to the resultant pressure surge during the start-up of the fire pump. (See Section 4.4 and accompanying commentary.)
7. For pressure-actuated fire pump controllers, simulate an automatic start for the fire pump by creating a pressure drop in the sensing line to the fire pump controller. This is typically accomplished by slowly opening the drain valve on the sensing line located near the fire pump controller until the fire pump starts automatically. The use of the "start" button on the fire pump controller is not acceptable for the purpose of simulating an automatic start. Note the start time of the fire pump to measure the run time duration and record the starting pressure. For pressure-actuated fire pump controllers that use an automatic timer, an automatic opening of a solenoid valve in the sensing line to the fire pump controller might be used to simulate the automatic start of the fire pump. These systems must include a record of the pressure drop on the pressure recorder for the controller. For non-pressure-actuated fire pump controllers, the automatic start can be simulated by other means.

   In all cases, the attendance of qualified personnel is required whenever the fire pump is in operation.
8. Immediately check the operating speed of the motor, noting the time required to reach rated speed. The motor should reach rated speed within 20 seconds. The measurement can be taken with a handheld tachometer. Note that the use of a strobe-type handheld tachometer requires advance preparation prior to the test for proper measurement, including the application of reflective tape on the shaft and/or removal of protective covers that shield the rotating shaft.
9. For reduced-voltage start or reduced-current start fire pump controllers, record the time the controller remains in the first step voltage. This transition is characterized by a distinct change in the sound of the motor rotation speed as the controller voltage/current goes to full output. The maximum time to transition to full voltage/current should not exceed 10 seconds.
10. Check the fire pump packing gland for a slight discharge (slow drip) of water, adjusting the packing gland nuts as needed to achieve approximately 1 drip per second. For safety purposes, the adjustment of the packing gland should be made while the pump is not running. Care should be exercised to ensure the glands are not tightened to the point of breaking.
11. Monitor the fire pump operation for any unusual noise, vibration, or other signs of malfunction.
12. Verify that the operation of the circulation (casing) relief valve has a steady stream of water to ensure proper cooling of the pump case.

13. If the fire pump is equipped with a main pressure relief valve, verify the operation of the pressure relief valve such that outlet pressures do not exceed the pressure rating of the piping downstream of the fire pump. Usually, this rating is 175 psi (12.1 bar); however, some systems are designed for higher pressures.

14. Record the suction and discharge pressures. Note that for vertical turbine pumps, only the discharge pressure is recorded.

15. Record the pressure at the fire pump controller pressure switch or pressure transducer, and compare it with the discharge pressure recorded above.

16. Check the packing gland box, shaft bearings, and pump casing for overheating approximately every 5 minutes during the test. The packing gland box and shaft bearings might be warm to the touch, and the pump casing should remain cool.

17. Allow the fire pump to continue operating uninterrupted for 10 minutes, rechecking for overheating periodically during the test, and then shut down manually at the end of the 10-minute duration. Note that some fire pump controllers might include automatic run timers that automatically shut down the pump after a specified run time. For these controllers, check the run time for the fire pump to ensure the required 10 minutes has elapsed.

18. If closed, reopen the fire pump discharge control valve and conduct a valve status test downstream of the closed valve.

19. Restore the fire pump to the automatic operating position.

20. Upon completion of all testing, notify the fire department and/or the alarm monitoring company (as needed), as well as the facility representatives that testing is complete. Reset fire alarm system as necessary.

Diesel-Driven Fire Pump

1. Prior to any testing, notify the fire department and/or the alarm monitoring company (as needed), as well as the facility representatives, that testing is going to be conducted.

2. The inspection activities required by Section 8.2 should be completed prior to any testing of the fire pump to ensure its readiness for testing.

3. Review the fire pump assembly nameplates, noting the rated speed and churn pressure for the unit.

4. Prior to operation of the fire pump, record the suction and discharge pressures. For fire pump controllers that use electronic pressure sensors, record the current pressure reading as well as the highest and lowest pressures indicated on the fire pump controller event log. Where these values are outside of the expected range, a record of the entire event log must be made and further investigation of the condition conducted. Appropriate corrective action should be taken prior to conducting the test.

5. Check the area surrounding any relief valve or cooling water discharge outlets to ensure that there are no obvious conditions that would prevent water from being discharged safely or cause direct damage in the immediate vicinity. Where the discharge of water is to an area subject to potential freezing conditions, the facility representative should be advised of the potential for icing conditions.

6. Consider closing the fire pump discharge control valve prior to conducting the test, to limit the exposure of the connected systems to the resultant pressure surge during the start-up of the fire pump. (See Section 4.4 and accompanying commentary.)

7. For pressure-actuated fire pump controllers, simulate an automatic start for the fire pump by creating a pressure drop in the sensing line to the fire pump controller. This is typically accomplished by slowly opening the drain valve on the sensing line located near the fire pump controller until the fire pump starts automatically. The use of the "start" button on the fire pump controller is not acceptable for the purpose of simulating an automatic start. Note the start time of the fire pump to measure the run time duration and record the starting pressure. For pressure-actuated fire pump controllers that use an automatic timer, an automatic opening of a solenoid valve in the sensing line to the fire pump controller might be used to simulate the automatic start of the fire pump. These systems must include a record of the pressure drop on the pressure recorder for the controller. For non-pressure-actuated fire pump controllers, the automatic start can be simulated by other means. In all cases, the attendance of qualified personnel is required whenever the fire pump is in operation.

8. Observe the amount of time required for the diesel engine to crank. Delays in starting of the engine should be investigated further, and corrective action should be taken as necessary. Typically, the controller will attempt three 15-second crank cycles before registering a failure-to-start trouble condition.

9. Immediately check the operating speed of the diesel engine, noting the time required to reach rated speed. The engine should reach rated speed within 20 seconds. The measurement can be taken from the engine instrument panel and can be verified by a handheld tachometer if necessary. Note that the use of a strobe-type handheld tachometer requires advance preparation prior to the test for proper measurement, including the application of reflective tape on the shaft and/or removal of protective covers that shield the rotating shaft.

No-Flow Condition Fire Pump (Non-Variable Speed) Test *(Continued)*

10. Observe the engine instrument panel to ensure that the engine oil pressure, operating speed, water and oil temperature, and charging rate are within the acceptable range, rechecking approximately every 5 minutes during the test.
11. Check the fire pump packing gland for a slight discharge (slow drip) of water, adjusting the packing gland nuts as needed to achieve approximately 1 drip per second. For safety purposes, the adjustment of the packing gland should be made while the pump is not running. Care should be exercised to ensure the glands are not tightened to the point of breaking.
12. Monitor the fire pump operation for any unusual noise, vibration, or other signs of malfunction.
13. For radiator-cooled diesel fire pumps, verify that the operation of the circulation (casing) relief valve has a steady stream of water to ensure proper cooling of the pump case.
14. For heat exchanger-cooled diesel fire pumps, verify that the heat exchanger has a proper flow of cooling water.
15. If the fire pump is equipped with a main pressure relief valve, verify the operation of the pressure relief valve such that outlet pressures do not exceed the pressure rating of the piping downstream of the fire pump. Usually, this rating is 175 psi (12.1 bar); however, some systems are designed for higher pressures.
16. Record the suction and discharge pressures. Note that for vertical turbine pumps, only the discharge pressure is recorded.
17. Record the pressure at the fire pump controller pressure switch or pressure transducer, and compare it with the discharge pressure recorded above.
18. Check the packing gland box, shaft bearings, and pump casing for overheating approximately every 5 minutes during the test. The packing gland box and shaft bearings might be warm to the touch, and the pump casing should remain cool.
19. Allow the fire pump to continue operating for 30 minutes. Recheck for overheating and abnormal readings on the engine instrument panel periodically during the test, and then shut down manually. Any observed abnormalities are to be recorded. Note that some fire pump controllers might include automatic run timers that automatically shut down the pump after a specified run time. For these controllers, check the run time for the fire pump to ensure the required 30 minutes has elapsed.
20. If closed, reopen the fire pump discharge control valve and conduct a valve status test downstream of the closed valve.
21. Inspect and clean any installed intake screens.
22. Where the fire pump controller is so equipped, replace any pressure recorder charts and rewind as necessary.
23. Restore the fire pump to the automatic operating position.
24. Upon completion of all testing, notify the fire department and/or the alarm monitoring company (as needed), as well as the facility representatives, that testing is complete. Reset the fire alarm system as necessary.

Evaluation of Results

An evaluation of the recorded test pressure should be conducted by comparing the test results with previous test results and by assessing the churn pressure achieved during the conduct of the test with the nameplate data on the fire pump unit. The churn pressure for a centrifugal pump is determined by subtracting the recorded suction pressure from the discharge pressure. For a vertical turbine pump, the churn pressure is determined by adding the elevation pressure difference between the water level in the wet pit or well supplying the pump and the discharge gauge to the recorded discharge pressure on the pump.

The elevation pressure difference is determined by multiplying the height differential in feet between the water level in the wet pit or well and the discharge gauge by 0.433 to determine a pressure difference in psi (height differentials in meters are converted to bar using a 0.0981 multiplier). A drop in churn pressure of more than 5 percent below the nameplate data should be investigated, and corrective action should be taken as necessary. It should be noted that the operation of a relief valve during the test will not result in true churn/no-flow conditions and should be considered in evaluating the results of the pressure readings for the fire pump.

Note that, at any time during the test, should abnormal conditions be observed that might result in personal injury or damage to the equipment or property, the fire pump should be immediately shut down and the test terminated until the cause can be investigated and corrective action taken as necessary.

Additionally, all abnormal conditions observed during the test, including those specified in the testing procedures above, should be referred for further investigation and corrective action taken as necessary. Minor field adjustments to correct for packing gland leakage rate, casing relief or cooling water discharge, or other situations might be conducted as part of the testing procedure.

The procedure(s) outlined above is not mandated by NFPA 25 and represents only one approach to conducting this test.

Annual Fire Pump (Non-Variable Speed) Flow Test

Purpose

The purpose of completing an annual flow test is to verify the adequacy of the fire pump performance through its range of operating conditions. In meeting this objective, a variety of normal operating conditions and performance measures are to be observed during the test.

Testing Via Hose Streams

Tools/Equipment

1. A handheld tachometer[1] is required to measure the operating speed of the fire pump.
2. A pitot tube together with a test-pressure gauge[2], suitable for the pressures to be expected, is required. [Usually, a 60 psi (4 bar) gauge is satisfactory.]

   A pitot-tube-and-gauge assembly is indispensable for conducting flow tests from nozzles. The small opening at the end of the tube — not more than 1/16 in. (1.6 mm) in diameter — is inserted in the center of the stream, in a direct line with the flow, at a distance in front of the opening equal to one-half the opening diameter. Velocity pressure is registered on the gauge attached to the tube.

   Some available test nozzles include an integral pitot tube or pitotless flow-measuring feature with an attached test gauge[2] allowing for direct measurement of flows without the use of a separate pitot tube.
3. Test-pressure gauges[2] suitable for measurement of the expected suction and discharge pressures on the fire pump are required. Note that the pressure gauge used on the suction side of the fire pump should be a compound pressure and vacuum gauge having pressure range of at least twice the static pressure available from the suction supply. The pressure gauge used on the discharge side of the fire pump should have a range of at least twice the rated working pressure of the fire pump.
4. A sufficient number of test nozzles are required, including hoses for connections where needed, to permit the measurement of a flow rate up to 150 percent of the rated capacity of the fire pump. [Typically 50 ft (15.2 m) lengths of lined 2½ in. (65 mm) hose are used for this purpose.] Test nozzles can include UL play pipes or other approved test nozzles. The flow characteristics (i.e., discharge coefficients) of the test nozzles must be known.
5. The various wrenches and tools necessary to facilitate required adjustments during the test and for the installation of the required test equipment are required.
6. A multimeter[1] and/or clamp-on ammeter[1] is required for taking voltage and amperage readings.
7. A timing device is required to measure the fire pump run time duration.
8. The required personal protective equipment for the job is needed. See Commentary Table 4.2.
9. A form for recording test data is required.

Procedure Steps

Electric-Driven Fire Pump

1. Prior to any testing, notify the fire department and/or the alarm monitoring company (as needed), as well as the facility representatives, that testing is going to be conducted.
2. The inspection activities required by Section 8.2 should be completed prior to any testing of the fire pump to ensure its readiness for testing.
3. Complete a check of the parallel and angular alignment of the fire pump and driver in accordance with 8.3.6.4.
4. Review the fire pump assembly nameplates, noting the following:
   a. Voltage rating
   b. Rated speed
   c. Rated capacity
   d. Churn pressure
   e. Rated pressure
   f. Overload pressure
5. Consider closing the fire pump discharge control valve prior to conducting the test, to limit the exposure of the connected systems to the resultant pressure surge during the start-up of the fire pump. (See Section 4.4 and accompanying commentary.)
6. Remove the installed pressure gauges on the suction and discharge side of the fire pump. Install the appropriate calibrated pressure gauges at each location. Note that for a vertical turbine fire pump there will only be a discharge pressure gauge.
7. Install sufficient flow measuring equipment, fed from the test header, to allow for the overload flow rate (150 percent flow) required to test the fire pump. This might include the use of hose connected to the test header and extending to flow measurement devices such as UL play pipes or other test nozzles that are adequately secured or protected against movement. In some cases, connecting the flow measurement devices directly to the test header might be

1 All test equipment should be calibrated by an approved testing laboratory within 12 months prior to the test.

2 Test-quality gauges should be used in accordance with ASME B40.100, *Pressure Gauges and Gauge Attachments*, having an accuracy of ±1%. The use of quality test gauges produces results that are considered reasonably accurate within the scope of the testing procedure. Care should be taken to protect the gauges from rough handling.

Gauges should be calibrated at least annually by means of a dead-weight or calibrated tester throughout the range of operation before a test series is started. Calibration sheets should be kept for each gauge and correction factors affixed to the back of each gauge.

Annual Fire Pump (Non-Variable Speed) Flow Test *(Continued)*

possible. The use of a flow diffuser can aid in preventing movement, breaking the directed stream, and managing resultant energy of the discharge.

8. Check the area surrounding any relief valve or cooling water discharge outlets — as well as the discharge points for the fire pump flow — to ensure that there are no obvious conditions that would prevent water from being discharged safely or cause direct damage in the immediate vicinity. Take appropriate caution to ensure personnel and property are protected from the resultant high-pressure hose stream discharge. The use of a flow diffuser can aid in breaking the directed stream and managing resultant energy of the discharge. Where the discharge of water is to an area subject to potential freezing conditions, the facility representative should be advised of the potential for icing conditions.

9. For testing using hose-connected flow measuring devices or UL play pipes directly connected to the test header, ensure that the individual hose connection valves on the test header are in the closed position. Slowly open the main test header control valve pressurizing the test header. For other flow-measuring devices directly connected to the test header, ensure that the main test header control valve is closed. Then, fully open a single hose connection valve readying the arrangement for the first flow point with the flow being controlled by the main test header control valve. Any time the use of an additional hose connection valve is required with this latter arrangement, the additional hose connection valves are to be fully opened and the flow again controlled by the adjustment of the main test header control valve, rather than the individual hose connection valves.

10. For pressure-actuated fire pump controllers where the fire pump does not automatically start as a result of completing Step 9 above, simulate an automatic start for the fire pump by creating a pressure drop in the sensing line to the fire pump controller. This is typically accomplished by slowly opening the drain valve on the sensing line located near the fire pump controller until the fire pump starts automatically. The use of the "start" button on the fire pump controller is not acceptable for the purpose of simulating an automatic start. Note the start time of the fire pump to measure the run time duration, and record the starting pressure. For pressure-actuated fire pump controllers that use an automatic timer, an automatic opening of a solenoid valve in the sensing line to the fire pump controller might be used to simulate the automatic start of the fire pump. These systems must include a record of the pressure drop on the pressure recorder for the controller. For non-pressure-actuated fire pump controllers, the automatic start can be simulated by other means.

11. Check the fire pump packing gland for a slight discharge (slow drip) of water, adjusting the packing gland nuts as needed to achieve approximately 1 drip per second. For safety purposes, the adjustment of the packing gland should be made while the pump is not running. Care should be exercised to ensure the glands are not tightened to the point of breaking.

12. Monitor the fire pump operation for any unusual noise, vibration, or other signs of malfunction.

13. Verify that the operation of the circulation (casing) relief valve has a steady stream of water to ensure proper cooling of the pump case.

14. Check the packing gland box, shaft bearings, and pump casing for overheating approximately every 5 minutes during the test. The packing gland box and shaft bearings might be warm to the touch, and the pump casing should remain cool throughout the test.

15. If the fire pump is equipped with a main pressure relief valve, verify the operation of the pressure relief valve such that outlet pressures do not exceed the pressure rating of the piping downstream of the fire pump. Usually, this rating is 175 psi (12.1 bar); however, some systems are designed for higher pressures.

16. Record the electric motor voltage and current on all phases (lines). This can be done with a multimeter and/or clamp-on ammeter. However, these readings should only be taken by individuals trained and qualified in electrical hazards and equipped with the needed safety equipment as outlined in NFPA *70E®*, *Standard for Electrical Safety in the Workplace®*. See 8.3.3.14 and Section 4.9, along with the associated commentary, for additional guidance. Alternatively, some newer fire pump controllers include a display of the voltage and amperage readings on the front of the controller.

17. Record the suction and discharge pressures. Note that for vertical turbine pumps, only the discharge pressure is recorded.

18. Record the operating speed (rpm) of the motor. The measurement can be taken with a handheld tachometer. Note that the use of a strobe-type handheld tachometer requires advance preparation prior to the test for proper measurement; this includes the application of reflective tape on the shaft and/or removal of protective covers that shield the rotating shaft.

19. For systems equipped with a main pressure relief valve as described in Step 15 above, adjust the pressure relief valve to temporarily stop the relief valve operation and repeat Step 16 through Step 18 above, then re-adjust the main relief valve to the normal operating position, and continue with Step 20 below.

20. Data recorded in Step 16 through Step 19 should be noted as the churn test point.

21. Initiate the flow from the test header by either slowly opening one of the hose connection control valves on the test header or by slowly opening the main test header control valve, depending on the arrangement selected in Step 9 above. As the valve is opened, take flow measurements to

determine the flow rate, adjusting the valve position until a measured flow rate equal to the rated capacity from the nameplate on the fire pump is achieved. Where the flow rate with the valve fully open is inadequate to meet this rated capacity, additional hose connection valves must be opened and adjustments made until the total measured flow rate equals the rated capacity. The flow rate should be stabilized as much as possible prior to taking the final flow measurements. When using multiple outlets, the final measurement on all outlets cannot accurately be made until all adjustments have been completed. See the discussion regarding flow measurement calculations near the end of this testing procedure.

22. Repeat Step 16 through Step 19 above, then continue with Step 23 below. The data recorded should be noted as the rated (or 100 percent flow) test point.

23. Continue to open hose valves and/or the main test header control valve, depending on the arrangement selected in Step 9 above. Take flow measurements to determine the flow rate; adjust the position of the valve(s) until a total measured flow rate equal to the 150 percent of the rated capacity from the nameplate on the fire pump is achieved, or until the maximum available flow rate available from the water supply is met, whichever is lower. The flow rate should be stabilized as much as possible prior to taking the final flow measurements. When using multiple outlets, the final measurement on all outlets cannot accurately be made until all adjustments have been completed. Care must be taken to ensure that the suction pressure does not fall below an acceptable level as the flow rate is increased to 150 percent. NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection,* allows a pressure at the suction flange of 0 psi (0 bar) for fire pumps connected to municipal supplies and –3 psi (–0.2 bar) for fire pumps taking suction from a grade level tank. Local water authorities might require a higher maintained pressure [commonly 20 psi (1.4 bar)] at the point of connection to the municipal supply.

24. Repeat Step 16 through Step 19 above, then continue with Step 25 below. The data recorded should be noted as the overload (or 150 percent flow) test point.

25. For installations including an automatic transfer switch, simulate a power failure condition and verify the following:

    a. That the transfer switch transitions to an alternate power source with continued operation of the fire pump

    b. That the operation of the pump continues for 10 minutes when the alternate power supply is from a separate electrical connection, or 30 minutes when the alternate power supply is from a standby generator set. Restore the normal power source and verify that the transfer switch transitions back to the normal power supply with continued operation of the fire pump.

26. Shut down the discharge flow by slowly closing the main test header control valve to avoid water hammer.

27. If the run time for the fire pump has not reached 10 minutes, then allow the fire pump to continue operating until a total run time of 10 minutes has elapsed, and then shut down manually upon completion of the test.

28. Verify the closure of the circulation relief valve and pressure relief valve (if installed) upon completion of the test.

29. Plot test the data against the manufacturer's specifications *before* removing test equipment, to verify that a retest is not required due to bad data recording or other reasons.

30. Remove all attached test equipment from the test header. Restore the closed position of all hose connection valves, and reinstall the hose caps. In locations subject to freezing, check that the test header properly drains or pumps out as necessary.

31. Remove the calibrated pressure gauges, and reinstall the original pressure gauges on the suction and discharge side of the fire pump.

32. Inspect and clean any installed intake screens.

33. Initiate a fire pump phase reversal supervisory signal by jumping across the monitored points in the fire pump controller (typically labeled on a wiring diagram posted on the inside of the fire pump controller) to simulate an activation. Verify that all of the fire pump supervisory signals, such as fire pump running, loss of power, or phase reversal, have been indicated at the fire pump controller as well as transmitted to any connected fire alarm control panels.

34. If closed, reopen the fire pump discharge control valve and conduct a valve status test downstream of the closed valve.

35. Restore the fire pump to the automatic operating position.

36. Upon completion of all testing, notify the fire department and/or the alarm monitoring company (as needed), as well as the facility representatives, that testing is complete. Reset the fire alarm system as necessary. A verification of the receipt of initiated signals with the fire department and/or the alarm monitoring company, where so connected, would be appropriate as part of this effort.

Diesel-Driven Fire Pump

1. Prior to any testing, notify the fire department and/or the alarm monitoring company (as needed), as well as the facility representatives, that testing is going to be conducted.

2. The inspection activities required by Section 8.2 should be completed prior to conducting any testing of the fire pump to ensure its readiness for testing.

3. Complete a check of the parallel and angular alignment of the fire pump and driver in accordance with 8.3.6.4.

Annual Fire Pump (Non-Variable Speed) Flow Test *(Continued)*

4. Review the fire pump assembly nameplates, noting the following:
    a. Rated speed
    b. Rated capacity
    c. Churn pressure
    d. Rated pressure
    e. Overload pressure
5. Where the pump churn pressure will exceed the rated pressure for the system components, the fire pump discharge control valve must be closed prior to the operation of the fire pump to limit the exposure of the connected systems to the resultant elevated pressures at churn. For all other systems, consider closing the fire pump discharge control valve prior to the test to limit the exposure of the connected systems to the resultant pressure surge during the start-up of the fire pump.
6. Remove the installed pressure gauges on the suction and discharge side of the fire pump, and install the appropriate calibrated pressure gauges at each location. Note that for a vertical turbine fire pump, there will only be a discharge pressure gauge.
7. Install sufficient flow measuring equipment, fed from the test header, to allow for the overload flow rate (150 percent flow) required to test the fire pump. This might include the use of hose connected to the test header and extending to flow measurement devices, such as UL play pipes or other test nozzles that are adequately secured or protected against movement. In some cases, the connection of the flow measurement devices directly to the test header might be possible. The use of a flow diffuser can aid in preventing movement, as well as breaking the directed stream and managing resultant energy of the discharge.
8. Check the area surrounding any relief valve or cooling water discharge outlets as well as the discharge points for the fire pump flow to ensure that there are no obvious conditions that would prevent water from being discharged safely or cause direct damage in the immediate vicinity. Take appropriate caution to ensure personnel and property are protected from the resultant high-pressure hose stream discharge. The use of a flow diffuser can aid in breaking the directed stream and managing resultant energy of the discharge. Where the discharge of water is to an area subject to potential freezing conditions, the facility representative should be advised of the potential for icing conditions.
9. For testing using hose-connected flow measuring devices or UL play pipes directly connected to the test header, ensure that the individual hose connection valves on the test header are in the closed position and slowly open the main test header control valve pressurizing the test header. For other flow-measuring devices directly connected to the test header, ensure that the main test header control valve is closed. Then fully open a single hose connection valve, readying the arrangement for the first flow point, with the flow being controlled by the main test header control valve. Any time the use of an additional hose connection valve is required with this latter arrangement, the additional hose connection valves are to be fully opened. The flow should again be controlled by the adjustment of the main test header control valve rather than the individual hose connection valves.
10. For pressure-actuated fire pump controllers where the fire pump does not automatically start as a result of completing Step 9 above, simulate an automatic start for the fire pump by creating a pressure drop in the sensing line to the fire pump controller. This is typically accomplished by slowly opening the drain valve on the sensing line located near the fire pump controller until the fire pump starts automatically. The use of the "start" button on the fire pump controller is not acceptable for the purpose of simulating an automatic start. Note the start time of the fire pump to measure the run time duration, and record the starting pressure. For pressure-actuated fire pump controllers that use an automatic timer, an automatic opening of a solenoid valve in the sensing line to the fire pump controller might be used to simulate the automatic start of the fire pump. These systems must include a record of the pressure drop on the pressure recorder for the controller. For non-pressure-actuated fire pump controllers, the automatic start can be simulated by other means.
11. Observe the engine instrument panel to ensure that the engine oil pressure, operating speed, water and oil temperature, and charging rate are within the acceptable range, rechecking approximately every 5 minutes.
12. Check the fire pump packing gland for a slight discharge (slow drip) of water, adjusting the packing gland nuts as needed to achieve approximately 1 drip per second. For safety purposes, the adjustment of the packing gland should be made while the pump is not running. Care should be exercised to ensure the glands are not tightened to the point of breaking.
13. Monitor the fire pump operation for any unusual noise, vibration, or other signs of malfunction.
14. For radiator-cooled diesel fire pumps, verify that the operation of the circulation (casing) relief valve has a steady stream of water to ensure proper cooling of the pump case.
15. For heat exchanger-cooled diesel fire pumps, verify that the heat exchanger has a proper flow of cooling water.
16. Check the packing gland box, shaft bearings, and pump casing for overheating approximately every 5 minutes during the test. The packing gland box and shaft bearings might be warm to the touch, and the pump casing should remain cool throughout the test.
17. If the fire pump is equipped with a main pressure relief valve, verify the operation of the pressure relief valve such

that outlet pressures do not exceed the pressure rating of the piping downstream of the fire pump. Usually, this rating is 175 psi (12.1 bar). However, some systems are designed for higher pressures.

18. Record the suction and discharge pressures. Note that for vertical turbine pumps, only the discharge pressure is recorded.

19. Record the operating speed (rpm) of the motor. The measurement can be taken with a handheld tachometer. Note that the use of a strobe-type handheld tachometer requires advance preparation prior to the test for proper measurement, including the application of reflective tape on the shaft and/or removal of protective covers that shield the rotating shaft.

20. For systems equipped with a main pressure relief valve as described in Step 17 above, adjust the pressure relief valve to temporarily stop the relief valve operation. Then, repeat Step 18 and Step 19 as described above, re-adjust the main relief valve to the normal operating position, and continue with Step 21 below.

21. The data recorded in Step 18 through Step 20 should be noted as the churn test point.

22. Initiate the flow from the test header by either slowly opening one of the hose connection control valves on the test header or by slowly opening the main test header control valve, depending on the arrangement selected in Step 9 above. As the valve is opened, take flow measurements to determine the flow rate, adjusting the valve position until a measured flow rate equal to the rated capacity from the nameplate on the fire pump is achieved. Where the flow rate with the valve fully open is inadequate to meet this rated capacity, additional hose connection valves must be opened and adjustments made until the total measured flow rate equals the rated capacity. The flow rate should be stabilized as much as possible prior to taking the final flow measurements. When using multiple outlets, the final measurement on all outlets cannot accurately be made until all adjustments have been completed. See the discussion of flow measurement calculations near the end of this testing procedure.

23. Repeat Step 18 through Step 20 above, then continue with Step 24 below. The data recorded should be noted as the rated (or 100 percent flow) test point.

24. Continue to open hose valves and/or the main test header control valve, depending on the arrangement selected in Step 9 above. Take flow measurements to determine the flow rate, adjusting the position of the valve(s) until a total measured flow rate equal to the 150 percent of the rated capacity from the nameplate on the fire pump is achieved or until the maximum available flow rate available from the water supply is met, whichever is lower. The flow rate should be stabilized as much as possible prior to taking the final flow measurements. When using multiple outlets, the final measurement on all outlets cannot accurately be made until all adjustments have been completed. Care must be taken to ensure that the suction pressure does not fall below an acceptable level as the flow rate is increased to 150 percent. NFPA 20 allows a pressure at the suction flange of 0 psi (0 bar) for fire pumps connected to municipal supplies and –3 psi (–0.2 bar) for fire pumps taking suction from a grade level tank. Local water authorities might require a higher maintained pressure [commonly 20 psi (1.4 bar)] at the point of connection to the municipal supply.

25. Repeat Step 18 and Step 19 above, then continue with Step 26 below. Data recorded should be noted as the overload (or 150 percent flow) test point.

26. Shut down the discharge flow by slowly closing the main test header control valve to avoid water hammer.

27. If the run time for the fire pump has not reached 30 minutes, then allow the fire pump to continue operating until a total run time of 30 minutes has elapsed. Then, shut it down manually upon completion of the test.

28. For engines that use an electronic fuel management control system, complete the following additional tests:

    a. Move the electronic control module (ECM) selector switch from the primary to the alternate position.

    b. Verify an alarm signal at the fire pump controller.

    c. Manually start the fire pump and verify normal operation.

    d. Manually shut down the fire pump.

    e. Reposition the ECM switch back to the primary position.

    f. Manually start the fire pump and verify the normal operation.

    g. With the fire pump still operating, disconnect the wire connection for each of the primary sensors for the ECM, verify the continued operation of the fire pump, and then reconnect the wires. Repeat the process on that same sensor removing the wires from the redundant sensor. This process should be completed for all of the primary and redundant sensors on the engine.

    h. Upon completion of the testing of all primary and redundant sensors, shut down the fire pump manually.

29. Verify the closure of the circulation relief and pressure relief valves (if installed) upon completion of the test.

30. Plot the test data against the manufacturer's specifications *before* removing test equipment, to verify a retest is not required due to bad data recording or other reasons.

31. Remove all attached test equipment from the test header, restore the closed position of all hose connection valves,

Annual Fire Pump (Non-Variable Speed) Flow Test *(Continued)*

and reinstall hose caps. In locations subject to freezing, check that the test header properly drains or pumps out as necessary.

32. Remove the calibrated pressure gauges. Reinstall the original pressure gauges on the suction and discharge side of the fire pump.
33. Inspect and clean any installed intake screens.
34. Initiate the various fire pump supervisory signals, such as low oil pressure, high coolant temperature, failure to start, or engine overspeed, to simulate an activation at the individual sensors. Verify that all of the fire pump supervisory signals, such as pump running, low oil pressure, high coolant temperature, failure to start, or engine overspeed, have been indicated at the fire pump controller as well as transmitted to any connected fire alarm panels.
35. If closed, reopen the fire pump discharge control valve and conduct a valve status test downstream of the closed valve.
36. Restore the fire pump to the automatic operating position.
37. Upon completion of all testing, notify the fire department and/or the alarm monitoring company (as needed), as well as the facility representatives, that testing is complete. Reset the fire alarm system as necessary. A verification of the receipt of initiated signals with the fire department and/or the alarm monitoring company, where so connected, would be appropriate as part of this effort.

Testing Via Flow Meter

Tools/Equipment

1. A handheld tachometer[1] is required to measure the operating speed of the fire pump.
2. Test-pressure gauges[2] suitable for measurement of the expected suction and discharge pressures on the fire pump are required. The pressure gauge used on the suction side of the fire pump should be a compound pressure and vacuum gauge having pressure range of at least twice the static pressure available from the suction supply. The pressure gauge used on the discharge side of the fire pump should have a range of at least twice the rated working pressure of the fire pump.
3. The various wrenches and tools necessary to allow for required adjustments during the test and for the installation of required test equipment are required.
4. A multimeter[1] and/or clamp-on ammeter[1] is required for taking voltage and amperage readings.
5. A timing device is needed to measure the fire pump run time duration.
6. The required personal protective equipment for the job is needed. See Commentary Table 4.2.
7. A form for recording test data is required.

Procedure Steps

Electric-Driven Fire Pump

1. Prior to any testing, notify the fire department and/or the alarm monitoring company (as needed), as well as the facility representatives, that testing is going to be conducted.
2. The inspection activities required by Section 8.2 should be completed prior to any testing of the fire pump to ensure its readiness for testing.
3. Complete a check of the parallel and angular alignment of the fire pump and driver in accordance with 8.3.6.4.
4. Review the fire pump assembly name plates noting the following:
   a. Voltage rating
   b. Rated speed
   c. Rated capacity
   d. Churn pressure
   e. Rated pressure
   f. Overload pressure
5. Where the pump churn pressure will exceed the rated pressure for the system components, the fire pump discharge control valve must be closed prior to the operation of the fire pump to limit the exposure of the connected systems to the resultant elevated pressures at churn. For all other systems, consider closing the fire pump discharge control valve prior to conducting the test, to limit the exposure of the connected systems to the resultant pressure surge during the start-up of the fire pump.
6. Remove the installed pressure gauges on the suction and discharge side of the fire pump. Install the appropriate calibrated pressure gauges at each location. Note that for a vertical turbine fire pump, there will only be a discharge pressure gauge.
7. Open the flow meter inlet control valve and ensure the flow meter outlet valve is closed.
8. Check the area surrounding any relief valve or cooling water discharge outlet — as well as the discharge points for the fire pump flow — to ensure that there are no obvious conditions that would prevent water from being discharged safely or cause direct damage in the immediate vicinity. Take appropriate caution to ensure personnel and property are protected from the resultant high-pressure discharge. Where the discharge of water is to an area subject to potential freezing conditions, the facility representative should be advised of the potential for icing conditions.
9. For pressure-actuated fire pump controllers, simulate an automatic start for the fire pump by creating a pressure drop in the sensing line to the fire pump controller. This is typically accomplished by slowly opening the drain

valve on the sensing line located near the fire pump controller until the fire pump starts automatically. The use of the "start" button on the fire pump controller is not acceptable for the purpose of simulating an automatic start. Note the start time of the fire pump to measure the run time duration and record the starting pressure. For pressure-actuated fire pump controllers that use an automatic timer, an automatic opening of a solenoid valve in the sensing line to the fire pump controller might be used to simulate the automatic start of the fire pump. These systems must include a record of the pressure drop on the pressure recorder for the controller. For non-pressure-actuated fire pump controllers, the automatic start can be simulated by other means.

10. Check the fire pump packing gland for a slight discharge (slow drip) of water, adjusting the packing gland nuts as needed to achieve approximately 1 drip per second. For safety purposes, the adjustment of the packing gland should be made while the pump is not running. Care should be exercised to ensure the glands are not tightened to the point of breaking.

11. Monitor the fire pump operation for any unusual noise, vibration, or other signs of malfunction.

12. Verify that the operation of the circulation (casing) relief valve has a steady stream of water to ensure proper cooling of the pump case.

13. Check the packing gland box, shaft bearings, and pump casing for overheating approximately every 5 minutes during the test. The packing gland box and shaft bearings might be warm to the touch, and the pump casing should remain cool throughout the test.

14. If the fire pump is equipped with a main pressure relief valve, verify the operation of the pressure relief valve such that outlet pressures do not exceed the pressure rating of the piping downstream of the fire pump. Usually, this rating is 175 psi (12.1 bar); however, some systems are designed for higher pressures.

15. Record the electric motor voltage and current on all phases (lines). This can be done with a multimeter and/or clamp-on ammeter. However, these readings should only be taken by individuals trained in and qualified in electrical hazards and equipped with the needed safety equipment as outlined in NFPA *70E®*, *Standard for Electrical Safety in the Workplace®*. Also see 8.3.3.14 and Section 4.9, along with the associated commentary, for additional guidance. Alternatively, some newer fire pump controllers include a display of the voltage and amperage readings on the front of the controller.

16. Record the suction and discharge pressures. Note that for vertical turbine pumps, only the discharge pressure is recorded.

17. Record the operating speed (rpm) of the motor. The measurement can be taken with a handheld tachometer. Note that the use of a strobe-type handheld tachometer requires advance preparation prior to the test for proper measurement, including the application of reflective tape on the shaft and/or removal of protective covers that shield the rotating shaft.

18. For systems equipped with a main pressure relief valve as described in Step 14 above, adjust the pressure relief valve to temporarily stop the relief valve operation and repeat Step 15 through Step 17 above. Then, re-adjust the main relief valve to the normal operating position, and continue with Step 19 below.

19. The data recorded in Step 15 through Step 18 should be noted as the churn test point.

20. Initiate the flow through the flow meter by slowly opening the flow meter throttling valve on the outlet side of the flow meter. Throttle the valve position to achieve a reading on the flow meter equal to the rated capacity from the nameplate on the fire pump. If the flow is circulated back to the fire pump suction, then the temperature of the re-circulated water must be monitored under flow conditions throughout the remainder of the test, to ensure that temperatures remain below that which would result in equipment damage, as defined by the pump and engine manufacturers.

21. Repeat Step 15 through Step 18 above, then continue with Step 23 below. The data recorded should be noted as the rated (or 100 percent flow) test point.

22. Continue to open the throttling valve to achieve a reading on the flow meter equal to the 150 percent of the rated capacity from the nameplate on the fire pump or until the maximum available flow rate available from the water supply is met, whichever is lower. Care must be taken to ensure that the suction pressure does not fall below an acceptable level as the flow rate is increased to 150 percent. NFPA 20 allows a pressure at the suction flange of 0 psi (0 bar) for fire pumps connected to municipal supplies and –3 psi (–0.2 bar) for fire pumps taking suction from a grade level tank. Local water authorities might require a higher maintained pressure [commonly 20 psi (1.4 bar)] at the point of connection to the municipal supply.

23. Repeat Step 15 through Step 18 above, then continue with Step 24 below. The data recorded should be noted as the overload (or 150 percent flow) test point.

24. For installations including an automatic transfer switch, simulate a power failure condition and verify the following:

    a. That the transfer switch transitions to an alternate power source with continued operation of the fire pump

    b. That the operation of the pump continues for 10 minutes when the alternate power supply is from a separate electrical connection, or 30 minutes when the alternate power supply is from a standby generator set. Restore the normal power source and verify that the transfer switch transitions back to the normal power supply with continued operation of the fire pump.

Annual Fire Pump (Non-Variable Speed) Flow Test *(Continued)*

25. Shut down the discharge flow by slowly closing the throttling valve to avoid water hammer.
26. If the run time for the fire pump has not reached 10 minutes, then allow the fire pump to continue operating until a total run time of 10 minutes has elapsed. Then, shut it down manually upon the completion of the test.
27. Verify the closure of the circulation relief valve and pressure relief valve (if installed) upon completion of the test.
28. Plot the test data against the manufacturer's specifications *before* removing test equipment, to verify a retest is not required due to bad data recording or other reasons.
29. Return the flow meter control valve to the closed position.
30. Remove the calibrated pressure gauges. Reinstall the original pressure gauges on the suction and discharge side of the fire pump.
31. Inspect and clean any installed intake screens.
32. Initiate a fire pump phase reversal supervisory signal by jumping across the monitored points in the fire pump controller (typically labeled on a wiring diagram posted on the inside of the fire pump controller) to simulate an activation. Verify that all of the fire pump supervisory signals, such as fire pump running, loss of power, or phase reversal, have been indicated at the fire pump controller as well as transmitted to any connected fire alarm control panels.
33. If closed, reopen the fire pump discharge control valve and conduct a valve status test downstream of the closed valve.
34. Restore the fire pump to the automatic operating position.
35. Upon completion of all testing, notify the fire department and/or the alarm monitoring company (as needed), as well as the facility representatives, that testing is complete. Reset the fire alarm system as necessary. A verification of the receipt of initiated signals with the fire department and/or the alarm monitoring company, where so connected, would be appropriate as part of this effort.

Diesel-Driven Fire Pump

1. Prior to any testing, notify the fire department and/or the alarm monitoring company (as needed), as well as the facility representatives, that testing is going to be conducted.
2. The inspection activities required by Section 8.2 should be completed prior to conducting any testing of the fire pump to ensure its readiness for testing.
3. Complete a check of the parallel and angular alignment of the fire pump and driver in accordance with 8.3.6.4.
4. Review the fire pump assembly nameplates, noting the following:
   a. Rated speed
   b. Rated capacity
   c. Churn pressure
   d. Rated pressure
   e. Overload pressure
5. Where the pump churn pressure will exceed the rated pressure for the system components, the fire pump discharge control valve must be closed prior to the operation of the fire pump to limit the exposure of the connected systems to the resultant elevated pressures at churn. For all other systems, consider closing the fire pump discharge control valve prior to the test to limit the exposure of the connected systems to the resultant pressure surge during the start-up of the fire pump.
6. Remove the installed pressure gauges on the suction and discharge side of the fire pump, and install the appropriate calibrated pressure gauges at each location. Note that for a vertical turbine fire pump, there will only be a discharge pressure gauge.
7. Open the flow meter inlet control valve and ensure the flow meter outlet valve is closed.
8. Check the area surrounding any relief valve or cooling water discharge outlets as well as the discharge points for the fire pump flow to ensure that there are no obvious conditions that would prevent water from being discharged safely or cause direct damage in the immediate vicinity. Take appropriate caution to ensure personnel and property are protected from the resultant high-pressure discharge. Where the discharge of water is to an area subject to potential freezing conditions, the facility representative should be advised of the potential for icing conditions.
9. For pressure-actuated fire pump controllers, simulate an automatic start for the fire pump by creating a pressure drop in the sensing line to the fire pump controller. This is typically accomplished by slowly opening the drain valve on the sensing line located near the fire pump controller until the fire pump starts automatically. The use of the "start" button on the fire pump controller is not acceptable for the purpose of simulating an automatic start. Note the start time of the fire pump to measure the run time duration, and record the starting pressure. For pressure-actuated fire pump controllers that use an automatic timer, an automatic opening of a solenoid valve in the sensing line to the fire pump controller might be used to simulate the automatic start of the fire pump. These systems must include a record of the pressure drop on the pressure recorder for the controller. For non-pressure-actuated fire pump controllers, the automatic start can be simulated by other means.
10. Observe the engine instrument panel to ensure that the engine oil pressure, operating speed, water and oil temperature, and charging rate are within the acceptable range, rechecking approximately every 5 minutes.
11. Check the fire pump packing gland for a slight discharge (slow drip) of water, adjusting the packing gland nuts as needed to achieve approximately 1 drip per second. For safety purposes, the adjustment of the packing gland

should be made while the pump is not running. Care should be exercised to ensure the glands are not tightened to the point of breaking.

12. Monitor the fire pump operation for any unusual noise, vibration, or other signs of malfunction.

13. For radiator-cooled diesel fire pumps, verify that the operation of the circulation (casing) relief valve has a steady stream of water to ensure proper cooling of the pump case.

14. For heat exchanger-cooled diesel fire pumps, verify that the heat exchanger has a proper flow of cooling water.

15. Check the packing gland box, shaft bearings, and pump casing for overheating approximately every 5 minutes during the test. The packing gland box and shaft bearings might be warm to the touch, and the pump casing should remain cool throughout the test.

16. If the fire pump is equipped with a main pressure relief valve, verify the operation of the pressure relief valve such that outlet pressures do not exceed the pressure rating of the piping downstream of the fire pump. Usually, this rating is 175 psi (12.1 bar); however, some systems are designed for higher pressures.

17. Record the suction and discharge pressures. Note that for vertical turbine pumps, only the discharge pressure is recorded.

18. Record the operating speed (rpm) of the motor. The measurement can be taken with a handheld tachometer. Note that the use of a strobe-type handheld tachometer requires advance preparation prior to the test for proper measurement, including the application of reflective tape on the shaft and/or removal of protective covers that shield the rotating shaft.

19. For systems equipped with a main pressure relief valve as described in Step 16 above, adjust the pressure relief valve to temporarily stop the relief valve operation and repeat Step 17 and Step 18 above, then re-adjust the main relief valve to the normal operating position, and continue with Step 20 below.

20. The data recorded in Step 17 through Step 19 should be noted as the churn test point.

21. Initiate the flow through the flow meter by slowly opening the flow meter throttling valve on the outlet side of the flow meter. Throttle the valve position to achieve a reading on the flow meter equal to the rated capacity from the nameplate on the fire pump. If the flow is circulated back to the fire pump suction, then the temperature of the re-circulated water must be monitored under flow conditions throughout the remainder of the test to ensure that temperatures remain below that which would result in equipment damage, as defined by the pump and engine manufacturers.

22. Repeat Step 17 through Step 19 above, then continue with Step 23 below. The data recorded should be noted as the rated (or 100 percent flow) test point.

23. Continue to open the throttling valve to achieve a reading on the flow meter equal to the 150 percent of the rated capacity from the nameplate on the fire pump, or until the maximum available flow rate available from the water supply is met, whichever is lower. Care must be taken to ensure that the suction pressure does not fall below an acceptable level as the flow rate is increased to 150 percent. NFPA 20 allows a pressure at the suction flange of 0 psi (0 bar) for fire pumps connected to municipal supplies and –3 psi (–0.2 bar) for fire pumps taking suction from a grade level tank. Local water authorities might require a higher maintained pressure [commonly 20 psi (1.4 bar)] at the point of connection to the municipal supply.

24. Repeat Step 17 through Step 19 above, and then continue with Step 25 below. The data recorded should be noted as the overload (or 150 percent flow) test point.

25. Shut down the discharge flow by slowly closing the throttling valve to avoid water hammer.

26. If the run time for the fire pump has not reached 30 minutes, then allow the fire pump to continue operating until a total run time of 30 minutes has elapsed, and then shut down manually upon completion of the test.

27. For engines that use an electronic fuel management control system complete the following additional tests:

    a. Move the electronic control module (ECM) selector switch from the primary to the alternate position.

    b. Verify an alarm signal at the fire pump controller.

    c. Manually start the fire pump and verify normal operation.

    d. Manually shut down the fire pump.

    e. Reposition the ECM switch back to the primary position.

    f. Manually start the fire pump and verify the normal operation.

    g. With the fire pump still operating, disconnect the wire connection for each of the primary sensors for the ECM, verify the continued operation of the fire pump, and then reconnect the wires. On that same sensor, repeat the process removing the wires from the redundant sensor. This process should be completed for all of the primary and redundant sensors on the engine.

    h. Upon completion of the testing of all primary and redundant sensors, shut down the fire pump manually.

28. Verify the closure of the circulation relief and pressure relief valves (if installed) upon completion of the test.

29. Plot the test data against the manufacturer's specifications *before* removing test equipment, to verify a retest is not required due to bad data recording or other reasons.

30. Return the flow meter control valve to the closed position.

Annual Fire Pump (Non-Variable Speed) Flow Test *(Continued)*

31. Remove the calibrated pressure gauges, and reinstall the original pressure gauges on the suction and discharge side of the fire pump.
32. Inspect and clean any installed intake screens.
33. Initiate the various fire pump supervisory signals, such as low oil pressure, high coolant temperature, failure to start, or engine overspeed, to simulate an activation at the individual sensors. Verify that all of the fire pump supervisory signals, such as pump running, low oil pressure, high coolant temperature, failure to start, or engine overspeed, have been indicated at the fire pump controller as well as transmitted to any connected fire alarm panels.
34. If closed, reopen the fire pump discharge control valve and conduct a valve status test downstream of the closed valve.
35. Restore the fire pump to the automatic operating position.
36. Upon completion of all testing, notify the fire department and/or the alarm monitoring company (as needed), as well as the facility representatives, that testing is complete. Reset the fire alarm system as necessary. A verification of the receipt of initiated signals with the fire department and/or the alarm monitoring company, where so connected, would be appropriate as part of this effort.

Flow Measurement Calculation

The pressure recorded by the pitot tube assembly is velocity pressure, which is used to calculate flow. Converting the pitot pressure to flow can be accomplished by using manufacturer supplied tables for the specific flow-measuring device, or it can be calculated by inserting the outlet coefficient (c), outlet diameter (d), and velocity pressure (p) into the following formula:

$$Q = 29.84cd^2 \cdot \sqrt{p}$$

where:
Q = flow in gpm
c = coefficient of discharge
d = diameter of outlet (in.)
p = flowing pressure (psi)

In metric units, the formula is as follows:

$$Q = 0.0666cd^2 \cdot \sqrt{p}$$

where:
Q = flow in L/min
c = coefficient of discharge
d = diameter of outlet (mm)
p = flowing pressure (bar)

Pitot readings of less than 10 psi (0.7 bar) or more than 30 psi (2.1 bar) at the flow nozzle should be avoided. To keep within these pressure limits, the rate of flow can be controlled by throttling the control valve, opening additional outlets, or both.

Evaluation of Results

For a complete analysis on evaluating the results of the annual flow test, refer to Supplement 1 of this handbook.

Note that, at any time during the test, should abnormal conditions be observed that might result in personal injury or damage to the equipment/property, the fire pump should be immediately shut down and the test terminated until the cause can be investigated and corrective action taken as necessary.

References

American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990.

ASME B40.100, *Pressure Gauges and Gauge Attachments,* 2013.

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection,* 2019 edition.

NFPA *70E®*, *Standard for Electrical Safety in the Workplace®*, 2018 edition.

The procedure(s) outlined above is not mandated by NFPA 25 and represents only one approach to conducting this test.

Annual Flow Test

Purpose

The following is a description of the testing procedures necessary to conduct the annual test required in 8.3.3.1. This test allows the owner/inspector to determine the fire pump's capability based on its current operating condition. The owner/inspector can then compare the current data to the certified shop test curve to quantify the pump degradation since its installation.

Tools/Equipment

The test equipment required should be in good working condition and of such quality as to not be questioned should a flow test fail. All gauges used in the test (i.e., those for the suction and discharge sides of the pump as well as the pitot tube) should have recent calibration within the past 6 to 12 months. Gauges should be calibrated at least annually by means of a dead-weight or calibrated tester throughout the range of operation. Calibration sheets should be kept for each gauge and correction factors affixed to the back of each gauge before a test series is begun. The flow characteristics of the test nozzles should be known, as well. While listed play pipes have standard flow performance curves, some proprietary flow devices, such as hose monster test nozzles, have equipment specific flow charts. If flow meters are used, they require pre-test calibration. Typical tools equipment used in annual pump flow testing are as follows:

1. A handheld tachometer[1] is required to measure the operating speed of the fire pump and verify that on the engine.
2. A pitot tube together with a test-pressure gauge[2], suitable for the pressures to be expected, is required. [Usually, a 60 psi (4 bar) gauge is satisfactory.] Test-quality gauges should be used in accordance with ASME B40.100, *Pressure Gauges and Gauge Attachments*, having an accuracy of ±1 percent. The use of quality test gauges produces results that are considered reasonably accurate within the scope of the testing procedure. Care should be taken to protect the gauges from rough handling. While pitot tubes for fire protection flow testing are not listed, the gauges used should be listed and should be acceptable for water or water/air systems and not only air systems. A pitot-tube-and-gauge assembly, such as the one shown in Testing Exhibit 7.1, is indispensable in conducting flow tests from hydrants and nozzles. The small opening at the end of the tube — not over $^{1}/_{16}$ in. (1.6 mm) in diameter — is inserted in the center of the stream, in a direct line with the flow, at a distance in front of the opening equal to one-half the opening diameter. Velocity pressure is registered on the gauge attached to the tube. Some available test nozzles, including an integral pitot tube, are pitotless flow measuring features with an attached test gauge allowing for direct measurement of flows without the use of a separate pitot tube.
3. Test-pressure gauges suitable for measurement of expected the suction and discharge pressures on the fire pump are required. Note that the gauge used on the suction side of the fire pump should be a compound pressure and vacuum gauge having a pressure range of at least twice the static pressure available from the suction supply. The gauge used on the discharge side of the fire pump should have a range of at least twice the rated working pressure of the fire pump.
4. A sufficient number of test nozzles are required, including hoses for connection to test headers where needed [typically 50 ft (15.2 m) lengths of lined 2½ in. (65 mm) hose might be used for this purpose], to permit the measurement of a flow rate up to 150 percent of the rated capacity of the fire pump. Test nozzles can include UL play pipes or other approved test nozzles. The flow characteristics of the test nozzles must be known.
5. The various wrenches and other specific tools necessary to allow for required adjustments during the test and for the installation of required test equipment are required.
6. For electric pump tests, a multimeter and/or clamp-on ammeter is required for taking voltage and amperage readings.
7. A timing device is required to measure the duration of the fire pump run (on acceptance tests).
8. A form for recording test data is required.
9. While not required for the actual pump test data collections, approved hearing protection and PPE are typically required. If PPE is not handy, then the start of pump testing can often be delayed while the PPE is being located.

Positive Displacement Pump Flow Tests

The pump flow for positive displacement pumps is completed to meet the specified rated performance criteria. Typically, one performance point is required to establish positive displacement pump performance. Many positive displacement pumps also have special applications, such as a component in foam or water mist systems. For these types of pumps, manufacturers' data should be referenced. The pump flow test for foam positive displacement pumps typically is completed using a flowmeter or orifice plate installed in a test loop back to the foam concentrate tank or the inlet side of a water pump. The flowmeter reading or discharge pressure should be recorded and should be in accordance with the pump manufacturer's flow performance data. If orifice plates are used, the orifice size and corresponding discharge pressure to be maintained on the upstream side

1. All test equipment should be calibrated by an approved testing laboratory within 12 months prior to the test.

2. Test-quality gauges should be used in accordance with ASME B40.100, Pressure *Gauges and Gauge Attachments,* having an accuracy of ±1%. The use of quality test gauges produces results that are considered reasonably accurate within the scope of the testing procedure. Care should be taken to protect the gauges from rough handling.

Gauges should be calibrated at least annually by means of a deadweight or calibrated tester throughout the range of operation before a test series is begun. Calibration sheets should be kept for each gauge and correction factors affixed to the back of each gauge.

Annual Flow Test *(Continued)*

of the orifice plate should be made available to the AHJ. Flow rates should be as specified while operating at the system design pressure.

In addition to manufacturers' recommendations, systems with positive displacement pumps should reference ANSI/Hydraulic Institute 3.6, *Rotary Pump Tests,* and Chapter 12, Chapter 13, and Annex C of NFPA 750, *Standard on Water Mist Fire Protection Systems.* ANSI 3.6 applies to industrial rotary positive displacement pumps, and it includes detailed procedures on the setup and methods for conducting hydrostatic test and performance tests of such pumps.

Steam-Driven Turbine Fire Pumps

While Chapter 13 of NFPA 20 is dedicated to these types of pumps, they are rarely installed today due to maintenance and reliability concerns both on the driver and steam source. A steam turbine driver for a fire pump should always be kept "warmed up" to permit instant operation at full rated speed. The automatic starting of the turbine should not be dependent on any manual valve operation or period of low-speed operation, and this should be verified as part of the test. Steam turbines are provided with governors to maintain a predetermined speed, with some adjustment for higher or lower speeds. Desired speeds below this range can be obtained by adjusting the main throttle valve.

Vertical Turbine and Horizontal Split Case Pump Flow Tests

As required by 8.3.3.1, pump flow and pressure, as well as drive shaft speed (rpm), is measured at a minimum of three points: churn (no flow), rated (100 percent flow), and peak/overload (150 percent flow).

Procedure Steps

Pre-Flow Activities/Planning

1. If the site has a fire alarm system, notify the alarm monitoring company and place the fire alarm system on test.
2. Notify all facility representatives that testing is going to be conducted. In some cases, the amount of water flowing on the ground might require extra maintenance personnel. Or, suction pressure requirements could affect site production equipment (i.e., site cooling towers could trip off line due to low supply pressure, and so forth.)
3. Notify the local fire department and/or any other AHJ that might want to attend, such as property insurance representatives.
4. Complete the required activities in Section 8.2 to ensure pump system readiness for full flow testing. This maintenance should include checking battery electrolyte levels and specific gravity, inspecting cable conditions, and checking for any corrosion on pipes and other system equipment.
5. Review the fire pump assembly nameplates, noting the following:
   a. Voltage rating (electric pumps)
   b. Rated speed
   c. Rated capacity (flow)
   d. Churn pressure
   e. Rated pressure
   f. Overload pressure
6. Ensure all valves are in the proper position. Normally, pump discharge valves that supply site fire systems or fire system loops should be kept fully open throughout both weekly testing and the annual pump test. These are closed sometimes due to concern that the "high pump pressure" or "pressure fluctuations" might damage the fire system where pipe integrity is a concern. However, if fire mains are subject to damage due to pump pressures, it is best to discover this during an annual test rather than an actual fire. However, where the pump churn pressure will significantly exceed the rated pressure for the system, the fire pump discharge control valve might be closed prior to the operation of the fire pump to limit the exposure of the connected systems. Consideration might be given to closure of the fire pump discharge control valve prior to conducting the test, to limit the exposure of the connected systems to the resultant pressure surge during the start-up of the fire pump. Another method to avoid potential water hammer affects is to partially open a test header outlet at start-up, and then close it for the churn pressure reading.
7. Replace suction and discharge pressure gauges with the appropriate calibrated test gauges. For a vertical turbine fire pump, there will only be a discharge gauge.
8. Install flow test equipment on the test header as required, to allow for the maximum flow rate. This might include the use of hoses connected to the test header and extending them to flow measurement devices, such as listed play pipes or other test nozzles.
9. Confirm that all test equipment, such as play pipes, hoses, play pipe test stands, and so forth, are adequately secured or protected against movement. Manually securing play pipes (i.e., by hand holding) is not acceptable and could cause serious personal damage. Swivel elbows, if installed on test headers, must be locked in place with set screws to avoid spinning during testing, which could cause serious personal damage. In some cases, the connection of flow test equipment, such as play pipes, can be made directly to the test header. The use of a flow diffuser can aid in preventing movement as well as breaking the directed stream.
10. For testing using hose-connected flow-measuring devices or UL play pipes directly connected to the test header, ensure that the individual hose connection valves on the test header are in the closed position. Slowly open the main test header control valve pressurizing the test header. For other flow measuring devices directly connected to the test header, ensure that the main test header control valve is closed. Then, fully open a single hose connection

valve, readying the arrangement for the first flow point, with the flow being controlled by the main test header control valve. Any time the use of an additional hose connection valve is required with this latter arrangement the additional hose connection valves are to be fully opened; the flow should again be controlled by the position of the main test header control valve rather than the individual hose connection valves.

11. Check the area surrounding the test per 8.3.3.9.1.2 for potential uncontrolled water flow that could cause damage — plugged drain pipes, local construction with open pits, berms subject to hydraulic erosion, and so forth. Check any relief valve or cooling water discharge outlets as well as the discharge points for the fire pump flow to ensure that there are no obvious conditions that would prevent water from being discharged safely or cause direct damage in the immediate vicinity. Where the discharge of water is to an area subject to potential freezing conditions, the facility representative should be advised of the potential for icing conditions.

12. Check the fire pump packing glands for a slight discharge (slow drip) of water, adjusting the packing gland nuts as needed to achieve approximately 1 drip per second. If the packing is completely dry before start-up, it could overheat and fail once the pump is turned for the pump test. The overheating of bearings could also quickly occur. For safety purposes, the adjustment of the packing gland should be made while the pump is not running. Care should be exercised to ensure the glands are not tightened to the point of breaking.

13. For vertical turbine pumps, make sure the pump is completely primed.

14. In cases where a handheld tachometer will be used, verify where the point readings will be taken from and that reflective tape is installed as required. Some handheld tachometers require advance preparation prior to the test for proper measurement, such as the application of reflective tape on the shaft. Care should be taken not to apply reflective tape on a shaft that already has it applied, because false "double readings" might occur. Since a reading will be required at each point during the actual test, care should be taken as to where the location tape is applied, considering the proximity to casing spray, hot engine exhaust, accessibility to the sides of a rotating shaft, and so forth.

Flow Test Activities/Planning

1. For pressure-actuated fire pump controllers, simulate an automatic start for the fire pump by creating a pressure drop in the sensing line to the fire pump controller. This is typically accomplished by slowly opening the drain valve on the sensing line located near the fire pump controller until the fire pump starts automatically. The use of the "start" button on the fire pump controller is not acceptable for the purpose of simulating an automatic start. Note the start time of the fire pump, and record the starting pressure. For pressure-actuated fire pump controllers that use an automatic timer, an automatic opening of a solenoid valve in the sensing line to the fire pump controller might be used to simulate the automatic start of the fire pump. These systems must include a record of the pressure drop on the pressure recorder for the controller. For non-pressure-actuated fire pump controllers, the automatic start can be simulated by other means.

2. Check the fire pump packing gland for a slight discharge (slow drip) of water, adjusting the packing gland nuts as needed to achieve approximately 1 drip per second. For safety purposes, the adjustment of the packing gland should be made while the pump is not running. Care should be exercised to ensure the glands are not tightened to the point of breaking.

3. Monitor the fire pump operation for any unusual noise, vibration, or other signs of malfunction.

4. For electric-driven pumps, verify that the operation of the circulation (casing) relief valve has a steady stream of water to ensure proper cooling of the pump case.

5. Check the packing gland box, shaft bearings, and pump casing for overheating approximately every 5 minutes during the test. The packing gland box and shaft bearings might be warm to the touch, but the pump casing should remain cool throughout the test.

6. If the fire pump is equipped with a main pressure relief valve, verify the operation of the pressure relief valve such that outlet pressures do not exceed the pressure rating of the piping downstream of the fire pump. Usually, this rating is 175 psi (12.1 bar); however, some systems might be designed for higher pressures.

7. For electric-driven pumps, motor voltage and current on all phases (lines) should be recorded. This can be done with a multimeter and clamp-on ammeter; however, these readings should only be taken by individuals trained and qualified in electrical hazards and equipped with the needed safety equipment as outlined in NFPA *70E®*, *Standard for Electrical Safety in the Workplace®*. Also see 8.3.3.14 and Section 4.9, along with the associated commentary, for additional guidance.

8. Record the suction and discharge pressures. Note that only the discharge pressure is recorded for vertical turbine pumps.

9. Record the operating speed (rpm) of the motor.

10. The data recorded in Step 8 and Step 9 should be noted as the churn test point.

11. Initiate the flow of the fire pump by slowly opening either hose control valves on the test header or by slowly opening the main test header control valve, depending on the arrangement selected. As the valve is opened, take flow measurements to determine the flow rate, adjusting each valve position until a combined flow rate equal to the rated capacity from the nameplate on the fire pump is achieved. Where the flow rate with the valve fully open is inadequate

Annual Flow Test *(Continued)*

to meet this rated capacity, additional hose valves must be opened and adjustments made until the total measured flow rate equals the rated capacity. For systems equipped with a main pressure relief valve, this should now be verified as closed and not flowing water. If it is flowing water, adjust the pressure relief valve to temporarily close.

12. Repeat Step 8 and Step 9.
13. The data recorded in Step 11 and Step 12 should be noted as the rated (or 100 percent flow) test point.
14. Continue to open hose valves and/or the main test header control valve, as in Step 11, and take flow measurements to determine the flow rate, adjusting the valve(s) position until a flow rate equal to the 150 percent of the rated capacity from the nameplate on the fire pump is achieved, or until the maximum available flow rate is achieved, whichever is lower. Care must be taken to ensure that the suction pressure (at the point of the city connection) does not fall below an acceptable level. NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection,* allows a suction pressure of 0 psi (0 bar) for fire pumps connected to municipal supplies and –3 psi (–0.2 bar) for fire pumps taking suction from a grade level tank. Some local water authorities might require a higher maintained pressure [typically 20 psi (1.4 bar) where this is a regulation], as the flow rate is increased to 150 percent.
15. Repeat Step 8 and Step 9.
16. The data recorded in Step 14 and Step 15 should be noted as the overload (or 150 percent flow) test point.
17. Shut down the flow by slowly closing the main test header control valve to avoid water hammer.
18. If the run time for the fire pump has not reached 10 minutes, then allow the fire pump to continue operating until a total run time of 10 minutes is reached. Recheck for overheating periodically during the test, and then shut down manually upon completion of the test.
19. Plot the test data against the manufacturer's specifications *before* removing test equipment, to verify a retest is not required due to bad data recording and other reasons.
20. Remove all attached test equipment from the test header, restore the closed position of all hose connection valves, and reinstall hose caps. In locations subject to freezing, check that the test header properly drains or pumps out as necessary.
21. Remove the calibrated gauges, and reinstall the original gauges on the suction and discharge side of the fire pump. Any gauges found out of calibration should be replaced.
22. Inspect and clean any installed intake screens.
23. For electric-driven pumps, verify a fire pump phase reversal supervisory signal by jumping across the monitored points in the fire pump controller (typically labeled on a wiring diagram posted on the inside the fire pump controller) to simulate an activation.
24. Verify that all of the fire pump supervisory signals (e.g., fire pump running, loss of power, phase reversal) required by NFPA 20 and NFPA 25 (see 8.3.3.13) have been indicated at the fire pump controller as well as transmitted to any connected fire alarm panels.
25. Verify the main pressure relief valve is properly set and adjusted.
26. Verify fire pump start-stop settings (see below).
27. If closed, reopen the fire pump discharge control valve, and conduct a valve status test downstream of the closed valve.
28. Restore the fire pump to the automatic operating position.
29. Complete a coupling alignment check.
30. Upon completion of all testing, notify the fire department and/or the alarm monitoring company (as needed), as well as the facility representatives, that testing is complete. Reset the fire alarm system as necessary.
31. Complete the pump test data analysis to determine compliance with 8.3.3.1 and 8.3.7.1. See Supplement 1.

    At each flow test point, the quantity of water discharging from the fire pump test assembly should be stabilized as best as possible before taking pitot readings. When using multiple outlets for pitot readings, final readings on all outlets cannot accurately be made until all adjustments are completed. Due to hydraulic principles, each time one test header outlet is adjusted, the flow on others will be affected. That is, opening an additional test header will cause the flow (and related pitot readings) on others flowing to drop to a different number than the reading taken before the additional valve was opened.

Fire Pump Operational Settings

The fire pump system, when started by pressure drop, should be arranged as follows:

1. The jockey pump stop point should equal the pump churn pressure plus the minimum static supply pressure.
2. The jockey pump start point should be at least 10 psi (0.7 bar) less than the jockey pump stop point.
3. The fire pump start point should be 5 psi (0. 4 bar) less than the jockey pump start point. Use 10 psi (0.7 bar) increments for each additional pump.
4. Where minimum run timers are provided, the pump will continue to operate after attaining these pressures. The final pressures should not exceed the pressure rating of the system.
5. Where the operating differential of pressure switches does not permit these settings, the settings should be as close as equipment will permit. The settings should be established by pressures observed on test gauges.

Evaluation of Results

Supplement 1 of this handbook provides an in-depth review of interpreting the results of the annual flow test and determining if the pump has seen more than a 5 percent degradation when compared to the certified shop test curve. For more information, see Supplement 1 of this handbook.

References

American Society of Mechanical Engineers, Two Park Avenue, New York, NY 10016-5990.

ASME B40.100, *Pressure Gauges and Gauge Attachments*, 2013.

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection,* 2019 edition.

NFPA *70E®*, *Standard for Electrical Safety in the Workplace®*, 2018 edition.

NFPA 750, *Standard on Water Mist Fire Protection Systems,* 2019 edition.

Hydraulic Institute, 6 Campus Drive First Floor North, Parsippany, NJ 07054-4406.

ANSI/Hydraulic Institute 3.6, *Rotary Pump Tests,* 2016 edition.

The procedure(s) outlined above is not mandated by NFPA 25 and represents only one approach to conducting this test.

What Are Water Storage Tanks?

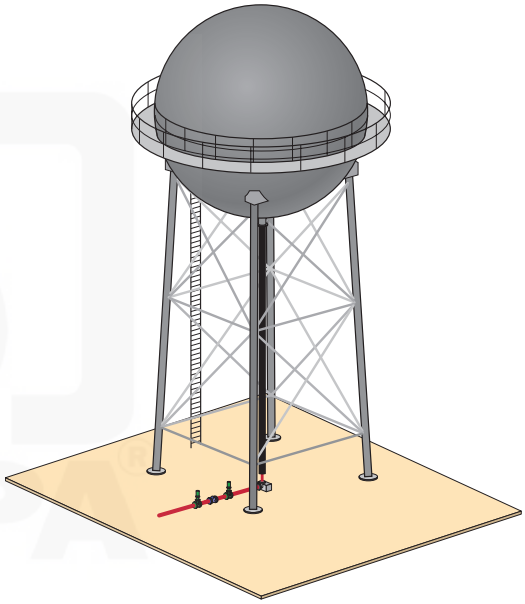
Water storage tanks are tanks that supply water for water-based fire protection systems. Water tanks can be used for several different scenarios but most commonly they are used where an adequate supply of water is not available or reliable. Water storage tanks can be made of various materials such as wood, steel, concrete, fiberglass-reinforced plastic (FRP), and rubberized fabric.

What Are the Types of Water Tanks?

There are several different types of water storage tanks. Depending on the needs of the system that the tanking is supporting and the geographical and topographical location of building, the type of tank that is used will vary. Each type of water storage tank can have vastly different system components.

Elevated Tanks

Elevated water tanks hold water at high elevations so that they can use gravity to create the pressure required by the fire suppression system it is serving.



Suction Tanks

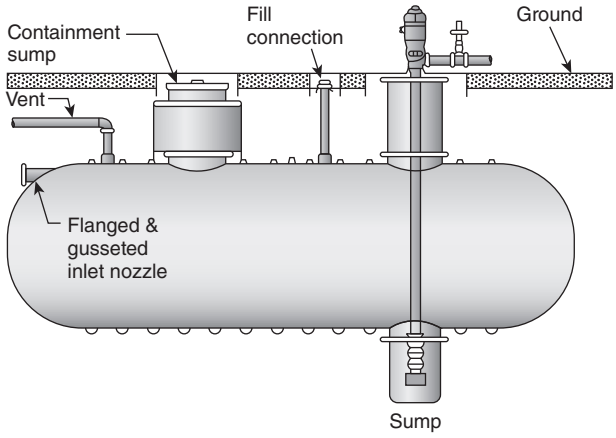
Suction water tanks do not create pressure, and because of that they need a fire pump to create the pressure for the fire suppression system. Suction tanks are typically installed at ground level.



Courtesy of Walter S. Beattie

Underground Tanks

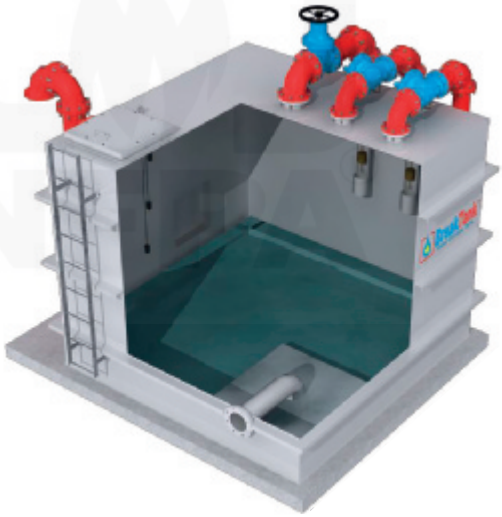
Underground tanks are similar to suction tanks in that they do not create their own pressure but rather they supply a fire pump with water. Underground tanks are always located below ground level.



Break Tanks

Breaks are tanks used in conjunction with fire pumps and serve several purposes:

- Serve as a backflow prevention device between the city water supply and the fire pump suction.
- Eliminate pressure fluctuations in the city water supply and provide a steady suction pressure to the fire pump.
- Augment the city water supply when the volume of water available from the city is inadequate for the fire protection system demand.



ITM

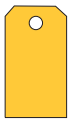
Water supplies are an essential component of water-based fire protection systems and provide the medium for fire suppression. Without proper inspection, testing, and maintenance (ITM) the risk of tanks not supplying adequate water increases.

For more information refer to NFPA 22, *Standard on Water Tanks for Private Fire Protection*.

Water Storage Tanks Inspection and Testing



NO DEFICIENCIES OR IMPAIRMENTS



NONCRITICAL DEFICIENCIES

Exterior

- Damaged tank exterior, supporting structure, vents, catwalks, or ladders (where provided)
- Area around tank has fire exposure hazard in form of combustible storage, trash, debris, brush, or material
- Accumulation of material on or near parts that could result in accelerated corrosion or rot
- Erosion exists on exterior sides or top of embankments supporting coated fabric tanks
- Hoops and grilles of wooden tanks in poor condition
- Exterior painted, coated, or insulated surfaces of tanks or supporting structure degraded

Gauges

- Not tested in 5 years, not accurate within 3% of scale

Interior

- Pitting, corrosion, spalling, rot, other forms of deterioration, waste materials exist, aquatic growth, local or general failure of interior coating
- Voids beneath floor, with sand in middle of tanks on ring-type foundations
- Heating system components or piping in poor condition but working

Interior testing

- Tank coating did not pass adhesion, coating thickness, or wet sponge test
- Tank walls and bottoms did not pass ultrasonic test
- Tank bottom seams did not pass vacuum-box test

Testing

- High water temperature limit switch did not pass test



CRITICAL DEFICIENCIES

Water level

- Level indicator lacked freedom of movement, or not accurate
- Water level and/or condition not correct

Heating system

- Not in working order
- Heating system not operational, water temperature below 40°F

Exterior

- Ice buildup on tank and support
- Expansion joints leaking or cracking

Interior

- Deterioration of antivortex plate

Testing

- Low water temperature alarm did not pass test
- High and low water level alarms did not pass test



IMPAIRMENTS

Water level

- Tank is empty

Air pressure

- Air pressure in pressure tanks not correct

Heating system

- Water temperature at or below 32°F

Interior

- Heating system components or heating system piping in poor condition and not working
- Blockage of antivortex plate

Source: Table A.3.3.8



9

WATER STORAGE TANKS

Chapter 9 of NFPA 25 covers the inspection, testing, and maintenance (ITM) activities necessary to ensure that water storage tanks will provide the proper quantity and, in some cases, pressure, in the event of a fire. Water storage tanks can be made of various materials such as wood, steel, concrete, fiberglass-reinforced plastic (FRP), and rubberized fabric. Each type of water storage tank, such as suction, gravity, or bladder tanks, can have vastly different system components.

Water storage tanks are frequently used where an adequate quantity or volume of water is not readily available. Depending on the needs of the system that the tanking is supporting and the geographical and topographical location of building, the type of tank that is used will vary. Accordingly, the ITM tasks that must be executed will also vary, because the components will vary based on the type of tank involved.

Some tanks, such as pressure tanks, serve dual purposes by providing the necessary quantity of water and the needed pressure to propel the water through a fire protection system. Section 14.5 of NFPA 22, *Standard for Water Tanks for Private Fire Protection,* gives requirements for "break tanks," which basically have the following three purposes:

1. Serve as a backflow prevention device between the city water supply and the fire pump suction.
2. Eliminate pressure fluctuations in the city water supply and provide a steady suction pressure to the fire pump.
3. Augment the city water supply when the volume of water available from the city is inadequate for the fire protection system demand.

A break tank, as its name suggests, provides a break or separation between a fire pump and a city water supply. Traditionally, a break tank is a small tank intended to isolate the fire pump from the water supply. However, a break tank can also be quite large.

Gravity tanks, as referred to in NFPA 22, rely on gravity to provide the 0.433 psi/ft (0.09 bar/m) of pressure necessary. Suction tanks rely on fire pumps to pressurize fire protection systems.

Regardless of the type or arrangement, water storage tanks are a critical part of the water-based fire protection system, and they must be properly maintained if they are to function when needed.

The requirements in Chapter 9, as well as those in NFPA 22, apply only to private tanks dedicated to fire protection and installed on private property. Storage tanks installed on public property serving public domestic water systems are not within the scope of the standard.

9.1* General.

A.9.1 One source of information on the inspection and maintenance of steel gravity and suction tanks is the AWWA *Manual of Water Supply Practices — M42 Steel Water-Storage Tanks*, Part III and Annex C.

In many cases, water storage tanks are the primary — if not the only — source of water for fire-fighting purposes. Requirements for the design, construction, and operation of water storage tanks can be found in NFPA 22.

The appropriate size of a dedicated water storage tank is determined by multiplying the water demand of the fire protection system it serves by the discharge duration specified in the installation standard. The total capacity is measured from the discharge pipe to the overflow pipe. Exhibit 9.1 shows a steel ground-level tank that constitutes the sole source of water for a small manufacturing plant.

Not all tanks are required to be designed around the total system demand. Break tanks can also be used to provide suction to a fire pump; however, their capacity is often less than the fire protection system demand, which is calculated as flow rate multiplied by the required flow duration. Break tanks may be used to avoid cavitation of the main upon initial startup of the fire pump, and they are usually sized for a minimum 15-minute water supply duration. Where a system design depends on an automatic fill valve to replace the water in the tank to achieve the required duration of the system demand (flow rate), inspection and testing of the refill mechanism is critically important.

Exhibit 9.2 shows an elevated storage tank with a riser more than 3 ft (0.9 m) in diameter. In some areas of the United States, the size of the riser will dictate the need for heating.

EXHIBIT 9.1 *Steel Ground-Level Tank.*





EXHIBIT 9.2 *Elevated Water Storage Tank.*



EXHIBIT 9.3 *Wooden Gravity Tanks.*

The use of wooden gravity (elevated) tanks for fire protection has decreased significantly over the past 100 years, although they are still found in many older cities (see Exhibit 9.3). These wooden tanks were installed high in the building (usually on or above the roof), feeding a sprinkler system by gravity. Exhibit 9.4 shows a wooden gravity tank under construction. Exhibit 9.5 shows a FRP tank. Exhibit 9.6 illustrates a ground-level suction tank and the discharge pipe connected to the bottom of the tank in a valve pit.

The use of steel pressure tanks, as shown in Exhibit 9.7, has declined largely due to space considerations. These tanks require a large volume of space to provide sufficient water capacity for a sprinkler system. Smaller-volume pressure tanks are now being provided, in part due to the introduction of residential sprinkler systems and the corresponding lower duration values they typically require when installed in accordance with NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*.

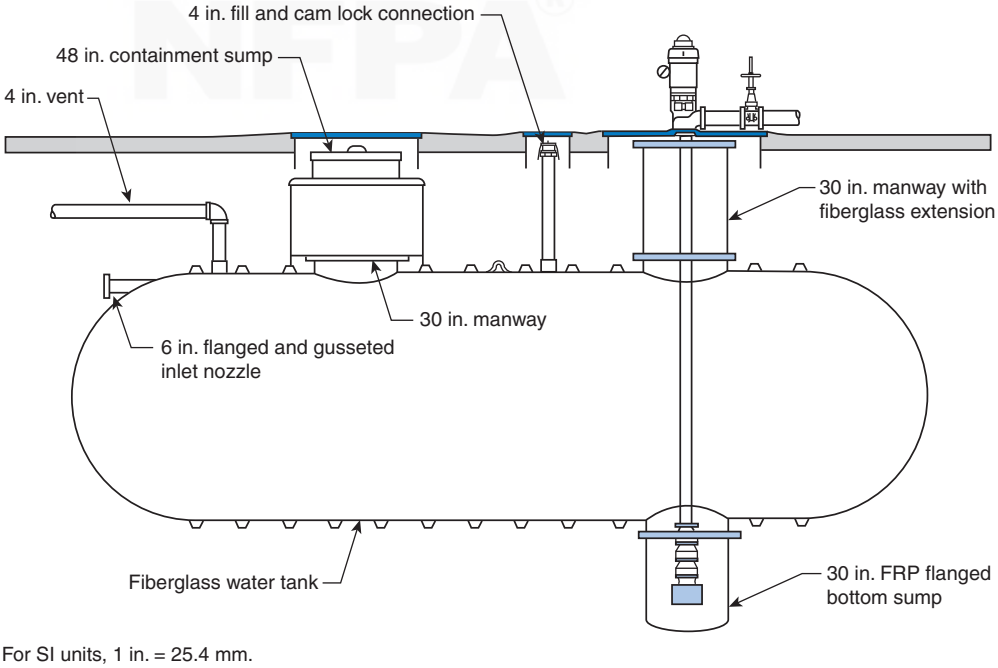
An embankment-supported fabric suction tank, as illustrated in Exhibit 9.8, is designed much like a waterbed. Water is enclosed in fabric that is given its shape by earthen berms located around the tank. The fabric reduces the likelihood of marine life attaching to the walls of the tank.

9.1.1 Minimum Requirements.

9.1.1.1 This chapter shall provide the minimum requirements for the routine inspection, testing, and maintenance of water storage tanks dedicated to fire protection use.

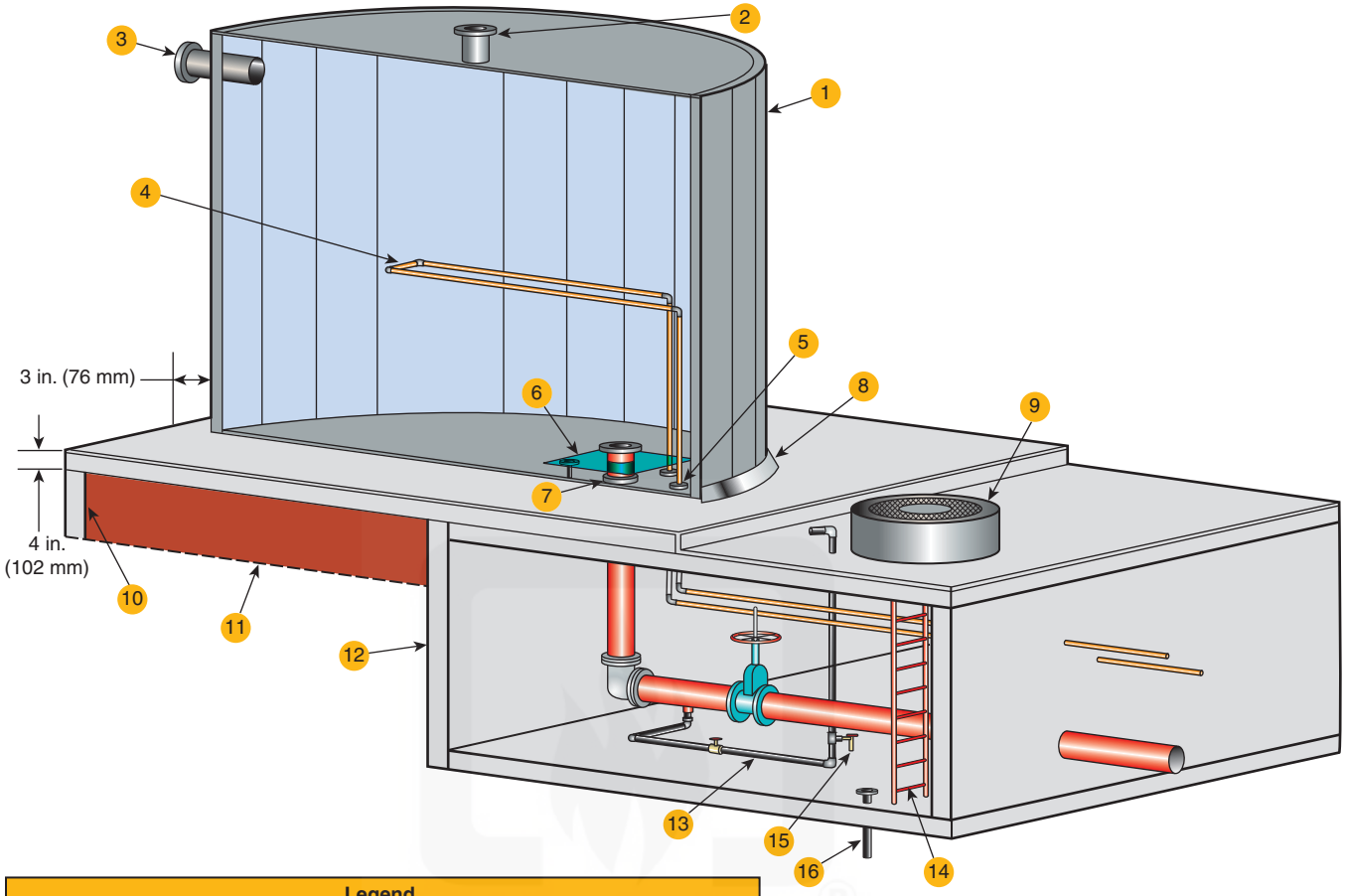


EXHIBIT 9.4 *Wooden Gravity Tank Under Construction. (Courtesy of Hall-Woolford Tank Co., Inc.)*



For SI units, 1 in. = 25.4 mm.

EXHIBIT 9.5 *Fiberglass-Reinforced Plastic (FRP) Tank.*



Legend

1. Pump suction tank
2. Screened vent
3. Stub overflow pipe
4. Steam coil for heating
5. Extra-heavy couplings welded to bottom of tank
6. Vortex plate
7. Watertight lead slip joint
8. Flashing around tank
9. Manhole with cover
10. Concrete ring wall
11. Sand or concrete pad (depending on soil condition)
12. Valve pit
13. Drain pipe
14. Ladder
15. Drain cock
16. Valve pit drain suction tank

EXHIBIT 9.6 *Ground-Level Suction Tank. (Courtesy of Stephan Laforest)*

The private fire service tanks referenced in this chapter are those tanks that are dedicated only to fire protection use. It is necessary to specify this because, in the past, this chapter has been incorrectly applied to municipal water storage tanks and private tanks that supply both domestic and fire protection water. The ITM of storage tanks for domestic potable water is not within the scope of this standard.

9.1.1.2 Table 9.1.1.2 shall be used to determine the minimum required frequencies for inspection, testing, and maintenance.

EXHIBIT 9.7 *Steel Pressure Tank.*



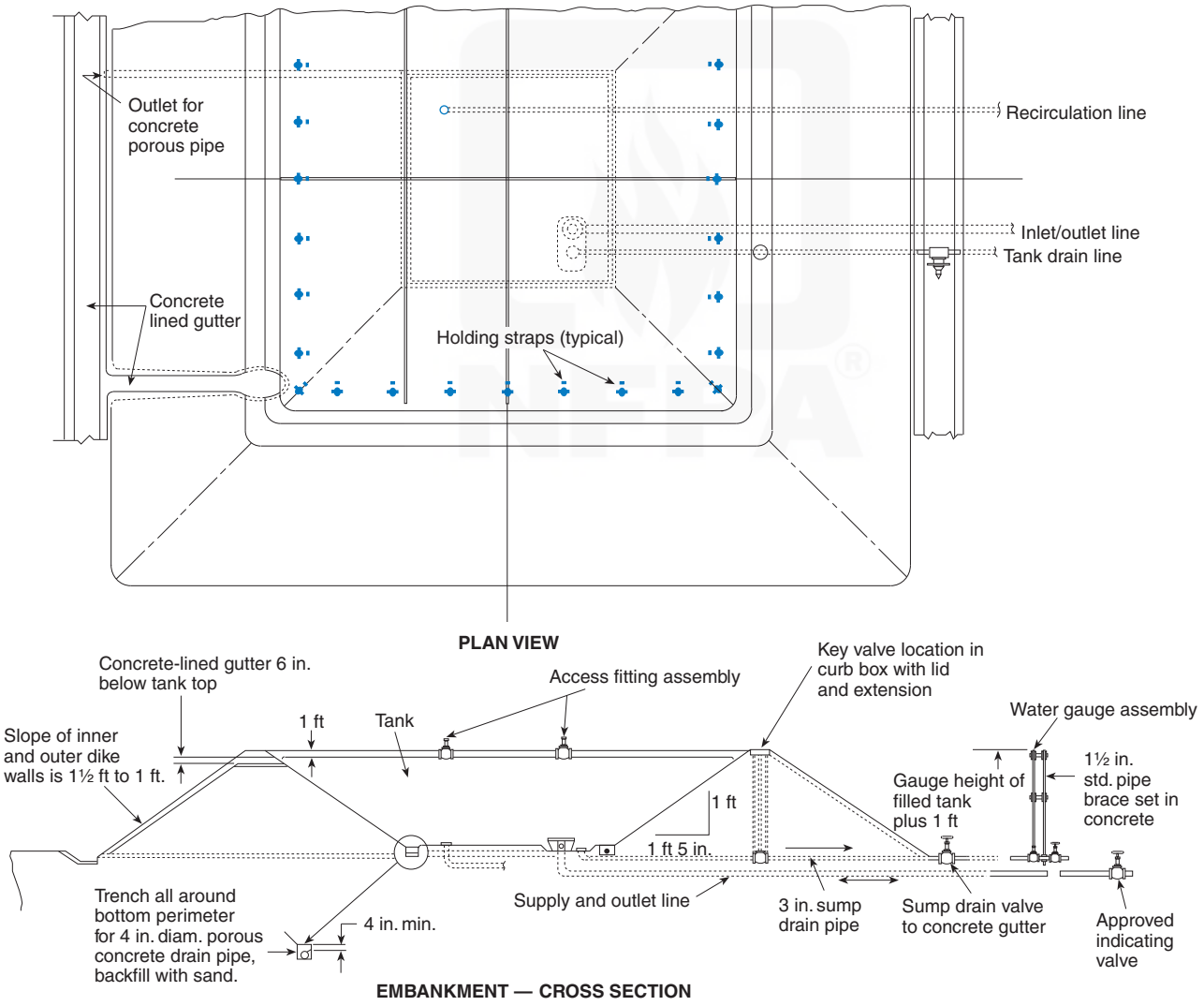


EXHIBIT 9.8 *Embankment-Supported Fabric Suction Tank. [Source: NFPA 22, 2018, Figure B.1(e)]*

Δ ***TABLE 9.1.1.2*** *Summary of Water Storage Tank Inspection, Testing, and Maintenance*

Item	*Frequency*	*Reference*
Inspection		
Catwalks and ladders	Quarterly	9.2.4.1
Check valves		Chapter 13
Control valves		Chapter 13
Expansion joints	Annually	9.2.4.3
Foundation	Quarterly	9.2.4.1
Heating system — tanks with supervised low-temperature alarms connected to constantly attended location	Quarterly	9.2.2.1
Heating system — tanks without supervised low-temperature alarms connected to constantly attended location	Daily*	9.2.2.2
Hoops and grillage	Annually	9.2.4.4
Interior — all other tanks	5 years	9.2.5.1.2
Interior — steel tanks without corrosion protection	3 years	9.2.5.1.1
Painted, coated, or insulated surfaces	Annually	9.2.4.5
Support structure	Quarterly	9.2.4.1
Surrounding area	Quarterly	9.2.4.2
Tank — exterior	Quarterly	9.2.4.1
Temperature alarms — connected to constantly attended location	Quarterly*	9.2.3.2
Temperature alarms — not connected to constantly attended location	Weekly*	9.2.3.3
Vents	Quarterly	9.2.4.1
Water level — tanks equipped with supervised water-level alarms connected to constantly attended location	Quarterly	9.2.1.1
Water level — tanks without supervised water-level alarms connected to constantly attended location	Monthly	9.2.1.2
Test		
High-temperature limit switches	Prior to heating season	9.3.4
Level indicators	5 years	9.3.1
Low-water temperature alarms	Prior to heating season	9.3.3
Pressure gauges		Chapter 13
Tank heating system	Prior to heating season	9.3.2
Valve status test		Chapter 13
Water-level signals (high and low)	Annually	9.3.5
Maintenance		
Check valves		Chapter 13
Control valves		Chapter 13
Embankment-supported coated fabric (ESCF)	2 years or per manufacturer	9.4.6.2
Water level		9.4.2

*Cold weather/heating season only.

Many of the inspections and tests of water storage tank components specify that they are required during cold weather/heating season only. It is important to keep in mind that this is not necessarily a particular time of the year, but rather tied to environmental conditions. If unseasonably cold weather occurs early or late in the normal heating season when freezing is not typically a concern, consideration should be given to performing these inspections and tests to ensure operational reliability of the system.

9.1.2 Common Components and Valves. Common components and valves shall be inspected, tested, and maintained in accordance with Chapter 13.

9.1.3 Obstruction Investigations. The procedures outlined in Chapter 14 shall be followed where there is a need to conduct an obstruction investigation.

9.1.4 Impairments. The procedures outlined in Chapter 15 shall be followed where an impairment to protection occurs.

The ITM of water storage tanks can involve or result in a system that is out of service. In cases where a tank is the sole source of supply to a fire protection system, it is recommended that an alternative water supply be arranged while maintenance is performed on the tank.

An alternative source of water can take the form of temporary hose connections to a nearby hydrant, the temporary placement of a tanker truck, portable storage tanks, or hose connections and a portable fire pump to a body of water, either natural or manmade. Exhibit 9.9 shows portable tanks that were used as an alternative water supply during the renovation of supply piping from the prime water source of a fire protection system in Yellowstone National Park.

9.2 Inspection.

There are several different types of inspections that must be conducted to ensure that a water storage tank is in good working order. Exhibit 9.10 is a sample form that can be used to record all the different inspection tasks outlined in Section 9.2 and Table 9.1.1.2. NFPA 25 does not require that this specific form be used. This is provided as just one example of an acceptable inspection form.



EXHIBIT 9.9 *Portable Storage Tanks as an Alternative Source of Water. (Courtesy of National Park Service)*

WATER STORAGE TANKS INSPECTION

Name of Property: _____ **Inspector:** _____

Address: _____ **Contract No.:** _____

Property Phone Number: _____ **Date:** _____

Inspections: Daily

☐ Yes	☐ No	☐ N/A	**(Cold Weather/Heating Season Only)**
☐ Yes	☐ No	☐ N/A	Heating system (when not supervised)

Inspectons: Weekly

			Control Valves
☐ Yes	☐ No	☐ N/A	In the correct (open or closed) position
☐ Yes	☐ No	☐ N/A	Sealed
☐ Yes	☐ No	☐ N/A	Accessible
☐ Yes	☐ No	☐ N/A	Post Indicator Valves (PIVs) are provided with correct wrenches
☐ Yes	☐ No	☐ N/A	Free from damage or leaks
☐ Yes	☐ No	☐ N/A	Proper signage
			(Cold Weather/Heating Season Only)
☐ Yes	☐ No	☐ N/A	Record Water temperature (when not supervised)
☐ Yes	☐ No	☐ N/A	Record water temperature (supervised systems)

Inspections: Monthly

☐ Yes	☐ No	☐ N/A	Gauges are in good operating condition
			Control Valves (Locked or Supervised)
☐ Yes	☐ No	☐ N/A	Water temperature (supervised systems)
☐ Yes	☐ No	☐ N/A	In the correct (open or closed) position
☐ Yes	☐ No	☐ N/A	Locked or supervised
☐ Yes	☐ No	☐ N/A	Accessible
☐ Yes	☐ No	☐ N/A	Post Indicator Valves (PIVs) are provided with correct wrenches
☐ Yes	☐ No	☐ N/A	Free from damage or leaks
☐ Yes	☐ No	☐ N/A	Proper signage
			Water Level
☐ Yes	☐ No	☐ N/A	Water level (unsupervised) full

Inspections: Quarterly

☐ Yes	☐ No	☐ N/A	Gauges — normal water pressure maintained
☐ Yes	☐ No	☐ N/A	Water level (supervised) full

NFPA 25 Handbook (p. 1 of 4)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT 9.10 *Sample Form for Inspection of Water Storage Tanks.*

WATER STORAGE TANKS INSPECTION (Continued)

Inspections: Quarterly			**Tank Exterior Inspection**
❑ Yes	❑ No	❑ N/A	Exterior of tank, supporting structure, vents, foundation, and catwalks or ladders are in good condition
❑ Yes	❑ No	❑ N/A	Area is free of combustible storage, trash, debris, brush, or material that could present a fire exposure hazard
❑ Yes	❑ No	❑ N/A	Area is free of accumulation of material on or near parts that could result in accelerated corrosion or rot
❑ Yes	❑ No	❑ N/A	Tank and support are free of ice buildup
❑ Yes	❑ No	❑ N/A	Exterior sides and top of embankments supporting coated fabric tanks are free of erosion
			(Cold Weather/Heating Season Only)
❑ Yes	❑ No	❑ N/A	Heating system (supervised systems)
			Control Valves (Electronically Supervised)
❑ Yes	❑ No	❑ N/A	In the correct (open or closed) position
❑ Yes	❑ No	❑ N/A	Electronically supervised
❑ Yes	❑ No	❑ N/A	Accessible
❑ Yes	❑ No	❑ N/A	Post Indicator Valves (PIVs) are provided with correct wrenches
❑ Yes	❑ No	❑ N/A	Free from damage or leaks
❑ Yes	❑ No	❑ N/A	Proper signage
			Surrounding Area
❑ Yes	❑ No	❑ N/A	Free of combustibles
❑ Yes	❑ No	❑ N/A	Free of material that could accelerate corrosion or not
❑ Yes	❑ No	❑ N/A	Free of ice buildup
❑ Yes	❑ No	❑ N/A	Embankments (for coated fabric tank) free of erosion
Inspections: Annual			
❑ Yes	❑ No	❑ N/A	Hoops and grillage (wooden tanks) are in good condition
❑ Yes	❑ No	❑ N/A	Painted/coated surfaces are in good condition
❑ Yes	❑ No	❑ N/A	Expansion joints are not cracked or leaking
Inspections: Three Years			**Steel Tank Interior Inspection (Without Corrosion Protection)**
❑ Yes	❑ No	❑ N/A	Silt has been removed for underwater evaluation
❑ Yes	❑ No	❑ N/A	Interior surfaces are free of pitting, corrosion, spalling, or other forms of deterioration
❑ Yes	❑ No	❑ N/A	Interior is free of waste material, aquatic growth, and debris
❑ Yes	❑ No	❑ N/A	Interior coating is intact
❑ Yes	❑ No	❑ N/A	Tank floor is free of dents
❑ Yes	❑ No	❑ N/A	Heating system and components are in good condition
❑ Yes	❑ No	❑ N/A	Anti-vortex plate is in good condition and is not obstructed

NFPA 25 Handbook (p. 2 of 4)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT 9.10 *Continued.*

WATER STORAGE TANKS INSPECTION (Continued)

Inspections: Five Years			**Interior Inspection (All Other Tank Types)**
❑ Yes	❑ No	❑ N/A	Silt has been removed for underwater evaluation
❑ Yes	❑ No	❑ N/A	Interior surfaces are free of pitting, corrosion, spalling, or other forms of deterioration
❑ Yes	❑ No	❑ N/A	Interior is free of waste material, aquatic growth, and debris
❑ Yes	❑ No	❑ N/A	Interior coating is intact
❑ Yes	❑ No	❑ N/A	Tank floor is free of dents
❑ Yes	❑ No	❑ N/A	Heating system and components are in good condition
❑ Yes	❑ No	❑ N/A	Anti-vortex plate is in good condition and is not obstructed
			Check Valves
❑ Yes	❑ No	❑ N/A	Check valve — internal moves freely and in good condition
Test Prior to Heating Season			**Tank Heating System**
❑ Yes	❑ No	❑ N/A	In proper working order
❑ Yes	❑ No	❑ N/A	Low water temperature signals
❑ Yes	❑ No	❑ N/A	High water temperature signals
Test: Monthly			**Water Temperature**
❑ Yes	❑ No	❑ N/A	Low temperature alarm is working correctly
❑ Yes	❑ No	❑ N/A	High temperature limit switch is working correctly
Test: Semiannual			
❑ Yes	❑ No	❑ N/A	High and low water level signals work correctly
Test: Annual			**Valve Status**
❑ Yes	❑ No	❑ N/A	Operated through its full range of motion
❑ Yes	❑ No	❑ N/A	Status test to verify valve(s) is in the open position
			Automatic Tank Fill Valve
❑ Yes	❑ No	❑ N/A	Valve actuated by lowering water level
❑ Yes	❑ No	❑ N/A	Measure and record refill rate
Test: Five Years			
❑ Yes	❑ No	❑ N/A	Level indicators are accurate and move freely
❑ Yes	❑ No	❑ N/A	Gauges tested or replaced
Maintenance			
❑ Yes	❑ No	❑ N/A	Tank maintained full or at designated water level
❑ Yes	❑ No	❑ N/A	Hatch covers in the roofs and the door at the top of frost-proof castings kept securely fastened
❑ Yes	❑ No	❑ N/A	Waste material in or on the tank
❑ Yes	❑ No	❑ N/A	Clean strainers quarterly

NFPA 25 Handbook (p. 3 of 4)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT 9.10 *Continued.*

WATER STORAGE TANKS INSPECTION (Continued)

Comments

Signature: _____ Date: _____

Contractor Name: _____

Contractor Address: _____

License/Certification No.: _____

NFPA 25 Handbook (p. 4 of 4)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT 9.10 *Continued.*

9.2.1 Water Level.

9.2.1.1* The water level in tanks equipped with supervised water level alarms that are supervised in accordance with *NFPA 72* shall be inspected quarterly.

A.9.2.1.1 More frequent inspections should be made where extreme conditions, such as freezing temperatures or arid climate, can increase the probability of adversely affecting the stored water.

Supervisory water level alarms installed on tanks provide notification that the tank water level is above or below an acceptable level. The water level of the tank is the main concern as opposed to the condition of the water. For convenience, inspection of the condition of the water can take place concurrently with the water level inspection.

The water level in a tank is determined by measuring the amount of water in the tank between the overflow and discharge outlet. This quantity is determined by the calculated flow of the fire protection system for a specified duration, such as 30, 60, or 90 minutes. The level should never be lower than 3 in. to 4 in. (76 mm to 102 mm) below the designated fire service level.

Exhibit 9.11 and Exhibit 9.12 show two different means to determine the quantity of water within a tank. Exhibit 9.11 shows the indicator running the full height of a gravity tank that is under construction. Exhibit 9.12 shows a sight glass on a steel pressure tank.

9.2.1.2 The water level in tanks not equipped with supervised water level alarms connected to a constantly attended location shall be inspected monthly.

N **9.2.1.3 Water Level Verification.**

N **9.2.1.3.1** Inspection of water level shall be verified through the level indicator, where provided.

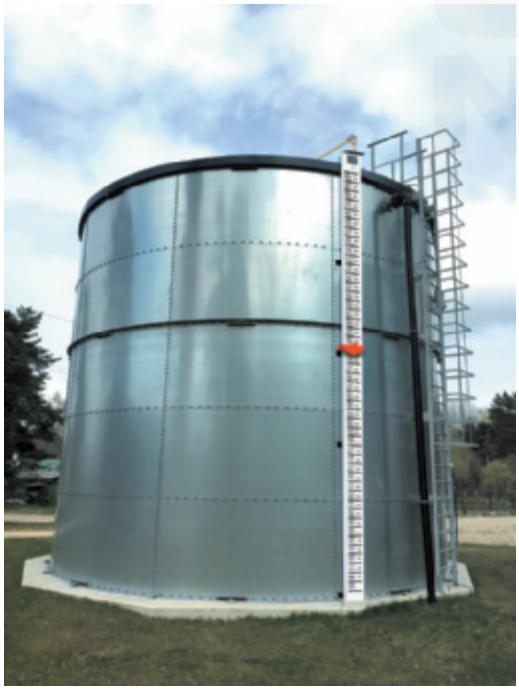


EXHIBIT 9.11 *Steel Tank with a Liquid Level Gauge. (Courtesy of Climate, Inc.)*



EXHIBIT 9.12 *Sight Glass on a Steel Pressure Tank. (Courtesy of National Fire Sprinkler Association)*

N **9.2.1.3.2*** The tank shall be at full or at the designed water level.

N **A.9.2.1.3.2** The designed water level should be based on the fire protection system having the largest stored water volume requirement based on its demand and required duration as defined by the appropriate referenced standards. The designed water level is often used as the set point for operation of the tank fill valve.

9.2.2 Heating System.

9.2.2.1 Tank heating systems installed on tanks equipped with low water temperature alarms supervised in accordance with *NFPA 72*, connected to a constantly attended location shall be inspected quarterly during the heating season.

9.2.2.2 Tank heating systems without a supervised low temperature alarm connected to a constantly attended location shall be inspected daily during the heating season.

9.2.3 Water Temperature.

9.2.3.1 The temperature of water in tanks shall not be less than 40°F (4°C).

9.2.3.2 The temperature of water in tanks with low temperature alarms supervised in accordance with *NFPA 72*, connected to a constantly attended location shall be inspected and recorded quarterly during the heating season when the mean temperature is less than 40°F (4°C).

ITM Deficiency, Impairment, or Hazard Evaluation?

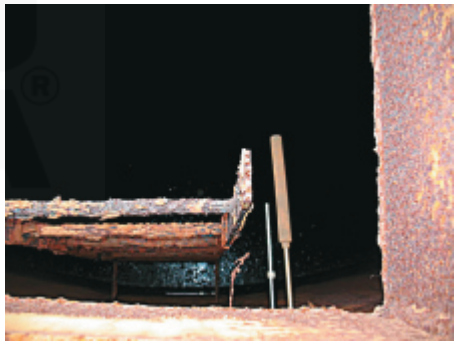
ANSWER: ITM DEFICIENCY AND POSSIBLE IMPAIRMENT

This photo shows the interior of a water storage tank. It was taken while an inspector was standing on the ladder on the outside of the tank and looking through the access hatch down the ladder that is inside the tank. The water level in this ground storage tank is below what is required for the fire protection system. Notice that the water level is well below the tank water level switch and tank temperature switch.

The water level in tanks with supervised water level alarms is required by 9.2.1.1 to be inspected quarterly. This requirement involves inherent safety risks such as climbing the ladder on the exterior of the tank and accessing a confined space, but it can be performed safely by using the proper safety equipment and following the required procedures.

In addition to the quarterly inspection, the water level alarm is required in 9.3.5 to be tested annually. The low water temperature alarm is required in 9.3.3 to be tested prior to the heating season. In the case of this photo, the water level switch should have signaled the low water condition. One method used to test this switch is to manually move the float up and down to simulate water levels in the tank. To test the thermostat in the low water temperature alarm switch, a manufacturer simply states that the device must be exposed to temperatures of 40°F and 140°F (4°C and 60°C). One way to test low temperature is to insert the probe into a bag of ice.

The low water condition found in this tank should be recorded as a critical deficiency if the tank is still partially full, which would allow the fire protection system to function in a fire event but with a reduced duration. If the tank is empty, the water tank unit is impaired. If this tank is the sole water supply source, the systems downstream would not function at all during a fire event, and the tank should be considered impaired. The impairment procedures in Chapter 15 should be implemented immediately.



(Courtesy of Byron Blake and SimplexGrinnell)

Case In Point

NFPA 22 recognizes the following heating systems:

- Steam water heaters
- Gas-fired water heaters
- Oil-fired water heaters
- Coal-burning water heaters
- Electric water heaters
- Vertical steam radiators
- Hot water
- Steam coils inside tanks
- Direct discharge of steam
- Solar heating

The requirements for each of these systems are discussed in Section 16.3 of NFPA 22. Regardless of which method is used to heat the tank, the intent is to ensure reliability by keeping the tank free of ice. An ice plug in a riser pipe, for example, can obstruct flow and could break the pipe. In addition, ice in or on the tank structure can cause the tank to collapse.

Generally, only tanks that are subject to freezing will have heating systems. The need for a tank heating system is based on the type of tank construction and the lowest one-day mean temperature. Heat loss calculations must be performed, as required by NFPA 22, in order to determine the method of heating. See NFPA 22 to determine whether a heating system is needed for a particular tank. The relevant equation from NFPA 22 is extracted below:

$$\left[\frac{A^2 * \Delta T}{R} + \left(\frac{A^2 * \Delta T}{R}\right) * W\right] * Sf$$

where:
A= Surface area of the tank [ft^2]
ΔT = The difference between desired tank water temperature and outside ambient temperature ($T_{tank} - T_{amb}$).[°F]
R = R-value of the tank material [$ft^2hr°F/Btu$]
Sf = Safety Factor, typically 10%, which would mean Sf = 1.1 [unitless]
W = 0.05 if tanks will not be exposed to winds above 20mph [unitless]
W = 0.10 if tanks are exposed to 25mph winds [unitless]
W = 0.15 if tanks are exposed to winds at or above 30mph [unitless]
Note: This equation is used to determine your method of heating as required in NFPA 22 and gives you an answer with units of Btu/hr

9.2.3.3 The temperature of water in tanks without low temperature alarms connected to a constantly attended location shall be inspected and recorded weekly during the heating season when the mean temperature is less than 40°F (4°C).

9.2.4 Exterior Inspection.

9.2.4.1* The exterior of the tank, supporting structure, vents, foundation, and catwalks or ladders, where provided, shall be inspected quarterly for signs of obvious damage or weakening.

The inspection required by 9.2.4.1 is a visual inspection, as indicated by the words "obvious damage." An exterior visual inspection should reveal loose or missing bolts, excessive corrosion, and cracking and peeling paint, among other items.

The roof vent provides ventilation above the maximum water level and also keeps birds and other animals out of the tank. The vent may be equipped with a perforated plate having 3/8 in. (9.5 mm) perforations or a corrosion-resistant screen. The perforations must be kept clean to maintain proper ventilation.

For FRP tanks, the exterior inspection should verify that the tank is protected from freezing, mechanical, and ultraviolet (UV) damage.

A.9.2.4.1 Lightning protection systems, where provided, should be inspected, tested, and maintained in accordance with NFPA 780.

ITM Deficiency, Impairment, or Hazard Evaluation?

ANSWER: ITM DEFICIENCY

This photo was taken during an inspection of a ground storage tank as required by Section 9.2, and it reveals a couple of problems that should be identified as deficiencies. First, the ladder is required to be inspected for signs of obvious damage or weakening as described in 9.2.4.1. This ladder is not only damaged but part of it is missing, and this should be noted as a deficiency. Second, the area surrounding the tank does not comply with the conditions described in 9.2.4.2, because there is brush that could present a fire exposure hazard.



(Courtesy of Byron Blake and SimplexGrinnell)

9.2.4.2 The area surrounding the tank and supporting structure, where provided, shall be inspected quarterly to ensure that the following conditions are met:

(1) The area is free of combustible storage, trash, debris, brush, or material that could present a fire exposure hazard.
(2) The area is free of the accumulation of material on or near parts that could result in accelerated corrosion or rot.
(3) The tank and support are free of ice buildup.
(4) The exterior sides and top of embankments supporting coated fabric tanks are free of erosion.

An inspection of the area surrounding the tank and supporting structure is similar to an exposure evaluation provided during an insurance inspection. It must be determined whether any surrounding material presents an exposure hazard to the tank or support structure. This exposure hazard can be from any of the following issues:

- Fires [see 9.2.4.2(1)]
- Corrosion [see 9.2.4.2(2)]
- Increased loads due to ice [see 9.2.4.2(3)]
- Erosion of the berm or embankment, as in the case of an embankment-supported coated fabric tank — [see 9.2.4.2(4)]

9.2.4.3 Expansion joints, where provided, shall be inspected annually for leaks and cracks.

9.2.4.4 The hoops and grillage of wooden tanks shall be inspected annually.

9.2.4.5 Exterior painted, coated, or insulated surfaces of the tank and supporting structure, where provided, shall be inspected annually for signs of degradation.

9.2.5 Interior Inspection.

Exhibit 9.13 shows the interior of a tank revealing silt and a noncompliant vortex plate. This material was found inside a 1 million gal (3,785,411 L) suction tank at a power plant. This tank supplies two 2000 gpm (7570 L/min) fire pumps. The photo demonstrates the importance of performing an interior inspection of water tanks supplying fire protection systems. See Exhibit 9.15 for a proper anti-vortex plate.

When an interior inspection of a tank is performed, it is critical to comply with proper safety precautions, including confined space entry requirements.

FAQ Is it necessary to drain a tank to perform an interior inspection?

It is not necessary to drain the tank for the inspection. One means of accomplishing a tank inspection without draining the tank is by using a certified commercial diver. An alternative approach would be to use remote video equipment if acceptable to the authority having jurisdiction (AHJ).

9.2.5.1 Frequency.

9.2.5.1.1* The interior of steel tanks without corrosion protection shall be inspected every 3 years.

A.9.2.5.1.1 To aid in the inspection and evaluation of test results, it is a good idea for the property owner or designated representative to stencil the last known date of an interior paint job on the exterior of the tank in a conspicuous place. A typical place is near one of the manways at eye level.

9.2.5.1.2* The interior of all other types of tanks shall be inspected every 5 years.

Tip for Owners

The guidance in A.9.2.5.1.1 will help ensure that the interior inspections are performed at the appropriate intervals and can also assist in identifying when a new paint job might be needed.



EXHIBIT 9.13 *Interior of Tank Requiring an Inspection.*

FAQ What is the inspection requirement for internal inspections of tanks used for fire protection?

A 3-year internal inspection is required for tanks that do not have corrosion protection (i.e., cathodic protection or equivalent). A 5-year internal inspection is required for all other tanks.

A.9.2.5.1.2 If written verification of interior corrosion protection for a tank per NFPA 22 cannot be provided by the building owner, the interior of the tank should be inspected every 3 years.

9.2.5.2 Where interior inspection is made by means of underwater evaluation, silt shall first be removed from the tank floor.

Underwater inspections are desirable because draining, inspecting, and refilling a tank can be time-consuming and costly and can create a lengthy system impairment. Over time, silt will accumulate on the bottom of a tank. This accumulation not only poses a threat to a diver, but it can also hide flaws in the tank.

It is important to note that NFPA 22 requires a fill connection that is designed to fill the tank within 8 hours. Therefore, draining, inspecting, and refilling can take longer than a normal work shift. Section 15.5 of NFPA 25 requires supplemental protection and special precautions for any impairment in excess of 10 hours in a 24-hour period. As a result, interior inspections can involve considerable planning and expense.

Also, it is important to verify that the diver is a certified commercial diver who is qualified for confined space entry. It is not advisable for certified recreational divers to attempt to perform internal tank inspections. Prior to entering the tank, it is critical to lock out the fire pump systems and observe all the requirements of Chapter 15 during this inspection. Failure to observe these basic safety practices can result in serious injury and even loss of life for the diver. In addition to diving expertise, the person conducting the inspections must also be qualified to identify the conditions that represent deficiencies and impairments in the system. For more information, see the commentary for 3.3.36.

Exhibit 9.14 illustrates the presence of a potential obstruction — a fish — inside a steel tank. The photo was taken during an internal inspection.

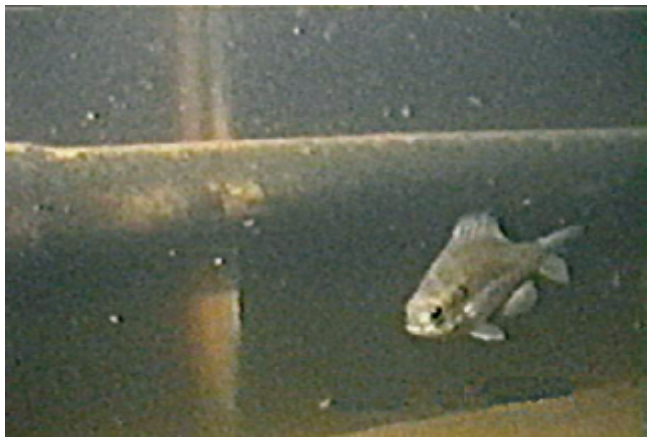


EXHIBIT 9.14 *Potential Obstruction Inside Steel Tank. (Courtesy of Conrady Consultant Services)*

9.2.5.3 The tank interior shall be inspected for signs of pitting, corrosion, spalling, rot, other forms of deterioration, waste materials and debris, aquatic growth, and local or general failure of interior coating.

9.2.5.4 Steel tanks exhibiting signs of interior pitting, corrosion, or failure of coating shall be tested in accordance with 9.2.6.

9.2.5.5* Tanks on ring-type foundations with sand in the middle shall be inspected for evidence of voids beneath the floor.

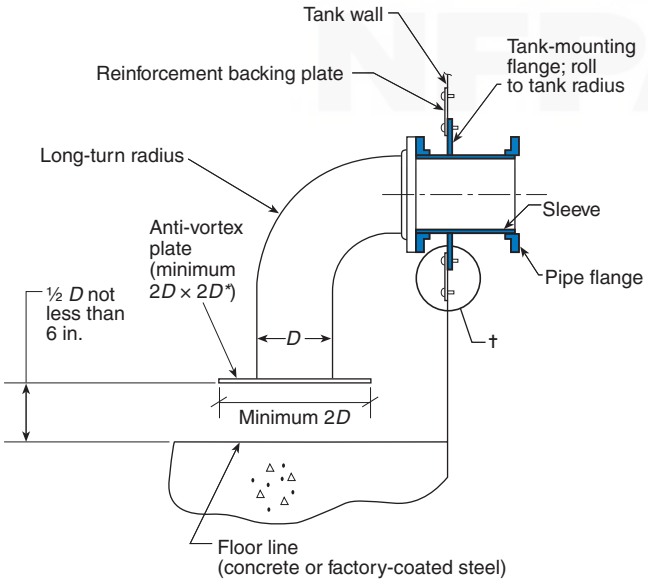
A.9.2.5.5 This inspection can be performed by looking for dents on the tank floor. Additionally, walking on the tank floor and looking for buckling of the floor will identify problem areas.

Ground-level suction tanks are typically set on crushed stone, sand, or concrete foundations. A concrete ring wall at least 2½ ft (760 mm) high and 10 in. (250 mm) thick surrounds the tank foundation. This ring typically projects 6 in. (152 mm) above grade, but it should be inspected carefully because the sand can shift beneath the tank and create a void. Leaks from the tank bottom can also cause subsurface erosion. Without adequate support at the void, failure of the tank bottom can occur.

9.2.5.6 The heating system and components including piping shall be inspected.

9.2.5.7 The anti-vortex plate shall be inspected for deterioration or blockage.

An anti-vortex plate, such as the one illustrated in Exhibit 9.15, is provided on a tank to reduce the likelihood of introducing air pockets into the suction line. The introduction of an air pocket into a pump suction line could result in cavitation of the pump; in turn, this could damage the pump casing and cause a reduction in pump performance.



For SI units, 1 in. = 25.4 mm.
*Frequently, a 48 in. × 48 in. size is used as a standard size that will work for any situation.
†For reinforcement requirements, see AWWA D103.

EXHIBIT 9.15 *Anti-Vortex Plate. [Source: NFPA 22, 2018, Figure B.1(p)]*

9.2.6 Tests During Interior Inspection. Where a drained interior inspection of a steel tank is required by 9.2.5.4, the following tests shall be conducted:

(1) Evaluation of tank coatings shall be made in accordance with the adhesion test of ASTM D3359, *Standard Test Methods for Rating Adhesion by Tape Test*, generally referred to as the "cross-hatch test."
(2) Dry film thickness measurements shall be taken at random locations to determine the overall coating thickness.
(3) Nondestructive ultrasonic readings shall be taken to evaluate the wall thickness where there is evidence of pitting or corrosion.
(4) Interior surfaces shall be spot wet-sponge tested to detect pinholes, cracks, or other compromises in the coating. Special attention shall be given to sharp edges such as ladder rungs, nuts, and bolts.
(5) Tank bottoms shall be tested for metal loss and/or rust on the underside by use of ultrasonic testing where there is evidence of pitting or corrosion. Removal, visual inspection, and replacement of random floor coupons shall be an acceptable alternative to ultrasonic testing.
(6) Tanks with flat bottoms shall be vacuum-box tested at bottom seams in accordance with test procedures found in NFPA 22.

All the tests required by 9.2.6 are intended to identify any failure points or weakened areas of the tank. The list identifies a specific and thorough series of tests to be conducted for a drained tank. Many of the deficiencies noted during this inspection are not going to be detected by a simple visual inspection. Therefore, it is critical to complete this more thorough internal investigation so that any areas that could cause catastrophic tank failure can be identified and corrected.

9.3 Testing.

9.3.1* Level indicators shall be tested every 5 years for accuracy and freedom of movement.

Testing Procedure Alert

While it is important to look at the manufacturer's instructions for testing procedures associated with water level indicators, there are many steps in the process of conducting the test mandated by 9.3.1 that apply to many tank arrangements. It is important to confirm that the indicator can move freely and has not become inadvertently "stuck" in the wrong position. For a detailed testing procedure to execute the test required by 9.3.1, see the Testing Procedures for 9.3.1 at the end of this chapter.

•

A.9.3.1 The testing procedure for listed mercury gauges is as follows.

To determine that the mercury gauge is accurate, the gauge should be tested every 5 years as follows [steps (1) through (7) coincide with Figure A.9.3.1]:

(1) Overflow the tank.
(2) Close valve F. Open test cock D. The mercury will drop quickly into the mercury pot. If it does not drop, there is an obstruction that needs to be removed from the pipe or pot between the test cock and the gauge glass.
(3) If the mercury does lower at once, close cock D and open valve F. If the mercury responds immediately and comes to rest promptly opposite the "FULL" mark on the gauge board, the instrument is functioning properly.

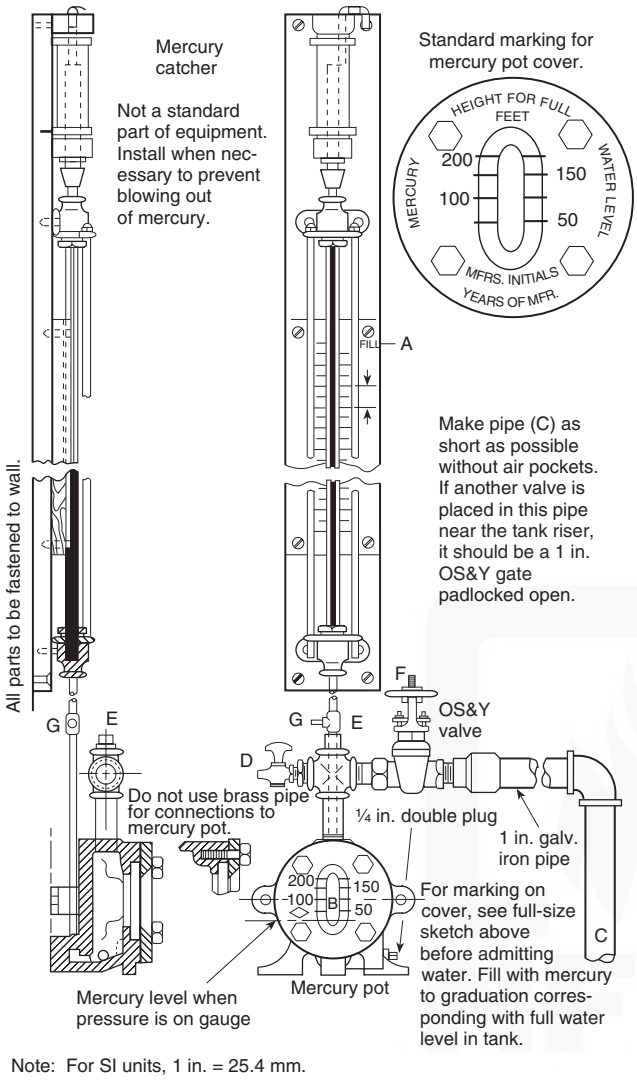


FIGURE A.9.3.1 *Mercury Gauge.*

(4) If the mercury column does not respond promptly and indicate the correct reading during the test, there probably are air pockets or obstructions in the water connecting pipe. Open cock D. Water should flow out forcibly. Allow water to flow through cock D until all air is expelled and rusty water from the tank riser appears. Close cock D. The gauge now likely will read correctly. If air separates from the water in the 1 in. (25 mm) pipe due to being enclosed in a buried tile conduit with steam pipes, the air can be removed automatically by installing a ¾ in. (20 mm) air trap at the high point of the piping. The air trap usually can be installed most easily in a tee connected by a short piece of pipe at E, with a plug in the top of the tee so that mercury can be added in the future, if necessary, without removing the trap. If there are inaccessible pockets in the piping, as where located below grade or under concrete floors, the air can be removed only through petcock D.

(5) If, in step (4), the water does not flow forcibly through cock D, there is an obstruction that needs to be removed from the outlet of the test cock or from the water pipe between the test cock and the tank riser.

(6) If there is water on top of the mercury column in the gauge glass, it will provide inaccurate readings and should be removed. First, lower the mercury into the pot as in step (2). Close cock D and remove plug G. Open valve F very slowly, causing the mercury to rise slowly and the water above it to drain through plug G. Close valve F quickly when mercury appears at plug G, but have a receptacle ready to catch any mercury that drains out. Replace plug G. Replace any escaped mercury in the pot.

(7) After testing, leave valve F open, except under the following conditions: If it is necessary to prevent forcing mercury and water into the mercury catcher, the controlling valve F can be permitted to be closed when filling the tank but should be left open after the tank is filled. In cases where the gauge is subjected to continual fluctuation of pressure, it could be necessary to keep the gauge shut off except when it needs to be read. Otherwise, it could be necessary to remove water frequently from the top of the mercury column as in step (5).



EXHIBIT 9.16 *Electronic Water Temperature Sensor. (Courtesy of Potter Electric Signal Company, LLC)*

A level indicator is a device used to measure the water level in a tank. Although mercury gauges are often used for this purpose, they are not permitted on new installations due to the health risks associated with ingestion of mercury vapors and mercury absorption through human skin. Therefore, they will be found only on older tanks. A mercury gauge should not be adjusted until a safety data sheet (SDS) is obtained from the property owner and all precautions have been followed. Electronic tank water level indicators should be tested in accordance with the manufacturer's instructions.

9.3.2 The tank heating system, where provided, shall be tested prior to the heating season to make certain it is in the proper working order.

9.3.3 Low water temperature signals, where provided, shall be tested prior to the heating season.

As the water level decreases, the likelihood of freezing increases. Therefore, testing must be done more frequently during cold weather. The water temperature sensor shown in Exhibit 9.16 is a common way to monitor water temperature during cold weather periods.

Testing Procedure Alert

Freezing water in a storage tank can be extremely problematic for several reasons. First, it will limit or, in some cases, eliminate the water that can be delivered to the system (e.g., sprinkler or standpipe system) that is trying to draw it. Additionally, it can lead to significant damage of the tank and its appurtenances, or it can cause a fire pump to run "dry" because no water is being drawn from the tank. For a process for conducting low temperature signal tests in accordance with 9.3.3, see the Testing Procedures for 9.3.3 at the end of this chapter.

9.3.4* High water temperature limit switches on tank heating systems, where provided, shall be tested prior to the heating season.

Testing Procedure Alert

The purpose of completing a high temperature limit switch test is to ensure that an initiated high temperature condition will cause the shutdown of the attached heating system. There are several ways to conduct this test, one of which is provided in the Testing Procedures for 9.3.4 at the end of this chapter.

• Δ **A.9.3.4** The manufacturer's instructions should be consulted for guidance on testing. In some situations, it might not be possible to test the actual initiating device. In such cases, only the circuitry should be tested.

9.3.5* High and low water level signals shall be tested annually.

Low water level alarms must be tested prior to the heating season as opposed to the annual test addressed in 9.3.5 (see 9.3.3 and related commentary). Exhibit 9.17 illustrates a water level indicator.

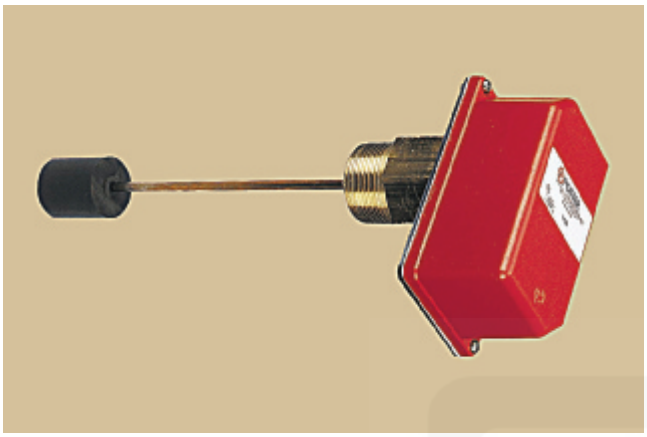


EXHIBIT 9.17 *Electronic Water Level Indicator. (Courtesy of Potter Electric Signal Company, LLC)*

Not unlike the level indicator test required by 9.3.1, this test focuses on making sure there is sufficient water in the tank. Rather than looking at the indicator, however, this test focuses on the functionality of the system components that send a signal to indicate that the tank is experiencing an issue with the water level. See the Testing Procedures for 9.3.5 at the end of this chapter for guidance in conducting this test.

Testing Procedure Alert

Δ **A.9.3.5** See A.9.3.4.

9.4 Maintenance.

9.4.1 Voids discovered beneath the floors of tanks shall be filled by pumping in grout or accessing the sand and replenishing.

Voids can result from slow leaks, which, if left untreated, could cause further subsoil erosion and result in failure of the tank bottom. This issue is addressed in greater detail in A.9.2.5.5 and its associated commentary.

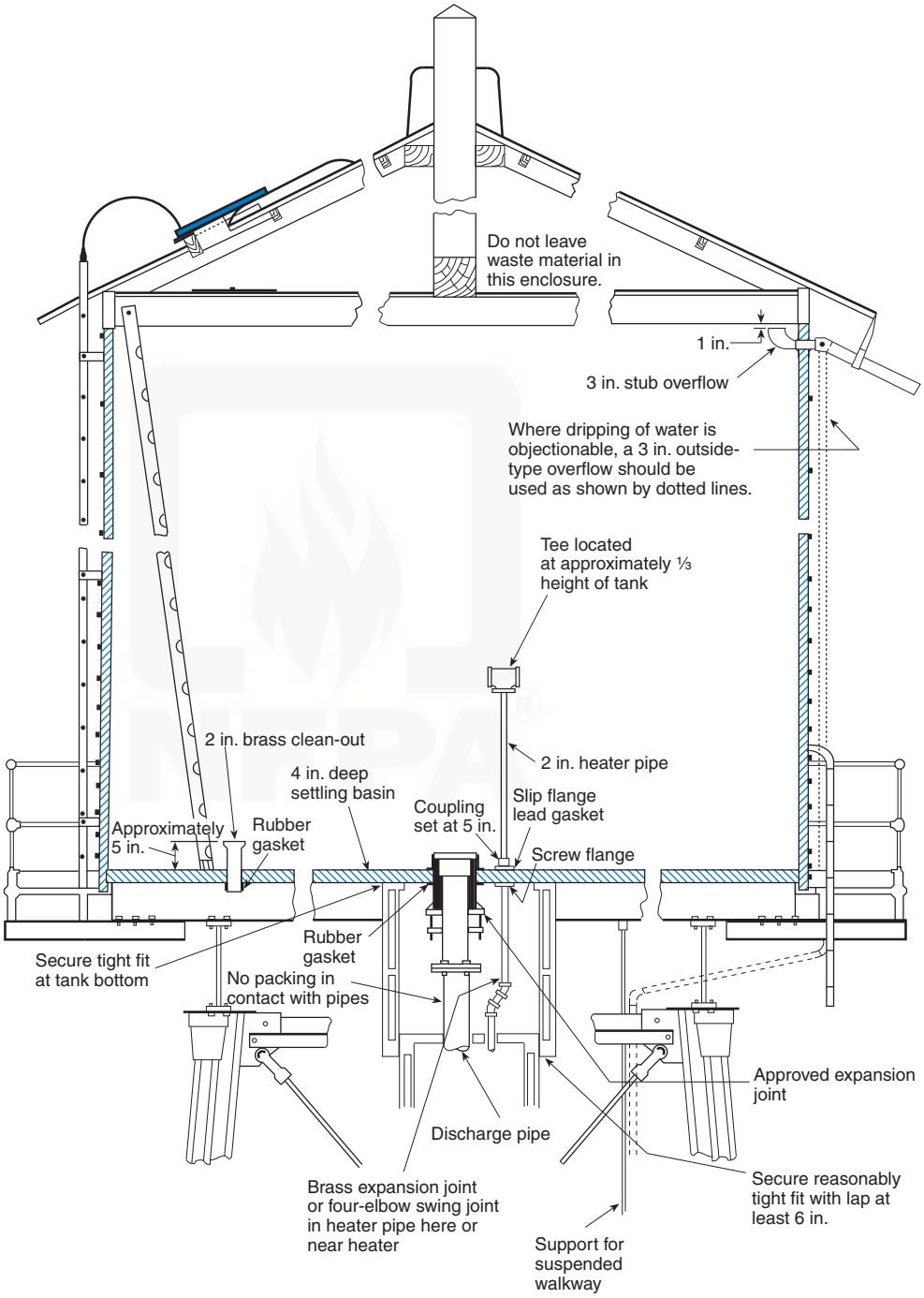
9.4.2 The tank shall be maintained full or at the designed water level.

The water level should never be lower than 3 in. to 4 in. (76 mm to 102 mm) below the designated fire service level.

9.4.3 The hatch covers in the roofs and the door at the top of the frostproof casing shall always be kept securely fastened with substantial catches as a protection against freezing and windstorm damage.

9.4.4 No waste materials, such as boards, paint cans, trim, or loose material, shall be left in the tank or on the surface of the tank.

Any material left in or on the tank could block the waterway. Steel tanks are easy to inspect for the presence of such material. However, certain wooden tanks have space below the roof (see Exhibit 9.18) in which old paint cans or similar items were commonly placed.



For SI units, 1 in. = 25.4 mm.

EXHIBIT 9.18 *Wooden Tank with Space Below the Roof. [Source: NFPA 22, 2018, Figure B.1(i)]*

9.4.5 Silt shall be removed during interior inspections or more frequently as needed to avoid accumulation to the level of the tank outlet.

The actual frequency required for removal of silt or other debris accumulation, as required by 9.4.5, is permitted to be identified over time. The requirement allows for this variation by using the wording "or more frequently as needed" to customize the testing based on the needs of the tank. For example, if a raw water source is used to fill the tank, the introduction of silt into the line presents a problem that must be dealt with more frequently than during the interior inspection.

9.4.6 Maintenance of Embankment-Supported Coated Fabric (ESCF) Suction Tanks.

Embankment-supported coated fabric tanks present a unique design and installation challenge. The tank manufacturer's maintenance requirements must be followed, in addition to those prescribed by the standard. Standard inspection requirements for these tanks, such as not allowing waste materials, not allowing large accumulations of ice to collect on top of the tank, and inspection of the berms for erosion, are outlined in the standard. However, specific maintenance requirements, such as painting or refurbishing the top surface of the tank, and interior inspection frequencies and methods, must come from the manufacturer.

9.4.6.1 The maintenance of ESCF tanks shall be completed in accordance with this section and the tank manufacturer's instructions.

9.4.6.2 The exposed surfaces of ESCF tanks shall be cleaned and painted every 2 years or in accordance with the manufacturer's instructions.

9.5 Automatic Tank Fill Valves.

Automatic tank fill valves are usually spring-loaded, diaphragm-type valves that sense pressure in the tank and open and close to maintain a constant water level in the tank. The valve manufacturer's instructions should be followed for testing, maintenance, and adjustment. Exhibit 9.19 shows an automatic tank fill valve.

9.5.1 Inspection.

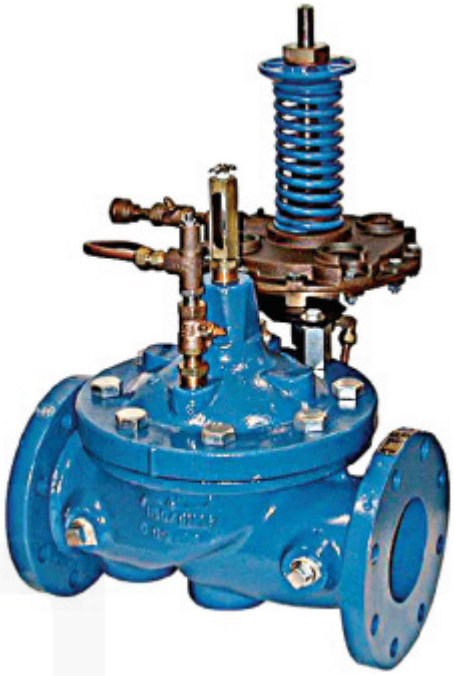
9.5.1.1 Automatic tank fill valves shall be inspected in accordance with Table 9.5.1.1.

Δ ***TABLE 9.5.1.1*** *Summary of Automatic Tank Fill Valve Inspection and Testing*

Item	*Frequency*	*Reference*
Inspection		
Enclosure (during cold weather)	Daily/weekly	Chapter 4
Exterior	Monthly	Chapter 13
Interior	Annually/5 years	Chapter 13
Strainers, filters, orifices (inspect)	5 years	Chapter 13
Test		
Automatic tank fill valve	Annually	9.5.3
Maintenance		
Strainers (clean)	Quarterly	9.5.2.3

9.5.1.1.1 OS&Y isolation valves that are a part of the automatic fill valves shall be inspected in accordance with Chapter 13.

EXHIBIT 9.19 *Automatic Tank Fill Valve.*



9.5.1.2 Valves secured with locks or electrically supervised in accordance with applicable NFPA standards shall be inspected monthly.

9.5.1.3 The enclosure shall be inspected to verify that it is heated and secured.

9.5.2 Maintenance.

9.5.2.1 Maintenance of all automatic tank fill valves shall be conducted by a qualified person following the manufacturer's instructions in accordance with the procedure and policies of the authority having jurisdiction.

9.5.2.2 Rubber parts shall be replaced in accordance with the frequency required by the authority having jurisdiction and the manufacturer's instructions.

9.5.2.3 Strainers shall be cleaned quarterly.

9.5.3 Testing. All automatic tank fill valves shall be tested yearly in accordance with the following:

(1) The valve shall be actuated automatically by lowering the water level in the tank.
(2) The refill rate shall be measured and recorded.

Testing Procedure Alert

While 9.3.1 and 9.3.5 focus on testing various components of the tank system to confirm there is sufficient water, 9.5.3 is aimed at making sure that where a low level signal is received, the refill valve activates appropriately and provides the correct refill rate for the tank. For more information on this test, including a detailed procedure for conducting it, see the Testing Procedures for 9.5.3 at the end of this chapter.

9.6 Component Action Requirements.

Component replacement tables offer guidance to the user of the standard when system components are adjusted, repaired, rebuilt, or replaced. It is not necessary in each case to require a complete acceptance test for each component when maintenance is performed.

9.6.1 Whenever a component in a water storage tank is adjusted, repaired, reconditioned, or replaced, the action required in Table 9.6.1 shall be performed.

Δ ***TABLE 9.6.1*** *Summary of Component Action Requirements*

Component	*Adjust*	*Repair/ Recondition*	*Replace*	*Test Criteria*
Tank Components				
Catwalks and ladders	X	X	X	Verify integrity in conformance with NFPA 22
Expansion joints	X	X	X	Verify integrity in conformance with NFPA 22
Heating system	X	X	X	Verify heating system is in conformance with NFPA 22
Hoops and grillage	X	X	X	Verify integrity in conformance with NFPA 22
Insulation		X	X	Verify integrity in conformance with NFPA 22
Overflow piping	X	X	X	Verify integrity in conformance with NFPA 22
Support structure		X	X	Verify integrity in conformance with NFPA 22
Tank exterior		X	X	Verify integrity in conformance with NFPA 22
Tank interior		X	X	Remove debris; verify integrity in conformance with NFPA 22
Alarm and Supervisory Components				
Enclosure temperature	X	X	X	Operational test for conformance with NFPA 22 and/or *NFPA 72*
High and low water level	X	X	X	Operational test for conformance with NFPA 22 and/or *NFPA 72* and the design water levels
Valve supervision	X	X	X	Operational test for conformance with NFPA 22 and/or *NFPA 72*
Water temperature	X	X	X	Operational test for conformance with NFPA 22 and/or *NFPA 72*
Fill and Discharge Components				
Automatic fill valves	X	X		Perform annual test in accordance with 9.5.3
Valves	X	X	X	See Chapter 13
Status Indicators				
Level indicators	X	X	X	Verify conformance with NFPA 22
Pressure gauges			X	Verify at 0 psi (0 bar) and at system working pressure

9.6.2 Where the original installation standard is different from the cited standard, the use of the appropriate installing standard shall be permitted.

9.6.3 These actions shall not require a design review, which is outside the scope of this standard.

References Cited in Commentary

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*, 2019 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection*, 2018 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, 2019 edition.

Water Tank Level Indicator Test (Float Type)

Purpose

The purpose of completing a test of the float-type water tank level indicator is to ensure that the indicator is accurate and moves freely throughout the full range of operation. Some tanks might also employ other types of level indicators such as sight glass tubes, altitude pressure gauges, or mercury gauges. The testing of these devices should be in accordance with the manufacturer's instructions as well as the specific criteria provided in A.9.3.1 for the testing of mercury gauges.

The float-type level indicator typically includes an internal float, which rises and drops with the water level inside the tank, connected through a cable and pulley system to an external target on the shell of the tank. The movement of the internal float with the water level causes a corresponding movement of the target on the exterior of the tank, which can be visually observed against an adjacent scale marking. Generally, these include a drop in the target position as the water level rises; however, some devices might include a compound pulley system that results in an upward movement of the external target to correspond directly with the water level in the tank. This testing can be coordinated with the drainage of a tank that is part of an internal tank inspection conducted as required by 9.2.5.1.

Tools/Equipment

1. The various wrenches and tools necessary to facilitate the removal of such equipment as drain flanges are required.

Procedure Steps

1. Prior to any testing, notify the fire department and/or the alarm monitoring company (if needed), as well as the facility representatives, that testing is going to be conducted. Make the necessary arrangements for a preplanned impairment in accordance with Section 15.5.
2. Close the control valves on any automatic fill line connection and the control valve on any outlet connections from the tank.
3. Visually check the position of the water level target to determine the designated position of the water within the tank. Confirm that the actual water level within the tank matches this designation.
4. Locate a drain connection for the tank and check the area surrounding the discharge point to ensure that there are no obvious conditions that would prevent water from being discharged safely or cause direct damage in the immediate vicinity. Where the discharge of water is to an area subject to potential freezing conditions, the facility representative should be advised of the potential for icing conditions.
5. Initiate the drainage of the tank by opening the located drain connection and observe the water level target for movement as the water level begins to drop. Make periodic checks of the target position against the provided scale to ensure the accuracy of the scale designation as the tank is drained.
6. Once the tank is completely drained, closely check the float, cable, pulleys, guides, and external target for signs of corrosion or deterioration, noting any conditions that might inhibit free movement of the system. Note that internal entry into the tank requires special precautions for confined space entry.
7. Close any tank drain connections that were opened in Step 5 above.
8. Open any control valves that were closed in the automatic fill line in Step 2 above, or open the manual refill line to initiate a refill of the tank and observe the water level target for movement as the water level begins to rise. Make periodic checks of the target position against the provided scale to ensure the accuracy of the scale as the tank is refilled.
9. Open any control valves that were closed in the tank outlet connections in Step 2 above.
10. Upon completion of all testing, notify the fire department and/or the alarm monitoring company (as needed), as well as the facility representatives, that testing is complete, and reset the fire alarm system as necessary.

Alternative Approaches

The drainage of a water storage tank is not mandated by 9.2.5.1, so alternative methods to the described process above could also be used. This could include the use of a certified commercial diver or remote video equipment to complete an internal inspection of the water tank where acceptable to the AHJ. Rather than checking the movement of the float with a change in actual water level, a certified commercial diver might manually cycle the system through a simulated movement by pulling the float to the bottom of the tank and returning it to the surface or by using some other alternative means to submerge the float.

These methods provide the benefit of not requiring drainage of the water tank and associated impairment of the system; however, the freedom of movement of the system cannot be fully assessed against an actual response of the system from a change in water level in the tank. This can be checked to some extent by conducting a partial drainage of the tank to ensure initiation of movement through the starting range for the system, but this will not check the full movement of the target.

Evaluation of Results

The water level indicator should provide an accurate indication of the actual water level within the tank throughout the full range of operation. The components of the water level indicator should not show signs of excessive corrosion, deterioration, or other conditions that inhibit the free movement of the system. Any noted inaccuracies or conditions that inhibit free movement should be investigated and corrective action should be taken as necessary.

The procedure(s) outlined above is not mandated by NFPA 25 and represents only one approach to conducting this test.

Water Tank Low Temperature Signal Test

Purpose

The purpose of completing a low temperature signal test is to ensure that an initiated low temperature supervisory switch will transmit a signal to the appropriate monitoring location. The actual testing of the low temperature supervisory switch would require the exposure of the switch to a temperature at or below its designated operating temperature. For a water storage tank, this would require the removal of the switch from the tank, which is not normally possible without draining the tank. As a result, the testing of the circuitry between the installed switch and the monitoring location is to be conducted. Some manufacturers might provide additional testing instructions for the internal circuitry of the switch.

Consideration might be given to removal and testing of the actual operation of the switch whenever the tank is drained for inspection or maintenance to ensure proper operation.

Tools/Equipment

1. The various tools necessary to facilitate the removal of cover plates and disconnection of wire connections are required.
2. A multimeter is required for additional manufacturers' recommended testing, as needed.

Procedure Steps

1. Prior to any testing, notify the fire department and/or the alarm monitoring company (as needed), as well as the facility representatives, that testing is going to be conducted.
2. Check the fire alarm control panel, remote annunciator, or other supervising panel to determine that the low temperature signal is not currently active on the system.
3. Remove the cover plate on the low temperature supervisory switch, exposing the wiring connection of the unit.
4. Disconnect one leg of the wired connection of the low temperature supervisory switch to simulate an open condition.
5. Verify the receipt of a low temperature supervisory signal at the fire alarm control panel, remote annunciator, or other supervising panel.
6. Complete additional testing of the switch as recommended by the manufacturer.
7. Reconnect the wiring connection for the low temperature supervisory switch and reinstall the cover plate.
8. Upon completion of all testing, notify the fire department and/or the alarm monitoring company (as needed), as well as the facility representatives, that testing is complete, and reset the fire alarm system as necessary. A verification of the receipt of initiated signals with the fire department and/or the alarm monitoring company, where so connected, would be appropriate as part of this effort.

Evaluation of Results

The transmission of the low temperature supervisory signal is verified by receipt at the fire alarm control panel, remote annunciator, or other supervising panel upon simulation of an activation of the low temperature supervisory switch. Failure to transmit a proper signal requires further investigation and corrective action as necessary.

The procedure(s) outlined above is not mandated by NFPA 25 and represents only one approach to conducting this test.

Water Tank High Temperature Limit Switch Test

Purpose

The purpose of completing a high temperature limit switch test is to ensure that an initiated high temperature condition will cause the shutdown of the attached heating system. The actual testing of the high temperature limit switch would require the exposure of the switch to a temperature at or above its designated operating temperature. For a water storage tank this would require the removal of the switch from the tank, which is not normally possible without draining the tank. As a result, the testing of the circuitry to cause a shutdown of the heating system is to be conducted. Some manufacturers might provide additional testing instructions for the internal circuitry of the switch.

Consideration might be given to removal and testing of the actual operation of the switch whenever the tank is drained for inspection or maintenance to ensure proper operation.

Tools/Equipment

1. The various tools necessary to facilitate the removal of cover plates and disconnection of wire connections are required.
2. A multimeter is required for additional manufacturers' recommended testing as needed.

Procedure Steps

1. Prior to any testing, notify the fire department and/or the alarm monitoring company (as needed), as well as the facility representatives, that testing is going to be conducted.
2. Check the heating system to ensure that it is in operation prior to initiating the test.
3. Remove the cover plate on the high temperature limit switch, exposing the wiring connection of the unit.
4. Disconnect one leg of the wired connection of the high temperature limit switch to simulate an open condition.
5. Verify the shutdown of the power or fuel source to the heating system.
6. Complete additional testing of the switch as recommended by the manufacturer.
7. Reconnect the wiring connection for the high temperature limit switch and reinstall the cover plate.
8. Upon completion of all testing, notify the fire department and/or the alarm monitoring company (as needed), as well as the facility representatives, that testing is complete. Reset the fire alarm system as necessary. An additional reset of the heating system might be required.

Evaluation of Results

The shutdown of the power or fuel source to the heating system upon simulation of a high temperature limit switch activation verifies the operation of the shutdown circuitry of the heating system from the connection to the high temperature limit switch to the heating system. Failure of the power or fuel source to shutdown requires further investigation and corrective action as necessary.

The procedure(s) outlined above is not mandated by NFPA 25 and represents only one approach to conducting this test.

Non-Pressure Water Tank High/Low Water Level Signal Test

Purpose

The purpose of completing a high/low water level signal test is to ensure that high and low water conditions (as monitored) are initiated and transmitted to the appropriate monitoring location. Some manufacturers might provide additional testing instructions for the internal circuitry of the switch.

Tools/Equipment

The various wrenches and tools necessary to facilitate the drainage of water from the tank and overfill are required.

1. A tape measure or other measuring means is required to measure the change in water level required to initiate the high/low water level signals.

Procedure Steps

1. Prior to any testing, notify the fire department and/or the alarm monitoring company (as needed), as well as the facility representatives, that testing is going to be conducted.
2. Check the fire alarm panel, remote annunciator, or other supervising panel to determine that a high/low water level signal is not currently active on the system.
3. Note the normal operating water level in the tank.
4. For tanks that include a high water level switch, complete Step 5 through Step 9. Otherwise, skip to Step 10.
5. Open the manual fill valve for the tank and monitor the fire alarm panel, remote annunciator, or other supervising panel to verify the initiation and transmission of the high water level signal. Ensure that signal is initiated prior to a rise in water level of more than 12 in. (300 mm) from the normal operating water level or overflow from the tank, whichever comes first.
6. Shut down the manual fill valve.
7. Locate a drain connection for the tank. Check the area surrounding the discharge point to ensure that there are no obvious conditions that would prevent water from being discharged safely or cause direct damage in the immediate vicinity. Where the discharge of water is to an area subject to potential freezing conditions, the facility representative should be advised of the potential for icing conditions.
8. Drain water from the tank down to the normal operating level.
9. Verify that the high water level signal is restored at the fire alarm panel, remote annunciator, or other supervising panel, resetting as necessary.
10. For tanks that include a low water level switch, complete Step 11 through Step 16. Otherwise, skip to Step 17.
11. Shut down the control valve for any automatic fill lines to the tank.
12. Locate a drain connection for the tank. Check the area surrounding the discharge point to ensure that there are no obvious conditions that would prevent water from being discharged safely or cause direct damage in the immediate vicinity. Where the discharge of water is to an area subject to potential freezing conditions, the facility representative should be advised of the potential for icing conditions.
13. Initiate drainage of water from the tank, monitor the fire alarm panel, remote annunciator, or other supervising panel, and verify the initiation and transmission of the low water level signal. Ensure that the signal is initiated prior to a drop in water level of more than 12 in. (300 mm) from the normal operating water level.
14. Shut down the drainage of the tank.
15. Open the manual fill valve, or open any control valves that were shut as a part of Step 11 above, and refill to the normal operating water level.
16. Verify that the low water level signal is restored at the fire alarm panel, remote annunciator, or other supervising panel, and reset them as necessary.
17. Upon completion of all testing, notify the fire department and/or the alarm monitoring company (as needed), as well as the facility representatives, that testing is complete, and reset the fire alarm system as necessary. A verification of the receipt of initiated signals with the fire department and/or the alarm monitoring company, where so connected, would be appropriate as part of this effort.

Evaluation of Results

The proper operation of the high/low water level signals is verified by the initiation and transmission of appropriate signals at the fire alarm panel, remote annunciator, or other supervising panel under the simulated high and low water conditions, as well as restoration upon return to the normal operating water level. The initiation of the high and low level water signals are to operate at not more than 12 in. (300 mm) above or below the normal operating water level. Failure of the high/low switches to initiate within the specified water levels and transmit a signal or to restore requires further investigation and corrective action as necessary.

The procedure(s) outlined above is not mandated by NFPA 25 and represents only one approach to conducting this test.

Water Tank Automatic Fill Valve Test

Purpose

The purpose of completing a test on the automatic fill valve is to ensure operation of the fill valve through the connected control system and to verify the refill rate of the installation. Some manufacturers might provide additional testing instructions for the fill valve.

Tools/Equipment

1. The various wrenches and tools necessary to facilitate the drainage of water from the tank and overfill are required.
2. A timing device is required to measure the time for refill of the tank.
3. A tape measure or other measuring means is required to determine the tank dimensions and measure the water fill height.

Procedure Steps

1. Prior to any testing, notify the fire department and/or the alarm monitoring company (as needed), as well as the facility representatives, that testing is going to be conducted.
2. Locate a drain connection for the tank, and check the area surrounding the discharge point to ensure that there are no obvious conditions that would prevent water from being discharged safely or cause direct damage in the immediate vicinity. Where the discharge of water is to an area subject to potential freezing conditions, the facility representative should be advised of the potential for icing conditions.
3. Initiate drainage of water from the tank, and monitor the automatic fill valve for actuation.
4. Shut down the drainage of the tank.
5. Close the control valve to the automatic fill line.
6. Continue drainage of the tank allowing a sufficient quantity of water to drain to provide for a measurable refill time for calculation of a refill rate. Depending on the size of the tank, a drop of 1 ft (0.3 m) to 5 ft (1.5 m) should be sufficient. Measure and record the drop in water level from the normal operating level.
7. Open the control valve to the automatic fill line.
8. Upon establishment of a full flow rate from the automatic fill valve, record a start time and establish a water level in the tank. Continue to monitor the refill process by recording the elapsed time to reach a specific increase in water level. Depending on the size of the tank, a rise of 1 ft (0.3 m) to 5 ft (1.5 m) should be sufficient.
9. Allow the automatic fill valve operation to return the tank to the normal operating level.
10. Upon completion of all testing, notify the fire department and/or the alarm monitoring company (as needed), as well as the facility representatives, that testing is complete, and reset the fire alarm system as necessary.

Evaluation of Results

The proper operation of the automatic fill valve is verified by the actuation of the valve upon a drop in water level. Failure of the automatic fill valve to operate and refill the tank to normal operating level and then shutoff requires further investigation and corrective action as necessary.

The determination of the fill rate is calculated by a timed average fill rate by using the measured time to refill a known height. An example of this calculation for a round vertical water tank is as follows. Calculate the fill rate from the automatic fill valve using the following formula, which applies to a round vertical water tank:

$$Q = \frac{352.5H \cdot d^2}{t}$$

where:
Q = fill rate (gpm)
H = tank height filled during the measured time duration t (ft)
d = tank diameter (ft)
t = measured time duration (seconds)

Where the automatic fill valve flow rate is intended to provide make-up water for tanks designed to meet a capacity less than the full required duration, a direct evaluation of the adequacy of this fill rate would require knowledge of the original design criteria for the system. However, a comparative assessment can also be made against previous test results, where available. A significant degradation in performance should warrant further investigation and corrective action as necessary. Fill rates below those known performance measures require further investigation and corrective action as necessary.

The procedure(s) outlined above is not mandated by NFPA 25 and represents only one approach to conducting this test.

What Are Water Spray Fixed Systems?

A water spray system is a special fixed pipe system connected to a supply of water and equipped with water spray nozzles to provide water discharge over the surface or area to be protected.



Courtesy of David Wayne Smith, Johnson Controls

What Are Water Spray Fixed Systems Used for?

A water spray fixed system is typically used to protect equipment such as cable trays, conveyor belts, pumps, compressors, vessels, transformers, structures, and other miscellaneous equipment. They can also be used to control flammable and combustible liquid pool fires and are frequently used for exposure protection.



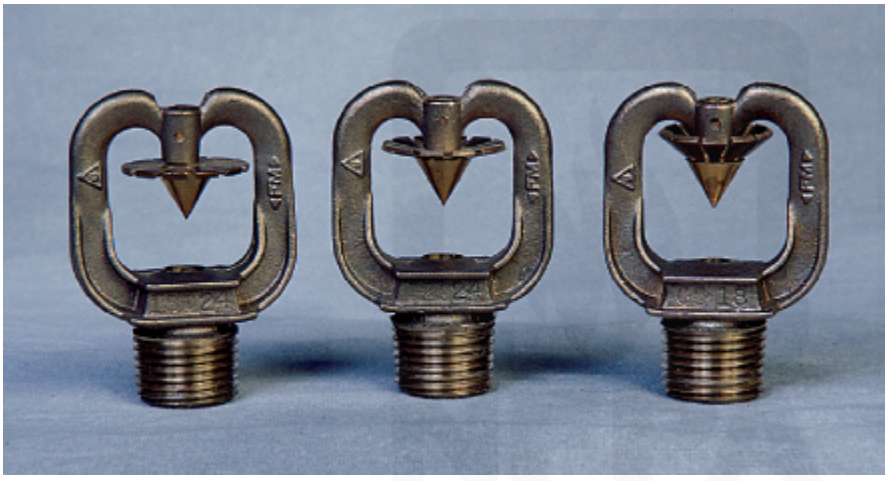
Courtesy of FOGTEC® Fire Protection

How Are Water Spray Fixed Systems Activated?

The piping system is connected to a water supply through a deluge valve that can be actuated both automatically and manually to initiate the flow of water. Automatic system can be actuated electrically by the operation of automatic detection equipment, such as heat detectors, relay circuits, and gas detectors, or mechanically by hydraulic or pneumatic systems.

What Is the Difference Between a Sprinkler System and a Water Spray Fixed System?

A sprinkler system is designed to cover a floor area while a water spray fixed system is designed to cover the surface area of a specific piece of equipment and is designed for specific hazards.



ITM

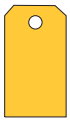
Due to the nature of the hazards that water spray fixed systems are designed to protect, extreme care must be given to the ITM of the system. Without proper inspection, testing, and maintenance (ITM) a water spray fixed system can be rendered ineffective and have catastrophic consequences.

For more information refer to NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*.

Water Spray Fixed Systems Inspection and Testing



NO DEFICIENCIES OR IMPAIRMENTS



NONCRITICAL DEFICIENCIES

- Strainer damaged or corroded
- Trap sumps and drainage trenches blocked, retention embankments or dikes in disrepair



CRITICAL DEFICIENCIES

Pipe and fittings

- Mechanical damage
- Missing or damaged paint or coating
- Rusted or corroded
- Not properly aligned or trapped sections
- Low-point drains not functioning
- Improper location of rubber-gasketed fittings

Hangers and seismic braces

- Damaged or missing
- Not securely attached to structural supports or piping
- Missing or damaged paint or coating
- Rusted or corroded

Water spray nozzles

- Discharge devices missing
- Not properly positioned or pointed in design direction
- Loaded or corroded
- Missing caps or plugs if required, or not free to operate as intended

Ultra-high-speed

- Detectors have physical damage or deposits on lenses of optical detectors
- Controllers found to have faults

Assessment of internal conditions

- Presence of MIC, zebra mussels, rust, and scale

Operational test

- Nozzles not correctly positioned
- Pressure readings not comparable to original design requirements

Main drain

- More than 10% drop in full flow pressure



IMPAIRMENTS

- Strainer plugged or fouled

Operational test

- Heat detection system did not operate within 40 seconds, flammable gas detection system did not operate within 20 seconds
- Nozzles plugged
- Manual actuation devices did not work properly

Ultra-high-speed operational test

- Response time was more than 100 milliseconds

Source: Table A.3.3.8

10

WATER SPRAY FIXED SYSTEMS

Chapter 10 of NFPA 25 covers the inspection, testing, and maintenance (ITM) of water spray fixed systems. Water spray fixed systems are highly specialized systems that are typically installed under the scope of NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*. These systems are used to protect equipment such as cable trays, belt conveyors, pumps, compressors, vessels, transformers, structures, and miscellaneous equipment. Water spray systems are also used to control flammable and combustible liquid pool fires and are frequently used for exposure protection.

Water spray fixed systems use different types of detection systems, such as electronic (including smoke, heat, infrared, and linear cable detection), pneumatic rate-of-rise, and wet and dry pilot detection systems for actuation. Depending on the detection system used, the ITM of water spray fixed systems may require specialized training beyond that required for conventional sprinkler systems. When detection systems are used, and the ITM of those systems is addressed by *NFPA 72®, National Fire Alarm and Signaling Code®*, the ITM of the fixed water spray system must be coordinated with that standard, as required in 1.1.1.

The inspection and testing of a water spray fixed system as prescribed in Chapter 10 requires knowledge of NFPA 15 and a familiarization with these systems. To determine if test results are acceptable, the original installation drawings and hydraulic calculations should be available for comparison. If these documents are not available, or if the inspector does not have sufficient knowledge of NFPA 15, the interpretation of test results might require the assistance of a professional engineer or an engineering technician. Due to the nature of the hazards being protected, extreme care must be given to the maintenance of the system, because a seemingly small deviation from the original design can have catastrophic consequences. Exhibit 10.1 shows a water spray fixed system being discharged as part of a test or routine inspection.



EXHIBIT 10.1 *Discharging System.*

10.1* General.

A.10.1 The effectiveness and reliability of water spray fixed systems depends on maintenance of the integrity of hydraulic characteristics, water control valves, deluge valves and their fire detection/actuation systems, pipe hangers, and prevention of obstructions to nozzle discharge patterns.

Water spray fixed systems are most commonly used to protect processing equipment and structures, flammable liquid and gas vessels, piping, and equipment such as transformers, oil switches, and motors. They also have been shown to be effective on many combustible solids.

Many of the components and subsystems found in a water spray system require the same inspection, test, and maintenance procedures where they are used in automatic sprinkler systems and other fixed water-based fire protection systems. Other chapters of this standard should be consulted for particulars on required inspection and maintenance.

Water spray fixed systems are designed and installed in accordance with the requirements of NFPA 15. These systems normally employ an open piping network with open spray nozzles that discharge water in a predetermined pattern on a hazard area, structure, or vessel (see Exhibit 10.2 through Exhibit 10.4). Exhibit 10.2 illustrates a typical water spray system

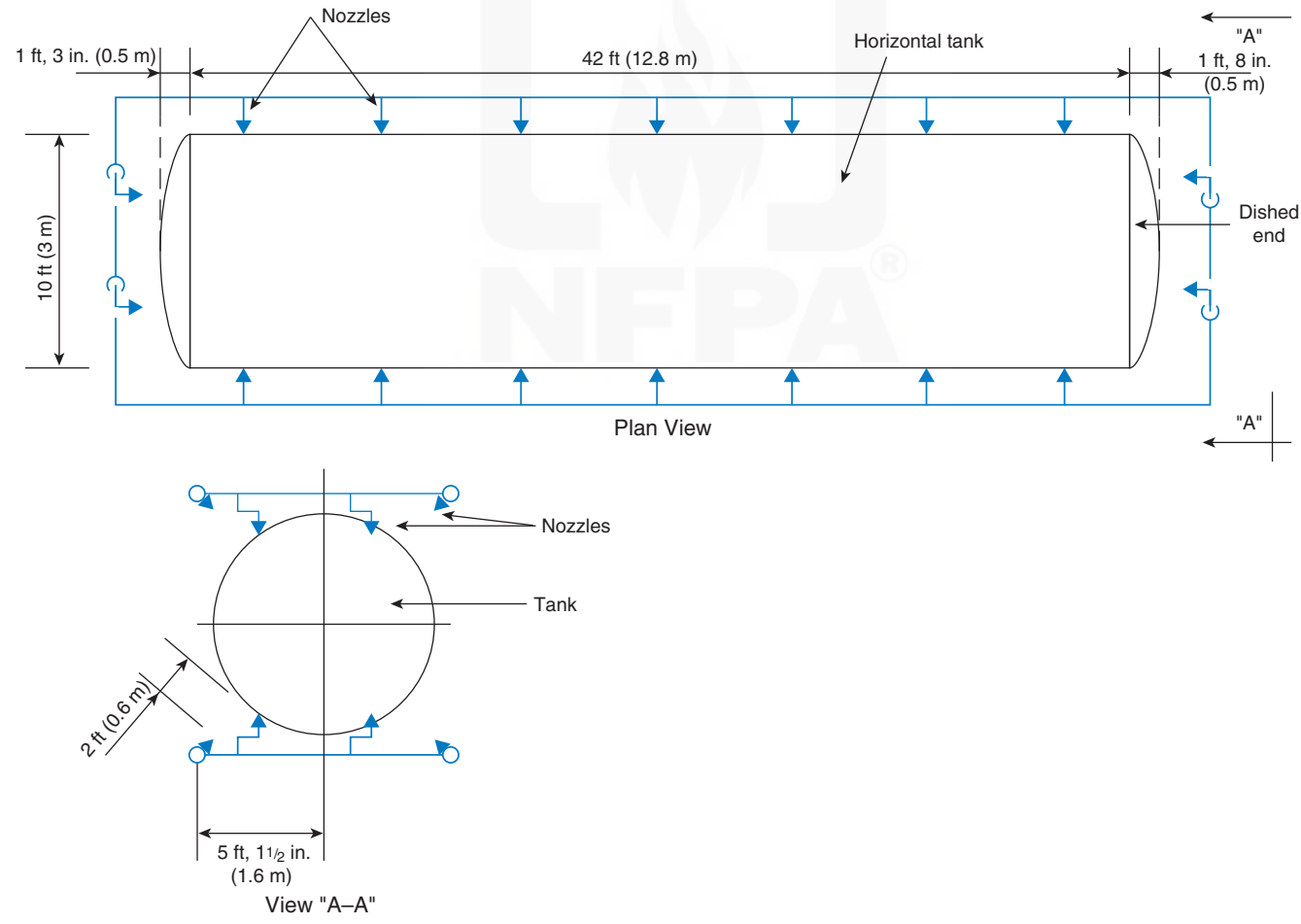


EXHIBIT 10.2 *Horizontal Chemical Tank Nozzle Arrangement. (Source: Adapted from Fire Protection Systems for Special Hazards, 2004, Figure 6.3)*

protecting a horizontal chemical storage tank, with two levels of nozzles used to completely engulf the tank in water spray. This type of system design is typically used for fire extinguishment as well as exposure protection.

Exhibit 10.3 illustrates water spray protection for a pipe rack assembly of the type that is usually located in a chemical processing plant or refinery. The water spray nozzles are intended to spray directly on process piping and, in some cases, are used to protect the structural steel of the pipe rack itself. In this illustration, water spray nozzles are also employed to protect a process pump.

Exhibit 10.4 illustrates the use of water spray nozzles to protect a conveyor for coal or another type of material. In this application, nozzles are located along the conveyor belt to spray water either across the width of the belt or along the length of the belt. There is a detector at the roof of this enclosed conveyor that is used to activate the deluge valve in the water spray system. Often, the detection system is tied into the operational controls for a facility in addition to the suppression system; if it is triggered, it can shut down conveyors or other pieces of industrial equipment.

The piping network is exposed to the atmosphere through the open spray nozzles, so these systems are subject to interior corrosion and blockages resulting from debris, such as insects nesting. Scale from the inside of the pipes can clog the water spray nozzles, affecting both the discharge pattern and density being applied to the surface of the hazard.

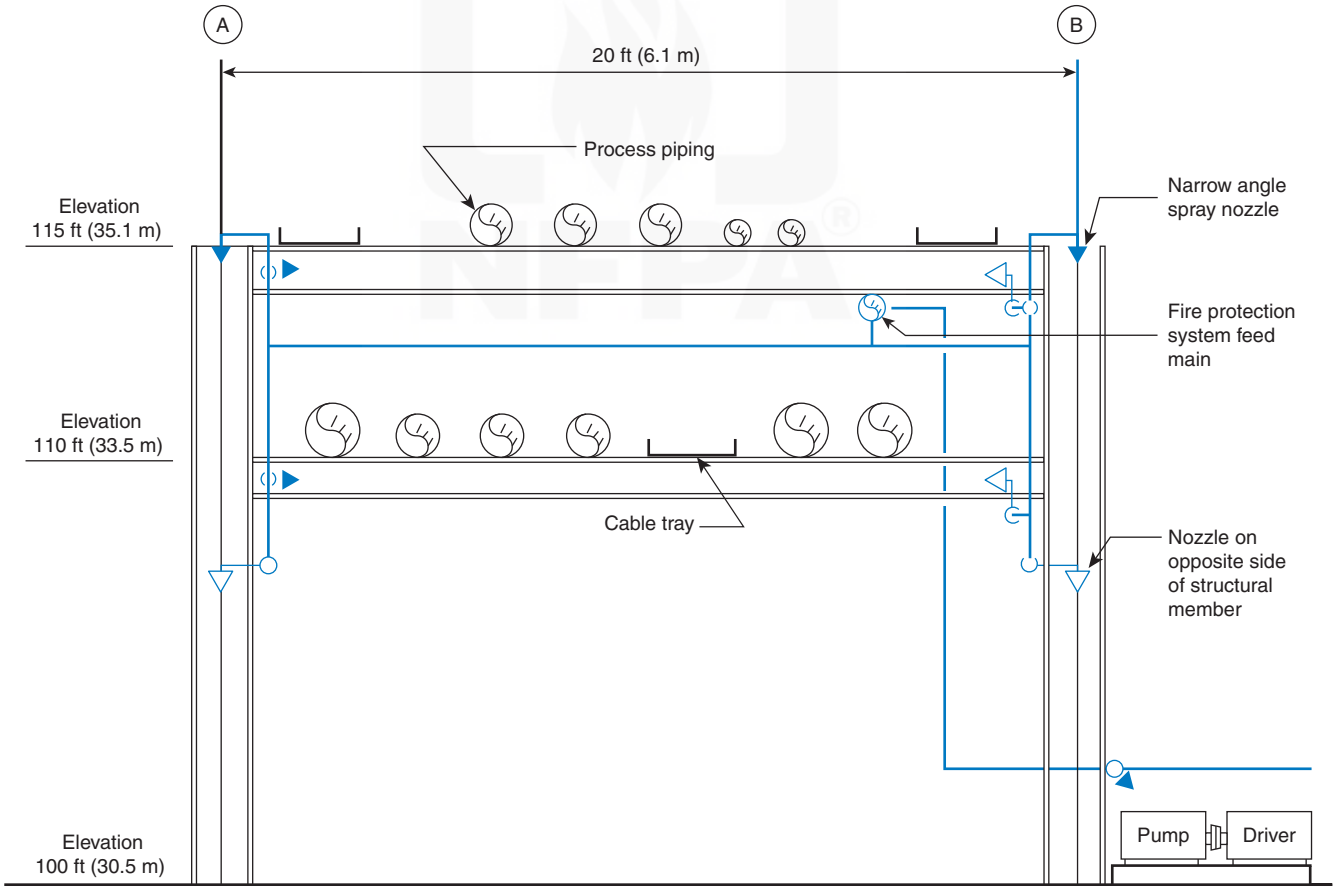
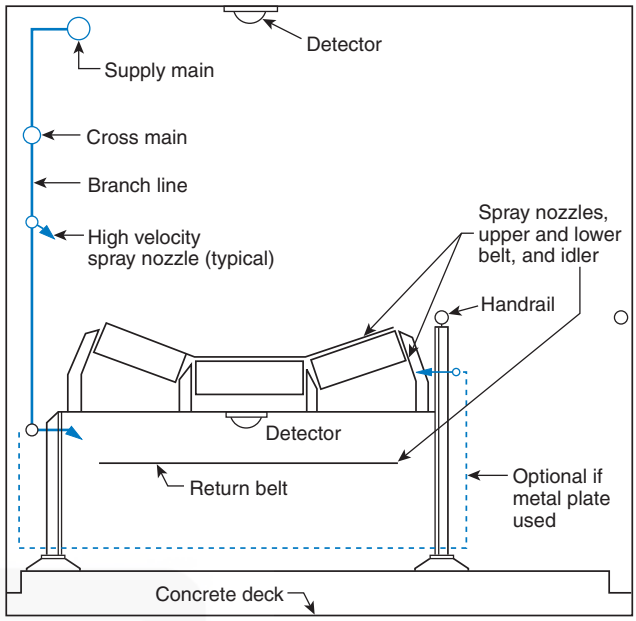


EXHIBIT 10.3 *Pipe Rack Nozzle Arrangement. (Source: Adapted from Fire Protection Systems for Special Hazards, 2004, Figure 6.16.)*

EXHIBIT 10.4 *Typical Conveyor Belt Protection. [Source: NFPA 15, 2017, Figure A.7.2.3.3.1(a)]*



Water spray fixed systems protect special hazards that require higher densities and direct impingement of water over the entire surface area of the equipment or structure. Examples of these special hazards include the following:

- Storage vessels containing hazardous chemicals or flammable and combustible liquids
- Piping and pumps involved in the processing or transfer of hazardous chemicals or flammable and combustible liquids
- Structural steel supporting vessels, piping, and other equipment used in the processing of hazardous chemicals or flammable and combustible liquids
- Cable trays and cable runs
- Transformers (see Exhibit 10.5 and Exhibit 10.6)
- Belt conveyors
- Turbine bearings
- Boiler fronts
- Other similar equipment involving the use of hazardous chemicals or flammable and combustible liquids

10.1.1 Minimum Requirements.

10.1.1.1 This chapter shall provide the minimum requirements for the routine inspection, testing, and maintenance of water spray protection from fixed nozzle systems only.

10.1.1.2 Table 10.1.1.2 shall be used to determine the minimum required frequencies for inspection, testing, and maintenance.

Many of the ITM requirements in Table 10.1.1.2 reference other chapters within NFPA 25 or other NFPA documents. Those components in a water spray fixed system that are common to other water-based fire protection systems, such as waterflow alarms, fire pumps, water storage tanks, and valves, are addressed in other chapters. The detection systems are addressed in *NFPA 72*. All other components specific to water spray fixed systems, such as the nozzles, pipe, fittings, hangers, supports, strainers, and manual releases, are addressed in the specific Chapter 10 paragraphs indicated in Table 10.1.1.2.

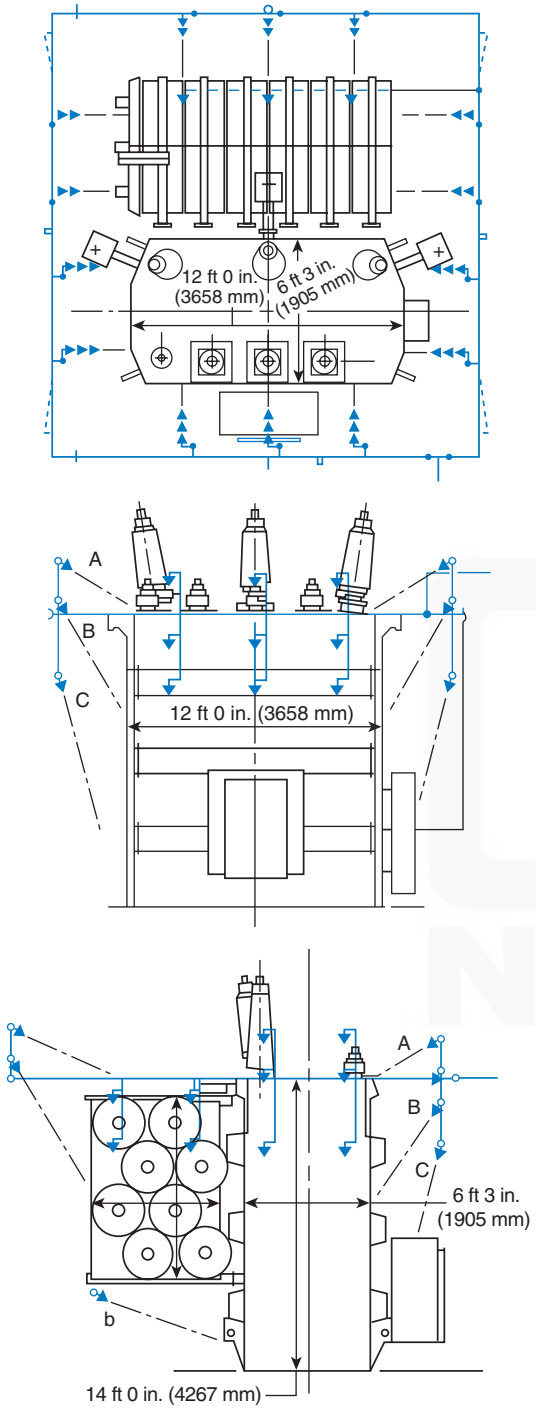


EXHIBIT 10.5 *Typical Transformer Water Spray System. (Source: NFPA 15, 2017, Figure A.7.4.4.1)*

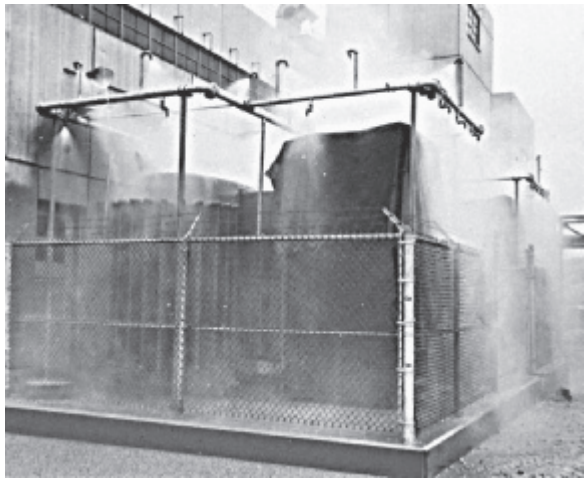


EXHIBIT 10.6 *Water Spray System for Oil-Filled Electric Power Transformers.*

Δ ***TABLE 10.1.1.2*** *Summary of Water Spray Fixed System Inspection, Testing, and Maintenance*

Item	*Frequency*	*Reference*
Inspection		
Backflow preventer		Chapter 13
Check valves		Chapter 13
Control valves		Chapter 13
Deluge valve		Chapter 13
Detection systems and components		*NFPA 72*
Detector check valves		Chapter 13
Drainage	Quarterly	10.2.7
Fire pump system		Chapter 8
Fittings	Annually	10.2.3, 10.2.3.1
Fittings (rubber-gasketed)	Annually and after each system activation	10.2.3.1
Gravity tanks		Chapter 9
Hangers, braces, and supports	Annually and after each system activation	10.2.3.2
Heat (deluge valve house)		Chapter 13
Nozzles	Annually and after each system activation	10.2.4
Piping	Annually and after each system activation	10.2.3.1
Pressure tank		Chapter 9
Strainers	Mainline — annually and after each system activation Others — per manufacturer's instruction	10.2.6
Suction tanks		Chapter 9
Water supply piping		10.2.5.2
UHSWSS — controllers	Start of each shift	10.4.3
UHSWSS — detectors	Monthly	10.4.2
UHSWSS — valves	Start of each shift	10.4.4
Operational Test		
Backflow preventer		Chapter 13
Check valves		Chapter 13
Control valves		Chapter 13
Deluge valve		Chapter 13
Detection systems		*NFPA 72*
Detector check valve		Chapter 13
Fire pump system		Chapter 8
Gravity tanks		Chapter 9
Main drain test		Chapter 13
Manual release	Annually	10.3.5
Nozzles	Annually	Section 10.3
Pressure tank		Chapter 9
Strainers	Annually	10.2.6

Δ ***TABLE 10.1.1.2*** *Continued*

Item	*Frequency*	*Reference*
Suction tanks		Chapter 9
Waterflow alarm		Chapter 5
Water spray system test		Chapter 13
Water supply flow test		Chapter 7
UHSWSS	Annually	Section 10.4
Valve status test		Chapter 13
Maintenance		
Backflow preventer		Chapter 13
Check valves		Chapter 13
Control valves		Chapter 13
Deluge valve		Chapter 13
Deluge valve enclosures		Chapter 4
Detection systems		*NFPA 72*
Detector check valve		Chapter 13
Fire pump system		Chapter 8
Gravity tanks		10.2.9, Chapter 9
Pressure tank		10.2.9, Chapter 9
Strainers	Annually	10.2.1.4, 10.2.1.6, 10.2.6
Strainers (baskets/screen)	5 years	10.2.1.4, 10.2.1.7, A.10.2.6
Suction tanks		Chapter 9
Water spray nozzles	Annually	10.2.4

10.1.2 Water Spray Protection. This chapter shall not cover water spray protection from portable nozzles, sprinkler systems, monitor nozzles, or other means of application.

Where NFPA 25 does not provide requirements for ITM activities, such as those listed in 10.1.2, other standards may need to be consulted. For example, monitor nozzles used in an aircraft hangar should be inspected, tested, and maintained in accordance with NFPA 409, *Standard on Aircraft Hangars*. However, monitor nozzles that are fed from a fire service underground main are covered in Chapter 7.

10.1.3* Design and Installation. NFPA 15 shall be consulted to determine the requirements for design and installation, including acceptance testing.

FAQ Is the inspector required to have in-depth knowledge of NFPA 15?

The inspector of a water-based fire protection system is not required to have complete knowledge of the design requirements of the installation standard NFPA 15. However, that standard should be consulted as required by 10.1.3, and a certain level of knowledge is necessary to properly inspect and test a water spray fixed system. It is important to understand the intended design of the system so that the location or quantity of water does not accidentally get modified during what can be considered routine maintenance or component replacement.

For example, an inspector might not be able to determine if the nozzles are aligned correctly, because it depends on whether direct impingement over the entire surface of the structure, vessel, or equipment is required, or if the system is intended to protect the

structure, vessel, or equipment from an exposure fire. An inspector familiar with NFPA 15 would be aware that, when protecting vessels to control burning, the nozzles are to be positioned to impinge directly on the vessel and on all areas around the vessel where a spill is likely to spread or accumulate; when protecting structural steel, water spray from the nozzles is required to impinge only on one side of the structural member, and rundown is anticipated.

A.10.1.3 Insulation acting in lieu of water spray protection is expected to protect a vessel or structure for the duration of the exposure. The insulation is to prevent the temperature from exceeding 850°F (454°C) for structural members and 650°F (393°C) for vessels. If the insulation is missing, the structure or vessel is not considered to be protected, regardless of water spray protection or insulation on other surfaces. To re-establish the proper protection, the insulation should be replaced or the water spray protection should be extended, using the appropriate density.

FAQ Why is it important to check insulation?

NFPA 15 allows encasing structural steel in fire-resistant insulating material approved by the authority having jurisdiction (AHJ), in lieu of protecting the steel with a water spray fixed system. Missing or damaged insulation has the same impact on the protection of the structure as does a totally clogged sprinkler nozzle. In cases of damaged or missing insulation, immediate corrective action should be taken. Therefore, it is important that the inspection of the water spray fixed system include a check of the integrity of any such insulation.

10.1.4 Obstruction Investigations. The procedures outlined in Chapter 14 shall be followed where there is a need to conduct an obstruction investigation.

10.1.5 Common Components and Valves. Common components and valves shall be inspected, tested, and maintained in accordance with Chapter 13.

10.1.6* Impairments. The procedures outlined in Chapter 15 shall be followed where an impairment to protection occurs.

Tip for Owners

The interconnection between the industrial processes being protected and the fire protection system should be considered during the design of the system and the preparation of the facility maintenance plan. When a system is shut down for maintenance or repair, the facility maintenance plan should account for the consequences of the planned system impairment and address the impaired condition.

A.10.1.6 The inspection, testing, and maintenance of water spray fixed systems can involve or result in a system that is out of service. Also see Chapter 15.

10.1.6.1 When a water spray fixed system or any portion thereof is out of service for any reason, notice shall be given to facility management, the local fire department, the on-site fire brigade, and other authorities having jurisdiction, as applicable.

Water spray fixed systems are typically employed in high-hazard or high-challenge areas. These are areas where the potential exists for fires of higher intensity than are ordinarily encountered in lower hazard occupancies, such as office buildings or residential occupancies. These areas are also subject to more hazardous activities, such as welding, and the use of flammable or combustible liquids.

In addition to the system impairment requirements prescribed by Chapter 15, controls over hazardous activities and operations must be considered during any system impairment.

10.1.6.2 A sign shall be posted at each fire department connection or system control valve indicating which portion of the system is out of service.

10.2 Inspection and Maintenance Procedures.

10.2.1 Components. The components described in this section shall be inspected and maintained at the frequency specified in Table 10.1.1.2 and in accordance with this standard and the manufacturer's instructions.

10.2.1.1 Items in areas that are inaccessible for safety considerations due to factors such as continuous process operations and energized electrical equipment shall be inspected during each scheduled shutdown but not more than every 18 months.

Because of the nature of the hazards typically protected by water spray fixed systems, it is not unusual for them to be installed in areas that are normally inaccessible due to safety factors. Special consideration should be given to coordinating regularly scheduled shutdowns with the qualified person conducting the ITM.

10.2.1.2 Inspections shall not be required for items in areas with no provision for access and that are not subject to the conditions noted in 10.2.3.1, 10.2.3.2, and 10.2.4.1.

10.2.1.3 Items in areas that are inaccessible for safety considerations shall be tested at longer intervals in accordance with 13.4.4.2.3.2.

Tip for Owners

The owner, or designated representative, is responsible for ensuring ITM happens at the frequencies required by this standard. In some cases, repairs or unscheduled maintenance will necessitate a shutdown, during which ITM activities can be conducted. If ITM activities have not been conducted for almost 18 months because no shutdown has occurred, a shutdown must be scheduled to allow these activities to take place.

ITM Deficiency, Impairment, or Hazard Evaluation?

ANSWER: ITM Deficiency

The condition of excessive external corrosion shown in this photo was found on the piping installed in a cooling tower. Galvanized pipes and fittings were installed, and there is some minor corrosion occurring at the pipe threads and on the fittings. However, significant corrosion is occurring at the hanger locations and a sample is shown in the picture. The hanger was removed to show the extent of the corrosion.

Table 10.1.1.2 indicates that the piping of a water spray fixed system is to be inspected annually and after each activation of the system. The requirements in 10.2.1.1, 10.2.1.2, 10.2.3, 10.2.3.1 are referenced in the table. Subsection 10.2.3.1 includes a list of the negative conditions the inspector is looking for. Item 2 in this list describes external conditions such as missing or damaged paint or coatings, rust, and corrosion. All of these conditions are found on the piping at all hanger locations during the inspection and should be recorded as a noncritical deficiency. However, time is of the essence to correct this deficiency, because the severity of corrosion could cause the pipe to start leaking and possibly rupture.

The cause of this accelerated corrosion at the hanger locations should be investigated as well. It would be appropriate for the inspector to recommend a hazard evaluation to determine the cause and any action needed to correct it.



(Courtesy of Jackie "JW" Ward and SimplexGrinnell)

FAQ Why does NFPA 25 allow longer intervals between discharge tests for inaccessible systems?

Water spray fixed systems are often used to protect equipment in industrial occupancies and are intended to discharge a considerable amount of water, so performing a functional test requires coordination with the property owner or operator. Discharge tests must be

planned carefully to avoid disrupting building or process operations, with further consideration given to potential damage to the building, equipment, or products. The standard allows a longer interval between discharge tests to facilitate this coordination for systems that are inaccessible.

NFPA 25 permits a second control valve to be installed above the deluge valve for the purpose of testing the valve and the detection system. Such tests are intended to provide only a partial test; they do not meet the requirements to provide a full flow trip test where all nozzles can be verified for proper aim and position and internal piping obstructions can be identified.

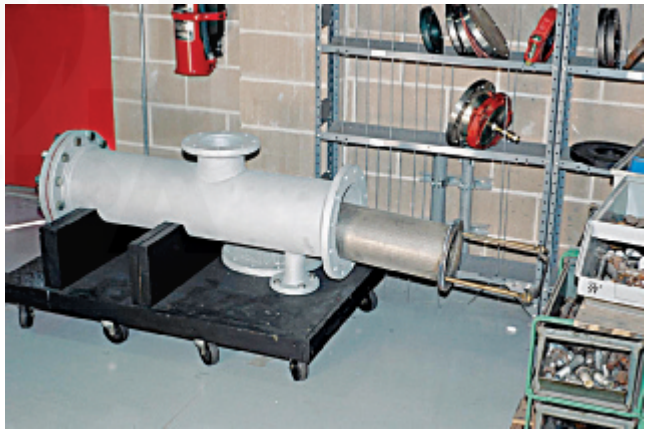
10.2.1.4 Other maintenance intervals shall be permitted, depending on the results of the visual inspection and operating tests.

10.2.1.5 Deluge valve enclosures shall be inspected in accordance with the provisions of Chapter 13.

10.2.1.6 Nozzle strainers shall be removed, inspected, and cleaned during the flushing procedure for the mainline strainer.

Nozzle strainers are installed only with certain types of nozzles. When a nozzle strainer is present, it will usually need cleaning as required by 10.2.1.6, since it is intended to capture obstructing material and prevent the plugging of the nozzle. Exhibit 10.7 shows a typical fire protection strainer with a basket-type screen of corrosion-resistant metal.

EXHIBIT 10.7 *Strainer with Basket-Type Screen.*



10.2.1.7 Mainline strainers shall be removed and inspected every 5 years for damaged and corroded parts.

10.2.2 Deluge Valves. Deluge valves shall be inspected, tested, and maintained in accordance with Chapter 13.

10.2.3* System Components. System piping, fittings, hangers, and supports shall be inspected and maintained to ensure continuity of water delivery to the spray nozzles at full waterflow and design pressure.

Due to the forces exerted on the pipe and pipe supports from the water spray coming from a system of open nozzles, water spray fixed systems are prone to water hammer and pipe vibration. It is therefore extremely important to inspect the integrity of the piping, the hanger or supports, and the nozzles.

A.10.2.3 The operation of the water spray system is dependent on the integrity of the piping, which should be kept free of mechanical damage. The pipe should not be used for support of ladders, stock, or other material. Where piping is subject to a corrosive atmosphere, a protective corrosion-resistant coating should be provided and maintained. Where the age or service conditions warrant, an internal examination of the piping should be made. Where it is necessary to flush all or part of the piping system, this work should be done by sprinkler contractors or other qualified workers.

In many cases, pipe in water spray fixed systems is installed near equipment, rather than in a more protected spot near the roof or ceiling, as in the case of sprinkler systems. Therefore, an inspection of piping is essential to ensure that pipe, fittings, and pipe supports are not damaged.

Usually, where piping is installed in corrosive atmospheres, the pipe, fittings, and pipe supports are galvanized. The galvanization protects against corrosion, which could lead to the eventual failure of the component. Inspections should be made to ensure that the galvanizing has not been removed through abrasion or any other means. As with sprinkler systems, water spray fixed systems must be supported in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*. NFPA 13 requires that pipe supports, other than those illustrated in the standard, be designed to support five times the weight of the water-filled pipe, plus a 250 lb (113.4 kg) safety factor. Otherwise, additional weight from ladders, stock, or other materials could place a load beyond that designed for the pipe support.

10.2.3.1* Piping and Fittings. System piping and fittings shall be inspected for the following:

(1) Mechanical damage (e.g., broken piping or cracked fittings)

Piping in a water spray fixed system is installed primarily in areas where production processes, machinery, and other equipment can come in contact with it. Therefore, it is more susceptible to mechanical damage and misalignment than piping in most other water-based fire protection systems.

Supporting detection system pipe or conduit is a common practice in the installation of water spray fixed systems. This practice is acceptable because the detection system is a component of the overall fire protection system. A release line hanger is typically used for hanging detection piping from the water piping. Angle iron or angle struts can also be used for this application.

No other items are permitted to be attached to or hung from the water spray fixed system piping.

(2) External conditions (e.g., missing or damaged paint or coatings, rust, and corrosion)

Many water spray fixed systems are installed outside or in atmospheres where corrosion is a common problem. Although it is required that piping be protected, rust, damaged paint, or other signs of corrosion are frequently found upon inspection.

(3) Misalignment or trapped sections

In many installations, water spray fixed system piping that surrounds equipment or vessels is installed in sections. This configuration allows the piping to be disassembled if the equipment or vessels need to be removed for repair or replacement. When such disassembly takes place, piping sections can be reinstalled incorrectly. The inspection should assess whether this has happened.

(4) Condition of low-point drains (automatic or manual)

Water spray fixed systems are often installed outdoors, and if they are exposed to freezing temperatures, these systems can freeze. Low-point drains and/or trapped sections of pipe should be inspected, particularly prior to the onset of cold weather. The guidance provided in A.13.4.5.3.2 on removing water from a dry system is also good practice to follow for a water spray fixed system, or any system that is expected to be maintained in a dry condition.

(5) Protection for rubber-gasketed fittings

Mechanical damage to fittings is more prevalent in a water spray system than in a wet or dry pipe system, because the pipe and fittings can be exposed to the hazard that is protected by the water spray system. For example, if pipe and fittings are exposed to heat prior to system actuation, the sudden contraction of cool water entering a hot pipe could fracture the pipe or fitting. Inspection of a water spray system should include a check for this type of failure.

A.10.2.3.1 Rubber-gasketed fittings in the fire areas are inspected to determine whether they are protected by the water spray or other approved means. Unless properly protected, fire could cause loss of the rubber gasket following excessive leakage in a fire situation.

NFPA 15 allows the use of rubber-gasketed fittings in fire areas if those fittings are also protected by a water spray fixed system that is automatically controlled through the use of a detection system.

Spray from the open nozzles on the system is expected to keep the gaskets from melting or disfiguring during a fire. These fittings may be protected by an adjacent system, provided that system is activated by a detection system in the same fire area as the fittings.

Rubber gaskets are normally found in the following two types of fittings that can be installed in a water spray fixed system: flanged fittings and grooved fittings.

When using flanged fittings and/or joints, a rubber gasket, usually red or black, is sandwiched between every two flanges to prevent leakage. These gaskets can be either the ring type that will be visible inside the ring of bolts holding the flanges together, or the full-face type that extends beyond the bolts to the outer edge of the flanges. There is a metallic alternative to rubber gaskets that can be used with flanges. These metallic gaskets, which are normally silver or gray, do not need protection when installed in a fire area.

Grooved fittings use rubber gaskets that are installed around the outside of the pipe in a coupling. These gaskets are not normally visible during an inspection. To date, there is no alternative to rubber gaskets in grooved fittings. Therefore, a water spray fixed system, or other method in accordance with NFPA 15, must protect all grooved fittings or couplings in a fire area.

10.2.3.2* Hangers, Braces, and Supports. Hangers, braces, and supports shall be inspected for the following and repaired or replaced as necessary:

(1) Condition (e.g., missing or damaged paint or coating, rust, and corrosion)
(2) Secure attachment to structural supports and piping
(3) Damaged or missing hangers, braces, and supports

A.10.2.3.2 Hangers and supports are designed to support and restrain the piping from severe movement when the water supply operates and to provide adequate pipe slope for drainage of water from the piping after the water spray system is shut down. Hangers should be kept in good repair. Broken or loose hangers can put undue strain on piping and fittings, cause pipe breaks, and interfere with proper drainage of the pipe. Broken or loose hangers should be replaced or refastened.

It is important to keep in mind that the inspection of hangers, braces, and supports is in accordance with the scope of NFPA 25, specifically the conditions noted in 10.2.3.2; it does not involve an evaluation of the design.

10.2.4* Water Spray Nozzles.

A.10.2.4 Systems need inspection to ensure water spray nozzles effectively discharge water unobstructed onto surfaces to be protected from radiant heat (exposure protection) or onto flaming surfaces to extinguish or control combustion. Factors affecting the proper placement of water spray nozzles include the following:

(1) Changes or additions to the protected area that obstruct existing nozzles or require additional coverage for compliance
(2) Removal of equipment from the protected area that results in nozzle placement at excessive distances from the hazard
(3) Mechanical damage or previous flow tests that have caused nozzles to be misdirected
(4) A change in the hazard being protected that requires more or different nozzles to provide adequate coverage for compliance

Spray nozzles can be permitted to be placed in any position necessary to obtain proper coverage of the protected area. Positioning of nozzles with respect to surfaces to be protected, or to fires to be controlled or extinguished, should be guided by the particular nozzle design and the character of water spray produced. In positioning nozzles, care should be taken that the water spray does not miss the targeted surface and reduce the efficiency or calculated discharge rate.

The following two basic types of nozzles are used on water spray fixed systems: automatic water spray nozzles and non-automatic water spray nozzles. The requirements of 10.2.4 apply to both types of nozzles.

Automatic water spray nozzles are intended to open automatically by operation of a heat-responsive element, which keeps the discharge orifice closed by the exertion of force on a cap (i.e., button or disc). When discharging water under pressure, the nozzle distributes the water in a specific, directional pattern similar to a sprinkler. In fact, automatic water spray nozzles are sometimes mistaken for sprinklers. Exhibit 10.8 shows typical automatic spray nozzles.

A non-automatic, or open, water spray nozzle is an open water discharge device. When it is discharging water under pressure, it will distribute the water in a specific, directional pattern. Some non-automatic nozzles resemble an operated sprinkler, while others appear very different. Exhibit 10.9 illustrates a low velocity non-automatic spray nozzle. Exhibit 10.10 shows a high velocity non-automatic spray nozzle in both its inert and activated states.

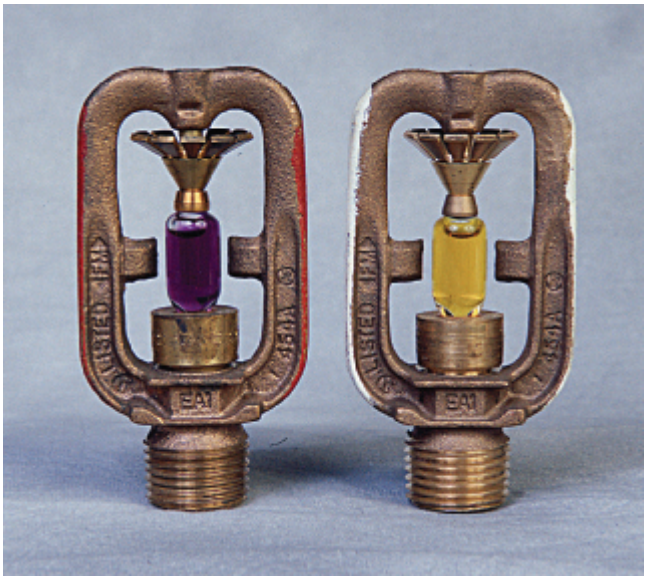


EXHIBIT 10.8 *Automatic Spray Nozzles.*

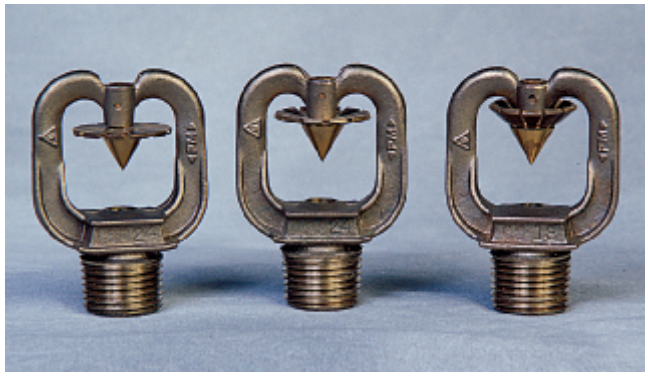


EXHIBIT 10.9 *Low Velocity Non-Automatic Water Spray Nozzles.*

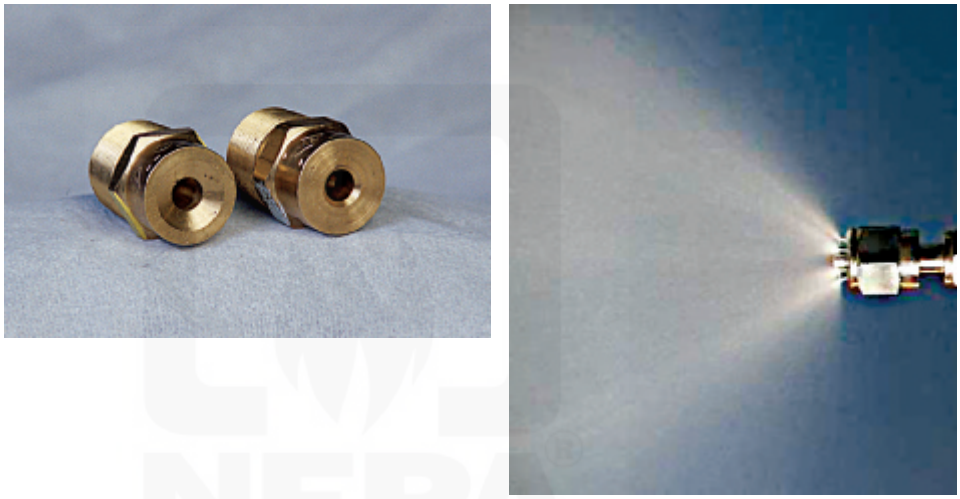


EXHIBIT 10.10 *High Velocity Non-Automatic Spray Nozzles (left) and Activated High Velocity Non-Automatic Spray Nozzle (right).*

10.2.4.1 Water spray nozzles shall be inspected and maintained to ensure that they are in place, continue to be aimed or pointed in the direction intended, and are free from external loading and corrosion.

The distinction between verifying that nozzles are still "pointed in the direction intended" and performing an evaluation of the system and its ability to protect the hazard is an important one. For more information, refer to the commentary for 1.1.3.1. In this case, the inspector will verify that normal wear and tear, such as a nozzle being struck by something and now pointing away from the equipment being protected, has not occurred. The requirements of 10.2.4.1 are also important because water spray nozzles are subject to corrosion from the effects of weather or exposure to corrosive chemicals. When water spray nozzles are installed in harsh environments, corrosion protection in the form of wax or lead coatings applied by the nozzle manufacturer are permitted to be used.

A problem commonly seen with the use of grooved fittings is the misalignment of piping sections due to the thrust from the nozzles, which causes the pipe to rotate. If this

condition is discovered during an inspection, nozzles should be realigned and additional restraints added.

10.2.4.2 Where caps or plugs are required, the inspection shall confirm they are in place and free to operate as intended.

FAQ Does NFPA 25 require systems to use plugs or caps?

Prior to an inspection, the inspector must determine if plugs or caps are required for the system, since not all systems require them. Bees and hornets have been known to build nests inside open nozzles and sprinklers, creating obstructions. Dust and dirt can also find their way into nozzles and piping. If nests or other obstructing material are found during an inspection on a system that does not require them, consideration should be given to the use of listed plastic plugs or nozzle caps as covered in 10.2.4.2. Only plastic plugs or caps listed for use with the nozzle can be used. Exhibit 10.11 shows an example of a nozzle with such a cap. The use of any plug or cap should be reviewed against the manufacturer's data to ensure that their inclusion does not prevent the system from operating as designed.

10.2.4.3 Misaligned water spray nozzles shall be adjusted (aimed) by visual means, and the discharge patterns shall be inspected at the next scheduled flow test.

When adjusting misaligned water spray nozzles as required by 10.2.4.3, if it is not obvious in what direction the nozzle should be aimed, that information should be obtained from the as-built drawings for the system.



EXHIBIT 10.11 *Nozzle with Blow-Off Cap. (Source: Fire Protection Handbook, 2003, Figure 10.15.11)*

ITM Deficiency, Impairment, or Hazard Evaluation?

ANSWER: ITM Deficiency or Impairment

Chapter 10 of NFPA 25 covers a group of systems installed to protect specialized hazards such as processing equipment and structures, flammable liquid and gas vessels, piping, and equipment such as transformers, oil switches, and motors. In this photo, the system protecting a transformer is being tested annually as required by Section 10.3.

One of the goals of the annual water spray test is to make sure the water spray nozzles "… continue to be aimed or pointed in the direction intended . . . ," as required in 10.2.4.1. Additionally, the ". . . water discharge patterns from all of the open spray nozzles shall be observed . . . to ensure that nozzles are correctly positioned, and to ensure that obstructions do not prevent discharge patterns from wetting surfaces to be protected," as required in 10.3.3.3.1.

In 10.1.3, the user is referred to NFPA 15 to determine the requirements for the design and installation as they apply to the requirements of NFPA 25. This does not mean that the design has to be verified or the installation has to be inspected to comply with NFPA 15. However, there are design objectives in NFPA 15 that must be understood and applied when inspecting and testing per NFPA 25.

For transformer protection, subsection 7.4.4.1 of NFPA 15 requires ". . . complete water spray impingement on all exposed exterior surfaces." In this picture, the spray from the nozzles is not reaching the surfaces between the cooling fins on the side of the transformer facing the photographer. If there were small dry areas requiring minor adjustments to the alignment of the nozzles, then describing this as a deficiency would probably be appropriate. However, in this case an entire side of the transformer is not getting direct impingement, which would elevate this situation to the level of impairment.



(Courtesy of Dave Smith and SimplexGrinnell)

10.2.5 Water Supply.

10.2.5.1 The dependability of the water supply shall be ensured by regular inspection and maintenance, whether furnished by a municipal source, on-site storage tanks, a fire pump, or private underground piping systems.

10.2.5.2* Water supply piping shall be maintained free of internal obstructions.

A.10.2.5.2 Water supply piping should be free of internal obstructions that can be caused by debris (e.g., rocks, mud, tubercles) or by closed or partially closed control valves. See Chapter 5 for inspection and maintenance requirements.

It is important to ensure that water supplies remain free of obstructing materials because nozzles can be easily obstructed. Therefore, it is critical to comply with the inspection and maintenance requirements of Chapter 7.

10.2.6* Strainers.

A.10.2.6 Mainline strainers should be removed and inspected for damaged and corroded parts every 5 years.

10.2.6.1 Mainline strainers (basket or screen) shall be flushed until clear after each operation or flow test.

Listed strainers are equipped with flushing connections that allow back-flushing of the strainer basket. If flushing — as required by 10.2.6.1 — reveals excessive obstructing material, the basket can be easily removed for visual inspection and cleaning.

10.2.6.2 Individual water spray nozzle strainers shall be removed, cleaned, and inspected after each operation or flow test.

10.2.6.3 All strainers shall be inspected and cleaned in accordance with the manufacturer's instructions.

10.2.6.4 Damaged or corroded parts shall be replaced or repaired.

10.2.7 Drainage. The area beneath and surrounding a water spray fixed system shall be inspected visually on a quarterly basis to ensure that drainage facilities, such as trap sumps and drainage trenches, are not blocked and retention embankments or dikes are in good repair.

10.2.8 Fire Pumps. Chapter 8 shall be followed for inspection and maintenance requirements.

10.2.9 Water Tanks (Gravity, Pressure, or Suction Tanks, or Reservoirs). Chapter 9 shall be followed for inspection and maintenance requirements.

10.3 Operational Tests.

Unlike many of the operational tests required by NFPA 25, the operational tests of a water spray fixed system require the inspector to have information about the design of the system. For example, the inspector might need to review the as-built working plans to determine the intended nozzle discharge patterns and to identify the surfaces that are intended to be wetted. Additionally, the inspector will need the original system design pressures to properly evaluate the pressure readings required in 10.3.3.4. If this information is not available, an evaluation of the system design criteria might be necessary to adequately test the system.

While NFPA 25 does not mandate that a specific form be used to record the information obtained while conducting the tests outlined in Section 10.3, Exhibit 10.12 is one example of a form that can be used to document these tests.

WATER SPRAY SYSTEMS INSPECTION, TESTING, AND MAINTENANCE

Name of Property: _____ **Inspector:** _____

Address: _____ **Contract No.:** _____

Property Phone Number: _____ **Date:** _____

Inspection Frequency: ❑ Daily ❑ Weekly ❑ Quarterly ❑ Semiannual ❑ Annual

Inspections: Daily			**Deluge Valve (Cold Weather/Heating Season Only)**
❑ Yes	❑ No	❑ N/A	Enclosure, not equipped with a low temperature alarm, is inspected during cold weather to verify a minimum temperature of 40°F (4°C)
Inspections Weekly			**Backflow**
❑ Yes	❑ No	❑ N/A	Isolation valves — open position and locked or supervised
❑ Yes	❑ No	❑ N/A	RPA and RPDA — differential-sensing relief valve operating correctly
			Control Valves
❑ Yes	❑ No	❑ N/A	In the correct (open or closed) position
❑ Yes	❑ No	❑ N/A	Sealed
❑ Yes	❑ No	❑ N/A	Accessible
❑ Yes	❑ No	❑ N/A	Post Indicator Valves (PIVs) are provided with correct wrenches
❑ Yes	❑ No	❑ N/A	Free from damage or leaks
❑ Yes	❑ No	❑ N/A	Proper signage
			Deluge Valve
❑ Yes	❑ No	❑ N/A	Enclosure, where equipped with low temperature alarm, is inspected during cold weather to verify a minimum temperature of 40°F (4°C)
Inspections: Monthly			
❑ Yes	❑ No	❑ N/A	Gauges are operable and not physically damaged
❑ Yes	❑ No	❑ N/A	Gauges — normal air or nitrogen pressure maintained (not supervised) psi
			Control Valves (Locked or Supervised)
❑ Yes	❑ No	❑ N/A	In the correct (open or closed) position
Yes	No	N/A	Locked or supervised
❑ Yes	❑ No	❑ N/A	Accessible
❑ Yes	❑ No	❑ N/A	Post Indicator Valves (PIVs) are provided with correct wrenches
❑ Yes	❑ No	❑ N/A	Free from damage or leaks
❑ Yes	❑ No	❑ N/A	Proper signage
			Deluge Valve
❑ Yes	❑ No	❑ N/A	Free from physical damage or leaks
❑ Yes	❑ No	❑ N/A	Electrical components are in service
❑ Yes	❑ No	❑ N/A	Trim valves are in the correct (open or closed) position
❑ Yes	❑ No	❑ N/A	Valve seat is not leaking
❑ Yes	❑ No	❑ N/A	Detection system gauge (if provided) — normal pressure is being maintained

NFPA 25 Handbook (p. 1 of 5)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT 10.12 *Sample Form for Testing of Water Spray Systems.*

WATER SPRAY SYSTEMS INSPECTION, TESTING, AND MAINTENANCE (Continued)

Inspections: Monthly			**UHSWSS Detectors**
Yes	No	N/A	Free of physical damage
Yes	No	N/A	Optical detectors (where used) — lenses clean
Inspections: Quarterly			
❑ Yes	❑ No	❑ N/A	Gauges — normal supply water pressure is being maintained _____ psi
❑ Yes	❑ No	❑ N/A	Gauges — normal air or nitrogen pressure maintained when supervised at a constantly attended location _____ psi
			Control Valves (Electronically Supervised)
❑ Yes	❑ No	❑ N/A	In the correct (open or closed) position
❑ Yes	❑ No	❑ N/A	Electronically supervised
❑ Yes	❑ No	❑ N/A	Accessible
❑ Yes	❑ No	❑ N/A	Post Indicator Valves (PIVs) are provided with correct wrenches
❑ Yes	❑ No	❑ N/A	Free from damage or leaks
❑ Yes	❑ No	❑ N/A	Proper signage
			Drainage
❑ Yes	❑ No	❑ N/A	Method is in good operating condition
❑ Yes	❑ No	❑ N/A	Retention embankments or dikes are in good condition
Inspections: Annual			**Support/Hangers**
❑ Yes	❑ No	❑ N/A	In good condition (no missing or damaged paint or coating, rust, or corrosion)
❑ Yes	❑ No	❑ N/A	Securely attached to structure and piping
❑ Yes	❑ No	❑ N/A	No damaged or missing hangers, braces, and support
			Pipes and Fittings
❑ Yes	❑ No	❑ N/A	In good condition with no external corrosion
❑ Yes	❑ No	❑ N/A	No leaks or mechanical damage
❑ Yes	❑ No	❑ N/A	Correct alignment with no external loads
❑ Yes	❑ No	❑ N/A	Low point drains maintained and in proper working order
❑ Yes	❑ No	❑ N/A	Rubber-gasketed fittings in good condition
			Nozzles
❑ Yes	❑ No	❑ N/A	In place, aimed, and pointed in the direction intended
❑ Yes	❑ No	❑ N/A	Free from external loading and corrosion
❑ Yes	❑ No	❑ N/A	Caps or plugs are in place (where required)

Note:
For fire pumps refer to NFPA 25, Chapter 8, and the appropriate inspection forms.
For water storage tanks refer to NFPA 25, Chapter 9, and the appropriate inspection forms.
For detection systems refer to *NFPA 72® National Fire Alarm and Signaling Code,* and the appropriate inspection forms.

NFPA 25 Handbook (p. 2 of 5)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT 10.12 *Continued.*

WATER SPRAY SYSTEMS INSPECTION, TESTING, AND MAINTENANCE (Continued)

Inspections: Annual

❑ Yes	❑ No	❑ N/A	**Deluge Valve**
❑ Yes	❑ No	❑ N/A	Inspection following trip test
❑ Yes	❑ No	❑ N/A	Detection device in good condition
			Building
❑ Yes	❑ No	❑ N/A	Prior to onset of freezing weather, all openings are closed and water-filled pipe is not exposed to freezing temperatures
❑ Yes	❑ No	❑ N/A	Heat trace is per manufacturer's instructions
❑ Yes	❑ No	❑ N/A	Low Temp alarm is free of physical damage

Inspections: Five Years

❑ Yes	❑ No	❑ N/A	Check valve — internal moves freely and in good condition
❑ Yes	❑ No	❑ N/A	Backflow — internal inspection
❑ Yes	❑ No	❑ N/A	Internal inspection of deluge valve strainers, filters, restricted orifices, and diaphragm chambers

Test: Quarterly

❑ Yes	❑ No	❑ N/A	Alarm devices — water motor gong
❑ Yes	❑ No	❑ N/A	Main drain test, if sole supply is through a backflow preventer or pressure-reducing valve
			Static psi _____ Residual psi _____
❑ Yes	❑ No	❑ N/A	Do results differ by more than 10% from previous test?
❑ Yes	❑ No	❑ N/A	Deluge valve priming water level tested
❑ Yes	❑ No	❑ N/A	Low air alarm tested per manufacturer's instructions (if provided)

Test: Semiannual

❑ Yes	❑ No	❑ N/A	Valve supervisory switch(es) function
❑ Yes	❑ No	❑ N/A	Alarm devices — inspector's test or bypass opened and observed waterflow

Test: Annual

❑ Yes	❑ No	❑ N/A	Supervisory switch(es) function
❑ Yes	❑ No	❑ N/A	Low temp alarm (if installed) at the beginning of heating season
			Main Drain Test
			Static psi _____ Residual psi _____
❑ Yes	❑ No	❑ N/A	Do results differ by more than 10% from previous test?
❑ Yes	❑ No	❑ N/A	All control valves operated through full range of motion and returned to normal position
			Full Flow Trip Test (Deluge Valve)
❑ Yes	❑ No	❑ N/A	Unobstructed discharge from all nozzles
			Pressure reading at most remote nozzle _____ psi
			Pressure reading at deluge valve _____ psi

NFPA 25 Handbook (p. 3 of 5)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT 10.12 *Continued.*

WATER SPRAY SYSTEMS INSPECTION, TESTING, AND MAINTENANCE (Continued)

Test: Annual			**Full Flow Trip Test (Deluge Valve)**
❑ Yes	❑ No	❑ N/A	Compare pressure readings to hydraulic design and water supply meets requirements
❑ Yes	❑ No	❑ N/A	Manual release functions correctly
❑ Yes	❑ No	❑ N/A	Valve status test performed
❑ Yes	❑ No	❑ N/A	Nozzle spray patterns and direction verified
❑ Yes	❑ No	❑ N/A	Air maintenance device functions correctly
❑ Yes	❑ No	❑ N/A	Mainline strainer flushed after trip test
❑ Yes	❑ No	❑ N/A	Backflow — forward flow test at a minimum flow rate of the system demand
❑ Yes	❑ No	❑ N/A	Detection system tested in accordance with *NFPA 72®*
			System Response Time
❑ Yes	❑ No	❑ N/A	Heat detection responded in _____ sec
❑ Yes	❑ No	❑ N/A	Flammable gas detection responded in _____ sec
			Discharge Time
❑ Yes	❑ No	❑ N/A	Time lapse between operation of detection systems and water delivery time to protected area _____ sec
❑ Yes	❑ No	❑ N/A	UHSWSS/response time does not exceed 100 milliseconds
Routine Maintenance			
❑ Yes	❑ No	❑ N/A	OS&Y — stems lubricated annually

Comments

Signature: _____ Date: _____

Contractor Name: _____

Contractor Address: _____

License/Certification No.: _____

NFPA 25 Handbook (p. 4 of 5)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT 10.12 *Continued.*

WATER SPRAY SYSTEMS INSPECTION, TESTING, AND MAINTENANCE (Continued)

This form covers a 6-month period.

Year: _____ **System:** _____

Location: _____

Inspection

Weekly

General

1. If valves are sealed, note "yes" in this block. If any are not sealed, reseal and note "resealed" in this block.
2. If all nozzles are in good condition and not blocked, note "yes" in block. If not, see that corrections are made and briefly describe under "notes."
3. Assure valve enclosure is maintained above 40ºF (4ºC).
4. Assure deluge or preaction valve is free of damage, trim valves are in proper position, and electrical components are operational.
5. Record any notes about the system that the inspector believes to be significant.

Date	Inspector	Valves Sealed (1)	Nozzles OK (2)	Alarm Valve OK (3)	Deluge Valve OK (4)	Notes (5)

NFPA 25 Handbook (p. 5 of 5)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT 10.12 *Continued.*

10.3.1 Performance.

10.3.1.1 Frequency of system tests shall be in accordance with Table 10.1.1.2.

10.3.1.2 Water spray fixed systems shall be serviced in accordance with this standard and with the manufacturer's instructions.

10.3.2* Test Preparation. Precautions shall be taken to prevent damage to property during the test.

A.10.3.2 The property owner or designated representative should take care to prevent damage to equipment or the structure during the test. Damage could be caused by the system discharge or by runoff from the test site. It should be verified that there is adequate and unobstructed drainage. Equipment should be removed or covered as necessary to prevent damage. Means such as curbing or sandbagging should be used to prevent entry of the water.

A test of a water spray fixed system can result in the discharge of water into the environment. Proper procedures for the disposal of test water must be followed based on local, state, and national environmental policies.

10.3.3 Operational Test Performance. Operational tests shall be conducted to ensure that the water spray fixed systems respond as designed, both automatically and manually.

For procedures necessary to satisfy the operational test requirement in 10.3.3, see 13.4.4.2, which details the testing requirements for deluge valves.

10.3.3.1* Response Time.

A.10.3.3.1 Test methods are as follows:

(1) Some detection circuits can be permitted to be deliberately desensitized in order to override unusual ambient conditions. In such cases, the response required in 10.3.3.1 can be permitted to be exceeded.
(2) Testing of integrating tubing systems can be permitted to be related to this test by means of a standard pressure impulse test specified by the listing laboratory.
(3) One method of testing heat detection uses a radiant heat surface at a temperature of 300°F (149°C) and a capacity of 350 watts at a distance of 1 in. (25 mm) but not more than 2 in. (50 mm) from the nearest part of the detector. This method of testing with an electric test set should not be used in hazardous locations. Other test methods can be permitted to be employed, but the results should be obtained under these conditions.

10.3.3.1.1 Under test conditions, the heat detection systems, where exposed to a heat test source, shall operate within 40 seconds.

10.3.3.1.2 Under test conditions, the flammable gas detection system, where exposed to a standard test gas concentration, shall operate within the time frame specified in the system design.

10.3.3.1.3 These response times shall be recorded.

10.3.3.2 Discharge Time. The time lapse between operation of detection systems and water delivery time to the protected area shall be recorded.

10.3.3.3* Discharge Patterns.

A.10.3.3.3 Spray nozzles can be of different sizes and types. Some are more subject to internal obstructions than others.

10.3.3.3.1* The water discharge patterns from all of the open spray nozzles shall be observed to ensure that patterns are not impeded by plugged nozzles, to ensure that nozzles are correctly

positioned, and to ensure that obstructions do not prevent discharge patterns from wetting surfaces to be protected.

The observation of water discharge patterns during the discharge test required by 10.3.3.3.1 is intended to verify not only that there are no obstructions but also that the water spray pattern attains complete impingement on the surface to be protected.

A.10.3.3.3.1 See 13.4.4.2.3.1.

10.3.3.3.1.1 Where the nature of the protected property is such that water cannot be discharged, the nozzles shall be inspected for proper orientation and the system tested with air to ensure that the nozzles are not obstructed.

10.3.3.3.2 Where obstructions occur, the piping and nozzles shall be cleaned and the system retested.

10.3.3.4 Pressure Readings.

10.3.3.4.1 Pressure readings shall be recorded at the hydraulically most remote nozzle to ensure the waterflow has not been impeded by partially closed valves or by plugged strainers or piping.

The proper functioning of a water spray nozzle is based on the nozzle pressure. To achieve the intended water spray pattern, pressures of either 15 psi (1 bar) or 30 psi (2.1 bar) are necessary for most nozzles. Evaluation of the most hydraulically demanding nozzle ensures that all other nozzles in the system will experience at least equivalent — if not higher — pressures.

10.3.3.4.2 A second pressure reading shall be recorded at the deluge valve to ensure the water supply is adequate.

10.3.3.4.3 Readings shall be compared to the hydraulic design pressures to ensure the original system design requirements are met and the water supply is adequate to meet the design requirements.

The residual pressure measured at the deluge valve should be compared to the calculated pressure as indicated in the hydraulic calculations. Any pressure in excess of that calculated pressure is cause for concern and should be sufficient to initiate a complete evaluation of the piping system.

10.3.3.4.3.1 Where the hydraulically most remote nozzle is inaccessible, nozzles shall be permitted to be checked visually without taking a pressure reading on the most remote nozzle.

10.3.3.4.3.2 Where the reading taken at the riser indicates that the water supply has deteriorated, a gauge shall be placed on the hydraulically most remote nozzle and the results compared with the required design pressure.

10.3.4 Multiple Systems. The maximum number of systems expected to operate in case of fire shall be tested simultaneously to inspect the adequacy of the water supply.

10.3.5 Manual Operation. Manual actuation devices shall be operated annually.

10.3.6 Return to Service. After the full flow test, the water spray system shall be maintained and returned to service in accordance with the manufacturer's instructions.

10.3.6.1 Low Point Drains.

10.3.6.1.1 To prevent freezing and corrosion, all low point drains in aboveground piping shall be opened, the pipe drained, and the valves closed and plugs replaced.

10.3.6.1.2 Where weep holes are provided in lieu of low-point drains, they shall be inspected to ensure they are clear and unobstructed.

The weep holes mentioned in 10.3.6.1.2 are usually holes 3⁄16 in. (5 mm) in diameter drilled into fittings to create an automatic drain for trapped sections of pipe. The presence of these drains might not be obvious, but once found, they must be carefully inspected.

Tip for Owners

Because of the nature of the hazards protected by these systems, the frequency of unsupervised or unlocked valve inspection exceeds that of typical control valves as required in Chapter 13. These daily inspections are normally conducted by trained facility managers or maintenance personnel. It should be noted, however, that the record-keeping requirements in Chapter 4 still apply. A procedure for adequately recording the inspections should be developed, and the documentation maintained in accordance with Section 4.3.

10.4 Ultra-High-Speed Water Spray System (UHSWSS) Operational Tests.

An ultra-high-speed water spray system (UHSWSS) is a type of automatic water spray system in which water spray is rapidly applied to protect specific hazards in areas where deflagrations are anticipated. Ultra-high-speed water spray systems are intended to operate in less than 100 milliseconds. Specialized training and experience are necessary to work on these systems.

10.4.1 A full operational test, including measurements of response time, shall be conducted at intervals not exceeding 1 year.

10.4.1.1 Systems out of service shall be tested before being placed back in service.

10.4.2 All detectors shall be tested and inspected monthly for physical damage and accumulation of deposits on the lenses of optical detectors.

10.4.3 Controllers shall be inspected for faults at the start of each working shift.

10.4.4 Valves.

10.4.4.1 Valves on the water supply line shall be inspected at the start of each working shift to verify they are open.

10.4.4.2 Valves secured in the open position with a locking device or monitored by a signaling device that sounds a trouble signal at the deluge system control panel or other central location shall not require inspection.

10.4.5 Response Time.

10.4.5.1 The response time shall be verified during the operational test.

10.4.5.2 The response time shall be in accordance with the requirements of the system but not more than 100 milliseconds.

10.5 Component Action Requirements.

FAQ Is an acceptance test required whenever maintenance is performed on a system component?

Component replacement tables provide guidance when system components are adjusted, repaired, rebuilt, or replaced. It is not necessary in each case to require a complete acceptance test for each component when maintenance is performed.

10.5.1 Whenever a component in a water spray fixed system is adjusted, repaired, reconditioned, or replaced, the action required in Table 10.5.1 shall be performed.

Δ ***TABLE 10.5.1*** *Summary of Component Action Requirements*

Component	*Adjust*	*Repair/ Recondition*	*Replace*	*Required Action*
Water Delivery Components				
Fire department connections				See Chapter 13
Manual release	X	X	X	(1) Operational test (2) Check for leaks at system working pressure (3) Test all alarms
Nozzles	X	X	X	Operational flow test
Pipe and fittings	X	X	X	Operational flow test
Alarm and Supervisory Components				
Detection system	X	X	X	Operational test for conformance with NFPA 15 and/or *NFPA 72*
Pressure-switch-type waterflow	X	X	X	Operational test using inspector's test connection
Valve supervisory device	X	X	X	Test for conformance with NFPA 15 and/or *NFPA 72*
Water motor gong	X	X	X	Operational test using inspector's test connection
Status-Indicating Components				
Gauges			X	Verify at 0 psi (0 bar) and system working pressure
Testing and Maintenance Components				
Auxiliary drains	X	X	X	(1) Inspect for leaks at system working pressure (2) Main drain test
Main drain	X	X	X	Full-flow main drain test
Structural Components				
Hanger/seismic bracing	X	X	X	Inspect for conformance with NFPA 15 and/or NFPA 13
Pipe stands	X	X	X	Inspect for conformance with NFPA 15 and/or NFPA 13
Informational Components				
Identification signs	X	X	X	Inspect for conformance with NFPA 15

10.5.2 Where the original installation standard is different from the cited standard, the use of the appropriate installing standard shall be permitted.

10.5.3 The actions of 10.5.1 shall not require a design review, which is outside the scope of this standard.

References Cited in Commentary

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

Cote, A. E., ed., *Fire Protection Handbook®,* 19th edition, 2003.

Hague, D. R., *Fire Protection Systems for Special Hazards*, 2004 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2019 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection,* 2017 edition.

NFPA 72®, National Fire Alarm and Signaling Code®, 2019 edition.

NFPA 409, *Standard on Aircraft Hangars,* 2016 edition.

What Are Foam Water Sprinkler Systems?

A foam water sprinkler system is a piping network employing automatic sprinklers, nozzles, or other discharge devices, connected to a source of foam concentrate and to a water supply.

Aqueous foam solutions, created using foam concentrate mixed with water, are expanded with air to create foam. Discharge devices include nozzles and sprinklers.

What Are Foam Water Sprinkler Systems Used for?

Foam water sprinkler systems are used in extra hazard areas containing flammable or combustible liquids. Typically, foam water sprinkler systems are installed in aircraft hangars, petrochemical plants, tank farms, fuel loading facilities, and power plants.



Courtesy of Prime Fire –www. primefire.us

How Do Foam Water Sprinkler Systems Work?

Foam is generated by combining a specific proportion of foam concentrate with water. When this foam-water mixture discharges from the sprinklers it suppresses liquid fuel vapors by forming a layer on top of the fuel and cools the liquid surface. After the foam concentrate has run out, the water will continue to flow from the sprinkler, cooling the foam and liquid surface.



Used with permission of Johnson Controls

ITM

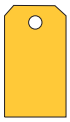
Proper inspection, testing, and maintenance (ITM) of a foam water sprinkler system helps ensure proper operation of the system when it is needed most and helps minimize accidental discharge of the system. Some of the key things that ITM is intended to ensure include making sure the valves are open, checking to see if the discharge devices are positioned correctly and unobstructed as well as testing the proportioning system to make sure it operates as intended.

For more information refer to NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems.*

Foam-Water Sprinkler Systems Inspection and Testing



NO DEFICIENCIES OR IMPAIRMENTS



NONCRITICAL DEFICIENCIES

- Physical damage apparent on alarm devices
- Trap sumps and drainage trenches blocked, retention embankments or dikes in disrepair
- Standard pressure proportioner automatic drains (ball drip valves) not free or open, external corrosion on foam concentrate tanks
- External corrosion on foam concentrate tank of bladder tank proportioner
- External corrosion on foam concentrate tank of line proportioner



CRITICAL DEFICIENCIES

PIPE AND FITTINGS

- Mechanical damage missing or damaged paint or coating, rusted or corroded, not properly aligned or trapped sections, low-point drains not functioning, improper location or poor condition of rubber-gasketed fittings

HANGERS AND SEISMIC BRACES

- Damaged or missing, not securely attached to structural supports or piping, missing or damaged paint or coating, rusted or corroded

FOAM-WATER DISCHARGE DEVICES

- Discharge devices not properly positioned or pointed in design direction, loaded or corroded
- Not free to operate as intended
- Missing caps or plugs if required
- Incorrect foam concentrate for application devices
- Foam concentrate strainers – Blowdown valve open or not plugged

PROPORTIONING SYSTEMS (ALL)

- Concentrate tank does not have correct quantity required by original design

LINE PROPORTIONER

- Strainer damaged, corroded, pressure vacuum vent not operating freely

STANDARD BALANCED PRESSURE PROPORTIONER

- Strainer damaged, corroded, plugged, or fouled, pressure vacuum vent not operating freely, gauges damaged or not showing proper pressures

IN-LINE BALANCED PRESSURE PROPORTIONER

- Strainer damaged, corroded, pressure vacuum vent not operating freely, gauges damaged or not showing proper pressures

ORIFICE PLATE PROPORTIONER

- Strainer damaged, corroded, pressure vacuum vent not operating freely, gauges damaged or not showing proper pressures

ALARM DEVICES —TESTING

- Water motor and gong not functioning
- Pressure switch or vane-type switch not functioning or no alarm

OPERATIONAL TEST

- Fire detection system did not operate within requirements of *NFPA 72*
- Nozzles not correctly positioned
- Pressure readings not comparable to original design requirements

MAIN DRAIN TEST

- More than 10% drop in full flow pressure

INTERNAL ASSESSMENT

- Inspection of internal condition revealed presence of MIC, zebra mussels, rust, and scale

FOAM CONCENTRATE

- Fails quality testing



IMPAIRMENTS

- Foam-water discharge devices missing

PROPORTIONING SYSTEMS (ALL)

- Proportioning system valves not in correct open/closed position in accordance with specified operating conditions
- Concentrate tank empty

BLADDER TANK PROPORTIONER

- Water control valve to foam concentrate in "closed" position
- Foam in water surrounding bladder

LINE PROPORTIONER

- Strainer plugged or fouled

STANDARD BALANCED PRESSURE PROPORTIONER

- Sensing line valves not open, no power to foam liquid pump

IN-LINE BALANCED PROPORTIONER

- Sensing line valves at pump unit or individual proportioner stations not open, no power to foam liquid pump
- Strainer plugged or fouled

ORIFICE PLATE PROPORTIONER

- No power to foam liquid pump
- Strainer plugged or fouled

OPERATIONAL TEST

- Nozzles plugged
- Manual actuation devices not working properly
- Foam sample failed concentration test

Source: Table A.3.3.8



11

FOAM-WATER SPRINKLER SYSTEMS

Chapter 11 of NFPA 25 covers the inspection, testing, and maintenance (ITM) of foam-water sprinkler and foam-water spray systems. Foam-water systems are used in extra hazard areas containing flammable or combustible liquids. As is the case with water spray fixed systems, the proper ITM of foam-water systems requires specialized training and experience. In addition to the requirements in this chapter, the manufacturer's instructions for ITM should be followed.

Foam-water sprinkler systems are installed to protect structures, equipment, and facilities where a potential hazard for a two-dimensional flammable liquid fire exists. These systems can provide prevention, extinguishment, control, and/or exposure protection, depending on the application. Typically, foam-water sprinkler systems are installed in aircraft hangars, petrochemical plants, tank farms, fuel-loading facilities, and power plants.

Protein, fluoroprotein, and aqueous film-forming concentrates or film-forming fluoroprotein foam concentrates are suitable for use with foam-water sprinklers. The latter type of foam concentrate also has proven suitable for use with standard sprinklers of the type referred to in NFPA 13, *Standard for the Installation of Sprinkler Systems*, where the system is provided with the necessary foam concentrate proportioning equipment. Foam products are tested to specific sprinklers; care should be exercised to ensure that the chosen concentrate and discharge device installed are listed for use together.

Historical Note

The uses of foam for fire protection have increased greatly since its first use in the 1900s. Early foam development and its use as a fire extinguishing agent started in the petroleum industry, as people in the industry began to recognize the special hazard of combustible and flammable liquids. In the 1930s, the U.S. Navy realized the need for improvement on the cumbersome, early foam systems and initiated further research. The U.S. military and numerous petrochemical companies continued this research for several years. The concept of using foam in ceiling-mounted systems was researched, developed, and tested through the 1950s. In 1961, Factory Mutual Research Corporation (now FM Global) began conducting tests of high-expansion foam systems for possible protection in various industries. That same year, the National Board of Fire Underwriters and the U.S. Naval Research Laboratory showed the effectiveness of foam-water sprinklers in test demonstrations, and NFPA published NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems,* which was the association's first standard on foam-water sprinklers. In 1969, testing conducted by FM Global and Grinnell (now Johnson Controls) showed the positive effects of foam-water deluge systems on jet fuel fires. This resulted in the formation of the committee for NFPA 409, *Standard on Aircraft Hangars,* which recommended these systems over regular water-based sprinkler systems (Richardson 2003).

11.1 General.

11.1.1 Minimum Requirements.

11.1.1.1 This chapter shall provide the minimum requirements for the routine inspection, testing, and maintenance of foam-water sprinkler systems.

11.1.1.2 Table 11.1.1.2 shall be used to determine the minimum required frequencies for inspection, testing, and maintenance.

Δ ***TABLE 11.1.1.2*** *Summary of Foam-Water Sprinkler System Inspection, Testing, and Maintenance*

System/Component	*Frequency*	*Reference*
Inspection		
Control valve(s)		Chapter 13
Deluge/preaction valve(s)		Chapter 13
Discharge device location (spray nozzle)	Monthly	11.2.4
Discharge device location (sprinkler)	Annually	11.2.4
Discharge device position (spray nozzle)	Monthly	11.2.4
Discharge device position (sprinkler)	Annually	11.2.4
Drainage in system area	Quarterly	11.2.7
Fire pump system		Chapter 8
Fittings corrosion	Annually	11.2.2
Fittings damage	Annually	11.2.2
Foam concentrate strainer(s)	Quarterly	11.2.6.4
Gauges		Chapter 13
Hangers/braces/supports	Annually	11.2.3
Pipe corrosion	Annually	11.2.2
Pipe damage	Annually	11.2.2
Proportioning system(s) — all	Monthly	11.2.8
Strainer(s) — Mainline	5 years	11.2.6.1
Water supply piping		11.2.5.1
Water supply tank(s)		Chapter 9
Waterflow alarm devices		Chapter 13
Test		
Backflow preventer(s)		Chapter 13
Complete foam-water sprinkler system(s) (operational test)	Annually	11.3.2, 11.3.3
Control valve(s)		Chapter 13
Deluge/preaction valve(s)		Chapter 13
Discharge device location	Annually	11.3.2.6
Discharge device obstruction	Annually	11.3.2.6
Discharge device position	Annually	11.3.2.6
Fire pump system		Chapter 8
Foam-water solution	Annually	11.3.5
Manual actuation device(s)	Annually	11.3.4
Valve status test		Chapter 13
Water supply flow test		Chapter 7
Water supply tank(s)		Chapter 9
Waterflow alarm devices		Chapter 13

Δ ***TABLE 11.1.1.2*** *Continued*

System/Component	*Frequency*	*Reference*
Maintenance		
Backflow preventer(s)		Chapter 13
Bladder tank type		
Foam concentrate tank — hydrostatic test	10 years	11.4.5.2
Sight glass	10 years	11.4.5.1
Check valve(s)		Chapter 13
Control valve(s)		Chapter 13
Deluge/preaction valves		Chapter 13
Detector check valve(s)		Chapter 13
Fire pump system		Chapter 8
Foam concentrate pump operation	Monthly	11.4.7.1
Foam concentrate samples	Per manufacturer's recommendation	11.4.2
Foam concentrate strainer(s)	Quarterly	Section 11.4
In-line balanced pressure type		
Balancing valve diaphragm	5 years	11.4.8.3
Foam concentrate pump(s)	5 years*	11.4.8.2
Foam concentrate tank	10 years	11.4.8.4
Line type		
Foam concentrate tank — corrosion and pickup pipes	10 years	11.4.6.1
Foam concentrate tank — drain and flush	10 years	11.4.6.2
Pressure vacuum vents	5 years	11.4.9
Proportioning system(s) standard pressure type		
Ball drip (automatic type) drain valves	5 years	11.4.4.1
Corrosion and hydrostatic test	10 years	11.4.4.4
Foam concentrate tank — drain and flush	10 years	11.4.4.2
Standard balanced pressure type		
Balancing valve diaphragm	5 years	11.4.7.3
Foam concentrate pump(s)	5 years*	11.4.7.2
Foam concentrate tank	10 years	11.4.7.4
Strainer(s) — mainline	5 years	11.2.6.1
Water supply	Annually	11.2.5.2
Water supply tank(s)		Chapter 9

*Also refer to manufacturer's instructions and frequency. Maintenance intervals other than preventive maintenance are not provided, as they depend on the results of the visual inspections and operational tests. For foam-water sprinkler systems in aircraft hangars, refer to the inspection, test, and maintenance requirements of Table 11.1.1 in NFPA 409.

11.1.2 Other System Components. Fire pumps, water storage tanks, common components, and valves common to other types of water-based fire protection systems shall be inspected, tested, and maintained in accordance with Chapters 8, 9, and 13, respectively, and as specified in Table 11.1.1.2.

11.1.3 Foam-Water Sprinkler Systems.

FAQ What is the difference between the various systems covered in NFPA 13, NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam,* NFPA 16, and the systems covered by Chapter 11 of NFPA 25?

NFPA 11 addresses low-, medium-, and high-expansion foam systems, while NFPA 16 addresses foam-water systems. NFPA 11 specifically indicates that foam-water sprinkler and spray systems, which are covered in NFPA 16, are outside of the scope of NFPA 25.

Chapter 11 of NFPA 25 addresses the foam-water system types and applications covered in NFPA 16. The NFPA 16 foam-water sprinkler systems addressed in this chapter are similar to the standard wet, dry, preaction, and deluge systems. The exception is that NFPA 16 systems discharge a foam-water extinguishing agent and, thus, are also equipped with added trim; this includes a foam concentrate connection, a proportioning device, and a foam concentrate storage tank.

Foam-water systems also use either aspirating foam-water nozzles or non-aspirating sprinklers in systems similar to a standard ceiling sprinkler system. Nozzles and sprinklers must be listed and tested for use with the specific foam used in the system. Specific foam concentrates are typically listed or approved with specific sprinklers. Part of the approval and listing is a minimum sprinkler operating pressure. Sprinkler operating pressure affects foam quality, discharge patterns, and fire extinguishment (or control) capabilities. Discharge pressures less than the specified minimum pressure should be corrected immediately; therefore, it is necessary to test under full flow conditions. In many cases, standard sprinklers that hold a double listing are used, meaning that they are used in both standard and foam-water systems.

Foam-water systems, like NFPA 13 sprinkler systems, will run until a shutoff valve is closed. If the foam concentrate supply is exhausted, these systems continue to operate with water discharge only. Also, in some installations, they are designed to sequence the discharge between water and foam.

11.1.3.1 This section shall apply to foam-water sprinkler systems as specified in NFPA 16.

11.1.3.2 This section shall not include systems detailed in NFPA 11.

NFPA 11 covers a different type of foam system from those addressed in NFPA 25. Where applicable, testing should include the requirements of Chapter 11 of NFPA 11, and maintenance should include the requirements of Chapter 12 of NFPA 11.

11.1.4 Foam-Water Sprinkler System.

11.1.4.1 If during routine inspection and testing the foam-water sprinkler system is determined to have been altered or replaced (e.g., equipment replaced, relocated, or foam concentrate replaced), it shall be determined whether the system operates properly.

Alterations or changes must be evaluated for compliance with NFPA 16. This evaluation might require referring to the original design and installation documents to determine if the system has been altered. The evaluation should be conducted by a qualified contractor, consultant, or engineer. Noting these changes is different from noting changes to the building or its contents, as described in 4.1.6. The person performing the inspection or testing of the systems addressed by Chapter 11 must have special knowledge of how the systems are designed to work. Because of that, identifying changes or alterations is possible. Conversely, identifying changes in use, process, or materials stored or used in the building would require the inspector/tester to become familiar with the operations of the facility, which NFPA 25 does cover.

Case In Point

TYPES OF FOAM CONCENTRATES

Foam-water systems, as referenced in NFPA 13, use aspirating foam-water nozzles or nonaspirating nozzles with low expansion–type foam only. For foam-only systems, see NFPA 11.

Foam-water spray systems are equipped with a foam concentrate connection and proportioning device connected to a foam concentrate storage tank. The types of foam concentrates used in these systems include protein, fluoroprotein, aqueous film-forming foam or film-forming fluoroprotein, or alcohol-resistant foam concentrates. These types of concentrates are described below and have been compiled from information in NFPA 11.

Protein-Foam Concentrate. Products from a natural hydrolyzed protein, plus added stabilizers and inhibitors to protect against freezing, prevent corrosion of equipment and containers, resist bacterial decomposition, control viscosity, and otherwise ensure readiness for use under emergency conditions. These are typically diluted with water to form 3 percent to 6 percent solutions, depending on the type, and are compatible with certain dry chemicals.

Aqueous Film-Forming Foam (AFFF) Concentrate. Products with fluorinated surfactants, plus stabilizers. These are typically diluted with water to a 1 percent, 3 percent, or 6 percent solution. The foam that forms acts as a barrier both to exclude air or oxygen and to develop an aqueous film on the fuel surface that is capable of suppressing the evolution of fuel vapors. These are suitable for use with dry chemicals.

Fluoroprotein-Foam (FP) Concentrate. Products similar to protein-foam concentrate but with a synthetic fluorinated surfactant additive. In addition to an air-excluding foam blanket, it also can deposit a vaporization-preventing film on the surface of a liquid fuel. These are typically diluted with water to form 3 percent to 6 percent solutions, depending on the type, and they are compatible with certain dry chemicals.

Film-Forming Fluoroprotein (FFFP) Foam Concentrate. Products with protein-based and fluorinated surfactants that produce a fluid aqueous film for suppressing hydrocarbon fuel vapors. This foam has stabilizers and inhibitors added to protect against freezing, corrosion, and bacterial decomposition for added resistance to prevent fuel pickup. These are typically diluted with water to a 3 percent or 6 percent solution and are dry chemical–compatible.

Alcohol-Resistant (AR) Foam Concentrate. Products used for fighting fires on water-soluble materials and other fuels destructive to regular AFFF or FFFP foams. It is also used for fires involving hydrocarbons. The three general types of alcohol-resistant foam concentrates are as follows:

1. Water-soluble natural polymers, such as protein or fluoroprotein concentrate, contain alcohol-insoluble materials that precipitate as an insoluble barrier in the bubble structure.
2. Water-soluble natural polymers, such as protein or fluoroprotein concentrates, contain a gelling agent that protects the foam from water-soluble fuels. This foam can also have film-forming and fluoroprotein characteristics on hydrocarbon fuels.
3. Synthetic concentrates contain gelling agents that surround the foam bubbles and form a protective raft on the surface of water-soluble fuels. These foams can also have film-forming characteristics on hydrocarbon fuels.

Alcohol-resistant aqueous film-forming foams (AR-AFFF) are foams resistant to the action of alcohols. These concentrates are typically used in up to 10 percent solutions, depending on the nature of the hazard to be protected and the type of concentrate.

NFPA 11 permits different brands of foam concentrate to be mixed if they are of the same type and the manufacturer provides data to the authority having jurisdiction (AHJ) demonstrating compatibility. Foam concentrates of different concentrations cannot be substituted.

11.1.5 Obstruction Investigations. The procedures outlined in Chapter 14 shall be followed where there is a need to conduct an obstruction investigation.

11.1.6 Impairments. The procedures outlined in Chapter 15 shall be followed where an impairment to protection occurs.

11.2 Inspection.

Systems shall be inspected in accordance with the frequency specified in Table 11.1.1.2.

11.2.1 Deluge Valves. Deluge valves shall be inspected in accordance with the provisions of Chapter 13.

11.2.2 System Piping and Fittings. System piping and fittings shall be inspected for the following:

(1) Mechanical damage (e.g., broken piping or cracked fittings)
(2) External conditions (e.g., missing or damaged paint or coatings, rust, and corrosion)
(3) Misalignment or trapped sections
(4) Low-point drains (automatic or manual)
(5) Location and condition of rubber-gasketed fittings

11.2.3 Hangers, Braces, and Supports. Hangers, braces, and supports shall be inspected for the following and repaired or replaced as necessary:

(1) Condition (e.g., missing or damaged paint or coating, rust, and corrosion)
(2) Secure attachment to structural supports and piping
(3) Damaged or missing hangers, braces, and supports

11.2.4* Foam-Water Discharge Devices.

Discharge devices for foam-water spray systems can be either air-aspirating nozzles or non-air-aspirating sprinklers. Discharge devices for foam-water sprinkler systems, such as wet, dry, or preaction systems, are automatic in operation; they must be non-air-aspirating and listed for use with the specific foam utilized. Exhibit 11.1 and Exhibit 11.2 show an air-aspirating discharge nozzle, while Exhibit 11.3 and Exhibit 11.4 show various deflector types for foam-water systems and foam-water spray nozzles.

A.11.2.4 Directional-type foam-water discharge devices are quite often located in heavy traffic areas and are more apt to be dislocated compared to ordinary sprinkler locations. Of particular concern are low-level discharge devices in loading racks in and around low-level tankage and monitor-mounted devices that have been pushed out of the way for convenience. Inspection frequency might have to be increased accordingly.

11.2.4.1 Foam-water discharge devices shall be inspected visually and maintained to ensure that they are in place, continue to be aimed or pointed in the direction intended in the system design, and are free from external loading and corrosion.

11.2.4.2 Where caps or plugs are required, the inspection shall confirm they are in place and free to operate as intended.

11.2.4.3 Misaligned discharge devices shall be adjusted (aimed) by visual means, and the discharge patterns shall be inspected at the next scheduled flow test.

11.2.4.4* Inspection shall verify that unlisted combinations of discharge devices and foam concentrate have not been substituted.

A.11.2.4.4 Discharge devices are listed or approved for particular foam concentrates.

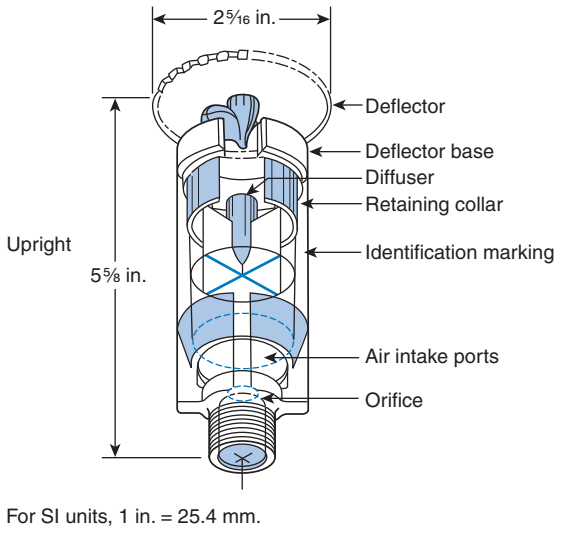


EXHIBIT 11.1 *Diagram of an Air-Aspirating Discharge Nozzle. (Courtesy of Kidde Fire Systems, Ashland, MA)*



EXHIBIT 11.2 *Air-Aspirating Discharge Nozzle.*

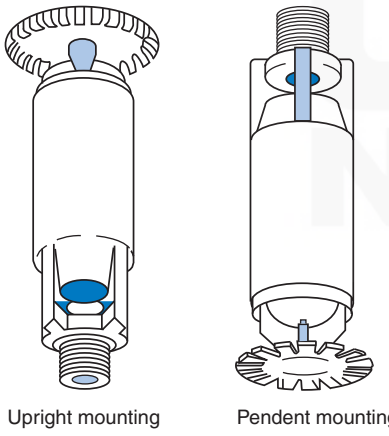


EXHIBIT 11.3 *Variations in Deflector Shape. (Source: NFPA 16, 2019, Figure A.3.3.6.1.)*



EXHIBIT 11.4 *Foam-Water Spray Nozzle. (Source: NFPA 16, 2019, Figure A.3.3.6.4.)*

11.2.5 Water Supply.

11.2.5.1 The dependability of the water supply shall be ensured by regular inspection and maintenance, whether furnished by a municipal source, on-site storage tanks, a fire pump, or private underground piping systems.

11.2.5.2* Water supply piping shall be maintained free of internal obstructions.

A.11.2.5.2 Water supply piping should be free of internal obstructions that can be caused by debris (e.g., rocks, mud, tubercles) or by closed or partially closed control valves. See Chapter 5 for inspection and maintenance requirements.

11.2.6 Strainers.

11.2.6.1 Mainline and individual discharge device strainers (basket or screen) shall be inspected every 5 years for damaged and corroded parts.

11.2.6.2 Other maintenance intervals shall be permitted, depending on the results of the visual inspection and operating tests.

11.2.6.3 Discharge device strainers shall be removed, inspected, and cleaned during the flushing procedure for the mainline strainer.

11.2.6.4 Foam concentrate strainers shall be inspected visually to ensure the blowdown valve is closed and plugged.

11.2.6.5 Baskets or screens shall be removed and inspected after each operation or flow test.

11.2.7 Drainage. The area beneath and surrounding a foam-water spray system shall be inspected to ensure that drainage facilities, such as trap sumps and drainage trenches, are not blocked, and retention embankments or dikes are in good repair.

11.2.8* Proportioning Systems.

The following description of various types of proportioning systems is adapted from A.8.4 of NFPA 16.

In *vacuum induction*, a venturi device, called an inductor, decreases the pressure in the foam concentrate proportioning inlet tube to the system flow passageway to below the atmospheric pressure in which the foam is pushed by atmospheric pressure through a calibrated orifice. This system is limited to deluge systems, and the friction loss of the discharge system to the discharge devices must be considered for proper performance. Proportioning percentage can vary based on the discharge and supply characteristics, as well as the foam concentrate. These systems require full system discharge flow testing to determine proper installation and sizing.

A *foam concentrate pump* discharges foam directly into the discharge system through a metering orifice specifically sized for the system performance that is being installed. This type of system is limited to deluge-type systems and must be flow tested at the desired maximum flow rate of the system. Each installation must be full system flow tested due to specific design parameters for a particular installation.

Balanced pressure proportioning with a foam pump or bladder tank uses a modified venturi proportioning device in the system water supply pipe. The waterflow to the system through the modified venturi causes a metered pressure drop in the foam concentrate inlet chamber. As the flow increases, the metered pressure loss increases, causing the increased flow of foam concentrate through a calibrated orifice into the system water supply. With a foam pump system, a balancing valve is used to measure the supply pressure at the inlet of the modified venturi proportioner and balance the foam concentrate pressure down to equal that pressure. When using a bladder tank, the foam concentrate is stored inside a bladder within a pressure vessel where the supply water in the system supply is directed to the outside of the bladder; this causes the foam concentrate to push out from the top or bottom of the tank and travel to the inlet of the modified venturi device. As the water pressure increases or decreases due to flow conditions, so does the foam concentrate pressure. In both the balanced pump system and the bladder tank system, when the inlet pressures of both foam concentrate and water supply match, the inlet calibrated orifice of the modified venturi device provides the proper mixture of foam to water as specified by the manufacturer. Also, both of these systems allow for system isolation test valves to be applied and divert test foam solution flow to a containment area that can be easily disposed of.

Positive pressure proportioning with a foam pump or pressure-controlled bladder tank system uses a system that supplies foam concentrate to a modified venturi at a higher

pressure than the supply water pressure. The modified venturi includes a calibrated orifice that is sized to match the system equipment and the foam concentrate being used.

Exhibit 11.5 illustrates a hydraulically operated concentrate valve. As the deluge valve on the system activates, water pressure is applied to the valve, allowing it to open. This valve should also be included in the ITM program for foam-water systems.



EXHIBIT 11.5 *Hydraulically Operated Concentrate Valve. (Courtesy of Devin O'Leary, Johnson Controls)*

A.11.2.8 Proportioning systems might or might not include foam concentrate pumps. If pumps are part of the proportioning system, the driver, pump, and gear reducer should be inspected in accordance with the manufacturer's recommendations, and the inspection can include items such as lubrication, fuel, filters, oil levels, and clutches.

11.2.8.1 The components of the various proportioning systems described in 11.2.8 shall be inspected in accordance with the frequency specified in Table 11.1.1.2.

11.2.8.2 Valves specified to be inspected shall be permitted to be open or closed, depending on specific functions within each foam-water sprinkler system.

11.2.8.3 The position (open or closed) of valves shall be verified in accordance with specified operating conditions.

11.2.8.4* Inspection of the concentrate tank shall include verification that the quantity of foam concentrate satisfies the requirements of the original design.

As specified in NFPA 16, the minimum quantity of foam concentrate required is determined by the following hydraulic calculation:

$$\% \text{ concentration} \times \text{amount of flow} \times \text{duration} = \text{foam concentrate quantity}$$

This minimum quantity should be maintained in the storage tank at all times.

A.11.2.8.4 In some cases, an adequate supply of foam liquid is available without a full tank. This is particularly true of foam liquid stored in nonmetallic tanks. If liquid is stored in metallic tanks, the proper liquid level should be one-half the distance into the expansion dome.

11.2.8.5 Additional inspection requirements shall be performed as detailed for the proportioning systems specified in 11.2.8.

11.2.8.5.1 Standard Pressure Proportioner.

11.2.8.5.1.1* The pressure shall be removed before the inspection to prevent injury.

Pressure can be removed by slowly opening the drain or vent valve.

A.11.2.8.5.1.1 The standard pressure proportioner is a pressure vessel. Although under normal standby conditions this type of proportioning system should not be pressurized, some installations allow for inadvertent pressurization. Pressure should be removed before inspection.

11.2.8.5.1.2 The inspection shall verify the following:

(1) Ball drip valves (automatic drains) are free and opened.
(2) External corrosion on foam concentrate storage tanks is not present.

11.2.8.5.2 Bladder Tank Proportioner.

11.2.8.5.2.1* The pressure shall be removed before the inspection to prevent injury.

A.11.2.8.5.2.1 The bladder tank proportioner is a pressure vessel. Where inspecting for a full liquid tank, the manufacturer's instructions should be followed. If inspected incorrectly, the tank sight gauges could indicate a full tank when the tank actually is empty of foam liquid. Some foam liquids, due to their viscosity, might not indicate true levels of foam liquid in the tank where inspected via the sight glass.

> **CAUTION:** Depending on system configuration, this type of proportioner system might be pressurized or nonpressurized under normal conditions. Pressure should be removed before inspection.

11.2.8.5.2.2 The inspection shall include the following:

(1) Water control valves to foam concentrate tank
(2) An inspection for external corrosion on foam concentrate storage tanks
(3) An inspection for the presence of foam in the water surrounding the bladder (annual)

11.2.8.5.3 Line Proportioner. The inspection shall include the following:

(1)* Strainers

A.11.2.8.5.3(1) See 11.2.6.1.

(2) *Verification that pressure vacuum vent is operating freely

A.11.2.8.5.3(2) See Figure A.3.3.34.

(3) An inspection for external corrosion on foam concentrate storage tanks

11.2.8.5.4 Standard Balanced Pressure Proportioner. The inspection shall include the following:

(1)* Strainers

A.11.2.8.5.4(1) See 11.2.6.1.

(2)* Verification that pressure vacuum vent is operating freely

A.11.2.8.5.4(2) See Figure A.3.3.34.

(3) Verification that gauges are in good operating condition
(4) Verification that sensing line valves are open
(5) Verification that power is available to foam liquid pump

11.2.8.5.5 In-Line Balanced Pressure Proportioner. The inspection shall include the following:
(1)* Strainers

ITM Deficiency, Impairment, or Hazard Evaluation?

ANSWER: Impairment

This photo shows the actual rubber bladder on a foam-water sprinkler system pulled from the bladder tank after it was determined that foam concentrate had leaked from it. The bladder is separated or torn at the bottom of the neck, allowing the concentrate to migrate from the bladder into the water surrounding it and the water to enter the bladder, diluting the concentrate. In addition, the amount of the diluted concentrate in the bladder was about half of what it should have been. This condition was discovered while performing the annual inspection and test required by Chapter 11. A subsequent pressure test on the bladder and vacuum test on the tank shell indicated that the integrity of the bladder itself had failed.

The dilution and amount of the foam concentrate in the tank created an impaired condition. This portion of the system will no longer function as intended in a fire event. Instead of delivering the proper duration of pure foam concentrate to the proportioner, only a short duration of diluted concentrate will be proportioned into this foam-water system. The hazard being protected requires a certain concentration of a foam-water solution in accordance with NFPA 16 for proper fire extinguishment or control. Because of the failure of the bladder, this system will not provide that concentration level.



(Courtesy of David W. Smith and SimplexGrinnell)

A.11.2.8.5.5(1) See 11.2.6.1.

(2)* Verification that pressure vacuum vent is operating freely

A.11.2.8.5.5(2) See Figure A.3.3.34.

(3) Verification that gauges are in good working condition
(4) Verification that sensing line valves at pump unit and individual proportioner stations are open
(5) Verification that power is available to foam liquid pump

11.2.8.5.6 Orifice Plate Proportioner. The inspection shall include the following:

(1)* Strainers

A.11.2.8.5.6(1) See 11.2.6.1.

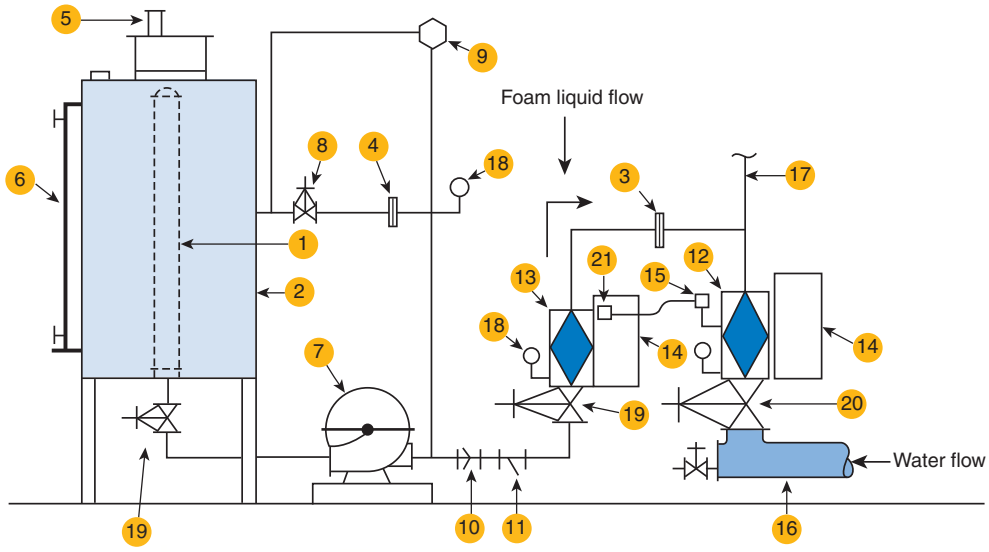
(2)* Verification that pressure vacuum vent is operating freely

A.11.2.8.5.6(2) See Figure A.3.3.34.

(3) Verification that gauges are in good working condition
(4) Verification that power is available to foam liquid pump

Exhibit 11.6 illustrates an arrangement for orifice plate proportioning. This method uses a second deluge valve supplied by a foam concentrate pump. The diameter of the orifice is determined by hydraulic calculations and controls the flow of foam concentrate.

EXHIBIT 11.6 *Orifice Plate Proportioning Arrangement.*



Legend

1. Strainer
2. Foam liquid storage tank
3. Flange with orifice plate (for calibration of foam liquid injection)
4. Flange with orifice plate (for pump test calibration)
5. Vent-vacuum breather
6. Sight glass
7. Foam liquid pump
8. Re-circulating and test line gate valve (N.C.)
9. Relief valve
10. Check valve
11. Foam liquid supply strainer
12. Deluge valve
13. Companion deluge valve
14. Deluge system control panel
15. Deluge valve solenoid
16. Water supply strainer
17. To system foam water solution
18. Pressure indicating gauge
19. Foam liquid control valve (N.O.)
20. Water supply control valve (N.O.)
21. Companion deluge valve solenoid

N.C. = Normally closed.
N.O. = Normally open.

11.3* Operational Tests.

Frequency of system tests shall be in accordance with Table 11.1.1.2.

Δ **A.11.3** Operational tests generally should be comprised of the following:

(1) A detection/actuation test with no flow to verify that all components such as automated valves, foam and water pumps, and alarms operate properly
(2) A water-only flow test to inspect piping continuity, discharge patterns, pressures, and line flushing
(3) A foam flow test to verify solution concentration
(4) Resetting of system to its normal standby condition, including draining of lines and filling of foam liquid tank

System tests must be conducted in accordance with Table 11.1.1.2. This testing includes annual testing of the foam concentrate, which helps ensure the reliability of the foam system.

Properly stored foam concentrates have an excellent record of effectiveness and longevity. Protein-type concentrates have an expected shelf life of approximately 7 to 10 years. Synthetic-type concentrates have an expected shelf life of 20 to 25 years. Factors affecting shelf life and effectiveness include wide temperature variations, high or low temperature extremes, evaporation, dilution, and contamination by foreign materials.

A test connection is normally provided as a means of periodically checking the performance of the proportioners used in foam sprinkler systems. Typical test connections are illustrated in Figure A.11.3.2. If the proportioning controller is located after the main sprinkler valve, an additional supervised outside screw and yoke (OS&Y) valve is provided to isolate the sprinkler overhead during the proportioner test. This additional precaution is intended to eliminate problems caused by air cushions in wet pipe sprinkler systems or the servicing delays that result from charging and draining preaction or deluge sprinkler systems. The manufacturer's test procedures should be followed closely.

11.3.1* Test Preparation. Precautions shall be taken to prevent damage to property during the test.

FAQ What precautions must be taken to prevent property damage during a discharge test?

Some of the precautions required by 11.3.1 to prevent property damage during a discharge test might include the following:

- Checking related facility systems for proper operation, to ensure that the water supply to the deluge system has been inspected and tested.
- Making sure sump tanks are empty and operating properly.
- Inspecting any drainage provisions required to contain or collect the foam-water discharging from the system.
- Making sure the owner or the owner's authorized representative has protected all exposed equipment or property that could be damaged by the system when discharging.
- Making sure proper post-test cleanup has been arranged and planned before testing.
- Making sure environmental compliance has been confirmed and planned before testing. Requirements for cleanup and disposal are often enforced differently in different jurisdictions, regardless of the safety data sheets' (SDS) indications.

A.11.3.1 The property owner or designated representative should take care to prevent damage to equipment or the structure during the test. Damage could be caused by the system discharge or by runoff from the test site. It should be verified that there is adequate and unobstructed drainage. Equipment should be removed or covered as necessary to prevent damage. Means such as curbing or sandbagging should be used to prevent entry of the foam-water solution.

During maintenance tests, only a small amount of foam concentrate should be discharged to verify the correct concentration of foam in the foam-water solution. Designated foam-water test ports can be designed into the piping system so that the discharge of foam-water solution can be directed to a controlled location; for example, a container could be transported to an approved disposal site by a licensed hazardous waste contractor. The remainder of the test should be conducted using water only.

Tip for Owners

The discharge of foam-water sprinkler systems has the potential to damage equipment and/or property. Subsection 11.3.1 requires that precautions be taken to prevent this. The owner should ensure that all exposed equipment or property that could be damaged by the discharge is protected.

11.3.2* Operational Test Performance.

See 13.2.6 for the recommended operational procedure.

A.11.3.2 An alternative method for achieving flow can be permitted to be an installation as shown in Figure A.11.3.2. This type of testing does not verify system pipe conditions or discharge device performance but only the water supply, foam concentrate supply, and proportioning accuracy.

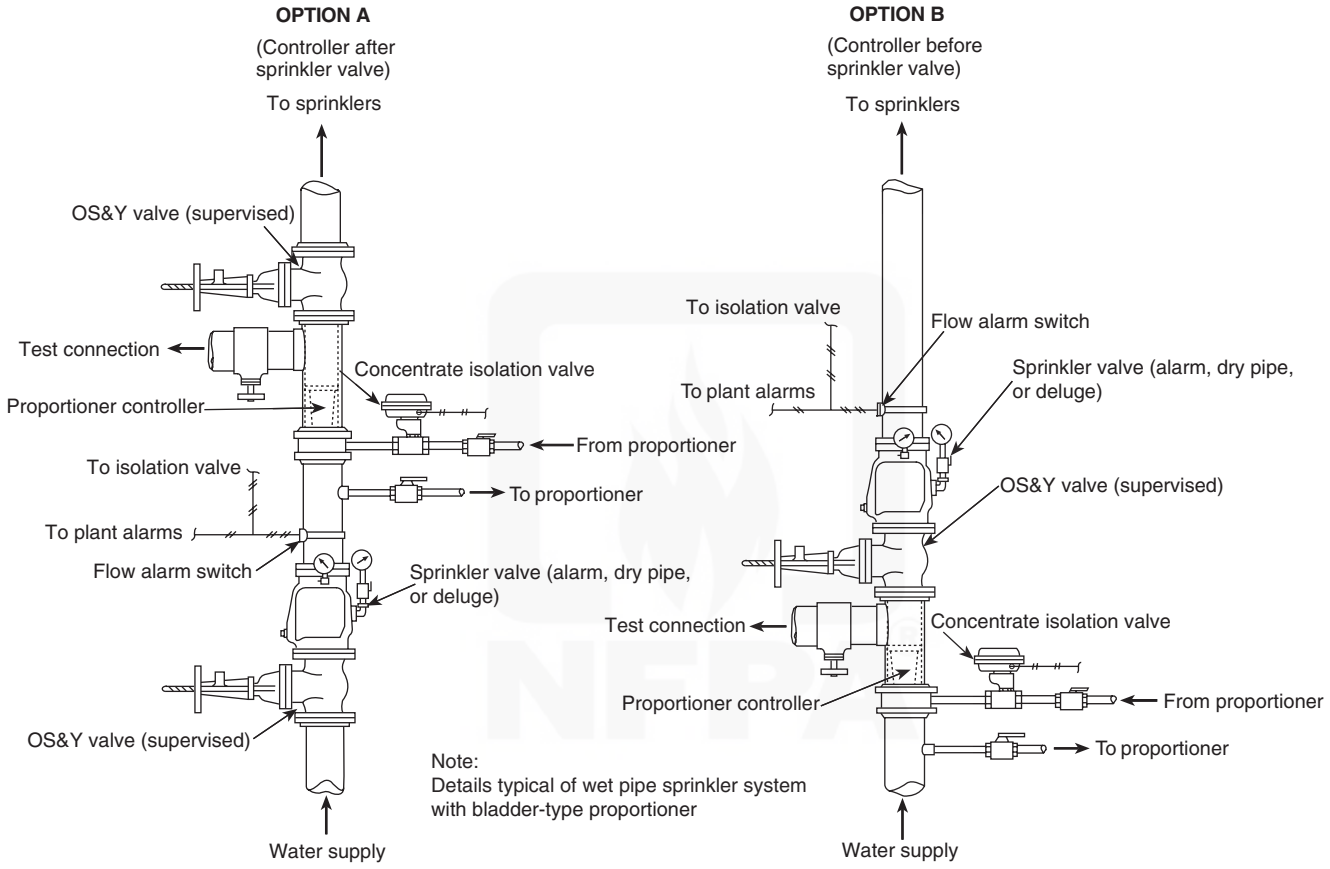


FIGURE A.11.3.2 *Foam System/Test Header Combination.*

Testing Procedure Alert

ITM NFPA 25

Foam-water systems are typically used where the fire hazard is greater than that of a hazard that can be protected by a standard water-only sprinkler system. The fires that occur in these areas can grow rapidly, which is why confirming system functionality through testing is critical. For a procedure for conducting this operational test, please refer to the detailed testing procedure at the end of this chapter.

11.3.2.1 Operational tests shall be conducted to ensure that the foam-water sprinkler system(s) responds as designed, both automatically and manually.

Knowledge of the specialized equipment and test apparatus is necessary to perform an acceptable test. Therefore, the tests should be conducted by qualified persons who are knowledgeable about foam equipment and systems.

11.3.2.2 The test procedures shall simulate anticipated emergency events so the response of the foam-water sprinkler system(s) can be evaluated.

11.3.2.3 Where discharge from the system discharge devices would create a hazardous condition or conflict with local requirements, an approved alternate method to achieve full flow conditions shall be permitted.

When an alternative method of achieving full flow conditions is permitted, full flow can be achieved from the discharge test connection at the system riser.

11.3.2.4 Response Time. Under test conditions, the automatic fire detection systems, when exposed to a test source, shall operate within the requirements of *NFPA 72* for the type of detector provided, and the response time shall be recorded.

11.3.2.5 Discharge Time. The time lapse between operation of detection systems and water delivery time to the protected area shall be recorded for open discharge devices.

11.3.2.6 Discharge Patterns.

11.3.2.6.1 The discharge patterns from all of the open spray devices shall be observed to ensure that patterns are not impeded by plugged discharge devices and to ensure that discharge devices are correctly positioned and that obstructions do not prevent discharge patterns from covering surfaces to be protected.

11.3.2.6.2 Where obstructions occur, the piping and discharge devices shall be cleaned and the system retested.

One of the advantages of foam is its ability to "blanket" an area, smothering flames and cooling surfaces. Obstructions to discharge patterns can disrupt that process and limit the ability of the system to perform as intended.

11.3.2.6.3 Discharge devices shall be permitted to be of different orifice sizes and types.

11.3.2.7* Pressure Readings.

Δ **A.11.3.2.7** Specific foam concentrates typically are listed or approved with specific sprinklers. Part of the approval and listing is a minimum sprinkler operating pressure. Sprinkler operating pressure affects foam quality, discharge patterns, and fire extinguishment (control) capabilities. Discharge pressures less than this specified minimum pressure should be corrected immediately; therefore, it is necessary to test under full flow conditions.

11.3.2.7.1 Pressure readings shall be recorded at the highest, most remote discharge device.

11.3.2.7.2 It shall be permissible to test the full flow discharge from foam-water deluge systems using water only in lieu of foam.

11.3.2.7.3 A second pressure reading shall be recorded at the main control valve.

11.3.2.7.4 Readings shall be compared to the hydraulic design pressures to ensure the original system design requirements are met.

11.3.3 Multiple Systems. The maximum number of systems expected to operate in case of fire shall be tested simultaneously to inspect the adequacy of the water supply and concentrate pump.

11.3.4 Manual Actuation Devices. Manual actuation devices shall be tested annually.

11.3.5 Concentration Testing.

ITM Deficiency, Impairment, or Hazard Evaluation?

ANSWER: Impairment

These three photos have to be viewed in a group to fully understand what they are showing. The foam concentrate line going from the foam concentrate tank to the proportioner was cut to determine the cause of a failed test. As can be seen, this piping was clogged with congealed foam concentrate.

During the annual system discharge test required by Table 11.1.1.2 and Section 11.3, a foam sample was taken as required in 11.3.5, and an attempt was made to verify the concentration. The use of a refractometer revealed that very little foam concentrate was mixing with the water, and the test was stopped. The investigation started at the tank and eventually led to this section of piping. At this point, the system was determined to be impaired, and the recommendation was made to the owner to begin the impairment procedures required in Chapter 15.







(Courtesy of David W. Smith and SimplexGrinnell)

11.3.5.1 During the operational test, a foam sample shall be taken.

11.3.5.2 Where approved by the authority having jurisdiction, simulated foam concentrates or alternative test systems shall be permitted to be substituted for actual foam concentrate, but system pressures and flows shall remain as described above and meet manufacturer's system requirements and recommendations. [**16:**8.4.1.6]

11.3.5.3 The foam sample shall be inspected by refractometric or other methods to verify concentration of the solution.

11.3.5.4 The foam concentrate induction rate of a proportioner, expressed as a percentage of the foam solution flow (water plus foam concentrate), shall be within minus 0 percent to plus 30 percent of the manufacturer's listed concentration, or plus 1 percentage point, whichever is less. [**16**:8.4.1.4]

11.3.6 Return to Service. After the full flow test, the foam-water sprinkler shall be returned to service and the foam concentrate tank shall be replenished to design level.

Testing Procedure Alert

The purpose of the test specified in 11.3.5 is to confirm foam concentrate levels. There are two methods used to determine the concentrate levels: the *refractometric* and the *conductivity* methods. See the detailed testing procedure at the end of this chapter for more information.

11.4* Maintenance.

A.11.4 The maintenance items specified in the body of this standard are in addition to the typical inspection and test procedures indicated. Foam-water sprinkler systems are, as are all fire protection systems, designed to be basically maintenance free. There are, however, some areas that need special attention. Foam concentrate shelf life varies between liquids and is affected by factors such as heat, cold, dilution, contamination, and many others. As with all systems, common sense dictates those maintenance-sensitive areas that should be given attention. Routine testing and inspection generally dictate the need for additional maintenance items. Those maintenance items specified are key procedures that should be performed routinely.

11.4.1 Maintenance of foam-water sprinkler systems shall be in accordance with the requirements of those chapters covering the specific component parts.

11.4.2 Foam Concentrate Samples. Samples of foam concentrates shall be sent to the manufacturer or qualified laboratory for quality condition testing at the frequency recommended by the manufacturer.

Manufacturers of foam concentrates provide laboratory testing services to analyze foam concentrate samples. The samples are then tested for chemical characteristics such as the pH level and specific gravity. They are also tested for contamination from water, oil, noncompatible foam concentrates, and possible microbiological organisms. In addition, changes in the concentrate due to storage temperature fluctuations and sediment are analyzed. Samples for testing should be taken according to the manufacturer's instructions.

11.4.3 Foam Components. Maintenance of specific foam components shall be in accordance with 11.4.4 through 11.4.8.

11.4.4 Standard Pressure Proportioner.

11.4.4.1 The ball drip (automatic-type) drain valves shall be disassembled, cleaned, and reassembled.

11.4.4.2* The foam liquid storage tank shall be drained of foam liquid and flushed.

A.11.4.4.2 Foam concentrates tend to settle out over time. Depending on the specific characteristics of the foam concentrate, sedimentation accumulates in the bottom of the storage vessel. This sediment can affect proportioning and foam concentrate integrity. Some concentrates tend to settle out more rapidly than others. If the annual samples indicate excessive sediment, flushing the tank could be required more frequently.

11.4.4.3 Foam liquid shall be permitted to be salvaged and reused.

11.4.4.4 The foam liquid tank shall be inspected for internal and external corrosion and hydrostatically tested to the specified working pressure.

11.4.5 Bladder Tank Proportioner.

11.4.5.1 Sight glass, where provided, shall be removed and cleaned.

11.4.5.2* The foam concentrate bladder tank shall be hydrostatically tested at system working pressure.

A.11.4.5.2 When hydrostatically testing bladder tanks, the generation of a pressure differential across the diaphragm could cause damage to the diaphragm. Tanks should be filled with agent to no less than the normal fill capacity and air should be vented from inside and outside the bladder before pressurizing.

N **11.4.5.2.1** The hydrostatic test shall not create a pressure differential across the diaphragm.

N **11.4.5.2.2** While under system working pressure, the exterior of the foam concentration bladder tank shall be inspected for leaks.

11.4.6 Line Proportioner.

11.4.6.1 The foam concentrate tank shall be inspected for internal corrosion.

11.4.6.2 Pickup pipes inside the tank shall be inspected for corrosion, separation, or plugging.

11.4.6.3 The foam concentrate tank shall be drained and flushed.

11.4.6.4 Foam concentrate shall be permitted to be salvaged and reused.

11.4.7 Standard Balanced Pressure Proportioner.

11.4.7.1 Pump Operation.

11.4.7.1.1 The foam concentrate pump shall be operated.

11.4.7.1.2 Foam concentrate shall be circulated back to the tank.

11.4.7.2 Servicing. Foam pumps, drive train, and drivers shall be serviced in accordance with the manufacturer's instructions and frequency but not at intervals of more than 5 years.

11.4.7.3 Flushing. The diaphragm balancing valve shall be flushed through the diaphragm section with water or foam concentrate until fluid appears clear or new.

11.4.7.4 Corrosion and Sediment.

11.4.7.4.1 The foam concentrate tank shall be inspected internally for corrosion and sediment.

11.4.7.4.2 Excessive sediment shall require draining and flushing of the tank.

11.4.8 In-Line Balanced Pressure Proportioner.

11.4.8.1 Pump Operation.

11.4.8.1.1 The foam concentrate pump shall be operated.

11.4.8.1.2 Foam concentrate shall be circulated back to the tank.

11.4.8.2 Servicing. Foam pumps, drive train, and drivers shall be serviced in accordance with the manufacturer's instructions and frequency but not at intervals of more than 5 years.

11.4.8.3 Flushing. The diaphragm balancing valve shall be flushed through the diaphragm section with water or foam concentrate until fluid appears clear or new.

11.4.8.4 Corrosion and Sediment.

11.4.8.4.1 The foam concentrate tank shall be inspected internally for corrosion and sediment.

11.4.8.4.2 Excessive sediment shall require draining and flushing of the tank.

11.4.9 Pressure Vacuum Vents. The procedures specified in 11.4.9.1 through 11.4.9.13 shall be performed on pressure vacuum vents every 5 years.

11.4.9.1 The vent shall be removed from the expansion dome.

11.4.9.2 The vent shall be inspected to ensure that the opening is not blocked and that dirt or other foreign objects do not enter the tank.

11.4.9.3 The vent bonnet shall be removed.

11.4.9.4 The vacuum valve and pressure valve shall be lifted out.

11.4.9.5 The vent body shall be flushed internally, and the vacuum valve and the pressure valve shall be washed thoroughly.

11.4.9.6 The vent shall be inspected to ensure that the screen is not clogged, and the use of any hard, pointed objects to clear the screen shall be avoided.

11.4.9.7 If the liquid has become excessively gummy or solidified, the vent body and parts shall be soaked in hot soapy water.

11.4.9.8 The vent body shall be turned upside down and drained thoroughly.

11.4.9.9 Parts shall be dried by placing them in a warm and dry area or by using an air hose.

11.4.9.10 Parts shall be sprayed with a light Teflon® coating, and the vent shall be reassembled.

11.4.9.11 The use of any type of oil for lubrication purposes shall not be permitted.

11.4.9.12 The vent bonnet shall be replaced, and the vent shall be turned upside down slowly a few times to ensure proper freedom of the movable parts.

11.4.9.13 The vent shall be attached to the liquid storage tank expansion dome.

11.5 Component Action Requirements.

Component replacement tables offer guidance for situations when system components are adjusted, repaired, rebuilt, or replaced. It is not necessary to conduct a complete acceptance test for each component when maintenance is performed.

11.5.1 Whenever a component in a foam-water sprinkler system is adjusted, repaired, reconditioned, or replaced, the action required in Table 11.5.1 shall be performed.

Δ ***TABLE 11.5.1*** *Summary of Component Action Requirements*

Component	*Adjust*	*Repair/ Recondition*	*Replace*	*Required Action*
Water Delivery Components				
Discharge devices	X		X	(1) Inspect for leaks at system working pressure (2) Inspect for impairments at orifice
Fire department connections	X	X	X	See Chapter 13
Manual release	X	X	X	(1) Operational test (2) Inspect for leaks at system working pressure (3) Test all alarms
Pipe and fittings on closed-head system	X	X	X	Hydrostatic test in conformance with NFPA 16
Pipe and fittings on open-head system	X	X	X	Operational flow test
Foam Components				
Ball drip (automatic-type) drain valves				See Chapter 13
Bladder tank	X	X	X	Inspect water jacket for presence of foam concentrate
Foam concentrate	X		X	Submit a sample for laboratory analysis for conformance with manufacturer's specifications
Foam concentrate pump				See Chapter 8

(*continues*)

N ***TABLE 11.5.1*** *Continued*

Component	*Adjust*	*Repair/ Recondition*	*Replace*	*Required Action*
Foam concentrate strainer(s)				See Chapter 13
Foam concentrate tank	X	X	X	Inspect for condition; repair as appropriate
Proportioning system(s)	X	X	X	Conduct flow test and inspect proportioning by refractometer test or equivalent
Water supply tank(s)				See Chapter 9
Alarm and Supervisory Components				
Detection system	X	X	X	Operational test for conformance with NFPA 16 and/or *NFPA 72*
Pressure-switch-type waterflow	X	X	X	Operational test using inspector's test connection
Valve supervisory device			X	Test for conformance with NFPA 16 and/or *NFPA 72*
Vane-type waterflow	X	X	X	Operational test using inspector's test connection
Water motor gong			X	Operational test using inspector's test connection
Status-Indicating Components				
Gauges	X		X	Verify at 0 psi (0 bar) and system working pressure; see Chapter 13 regarding calibration
Testing and Maintenance Components				
Auxiliary drains	X	X	X	Inspect for leaks at system working pressure
Inspector's test connection	X	X	X	Inspect for leaks at system working pressure
Main drain	X	X	X	Full-flow main drain test
Structural Components				
Hanger/seismic bracing	X	X	X	Inspect for conformance with NFPA 16 and/or NFPA 13
Pipe stands	X	X	X	Inspect for conformance with NFPA 16 and/or NFPA 13
Informational Components				
General information sign	X	X	X	Inspect for conformance with NFPA 16 and/or NFPA 13
Hydraulic information sign	X	X	X	Inspect for conformance with NFPA 16 and/or NFPA 13
Valve signs	X	X	X	Inspect for conformance with NFPA 16 and/or NFPA 13

11.5.2 Where the original installation standard is different from the cited standard, the use of the appropriate installing standard shall be permitted.

11.5.3 The actions of 11.5.1 and 11.5.2 shall not require a design review, which is outside the scope of this standard.

References Cited in Commentary

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*, 2016 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2019 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection,* 2017 edition.

NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems,* 2019 edition.

NFPA 409, *Standard on Aircraft Hangars,* 2016 edition.

NFPA 750, *Standard on Water Mist Fire Protection Systems,* 2019 edition.

Richardson, L. K. (ed.), *History of Fire Protection Engineering,* 2003.

Foam-Water Operational Test

Purpose

The following procedure is recommended when conducting a full flow operational test of a foam-water deluge system. This procedure will vary slightly based on the equipment installed.

Tools/Equipment

Equipment including a pipette, graduated cylinder, and refractometer are used when conducting this test.

Procedure Steps

Step 1: Inspect the deluge valve.

A. Check the deluge valve, trim piping and valves, and associated riser piping and valves for proper arrangement.

B. Position all system and trim valves properly, including any low-point drains, in accordance with the system installation drawings or the valve schematic.

Step 2: Isolate the foam supply from the deluge system.

A. Shut the tank foam liquid supply valve.

B. Disconnect the electrical service to the foam concentrate pump(s) if applicable, or shut off the water pressure supply to the bladder tank.

Step 3: Check the deluge system for proper operation.

A. Run and test any fire pumps.

B. Open the test valve to trip the deluge valve.

C. Allow water to flow through the system, flushing all piping until the water runs clear.

D. Check for obstructed nozzles.

Step 4: Prepare the system for concentration test.

A. Test detectors.

B. Test manual actuation.

C. Test alarms and auxiliary equipment shutdowns.

Step 5: Return the foam tank and proportioning system to normal condition.

A. If a foam concentrate pump is used, check the oil level and re-energize the power supply to the pump.

B. Inspect the foam tank for proper setup and check the level of foam concentrate.

C. If a bladder tank is used, avoid damage to the bladder tank by carefully opening the water pressure supply to the tank in accordance with the manufacturer's procedures.

D. Set up the remaining proportioning equipment, and open the tank foam liquid supply valve.

Step 6: Make sample foam mixtures.

A. Both the foam concentrate and the water used for the mixtures must be taken from the site supply.

B. Mix in 3.4 fl oz (100 mL) graduated cylinders. If the same cylinder and pipette are used for both samples, clean them thoroughly before each use.

C. For 3 percent mixture, add 3 parts foam concentrate to 97 parts water. For 6 percent mixture, add 6 parts foam concentrate to 94 parts water.

D. Using a pipette, stir each sample until thoroughly mixed.

E. Using the pipette, place a small amount of the 3 percent mixture on the refractometer.

F. Thoroughly clean the refractometer and repeat for the 6 percent mixture.

G. Plot the refractometer reading on the graph. The graph should now include all information except the plot point from the actual system full flow discharge test sample and the end head residual pressure.

Step 7: Prepare the highest, most remote branch line for the end head residual pressure recording.

A. Remove the end head (discharge device) from the highest, most remote branch line.

B. Install ½ in. to ¼ in. (15 mm to 6 mm) adapter, or whatever size is needed.

C. Attach ¼ in. (15 mm) hose to the adapter. A 20 ft (6.1 m) hose is recommended unless a longer one is necessary.

D. Attach a pressure gauge with a 0–250 psi (0–17 bar) range and a valve to the end of the hose.

E. The valve will be used to take a foam sample and will then be shut to record the residual pressure.

Step 8: Prepare to perform the operational test of the system.

A. Using the system installation drawings and hydraulic calculations, determine the pressure required at the highest, most remote discharge outlet. Record this pressure on the test graph in the appropriate place.

B. Check fire pump(s), foam tank, foam concentrate piping, and proportioning system, to make sure all components are set up in normal mode.

C. Check all system valves to make sure they are in the normally open or normally closed position, as appropriate for the system discharge test.

D. Prepare the area for the full flow operational test.

E. Coordinate the efforts of the testing personnel before the test begins, to minimize the amount of time the system discharges.

F. Notify all testing and witnessing personnel that the test is about to begin.

Step 9: Trip the system and record the results.

A. Manually trip the system using the manual pull station at the deluge valve.

B. Allow the system to flow long enough for the discharge from the nozzles to stabilize before checking spray patterns and taking foam-water samples.

C. Visually inspect nozzles for proper discharge. Note any deficiencies.

D. Take three foam-water samples as follows: one from the valve attached to the highest, most remote discharge outlet (see Step 7E), and two from the foam blanket.

E. Shut off the valve attached to the highest, most remote discharge outlet.

F. Take residual pressure readings at the system deluge valve and at the gauge installed at the highest, most remote discharge outlet.

Step 10: Begin system shutdown procedures.

A. Shut off the foam supply. Allow only water to flow through the system until the system is flushed clear.

B. Shut the water supply valve to the deluge system.

C. Open system drains.

Step 11: Determine foam concentrate levels from the samples taken during the test.

A. Use the pipette to apply a drop of foam-water sample #1 to the refractometer, then take reading #1.

B. Clean the pipette and refractometer after each reading, and follow this procedure for foam-water samples #2 and #3.

C. Plot the single best result from the three foam-water samples on the graph.

D. Adjust the pressure recorded from the gauge connected to the end of the hose to that from the highest, most remote discharge outlet by determining the head pressure caused by the elevation difference between the gauge and the branch line fitting and subtracting it from the gauge reading.

For example, if the gauge at the end of the hose is 15 ft (4.57 m) below the branch line fitting, the pressure difference caused by elevation is calculated as follows:

$$P_e = 15 \times 0.433 \text{ psi} \qquad (P_e = 4.57 \times 0.0978 \text{ bar})$$

$$P_e = 6.5 \text{ psi} \qquad (P_e = 0.45 \text{ bar})$$

Subtracting the head pressure [6.5 psi (0.45 bar)] from the pressure recorded at the gauge at the end of the hose will provide the actual pressure at the highest, most remote discharge outlet. Record this pressure in the appropriate place on the graph.

Evaluation of Results

Analyze the test results against those from previous tests and the installation requirements. Where the results of this test do not compare favorably to previous tests, system modifications might be necessary.

The procedure(s) outlined above is not mandated by NFPA 25 and represents only one approach to conducting this test.

Solution Concentration Testing

Purpose

The purpose of this test is to identify foam concentrate levels. The two methods shown below — the *refractometric* and *conductivity* methods — are used to determine the required foam concentration levels.

Refractometric Method

The *refractometric method* uses a prism that has a much greater refractive index than the sample solution to be measured. Measurements are made at the interface of the prism and the sample solution. For a weak (low-concentration) solution, the difference between the refractive index of the prism and that of the solution is high. For a strong (high-concentration) solution, the difference between the refractive index of the prism and that of the sample is smaller. The following is a sample test procedure for foam concentration determination.

The foam solution concentration determination test is used to determine the percent concentration of a foam concentrate in the water being used to generate foam. It is typically used as a means of determining the accuracy of a system's proportioning equipment. If the level of foam concentrate injection varies widely from that of the design, it may abnormally influence the expansion and drainage foam quality values; this may, in turn, affect the foam's fire performance.

A handheld refractometer is used to measure the refractive index of the foam solution samples. This method is not particularly accurate for aqueous film-forming foam (AFFF) concentrate or alcohol-resistant AFFFs, since they typically exhibit very low refractive index readings. For this reason, the conductivity method might be preferred where these products are used.

A detailed procedure illustrating the use of the refractive index method, as found in Annex B of NFPA 16, follows.

Tools/Equipment

Prepare a base (calibration) curve using the following apparatus:

- Four 3.4 fl oz (100 mL) or larger plastic bottles with caps
- One measuring pipette [0.34 fl oz (10 mL)] or syringe [0.34 fl oz (10 mL)]
- One 3.4 fl oz (100 mL) or larger graduated cylinder
- Three plastic-coated magnetic stirring bars
- One handheld refractometer — American Optical Model 10400 or 10441, Atago #N1, or equivalent
- Standard graph paper
- Ruler or other straightedge

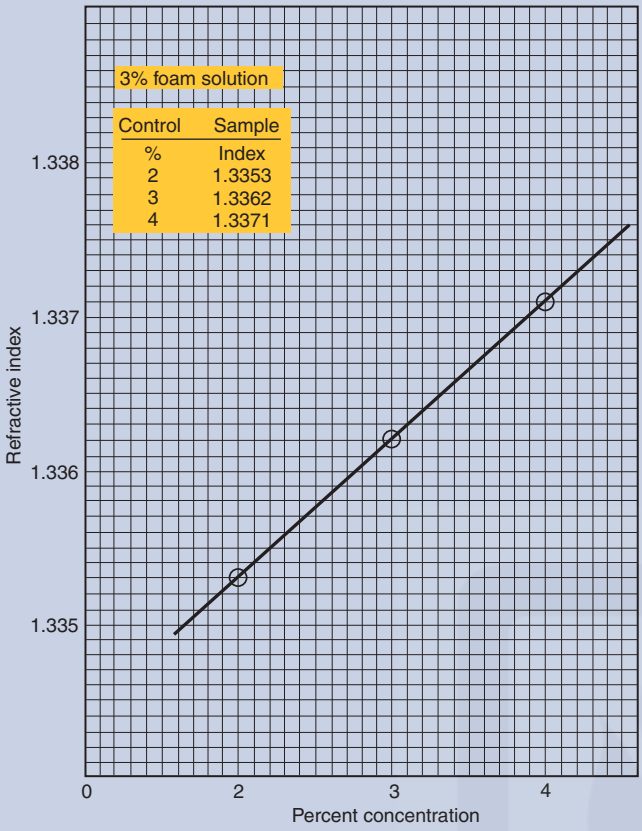
Procedures

1. Using water and foam concentrate from the system to be tested, make up three standard solutions using the 3.4 fl oz (100 mL) or larger graduated cylinders. These samples should include the nominal intended percentage of injection, the nominal percentage plus 1 percent, and the nominal percentage minus 1 percent.
2. Place the water in the graduated cylinders (leaving adequate space for the foam concentrate), and then carefully measure the foam concentrate samples into the water using the pipette or syringe. Use care not to pick up air in the foam concentrate samples.
3. Pour each measured foam solution from the graduated cylinder into a 3.4 fl oz (100 mL) or larger plastic bottle. Each bottle should be marked with the percent solution it contains. Add a plastic stirring bar to the bottle, cap it, and shake it thoroughly to mix the foam solution.
4. After thoroughly mixing the foam solution samples, take a refractive index reading of each sample. To do this, place a few drops of the solution on the refractometer prism, close the cover plate, and observe the scale reading at the dark field intersection. Since the refractometer is temperature compensated, it might take 10 to 20 seconds for the sample to be read properly. It is important to take all refractometer readings at ambient temperatures of 50°F (10°C) or above.
5. Using standard graph paper, plot the refractive index readings on one axis and the percent concentration readings on the other (see Testing Procedure Exhibit 11.3). This plotted curve will serve as the known baseline for the test series.
6. Set the solution samples aside in the event the measurements need to be checked.
7. *Sampling.* Collect foam solution samples from the proportioning system, being careful to ensure that the samples are taken at an adequate distance downstream of the proportioner being tested.

Evaluation of Results

Take refractive index readings of the sample and compare them to the plotted curve to determine the percentage of the samples. Testing Procedure Exhibit 11.1 shows a typical graph of refractive index versus foam concentrate.

Both the conductivity and refractometric methods of measuring foam concentrate involve comparing foam solution test samples to premeasured solutions that are plotted on a baseline graph of percent.



TESTING PROCEDURE EXHIBIT 11.1 *Typical Graph of Refractive Index Versus Foam Concentration. (Source: NFPA 11, 2016, Figure D.2.1.1.2)*

Conductivity Method

The conductivity method uses a conductivity meter (as shown in Testing Procedure Exhibit 11.2), which evaluates changes in electrical conductivity as foam concentrate is added to water.

The conductivity method is accurate for measuring foam concentrate percentage, provided there are substantial changes in conductivity, as foam concentrate is added to the water in relatively low percentages. Because it is highly conductive, the use of salt or brackish water might not be suitable for this method, due to small conductivity changes as foam concentrate is added. It will be necessary to make foam and water solutions in advance to determine if adequate changes in conductivity can be detected if the water source is salty or brackish.

A detailed procedure illustrating the use of the conductivity method, as found in Annex D of NFPA 11, follows.



TESTING PROCEDURE EXHIBIT 11.2 *Equipment Needed for Conductivity Method of Proportioning Measurement. (Source: NFPA 11, 2016, Figure D.2.1.2)*

Tools/Equipment

Prepare a base (calibration) curve using the following apparatus:

- Four 3.4 fl oz (100 mL) or larger plastic bottles with caps
- One measuring pipette [0.34 fl oz (10 mL)] or syringe [0.34 fl oz (10 mL)]
- One 3.4 fl oz (100 mL) or larger graduated cylinder
- Three plastic-coated magnetic stirring bars
- A portable, temperature-compensated conductivity meter — Omega Model CDH-70, VWR Scientific Model 23198-014, or equivalent
- Standard graph paper
- Ruler or other straight edge

Testing Procedure Exhibit 11.2 shows the equipment needed for using the conductivity method.

Procedure Steps

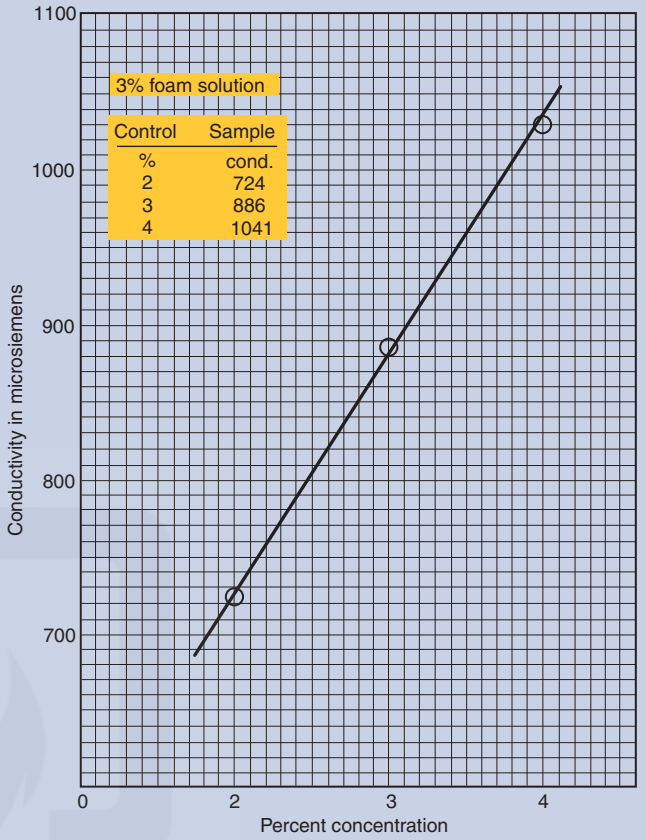
1. Using water and foam concentrate from the system to be tested, make up three standard solutions using the 3.4 fl oz (100 mL) or larger graduated cylinders. These samples should include the nominal intended percentage of injection, the nominal percentage plus 1 percent, and the nominal percentage minus 1 percent.
2. Place the water in the graduated cylinders (leaving adequate space for the foam concentrate), and then carefully measure the foam concentrate samples into the water using the pipette or syringe. Use care not to pick up air in the foam concentrate samples.

Solution Concentration Testing (*Continued*)

3. Pour each measured foam solution from the graduated cylinder into a 3.4 fl oz (100 mL) or larger plastic bottle. Each bottle should be marked with the percent solution it contains. Add a plastic stirring bar to the bottle, cap it, and shake it thoroughly to mix the foam solution.
4. After making the three foam solutions in this manner, measure the conductivity of each. Refer to the instructions that came with the conductivity meter to determine proper procedures for taking readings. It will be necessary to switch the meter to the correct conductivity range setting to obtain a proper reading.
5. Most synthetic-based foams used with fresh water result in foam solution conductivity readings of less than 2000 microsiemens. Protein-based foams in fresh water solutions generally produce conductivity readings in excess of 2000 microsiemens. Due to the temperature compensation feature of the conductivity meter, it may take a short time to obtain a consistent reading.
6. Once the solution samples have been measured and recorded, set the bottles aside for control sample reference. The conductivity readings then should be plotted on the graph paper (see Testing Procedure Exhibit 11.3). It is most convenient to place the foam solution percentage on the horizontal axis and the conductivity readings on the vertical axis.
7. Use a ruler or straightedge to draw a line that approximates connecting all three points. Although it might not be possible to hit all three points with a straight line, they should be very close. If not, repeat the conductivity measurements and, if necessary, make new control sample solutions until all three points plot in a nearly straight line. This plot will serve as the known base (calibration) curve to be used for the test series.
8. *Sampling.* Collect foam solution samples from the proportioning system, being careful to ensure that the samples are taken at an adequate distance downstream of the proportioner being tested. Using foam solution samples that are allowed to drain from expanded foam is not recommended, because doing so may produce misleading conductivity readings.

Evaluation of Results

Once one or more samples have been collected, read the conductivity of each. Then, find the corresponding percentage from the base curve prepared from the control sample solutions. Testing Procedure Exhibit 11.3 shows a typical graph of conductivity versus foam concentration.



TESTING PROCEDURE EXHIBIT 11.3 *Typical Graph of Conductivity Versus Foam Concentration. (Source: NFPA 11, 2016, Figure D.2.1.2.2)*

Both the conductivity and refractometric methods of measuring foam concentrate involve comparing foam solution test samples to premeasured solutions that are plotted on a baseline graph of percent.

References

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*, 2016 edition.

NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*, 2019 edition.

The procedure(s) outlined above is not mandated by NFPA 25 and represents only one approach to conducting this test.

NFPA



Courtesy of FOGTEC® Fire Protection

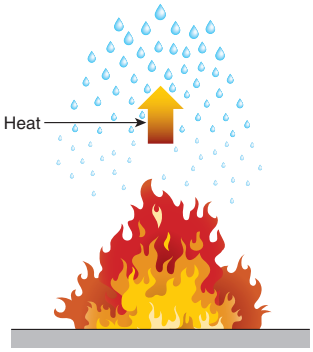
What Is a Water Mist Fire Protection System?

A water mist fire protection system utilizes fine water droplets to control, suppress, or extinguish fires through heat extraction, oxygen displacement, and blocking of radiant heat. Due to the smaller droplet sizes, water mist systems utilize a lower volume of water at a higher pressure.

How Does a Water Mist Fire Protection System Work?

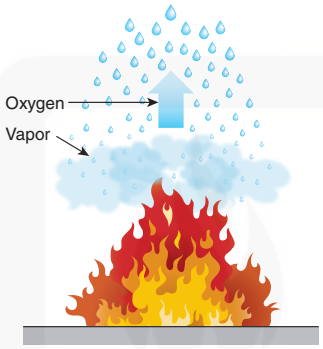
Heat Extraction (Cooling)

Reducing the drop size increases the surface area of the water mass and increases the rate of heat transfer. This allows for a greater cooling of the fire and surrounding area with less water.



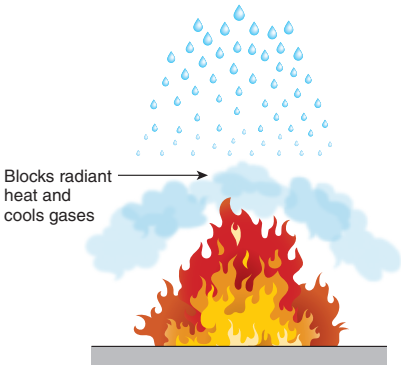
Oxygen Displacement

When heated, the water droplets expand to approximately 1900 times their size when evaporated. This large volume of generated steam displaces the oxygen that is needed by the fire for combustion.



Blocking Radiant Heat

The water droplets within the air reduces the amount of radiant energy that can transfer from the flame, which reduces the spread of the fire.



Where Is Water Mist Fire Protection Used?

Water mist can be used in many applications, including machinery spaces, turbine enclosures, marine applications (including public spaces and service areas), hotels, heritage buildings, galleries, electrical equipment rooms, computer rooms, and tunnels.

How Is the Water Mist Created?

There are three basic principles to the generation of water mist.

Impingement

Impingement nozzles utilizes a solid jet of water striking a deflector and breaking up into small drops. These water mist nozzles look similar to a typical sprinkler, but use smaller orifice sizes and higher pressures to create smaller droplet sizes.



Used with permission of Johnson Controls

Pressure Jet

Pressure jet nozzles work by pushing a jet of water through a small orifice at a high velocity with high pressure water.



Used with permission of UTC Climate, Controls & Security

Twin Fluid

Twin fluid nozzles utilize compressed gas with water or steam to shear the water into fine droplets.



Courtesy of Victaulic

Operating Pressures

Water mist systems operate at pressures that are higher than most other fire protection systems. Low pressure water mist systems operate at pressures of 175 psi (12 bar) or less, intermediate-pressure systems operate at pressures greater than 175 psi (12 bar) and less than 500 psi (34 bar), and high-pressure systems operate at pressures of 500 psi (34 bar) or greater.

What Types of Water Supplies Do Water Mist Systems Have?

Because of the increased pressure, water mist systems utilize positive displacement pumps or a combination of compressed gas cylinders and high pressure water cylinders as a water supply.



Used with permission of UTC Climate, Controls & Security



Used with permission of UTC Climate, Controls & Security



Used with permission of Johnson Controls



Used with permission of Johnson Controls

ITM

Water mist systems can contain components from gaseous agent extinguishment systems such as compressed gas cylinders, pressure regulators, and pneumatic control valves as well as high pressure piping and positive displacement pumps. Many inspectors familiar with the inspection, testing, and maintenance (ITM) of fire pumps and sprinkler systems may be unfamiliar with some of the hardware used.

For more information refer to NFPA 750, *Standard on Water Mist Fire Protection Systems.*

NFPA



12

WATER MIST SYSTEMS

Chapter 12 covers the inspection, testing, and maintenance (ITM) of water mist systems. These systems, which are simple when compared to today's complex water-based fire protection systems, were first used to protect ferries in the 1940s. Today, water mist systems are used widely in the marine sector as alternatives to sprinkler systems on passenger cruise ships. Water mist systems are also increasingly used in special hazards and equipment protection, such as for turbines, generators, industrial deep fat frying equipment, cleanroom production tools, and mobile mining equipment. They are also being installed for protection in historic buildings and computer rooms (i.e., for subfloor protection). Some are also approved for use to protect light hazard occupancies. As with any fire protection system, water mist systems require reliable, competent ITM to ensure they will perform properly if a fire occurs.

FAQ What is involved in inspecting a water mist system?

The term *inspection* is defined in Chapter 3. When inspecting a component, a qualified individual visually examines it to ascertain whether it appears to be in its normal operating state and is undamaged.

Testing involves the actual operation of devices and is more involved than simply inspecting components. There are different levels of testing. Some components are tested without involving other components in the system. For example, a fire pump can be started to confirm that electric power or diesel fuel is available and that starting switches work. There are other tests, however, that cannot be performed without involving most elements of the system. Testing a pressure regulating valve or an automatic sectional control valve, for example, may require releasing compressed gas cylinders or flowing water into overhead piping.

The manufacturer of a water mist system must produce a design, installation, operation, and maintenance (DIOM) manual as part of the listing or approval documentation for the system. The DIOM manual contains specific ITM instructions for specialized or proprietary components or system features, which must be followed in addition to the requirements of this chapter. A copy of the manufacturer's DIOM manual must be provided to the user upon completion of the installation per 13.4.3 of NFPA 750, *Standard on Water Mist Fire Protection Systems*. The DIOM manual is required to provide enough information to allow the user or a third party to verify that the system has been designed and installed properly.

Tip for Owners

The requirements for ITM of water mist systems in NFPA 25 must be supplemented by the specific requirements contained in each design, installation, operation, and maintenance (DIOM) manual. A DIOM manual is required for all listed or approved water mist system equipment and should be readily available for reference.

FAQ What qualifications are needed to service a water mist system?

Extensive expertise is required to service any water mist system, since it involves testing and maintaining the system components, as well as draining the system, replacing gas cylinders, and putting the system back in operating order. The owner or occupant might employ a specialized contractor with the necessary training and experience to carry out the inspections. The ITM service contractor should provide certificates issued by the water mist system manufacturer confirming the training of the employees/inspectors who will inspect, test, or provide maintenance on a water mist system.

FAQ Can water mist systems use the same components as a sprinkler system?

Water mist systems use different components and fire control concepts from the more commonly known water-based fire protection systems that comply with NFPA 13, *Standard for the Installation of Sprinkler Systems.* Some system configurations involve components borrowed from gaseous agent extinguishing systems, such as compressed gas cylinders, pressure regulators, and pneumatic control valves. Others use positive displacement pumps and high pressure piping or tubing not previously used in fire protection. Many inspectors familiar with the ITM of fire pumps, sprinkler systems, and water spray or foam-deluge systems will be unfamiliar with some of the hardware used in a water mist system. Similarly, inspectors familiar with gaseous clean agent systems might not be familiar with pumps, controllers, filters, and water storage equipment.

The design and performance criteria of a water mist system are also different from those of a typical sprinkler system. NFPA 750 is founded on the premise of performance-based design and mandates that the application density for each type of water mist system be individually determined. This determination is required to be completed by fire testing to a comprehensive, unbiased fire test protocol. Unlike NFPA 13, which dictates that all pumps, pipes, fittings, and components be of a certain type and pressure rating, NFPA 750 allows for a range of pressure arrangements, power sources, and component technologies. Some water mist systems exceed an operating pressure of more than 500 psi (34.5 bar). Thus, NFPA 750 establishes only general design factors applicable to all water mist systems, such as hydraulic calculation procedures, acceptance testing, water quality, and duration of protection, as well as only generic requirements, such as those needed for corrosion control and mechanical strength.

Guidance is provided for testing agencies on characteristics of an adequate fire test protocol but relies on the manufacturers and the listing or approval agencies for details that might be unique to a particular technology or manufacturer. Special training by the manufacturer's representative is often necessary, especially where proprietary differences exist between water mist systems developed by different manufacturers.

Tip for Owners

Relevant plant operations personnel should be informed of any temporary shutdowns. Where such interlocks exist, the owner should ensure that the service contractor is familiar with the entire integrated system and associated interlocks before beginning system testing or maintenance. It should be verified that the temporary shutdown of the water mist system or associated interlocks will not inadvertently interrupt important site operations.

12.1 General.

12.1.1 Minimum Requirements.

Some of the components of water mist systems are similar to those of other water-based extinguishing systems, such as ancillary fire and smoke detection and activation systems. Detection and activation systems are addressed by *NFPA 72®, National Fire Alarm and Signaling Code®*. All other components specific to water mist systems — such as special pump assemblies, gas cylinders, control valves, nozzles, pipe and stainless steel tubing, hangers, supports, strainers and filters, and manual releases — are addressed in specific paragraphs in this chapter.

12.1.1.1 This chapter shall provide the minimum requirements for the routine inspection, testing, and maintenance of water mist systems only.

A water mist system can be interlocked with other mechanical systems such as automatic door closers, emergency power shutdown, stopping or starting of ventilation fans, opening or closing of automatic fire dampers, stopping of production lines, or other ancillary actions integrated in a cause and effect protocol. In these cases, interlocked systems might need to be shut down temporarily for testing. The person conducting the inspection and testing of the water mist system may not be trained in individual building systems such as those mentioned above. It is often necessary to coordinate not only the shutting down of these systems, but just as importantly, their proper return to service with someone who is adequately trained and familiar with their operation.

ITM Deficiency, Impairment, or Hazard Evaluation?

ANSWER: ITM Deficiency

Water tanks for water mist systems are to be inspected weekly or monthly for the proper water level, and all valves and appurtenances are to be inspected semiannually as required by Table 12.1.2. The relief valve on this hydropneumatic tank was found to have a plug installed that will not allow the valve to operate to perform its intended function as required by 12.1.1.1. This valve is required by NFPA 750 as a safety device to relieve excess pressure.

The purpose of an inspection is to verify that the items being inspected appear in operating condition and are free of physical damage. In this case, the relief valve is not in operating condition, and this finding should be considered a critical deficiency. Although this condition will probably not have a material effect on the ability of the system to function as intended in a fire event, excess pressure in the tank could cause a failure of the tank, or the components connected to the tank, and presents a possible safety hazard to personnel.



(Courtesy of Zachary Magnone and Tyco Fire Protection Products)

Δ **12.1.1.2** Table 12.1.1.2 shall be used to determine the minimum required infrequencies for inspection, testing, and maintenance.

Some water mist systems have used aqueous film-forming foam (AFFF) as an additive to increase suppression capabilities. Such additives have been used for bilge area and large mobile mining equipment systems. AFFF additives are particularly suited for semi-enclosed equipment and areas. The AFFF solution storage and injection system typically is supplied by pressurized nitrogen gas, and special valves must open in order to propel the foam solution into the water stream. The requirement in 12.1.1.2 recognizes that the additive feed line is an essential part of the system and must be included in any functional or operational tests. The actual additive, not a substitute, must be used. The testing must confirm that the correct quantity of additive is injected at the correct rate.

Details of the intended operation of all elements of the system, including the additive injection system, are described in the "written sequence of operations" specified in 13.4.5 of NFPA 750. This written description is required by NFPA 750 to be submitted with the system documentation.

N ***TABLE 12.1.1.2*** *Summary of Water Mist System Inspection, Testing, and Maintenance*

Item	*Frequency*	*Reference*
Inspection		
Additive storage cylinders	Quarterly/semiannually	12.2.7
Air compressors and receivers		Chapter 13
Backflow preventers		Chapter 13
Compressed gas storage cylinders, hoses, support, and restraint	Quarterly/annually/every 5 years	12.2.5.1.1, 12.2.5.2, 12.2.5.3, 12.2.5.9
Compressed gas storage cylinder valve and pressure	Semiannually/annually	12.2.5.4, 12.2.5.4.1, 12.2.5.4.2, 12.2.5.8
Control equipment		*NFPA 72*
Detection systems		*NFPA 72*
Enclosure features, interlocks	Semiannually	12.2.11
Fire pump system		Chapter 8
Gauges (piping system)		Chapter 13
Hangers, braces, and supports	Annually and after each system discharge or activation	12.2.4
Internal piping conditions		Chapter 14
Nozzles	Annually and after each system discharge or activation	12.2.1
Pneumatically operated valves and tubing	Semiannually	12.2.6
Pneumatically operated standby pumps	Monthly	12.2.9
Strainers and filters	After each system discharge or activation	12.2.2
System control valves		Chapter 13
System piping, tubing, and fittings	Annually and after each system discharge or activation	12.2.3
Water recirculation tanks	Monthly/quarterly/annually	12.2.8
Water storage cylinders (high pressure)	Quarterly/semiannually/annually	12.2.5.1.2, 12.2.5.4, 12.2.5.4.3, 12.2.5.5, 12.2.5.6, 12.2.5.7, 12.2.5.8
Water storage tanks		Chapter 9
Water supply	Quarterly/annually	12.2.10
Testing		
Additives and injection system	Annually	12.3.4, 12.3.5
Air compressors and receivers	Annually	Chapter 13
Backflow preventers		Chapter 13
Compressed gas storage cylinder	5–12 years	12.3.6
Control equipment		12.3.7
Detection systems		12.3.8
Fire pump system		Chapter 8, 12.3.9
Gauges (piping system)		Chapter 13
Hoses	5 years	12.3.10
Interlocks	Annually	12.3.11
Nozzles, automatic	At 10 years and every 5 years thereafter	12.3.1.2
Nozzles, automatic (harsh environments)	At 5 years and every 5 years thereafter	12.3.1.3
Nozzles, open	At 10 years and every 5 years thereafter	12.3.2.3
Nozzles, open (harsh environments)	Annually	12.3.2.2
Pneumatic valves	Semiannually	12.3.12
Pneumatic valve solenoid releases	Annually	12.3.13
Pneumatically operated standby pumps	Annually	12.3.14
Strainers and filters	Annually	12.3.3
System control valves	Annually	12.3.15

(continues)

N **TABLE 12.1.1.2** *Continued*

Item	*Frequency*	*Reference*
Water mist system	Annually	12.3.16
Water recirculation tanks	Annually	12.3.17
Water storage cylinders (high pressure)	5–12 years	12.3.18
Water storage tanks		12.3.19
Water supply	Annually	12.3.20
Maintenance		
Air compressors and receivers		Chapter 13
Backflow preventers		Chapter 13
Control equipment		*NFPA 72*
Detection systems		*NFPA 72*
Fire pump system		Chapter 8
Pneumatically operated standby pumps	Every 5 years	12.4.3
Strainers and filters	Annually and after each system discharge	12.2.2
Water mist system	Annually	12.4.1
Water tanks	Annually	12.4.1

Table 12.1.2 is a detailed list of the types of components that might be included in water mist systems. Not all of the components listed are found in every water mist system. The table indicates the number of times per year each component should be inspected or tested to the degree indicated. The manufacturer's DIOM manual must be consulted to determine if more frequent inspection or testing is recommended.

In this commentary, each grouping of components in Table 12.1.2 is followed by additional explanatory information. Schematic diagrams in Exhibit 12.4 through Exhibit 12.6 illustrate different types of components and arrangements typically encountered in water mist systems.

The inspection service provider is directed to Chapter 12 of NFPA 750, which provides details on functionality testing of water mist systems. The requirement in 14.2.5 of NFPA 750 describes preliminary functional tests to be performed to confirm that detection devices, supervisory devices, automatic and manual releasing devices, and pneumatic and hydraulic components are functional. Auxiliary functions such as alarm functions, remote annunciators, air handling shutdown, and power shutdown are checked for operation in accordance with the system requirements. Depending on the nature of the repair that was performed to remediate the deficiency or impairment, some or all of the functional and operational tests of the system should be performed.

Minor deficiencies can be repaired by the owner or owner's representative if qualified. Repairs requiring specialized knowledge of the components should be undertaken only by a qualified contractor, service provider, or the manufacturer's representative.

The following commentary is divided into sections with titles corresponding to the related requirements in Table 12.1.2.

Water Supply. A reliable water source is essential for any water-based fire protection system. Chapter 12 of NFPA 750 requires that the water supply be capable of supplying, for a specified duration, the largest single hazard or group of hazards to be protected simultaneously. An annual waterflow test is required to confirm flow rate and pressure. Where the water supply is taken from a reliable large system, testing for "quantity" may not be required, but where it is taken from a potentially limited source such as a tank, the quantity of water available should be checked. The quantity available must be sufficient to meet the design flow rate for the specified duration of protection. The basic requirement in NFPA 750 is for

Tip for Owners

It might be necessary to coordinate the annual ITM tasks for the water mist system with another activity that requires system shutdown, so that access can be gained to protected spaces for inspection of the piping and nozzles. For example, it is not normally possible to enter a turbine enclosure while it is running, but if it is shut down for routine maintenance, an inspection of the water mist system could be scheduled at the same time to minimize disruption.

a 30-minute duration of protection. That duration might be relaxed for pre-engineered systems.

If the minimum duration intended for the system is less than 30 minutes, this specification should be identified on the "system design information sign" required in 13.4.4 of NFPA 750 or in other system documentation. The intent is to ensure that all pertinent design information be displayed on the sign. If the design duration of protection is not indicated on the sign, the as-built design documents and acceptance test forms should be consulted.

The water supply must be taken from a source that is equivalent in quality to potable water, with respect to bacteria, particulates, and dissolved solids, or from a source of natural seawater. Marine vessels can use natural seawater after the potable water supply has been depleted. As vessels enter waters of different quality in different ports, however, bacteria-free and silt-free seawater is not always available. In some cases, the high chloride content of seawater would be damaging to stainless steel components; also, switching to seawater would shorten the service life of such piping systems, so this step is not always recommended.

Water Storage Tanks. When maintaining water storage tanks, the owner or the designated representative should be concerned primarily with confirming the following issues about the tank:

1. It contains the correct quantity of water.
2. The water quality is acceptable.
3. The discharge valves are open.

It is also important to confirm that the ambient temperature at the tank location is within the acceptable range of 40°F to 130°F (4°C to 54°C) and that there are no signs of leakage or corrosion.

For water storage tanks that are not supervised by means of a low water level switch connected to an alarm panel, the water level in the tank must be verified visually on a weekly basis. A sight glass or other means of quickly verifying the water level in a tank is required. If a tank is supervised by low water level switches connected to an alarm panel, a quarterly inspection will suffice.

Even if the quality of the source water used to fill a tank is shown to be adequate, the quality of stored water must be carefully monitored. The task list in Table 12.1.2 for storage tanks indicates that the tank's water quality should be checked annually. As indicated previously for the water source, at a minimum, a semiannual check should be made during the first year. It is not advisable to wait for 1 full year to evaluate whether the quality of the water in the storage tank is deteriorating. The two greatest concerns with respect to quality of stored water are bacteria and algae growth. Algae will plug screens and small nozzle orifices; bacteria such as *Legionella* can cause illness.

A visual check for algae growth and discoloration might be enough to identify the presence of fouling substances. However, where people could be exposed to the water mist taken from stored water, it is advisable to send water samples to a laboratory to test for *Legionella* and *E. coli* bacteria. *Legionella* bacteria have been identified in some water storage tanks for water mist systems, and ultraviolet (UV) antibacterial systems have been installed as a remedial measure. Efficient UV devices can be installed inside each storage tank, which eliminates the need for re-circulation piping. If present, ancillary devices associated with the tank must be included in the ITM task list.

Paragraph 12.5.1.5.3 of NFPA 750 requires that a filter or strainer be supplied downstream (on the system side) of any water storage reservoir or break tank with an air–water interface greater than 11 ft^2 (1 m^2). For a circular tank, this interface corresponds to a tank diameter of approximately 4 ft (1.2 m). (See Exhibit 12.4.) The objective of the strainer is to remove any algae that might grow in the tank before it enters the water mist system piping. The intent of NFPA 750 is to protect tanks with a "large" air–water interface. Listed water mist

systems currently on the market that use a water tank ensure that the water going into the tank is filtered. However, if algae grow in the water once the water is inside the tank, fibrous material will clog valves and nozzles in the water mist system if discharged. Notwithstanding the limit in NFPA 750, the potential exists for algae growth in stored water in tanks of diameters less than 4 ft (1.2 m).

An inspector should check for the presence of algae in stored water. A sample of water — approximately 1 qt (1 L) — should be removed via the tank clean-out access and examined under good lighting for the presence of algae. A water sample should be sent to a laboratory for bacterial analysis and turbidity and chloride tests.

As indicated under preventive maintenance, once per year, the tank must be completely emptied, cleaned, inspected for corrosion, and refilled with filtered water.

Plant Air, Compressors, and Receivers. Systems that use plant air tend to be small systems, such as a twin-fluid system for wet benches or fume hood protection. Generally, it is preferable to have a dedicated air supply for these systems, which can be better controlled than a compressed gas system serving other purposes. It is difficult for a fire protection ITM service provider to have access to test plant air compressors. The full capacity of the plant supply will have been verified during the original system acceptance tests. The plant supply should be inspected annually to confirm that assumptions about the plant capacity are still valid (e.g., that there are no new demands or operational constraints). A means should be devised for confirming the capacity of the air supply at the point of connection to the water mist system.

System Control Valves. As on any water-based fire protection system, all primary control valves must be supervised. Valves identified with tag number 10 in Exhibit 12.6 are lever-handled ball valves. They can be visually determined to be "open" and can be supervised by using a standard tamper switch arranged to indicate a movement of the lever handle.

Zone control valves operate in a manner similar to deluge valves on sprinkler and water spray systems. On high pressure systems, zone control valves are specially designed to be able to hold back high pressure water but open the control valve with a small solenoid valve typical of standard deluge systems, such as a 1 amp maximum draw. See valves identified with tag number 11 in Exhibit 12.6. Special steps are required to ensure that such valves are properly set to be released upon a signal from the releasing panel. During the annual inspection and testing, all solenoid valves and zone control valves must be tested to ensure that they operate properly.

It is particularly important to test the sectional control valves used in large water mist systems. These valves are electrically activated. They might be non-indicating, and it might not be clear how to open them manually. Even during a trip test, it is not possible to tell by visual inspection whether they are fully or partially open.

On the high pressure systems, friction loss through sectional control valves can be very high. To limit friction losses within reasonable bounds, the total flow to a system might be divided among two or more sectional valves. This introduces the possibility that one of the valves in the group could fail to open, and the hydraulic performance of the system could be adversely affected. The only way to test sectional control valves is to open them under full pressure and flow water. In facilities where a full flow test can be conducted annually, the performance of sectional valves can be easily tested. If it is not possible to do a full system discharge, an alternative means of testing the functionality of the valves must be found. It might be necessary to install a test line on each individual zone in a water mist system, downstream of (on the system side of) each sectional control valve so that the valve can be tested.

12.1.2 Common Components and Valves. Where inspection, testing, and maintenance criteria for common components and valves are not specified in Chapter 12, the requirements of Chapter 13 shall apply.

N 12.1.3 Impairments. The procedures outlined in Chapter 15 shall be followed where an impairment to protection occurs.

N 12.1.4 Hose Connections. Hose connections shall be inspected, tested, and maintained in accordance with Chapters 6 and 13.

N 12.2 Inspection.

N 12.2.1 Water Mist Nozzles.

12.2.1.1 Water mist nozzles shall be inspected from the floor level annually.

Exhibit 12.1 through Exhibit 12.3 illustrate several different styles of nozzles that might be used on water mist systems.

12.2.1.1.1 Any water mist nozzle that shows signs of any of the following shall be replaced:

(1) Leakage
(2) Corrosion
(3) Physical damage
(4) Loss of fluid in the glass bulb heat responsive element
(5) *Loading

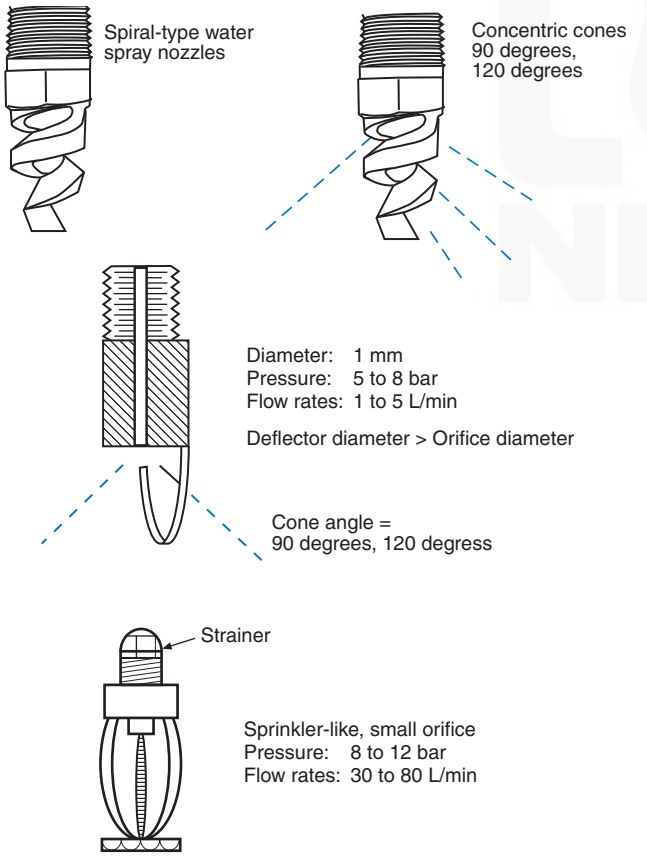


EXHIBIT 12.1 *Several Types of Impingement Nozzles for Fine Sprays. (Source: Fire Protection Handbook, 2008, Figure 16.8.12)*

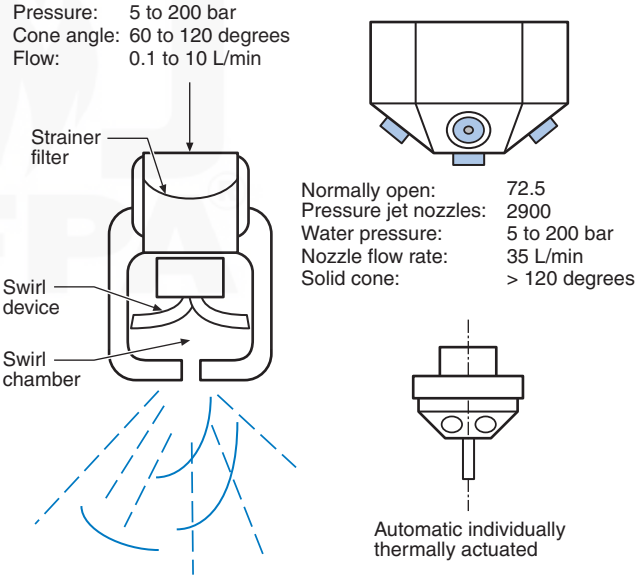


EXHIBIT 12.2 *Pressure Jet Nozzles. (Source: Fire Protection Handbook, 2008, Figure 16.8.13)*

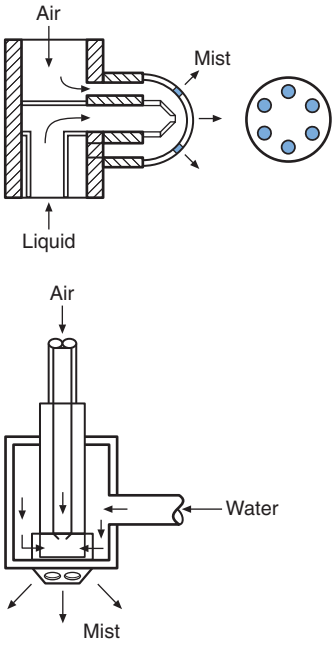


EXHIBIT 12.3 *Two Designs for Twin-Fluid Nozzles. (Source: Fire Protection Handbook, 2008, Figure 16.8.14)*

A.12.2.1.1.1(5) In lieu of replacing water mist nozzles that are loaded with a coating of dust, it is permitted to clean the nozzles with compressed air or by a vacuum provided that the equipment does not touch the nozzle.

(6) Painting, unless painted by the water mist nozzle manufacturer

ITM Deficiency, Impairment, or Hazard Evaluation?

ANSWER: ITM Deficiency and Possible Impairment

Compressed gas cylinders for water mist systems are to be inspected monthly (if unsupervised) or semiannually (if supervised) for proper cylinder pressure as required by Table 12.1.1.2. The gauge shown in this photo indicates there is no pressure in the cylinder. Compressed gas cylinders can be used to pressurize a self-contained water source, such as a tank or water cylinders, or can be used as an atomizing media to create the mist that is common in twin fluid systems.

Based on the number of compressed gas cylinders on the system, this finding could be considered either a critical deficiency or an impairment. If this is one of multiple cylinders and the others have the required pressure as indicated on the gauge, this could be considered a critical deficiency because the system will still function in a fire event. The lack of pressure from this one cylinder will adversely impact the system performance by lowering the duration time of the discharge, by lowering the discharge pressure, or both. However, if this is the only compressed gas cylinder for the system, then the system should be considered impaired. Then, the impairment procedures in Chapter 15 should be implemented immediately.



(Courtesy of Zachary Magnone and Tyco Fire Protection Products)

Tip for Owners

The process or equipment being protected can create unsafe conditions for an inspector while the process is active. It might be necessary to coordinate the annual ITM tasks for the water mist system with another activity that requires system shutdown, so that access can be gained to protected spaces for inspection of the piping and nozzles.

Tip for Owners

It is necessary to maintain a supply of spare automatic water mist nozzles, including all of the types installed in the system, to ensure systems can be returned to service immediately following a fire event or in case a nozzle has been damaged. It is important to verify that the spare nozzles that are provided match the characteristics of the nozzles installed. See 12.4.2 for more details on the required spare nozzles.

12.2.1.1.2 Any water mist nozzle that has been installed in the incorrect orientation shall be corrected by repositioning the branch line, drop, or sprig, or shall be replaced.

12.2.1.1.3 Water mist nozzles with glass bulbs shall be replaced if the bulbs are partially or fully empty of fluid.

12.2.1.1.4 Water mist nozzles installed in concealed spaces such as above suspended ceilings shall not require inspection.

12.2.1.1.5 Water mist nozzles installed in areas that are inaccessible for safety considerations due to process operations shall be inspected during each scheduled shutdown.

12.2.1.1.6 Stock, furnishings, or equipment closer to the water mist nozzle than permitted by the clearance specified in the manufacturer's installation instructions shall be corrected.

N **12.2.1.1.7** Open nozzles shall be removed, inspected, and cleaned during the flushing procedure for the mainline strainer.

12.2.1.2 The supply of spare automatic water mist nozzles shall be inspected annually for the correct number and type of water mist nozzles as required by NFPA 750.

N **12.2.2 Strainers and Filters.**

N **12.2.2.1** Mainline strainers and filters shall be flushed until clear after each operation or flow test.

N **12.2.2.2** Individual water mist nozzle strainers and filters shall be inspected and cleaned after each operation or flow test.

N **12.2.2.3** All strainers and filters shall be inspected and cleaned in accordance with the manufacturer's instructions.

N **12.2.2.4** Damaged or corroded parts or assemblies shall be replaced or repaired.

N **12.2.3 System Piping, Tubing, and Fittings.**

N **12.2.3.1** Water mist system distribution piping, tubing, and fittings shall be inspected annually from the floor level.

N **12.2.3.2** Piping, tubing, and fittings shall be free of mechanical damage, leakage, and corrosion.

N **12.2.3.3** Water mist system distribution piping shall not be subjected to external loads by materials either resting on the pipe or hung from the pipe.

N **12.2.3.4** Piping, tubing, and fittings installed in concealed spaces such as above suspended ceilings shall not require inspection.

N **12.2.3.5** Piping, tubing, and fittings installed in areas that are inaccessible for safety considerations due to process operations shall be inspected during each scheduled shutdown.

N **12.2.4 Hangers, Braces, and Supports.** *(See also A.5.2.3.)*

N **12.2.4.1** Water mist system distribution pipe hangers, braces, and supports shall be inspected annually from the floor level.

N **12.2.4.2** Hangers, braces, and supports shall not be damaged, loose, or unattached.

N **12.2.4.3** Hangers, braces, and supports that are damaged, loose, or unattached shall be replaced or refastened.

N **12.2.4.4*** Hangers, braces, and supports installed in concealed spaces such as above suspended ceilings shall not require inspection.

N **A.12.2.4.4** Examples of hangers and seismic braces installed in concealed areas include some floor/ceiling or roof/ceiling assemblies, pipe chases, and other inaccessible areas.

N **12.2.4.5** Hangers, braces, and supports installed in areas that are inaccessible for safety considerations due to process operations shall be inspected during each scheduled shutdown.

N 12.2.5 High Pressure Storage Cylinder Assemblies (Gas and Water).

Exhibit 12.4 and Exhibit 12.5 illustrate two types of water mist systems that use compressed gas cylinders as the propellant or as the atomizing medium. Exhibit 12.4 shows a twin-fluid system, which includes a pressure-reducing valve to create a high pressure side and a low pressure side. The compressed air is reduced [from typically 2175 psi to 116 psi (150 bar to 8 bar)], which drives the water out of the water storage tank and acts as a propellant. This compressed air also goes to the air inlet of each of several twin-fluid nozzles, to act as the atomizing medium. The twin-fluid system is a low pressure water mist system; therefore, the water storage tank is not rated for high pressure. A similar arrangement is used for single-fluid low or intermediate pressure water mist systems.

Exhibit 12.5 represents a decaying pressure, high pressure water mist system. The compressed gas cylinder pressure is typically between 2175 psi and 2900 psi (150 bar and 200 bar), and the pressure is not regulated to a lower pressure. The compressed gas forces the water out of the high pressure water storage cylinders and into the water mist system piping. The pressure in the system piping typically starts at about 1450 psi (100 bar) and declines over approximately 10 minutes to about 290 psi (20 bar). Typical applications for a high pressure water mist system include turbine enclosures and machinery spaces.

Gas-driven water mist systems involve components not previously used with water-based fire protection systems. There are "master" and "slave" pneumatic releasing valves that are interconnected by compressed gas tubing. If the technician accidentally activates a slave valve instead of a master valve, it is possible that not all cylinders will discharge. The testing of compressed gas cylinders and their interconnections should be performed only by technicians with specialized training and experience with the particular equipment involved.

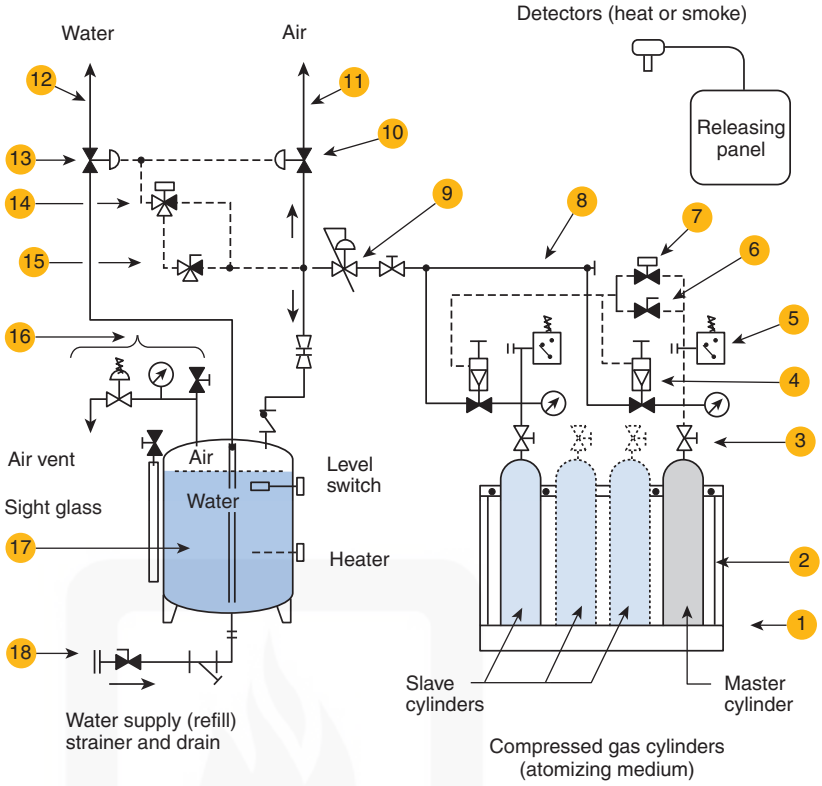
Water storage cylinders are modified compressed gas cylinders; they have a special head assembly that allows water to enter and air to escape from the cylinder for refilling. Exhibit 12.5 is a schematic diagram of a water mist system using these water storage cylinders. The cylinders are typically lined with a corrosion-resistant coating. Refilling is done by connecting a fill line to an inlet and opening a vent port. The cylinder is full when water starts to flow out of the open vent port. Only an experienced technician should perform the filling operation. A permanent water supply connection with a filter and hose valve should be mounted near the unit to facilitate refilling with filtered water. The intent of this provision is that concern about algae growth in water stored in cylinders is minimal because the air–water interface in a full cylinder is very small.

FAQ How can it be determined whether the water storage cylinders are full?

Some manufacturers provide a dipstick on each water storage cylinder to allow an inspector to easily verify that the tanks are full. However, with some water mist systems, once the cylinders are filled and the vent ports sealed, it is not possible to visually confirm that water storage cylinders are full of water. A written record of who last filled the cylinders must be maintained at the cylinder station. If the person doing a monthly or quarterly inspection is not the person who last filled the system, he or she must rely on the written record as the only evidence that the cylinders were at least full of water at some time in the recent past.

Some end users require placing the cylinder rack on load cells to continuously monitor the weight of the cylinders. This is the best way to supervise the water level in such closed cylinders.

EXHIBIT 12.4 *Gas-Driven System with Water Stored in Tank with Air-Water Interface Greater than 11 ft² (1 m²).*



Legend

1. Steel base and frame
2. Compressed gas cylinders (atomizing medium): master and slave cylinders
3. Cylinder control valve
4. Pneumatic cylinder release valve
5. Pressure supervisory switch with burst disc
6. Manually operated master release valve
7. Solenoid operated master release valve
8. High pressure tubing manifold
9. Air pressure control valve (high to low pressure)
10. Air-actuated globe valve
11. Air line to twin-fluid nozzles (low pressure)
12. Water line to twin-fluid nozzles (low pressure)
13. Air-actuated globe valve (cycle water line)
14. Low pressure solenoid valves (for operating air-actuated globe valves)
15. Manual release valve (opens globe valves)
16. Pressure gauge, pressure relief valve, and vent valve
17. Low pressure rated water tank
18. Drain and refill connection with strainer

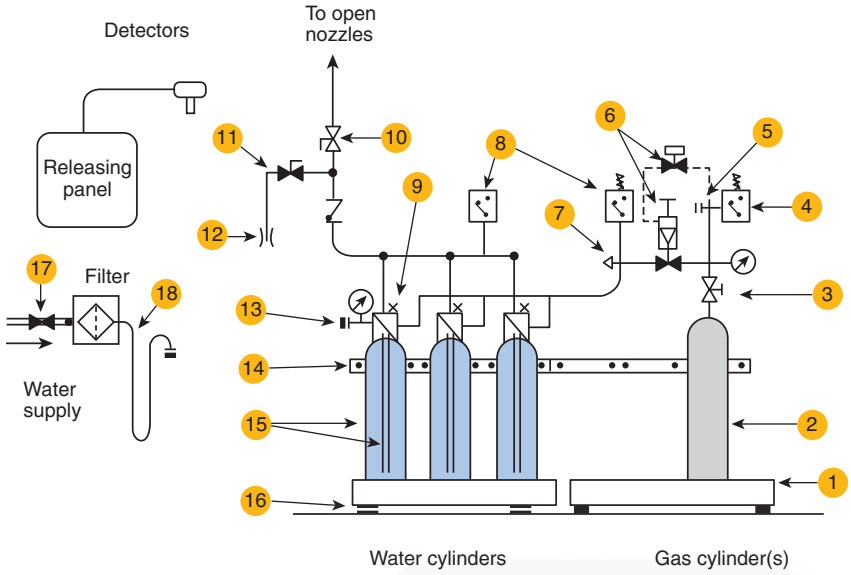
N **12.2.5.1** All cylinders and mounting brackets shall be fastened securely in accordance with the manufacturer's requirements.

N **12.2.5.1.1** Quarterly, compressed gas cylinders shall be inspected for proper securement.

N **12.2.5.1.2** Annually, high pressure water cylinders shall be inspected for proper securement.

N **12.2.5.2*** Compressed gas cylinders continuously in service without discharging shall be given a complete external visual inspection every 5 years or more frequently if required.

N **A.12.2.5.2** These guidelines apply only to the external inspection of containers continuously in service in the water mist system and should not be confused with the DOT retest requirements for visual inspection described in 49 CFR.



Legend

1. Steel base and frame
2. Compressed gas cylinders (driving medium)
3. Cylinder control valve
4. Pressure switch, supervise cylinder pressure
5. Burst disc
6. Solenoid operated master release valve
7. Micro-leakage valve
8. Pressure switches, alarm if system trips
9. Vent port, for filling water cylinders (fill until water discharges from open port)
10. Primary system or sectional control valve
11. Test connection and drain
12. Test orifice (alternative to full discharge)
13. Cylinder discharge header with filling port
14. Cylinder rack with restraints
15. Pressure-rated water = 150 cylinders with dip tube
16. Optional load cells to confirm water level in cylinders
17. Water supply valve, normally closed
18. Filter and hose with adaptor fitting for filling

EXHIBIT 12.5 *Pre-engineered, Gas-Driven Single Fluid, High Pressure Water Mist System with Water Stored in High Pressure Cylinders.*

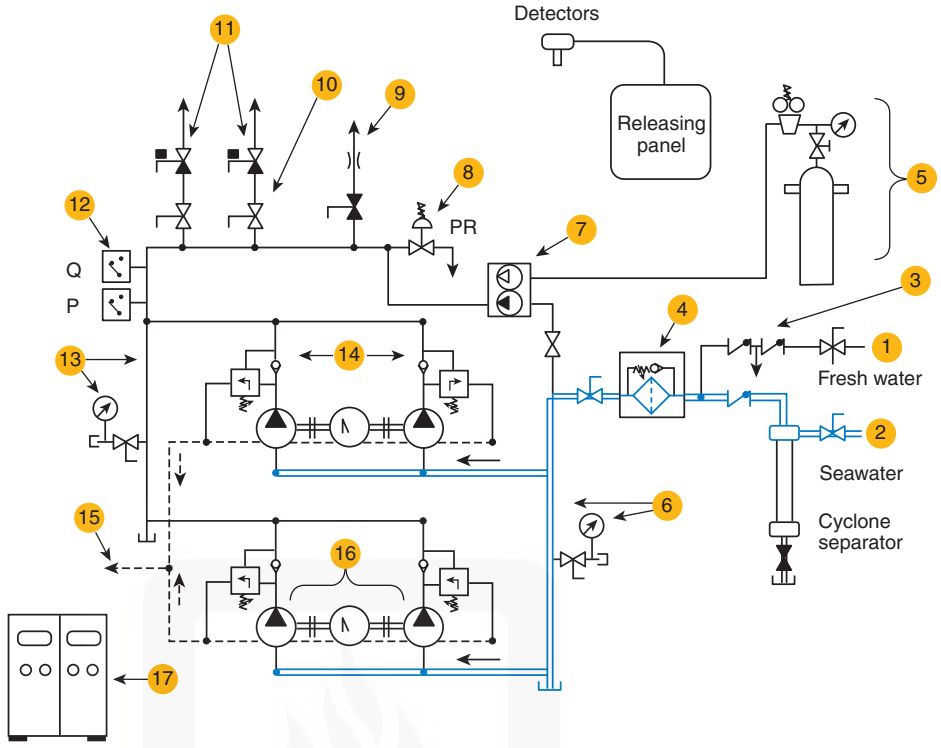
Proper recordkeeping is an important part of every inspection. The inspector should be guided by the following outline to ensure that the minimum information is recorded:

(1) Record tag. A record tag should be attached to every container being inspected for future reference. The record tag should be marked with the date of inspection (month/year), name of individuals(s) and company performing the inspection, container serial number, condition of the container (paint, corrosion, dents, gouges, etc.), and disposition.

(2) Inspection report. The inspection report should record the date of inspection (month/year), name of individual(s) and company performing the inspection, DOT specification number, container serial number, date of manufacture, date of previous inspection and/or test, type of protective coating, surface condition (corrosion, dents, gouges, fire damage, etc.), and disposition (satisfactory, repaint, repair, scrap, etc.). A sample of a suitable inspection report form can be found in Appendix A of CGA C-6, *Standard for Visual Inspection of Steel Compressed Gas Cylinders*.

N **12.2.5.2.1** The visual inspection shall be in accordance with Section 3 of CGA C-6, *Standard for Visual Inspection of Steel Compressed Gas Cylinders*, except that the cylinders need not be emptied or stamped while under pressure.

EXHIBIT 12.6 *Engineered Water Mist System with Positive Displacement Pump Assembly That Has Unloader Valves on Individual Pumps and Sectional Control Valves for Separate Zones.*



Legend

1. Fresh water supply
2. Seawater supply with cyclone separator (marine systems only)
3. Backflow device (optional)
4. Filters or screens with bypass
5. Air-supply and regulator for standby pressure maintenance pump
6. Suction manifold with NPSH gauge (+/–)
7. Pneumatic standby pressure pump
8. Pressure relief valve
9. Test connection with flowmeter
10. Isolation valve for sectional valves
11. Solenoid actuated sectional control valves
12. Control sensors, pressure (P) and flow (Q), connected to programmable controller
13. Discharge manifold with pressure gauge
14. Unloader valve (one per pump)
15. Unloader valve discharge bypass line (to drain)
16. Positive displacement pumps (2 per motor)
17. Programmable pump controllers in bank (one per motor)

N **12.2.5.2.2** Inspections shall be made only by competent personnel.

N **12.2.5.2.3** The inspection results shall be recorded on both of the following:

(1) A record tag permanently attached to each cylinder
(2) A suitable inspection report

N **12.2.5.2.3.1** A completed copy of the inspection report shall be furnished to the owner of the system or an authorized representative.

N **12.2.5.2.3.2** These records shall be retained by the owner for the life of the system.

N **12.2.5.3** Annually, the cylinder shall be visually inspected for the proper specification, capacity, and pressure rating.

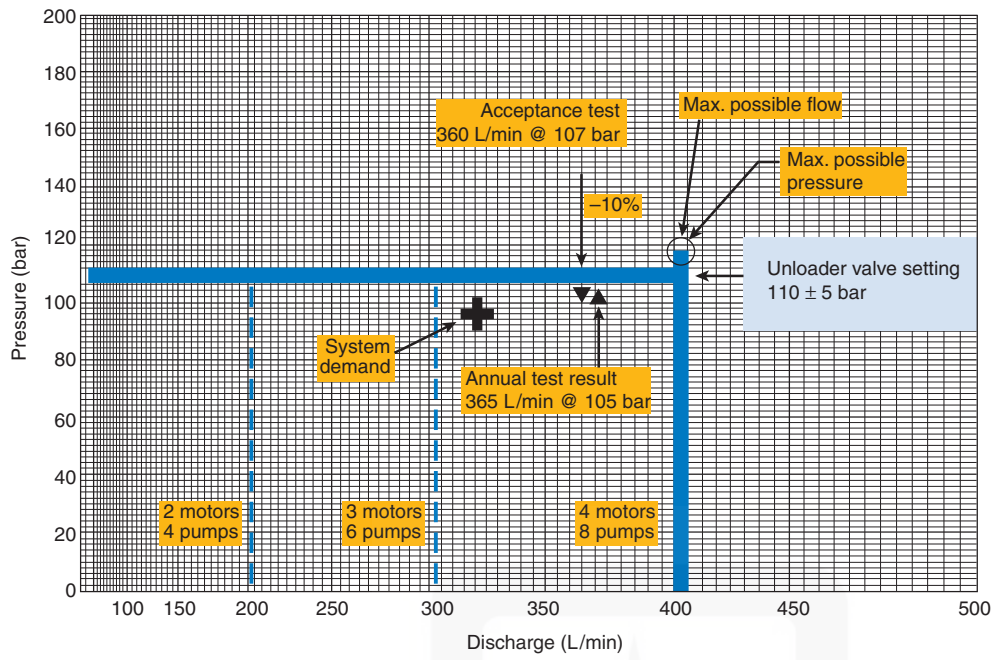


EXHIBIT 12.7 *Composite Pump Curve for a Four-Motor, Eight-Pump Assembly, with All Eight Unloader Valves Set at 1595 psi (±72.5 psi) [110 bar (±5 bar)].*

N **12.2.5.4** The pressure in the high-pressure storage containers shall be within the water mist manufacturer's specifications.

N **12.2.5.4.1** Pressure in compressed gas cylinders that are electrically supervised and monitored shall be inspected, at a minimum, semiannually, or in accordance with the manufacturer's specifications.

N **12.2.5.4.2** Pressure in compressed gas cylinders that are not electrically supervised and monitored shall be inspected, at a minimum, monthly, or in accordance with the manufacturer's specifications.

N **12.2.5.4.3** The cylinder pressure on the discharge side of a high-pressure water storage container shall be inspected annually.

N **12.2.5.5** The water level in the high-pressure storage containers shall be within the water mist manufacturer's specifications.

N **12.2.5.5.1** Unsupervised water levels in high-pressure cylinders shall be inspected quarterly.

N **12.2.5.5.2** Supervised water levels in high-pressure cylinders shall be inspected semiannually.

N **12.2.5.6** Annually, the vent plugs on high-pressure water storage containers shall be visually inspected to ensure the vent is not ruptured or open.

N **12.2.5.7** Annually, the filter on high-pressure water storage containers shall be visually inspected to ensure it is clean.

N **12.2.5.8** All manually operated indicating control valves shall be visually inspected to confirm that they are in proper position, at a minimum, semiannually, or in accordance with manufacturer's specifications.

N **12.2.5.9** Annually, all hoses used as a part of the system shall be visually inspected for damage.

N 12.2.6 Pneumatic Valves and Tubing.

Exhibits 12.4 and 12.5 show compressed gas cylinders used for two types of gas-driven water mist systems. Special pneumatic valves are released by a solenoid valve to activate the systems. On some systems, there is a master valve on the first cylinder, which is electrically released on a signal from the releasing panel. A pneumatic line then connects the first releasing valve to additional valves on the remaining cylinders.

The integrity of pneumatic tubing connecting master and slave valves is seldom or never supervised. For that reason, pneumatic valves must be inspected carefully for possible problems with the control tubing. Generally, the system can only be determined to function properly at the time of an annual trip test of the system.

Some water mist systems are designed to cycle flow on and off for specified periods of time. For example, the system might be designed to discharge water for 60 seconds, stop for 40 seconds, and then resume discharging water mist for another 60 seconds. The cycle is repeated for the intended duration of protection, which is usually 10 minutes.

FAQ How should the total volume of water required for 10 minutes of protection be calculated for a cycling system?

The total volume of water required for 10 minutes of protection for a cycling system is based on the total number of minutes of actual discharge, not on the total elapsed time from the start of discharge.

Under ideal conditions, cycling systems can extinguish hydrocarbon fires in enclosures more quickly and with less total water usage than continuous discharge systems. They rely, however, on the confinement of heat and water vapor inside the enclosure to assist in extinguishing fire. During each "off" cycle at the start of discharge, a hydrocarbon fire might regrow and increase the temperature in the enclosure and, hence, the amount of water vapor that can be held in the vapor state. By the third or fourth cycle, the enclosure is warm enough to sustain a high water vapor concentration, which reduces the oxygen concentration and results in extinguishing the fire. Therefore, all ventilation to an enclosure must be interlocked to stop on activation of the water mist system. It is also critical to verify that the enclosure integrity is maintained for such systems.

The timing of the on and off cycles is controlled by a system control panel and specialized solenoid valves. The operation of the timing circuit should be tested during the annual inspection.

Pneumatically operated valves and pneumatic tubing shall be visually inspected, at a minimum, semiannually, or in accordance with the manufacturer's specifications.

N 12.2.7 Additive Storage Cylinders.

The most commonly used additive with water mist systems, AFFF, is used in some marine systems for bilge nozzles. ITM procedures for reservoirs of AFFF solution should comply with Chapter 11 of NFPA 25. Specialized water mist systems might incorporate additives to prevent freezing or to enhance extinguishing effectiveness. For the most part, these are small pre-engineered systems for which the additive is pre-mixed with water in the water storage container. ITM activities for such systems should follow the manufacturer's recommendations.

N 12.2.7.1 Quarterly, the storage cylinder shall be visually inspected for external corrosion or damage.

N 12.2.7.2 Semiannually, the quantity of the additive agent shall be inspected.

N 12.2.8 Water Recirculation Tanks.

Water recirculation tanks are also referred to as *break tanks* and are commonly used on marine systems. The break tank is typically built into the frame of the pump assembly with direct connections to the suction inlets of the pumps. The water level is usually supervised. If the water level drops to a certain level, the "float-operated valve" will open and allow water from a permanent source to flow into the tank. It is preferable to have an additional low-level alarm for supervision of the water level, to provide an alert to the declining water level without having to wait for the refill switch to activate. Inspection and testing must include the water supply to the break tank, which might include a backflow prevention device and/or a seawater connection with cyclone separator. The water supply to the break tank must be tested for capacity: the minimum flow rate must equal or exceed the maximum output capacity of the pump assembly.

The quality of the water in the break tank should be checked frequently. If there is algae growth in the water and there is no strainer on the outlet from the tank to the suction inlet of the pumps, fibrous algae material can pass through the pumps and into the water mist system piping, where it will clog vital components. The possibility of algae growth can be reduced by frequent changeover of the water in the tank, which can occur with weekly startup of the pump assembly. Otherwise, fixed UV antibacterial units can be installed directly in the break tank.

N **12.2.8.1** All tank attachments and supports shall be secured in accordance with the manufacturer's requirements.

N **12.2.8.2** The water level in recirculation tanks shall be within the water mist manufacturer's specifications.

N **12.2.8.2.1** Unsupervised water levels in recirculation tanks shall be inspected monthly.

N **12.2.8.2.2** Supervised water levels in recirculation tanks shall be inspected quarterly.

N **12.2.8.3** Annually, the water quality shall be inspected and drained, flushed, and refilled as necessary.

N **12.2.8.4** Annually, the filters, strainers, and cyclone separator shall be visually inspected and cleaned as necessary.

N 12.2.9 Pneumatically Operated Standby Pumps.

N **12.2.9.1** Monthly, the moisture trap shall be visually inspected and emptied.

N **12.2.9.2** Monthly, the compressed gas supply and inlet air pressure shall be visually inspected in accordance with the manufacturer's specifications.

N **12.2.9.3** Monthly, the outlet water (standby) pressure shall be visually inspected in accordance with the manufacturer's specifications.

N **12.2.9.4** Monthly, the oil level on air regulator units shall be visually inspected in accordance with the manufacturer's specifications.

N 12.2.10 Water Supply.

N **12.2.10.1** Quarterly, the water supply pressure shall be visually inspected to determine that it is within the water mist manufacturer's specifications.

N **12.2.10.2** The water quality shall be inspected semiannually for the first year and then annually thereafter.

FAQ What types of water quality tests should be conducted during the first semiannual inspection?

Checking water quality requires sending at least one sample of water to a water quality testing laboratory. During the first semiannual inspection, at a minimum, tests should be conducted for turbidity, algae, *Legionella* bacteria, *E. coli* bacteria, and chloride content. For stainless steel piping systems, the chloride content of water should not exceed 50 ppm. The need for laboratory testing may be reduced in future inspections if the quality of the source water is found to be acceptable over at least two consecutive semiannual tests.

The quality of the source water should be checked semiannually during the first year. If no adverse conditions are noted, it is acceptable to test the water quality annually. If adverse conditions are found, remedial measures should be taken and the water quality should be tested monthly until it is assured that the quality has improved.

N **12.2.11 Enclosures and Interlocks.** Semiannually, the integrity of the enclosure and interlocks shall be inspected.

N 12.3 Testing.

N 12.3.1 Nozzles, Automatic.

12.3.1.1* Where required by this section, sample automatic water mist nozzles shall be submitted to a recognized testing laboratory acceptable to the authority having jurisdiction for functional testing.

A.12.3.1.1 Water mist nozzles should be first given a visual inspection for signs of mechanical damage, cleaning, painting, leakage in service, or severe loading or corrosion, all of which are causes for immediate replacement.

Automatic nozzles that have passed the visual inspection should be laboratory tested for sensitivity (RTI), functionality, and K-factor. Thermal sensitivity should be not less than that permitted in post-corrosion testing of new automatic water mist nozzles of the same type. Automatic water mist nozzles should be tested for functionality at their minimum operating pressure specified by the manufacturer. Automatic water mist nozzles should have a K-factor within ±5 percent of the value published by the manufacturer.

Some example testing standards include EN 12259-1, *Fixed firefighting systems – Components for sprinkler and water spray systems – Part 1: Sprinklers*; UL 2167, *Standard for Water Mist Nozzles for Fire Protection Service*; and FM Approvals Standard 5560, *Water Mist Systems*.

Water mist nozzles that have been in service for a number of years should not be expected to have all of the performance measurements of a new water mist nozzle. However, if there is any question about their continued satisfactory performance, the water mist nozzles should be replaced.

12.3.1.2 Automatic water mist nozzles that have been installed for 10 years shall be replaced, or representative samples shall be tested and then retested at 5-year intervals.

12.3.1.3* Where water mist nozzles are subjected to harsh environments, including corrosive atmospheres and corrosive water supplies, they shall be either replaced or representative samples tested on a 5-year basis.

A.12.3.1.3 These environments include outdoor weather conditions and portions of any area where corrosive vapors prevail. Harsh water environments include water supplies that are chemically reactive. An example of a corrosive atmosphere is a marine environment. The testing requirements for these types of environments are also described in the International Maritime Organization's MSC.1/Circular 1432, *Guidelines for the Maintenance and Inspection of Fire Protection Systems and Appliances*.

12.3.1.4* A representative sample of water mist nozzles for testing per 12.3.1.2 or 12.3.1.3 shall consist of a minimum of four water mist nozzles or 1 percent of the number of water mist nozzles per individual water mist nozzle sample, whichever is greater.

A.12.3.1.4 Within the area represented by the selected sample, water mist nozzles of the same design produced by the same manufacturer can be considered part of the same sample, but additional water mist nozzles would need to be selected if produced by a different manufacturer.

12.3.1.5* Where one water mist nozzle within a representative sample fails to meet the test requirement, all water mist nozzles within the area represented by that sample shall be replaced.

N **A.12.3.1.5** When acceptable to the authority having jurisdiction, in lieu of replacement of all the water mist nozzles within the area represented, additional representative samples could be tested to assess the performance of the water mist nozzles in that area.

N **12.3.1.6** Automatic water mist nozzles that need to be replaced shall be in accordance with the requirements of 12.4.2.

N 12.3.2 Nozzles, Open.

N **12.3.2.1** Water mist nozzles installed to protect application areas without protective coverings shall be capable to operate and protect the hazard with an overspray residue in the event of a fire.

N **12.3.2.2*** Where water mist nozzles are subjected to environments with residues, including corrosive atmospheres and corrosive water supplies, they shall be either replaced or representative samples tested on a 1-year basis. *(See also A.12.3.1.3.)*

N **A.12.3.2.2** Water mist nozzles should be first given a visual inspection for signs of mechanical damage, cleaning, painting, or severe loading or corrosion, all of which are causes for immediate replacement.

Open nozzles that have passed the visual inspection should be laboratory tested for functionality and K-factor. Open water mist nozzles with blow-off caps and/or dust plugs should be tested for functionality at their minimum operating pressure specified by the manufacturer. Open water mist nozzles should have a K-factor within −5 percent of the value published by the manufacturer.

Some example testing standards include EN 12259-1, *Fixed firefighting systems – Components for sprinkler and water spray systems – Part 1: Sprinklers*; UL 2167, *Standard for Water Mist Nozzles for Fire Protection Service*; and FM Approvals Standard 5560, *Water Mist Systems*.

Water mist nozzles that have been in service for a number of years should not be expected to have all of the same performance measurements of a new water mist nozzle. However, if there is any question about their continued satisfactory performance, the water mist nozzles should be replaced.

N **12.3.2.3** Where the nature of the protected property is such that water cannot be discharged annually as indicated in 12.3.16.5 and not subject to the conditions in 12.3.2.2, Open water mist nozzles that have been in service for 10 years shall be either replaced or representative samples shall be tested and then retested at 5-year intervals. *(See A.12.3.2.2)*

N **12.3.2.4** A representative sample of water mist nozzles for testing per 12.2.10.2 shall consist of a minimum of three water mist nozzles or 1 percent of the number of water mist nozzles per individual water mist nozzle sample, whichever is greater.

N **12.3.2.5*** Where one water mist nozzle within a representative sample fails to meet the test requirement, all water mist nozzles within the area represented by that sample shall be replaced.

N **A.12.3.2.5** Where acceptable to the authority having jurisdiction, in lieu of replacement of all the water mist nozzles within the area represented, additional representative samples could be tested to assess the performance of the water mist nozzles in that area.

N **12.3.3 Strainers and Filters.** Mainline strainers (basket or screen) shall be flushed until clear after each operation or flow test.

N **12.3.4 Additives.** Samples of the additive shall be submitted in accordance with the manufacturer's recommended sampling procedures for evaluation of quality to its specification.

N 12.3.5 Operational Test Performance with Additives.

N **12.3.5.1** Operational tests shall be conducted to ensure the injection rate of the additive for the water mist system responds as designed, both automatically and manually.

N **12.3.5.2** The test procedures shall simulate anticipated emergency events so the response of the water mist system can be evaluated.

N **12.3.5.3** Where a discharge from the system discharge devices would create a hazardous condition or conflict with local requirements, an approved alternate method to achieve full flow conditions shall be permitted.

N **12.3.5.4** It shall be permissible to test the full flow discharge from the water mist system with additive using water only in lieu of the additive.

N **12.3.5.5** Under test conditions, the automatic fire detection systems, when exposed to a test source, shall operate within the requirements of *NFPA 72* for the type of detector provided, and the response time shall be recorded.

N **12.3.5.6** The time lapse between operation of detection systems and water delivery time to the protected area shall be recorded for open discharge devices.

N 12.3.6 Compressed Gas Storage Cylinders.

N **12.3.6.1** Gas cylinders designed in accordance with U.S. Department of Transportation (DOT), Canadian Transport Commission (CTC), or similar containers shall not be recharged without retesting if more than 5 years have elapsed since the date of last test.

N **12.3.6.2** A completed copy of the test report shall be furnished to the owner of the system or an authorized representative.

N **12.3.6.3** These records shall be retained by the owner for the life of the system.

FAQ How long are water mist tanks allowed to be kept in service? How are they refilled?

As indicated in Table 12.1.1.2, high pressure compressed gas cylinders are permitted to be kept in service (if not discharged) for up to 12 years. Generally, cylinders that are discharged are replaced by new cylinders that are provided by a compressed gas supplier; therefore, it is seldom necessary to send cylinders out for hydrostatic testing. Some water mist systems, however, use customized compressed gas cylinders or fixed banks of cylinders that are intended to be refilled in place. A special fill connection should be provided on the manifold to permit refill in place. If the system is discharged after the first 5 years, the cylinders must be removed and sent for hydrostatic testing.

If refilling in place cannot be easily accomplished within 24 hours of a system release, replacement cylinders should be kept in stock. The spent cylinders should be removed and sent to a supplier to be refilled, and the stock replacement cylinders should be installed.

Exhibit 12.8 shows an assembly of high pressure nitrogen cylinders used as the driving medium for a water mist system. Each cylinder has its own low pressure alarm pressure switch. The manifold is designed to permit refill in place.

Different countries have different pressure ratings for cylinders. In Europe, Asia, and Australia, 2900 psi (200 bar) cylinders are standard. In North America, commercially available cylinders are typically 2250 psi (155 bar). It is important to check the actual cylinder volume

and pressure whenever a new cylinder is installed. For example, it is not uncommon to find a commercially supplied cylinder at 2175 psi (150 bar), about 3 percent less than the 2250 (155 bar) expected. A small difference (e.g., ~3 percent) probably will not significantly affect the overall performance of the system.

The calculation to determine the number of cylinders needed for a given duration of discharge is based on the volume of the cylinders and the pressure. If the water mist system was designed on the basis of 50 liter cylinders at 2900 psi (200 bar) and similarly sized replacement cylinders were only 2250 psi (155 bar), the duration of protection would be reduced. Before any cylinders are replaced, the system documentation should be consulted to determine the minimum acceptable cylinder volume and pressure.



EXHIBIT 12.8 *Compressed Gas Cylinders for Use as Propellant for a Water Mist System.*

N 12.3.7 Control Equipment.

Water mist systems rely on a separate detection system to activate. The one exception is water mist systems that are sprinkler equivalents and use thermally activated (automatic) nozzles. Inspection and testing procedures, therefore, must include the detection system. The type of detection is often dictated by the listing for the system. For example, turbine enclosures and machinery spaces listed by FM Global are required to use thermal detectors. The listing also indicates that certain shutdown events must be synchronized with the release of the system. The ventilation system should be shut down, door holders released, dampers closed, and lubrication or fuel lines shut off. Obviously, the annual testing of a water mist system must confirm the proper operation of all events associated with release of the water mist system.

Where a cause and effect protocol has been developed to identify how the water mist system integrates with other process and safety operations, the protocol should be available to the water mist system inspector.

N **12.3.7.1** Operational tests shall be conducted to ensure the control equipment for the water mist system responds as designed, both automatically and manually.

N **12.3.7.2** Annual operational testing shall be conducted in accordance with the requirements of *NFPA 72*.

N **12.3.7.3** Where a discharge from the system discharge devices would create a hazardous condition or conflict with local requirements, an approved alternate method to achieve full flow conditions shall be permitted.

N 12.3.8 Detection Systems.

N 12.3.8.1 Operational tests shall be conducted to ensure the control equipment for the water mist system responds as designed, both automatically and manually.

N 12.3.8.2 Conduct annual operational testing of the initiating devices for detection in accordance with the requirements of *NFPA 72*.

N 12.3.8.3 Under test conditions, the automatic fire detection systems, when exposed to a test source, shall operate within the requirements of *NFPA 72* for the type of detector provided, and the response time shall be recorded.

N 12.3.8.4 The time lapse between operation of detection systems and water delivery time to the protected area shall be recorded for open discharge devices.

N 12.3.9 Fire Pumps and Drivers.

Large water mist systems that are used to protect entire passenger ships — or as equivalent sprinkler systems in buildings — may utilize a pumped water supply. The ITM procedures for standard fire pumps, as provided in Chapter 8 of NFPA 25, generally apply equally well to water mist systems involving pumps. Some additional requirements or cautions, however, should be observed for water mist systems that use positive displacement pumps.

When using positive displacement pumps to supply fire protection systems that have widely varying demands, the challenge is to provide a means of bypassing pump water flow that cannot be discharged from the number of open nozzles. The operation of flow-bypass valves (called *unloader valves*) is critically important to the operation of the system. Even if only a few thermally activated water mist nozzles operate, the pump assembly must deliver the proper flow to those nozzles while bypassing the unused portion of the flow. If many nozzles are opened by heat so that the entire output from the pump assembly is required, the unloader valves should not allow any water to flow to the bypass. The operation of the pump assembly for both small and maximum demands will have been verified at the acceptance test. It is important not to disturb any of the settings on the unloader valves in the course of the annual pump testing.

Exhibit 12.6 is a schematic of one type of high pressure pump assembly for an engineered water mist system. The assembly consists of two electric motors, each driving two small piston pumps. The total capacity of the pump assembly is the sum of the output of the four pumps. If there are not enough nozzles opened on the system to flow the full capacity of the assembly, the system pressure will rise until it causes one or more unloader valves to divert the pump flow to the bypass line. The pressure at which an unloader valve opens is pre-set at the time of the system design. Typical applications for this pump assembly include passenger ships, multi-zone industrial systems, and sprinkler-equivalent systems in buildings.

As shown with the tag numbered 9 in Exhibit 12.6, a test connection should be provided on the discharge manifold. The test connection should include a predesigned orifice device that will allow the full flow of the pump at the desired backpressure. Since the unloader valves respond to the system backpressure, it will not be possible to verify the proper operation of all contributing pumps without approximately matching the corresponding system pressure. A throttling valve can be installed on the discharge line to allow the backpressure in the system to be modified.

Some high pressure pump assemblies do not have unloader valves installed on each pump but, instead, have an equivalent large-volume pressure relief valve on the discharge manifold. (See the valve identified with tag number 8 in Exhibit 12.6.) Before conducting annual flow testing, the inspector must understand the intended operation of all pressure or flow control devices.

In Exhibit 12.6, the fire pump controller is shown as a pair of controllers. Listings for the pump assembly requires one controller per electric motor (per NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*). The controller is usually programmed to start or stop individual motors according to the demands on the system. Pressure and flow sensors are provided on the pump assembly, which are used in the system control logic program, to determine if another motor is needed or if one of several motors can be shut down. These programmable features are different from a standard fire pump installation, which usually involves only one motor and one pump.

The waterflow test results from the annual pump test need to be compared to the flow test results obtained during the acceptance testing of the system. This is relatively straightforward for low and intermediate pressure systems that use centrifugal-type pumps. As indicated in Chapter 8 of NFPA 25, the usual practice is to plot at least three points from the flow test on a pressure versus flow plot, subtract the water supply pressures from the test pressures, and draw a smooth curve through the resulting points. The smooth curve should lie on or above the "factory" pump curve. If it does not, one concludes that some impairment has occurred.

The situation is more complex for a positive displacement pump or pump assembly. One reason is that the unloader valves or pressure relief valve on the manifold are usually set at less than the maximum possible pump pressure, and there may be at least a 5 percent variation in the settings of individual unloader valves. The pump curve for the output of an assembly of positive displacement pumps, with all pumps contributing, will invariably be less than the presumed unloader setting, and the flow will be less than the theoretical sum of the individual pumps. Exhibit 12.7 illustrates the theoretical pump curve for a positive displacement pump assembly with eight pumps and eight unloader valves set nominally at 1595 psi (110 bar).

FAQ What factors determine whether the pump assembly is operating properly?

The key to determining whether the pump assembly is operating as it should is to ensure that the pressure achieved at maximum flow is within 5 percent of the pressure relief valve setting or the highest unloader valve setting and that the total flow is within 10 percent of the theoretical maximum flow rate, as shown in Exhibit 12.7

Exhibit 12.7 illustrates one flow test comparison with the acceptance test result. During the acceptance test, a maximum flow/pressure result of 9 gpm at 1552 psi (360 L/min at 107 bar) was accepted. That result was 10 percent lower flow than the theoretical maximum of 10 gpm at 1552 psi (400 L/min at 107 bar), and 1552 psi (107 bar) was within the ±70 psi (±5 bar) precision of the unloader valves. During the annual flow test, a maximum flow rate of 9 gpm (365 L/min) was recorded at a pressure of 1524 psi (105 bar). This was an acceptable condition, since the flow was slightly greater than the acceptance test, and within 10 percent of the maximum; and the pressure was within the ±70 psi (±5 bar) precision of the unloader valve settings.

In the case of high pressure pumps operating at around 1450 psi (100 bar), the supply water pressure [typically less than 30 psi (2 bar)] does not show up on the scale. The pressure at the suction inlet to the pumps is nevertheless important. Positive displacement pumps are more sensitive to net positive suction head (NPSH) problems than centrifugal pumps. The need to filter all water going to the system adds hydraulic resistance to the suction inlet line. If filters are present on the suction line, friction losses in the suction supply might become too high. In some cases, a suction booster pump might be used to increase the suction line pressure to overcome friction loss through the filters. Starting of the positive displacement pumps must then be preceded by starting the suction booster pump.

It is important that filters be able to accommodate the maximum system demand flow rate for an extended period of time without clogging. Unlike the manual-fill systems suitable for pre-engineered systems (see Exhibit 12.5), which only need to accommodate the

flow needed to refill a reservoir in a reasonable period of time, the filters on the suction supply to a pumped system must be sized for the maximum system flow rate. In Exhibit 12.6 a spring-loaded check valve is placed on a bypass around the filters (tag number 4). If the filters become plugged, the bypass line should automatically open to allow a flow of unfiltered water to the pumps. This must be tested during the annual discharge test.

Gauges on the suction side of the pumps should be checked to ensure that they are capable of measuring the range of suction line pressures. If they are not, then a new gauge with the appropriate scale to read the NPSH will need to be installed. Other pumps use two banks of filters in parallel, with a pressure transducer connected to the pump controller. If the head loss across the first bank of filters becomes too high (as the filters become clogged), a solenoid valve opens and reroutes the flow through the redundant bank of filters.

The maintenance plan for a water mist pump system must be designed to evaluate the specific details of the suction supply to the pumps. It is recommended that temporary supplemental instrumentation be installed to measure performance factors during the annual discharge test.

Standby Pumps. ITM tasks for standby pumps on low or intermediate pressure water mist systems are covered in Chapter 8 of NFPA 25. High pressure water mist systems may use a pneumatic pump to maintain the system piping at an elevated pressure [e.g., 360 psi (25 bar)]. Inspection and testing of such pumps might not be covered in Chapter 8. Tag number 7 in Exhibit 12.6 shows the symbol for a pneumatic standby pump with dedicated cylinders of compressed gas. The pneumatic pump activates on a signal from the pump controller panel (tag number 17), which receives pressure and flow information from the switches identified by tag number 12. It is important to check the compressed gas supply and outlet pressure on a monthly basis. The owner's personnel can monitor the standby pump on a monthly basis, but the ITM service provider should perform a test of the unit during the annual servicing.

N **12.3.9.1** Fire pumps shall be tested in accordance with the requirements of Section 8.3.

N **12.3.9.2** Water mist systems that are powered by or operated by pressurized gas (normally air or nitrogen) cylinders or pressure vessels shall be tested quarterly or determined by an approved risk analysis in accordance with the manufacturer's specifications using pressurized gas and water from either the primary cylinders or pressure vessels and/or tanks or by using temporary/test cylinders or tanks to verify nozzle flows (no blockage, fully developed spray pattern) upon operation.

N 12.3.10 Hoses.

N **12.3.10.1** All hose shall be tested every 5 years.

N **12.3.10.2** All hose shall be tested at 1½ times the maximum container pressure at 130°F (54.4°C).

N **12.3.10.3** The hose testing procedure shall be as follows:

(1) The hose is removed from any attachment.
(2) The hose assembly is then placed in a protective enclosure designed to permit visual observation of the test.
(3) The hose must be completely filled with water before testing.
(4) Pressure then is applied at a rate-of-pressure rise to reach the test pressure within 1 minute. The test pressure is then maintained for 1 full minute. Observations are then made to note any distortion or leakage.
(5) If the test pressure has not dropped or if the couplings have not moved, the pressure is released. The hose assembly is considered to have passed the hydrostatic test if no permanent distortion has taken place.
(6) Hose assembly passing the test must be completely dried internally. If heat is used for drying, the temperature must not exceed the manufacturer's specifications.

(7) Hose assemblies failing a hydrostatic test must be marked and destroyed and be replaced with new assemblies.
(8) Each hose assembly passing the hydrostatic test is marked to show the date of test.

N **12.3.11 Interlocks.**

N **12.3.11.1** Annual testing to confirm the operation of the interlock for ventilation shall be conducted, if required.

N **12.3.11.2** Annual testing to confirm the operation of the interlock for fuel or lubrication systems shall be conducted, if required.

N **12.3.12 Pneumatic Valves.**

N **12.3.12.1** Operational tests shall be conducted to ensure the pneumatic valves for the water mist system respond as designed, both automatically and manually.

N **12.3.12.2** Semiannual testing of the following pneumatic valves shall be conducted for operation in accordance with the manufacturer's instructions:

(1) Slave valves
(2) Valves intended to cycle on–off

N **12.3.12.3** All pneumatic cylinder release valves shall be reset after testing.

N **12.3.13 Pneumatic Valve Solenoid Releases.** All pneumatic cylinder release valves shall be reset after testing.

N **12.3.13.1** Operational tests shall be conducted to ensure the pneumatic valve solenoid releases for the water mist system responds as designed, both automatically and manually.

N **12.3.13.2** Annual testing of the following pneumatic solenoid valve releases shall be conducted for operation in accordance with the manufacturer's instructions:

(1) Electric release
(2) Manual release

N **12.3.14 Pneumatically Operated Standby Pumps.**

N **12.3.14.1** Pumps (booster pumps, jockey pumps or transfer pumps) used in the water mist system that are not main pressure pumps shall be operated to demonstrate support of their design function for the main pressure pumps.

N **12.3.14.2** Standby pumps shall be operated at least annually to demonstrate their system flow support when the main pressure pumps are tested.

N **12.3.15 System Control Valves.** Each control valve for a zone of protection by the water mist system shall be operated annually through its full range and returned to its normal position.

N **12.3.16 Water Mist System.** Water mist systems shall be operated annually in accordance with the manufacturer's instructions.

N **12.3.16.1 Test Preparation.** Precautions shall be taken to prevent damage to property during the test. *(See also A.10.3.2.)*

N **12.3.16.2 Operational Test Performance.** Operational tests shall be conducted to ensure the water mist system responds as designed, both automatically and manually.

N **12.3.16.2.1** Where the nature of the protected property is such that water cannot be discharged into the occupancy or onto the hazard, an operational test shall be conducted from a test connection with an orifice equivalent to the friction loss for the total number of nozzles.

N **12.3.16.3* Response Time.**

N **A.12.3.16.3** Test methods are as follows:

(1) Some detection circuits can be permitted to be deliberately desensitized in order to override unusual ambient conditions. In such cases, the response required in 12.3.16.3 can be permitted to be exceeded.
(2) Testing of integrating tubing systems can be permitted to be related to this test by means of a standard pressure impulse test specified by the listing laboratory.

One method of testing heat detection uses a radiant heat surface at a temperature of 300°F (149°C) and a capacity of 350 watts at a distance of 1 in. (25 mm) but not more than 2 in. (50 mm) from the nearest part of the detector. This method of testing with an electric test set should not be used in hazardous locations. Other test methods can be permitted to be employed, but the results should be obtained under these conditions.

N **12.3.16.3.1** Under test conditions, the detection systems, shall operate with the specifications from the acceptance test and 12.3.7.

N **12.3.16.3.2** The response times shall be recorded.

N **12.3.16.4 Discharge Time.** The time lapse between operation of detection systems and water delivery time to the protected area shall be recorded.

N **12.3.16.5* Discharge Patterns.**

N **A.12.3.16.5** Water mist nozzles can be of different sizes and types. Some might be more susceptible to internal obstructions than others.

N **12.3.16.5.1** The water discharge patterns from all of the open water mist nozzles shall be observed to ensure that patterns are not impeded by plugged nozzles, to ensure that nozzles are correctly positioned, and to ensure that obstructions do not prevent discharge patterns from fully developing. (*See also 13.4.4.2.3.1.*)

N **12.3.16.5.2** Where the nature of the protected property is such that water cannot be discharged, the nozzles shall be inspected for proper orientation and the system tested with air to ensure that the nozzles are not obstructed.

N **12.3.16.5.3** Where obstructions occur, the piping and nozzles shall be cleaned and the system retested.

N **12.3.16.6 Pressure Readings.**

N **12.3.16.6.1** Pressure readings shall be recorded at the hydraulically most remote nozzle or test connection to ensure the water flow has not been impeded by partially closed valves or by plugged strainers or piping.

N **12.3.16.6.2** For water mist systems with a deluge valve, a second pressure reading shall be recorded at the deluge valve to ensure the water supply is adequate.

N **12.3.16.6.3** Readings shall be compared to the hydraulic design pressures to ensure the original system design requirements are met and the water supply is adequate to meet the design requirements.

N **12.3.16.6.3.1** Where the hydraulically most remote nozzle is inaccessible, nozzles shall be permitted to be checked visually without taking a pressure reading on the most remote nozzle.

N **12.3.16.6.3.2** Where the reading taken at the riser indicates that the water supply has deteriorated, a gauge shall be placed on the hydraulically most remote nozzle and the results compared with the required design pressure.

N **12.3.16.7 Multiple Systems.** The maximum number of systems expected to operate in case of fire shall be tested simultaneously to inspect the adequacy of the water supply.

N **12.3.16.8 Return to Service.** After the full flow test, the water mist system shall be returned to service in accordance with the manufacturer's instructions.

N **12.3.17 Water Recirculation Tanks.**

N **12.3.17.1** Operational tests shall be conducted to ensure water recirculation tanks for the water mist system responds as designed, both automatically and manually.

N **12.3.17.2** Annual testing shall be conducted for operation in accordance with the manufacturer's instructions:

(1) Float-operated valves
(2) Backflow prevention device, when present

N **12.3.17.3** Pressure reading shall be recorded at the outlet of the recirculation tank during the operational discharge test of the water mist system.

N **12.3.18 Water Storage Cylinders (High Pressure).**

N **12.3.18.1*** Water cylinders used with high pressure for power to deliver the water mist, or those that become pressurized at activation or water delivery or as the water source for a water mist system shall be tested in accordance with applicable current pressure vessel standard or code.

N **A.12.3.18.1** A source for test requirements is the most current FSSA Cylinder Service Guide. There are the same requirements that are applicable to cylinders, pressure tanks or pressure vessels used for pressurized gas agents.

N **12.3.18.2** Water cylinders designed in accordance with U.S. Department of Transportation (DOT), Canadian Transport Commission (CTC), or similar containers shall not be recharged without retesting if more than 5 years have elapsed since the date of last test.

N **12.3.18.3** A completed copy of the test report shall be furnished to the owner of the system or an authorized representative.

N **12.3.18.4** The records shall be retained by the owner for the life of the system.

N **12.3.19 Water Storage Tanks.** Water storage tanks or cylinders shall be tested in accordance with the requirements of Section 9.3.

N **12.3.20 Water Supply.** Annual testing shall be conducted in accordance with Section 7.3 to verify the source:

(1) Pressure
(2) Flow
(3) Quantity
(4) Duration

12.4 Maintenance.

Δ **12.4.1 General.**

12.4.1.1 Maintenance shall be performed to keep the system equipment operable or to make repairs.

FAQ How should the inspector notify the owner or the designated representative of any deficiency or impairment found in the system?

If the inspection and testing activity identifies a deficiency or impairment in the system, the ITM service provider must bring the problem to the attention of the owner or designated representative. The owner, or a representative of the owner who has some authority to act, should be verbally informed of the problem. Additionally, a signed inspection form should be submitted with the deficiency clearly marked. Section 4.3 addresses the records requirements for all ITM required by NFPA 25. Those requirements include documenting the procedure performed and the results. Additionally, 4.1.5.1 requires the correction or repair of deficiencies and impairments. Immediate action should be taken to restore the system to its intended level of operation in as short a time as possible.

12.4.1.1.1 Where required by the manufacturer, maintenance shall be performed on devices not described in this standard.

12.4.1.2 As-built system installation drawings, original acceptance test records, and device manufacturer's maintenance bulletins shall be retained to assist in the proper care of the system and its components.

ITM tasks associated with a water mist system should not be undertaken without the as-built drawings and original acceptance test records. The ITM service provider should also ensure that copies of the drawings and acceptance test records are kept with the new test record.

The ITM service provider is not required to confirm that the original design for a particular installation was appropriate for the hazard. However, information on the original design is provided on the system design information sign required by 13.4.4 of NFPA 750. The sign provides a description of the hazard protected that the maintenance service provider can check against the observed conditions.

Tip for Owners

At the completion of the system installation, the service provider is required to provide the owner with the as-built installation drawings, as noted in 13.4.2 of NFPA 750. The service provider should review these drawings with the owner and, if necessary, the designated representative, and note any changes in ventilation, compartment size, and obstructions. These changes could significantly alter the ability of the water mist system to achieve its intended performance.

12.4.1.3 Replacement components shall be in accordance with the manufacturer's specifications and the original system design.

Certain components of water mist systems can have relatively long delivery times for replacement. If a component must be removed for repair, such work should be scheduled to minimize the amount of time the system will be out of service.

12.4.1.4 Spare components shall be accessible and shall be stored in a manner to prevent damage or contamination.

12.4.1.5* After each system operation, a representative sample of operated water mist nozzles in the activated zone shall be inspected.

A.12.4.1.5 The representative sample should include 10 percent of the water mist nozzles in the activated zone. If contamination of filters or strainers is found on inspection, it is recommended that all nozzles within the activated zone be inspected.

12.4.1.6 After each system operation due to fire, the system filters and strainers shall be cleaned or replaced.

Δ **12.4.1.7** Annually, a water tank used to supply a water mist system shall be drained and refilled.

N **12.4.1.8** Annually, a water mist system with open nozzles shall be flushed.

12.4.2 Water Mist Nozzles.

12.4.2.1* Replacement water mist nozzles shall have the proper characteristics for the application intended, including the nozzle model and temperature rating.

A.12.4.2.1 Each water mist nozzle has unique requirements for protection applications and end-use limitations.

12.4.2.2 Only new water mist nozzles shall be used to replace existing water mist nozzles.

12.4.2.3* A supply of spare water mist nozzles (never fewer than three) shall be maintained on the premises so that any water mist nozzles that have operated or been damaged in any way can be promptly replaced.

A.12.4.2.3 A minimum of two water mist nozzles of each type and temperature rating installed should be provided.

12.4.2.3.1 The water mist nozzles shall correspond to the manufacturer(s), models, and temperature ratings of the water mist nozzles in the property.

12.4.2.3.2 The automatic water mist nozzles shall be kept in a cabinet located where the temperature will at no time exceed 100°F (38°C).

12.4.2.3.3 The stock of spare thermally activated nozzles shall include all types and ratings installed and shall be as follows:

(1) For systems having fewer than 50 nozzles, not fewer than 3 nozzles
(2) For systems having 50 to 300 nozzles, not fewer than 6 nozzles
(3) For systems having 301 to 1000 nozzles, not fewer than 12 nozzles
(4) For systems having over 1000 nozzles, not fewer than 24 nozzles

12.4.2.4* Where required by the manufacturer, a special water mist nozzle wrench shall be provided and kept in the cabinet to be used for the removal and installation of nozzles.

A.12.4.2.4 Other types of wrenches could damage the water mist nozzles.

12.4.2.4.1 One water mist nozzle wrench shall be provided for each type of nozzle installed.

12.4.2.5 Protective Coverings.

12.4.2.5.1 Water mist nozzles protecting spray areas and mixing rooms in resin application areas installed with protective coverings shall continue to be protected against overspray residue so that they will operate in the event of fire.

12.4.2.5.2* Water mist nozzles installed as described in 12.4.2.5.1 shall be protected using cellophane bags having a thickness of 0.003 in. (0.076 mm) or less or thin paper bags.

A.12.4.2.5.2 Typical sandwich bags purchased in a grocery store are generally plastic, not cellophane. Plastic bags have a tendency to shrink and adhere to the nozzles prior to nozzle activation, creating the potential for disruption of nozzle spray pattern. Bags placed over nozzles need to be cellophane or paper.

12.4.2.5.3 Coverings shall be replaced periodically so that heavy deposits of residue do not accumulate.

12.4.2.6 Water mist nozzles shall not be altered in any respect or have any type of ornamentation, paint, or coatings applied after shipment from the manufacturer.

12.4.2.7 Automatic water mist nozzles used for protecting commercial-type cooking equipment and ventilating systems shall be replaced annually.

12.4.2.7.1 Where automatic water mist nozzles are used and annual examination shows no buildup of grease or other material on the nozzles, the nozzles shall not be required to be replaced.

N **12.4.3 Pneumatically Operated Standby Pumps.** Pneumatically operated standby pumps shall be rebuilt every 5 years or as specified by the manufacturer.

12.5 Training.

12.5.1 All persons who might be expected to inspect, test, maintain, or operate water mist systems shall be trained thoroughly in the functions they are expected to perform.

Most manufacturers of water mist systems equipment provide training on their equipment. Some manufacturers provide certificates for confirmation that specific employees have completed the specialized training.

In addition to familiarity with the various types of hardware encountered in water mist systems, it is important that the service provider be familiar with the features and limitations of the particular system. The service provider should obtain and study all of the system documentation provided before beginning testing or maintenance work on the system.

12.5.2 Refresher training shall be provided as recommended by the manufacturer or by the authority having jurisdiction.

New technology and procedures in water mist systems are being introduced with increasing speed — this necessitates that continuing education should be undertaken at a similar speed. The investment in ongoing training usually provides a significant return by helping to prevent large capital expenditures for replacing neglected equipment, with the ultimate return evident when a system operates as intended and prevents a catastrophic loss. In addition, personnel changes in an ITM service company can result in an employee who received specialized training leaving the company. It is intended that all employees who work on a water mist system receive the specialized training provided by the manufacturer.

Case In Point

Annex D of NFPA 750 provides a Water Mist System Questionnaire that is intended to collect information on the reliability of water mist systems. If a water mist system operates for any reason, either accidentally or due to fire, it is likely that the ITM service provider will be involved in restoring the system. It would be valuable if the service provider would consent to completing and sending the questionnaire to the NFPA staff liaison responsible for NFPA 750.

References Cited in Commentary

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

Cote, A. E., ed., *Fire Protection Handbook®,* 20th edition, 2008.

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2019 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, 2019 edition.

NFPA 72®, *National Fire Alarm and Signaling Code®*, 2019 edition.

NFPA 750, *Standard on Water Mist Fire Protection Systems*, 2019 edition.

NFPA

What Are Common Components and Valves?

Components and valves listed in Chapter 13 of NFPA 25 are those components of a fire protection system that are common to several systems covered by NFPA 25. Instead of repeating the requirements for these components in their individual chapters, they are located in this chapter to avoid repetition.

Types of Valves

Control Valves

A control valve is a valve that controls the flow of water to a water-based fire protection system. With this valve closed, water does not enter the system.



Courtesy of Watts

Pressure Reducing Valves

A valve designed to reduce the downstream water pressure.



Courtesy of Cla-Val Company

Relief Valves

A device that allows the diversion of liquid to limit excess pressure in a system.



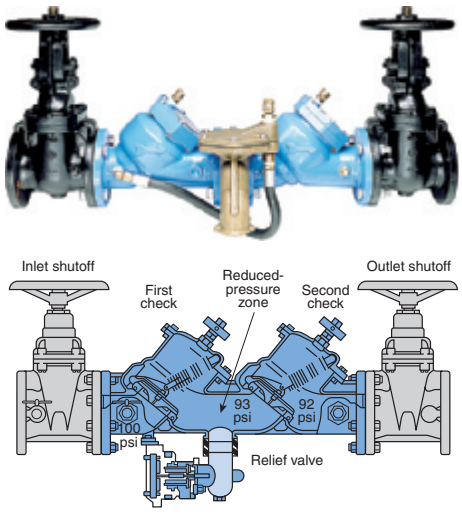
Courtesy of Victaulic Bermad Technologies, LLC

Backflow Prevention Assemblies

A backflow prevention assembly is used to prevent backflow in a system. It is typically made out of two check valves and two shutoff valves but can also include a pressure relief valve or a water meter. These are used in fire protection systems to prevent the fire protection water that sits static for long periods of time from entering the city water supply or potable water supply.



Courtesy of Watts



Fire Department Connections

A fire department connection (FDC) is a connection through which the fire department can pump additional water into a water-based fire protection system to supplement both flow and pressure of the normal water supplies.



Automatic Detection Equipment

Automatic detection equipment is equipment that automatically detects heat, flame, products of combustion, flammable gases, or other conditions likely to produce fire or explosion. Some of the systems addressed by NFPA 25 rely on detection equipment to activate the flow of water. The ITM for automatic detection equipment, is provided in *NFPA 72®*, *National Fire Alarm and Signaling Code®*.



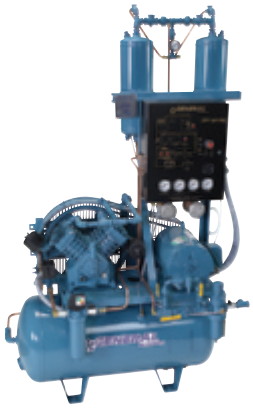
Courtesy of System Sensor Corp



Courtesy of Edwards

Air Compressors

An air compressor converts power, typically using an electric motor into pressurized air. Air compressors are commonly used to provide air in dry or preaction system.



Courtesy of General Air Products, Inc

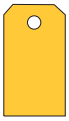
ITM

The inspection, testing, and maintenance (ITM) of these common components and valves are all important to the overall functionality of the system. They all have the potential to prevent the system from operating properly if not appropriately inspected, tested, and maintained.

Valves, Valve Components, and Trim Inspection and Testing



NO DEFICIENCIES OR IMPAIRMENTS



NONCRITICAL DEFICIENCIES

- Gauges not operating or damaged
- Gauges not replaced or calibrated in 5 years, not accurate within 3% of scale
- Control valve not accessible, no appropriate wrench if required, no identification
- Hose connection pressure-reducing valves — cap missing
- Missing identification sign for fire department connection
- Automatic air maintenance device for preaction valve did not pass test



CRITICAL DEFICIENCIES

- Gauges not showing normal water/air pressure
- Control valve in improper open position, leaking
- Control valve not sealed, locked, or supervised
- External physical damage to alarm valve, trim valves not in appropriate open or closed position, retard chamber or alarm drain leaking
- Upon visual observation, valve enclosure not maintaining minimum 40°F (4°C) temperature
- Low temperature alarms for valve enclosure (if installed) are physically damaged
- External physical damage to preaction valve and deluge valve, trim valves not in appropriate open or closed position, valve seat leaking
- External physical damage to dry pipe valve/quick-opening device, trim valves not in appropriate open or closed position, intermediate chamber leaking
- Sprinkler pressure-reducing control valves not maintaining downstream pressures in accordance with design criteria
- Sprinkler pressure-reducing control valves leaking, valve damaged, hand wheel missing or broken
- Hose connection pressure-reducing valves hand wheel broken or missing, hose threads damaged, leaking, reducer missing
- Hose rack assembly pressure-reducing valve hand wheel broken or missing, leaking
- Hose valves leaking, visible obstructions, caps, hose threads, valve handle, cap gasket, no restricting device, damaged, or in poor condition
- Reduced-pressure backflow prevention assemblies, differential-sensing valve relief port continuously discharging
- Fire department connection couplings and swivels damaged, do not rotate smoothly, check valve leaking, automatic drain not operating properly or missing
- Main drain test — more than 10% drop in full flow pressure
- Water motor and gong not functioning
- Alarm device pressure switch or vane-type switch not functioning, no alarm
- Control valve not operating through its full range
- Supervisory switches — no signal from two revolutions of hand wheel from normal position or when stem has moved one-fifth of distance from normal position, signal restored in position other than normal
- Preaction valve — priming water level not correct
- Preaction valve — three-year leakage test failed
- Deluge valve — pressure reading at hydraulically most remote nozzle and/or at valve not compatible with original design values
- Preaction valve — low air pressure switch did not send signal, no alarm
- Preaction and deluge valve — low temperature switch did not send signal, no alarm
- Dry pipe valve — priming water level not correct
- Dry pipe valve — test results not comparable with previous results
- Quick-opening device did not pass test
- Dry pipe valve — low air pressure switch did not send signal, no alarm
- Dry pipe valve — low temperature switch did not send signal, no alarm
- Dry pipe valve — automatic air maintenance device did not pass test
- Dry pipe system — three-year leakage test failed
- Sprinkler pressure-regulating control valves — test results not comparable to previous results
- Hose connection pressure-regulating valves — test results not comparable to previous results
- Hose rack assembly pressure-reducing valve — test results not comparable to previous results
- Hose valves (Class I and Class III standpipe system) — annual test revealed valve leaking or difficult to operate
- Hose valves (Class II standpipe system) — test revealed valve leaking or difficult to operate
- Air compressor and/or nitrogen generator unit does not start at required pressure, does not restore normal supervisory air pressure in required time frame, unit overheats while operating



IMPAIRMENTS

- Control valve in improper closed position
- Preaction valve and deluge valve electrical components not in service
- Sprinkler pressure-reducing control valves not in open position
- Hose valves — threads not compatible
- Fire department connection not accessible, damaged couplings, or clapper not operating properly or missing
- Control valve — no spring or torsion felt in rod when opening post indicator valve
- Deluge valve — annual full flow trip test revealed plugged nozzles, manual actuation devices did not operate properly
- Deluge valve does not trip during test
- Backflow prevention assembly did not pass minimum flow requirements for forward flow test

Source: Table A.3.3.8

13

COMMON COMPONENTS AND VALVES

Chapter 13 covers the inspection, testing, and maintenance (ITM) activities for components that are common to multiple systems. This includes valves, gauges, and other components that are found in most systems. The requirements of Chapter 13 apply anywhere the components addressed by this chapter are found on any of the water-based fire protection systems within the scope of NFPA 25. The chapter consolidates the ITM requirements for these common system components into one place, as opposed to repeating them in each chapter. Therefore, when inspecting, testing, and maintaining any water-based system, Chapter 13 should always be referenced, along with the requirements for specific hardware or components covered in the system-specific chapters.

One common system component is valves. Every type of water-based fire protection system has one or more valves that affect system operation. System and control valves form a critical part of any fire protection system; from the time the first fire protection systems were installed, both closed and partially closed valves have caused systems to not work as intended, resulting in major fire loss. A fully maintained and tested fire sprinkler or fire pump system will only work well as long as the valves controlling the system are fully open. Thus, a comprehensive ITM program is not complete without diligence to constantly ensure system valves and associated components operate correctly and are in the correct position.

Although system control valves are not necessarily complex, they do require specialized care by a qualified contractor to remain functional throughout their life cycle. Additionally, when a fire protection system control valve must be closed for any reason, the requirements in Chapter 15 must also be implemented.

FAQ What does the term *trim* refer to in relation to water-based fire protection systems?

Trim is a term not defined in any NFPA water-based fire protection system document, including NFPA 13, *Standard for the Installation of Sprinkler Systems*, NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, or NFPA 25. The term is loosely used in NFPA 25 to reference equipment that is peripheral to the primary fire system components. For example, pressure gauges could be considered trim on alarm valves, sprinkler risers, and fire pumps. And alarm check valves have trim that might include pressure gauges, a main drain valve and piping, a water motor gong, and a water motor gong retard chamber.

Some types of trim have specific ITM requirements and some do not. As such, the proper maintenance of trim is required because trim is considered a component of the primary equipment that it supports. Some types of trim, such as a gauge, have requirements to be listed. However, other types of trim, such as main drain lines, do not. Additionally, some types of trim, such as a quarter-turn valve on a dry pipe valve, are not required to be specifically listed, but might be listed as part of an assembly. Some components also must be listed

but do not hold listings for fire service and vice versa. Such is the case with jockey pumps that could be considered to be trim to a fire pump assembly.

13.1* General.

A.13.1 *Alarm Valves.* Alarm valves are installed in water-based fire protection systems to sound a fire alarm when a flow of water from the system equals or exceeds the flow of a single discharge device. A retarding chamber, which minimizes false alarms due to surges and fluctuating water supply pressure, can be supplied with the alarm valve.

An alarm valve is a regular swing check valve with several trim options to allow for a water motor gong alarm connection. The alarm trim options provide pipe to a water motor alarm gong for the purpose of generating a waterflow alarm. The water motor gong retard chamber is used to snub water pressure surges, which could create false local alarms. In many systems, a water gong is replaced by an electrically operated annunciator, which may or may not be connected or operated by an alarm check trip. Exhibit 13.1 shows a piping system that includes an alarm check valve with a hydraulically operated water motor gong as the alarm trim option (see also Exhibit 13.2).

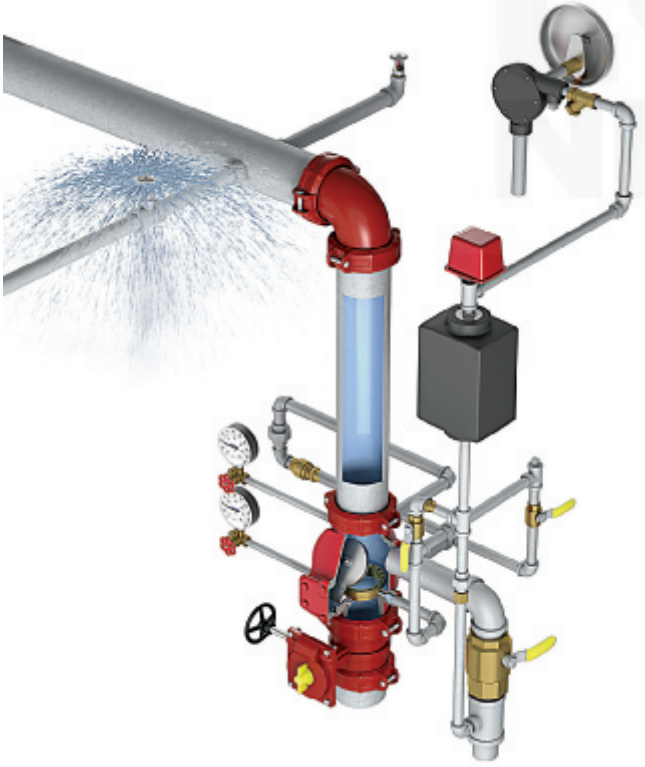


EXHIBIT 13.1 *Wet Pipe System Riser with Alarm Valve and Trim. (Courtesy of Jesse Cappon and Viking®)*

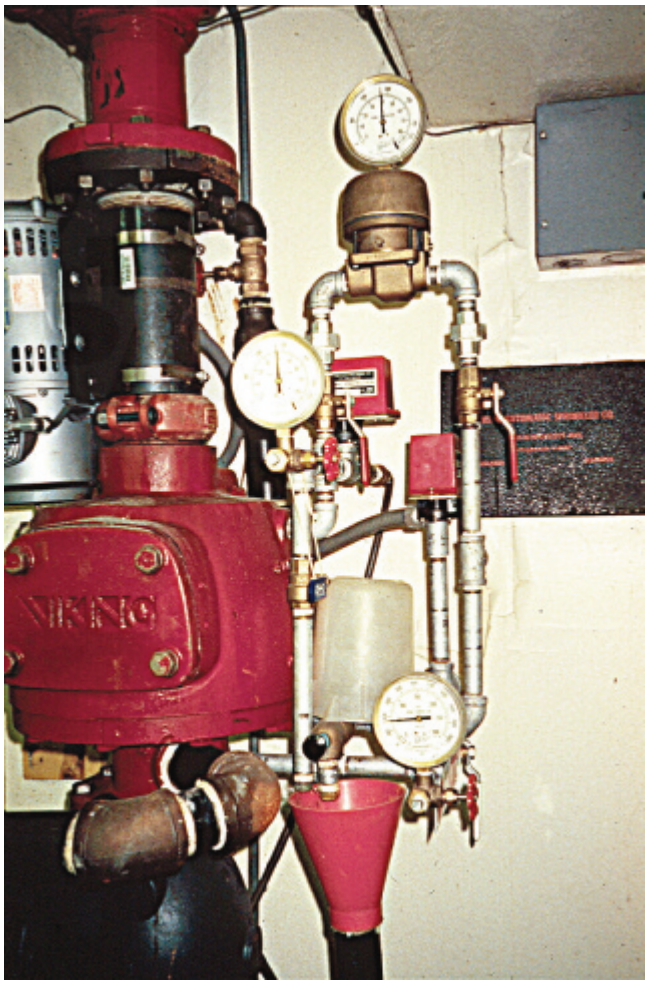


EXHIBIT 13.2 *Pressure Type Waterflow Alarm on Sprinkler System Riser Bypass Line.*

Exhibit 13.3 shows a typical trip arrangement and a connection for an optional alarm pressure switch that could also be connected to annunciate -+ an electric bell. This switch is shown in Exhibit 13.4.

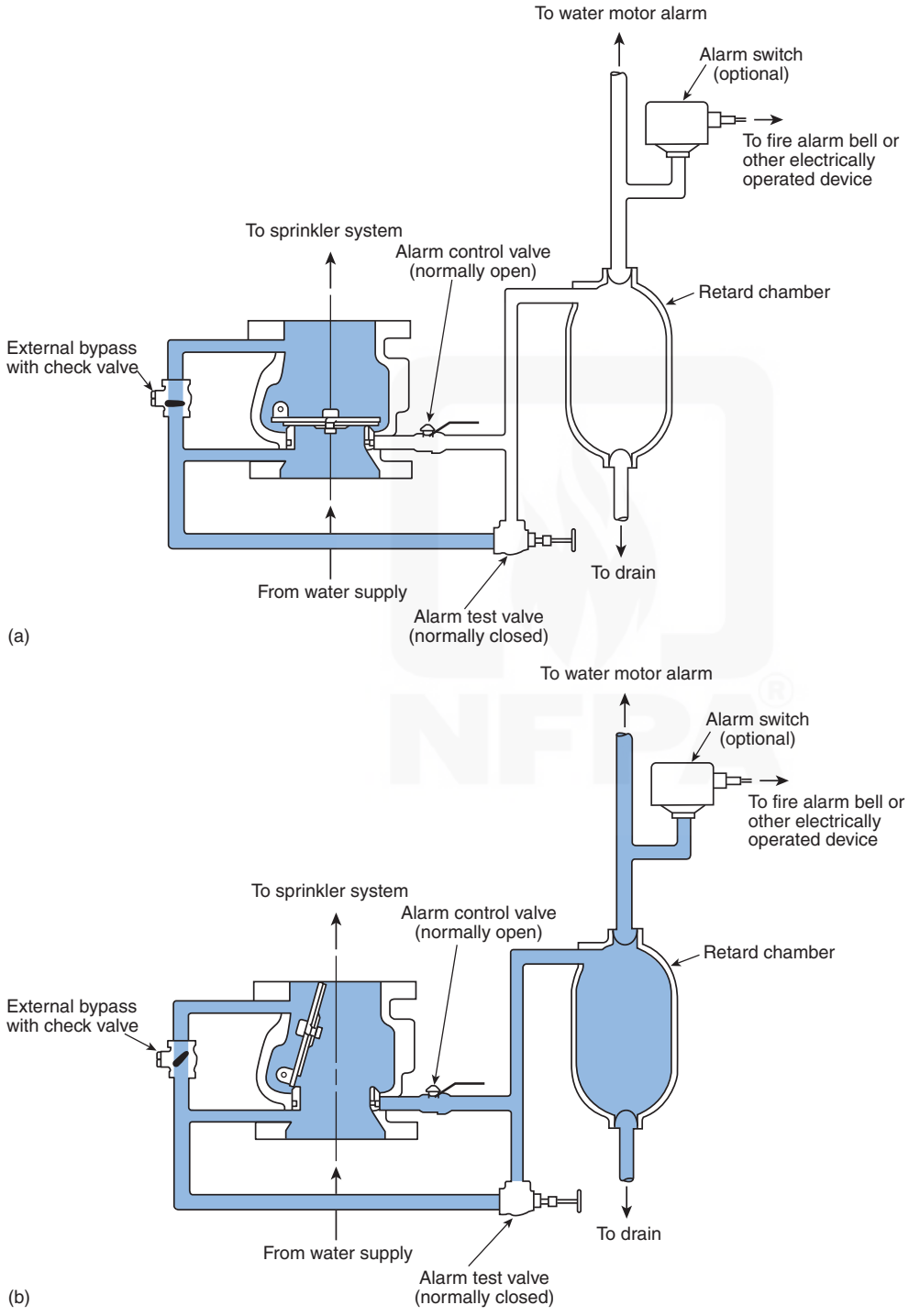


EXHIBIT 13.3 *Pressure Type Waterflow Alarm on Standard Alarm Check Valve: (a) Closed (Set) and (b) Open (Activated).*



EXHIBIT 13.4 *Pressure Type Waterflow Alarm Switch. (Courtesy of Potter Electric Signal Company, LLC)*

Backflow Prevention Devices. Backflow prevention devices are used to prevent water in a fire protection system from entering the public water supply due to a reverse flow of water, thermal expansion, hydraulic shock, back pressure, or back siphonage. *[See Figure A.13.1(a).]*

Backflow prevention devices, which are commonly called backflow assemblies when installed with valve trim, are not required for fire protection purposes by NFPA 13. They are typically required on fire systems connected to potable water sources by private and municipal water companies. These are installed as part of efforts to comply with the Safe Drinking Water Act, the 1974 federal law that requires that all suppliers (both public and private) guarantee their consumers receive clean drinking water and protection from water supply contamination.

Specific installation requirements are based on enforcement by local water authorities and can vary between municipalities. The type of backflow apparatus required to be installed is typically based on the type of fire systems installed on the premises. The municipal enforcement is based on the perceived risk of contamination from the fire system to the municipal water supply. For example, systems that have antifreeze or foam concentrates in the systems typically require a more sophisticated type of backflow apparatus. And this

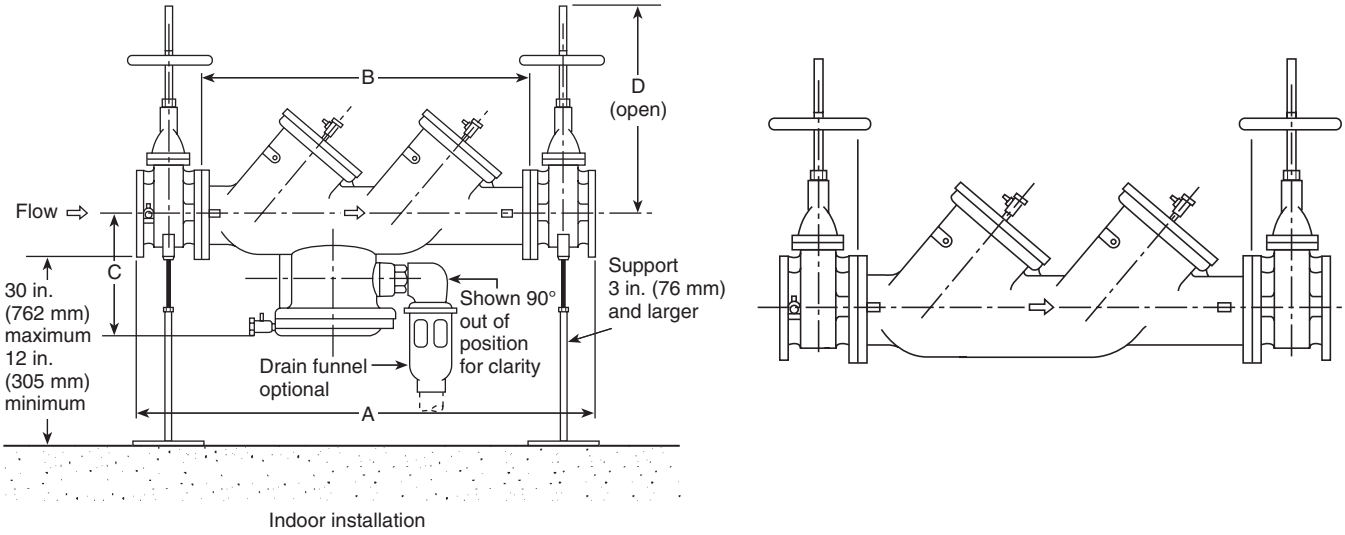


FIGURE A.13.1(a) *Reduced-Pressure Backflow Preventers (left) and Double Check Valve Assemblies (right).*

determination, where enforced, normally references the American Water Works Association Manual M14, *Recommended Practice for Backflow Prevention and Cross-Connection Control.*

There are two primary types of backflow prevention devices used in fire protection systems: a reduced-pressure (RP) type and a double check (DC) type. Both are required to be listed as complete assemblies that include shutoff valves and test cocks at each end of the apparatus. The double check type can sometimes include air gap trim, which provides an air gap barrier to virtually eliminate any chance of backflow.

A reduced-pressure backflow preventer consists of two independently acting, spring-loaded check valves with a hydraulically operating, mechanically independent, spring-loaded pressure differential relief valve between the check valves and below the first check valve. These provide a level of protection higher than a standard double check valve assembly, which consists only of two independently acting, spring-loaded check valves.

While NFPA 13 does not require the backflow preventer to be installed as part of a fire protection system, it does require that, if installed, a means be included downstream to flow test them regularly per NFPA 25. Poorly performing backflow check valve assemblies can result in an impaired fire protection sprinkler system. Backflow assemblies must be listed. Part of this listing for use in a fire protection system includes evaluations for durability, reliability, and flow characteristics. Each assembly has flow characteristics that show pressure drop related to flow. This must be evaluated with system demands, especially when installed on a pre-existing system. For more information on the testing requirements for backflow prevention assemblies, see Section 13.7 and associated commentary.

Ball Valves. Ball valves are manually operated through their full range of open to closed positions with a one-quarter turn.

Ball valves cannot be used for controlling fire protection system water supplies or sprinkler system operation. NFPA 13 requires that listed indicating valves be used where controlling connections *to* water supplies and sprinkler systems. NFPA 13 also requires that all valves listed for fire service control not be designed to close in less than 5 seconds when operated at maximum speed. The purpose of this second requirement is to prevent water hammering and valve damage; this eliminates ball valves as they can quickly be closed with a quarter turn. Thus, ball valves are only used for trim on alarm valves or to control waterflow discharge *from* sprinkler systems on inspector's test connections, auxiliary drains, and main drain valves. Ball valves are not required to be listed, but some that are installed in inspector's tests connections are for use other than for fire system control. Exhibit 13.5 shows a ball valve commonly used on an inspector's test connection. Exhibit 13.6 shows a listed combination auxiliary drain and inspector's test valve.

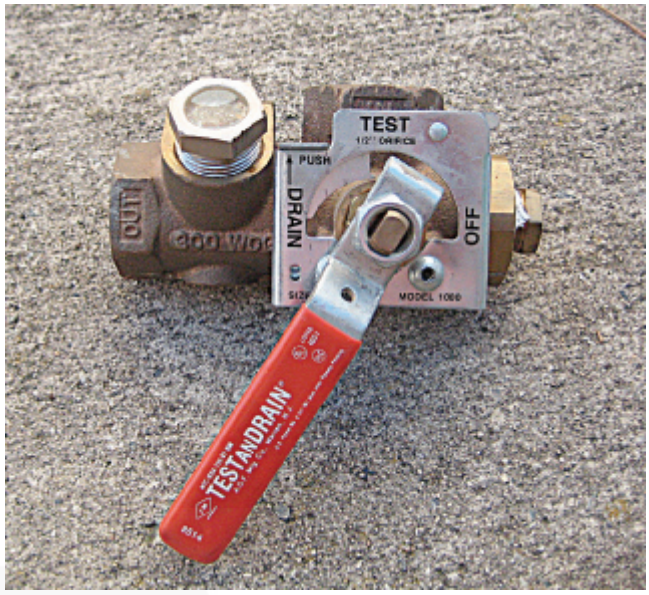


EXHIBIT 13.5 *Typical Ball Valve. (Courtesy of Potter Electric Signal Company, LLC)*



FIGURE A.13.1(b) *Butterfly Post Indicator Valve. (Courtesy of Henry Pratt Co.)*

EXHIBIT 13.6 *Listed Combination Auxiliary Drain and Inspector's Test Valve.*



Butterfly Valves. Butterfly valves are water supply control valves with gear operators to assist in opening and closing. Butterfly valves can be of the wafer or grooved-end type. *[See Figure A.13.1(b).]*

Butterfly valves, such as the one shown in Exhibit 13.7, are typically used as a lighter, less-expensive alternative to outside screw and yoke (OS&Y) valves. They are indicating and are usually equipped with a factory-installed tamper switch. There are specific restrictions to their use in NFPA 20 on suction supplies for fire pumps.

Check Valves. Check valves allow waterflow in one direction only. *[See Figure A.13.1(c).]*

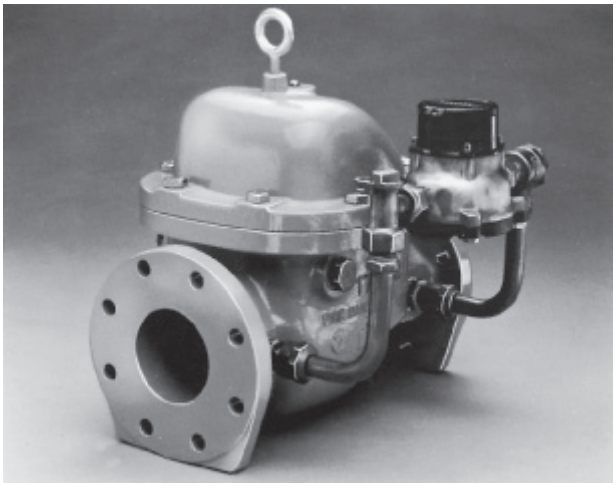


FIGURE A.13.1(c) *Detector Check Valve.*

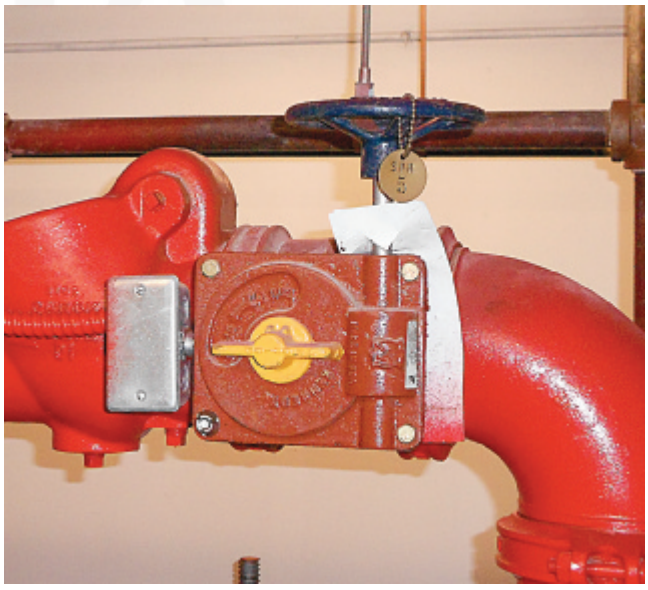


EXHIBIT 13.7 *Butterfly Valve.*

DCA. A double check assembly (DCA) consists of two independently operating spring-loaded check valves. The assembly includes two resilient-seated isolation valves and four test cocks required for testing.

DCDA. A double check detector assembly (DCDA) is hydraulically balanced to include a metered bypass assembly to detect system leakage. The main valve assembly and bypass assembly afford equal levels of backflow prevention and are each equipped with two resilient-seated isolation valves and four test cocks required for testing.

Deluge Valves. Deluge valves hold water at the valve until actuated by the operation of a detection system or manual release. *[See Figure A.13.1(d).]*

See Exhibit 13.8 for an illustration of a double check detector assembly (DCDA) valve. Backflow assemblies can be found mounted vertically, but they must be listed for installation in that orientation. Some types are also reconfigured for space requirements and other considerations, as shown in Exhibit 13.9 and Exhibit 13.10.



EXHIBIT 13.8 *Typical Double Check Detector Assembly.*

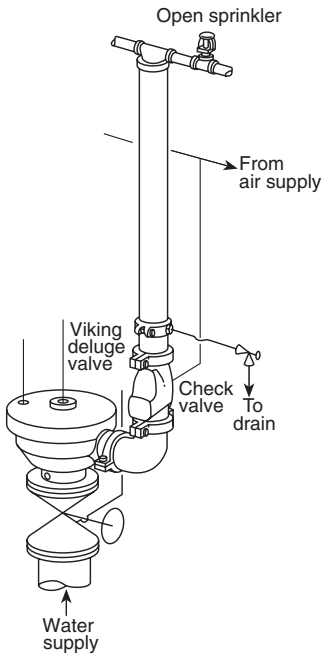


FIGURE A.13.1(d) *Deluge Valve.*

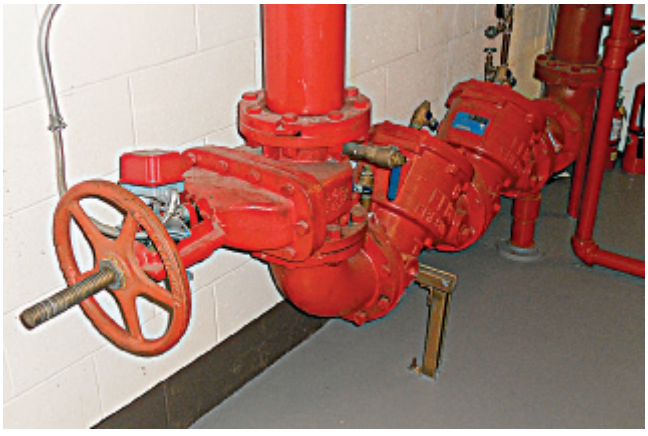


EXHIBIT 13.9 *Backflow Preventer with Outside Screw and Yoke (OS&Y) Valve with Its Position Supervised by a Tamper Switch.*



EXHIBIT 13.10 *Backflow Preventer and Fire Department Connection. (Courtesy of American Fire Sprinkler Association)*

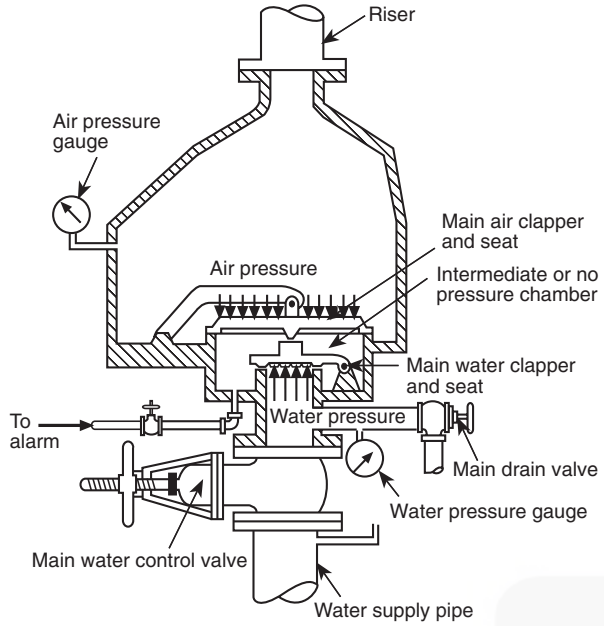


FIGURE A.13.1(e) *Dry Pipe Valve.*

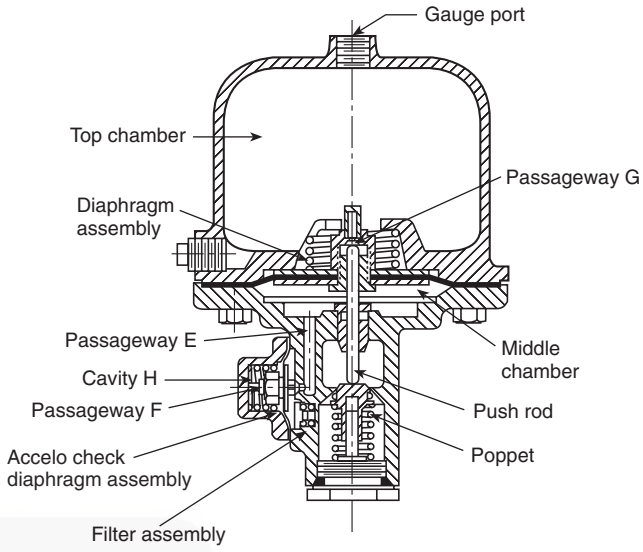


FIGURE A.13.1(f) *Dry Pipe System Accelerator. (Courtesy of The Reliable Automatic Sprinkler Co., Inc.)*

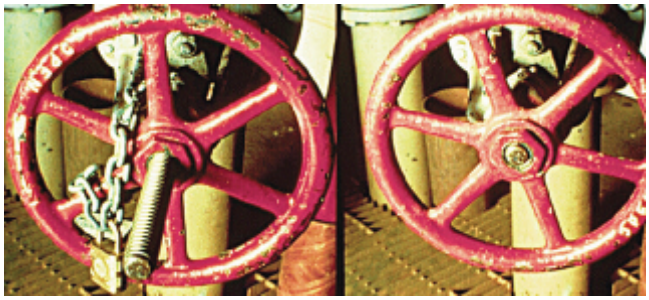
Drip Valves. Drip valves automatically drain condensation or small amounts of water that have leaked into system piping or valves. Drip valves close when exposed to system pressure.

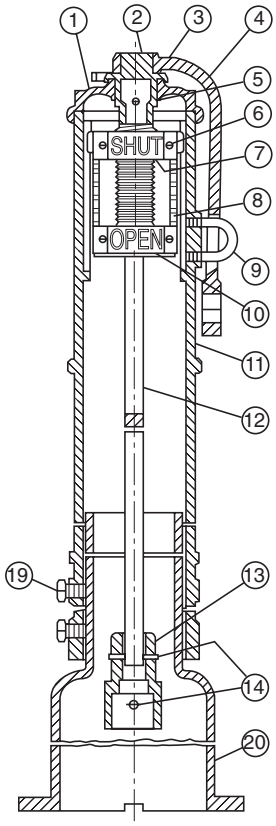
Dry Pipe Valves. Dry pipe valves control the flow of water to areas that could be exposed to freezing conditions. Water is held at the valve by air pressure in the system piping. When the air pressure is reduced, the valve operates and floods the system. *[See Figure A.13.1(e) and Figure A.13.1(f).]*

Indicating Valves. Indicating valves provide a dependable, visible indication of the open position, even at a distance.

Exhibit 13.11 shows two OS&Y valves: one open and one closed. The stem of the valve on the right is flush with the hand wheel or yoke, so it visually indicates being in the closed position. The open status of the valve on the left is indicated by the protruding stem. Valves controlling connections to water supplies and water supplies to sprinklers must be an indicating type valve per NFPA 13. There is an exception for permitting the use of roadway-box type gate valves under certain conditions and where use is acceptable to the authority having jurisdiction (AHJ). These conditions include a requirement that an on-site T-wrench be accessible to open or close the valve in an emergency.

EXHIBIT 13.11 *OS&Y Indicating Valves Showing Open (left) and Closed (right).*





Parts list	
No	Description
1	Cap
2	Operating stem
3	Operating stem oil hole screw
4	Operating wrench
5	Retaining ring
6	Target plate screw and nut
7	Target plate — shut
8	Target
9	Indicator post staple
10	Target plate — open
11	Indicator post
12	Extension rod — specify length
13	Extension rod coupling
14	Coupling pin
15	Window glass
16	Window frame
17	Window frame screw
18	Cap bolt and nut
19	Set screw
20	Sleeve bonnet

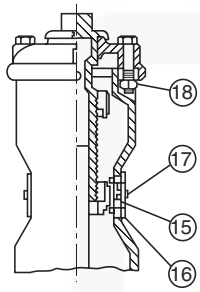


FIGURE A.13.1(g) *Vertical Indicator Post.*

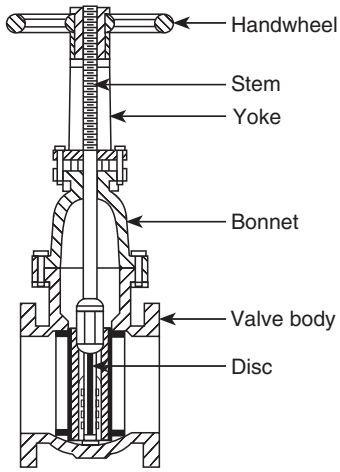


FIGURE A.13.1(h) *OS&Y Gate Valve.*

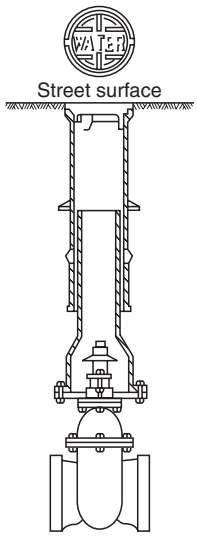


FIGURE A.13.1(i) *Nonindicating-Type Gate Valve.*

Indicator Posts. Indicator posts include wall and underground types and are intended for use in operating inside screwed pattern gate valves and for indicating the position of the gates in the valves. *[See Figure A.13.1(g).]*

NRS Gate Valves, OS&Y Gate Valves. Nonrising stem (NRS) gate valves are used underground with indicator posts attached or as roadway box valves (curb-box installation). Outside screw and yoke (OS&Y) gate valves are used indoors and in pits outdoors. The valve stem moves out when the valve is open and moves in when it is closed. The stem indicates the position of the valve. *[See Figure A.13.1(h) and Figure A.13.1(i).]*

Care should be taken when inspecting indicator posts connected to underground nonrising stem (NRS) valves. It is important to verify that the indicator post is set with the "target" indicating the correct position of the valve ("open" or "shut"). When fully closing and opening the valve during the annual test, it is best practice to count and record the number of revolutions, which will provide an indication of the position of the valve for comparison to future tests. This number should be included in test forms as well. The manufacturer should be contacted for the number of turns needed to fully open or close a particular valve if it is not known and an issue is suspected.

RPA. A reduced-pressure zone principle assembly (RPA) consists of two independently spring-loaded check valves separated by a differential-sensing valve. The differential-sensing valve includes a relief port to atmosphere that discharges excess water resulting from supply system fluctuations. The assembly includes two resilient-seated isolation valves and four test cocks required for testing.

RPDA. A reduced-pressure detector assembly (RPDA) is hydraulically balanced to include a metered bypass assembly to detect system leakage. The main valve assembly and bypass assembly afford equal levels of backflow prevention, and each assembly is equipped with two resilient-seated isolation valves and four test cocks required for testing.

Strainers. Strainers are used for protection against clogging of water discharge openings.

Waterflow Detector Check Valves. Detector-type check valves allow flow in one direction only and have provisions for the connection of a bypass meter around the check valve. *[See Figure A.13.1(c).]*

13.1.1 Minimum Requirements.

13.1.1.1 This chapter shall provide the minimum requirements for the routine inspection, testing, and maintenance of common components and valves.

The term *valve* as used in this standard includes valves that are used to control water supplies, sprinkler systems, and trim valves. NFPA 13 requires that listed indicating valves be used where controlling connections *to* water supplies and sprinkler systems. These valves must be listed for fire service. The term *valve* also includes valves considered to be trim used to control waterflow discharge *from* sprinkler systems. These can, but are not required to be, individually listed. Some valves that control water flow *from* fire protection systems or are secondary as trim are specifically excluded in NFPA 13 from the listing requirement, including hose valves, inspector's test valves, drain valves, relief valves, or trim valves for dry pipe, preaction, and deluge valves. This chapter also covers backflow prevention apparatus valves, which are typically standard OS&Y valves that are attached to a backflow device and then included as part of an installed backflow assembly.

NFPA 13 states that all materials and devices essential to successful system operation shall be listed. however, it specifically indicates that components that do not affect system performance are not required to be listed. This includes valve trim valve components, which therefore do not need to be individually listed. The Underwriters Laboratories (UL) listing program for valves classifies the various types as follows (shown with the specific UL testing protocol):

- ANSI/UL 193, *Alarm Valves for Fire-Protection Service*
- ANSI/UL 260, *Dry Pipe and Deluge Valves for Fire-Protection Service*
- UL 262, *Gate Valves for Fire-Protection Service*
- ANSI/UL 312, *Check Valves for Fire-Protection Service*
- UL 1091, *Butterfly Valves for Fire-Protection Service*
- Subject 258, *Outline of Investigation for Shutoff Valves for Trim and Drain Purposes*

Exhibit 13.12 illustrates a post indicator valve (PIV) and Exhibit 13.13 shows a wall post indicator valve (WPIV), which are both types of control gate valves.

13.1.1.2 Table 13.1.1.2 shall be used to determine the minimum required frequencies for inspection, testing, and maintenance.

Case In Point

The term *valve components* can refer to the parts that make up an operational assembly or control valve. These components can also be called *trim*. *Trim* refers to the exterior parts of an operational valve or system component, such as the valve components (piping and smaller ball valves) that make up an alarm check valve or the connection to a water motor gong and retard chamber. A main drain valve connection could also be considered trim on a sprinkler riser.

Δ ***TABLE 13.1.1.2*** *Summary of Valves, Valve Components, and Trim Inspection, Testing, and Maintenance*

Item	*Frequency*	*Reference*
Inspection		
Alarm Valves		
Exterior	Quarterly	13.4.1.1
Interior	5 years	13.4.1.2
Strainers, filters, orifices	5 years	13.4.1.2
Backflow Prevention Assemblies		
Reduced pressure	Weekly	13.7.1
Reduced-pressure detectors	Weekly	13.7.1
Interior	5 years	13.7.1.3
Check Valves		
Interior	5 years	13.4.2.1
Control Valves		
All valves except locked or supervised	Weekly	13.3.2.1
Locked or supervised	Monthly	13.3.2.1.1
Electrically supervised	Quarterly	13.3.2.1.2
Dry Pipe Valves/Quick-Opening Devices		
Enclosure (during cold weather)		Chapter 4
Exterior	Monthly	13.4.5.1.2
Interior	Annually	13.4.5.1.3
Strainers, filters, orifices	5 years	13.4.5.1.4
Low temperature alarm	Annually	Chapter 4
Deluge Valves		
Enclosure (during cold weather)	Daily/weekly	Chapter 4
Exterior	Monthly	13.4.4.1.1
Interior	Annually/5 years	13.4.4.1.2
Strainers, filters, orifices	5 years	13.4.4.1.3
Fire Department Connections	Quarterly	13.8.1
Gauges	Monthly/quarterly	13.2.5
Hose Valves	Quarterly	13.6.1
Preaction Valves		
Enclosure (during cold weather)		Chapter 4
Exterior	Monthly	13.4.3.1.1
Interior	Annually/5 years	13.4.3.1.2
Strainers, filters, orifices	5 years	13.4.3.1.3
Pressure-Regulating and Relief Valves		
Master pressure-regulating	Weekly	13.5.4.1
Sprinkler system pressure-reducing	Quarterly	13.5.1.1
Hose connection pressure-regulating	Annually	13.5.2.1
Hose rack pressure-regulating	Annually	13.5.3.1
Fire pump circulation relief	With no flow test	13.5.6.1
Fire pump main pressure-relief	With fire pump test	13.5.6.2.1
Valve Supervisory Signal Initiating Device	Quarterly	13.3.2.1.3
Supervisory Signal Devices (except valve supervisory switches)	Quarterly	13.2.6.1
Testing		
Backflow Prevention Assemblies	Annually	13.7.2
Control Valves		
Operation and position	Annually	13.3.3.1

(continues)

Δ ***TABLE 13.1.1.2*** *(Continued)*

Item	*Frequency*	*Reference*
Valve status test	After the control valve closed and reopened	13.3.3.4
Supervisory	Semiannually	13.3.3.5
Deluge Valves		
Trip test	Annually/3 years	13.4.4.2.3
Dry Pipe Valves/Quick-Opening Devices		
Air leakage	3 years	13.4.5.2.9
Priming water	Quarterly	13.4.5.2.1
Low air pressure alarm	Annually	13.4.5.2.6
Quick-opening devices	Quarterly	13.4.5.2.4
Trip test	Annually	13.4.5.2.2
Full-flow trip test	3 years	13.4.5.2.2.2
Gauges	5 years	13.2.5.2
Main Drains	Annually/quarterly	13.2.3
Preaction Valves		
Priming water	Quarterly	13.4.3.2.1
Low air pressure alarms	Quarterly	13.4.3.2.11
Trip test	Annually/3 years	13.4.3.2.2 and 13.4.3.2.3
Air leakage	3 years	13.4.3.2.6
Low-temperature alarm	Annually	13.4.3.2.12
Pressure-Regulating and Relief Valves		
Master pressure-regulating	Quarterly/annually	13.5.4.2 and 13.5.4.3
Sprinkler systems pressure-reducing	Annually/5 years	13.5.1.3 and 13.5.1.2
Hose connection pressure-regulating	Annually/5 years	13.5.2.3 and 13.5.2.2
Hose rack pressure-regulating	Annually/5 years	13.5.3.3 and 13.5.3.2
Fire pump circulation relief	With churn test	13.5.6.1.2
Fire pump pressure relief valves	With fire pump test	13.5.6.2.2
Hose Valves	Annually/3 years	13.6.2
Waterflow Alarms	Quarterly/semiannually	13.2.4
Supervisory Signal Devices (except valve supervisory switches)	Annually	13.2.6.2
Maintenance		
Alarm Valves	Per manufacturer	13.4.1.3
Backflow Prevention Assemblies	Per manufacturer	13.7.3
Check Valves	Per manufacturer	13.4.2.2
Control Valves (outside screw and yoke)	Annually	13.3.4
Deluge Valves	Annually/5 years	13.4.4.3
Dry Pipe Valves/Quick-Opening Devices	Annually	13.4.5.3
Hose Valves	As needed	13.6.3
Preaction Valves	Annually/5 years	13.4.3.3

In the 2017 edition, the ITM requirements for most common system components were relocated from other places in the standard to Chapter 13. For example, most systems addressed by NFPA 25 use gauges for measuring static pressure in the system, and the requirements for inspecting, testing, and maintaining these gauges appeared in most system-specific chapters (Chapter 5 through Chapter 12) prior to this change. Now, owners and ITM service



EXHIBIT 13.12 *Post Indicator Valve and Fire Department Connection. (Courtesy of Josh Elvove)*



EXHIBIT 13.13 *Wall Post Indicator Valve.*

providers can go to one place to find all the rules for gauges (except for use with fire pumps, see Chapter 8), regardless of what type of system they may be attached to.

13.2 General Provisions.

13.2.1 The property owner or designated representative shall have manufacturers' literature available to provide specific instructions for inspecting, testing, and maintaining the valves and associated equipment.

Case In Point

The manufacturers' literature mentioned in 13.2.1 refers to the operation and equipment maintenance (OEM) manuals as required by the Contractor's Material and Test Certificate at the time of installation.

The OEM manuals are an excellent source of information for the inspector and maintenance contractor; they should include a system narrative report that describes all aspects of the initial construction project and a complete list of equipment installed, including the contact information for the equipment suppliers. These documents should also include operation and maintenance instructions for all system components, any previous inspection or test reports, and recommended spare parts. Section 4.3 contains the minimum requirements for the maintenance of these records.

Tip for Owners

The phrase *property owner or designated representative* in 13.2.1 applies to whoever is responsible for the ITM of the equipment (see Section 4.1). Any portion of the ITM — or all of it — is permitted to be contracted with an ITM service. However, the ultimate responsibility falls on the building owner unless these responsibilities have been contractually transferred.

13.2.2* All system valves shall be protected from physical damage and shall be accessible.

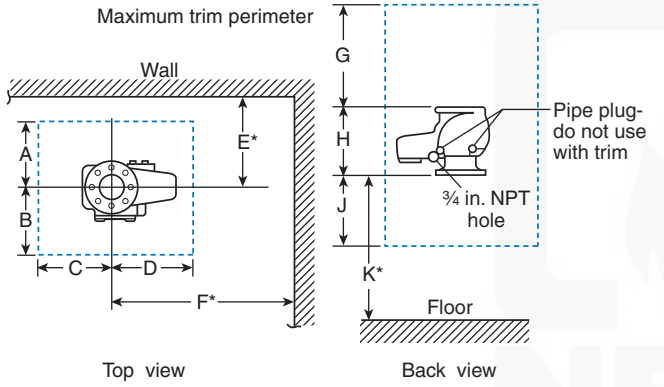
A.13.2.2 The valves are not required to be exposed. Doors, removable panels, or valve pits can be permitted to satisfy this requirement. Such equipment should not be obstructed by features such as walls, ducts, columns, direct burial, or stock storage.

Tip for Owners

If such a manual is not present, the owner should ask the maintenance contractor to provide one for future reference, complete with a telephone number for emergency service. See NFPA 3, *Recommended Practice for Commissioning of Fire Protection and Life Safety Systems*, for more information and guidance on this topic.

NFPA 13 indicates that all control valves must be accessible — and accessible without obstructions that must be moved — but otherwise provides little specific guidance. *Accessible* is not defined in Chapter 3 of NFPA 25, but annex guidance is provided for this section and for 4.1.3. Also see the commentary following 4.1.3 for more information. Most manufacturers, however, will provide specific clearance dimensions for their valves in product data literature. These dimensions should be maintained on all sides of the valve.

For example, operational valves and alarm check, dry pipe, and deluge valves on sprinkler system risers should have adequate clearance on all sides to allow accessibility for normal ITM activities. Exhibit 13.14 shows a typical valve clearance dimension diagram. The dimensions shown should be used as a minimum to maintain access to the valve for operation and maintenance purposes.



Dimension	2-½ in. (63.5 mm) valve	4 in. (101.6 mm) valve	6 in. (152.4 mm) valve
A	8-¾ in. (222.2 mm)	9-½ in. (241.3 mm)	9 in. (228.6 mm)
B	9 in. (228.6 mm)	10-¼ in. (260.3 mm)	11-¼ in. (285.7 mm)
C	9-¾ in. (247.6 mm)	9-¾ in. (247.6 mm)	11 in. (279.4 mm)
D	10-½ in. (266.7 mm)	15-¾ in. (400.0 mm)	13-½ in. (342.9 mm)
E*	12 in. (304.8 mm)	12-½ in. (317.5 mm)	15 in. (381.0 mm)
F*	24 in. (609.6 mm)	24 in. (609.6 mm)	24 in. (609.6 mm)
G	10-½ in. (266.7 mm)	7 in. (177.8 mm)	5 in. (127.0 mm)
H	9 in. (228.6 mm)	12-¼ in. (311.1 mm)	18 in. (457.2 mm)
J	9-¼ in. (234.9 mm)	10-¼ in. (260.3 mm)	5-¼ in. (133.3 mm)
K*	48 in. (1219.2 mm)	48 in. (1219.2 mm)	48 in. (1219.2 mm)

*These dimensions represent minimum recommended clearances.

EXHIBIT 13.14 *Typical Manufacturer's Valve Clearance Dimensions.*

Tip for Owners

It is not necessary to notify the AHJ when inspection activities will take place, because alarm initiating devices are not necessarily activated. However, when testing is conducted, alarms typically will be activated and the AHJ should be notified.

- **13.2.3* Main Drain Test.**

A main drain test shall be conducted annually for each water supply lead-in to a building water-based fire protection system to determine whether there has been a change in the condition of the water supply.

Δ **A.13.2.3** Main drains are installed on system risers for one principal reason: to drain water from the overhead piping after the system is shut off. This allows the contractor or plant maintenance department to perform work on the system or to replace nozzles after a fire or other incident involving system operation.

Data collected from the suction gauges during a fire pump flow test that test the water supply would satisfy the requirements for a main drain test.

Testing Procedure Alert

To assess the adequacy of the system's water source, a main drain test must be conducted. While the main drain test is not a quantifiable assessment of the flow and pressure, it will give the owner and inspector a general sense if there has been a reduction in flow when compared to the previous main drain test. A reduction in flow would alert the inspector and owner to a partially closed valve or obstruction, which might lead to an obstruction investigation. For more information on conducting a main drain test, including procedures for systems supplied by fire pumps and those that are not, refer to the testing procedure at the end of this chapter.

These drains also are used to determine whether there is a major reduction in waterflow to the system, such as could be caused by a major obstruction, a dropped gate, a valve that is almost fully closed, or a check valve clapper stuck to the valve seat.

A satisfactory main drain test (i.e., one that reflects the results of previous tests) does not necessarily indicate an unobstructed passage, nor does it prove that all valves in the upstream flow of water are fully opened. However, these tests provide a reasonable level of confidence that the water supply has not been compromised.

The main drain test is conducted in the following manner:

(1) Record the pressure indicated by the supply water gauge.
(2) Close the alarm control valve on alarm valves.
(3) Fully open the main drain valve.
(4) After the flow has stabilized, record the residual (flowing) pressure indicated by the water supply gauge.
(5) Close the main drain valve slowly.

FAQ What is the purpose of the main drain test?

The two major reasons to conduct a main drain test are to verify the following:

1. Water supply pressure is similar to the original acceptance test or to other previous tests.
2. A system control valve is not fully closed after having been closed and reopened during annual testing.

Exhibit 13.15 shows the discharge from a 2 in. (50 mm) main drain test. It is critical to understand that the purpose of a main drain test is not to confirm if a control valve is fully open, but to confirm that it is not fully closed. A main drain test might not reveal a partially closed valve in a large-diameter supply pipe. In most typical systems, a gate valve closure up to approximately 70 percent to 80 percent would not be detected with a main drain test, since the area still open under the gate is larger than the size of the main drain [typically a 2 in. (50 mm) diameter or about 6 percent of an 8 in. (200 mm) diameter pipe]. The results of the main drain test should be compared to those of reliable previous tests, including the original acceptance test. One good way to identify previous tests is to mark the static and residual marks on the gauge. This method also makes it easier to detect a 10 percent drop, as required by 13.2.3.3. This "alert" point can also be marked on gauges for reference.

Water damage that results from opening main drains and other test connections, without first verifying where water will flow to, is one of the most common causes of damage and customer complaints faced by inspectors. Before conducting tests that involve the flowing of water under pressure, the inspector should make sure that the area around the discharge fitting is clear. If the discharge is flowing into a floor drain or sink, the flow should be



EXHIBIT 13.15 *Discharge from a Main Drain Test.*

monitored to make sure that the drain is not clogged or undersized, since either situation could result in water spilling onto the floor and creating a hazard. If the discharge location is adjacent to a building's exterior, make sure water will not flow into trenches recently dug for construction, into dirt basins that could project rocks or mud at clean cars, onto walkways where pedestrians could slip, or into vegetation that could be destroyed.

Case In Point

In high-rise buildings that have sprinkler risers in the stairway, a separate drain line is often installed that is one diameter larger than the largest main drain valve connected to the drain line. The drain line should not be considered a main drain connection but should be viewed as an auxiliary drain for each floor. Unlike the main drain, the auxiliary drain is not intended to be flow tested. The auxiliary drain line can be used to conduct flow tests on pressure-regulating valves installed in the fire sprinkler system and in the fire department standpipe system. It can also be used to test the system flow switch.

13.2.3.1 Where the lead-in to a building supplies a header or manifold serving multiple systems, a single main drain test shall be permitted.

Both 13.2.3 and 13.2.3.1 make it clear that only one main drain test required by these sections is necessary, even when the water supply serves multiple systems. As indicated in the commentary following A.13.2.3, the purpose of the test is to assess water supply. Since, in these cases, there is a single water supply source (i.e., the lead-in into the building), the requirement is met with a single test. Conducting a main drain test at each riser is redundant and flows large volumes of water unnecessarily.

13.2.3.2 In systems where the sole water supply is through a backflow preventer and/or pressure-reducing valves, the main drain test of at least one system downstream of the device shall be conducted on a quarterly basis.

FAQ Why do backflow preventers in water supplies change the frequency of the main drain test requirement from annually to quarterly?

The intent of 13.2.3.2 is to exercise the backflow preventers by producing periodic flow through them. Fire protection systems are relatively static, only flowing when a fire occurs. The backflow prevention device was originally designed to be used for domestic water applications that continually cycle water through these devices. In a fire protection system where there is no day-to-day exercising of the equipment, a means is needed to regularly exercise them and determine that the components are still functioning properly.

13.2.3.3 When there is a 10 percent reduction in full flow pressure when compared to the original acceptance test or previously performed tests, the cause of the reduction shall be identified and corrected if necessary.

Note that the 10 percent reduction threshold includes both the original acceptance test and previously performed tests. A gradual degradation of the water supply might only result in a minor reduction in psi each test cycle, but when compared to the original, the potential problem would be more noticeable. The requirement in 13.2.3.3 does not necessarily require any corrective action for a water supply that exhibits lower pressure readings during the main drain test. However, it does require an investigation as to the cause of the depleted pressure. While a reduction in the available pressure from the attached water supply is a concern, it is critical that the water supply can still meet or exceed the system demand.

Testing Procedure Alert

A waterflow alarm device, such as a vane-type water flow switch, is the connection between the water-based system and the fire alarm system, ensuring that notification of a fire is not only sent to a notification appliance but also, in many cases, to the local fire department. For procedures of testing, both mechanical and electrical type waterflow alarm initiating devices, see the testing procedure at the end of this chapter.

ITM NFPA 25

13.2.4 Waterflow Alarm Devices.

N **13.2.4.1** Activation of the waterflow alarm device shall result in an audible alarm within 5 minutes after such flow begins and until such flow stops.

N **13.2.4.2** Activation of the initiating device shall occur within 90 seconds of waterflow at the alarm-initiating device when flow occurs that is equal to or greater than that from a single sprinkler of the smallest orifice size installed in the system. **[72:17.13.2]**

13.2.4.3 Mechanical Waterflow Alarm Devices, Including, but Not Limited to, Water Motor Gongs.

13.2.4.3.1 Mechanical waterflow alarm devices shall be inspected quarterly to verify that they are free of physical damage

13.2.4.3.2 Mechanical waterflow alarm devices shall be tested quarterly.

Mechanical waterflow devices use the actual flow of water to drive the alarm itself. Due to the design of some of these devices, water motor gongs in particular, and their location on the outside of buildings, debris such as birds' nests can physically block the striker arm from hitting the gong. Therefore, as required in 5.3.3.1, water motor gongs must be tested quarterly. According to 5.3.3.2, however, vane-type waterflow alarm devices (called paddle-type waterflow alarms in NFPA 13) and pressure switches only require semiannual testing for compliance with NFPA 25.

Historical Note

This difference in requirements is a result of the excellent performance record of vane-type waterflow alarm devices, which, after review, persuaded the NFPA 25 committee to change the testing frequency from quarterly to semiannually in the 2008 edition.

Quarterly visual inspections of waterflow alarm devices are still required per 5.2.4 of NFPA 25 to verify there has not been any physical damage to the device.

Exhibit 13.16 shows two vane-type waterflow alarm devices mounted in a sprinkler riser. See also Exhibit 13.4, which shows a typical riser-installed vane-type waterflow device, and Exhibit 13.2, which shows pressure waterflow alarm devices that are mounted on a water motor gong supply line or alarm bypass line.

See Exhibit 13.3, which illustrates the closed (set) position and the open (operating) position for an alarm valve. Exhibit 13.17 illustrates the closed (set) position and the open (activated) position for a deluge valve. Understanding the differences and installation limitations between the various valve positions is important for individuals conducting visual inspections on the devices. NFPA 13 prohibits paddle (i.e., vane-type) waterflow alarm devices on any systems other than wet pipe systems.

The waterflow alarm device test can have two purposes. One is an NFPA 13 requirement to measure the time to annunciate locally. The other is an *NFPA 72®, National Fire Alarm and Signaling Code®,* requirement to measure the time to annunciate on an alarm initiating device or at an alarm monitoring company, if provided. Both tests require a simulation of one sprinkler being activated. This must be based on the smallest orifice sprinkler on the system being tested. For example, if a building uses early suppression fast-response (ESFR) K-25 sprinklers in a warehouse area and K-5.6 sprinklers in an office area, and each are fed from separate system risers, the warehouse waterflow device test should simulate flow from an orifice equal in size to one K-25 sprinkler and the office system must be tested based on the flow from a K-5.6 orifice or smaller sprinkler. If systems supply sprinklers of more than one size, the system must be set to an orifice equal to or smaller than the smallest sprinkler. For example, if a building uses ESFR K-25 sprinklers in a warehouse area, and K-5.6 sprinklers

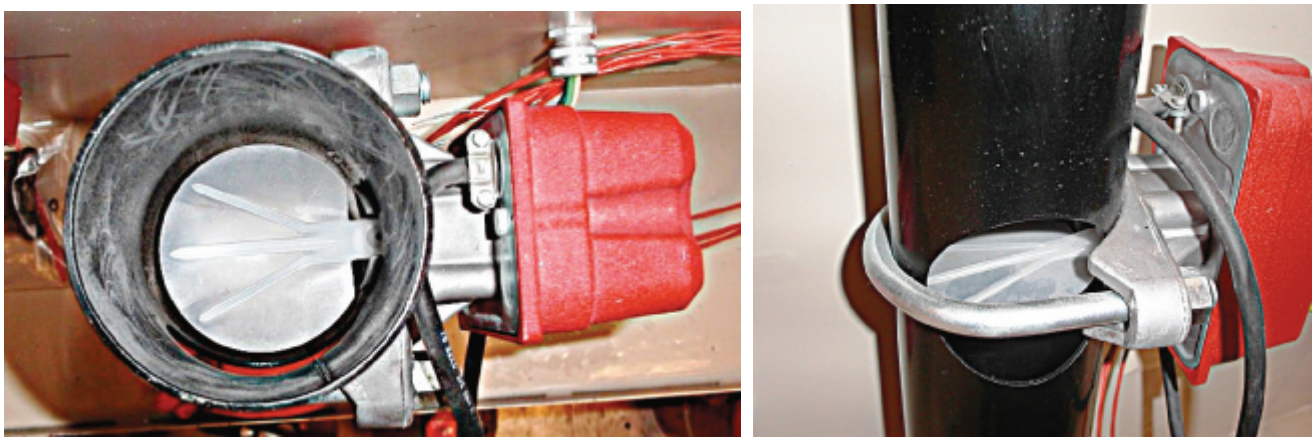


EXHIBIT 13.16 *Vane (or Paddle) Type Waterflow Alarm Devices.*

in an office fed from a common sprinkler riser, the building alarm test should simulate flow from an orifice equal in size to one K-5.6 orifice or smaller sprinkler.

Per Section 7.7 of NFPA 13, waterflow alarm devices must create an audible alarm on site within 5 minutes of one sprinkler activating. Per 17.13.2 of *NFPA 72,* waterflow alarm devices must create activation of the alarm initiating circuit locally and annunciate at a monitoring company within 90 seconds of one sprinkler head activating. Testing a waterflow alarm device is typically completed by opening an inspector's test valve or alarm bypass valve and recording the time. For locations that have alarm monitoring companies, the operator at this location must also verify that alarm signals are received.

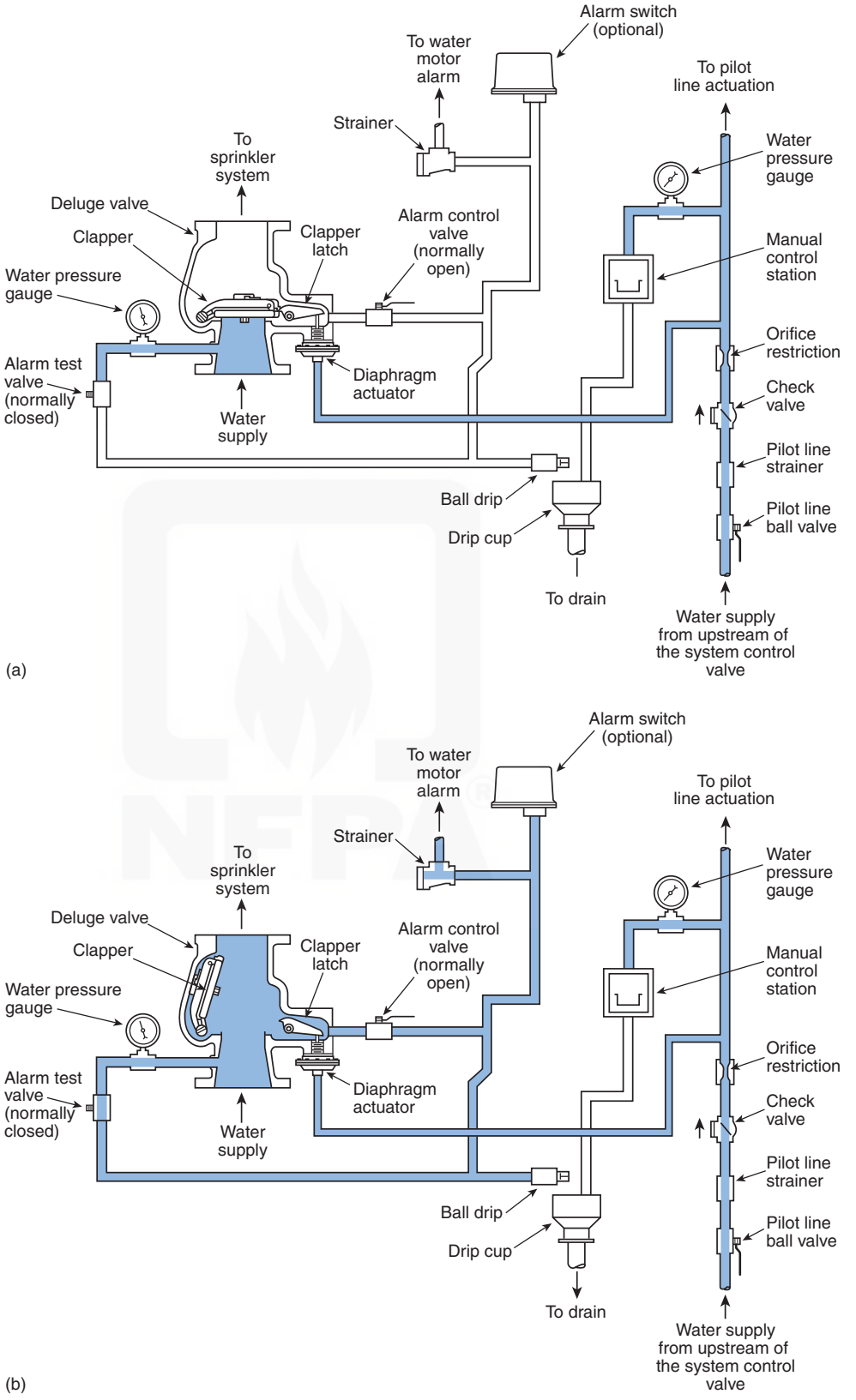
Although NFPA 25 does not specify that the receipt of the alarm signals be confirmed with a central station or monitoring provider, it is good practice to have the receipt of the alarms verified by the owner when the system is reset and removed from the test mode. The exact description on the signal received should also be verified to ensure alarm signals do not annunciate as trouble signals, which could delay a fire department response when required.

Dry pipe and deluge systems equipped with waterflow alarm devices should operate similarly to wet pipe systems. However, these typically annunciate using devices covered in *NFPA 72*.

Most preaction systems, with the exception of double interlock preaction systems, do not have an inspector's test connection that uses water. In these systems, testing the supervisory alarm involves lowering the supervisory air pressure, which can be done by opening the inspector's test connection to bleed off supervisory air. When the air pressure is lowered to the alarm set point, a signal will sound at the preaction control panel. This will activate the preaction valve, allowing the system to fill with water. When the system is filled with water, the waterflow alarm pressure switch or water motor gong will sound, sending a signal to the preaction control panel and sounding the audible alarm signal.

Double interlock preaction systems have an inspector's test connection similar to that of a dry pipe system.

EXHIBIT 13.17 *Pressure Type Waterflow Alarm on Typical Deluge System: (a) Closed (Set) and (b) Open (Activated).*



13.2.4.4 Vane-Type, Paddle-Type, and Pressure-Switch-Type Waterflow Devices

13.2.4.4.1 Vane-type, paddle-type, and pressure-switch-type waterflow alarm devices shall be inspected quarterly to verify that they are free of physical damage.

13.2.4.4.2 Vane-type, paddle-type, and pressure-switch-type waterflow alarm devices shall be tested semiannually.

System Tagging

The paddle in this control valve is cracked and will make stopping the flow of water difficult. Furthermore, as a result of the crack, a section of the paddle could break off and become lodged somewhere in the system, which could cause reduced flow during a fire event. This condition would be considered a critical deficiency and would need to be corrected quickly.



(Courtesy of Byron Blake and SimplexGrinnell)


Noncritical Deficiency


Critical Deficiency


Impairment

13.2.4.5 Testing waterflow alarm devices on wet pipe systems shall be accomplished by opening the inspector's test valve or by using the automated test equipment in accordance with 4.6.6.

Subsection 4.6.6 permits the recirculation of water rather than the discharge of water in most cases, or testing without flowing water depending on the automated test device's capabilities (see 4.6.6 for frequency requirements). However, there is still a minimum frequency with which water must be visually observed while flowing.

13.2.4.6 Where freezing weather conditions or other circumstances prohibits the use of the inspector's test valve, the bypass connection shall be permitted to be used.

13.2.4.7 Fire pumps shall not be taken out of service during testing unless constantly attended by qualified personnel, or all impairment procedures contained in Chapter 15 are followed.

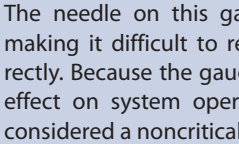
13.2.4.8* Testing waterflow alarm devices on dry pipe, preaction, or deluge systems shall be accomplished by using the bypass connection.

A.13.2.4.8 Opening the inspector's test connection can cause the system to trip accidentally.

13.2.5 Gauges.

System Tagging

The needle on this gauge has been bent, making it difficult to read the pressure correctly. Because the gauge does not have any effect on system operation, this would be considered a noncritical deficiency.



Noncritical Deficiency



Critical Deficiency



Impairment



(Courtesy of Byron Blake and SimplexGrinnell)

13.2.5.1* Inspections.

A.13.2.5.1 The inspection frequencies identified in this section apply to all systems and devices covered by this standard.

13.2.5.1.1* Gauges shall be inspected monthly to verify that the gauges are operable and not physically damaged.

Exhibit 13.18 shows a pressure gauge that is not mechanically damaged but has become difficult to read and has questionable reliability due to its general condition. Thus, this would require replacement.

A.13.2.5.1.1 "Normal water supply pressure" could be a pressure reading that is too high or too low relative to what reasonably would be expected based on system design information, knowledge of the connected water supply, and/or reading data based on past inspections. "Normal" pressure includes pressure expected to be found on a system in order to adequately supply the supplied fire sprinkler system. For example, a gauge reading a pressure close to or below a sprinkler system's demand listed on the design placard would not be expected to be normal because as, the system could have a water supply issue. Normal water supply pressure on a gauge above an alarm or system check valve might be higher than that of a gauge below as a result of trapped pressure surges. This can be typical in buildings with trapped air located close to metal deck roofs without air conditioning. Gridded systems also have a high probability of excess pressure development, which is why NFPA 13 requires relief valves on such systems.

Due to the high probability of excess pressure buildup, gridded wet pipe systems should be provided with a relief valve not less than ¼ in. (6.3 mm) in accordance with NFPA 13. It is normal, though, that the pressure above the alarm or system check valve is typically higher than that of the water supply as a result of trapped pressure surges.



EXHIBIT 13.18 *Pressure Gauge that Is Difficult to Read. (Courtesy of Wiginton Fire Systems)*

13.2.5.1.2 Gauges monitoring water pressure shall be inspected quarterly to verify that normal water supply pressure is being maintained.

13.2.5.1.3 Gauges monitoring air or nitrogen pressure shall be inspected monthly to verify that normal air or nitrogen pressure are being maintained.

13.2.5.1.3.1 The gauge on the quick-opening device, if provided, shall indicate the same pressure as the gauge on the system side of the dry pipe valve.

13.2.5.1.3.2 Where air pressure supervision is connected to a constantly attended location, gauges shall be inspected quarterly.

13.2.5.1.4* For dry pipe or preaction systems protecting freezers with an air pressure gauge(s) on the air line(s) between the compressor and the dry pipe or preaction valve, the air pressure gauge near the compressor shall be compared monthly to the pressure gauge above the dry pipe or preaction valve.

A.13.2.5.1.4 See Figure A.13.2.5.1.4.

13.2.5.1.4.1 When the gauge near the compressor is reading higher than the gauge near the dry pipe valve, the air line in service shall be taken out of service and the alternate air line shall be opened to equalize the pressure.

13.2.5.1.4.2 An air line taken out of service in accordance with 13.2.5.1.4.1 shall be internally inspected, removed of all ice blockage, and reassembled for use as a future alternate air line.

13.2.5.2 Gauges shall be replaced every 5 years or tested every 5 years by comparison with a calibrated gauge.

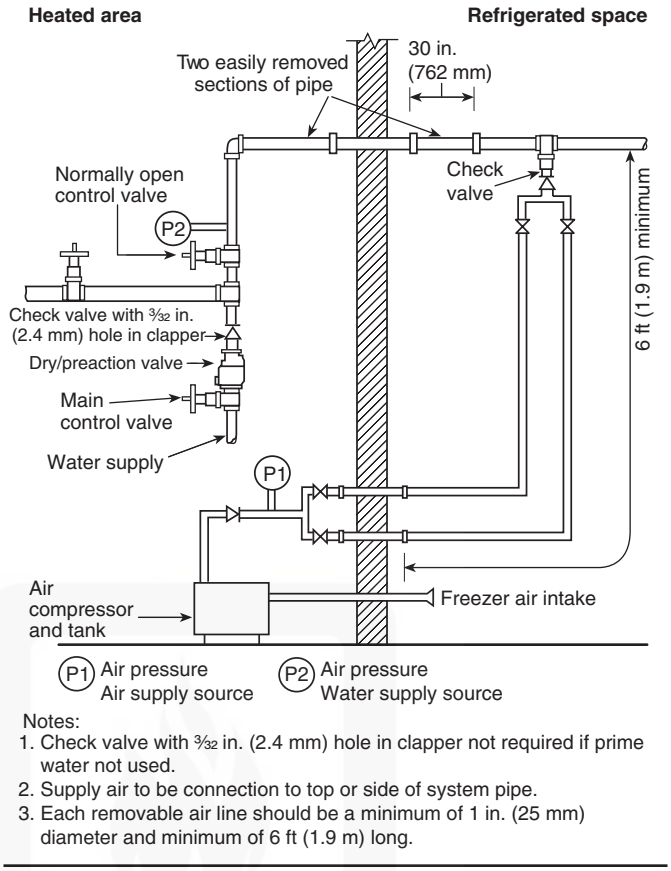


FIGURE A.13.2.5.1.4 *Refrigerator Area Sprinkler System Used to Minimize Chances of Developing Ice Plugs.*

The requirement in 13.2.5.2 provides the option of replacing a gauge in lieu of testing the gauge. In many cases, replacement might be more economical than testing. If after 5 years an installed gauge is still operating within the original range and with the required accuracy, replacement is not required.

Testing Procedure Alert

While an inaccurate gauge will not lead to a sprinkler or standpipe system not operating or not receiving enough water, it is important to make sure that the gauges read properly. Gauges on water-based suppression systems allow for an owner, inspector, or AHJ to obtain an instant read on a system's pressure condition and can also provide some insight into closed valves. For more information on conducting the gauge accuracy test required by 13.2.5.2, see the testing procedure at the end of this chapter.

13.2.5.3 Gauges not accurate to within 3 percent of the full scale shall be recalibrated or replaced.

Inaccurate gauges are required to be recalibrated or replaced. The gauge's accuracy should be checked and a comparison pressure table developed to determine the actual readings at various gauge settings. Results from this table should be used as an alternative to

replacement to maintain normal pressure. Most gauges used in fire protection systems cannot realistically be recalibrated due to their design. When such a gauge is found to be inaccurate, the alternative is replacement.

System Tagging

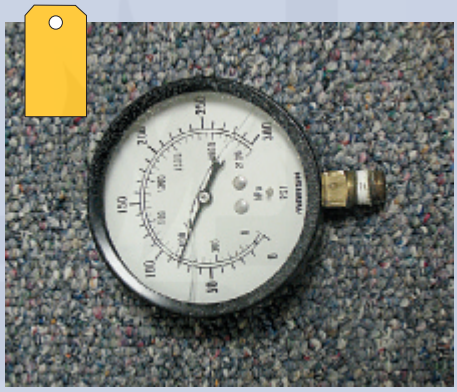
A gauge that has lost its seal or experienced mechanical damage, as shown in these photos, does not impact system performance and should be considered a noncritical deficiency.



Noncritical Deficiency

Critical Deficiency

Impairment



(Courtesy of Byron Blake and SimplexGrinnell)

13.2.6 Supervisory Signal Devices (except valve supervisory switches).

The requirements for coordination with *NFPA 72* are addressed in 1.1.1. See the commentary following 1.1.1 for additional information.

13.2.6.1 Supervisory signal devices shall be inspected quarterly to verify that they are free of physical damage.

13.2.6.2 Supervisory signal devices shall be tested annually in accordance with the manufacturer's instructions.

13.2.7 Records.

Records shall be maintained in accordance with Section 4.3.

Tip for Owners

Section 4.3 states that it is the owner's responsibility for maintaining records. See Section 4.3 and the associated commentary for additional information.

13.3 Control Valves in Water-Based Fire Protection Systems.

13.3.1* Each control valve shall be identified and have a sign indicating the system or portion of the system it controls.

A.13.3.1 Signs identifying underground fire service main control valves in roadway boxes should indicate the direction of valve opening, the distance and direction of the valve from the sign location (if the valve is subject to being covered by snow or ice), and the location of the wrench if not located with the sign.

13.3.1.1 Systems that have more than one control valve that must be closed to work on a system shall have a sign on each affected valve referring to the existence and location of other valves.

13.3.1.2* When a normally open valve is closed, the procedures established in Chapter 15 shall be followed.

A.13.3.1.2 Valves that normally are closed during cold weather should be removed and replaced with devices that provide continuous fire protection service.

Paragraph 13.3.1.2 stipulates under what conditions the requirements in Chapter 15 — which refer to fire protection impairments — must be followed.

If the annual testing of a valve requires the closing of that valve, the valve should be returned to its normal open position immediately after testing. The number of turns required to close the valve should be recorded. That information can then be used to make sure the valve is reopened all the way. The manufacturer's literature will also indicate the number of turns necessary to operate the valve through its full range of motion.

Any supervisory device should be returned to its normal position and no trouble signal should be observed at the fire alarm panel.

13.3.1.3 Each normally open valve shall be secured by means of a seal or a lock or shall be electrically supervised in accordance with the applicable NFPA standards.

13.3.1.4 Normally closed valves shall be secured by means of a seal or shall be electrically supervised in accordance with the applicable NFPA standard.

Electrically supervised valves must send a signal within the first two valve revolutions or one-fifth of the distance from its normal position, per 13.3.3.5.2. Thus, when testing these valves, if a tamper alarm is not transmitted to an alarm panel within this time, the test is considered a failure and maintenance must be performed to adjust the tamper switch. Exhibit 13.19 shows a control valve with an electronic supervisory device that has not been connected.

13.3.1.5 Sealing or electrical supervision shall not be required for hose valves.

13.3.2 Inspection.

13.3.2.1 All valves shall be inspected weekly.

13.3.2.1.1 Valves secured with locks or supervised in accordance with applicable NFPA standards shall be permitted to be inspected monthly.

13.3.2.1.2 Valves that are electrically supervised shall be permitted to be inspected quarterly.



EXHIBIT 13.19 *Butterfly Valve with Built-In Supervisory Switch (Not Wired).*

Paragraphs 13.3.2.1 through 13.3.2.1.2 take users of NFPA 25 through a progression of valve supervision (or nonsupervision) arrangements. While this standard does not require valve supervision, it does permit extending inspection frequencies in this case, based on the presence of supervision. These paragraphs illustrate the value of supervision in that valve inspection frequencies range from weekly for unlocked and unsupervised valves to quarterly for those that are electronically supervised.

13.3.2.1.3 Control valve supervisory alarm devices shall be inspected quarterly to verify that they are free of physical damage.

13.3.2.1.4 After any alterations or repairs, an inspection shall be made by the property owner or designated representative to ensure that the system is in service and all valves are in the normal position and properly sealed, locked, or electrically supervised.

13.3.2.2* The valve inspection shall verify that the valves are in the following condition:

(1) In the normal open or closed position
(2)* Sealed, locked, or supervised

A.13.3.2.2(2) The purpose of the valve sealing program is as follows:

(1) The presence of a seal on a control valve is a deterrent to closing a valve indiscriminately without obtaining the proper authority.
(2) A broken or missing seal on a valve is cause for the plant inspector to verify that protection is not impaired and to notify superiors of the fact that a valve could have been closed without following procedures.

ITM Deficiency, Impairment, or Hazard Evaluation?

ANSWER: Impairment

While performing the inspection required by 13.3.2.1.1, this normally open water control valve was found in the closed position. When the indicating flag is parallel to the piping, the valve is open, and when perpendicular, the valve is closed. The flag position will also indicate when a valve is only partially open. The water gauge is showing no water pressure below the seat of this dry pipe valve, which is another indicator of a closed water control valve.

This system will not function at all during a fire event and should be considered impaired. The impairment procedures in Chapter 15 should be implemented immediately.



(Courtesy of John Johnson, Tyco Fire Protection Products)

ITM Deficiency, Impairment, or Hazard Evaluation?

ANSWER: ITM Deficiency or Impairment

At first glance, this post indicator valve (PIV) and post appear to be just fine, with the wrench attached and locked and no physical damage. However, upon closer examination, the target that indicates whether the valve is open or shut is not visible in the window. In 13.3.2.2(1), the inspector is required to verify whether the water control valve is "in the normal open or closed position." Without the visible target as the indicator, the position of the valve cannot be determined, and the assembly is either broken or the target is off track.

As defined in 3.3.24, an inspection is "a visual examination of a system or portion thereof to verify that it appears to be in operating condition and is free of physical damage." In this case, the PIV is obviously not in good operating condition, and as long as the valve can be confirmed to be in its normal open or closed position, this finding should be classified as a deficiency. If a further investigation reveals that the valve is not in its normal open position, then the system should be considered impaired and the impairment procedures in Chapter 15 should be implemented immediately.



(Courtesy of Byron Blake and SimplexGrinnell)

(3) Accessible
(4) Post indicator valves (PIVs) are provided with correct wrenches
(5) Free from external leaks
(6) Provided with applicable identification

Exhibit 13.20 shows a WPIV that has been rendered inoperable by the growth of a nearby tree branch.



EXHIBIT 13.20 *Inoperable WPIV. (Courtesy of John Jensen)*

A.13.3.2.2 Valves should be kept free of snow, ice, storage, or other obstructions so that access is ensured.

Testing Procedure Alert

Confirmation that a control valve can operate through its full range of motion is important for several reasons. First, it is imperative that the valve can be opened 100 percent so that the full flow of water that is needed can get through the device. It is also important to confirm that a valve can close so that routine testing and maintenance can be done on schedule. When valves do not operate from fully closed to fully open, it typically signifies an obstruction or other impairment. For more information and a procedure for conducting the control valve for several different types of control valves, see the testing procedure at the end of this chapter.

13.3.3 Testing.

13.3.3.1 Each control valve shall be operated annually through its full range and returned to its normal position.

When testing a nonindicating gate valve such as an underground sectional valve as required by 13.3.3.1, the number of turns needed to fully close and open the valve should be noted and compared to the number of turns needed to open and close as noted in the manufacturer's literature. This number should be recorded on the inspection form and retained for future reference.

Valves typically require lubrication annually per manufacturer's specifications. Valves that are difficult to turn might require maintenance. Forcing sticking valves to turn could result in breaking the valve shaft and creating an unplanned system impairment until repairs can be made. Valves should be able to turn smoothly and with minimal effort. If valves

require the use of a person's full weight or a cheater bar to turn, the valve should be repaired or replaced. In the case of an emergency, this could lead to breaking the shaft limiting or eliminating the functionality of the valve.

FAQ How often do PIVs need to be cycled?

All control valves are required to be operated annually through their full range of motion per 13.3.3.1. Often, PIVs are not exercised, since they are not considered a control valve because they sit outside of the building envelope.

13.3.3.2* Post indicator valves shall be opened until spring or torsion is felt in the rod, indicating that the rod has not become detached from the valve.

A.13.3.3.2 A proper wrench needs to be used for this test. Using an improper wrench such as a pipe wrench has resulted in damage to the operating nut. The use of break over bars and extensions on the wrench can damage the valve and/or the post. If the valve cannot be closed and reopened using the proper wrench with reasonable force, then some maintenance and/or repairs are necessary so the valve can be operated when needed in a fire event. These "spring tests" are made to verify that a post indicator valve is fully open. If an operator feels the valve is fully open, he or she should push in the "open" direction. The handle usually moves a short distance (approximately a one-quarter turn) and "springs" back toward the operator in a subtle move when released. This spring occurs when the valve gate pulls up tight against the top of its casting and the valve shaft (being fairly long) twists slightly. The spring indicates that the valve is fully opened and that the gate is attached to the handle. If the gate is jammed due to a foreign particle, the handle is not likely to spring back. If the gate is loose from the handle, the handle continues to turn in the "open" direction with little resistance.

13.3.3.2.1 This test shall be conducted every time the valve is closed.

13.3.3.3 Post indicator and outside screw and yoke valves shall be backed a one-quarter turn from the fully open position to prevent jamming.

13.3.3.4 A valve status test shall be conducted any time the control valve is closed and reopened at system riser.

This requirement is intended to verify that the control valve has not been left fully closed. It is not meant to test that a valve has been returned to the fully open position. A main drain test might not reveal a partially closed (or partially open) valve in a large-diameter supply pipe. In most typical systems, a gate valve closure up to approximately 70 percent to 80 percent would not be detected with a main drain test. This is because the area that is still open under the gate has a combined area at least equal to that of the drain pipe and valve.

Testing Procedure Alert

The valve status test was introduced in the 2014 edition of NFPA 25, and its importance cannot be overstated. The most common cause for system ineffectiveness in water-based fire protection systems is a closed valve. A rather simple test allows the owner or inspector to confirm that not only do the valves appear to be open but that water is in fact flowing through the control valve that had been recently closed. A process for conducting this test is provided at the end of this chapter.

13.3.3.5* Valve Supervisory Switches.

A.13.3.3.5 For further information, see *NFPA 72*.

13.3.3.5.1 Valve supervisory switches shall be tested semiannually.

13.3.3.5.2 A distinctive signal shall indicate movement from the valve's normal position during either the first two revolutions of a handwheel or when the stem of the valve has moved one-fifth of the distance from its normal position.

This requirement is not meant to imply each valve tamper device must have its own distinctive signal at an annunciator panel. While highly advisable on larger systems with more than one valve, all tamper devices can annunciate as a single signal. Chapter 17 of *NFPA 72* requires valve tamper switches initiate a supervisory signal.

13.3.3.5.3 The signal shall not be restored at any valve position except the normal position.

Some approved valve tamper devices are easy to reset. These devices allow the alarm panel to indicate that all valves are open, when in actuality, the valves are closed. When circuit lacing devices are used, special care must be taken in restoration. Exhibit 13.21 shows a valve monitored by lacing a wire around the valve handle.

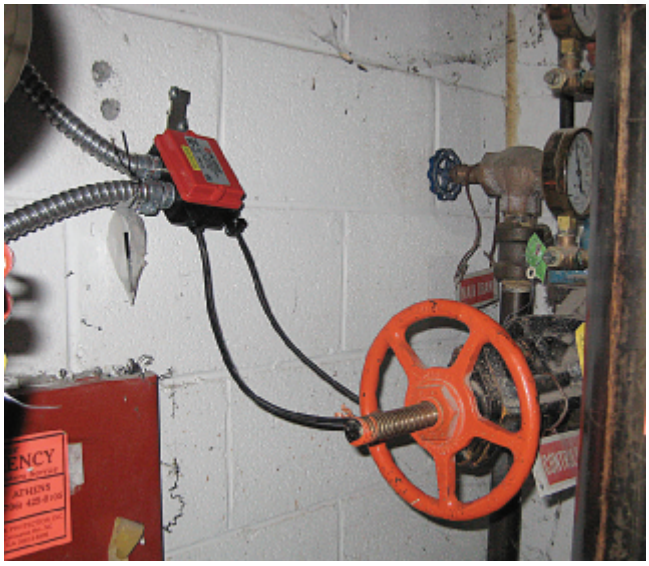


EXHIBIT 13.21 *Valve Monitored by Wire Laced Through Handle.*

13.3.4 Maintenance.

13.3.4.1 The operating stems of outside screw and yoke valves shall be lubricated annually.

13.3.4.2 The valve then shall be completely closed and reopened to test its operation and distribute the lubricant.

13.4 System Valves.

13.4.1 Inspection of Alarm Valves. Alarm valves shall be inspected as described in 13.4.1.1 and 13.4.1.2.

13.4.1.1* Alarm valves and system riser check valves shall be externally inspected quarterly and shall verify the following:

(1) The gauges indicate normal supply water pressure is being maintained.
(2) The valves and trim are free of physical damage.
(3) All valves are in the appropriate open or closed position.
(4) The retarding chamber or alarm drains are not leaking.

A.13.4.1.1 A higher pressure reading on the system gauge is normal in variable pressure water supplies. Pressure over 175 psi (12.1 bar) can be caused by fire pump tests or thermal expansion and should be investigated and corrected.

13.4.1.2* Alarm valves and their associated strainers, filters, and restriction orifices shall be inspected internally every 5 years unless tests indicate a greater frequency is necessary.

A.13.4.1.2 The system should be drained for internal inspection of valve components as follows:

(1) Close the control valve
(2) Open the main drain valve
(3) Open the inspector's test valve
(4) Wait for the sound of draining water to cease and for all gauges to indicate 0 psi (0 bar) before removing the handhole cover or dismantling any component

FAQ Is the requirement for the 5-year internal inspection of an alarm check valve valid if the valve no longer has an active retard chamber?

The internal inspection of an alarm valve is not contingent upon retard chambers or any other trim. The purpose of the internal inspection is to verify the operation of the clapper and the condition of the valve seats, as well as to look for evidence of corrosion or obstructing material (inorganic and organic). This can also meet the requirement of an internal obstruction investigation if required per 14.3.2.2(2). Exhibit 13.22 illustrates the internal components of an alarm check valve that would be seen upon an internal inspection. Exhibit 13.23 shows the interior corrosion of an alarm valve during an internal inspection.

FAQ What test results would indicate that more frequent internal inspections of alarm valves are needed?

Test results that might indicate more frequent inspections are needed include the following:

- Internal biological growth
- Significant corrosion on internal metal parts, such as the check valve plate
- Previously found obstructions that, due to water supply sources or other reasons, could be expected to occur again

If the presence of foreign material is enough to warrant increasing the frequency of internal inspections of the valve, consideration must also be given to the requirements of Chapter 14. That chapter contains triggers for conducting obstruction investigations. See 14.3.1 for more information.

13.4.1.3 Maintenance.

13.4.1.3.1 Internal components shall be cleaned/repaired as necessary in accordance with the manufacturer's instructions.

13.4.1.3.2 The system shall be returned to service in accordance with the manufacturer's instructions.

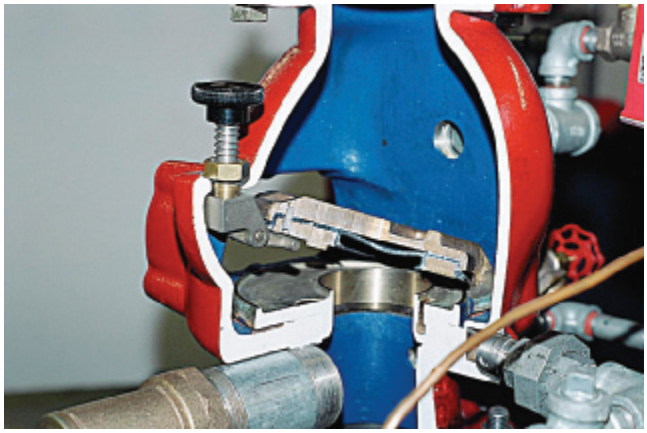


EXHIBIT 13.22 *Alarm Valve Internal Inspection.*

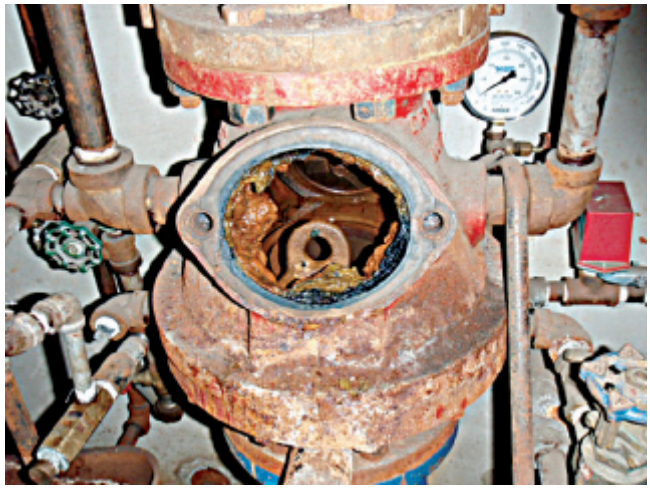


EXHIBIT 13.23 *Interior Valve Corrosion. (Courtesy of Wayne Automatic Fire Sprinklers, Inc.)*

13.4.2 Check Valves.

13.4.2.1 Inspection.
Valves shall be inspected internally every 5 years to verify that all of the valve's components operate correctly.

13.4.2.2 Maintenance.
Internal components shall be cleaned, repaired, or replaced as necessary in accordance with the manufacturer's instructions.

13.4.3 Preaction Valves.

FAQ What is the difference between a preaction valve and a deluge valve?

Preaction and deluge valves have identical main valves but with different trim, which is arranged based on the type of operation. For example, a deluge valve activates and discharges water into a piping system of open nozzles or sprinklers, whereas a preaction system trips and floods a piping system of closed sprinklers and will not discharge water until a sprinkler activates. Therefore, a preaction system has a check valve installed immediately above the preaction valve to isolate it from the system air pressure. Except for this difference, the two valve bodies (preaction and deluge) are basically the same. See Exhibit 13.24 for a typical preaction valve arrangement and a typical deluge valve arrangement.

13.4.3.1 Inspection.

13.4.3.1.1 The preaction valve shall be externally inspected monthly to verify the following:

(1) The valve is free from physical damage.
(2) All trim valves are in the appropriate open or closed position.
(3) The valve seat is not leaking.
(4) Electrical components are in service.

The external inspection of the preaction valve required by 13.4.3.1.1 should also include inspection of pneumatic components.

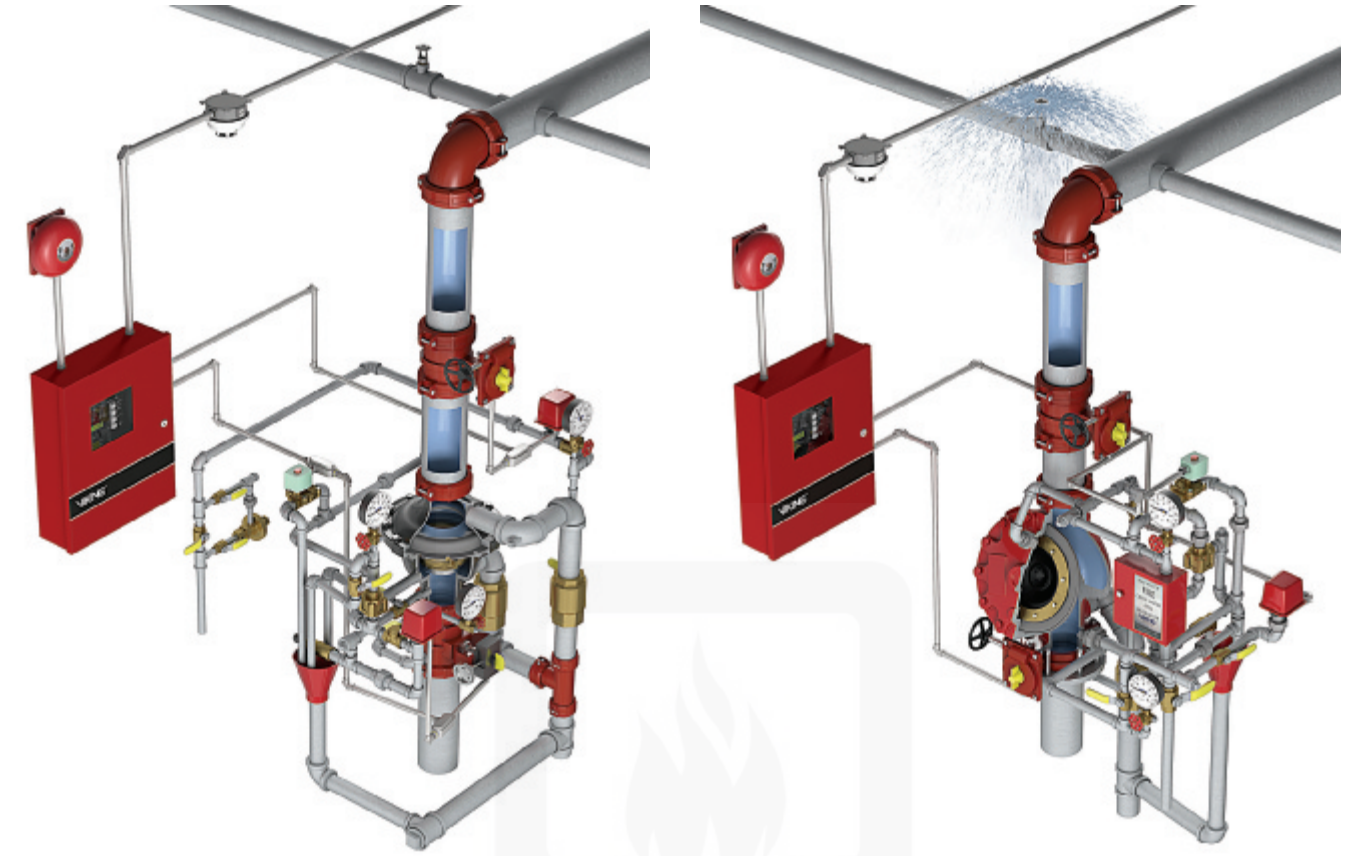


EXHIBIT 13.24 *Preaction Valve with Trim Piping and Accessories (left) and Deluge Valve with Trim Piping and Accessories (right). (Courtesy of Jesse Cappon and Viking®)*

13.4.3.1.2 The interior of the preaction valve and the condition of detection devices shall be inspected annually when the trip test is conducted.

Testing Procedure Alert

The purpose of completing a trip test (partial or full) for a preaction valve is to ensure the system operates in a manner consistent with the original design application. A comparative assessment of the water delivery time during the full trip test of a double interlock preaction and combined dry pipe/preaction system can reveal significant delays in system operation. For more information on conducting this test, see the testing procedure at the end of this chapter.

13.4.3.1.2.1 Internal inspection of valves that can be reset without removal of a faceplate shall be permitted to be conducted every 5 years.

13.4.3.1.3 Strainers, filters, restricted orifices, and diaphragm chambers shall be inspected internally every 5 years unless tests indicate a greater frequency is necessary.

A situation in which a more frequent inspection is required per 13.4.3.1.3 would be a reservoir, where water supply conditions can lead to obstructing material or rapid corrosion.

13.4.3.1.4 Preaction systems with auxiliary drains shall require a sign at the valve indicating the number of auxiliary drains and the location of each individual drain.

13.4.3.2 Testing.

13.4.3.2.1* The priming water level in supervised preaction systems shall be tested quarterly for compliance with the manufacturer's instructions.

A.13.4.3.2.1 High priming water levels can adversely affect the operation of supervisory air. Test the water level as follows:

(1) Open the priming level test valve.
(2) If water flows, drain it.
(3) Close the valve when water stops flowing and air discharges.
(4) If air discharges when the valve is opened, the priming water level could be too low. To add priming water, refer to the manufacturer's instructions.

13.4.3.2.2 Except for preaction systems covered by 13.4.3.2.5, every 3 years the preaction valve shall be trip tested with the control valve fully open.

13.4.3.2.3 During those years when full flow testing in accordance with 13.4.3.2.2 is not required, the preaction valve shall be trip tested with the control valve partially open.

N **13.4.3.2.4*** Preaction valve flow tests shall incorporate full functionality of the system as a unit, including automatic and manual activation.

N **A.13.4.3.2.4** It is necessary that the full flow test incorporate the full functionality of the system, which would include any solenoid valves or other actuation devices. It was common practice in the past to test the detection system or manual pull station up to the solenoid valve or actuator and to separately test the preaction valve and system after the solenoid valve or actuator. The detectors on the system can be tested separately as long as the functional test includes activation of the actuator or solenoid when it receives an actual or simulated signal.

13.4.3.2.5 Preaction valves protecting freezers shall be trip tested in a manner that does not introduce moisture into the piping in the freezer.

13.4.3.2.6 Preaction systems shall be tested once every 3 years for air leakage, using one of the following test methods:

(1) Perform a pressure test at 40 psi (3.2 bar) for 2 hours. The system shall be permitted to lose up to 3 psi (0.2 bar) during the duration of the test. Air leaks shall be addressed if the system loses more than 3 psi (0.2 bar) during this test.
(2) With the system at normal system pressure, shut off the air source (compressor or shop air) for 4 hours. If the low air pressure alarm goes off within this period, the air leaks shall be addressed.

Paragraph 13.4.3.2.6 addresses the integrity of preaction systems that have supervisory air pressure. Single interlock preaction systems are not typically equipped with supervisory air pressure and, as a result, would not be subject to the test required in this paragraph.

13.4.3.2.7 Manual Operation. Manual actuation devices shall be operated annually.

13.4.3.2.8 Return to Service. After the annual trip test, the preaction system shall be returned to service in accordance with the manufacturer's instructions.

13.4.3.2.9 Grease or other sealing materials shall not be applied to the seating surfaces of preaction valves.

13.4.3.2.10* Records indicating the date the preaction valve was last tripped and the tripping time, as well as the individual and organization conducting the test, shall be maintained at a location or in a manner readily available for review by the authority having jurisdiction.

A.13.4.3.2.10 Methods of recording maintenance include tags attached at each riser, records retained at each building, and records retained at one building in a complex.

See Supplement 4 for sample report forms. Note that 13.4.3.2.10 does not preclude the use of electronic reporting systems or other methods for documenting the service history of valves and other equipment.

13.4.3.2.11 Low air pressure alarms, if provided, shall be tested quarterly in accordance with the manufacturer's instructions.

13.4.3.2.12 Low temperature alarms, if installed in valve enclosures, shall be tested annually at the beginning of the heating season.

13.4.3.2.13 Automatic air pressure maintenance devices, if provided, shall be tested yearly at the time of the annual preaction valve trip test, in accordance with the manufacturer's instructions.

13.4.3.3 Maintenance.

13.4.3.3.1 Leaks causing drops in supervisory pressure sufficient to sound warning alarms and electrical malfunctions causing alarms to sound shall be located and repaired.

13.4.3.3.2 During the annual trip test, the interior of the preaction valve shall be cleaned thoroughly and the parts replaced or repaired as necessary.

13.4.3.3.2.1 Interior cleaning and parts replacement or repair shall be permitted every 5 years for valves that can be reset without removal of a faceplate.

13.4.3.3.3* Auxiliary drains in preaction systems shall be operated after each system operation and before the onset of freezing conditions (and thereafter as needed).

A.13.4.3.3.3 Suitable facilities should be provided to dispose of drained water. Low points equipped with a single valve should be drained as follows:

(1) Open the low-point drain valve slowly.
(2) Close the drain valve as soon as water ceases to discharge, and allow time for additional accumulation above the valve.
(3) Repeat this procedure until water ceases to discharge.
(4) Replace plug or nipple and cap as necessary.

Low points equipped with dual valves should be drained as follows:

(1) Close the upper valve.
(2) Open the lower valve, and drain the accumulated water.
(3) Close the lower valve, open the upper valve, and allow time for additional water accumulation.
(4) Repeat this procedure until water ceases to discharge.
(5) Replace plug or nipple and cap in lower valve.

Removing water from a deluge system is an essential part of a good maintenance program. Failure to keep these systems free of water can result in damage and expensive repairs to both the system and the building. A program for monitoring the condition of the system and the operation of the auxiliary drains should be instituted. Auxiliary drains should be operated on a daily basis after a system operation until several days pass with no discharge of water from the drain valve. Thereafter, it might be possible to decrease the frequency to weekly or

longer intervals, depending on the volume of water discharged. Likewise, when preparing for cold weather, the auxiliary drains should be operated daily, with the frequency of operation decreasing depending on the discharge of accumulated water. In many cases, the frequency of the operation can decrease significantly if a system is shown to be dry.

It is important that the piping be kept dry, particularly in areas subject to freezing. When a system is tripped during testing or as the result of a fire or other event, it is important to follow a plan to monitor the removal of any water as it accumulates in the system. Systems located in conditioned spaces that have supervised air pressure are particularly susceptible to moisture accumulating during the summer season as a result of warm moist air being introduced into the system.

13.4.3.3.4 Additional maintenance as required by the manufacturer's instructions shall be provided.

13.4.4 Deluge Valves.

13.4.4.1 Inspection.

13.4.4.1.1 The deluge valve shall be externally inspected monthly to verify the following:

(1) The valve is free from physical damage.
(2) All trim valves are in the appropriate open or closed position.
(3) The valve seat is not leaking.
(4) Electrical components are in service.

13.4.4.1.2 The interior of the deluge valve and the condition of detection devices shall be inspected annually when the trip test is conducted.

13.4.4.1.2.1 Internal inspection of valves that can be reset without removal of a faceplate shall be permitted to be conducted every 5 years.

The requirement in 13.4.4.1.2.1 acknowledges the fact that some listed deluge valves do not have to be opened to be reset. The arrangement of the deluge valve with accessories shown in Exhibit 13.24 illustrates an externally reset deluge valve.

13.4.4.1.3 Strainers, filters, restricted orifices, and diaphragm chambers shall be inspected internally every 5 years unless tests indicate a greater frequency is necessary.

13.4.4.2 Testing.

13.4.4.2.1 Deluge valve flow tests shall incorporate full functionality of the system as a unit, including automatic and manual activation.

To ensure that the deluge valve will release and open when needed, testing must include all of the components. Paragraph 13.4.4.2.1 requires that activation systems be tested and that the valve opens as part of the same test.

13.4.4.2.2 Protection shall be provided for any devices or equipment subject to damage by system discharge during flow tests.

13.4.4.2.3* Except as provided by 13.4.4.2.3.1 and 13.4.4.2.3.2, each deluge valve shall be trip tested annually at full flow in warm weather and in accordance with the manufacturer's instructions.

A.13.4.4.2.3 Deluge valves in areas subject to freezing should be trip tested in the spring to allow time before the onset of cold weather for all water that has entered the system or condensation to drain to low points or back to the valve.

See the commentary for 13.4.3.1.1.

13.4.4.2.3.1* Where the nature of the protected property is such that water cannot be discharged for test purposes, an annual trip test shall be permitted to be conducted in a manner that does not necessitate discharge in the protected area.

One method of complying with 13.4.4.2.3.1 is to throttle the water supply by closing the control valve so that it is one or two turns open. When the deluge valve operates, the water supply control valve can be closed quickly before water discharges into the protected area.

A method for conducting a trip test without flowing water entails removing the head of the deluge valve solenoid. When a signal is received at the solenoid, the solenoid becomes magnetized. The magnetization confirms that the alarm system is functioning. This method is not preferred for performing a discharge test of a deluge valve, because it does not verify that the valve is operating properly, only that the system functions.

A.13.4.4.2.3.1 It is necessary that the full flow test incorporate the full functionality of the system, which would include any solenoid valves or other actuation devices. It was a common practice in the past to test the detection system or manual pull station up to the solenoid valve or actuator and to separately test the deluge valve and system after the solenoid valve or actuator. The detectors on the system can be tested separately as long as the functional test includes activation of the actuator or solenoid when it receives an actual or simulated signal.

Tip for Owners

In some facilities, conducting a trip test that results in flow could damage equipment or overly impact the process and operations of the facility. The allowance in 13.4.4.2.3.2 allows for trip testing to be conducted in a manner that does not necessitate discharge in the protected area. However, 13.4.4.2.3.2 requires that a full flow system test be conducted at the next system shutdown when this allowance is taken. Either way, 13.4.4.2.3.3 requires the full flow test be conducted within 3 years.

13.4.4.2.3.2 Where the nature of the protected property is such that water cannot be discharged unless protected equipment is shut down (e.g., energized electrical equipment), a full flow system test shall be conducted at the next scheduled shutdown.

13.4.4.2.3.3 For full flow tests in accordance with 13.4.4.2.3.2, the test frequency shall not exceed 3 years.

13.4.4.2.4 During the annual full flow test, the water discharge patterns from all of the open spray nozzles or sprinklers shall be observed to ensure that patterns are not impeded by plugged nozzles, that nozzles are correctly positioned, and that obstructions do not prevent discharge patterns from wetting surfaces to be protected.

13.4.4.2.4.1 Where the nature of the protected property is such that water cannot be discharged, the nozzles or open sprinklers shall be inspected for correct orientation.

13.4.4.2.4.2 Where the nature of the protected property is such that water cannot be discharged unless protected equipment is shut down (e.g., energized electrical equipment), all open spray nozzles or sprinklers shall be inspected in accordance with 13.4.4.2.4 during the full flow system test conducted at the next scheduled shutdown.

13.4.4.2.4.3 Where misalignment or obstructions occur, the piping and sprinklers or nozzles shall be adjusted and/or cleaned to correct the condition, and the system shall be retested.

13.4.4.2.5 Full flow deluge valve tests, in accordance with 13.4.4.2.3 and 13.4.4.2.3.2, shall be conducted with the deluge system control valve fully open.

13.4.4.2.6 Deluge valve trip tests, in accordance with 13.4.4.2.3.1, shall be permitted to be conducted with the deluge system control valve partially open.

13.4.4.2.7 Deluge System Pressure Readings.

13.4.4.2.7.1 Pressure readings shall be recorded at the hydraulically most remote nozzle or sprinkler.

Deluge systems typically protect high-hazard or high-challenge risks. It is important to verify the condition of the piping and sprinklers or nozzles. The measurement required in 13.4.4.2.7.1 is intended to confirm that there is adequate pressure at the discharge device to deliver the required density. To perform this task, it is necessary to reference the original design criteria and system hydraulic information.

13.4.4.2.7.2 A second pressure reading shall be recorded at the deluge valve.

13.4.4.2.7.3 These readings shall be compared to the hydraulic design pressures to ensure the original system design requirements are met by the water supply.

Most hydraulic calculation programs calculate pressure at the base of the riser. The pressure should be found by referring to the hydraulic design information sign. A reading taken at the deluge valve, as required by 13.4.4.2.7.2, provides an adequate comparison.

13.4.4.2.7.4 Where the hydraulically most remote nozzle or sprinkler is inaccessible, nozzles or sprinklers in other than foam-water sprinkler systems shall be permitted to be inspected visually without taking a pressure reading on the most remote nozzle or sprinkler.

13.4.4.2.7.5 Where the reading taken at the riser indicates that the water supply has deteriorated, a gauge shall be placed on the hydraulically most remote nozzle or sprinkler and the results compared with the required design pressure.

If the pressure readings are lower than those indicated on the design documents or hydraulic design information signs, the inspector should notify the owner. The owner should immediately investigate to determine the cause and correct the problem.

13.4.4.2.8 Multiple Systems. The maximum number of systems expected to operate in case of fire shall be tested simultaneously to inspect the adequacy of the water supply.

Paragraph 13.4.4.2.8 requires the simultaneous testing of multiple systems because the discharge of multiple systems will have an effect on the water supply. It is important to test under conditions that might prevail during a fire. It is not the intent to require testing of multiple systems wherever they exist, but rather only where the discharge of multiple systems is needed, as based on the system design documents. Exhibit 13.25 illustrates several types of systems in a building, not all of which would require simultaneous discharge or testing.

Tip for Owners

If the original design criteria and system hydraulic information are not available, the owner might need to have a hydraulic evaluation of the system completed. This evaluation would be outside of the normal ITM work identified in this standard.

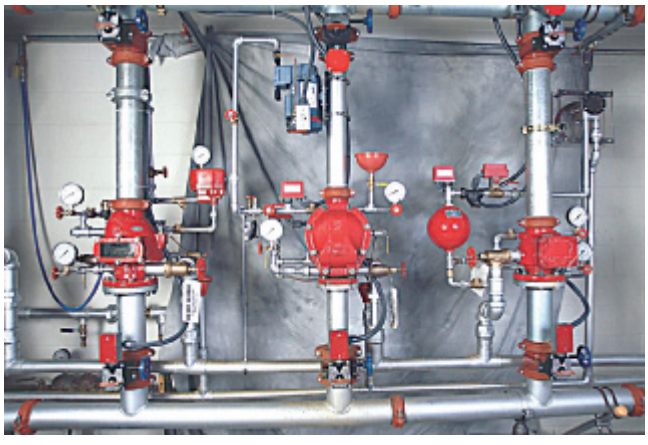


EXHIBIT 13.25 *Multiple System Manifold.*

13.4.4.2.9 Manual Operation. Manual actuation devices shall be operated annually.

13.4.4.2.10 Return to Service. After the annual trip test, the system shall be returned to service in accordance with the manufacturer's instructions.

13.4.4.2.11 Grease or other sealing materials shall not be applied to the seating surfaces of deluge valves.

13.4.4.2.12* Records indicating the date the deluge valve was last tripped and the tripping time, as well as the individual and organization conducting the test, shall be maintained at a location or in a manner readily available for review by the authority having jurisdiction.

See Supplement 4 for a sample report form. Note that 13.4.4.2.12 does not preclude the use of electronic reporting systems or other methods for documenting the service history of valves and other equipment.

A.13.4.4.2.12 Methods of recording maintenance include tags attached at each riser, records retained at each building, and records retained at one building in a complex.

13.4.4.2.13 Low air pressure supervisory devices, if provided on the detection system, shall be tested quarterly in accordance with the manufacturer's instructions.

13.4.4.2.14 Low temperature alarms, if installed in valve enclosures, shall be tested annually at the beginning of the heating season.

13.4.4.2.15 Automatic air pressure maintenance devices, if provided on the detection system, shall be tested yearly at the time of the annual deluge valve trip test, in accordance with the manufacturer's instructions.

13.4.4.3 Maintenance.

13.4.4.3.1 Leaks causing drops in supervisory pressure sufficient to sound warning alarms and electrical malfunctions causing alarms to sound shall be located and repaired.

13.4.4.3.2 During the annual trip test, the interior of the deluge valve shall be cleaned thoroughly and the parts replaced or repaired as necessary.

13.4.4.3.2.1 Interior cleaning and parts replacement or repair shall be permitted every 5 years for valves that can be reset without removal of a faceplate.

13.4.4.3.3* Auxiliary drains in deluge systems shall be operated after each system operation and before the onset of freezing conditions (and thereafter as needed).

A.13.4.4.3.3 Suitable facilities should be provided to dispose of drained water. Low points equipped with a single valve should be drained as follows:

(1) Open the low-point drain valve slowly.
(2) Close the drain valve as soon as water ceases to discharge, and allow time for additional accumulation above the valve.
(3) Repeat this procedure until water ceases to discharge.
(4) Replace plug or nipple and cap as necessary.

Low points equipped with dual valves should be drained as follows:

(1) Close the upper valve.
(2) Open the lower valve, and drain the accumulated water.
(3) Close the lower valve, open the upper valve, and allow time for additional water accumulation.
(4) Repeat this procedure until water ceases to discharge.
(5) Replace plug or nipple and cap in lower valve.

Removing water from a preaction system is an essential part of a good maintenance program. Failure to keep these systems free of water can result in damage and expensive repairs to both the system and the building. A program for monitoring the condition of the system and the operation of the auxiliary drains should be instituted. Auxiliary drains should be operated on a daily basis after a system operation until several days pass with no discharge of water from the drain valve. Thereafter, it might be possible to decrease the frequency to weekly or longer intervals depending on the volume of water discharged. Likewise, when preparing for cold weather, the auxiliary drains should be operated daily, with the frequency of operation decreasing depending on the discharge of accumulated water. In many cases, the frequency of the operation can decrease significantly if a system is shown to be dry.

It is important that the piping be kept dry, particularly in areas subject to freezing. When a system is tripped during testing or as the result of a fire or other event, it is important to follow a plan to monitor the removal of any water as it accumulates in the system. Systems located in conditioned spaces that have supervised air pressure are particularly susceptible to moisture accumulating during the summer season as a result of warm moist air being introduced into the system.

13.4.4.3.4 Additional maintenance as required by the manufacturer's instructions shall be provided.

13.4.5 Dry Pipe Valves/Quick-Opening Devices.

A dry pipe system valve is a differential-type valve and is more sophisticated than an alarm check valve. Consequently, a dry pipe valve requires more testing and maintenance than an alarm check valve. See Exhibit 13.26 for a typical dry pipe valve.

13.4.5.1 Inspection.

13.4.5.1.1 Systems with auxiliary drains shall require a sign at the dry valve indicating the number of auxiliary drains and the location of each individual drain.

Historical Note

The requirement in 13.4.5.1.1 was added in the 2008 edition of the standard and is retroactive, so systems maintained under previous editions of the standard must be retrofitted to comply.

Many systems have auxiliary drains that are located above ceilings or in other hard-to-find locations. Service providers should consult with the owner before performing trip tests or maintenance work to verify that all drains have been located and identified.

13.4.5.1.2 The dry pipe valve shall be externally inspected monthly to verify the following:

(1) The valve is free of physical damage.
(2) All trim valves are in the appropriate open or closed position.
(3) The intermediate chamber is not leaking.

13.4.5.1.3 The interior of the dry pipe valve shall be inspected annually when the trip test is conducted.

13.4.5.1.4 Strainers, filters, and restricted orifices shall be inspected internally every 5 years unless tests indicate a greater frequency is necessary.

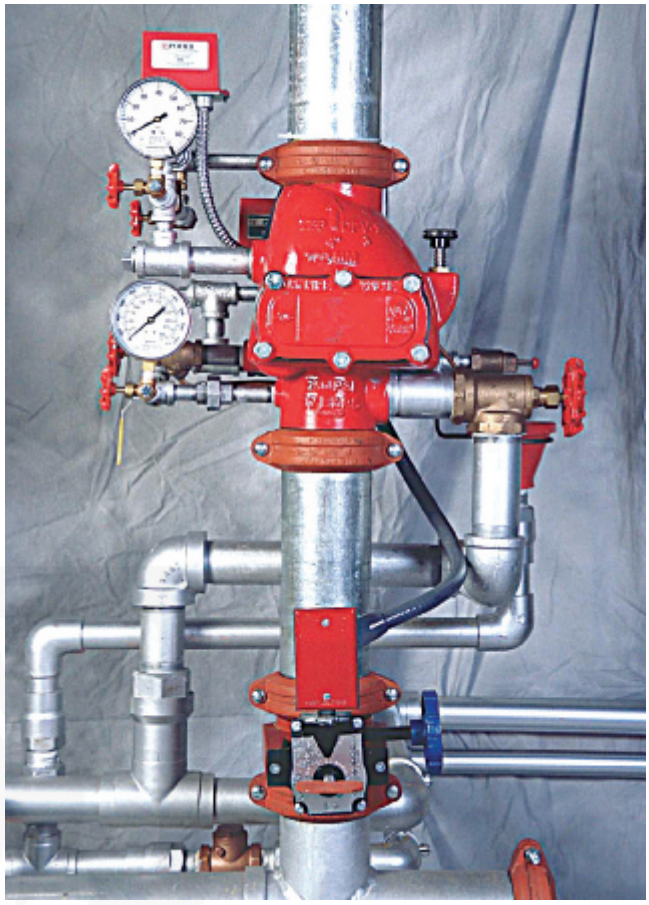


EXHIBIT 13.26 *Typical Dry Pipe Valve.*

13.4.5.2 Testing.

13.4.5.2.1* The priming water level shall be tested quarterly.

A.13.4.5.2.1 High priming water levels can affect the operation of supervisory air or nitrogen pressure maintenance devices. Test the water level as follows:

(1) Open the priming level test valve.
(2) If water flows, drain it.
(3) Close the valve when water stops flowing and air discharges.
(4) If air discharges when the valve is opened, the priming water level could be too low. To add priming water, refer to the manufacturer's instructions.

13.4.5.2.2* Each dry pipe valve shall be trip tested annually during warm weather.

Δ **A.13.4.5.2.2** Dry pipe valves should be trip tested in the spring to allow time before the onset of cold weather for all water that has entered the system or condensation to drain to low points or back to the valve.

13.4.5.2.2.1 Dry pipe valves protecting freezers shall be trip tested in a manner that does not introduce moisture into the piping in the freezers.

13.4.5.2.2.2* Every 3 years and whenever the system is altered, the dry pipe valve shall be trip tested with the control valve fully open and the quick-opening device, if provided, in service.

The purpose of completing a trip test for a dry pipe valve, be it a partial test or a full test, is to ensure that the system will operate. The full trip test of a dry pipe system allows for a comparative assessment of the water delivery time that can reveal significant delays in system operation. For a series of steps that can be taken to execute this test, refer to the testing procedure at the end of this chapter.

Testing Procedure Alert



A.13.4.5.2.2.2 A full flow trip test generally requires at least two individuals, one of whom is situated at the dry pipe valve while the other is at the inspector's test. If possible, they should be in communication with each other. A full flow trip test is conducted as follows:

(1) The main drain valve is fully opened to clean any accumulated scale or foreign material from the supply water piping. The main drain valve then is closed.
(2) The system air or nitrogen pressure and the supply water pressure are recorded.
(3) The system air or nitrogen pressure is relieved by opening the inspector's test valve completely. Concurrent with opening the valve, both testers start their stopwatches. If two-way communication is not available, the tester at the dry valve is to react to the start of downward movement on the air pressure gauge.
(4) Testers at the dry pipe valve note the air pressure at which the valve trips and note the tripping time.
(5) Testers at the inspector's test note the time at which water flows steadily from the test connection. This time is noted for comparison purposes to previous tests and is not meant to be a specific pass/fail criterion. Note that NFPA 13 does not require water delivery in 60 seconds for all systems.
(6) When clean water flows, the test is terminated by closing the system control valve.
(7) The air or nitrogen pressure and the time elapsed are to be recorded as follows:
    (a) From the complete opening of the test valve to the tripping of the valve
    (b) From the complete opening of inspector's valve to the start of steady flow from the test connection
(8) All low-point drains are opened and then closed when water ceases to flow.
(9) The dry pipe valve and quick-opening device are reset, if installed, in accordance with the manufacturer's instructions, and the system is returned to service.

For dry pipe systems that were designed and installed using either a manual demonstration or a computer calculation to simulate multiple openings to predict water delivery time, a full flow trip test from a single inspector's test connection should have been conducted during the original system acceptance and a full flow trip test from the single inspector's test should continue to be conducted every 3 years. The system is not required to achieve water delivery to the inspector's test connection in 60 seconds, but comparison to the water delivery time during the original acceptance will determine if there is a problem with the system.

Given the wide range of acceptable water delivery times, it is not the intent of NFPA 25 to reverify any specific time limits with the full flow trip test. Rather, it is the intent of NFPA 25 to reveal substantial delays for the water delivery time of dry pipe systems, since significant differences from one test to another are an indication of possible operational problems with the system. A drastic increase in the water delivery time from one full flow trip test of a dry pipe system to the next is of major concern, because such an increase is most likely due to corrosion of the system piping. This is one condition that would trigger the requirement for an internal obstruction investigation per 14.3.1(15).

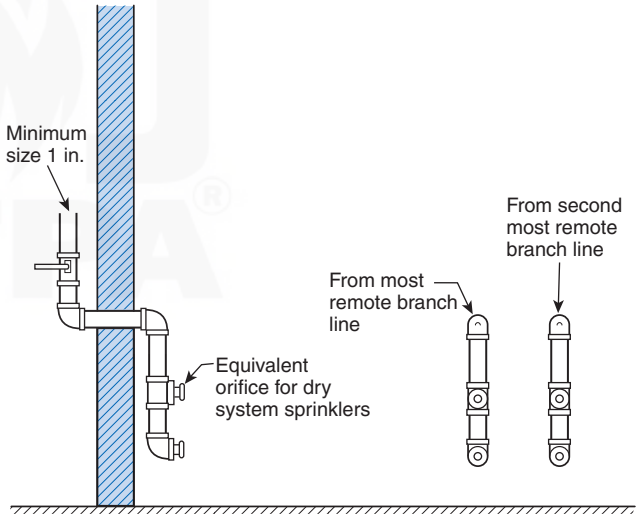
An increase in delivery time might also be an indication that physical changes have been made to the system, such as a revision in the piping layout or the orifice size of sprinklers. It might also indicate that the water supply characteristics have changed. Any substantial change in water delivery time from one test to another is cause for investigation into the source of the problem.

Dry systems are limited in size by the time needed for the system to deliver water to the inspector's test connection per NFPA 13. NFPA 13 places no time limit on water delivery for systems with a volume of 500 gal (1893 L) or less or for systems of 750 gal (2839 L) or less that are equipped with a quick opening device, because systems of these sizes typically deliver the water in a relatively short time. Systems with a volume greater than 750 gal (2839 L) must deliver water in not more than 60 seconds as determined by a listed calculation program, or the water discharge must be verified by an appropriately sized test manifold (see Exhibit 13.27) in accordance with the time limits shown in Commentary Table 13.1.

COMMENTARY TABLE 13.1 *Dry System Water Delivery*

Hazard	*Number of Most Remote Sprinklers Initially Open*	*Maximum Time of Water Delivery (seconds)*
Light	1	60
Ordinary I	2	50
Ordinary II	2	50
Extra I	4	45
Extra II	4	45
High piled	4	40

EXHIBIT 13.27 *Example Manifold Arrangement — Four Sprinklers. (Source: NFPA 13, 2010, Figure A.7.2.3.7)*



13.4.5.2.2.3* During those years when full flow testing in accordance with 13.4.5.2.2.2 is not required, each dry pipe valve shall be trip tested with the control valve partially open.

A.13.4.5.2.2.3 A partial flow trip test is conducted in the following manner:

(1) Fully open the main drain valve to clean any accumulated scale or foreign material from the supply water piping.
(2) Close the control valve to the point where additional closure cannot provide flow through the entire area of the drain outlet.
(3) Close the valve controlling flow to the device if a quick-opening device is installed.
(4) Record the system air or nitrogen pressure and the supply water pressure.
(5) Relieve system air or nitrogen pressure by opening the priming level test valve or the inspector's test valve.

(6) Note and record the air or nitrogen pressure, and supply water pressure when the dry pipe valve trips.
(7) Immediately close the system control valve, and open the main drain valve to minimize the amount of water entering the system piping.
(8) Trip test the quick-opening device, if installed, in accordance with the manufacturer's instructions.
(9) Open all low point drains, and close them when water ceases to flow.
(10) Reset the dry pipe valve and quick-opening device, if installed, in accordance with the manufacturer's instructions, and return the system to service.

CAUTION: A partial flow trip test does not provide a high enough rate of flow to latch the clappers of some dry pipe valve models in the open position. When resetting such valves, check that the latching equipment is operative.

13.4.5.2.2.4 When refilling a dry system, the air supply shall be capable of restoring normal air pressure in the system within 30 minutes.

13.4.5.2.2.5 The requirements of 13.4.5.2.2.4 shall not apply in refrigerated spaces maintained below 5°F (–15°C), where normal system air pressure shall be permitted to be restored within 60 minutes.

13.4.5.2.3 Grease or other sealing materials shall not be applied to the seating surfaces of dry pipe valves.

13.4.5.2.4* Quick-opening devices, if provided, shall be tested quarterly.

Δ **A.13.4.5.2.4** Except when a full flow trip test is conducted in accordance with A.13.4.5.2.2.2, a quick-opening device should be tested in the following manner:

(1) Close the system control valve
(2) Open the main drain valve, and keep it in the open position
(3) Verify that the quick-opening device control valve is open
(4) Open the inspector's test valve. (Note that a burst of air from the device indicates that it has tripped)
(5) Close the device's control valve
(6) Return the device to service in accordance with the manufacturer's instructions and return the system to service

13.4.5.2.5 A tag or card that shows the date on which the dry pipe valve was last tripped, and the name of the person and organization conducting the test, shall be attached to the valve.

13.4.5.2.5.1 Separate records of initial air and water pressure, tripping air pressure, and dry pipe valve operating conditions shall be maintained on the premises for comparison with previous test results.

Section 4.3 contains the minimum requirements for the maintenance of these records.

13.4.5.2.5.2 Records of dry pipe valve tripping time and water transit delivery time to the inspector's test connection shall be maintained for full flow trip tests.

See Supplement 4 for sample trip test report forms.

13.4.5.2.6 Low air pressure alarms, if provided, shall be tested annually in accordance with the manufacturer's instructions.

13.4.5.2.7 Low temperature alarms, if installed in valve enclosures, shall be tested annually at the beginning of the heating season.

13.4.5.2.8 Automatic air pressure maintenance devices, if provided, shall be tested annually during the dry pipe valve trip test in accordance with the manufacturer's instructions.

Testing Procedure Alert



The low air pressure switch is an important piece of equipment in a dry system, because it is the device that signals the dry valve to open at the desired system pressure. Failure of the pressure switches to operate can delay the opening of the dry valve or, in some cases, can cause the valve to open and fill the system when there is no fire event. For more information on conducting this test, see the testing procedure at the end of this chapter.

13.4.5.2.9 Dry pipe systems shall be tested once every 3 years for gas leakage, using one of the following test methods:

(1) A gas (air or nitrogen) pressure test at 40 psi (3.2 bar) shall be performed for 2 hours.
   (a) The system shall be permitted to lose up to 3 psi (0.2 bar) during the duration of the test.
   (b) Gas leaks shall be addressed if the system loses more than 3 psi (0.2 bar) during this test.
(2) With the system at normal system pressure, the gas source (nitrogen supply, compressor, or shop air) shall be shut off for 4 hours. If the low pressure alarm goes off within this period, the leaks shall be addressed.

Historical Note

The test required by 13.4.5.2.9 was introduced in the 2008 edition of the standard. The previous requirement called for a 10 psi (0.7 bar) pressure loss per week, but this loss was difficult to ascertain because the automatic air supply would generally maintain pressure by cycling on and off.

The intent of the air pressure test is to determine if a significant problem exists. A dry pipe system must be capable of staying closed without any trips of the dry pipe valve for short periods of time, such as during a power outage, without the air compressor maintaining pressure. Either method listed in 13.4.5.2.9 can be used to demonstrate the integrity of the system.

If a dry pipe valve is designed to trip at 25 psi (1.7 bar), the air supply should be set to provide 20 psi (1.4 bar) in excess of this pressure or 45 psi (3.1 bar). The automatic air compressor could be set to turn on at 35 psi (2.4 bar) and turn off at 45 psi (3.1 bar). The low air pressure switch might be set at 30 psi (2.1 bar) to produce a low air alarm. In this case, assuming the air compressor is about to turn on (a worst-case scenario), the system would be permitted to lose only 5 psi (0.3 bar). At the high end of the air compressor cycle, the system would be permitted to lose 15 psi (1 bar).

Testing Procedure Alert



Dry pipe systems that have excessive leakage can become costly for owners who constantly have to drain dry piping that becomes inadvertently filled. When dry systems leak, the low air pressure switch acknowledges the pressure drop and sends a signal to the valve to open. If this is due to leakage, as opposed to a sprinkler activating, it is important to drain the system so that a freeze situation does not occur. To learn how to conduct a test to make sure dry systems are sufficiently "tight," refer to the testing procedure at the end of this chapter.

13.4.5.3 Maintenance.

13.4.5.3.1 During the annual trip test, the interior of the dry pipe valve shall be cleaned thoroughly, and parts replaced or repaired as necessary.

13.4.5.3.2* Auxiliary drains in dry pipe sprinkler systems shall be drained after each operation of the system, before the onset of freezing weather conditions, and thereafter as needed.

A.13.4.5.3.2 Removing water from a dry system is an essential part of a good maintenance program. Failure to keep the dry system free of water can result in damage and expensive repairs to both the system and building. A program for monitoring the condition of the system and the operation of the auxiliary drains should be instituted. Auxiliary drains should be operated on a daily basis after a dry sprinkler system operation until several days pass with no discharge of water from the drain valve. Thereafter, it might be possible to decrease the frequency to weekly or longer intervals depending on the volume of water discharged. Likewise, when preparing for cold weather, the auxiliary drains should be operated daily with the frequency of operation decreasing depending on the discharge of accumulated water. In many cases, the frequency of the operation can decrease significantly if a system is shown to be dry. A quick-opening device, if installed, should be removed temporarily from service prior to draining low points.

The low point drain in a dry pipe system is commonly referred to as a condensate nipple. The condensate nipple consists of a 1 ft (0.3 m) length of 2 in. (50 mm) pipe with a 1 in. (25 mm) valve on each end. The upper valve is closed to isolate the condensate nipple from the dry pipe system. Next, the lower valve is opened to drain any moisture from within. Once draining is complete, the upper valve is opened to allow moisture to drain into the condensate nipple.

Exhibit 13.28 shows a low point drain on a dry pipe system where any excess moisture is drained following the test. Exhibit 13.29 shows a corroded pipe from a dry pipe system that was not drained properly. See the commentary following A.13.4.3.3.3 for more information on dry piping.



EXHIBIT 13.28 *Low Point Drain.*



EXHIBIT 13.29 *Corroded Pipe.*

13.5 Pressure-Reducing Valves and Relief Valves.

Pressure-reducing valves, such as the one shown in Exhibit 13.30, and relief valves are installed to control pressures in fire protection systems. They are usually set to reduce pressures on the system side of the valve to pressures not exceeding 175 psi (12.1 bar), the maximum working pressure for most listed sprinkler system components. The maximum pressure allowed for larger standpipe hose connections is 175 psi (12.1 bar). The maximum pressure allowed for connections supplying small hose is 100 psi (6.9 bar). Pressure-reducing and relief valves, as illustrated in Exhibit 13.31, are installed to control pressures in fire protection systems such as sprinkler and standpipe systems. Exhibit 13.32 illustrates a system pressure relief valve located in a fire pump room.

13.5.1 Inspection and Testing of Sprinkler Pressure-Reducing Valves. Sprinkler pressure-reducing valves shall be inspected and tested as described in 13.5.1.1 and 13.5.1.2.

13.5.1.1 All valves shall be inspected quarterly to verify that the valves are in the following condition:

(1) In the open position
(2) Not leaking
(3) Maintaining downstream pressures in accordance with the design criteria
(4) Handwheels installed and unbroken

13.5.1.2 A full flow test shall be conducted on each valve at 5-year intervals and shall be compared to previous test results.

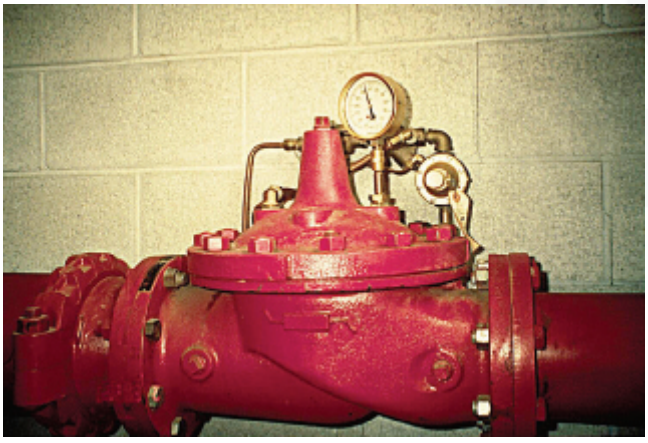


EXHIBIT 13.30 *Master Pressure-Reducing Valve Typically Seen on the Discharge Side of a Fire Pump.*



EXHIBIT 13.31 *Standpipe with Both a Sprinkler System Pressure-Reducing Valve and a Hose Connection Pressure Reducing Valve.*

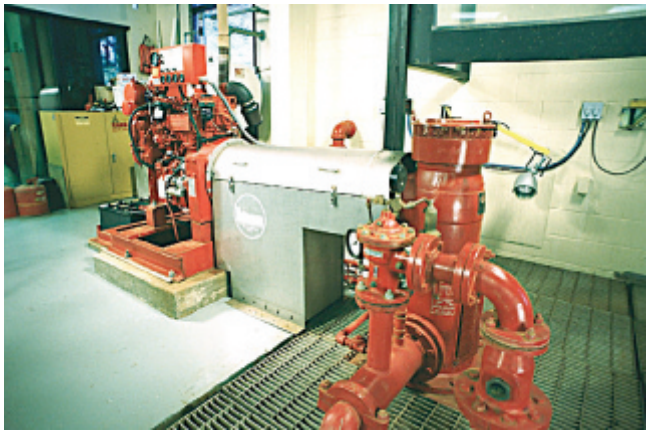


EXHIBIT 13.32 *Pressure-Relief Valve Typically Seen on the Discharge Side of a Fire Pump.*

The system pressure-reducing valve is responsible for maintaining downstream system pressures at a level lower than the pressure rating of the system components on the system side of the valve. In 13.5.1.2, NFPA 25 requires a full flow test of this valve to provide the owner and other stakeholders with assurance that the downstream system components will not see pressures in excess of what they are designed to handle. To learn more about this test, including an approach on how to conduct it, refer to the testing procedures at the end of this chapter.

Testing Procedure Alert

ITM NFPA 25

This testing involves discharging water approximating the system demand, to allow for measurement of the water flow rate and the reading of the pressure gauges. NFPA 13 requires that "means shall be provided downstream of all pressure-reducing valves for flow tests at sprinkler system demand." Pressures should be measured on each side of the valve to verify that high pressures on the supply side of the valve are reduced to a pressure that is less than the rating of the system components on the system side of the valve. Sprinkler systems are typically rated for a maximum of 175 psi (12.1 bar). However, there are systems equipped with components — including the sprinklers — that are rated for pressures higher than 175 psi (12.1 bar). Discharge should be to a drain connection or receptacle that can accommodate the flow without spilling.

13.5.1.2.1 Adjustments shall be made in accordance with the manufacturer's instructions.

Not all valves are field adjustable. Valves that are adjustable should be adjusted in accordance with the design and installation documents and, as required by 13.5.1.2.1, with the manufacturer's instructions.

13.5.1.3 A partial flow test adequate to move the valve from its seat shall be conducted annually.

The test required in 13.5.1.3 is intended to exercise the valve and to ensure that it is not obstructed and will reseat. A full flow test is not required because a properly functioning valve will move and reseat with a relatively small flow of water.

13.5.2 Hose Connection Pressure-Regulating Devices.

Pressure-reducing valves for hose connections are installed to reduce pressures to a safe level for those individuals that are trained in the use of fire hose.

Small hose connections are provided in 1½ in. (40 mm) diameters and must be restricted to not more than 100 psi (6.9 bar). Connections for heavy hose [2½ in. (65 mm) diameter]

must be restricted to not more than 175 psi (12.1 bar). For more information regarding hose connection pressures, see Chapter 7 of NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*. Exhibit 13.33 illustrates apparatus for testing a pressure-reducing valve.

EXHIBIT 13.33 *Testing a Pressure-Reducing Hose Valve. (Courtesy of the Hose Monster Company)*



13.5.2.1 All devices shall be inspected annually to verify the following:

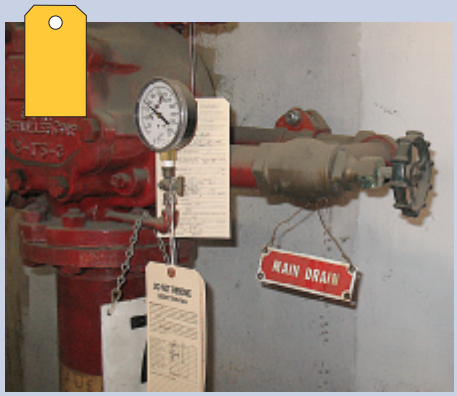
(1) The handwheel is not broken or missing.
(2) The outlet hose threads are not damaged.
(3) No leaks are present.
(4) The hose adapter and the cap are not missing.

The hose connection cap, which is permitted to be plastic, is intended to protect the hose threads only. However, it also serves the vital function of protecting the integrity of the system by preventing obstructions. If the cap is removed, material such as trash could enter the valve, creating an obstruction and rendering the system ineffective.

System Tagging

In Table A.3.3.8, a distinction is made between dripping and spraying leaks in system piping. This drain valve is dripping and would therefore be considered a noncritical deficiency. The component is part of the drain system, which is not vital to suppressing a fire, and there is only a limited amount of water leaking from the valve.





(Courtesy of Byron Blake and SimplexGrinnell)

13.5.2.2* A full flow test shall be conducted on each device at 5-year intervals and shall be compared to previous test results.

Hose connection pressure-regulating devices are designed to maintain downstream pressures to an appropriate level based on the type of hose connection present. This test is designed to confirm that these devices are functioning properly and that there are not excessive pressures at the hose outlet that can damage equipment and potentially endanger users. For information on conducting this test, refer to the testing procedure at the end of this chapter.

Testing Procedure Alert

Δ **A.13.5.2.2** PRV devices can be bench tested in accordance with the manufacturer's instructions or tested in place. To test in place, a gauge is connected on both the inlet side and the outlet side of the device, and flow readings are taken using a Pitot tube or a flowmeter. Water is discharged through a roof manifold, if available, or through hose to the exterior of the building. Another acceptable method for systems having at least two risers is to take one standpipe out of service and use it as a drain by removing PRV devices and attaching hoses at the outlets near the ground floor level. When testing in this manner, a flowmeter should be used and a hose line utilized to connect the riser being tested and the drain riser.

Readings are to be compared to the system's hydraulic demands at the test location. Field-adjustable valves are to be reset in accordance with manufacturer's instructions. Nonadjustable valves should be replaced. Extreme caution should be exercised because of the high pressure involved when testing.

Historical Note

Standpipe systems installed prior to 1993 must be tested as described in A.13.5.2.2. Since 1993, NFPA 14 has required the installation of a 3 in. (75 mm) drain riser where pressure-reducing devices are installed in a standpipe system. The drain riser must provide a 2½ in. (65 mm) swivel outlet on every other floor for connection of hose.

13.5.2.2.1 Adjustments shall be made in accordance with the manufacturer's instructions.

13.5.2.3 A partial flow test for pressure-reducing valves adequate to move the device from its seat shall be conducted annually.

As described in 13.5.1.3, the test in 13.5.2.3 is intended to exercise the valve and to ensure that it is not obstructed and will reseat. A partial flow test is sufficient to indicate whether the valve is functioning properly.

13.5.3 Hose Rack Assembly Pressure-Regulating Devices.

Hose rack pressure-reducing valves, covered in 13.5.3, can be either 1½ in. (40 mm) or 2½ in. (65 mm) in size and are pre-connected to a hose rack complete with hose and nozzle. A hose rack can be connected to a sprinkler system or be part of a standpipe system. In either case, the test requirements for the valve are identical to those specified in 13.5.2.

13.5.3.1 All devices shall be inspected annually to verify the following:

(1) The handwheel is not missing or broken.
(2) No leaks are present.

13.5.3.2 A full flow test shall be conducted on each device at 5-year intervals and compared to previous test results.

13.5.3.2.1 Adjustments shall be made in accordance with the manufacturer's instructions.

13.5.3.3 A partial flow test for pressure-reducing valves adequate to move the device from its seat shall be conducted annually.

13.5.4 Master Pressure-Regulating Devices.

Historical Note

Beginning with the 2007 edition, NFPA 14 has recognized the use of a master pressure-reducing valve (PRV) in standpipe systems. This device is permitted to be installed downstream of the fire pump discharge piping and can be installed in such a way as to control the pressure to an entire system or an entire zone of a standpipe system.

The master PRV must be installed with a bypass arrangement that will permit maintenance of the device without initiating an impairment procedure. Valves must also be installed to allow isolation of the device for maintenance and testing purposes. Some installations might include multiple master PRVs: one for the higher flow of standpipe systems and one for the lower flows of sprinkler systems. Other installations might include two PRVs installed in series to prevent over-pressurization of a standpipe system should one valve fail. See Exhibit 13.34 for typical PRV arrangements, including a dual pressure-regulating device arrangement.

13.5.4.1 Devices shall be inspected weekly to verify that the devices are in the following condition:

(1) *Normal downstream pressures are maintained.

A.13.5.4.1(1) Pressures downstream of the master PRV should not exceed the maximum pressure rating of the system components.

(2) Normal supply pressure is maintained.
(3) Devices and associated trim components are free of physical damage and are not leaking.

13.5.4.2* A partial flow test adequate to move the valve from its seat shall be conducted quarterly.

A.13.5.4.2 The partial flow test of the master PRV can be performed during the quarterly main drain test. *(See 13.2.3.2.)*

13.5.4.3 A full flow test shall be conducted on each valve annually and shall be compared to previous test results.

13.5.4.4 When valve adjustments are necessary, they shall be made in accordance with the manufacturer's instructions.

13.5.5 Pressure-Reducing Valves.

13.5.5.1 All pressure-reducing valves installed on fire protection systems not covered by 13.5.1, 13.5.2, 13.5.3, or 13.5.4 shall be inspected in accordance with 13.5.1.1.

13.5.5.2 All pressure-reducing valves installed on fire protection systems not covered by 13.5.1, 13.5.2, 13.5.3, or 13.5.4 shall be tested in accordance with 13.5.1.2.

13.5.6 Fire Pump Relief Valves.

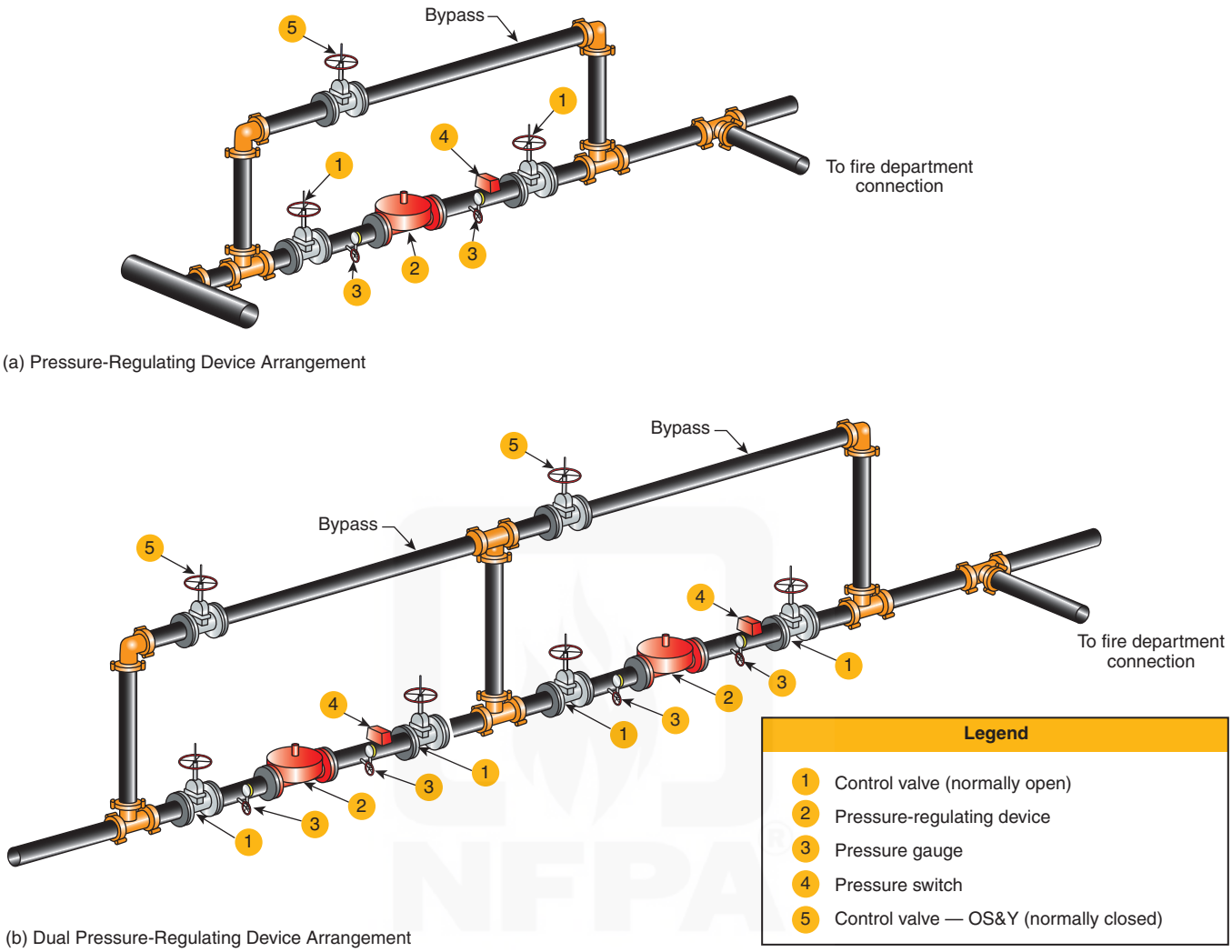


EXHIBIT 13.34 *Pressure-Regulating Device Arrangements. (Courtesy of Stephan Laforest)*

13.5.6.1 Circulation Relief Valves.

13.5.6.1.1 Where installed, circulation relief valves shall be inspected on the same frequency as the no-flow (churn) test.

13.5.6.1.2 The inspection shall verify that water flows through the valve when the fire pump is operating at shutoff pressure (i.e., churn) to prevent the pump from overheating.

13.5.6.1.3 On completion of any fire pump test, the closure of the circulation relief valve shall be verified.

13.5.6.2 Main Pressure Relief Valve.

13.5.6.2.1 Where installed, main pressure relief valves shall be inspected during any fire pump test.

13.5.6.2.2 The inspection shall verify that the pressure downstream of the relief valve fittings in the fire pump discharge piping does not exceed the pressure for which the system components are rated.

Paragraph 13.5.6.2.2 applies only to those pump installations equipped with a pressure relief valve. Such installations are those that produce pressures in excess of the listing for system components. An example of this type of system is illustrated in Exhibit 13.35. Other installations will not be so equipped.



EXHIBIT 13.35 *Pressure Relief Valve with Sight Glass. (Courtesy of John Jensen)*

13.5.6.2.3 During the annual fire pump flow test, the pressure relief valve shall be verified to be correctly adjusted and set to relieve at the correct pressure and to close below that pressure setting.

13.5.7 Maintenance. All damaged or missing components noted during the inspections specified in 13.6.1 through 13.6.2.2 shall be repaired or replaced in accordance with the manufacturer's instructions.

13.6 Hose Valves.

13.6.1 Inspection.

13.6.1.1 Hose valves shall be inspected quarterly to verify that the valves are in the following condition:

(1) Hose caps are in place and not damaged.
(2) Hose threads are not damaged.
(3) Valve handles are present and not damaged.
(4) Gaskets are not damaged or showing signs of deterioration.
(5) No leaks are present.
(6) Valves are not obstructed or otherwise not capable of normal operation.

13.6.1.2 Hose valves shall be inspected to ensure that hose caps are in place and not damaged.

13.6.1.3 Hose threads shall be inspected for damage.

13.6.1.4 Valve handles shall be present and not damaged.

13.6.1.5 Gaskets shall be inspected for damage or deterioration.

13.6.1.6 Hose valves shall be inspected for leaks.

13.6.1.7 Hose valves shall be inspected to ensure no obstructions are present.

13.6.1.8 Hose valves shall be inspected to ensure that restricting devices are present.

13.6.2 Testing.

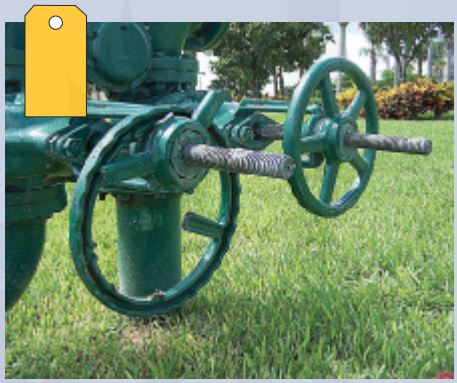
The testing and maintenance requirements described in 13.6.2 should be performed by a qualified contractor or service provider. A *qualified* individual is defined in 3.3.36 as someone who has met the requirements and training for a given field acceptable to the AHJ. This qualification is not standardized and can vary by jurisdiction.

13.6.2.1* Class I and Class III standpipe system hose valves shall be tested annually by fully opening and closing the valves.

System Tagging

Each of these photos shows a broken control valve, which will typically be considered a noncritical deficiency. The ability to turn the control valve does not impact the operation of a system. However, it should be noted that, for control valves that are in the closed position when a handle breaks, this issue can be considered an impairment or critical deficiency if there is no way to get the system back on-line.





(Courtesy of Byron Blake and SimplexGrinnell)

Noncritical Deficiency Critical Deficiency Impairment

A.13.6.2.1 Hose valves can be tested without a full flow if the cap is left on the hose threads. The purpose of this requirement is to exercise the valve so it can be operated easily.

FAQ Do the valves need to be flowed or just opened and closed to comply with 13.6.2.1?

The valves do not need to be flowed for this test. The purpose of this requirement is to exercise the valve so it can be operated easily. This test often will indicate whether the valve is sticking, which allows maintenance personnel to correct the issue so that the valve functions properly when it is needed. This test is not intended to be a prolonged flow test used for the removal of foreign objects in the systems.

13.6.2.1.1 Class I and Class III standpipe system hose valves that are difficult to operate or leak shall be repaired or replaced.

13.6.2.2* Hose valves on hose stations attached to sprinkler systems and Class II standpipe systems shall be tested every 3 years by opening and closing the valves.

A.13.6.2.2 See A.13.6.2.1.

13.6.2.2.1 Hose valves on hose stations attached to sprinkler systems and Class II standpipe systems that are difficult to operate or leak shall be repaired or replaced.

13.6.3 Maintenance. Hose valves that do not operate smoothly or open fully shall be lubricated, repaired, or replaced.

13.7 Backflow Prevention Assemblies.

13.7.1 Inspection. Inspection of backflow prevention assemblies shall be as described in 13.7.1.1 through 13.7.1.3.

13.7.1.1 Reduced-pressure assemblies and reduced-pressure detector assemblies shall be inspected weekly to ensure that the differential-sensing valve relief port is not continuously discharging.

Backflow assemblies contain OS&Y valves to isolate backflow devices for maintenance and for fire system control. These control valves must be inspected and tested in accordance with NFPA 25. While the backflow itself might require a licensed contractor for testing control valve inspections, it can be accomplished by the property owner or designee subject to AHJ approval.

13.7.1.2 After any testing or repair, an inspection by the property owner or designated representative shall be made to ensure that the system is in service and all isolation valves are in the normal open position and properly locked or electrically supervised.

13.7.1.3* Backflow prevention assemblies shall be inspected internally every 5 years to verify that all components operate correctly, move freely, and are in good condition.

A.13.7.1.3 Where annual maintenance includes an internal inspection performed by a qualified person, this requirement is satisfied.

13.7.2 Testing.

13.7.2.1* All backflow preventers installed in fire protection system piping shall be exercised annually by conducting a forward flow test at a minimum flow rate of the system demand.

A.13.7.2.1 The full flow test of the backflow prevention valve can be performed with a test header or other connections downstream of the valve. A bypass around the check valve in the fire department connection line with a control valve in the normally closed position can be an acceptable arrangement. When flow to a visible drain cannot be accomplished, closed loop flow can be acceptable if a flowmeter or sight glass is incorporated into the system to ensure flow.

FAQ Is backflow testing required by NFPA 25?

Beginning with the 2011 edition of this standard, only a forward flow test of the system through the backflow preventer is required. The backflow test was deemed by the technical committee to be outside the scope of the standard, because it is a requirement of water quality standards and performed by an individual with specific training and licensing. However, many contractors have obtained the required licenses to perform the backflow test and do so as part of their fire protection system servicing.

13.7.2.1.1 Where water rationing is enforced during shortages lasting more than 1 year, an internal inspection of the backflow preventer to ensure the check valves will fully open shall be permitted in lieu of conducting the annual forward flow test.

13.7.2.1.2 The forward flow test shall not be required where annual fire pump testing causes the system flow rate to flow through the backflow preventer device.

Many local health authorities require that a backflow preventer be the first device installed on a water supply pipe. In such cases, the annual fire pump test will produce sufficient flow through the backflow preventer to meet the full forward flow test requirement. In some cases, a backflow preventer can be installed on the system side of a fire pump — ordinarily between the fire department connection (FDC) and the potable water supply — so that the annual fire pump test would not produce any flow through the backflow preventer. When this is the case, a separate flow test is necessary.

13.7.2.2 Where hydrants or inside hose stations are located downstream of the backflow preventer, the forward flow test shall include hose stream demand.

Historical Note

On systems installed under the requirements of the 1996 and subsequent editions of NFPA 13, the forward flow test at system demand has been a part of the system acceptance test. However, due to a lack of enforcement, few systems are equipped with a means to conduct the test. As a result, the technical committee has limited this test requirement to only require flow to the amount of water equivalent to the system demand to configurations where some means of testing, such as a fire hydrant or hose connections, are available downstream of the backflow device.

Paragraph 13.7.2.2 allows the test to be conducted using the maximum flow rate possible. Flow testing at the highest rate possible does not necessarily mean a simple main drain test. It might necessitate opening the inspector's test connections along with the main drain or, where multiple systems are present, opening multiple main drains. For example, a typical big box retail warehouse has multiple systems, with each individual system requiring a flow of 1500 gpm (5678 L/min) or more. The main drain valves on these multiple systems could be opened simultaneously to flow a volume of water that is close to the system demand.

Poorly performing backflow check valve assemblies can result in an impaired fire protection sprinkler system. Backflow assemblies must be listed. Part of this listing for use in a fire protection system includes evaluations for durability, reliability, and flow characteristics. Each assembly has flow characteristics that show pressure drop related to flow. This must be evaluated with system demands, especially when installed on a pre-existing system.

13.7.2.3 Where connections do not permit verification of the forward flow test at the minimum flow rate of system demand, tests shall be conducted at the maximum flow rate possible.

13.7.3 Maintenance. Maintenance of all backflow prevention assemblies shall be conducted by a qualified individual following the manufacturer's instructions in accordance with the procedure and policies of the authority having jurisdiction.

13.8 Fire Department Connections.

13.8.1 Fire department connections shall be inspected quarterly to verify the following:

(1) Fire department connections are visible and accessible.
(2) Couplings or swivels are not damaged and rotate smoothly.

System Tagging

A failed FDC should be repaired when it is found, because the FDC is an integral part of fire-fighting operations. A leaky FDC caused by a broken gasket will not prevent water from getting to the system, so this is typically considered a noncritical deficiency. However, it is important to check with the fire department, because their perspective may differ from the perspective of the users of the device.



(Courtesy of Byron Blake and SimplexGrinnell)

Noncritical Deficiency

Critical Deficiency

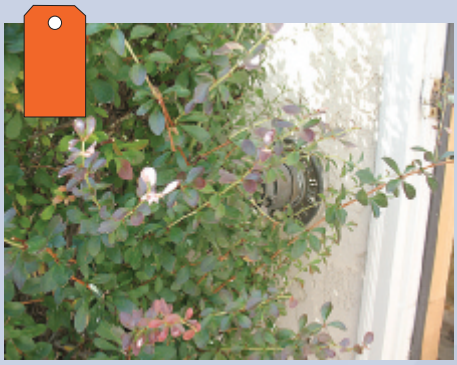
Impairment

(3) Plugs or caps are in place and undamaged.
(4) Gaskets are in place.
(5) Identification signs are in place.
(6) Check valve is not leaking.
(7) Automatic drain valve is in place and operating properly.
(8) Fire department connection clapper(s) is in place and operating properly.

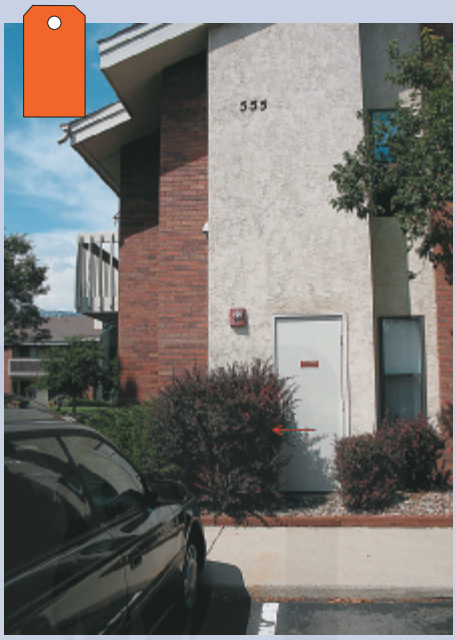
Exhibit 13.36 illustrates a typical FDC inspection where the caps are removed. The inspector examines inside the FDC for evidence of obstructing material and checks that the couplings are not damaged, the gaskets are in good condition, and the swivels rotate properly. Exhibit 13.37 illustrates an FDC that is obscured from view by vegetation. Visibility, particularly at night, is important so that the fire department can locate the device easily. Exhibit 13.38 illustrates an FDC that has been broken or vandalized. In this case, a threaded outlet and cap are missing, which can allow obstructing material to enter the device, as demonstrated by the trash visible in the valve openings of the FDC shown in Exhibit 13.39. Exhibit 13.40 illustrates an FDC that is leaking as evidenced by the staining on the building façade. Exhibit 13.41 shows an FDC that cannot accept a fire department hose due to the FDC's proximity to a large tree. Exhibit 13.42 shows an FDC that has not been maintained and inspected and can no longer accept a threaded hose fitting due to corrosion.

System Tagging

The FDC shown in this picture is blocked by shrubbery and would be difficult, if not impossible, for the fire department to see from a roadway or parking lot. An FDC that is not visible might be considered a critical deficiency. In cases where the fire department cannot access the device, it would be considered an impairment per Table A.3.3.8. In this case, the device is accessible and will become more so when responding personnel simply cut down the shrub to hook up to the FDC during a fire.



(Courtesy of Byron Blake and SimplexGrinnell)



Noncritical Deficiency Critical Deficiency Impairment



EXHIBIT 13.36 *FDC Inspection.*



EXHIBIT 13.37 *FDC Obstructed by Vegetation.*



EXHIBIT 13.38 *FDC Missing Threaded Outlet and Cap.*



EXHIBIT 13.39 *FDC Showing Clear Access with Caps Missing.*



EXHIBIT 13.40 *Leaking FDC Indicating Replacement of the Check Valve Is Likely Required.*



EXHIBIT 13.41 *Inaccessible FDC. (Courtesy of Wayne Automatic Fire Sprinklers, Inc.)*

(9) *Interior of the connection is inspected for obstructions.

While 13.8.1(9) does not require all of the FDC piping to be internally inspected, where the connection itself shows signs of obstructions, it should warrant a further investigation to determine the extent of the problem.

A.13.8.1(9) It is not the intent of this section for all fire department connection piping to be inspected for obstructions but only the interior of the connection itself.

(10) Visible piping supplying the fire department connection is undamaged.

13.8.2 Interior inspections shall be conducted annually if approved locking caps or locking plugs are installed.



EXHIBIT 13.42 *FDC Heavily Corroded Due to Lack of Maintenance and Inspections. (Courtesy of Wayne Automatic Fire Sprinklers, Inc.)*

System Tagging

Missing caps on FDCs might be treated as a critical deficiency. The FDC is essential to fire-fighting operations and the equipment must be in proper working order. In many instances, the fire department will also require a flushing test or an investigation into the FDC piping where it has been recorded that the caps are missing. It is not uncommon for people passing by to put trash — such as soda bottles or cans — in an FDC, which can render the piping impaired.



(Courtesy of Byron Blake and SimplexGrinnell)



Noncritical Deficiency Critical Deficiency Impairment

Because locking caps or plugs both protect couplings and threads and prevent vandalism, the frequency of internal inspections is extended when they are installed (see Exhibit 13.43). While it is not the intent of this requirement that the entire run of piping connecting the FDC to the check valve be internally inspected, this could be the only way to ensure that there are no interior obstructions. A small rock or ball dropped into an FDC could roll all the way down to the check valve. This valve could be underground or many feet from the actual FDC header. The easiest way to do a complete inspection in these cases is with a borescope. If foreign material is seen, it must be removed. This might require excavation of the FDC piping up to the check valve.



EXHIBIT 13.43 *Locking Caps on FDCs. (Courtesy of the National Fire Sprinkler Association)*

13.8.3 Components shall be repaired or replaced as necessary in accordance with the manufacturer's instructions.

13.8.4 Any obstructions that are present shall be removed.

13.8.5 The piping from the fire department connection to the fire department check valve shall be hydrostatically tested at 150 psi (10 bar) for 2 hours at least once every 5 years.

13.9 Automatic Detection Equipment.

13.9.1 Automatic detection equipment used to actuate water-based fire protection systems shall be inspected, tested, and maintained in accordance with *NFPA 72*.

13.9.2 Automatic detection equipment used to actuate water-based fire protection systems that is not covered by *NFPA 72* shall be inspected, tested, and maintained to ensure that the detectors are in place, securely fastened, and protected from corrosion, weather, and mechanical damage and to ensure that the communication wiring, control panels, or pneumatic tubing system is functional.

13.10 Air Compressors and Nitrogen Generators.

Δ **13.10.1 General.**

N **13.10.1.1** Air compressors and nitrogen generators dedicated to water-based fire protection systems shall be inspected, tested, and maintained in accordance with 13.10.2, 13.10.3, and 13.10.4.

13.10.1.2 Air compressors not dedicated to water-based fire protection systems shall be inspected, tested, and maintained in accordance with the manufacturer's instructions.

13.10.2 Inspection.
Air compressors and nitrogen generators dedicated to water-based fire protection systems shall be inspected monthly to verify the following:

(1) Air compressor or nitrogen generator is free of physical damage.
(2) Power wiring to the air compressor is intact and free of physical damage.
(3) Piping from the air compressor or nitrogen generator to the fire protection system is intact and free of physical damage.

(4) The means of anchoring the air compressor or nitrogen generator to the structure or to the system piping is secure, tight, and free of physical damage.
(5) Air compressors requiring oil have the required amount of oil in the oil reservoir.

13.10.3 Testing.

Air compressors or nitrogen generator dedicated to water-based fire protection systems shall be tested annually to verify the following:

(1) Air compressor or nitrogen generator operates as intended on the proper drop of air pressure in the fire protection system.
(2) *Air compressor or nitrogen generator restores normal supervisory pressure in the fire protection system in the required time frame.

N **A.13.10.3(2)** Nitrogen generator might have to switch from maintain mode to fill mode to meet the restoration time.

(3) Air compressor does not overheat while running.

13.10.4 Maintenance.

13.10.4.1 Air compressors or nitrogen generators dedicated to water-based fire protection systems shall be maintained in accordance with the manufacturer's instructions.

13.10.4.2 Compressors requiring oil shall have the oil replaced on an annual basis unless the manufacturer's instructions require more frequent replacement.

13.11 Component Testing Requirements.

13.11.1 Whenever a valve, valve component, and/or valve trim is adjusted, repaired, reconditioned, or replaced, the action required in Table 13.11.1 shall be performed.

Δ ***TABLE 13.11.1*** *Summary of Component Action Requirements*

Component	*Adjust*	*Repair/ Recondition*	*Replace*	*Inspection, Test, and Maintenance Procedures*
Water delivery components				
Post indicator and wall indicator valves	X	X	X	(1) Inspect for leaks at system pressure (2) Perform full operational test conforming to 13.3.3.1 (3) Perform spring torsion inspection conforming to 13.3.3.2 (4) Verify target visibility at shut and full open position (5) Test supervisory device (6) Valve status test
Control valves other than post indicator and wall indicator valves	X	X	X	(1) Inspect for leaks at system pressure (2) Perform full operational test conforming to 13.3.3.1 (3) Valves to be backed one-quarter turn from fully open to prevent jamming in accordance with 13.3.3.3 (4) Verify supervisory device (5) Valve status test
Alarm check valve	X	X	X	(1) Inspect for leaks at system pressure per 13.4.1 (2) Test all alarms and supervisory signals affected by the alarm valve (3) Valve status test

(continues)

Δ ***TABLE 13.11.1*** *Continued*

Component	*Adjust*	*Repair/ Recondition*	*Replace*	*Inspection, Test, and Maintenance Procedures*
Dry pipe valve	X	X	X	(1) Inspect for leaks at system pressure (2) Trip test per 13.4.5.2 (3) Inspect condition of valve seat (4) Test all dry pipe system alarms and supervisory signals (5) Valve status test
Deluge/preaction valve	X	X	X	(1) Inspect for leaks at system pressure per 13.4.4/13.4.3 (2) Trip test (3) Inspect condition of valve seat (4) Test all deluge/preaction system alarms and supervisory signals (5) Valve status test
Quick-opening device	X	X	X	(1) Inspect for leaks at system pressure per 13.4.5.2.9 (2) Trip test (3) Valve status test
Pressure-regulating device — hose valves	X	X	X	(1) Inspect for leaks at system pressure per 13.5.2 (2) Full flow test (3) Valve status test
Pressure-regulating devices — other than hose valves	X	X	X	(1) Inspect for leaks at system pressure per Section 13.5 (2) Test pressure setting with full flow and without flow (3) Test supervisory device and alarm (4) Valve status test
Hose valve	X	X	X	(1) Inspect for leaks at system pressure per Section 13.6 (2) Valve status test
Backflow prevention device	X	X	X	(1) Inspect for leaks at system pressure per Section 13.7 (2) Forward flow test per 13.7.2.1 (3) Test supervisory device and alarm (4) Valve status test
Check valves	X	X	X	(1) Inspect for leaks at system pressure per 13.4.2 (2) Inspect for leaking through check valve (3) Valve status test
Fire department connection	X	X		(1) Inspect for leaks at system pressure per Section 13.8 (2) Valve status test
Fire department connection — sprinkler system(s)			X	(1) Isolate and hydrostatic test for 2 hours at 150 psi (10 bar) (2) Valve status test
Fire department connection — other than sprinkler system(s)			X	(1) Isolate and hydrostatic test for 2 hours at 50 psi (3.5 bar) above the normal working pressure [200 psi (14 bar) minimum] (2) Valve status test
Strainers	X	X	X	Inspect and clean in accordance with manufacturer's instructions
Main drain valves	X	X	X	Main drain test per 13.2.3

TABLE 13.11.1 *Continued*

Component	*Adjust*	*Repair/ Recondition*	*Replace*	*Inspection, Test, and Maintenance Procedures*
Gauges			X	Calibrate per 13.2.5
Alarm and supervisory components				
Alarm device	X	X	X	Test for conformance with NFPA 13 and/or *NFPA 72*
Supervisory device	X	X	X	Test for conformance with NFPA 13 and/or *NFPA 72*
System protection components				
Pressure relief valve — fire pump installation	X	X	X	See 8.3.3.11 and 13.5.6
Pressure relief valve — other than fire pump installation			X	Verify relief valve is listed or approved for the application and set to the correct pressure
Informational components				
Identification signs	X	X	X	Inspect for compliance with NFPA 13 and 13.3.1

13.11.2 Where the original installation standard is different from the cited standard, the use of the appropriate installing standard shall be permitted.

13.11.3* These actions shall not require a design review.

A.13.11.3 Design review is outside the scope of this standard.

References Cited in Commentary

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 3, *Recommended Practice for Commissioning of Fire Protection and Life Safety Systems*, 2018 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2019 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 2019 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, 2019 edition.

NFPA 72®, National Fire Alarm and Signaling Code®, 2019 edition.

American Water Works Association, 6666 West Quincy Avenue, Denver, CO 80235.

Manual M14, *Recommended Practice for Backflow Prevention and Cross-Connection Control*, 4th edition, 2015.

U.S. Government Printing Office, Washington, DC 20402.

Title 42, United States Code, "Safe Drinking Water Act," Public Law 93-523, 1974.

Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

ANSI/UL 193, *Alarm Valves for Fire-Protection Service*, 2016.

ANSI/UL 260, *Dry Pipe and Deluge Valves for Fire-Protection Service*, 2004.

UL 262, *Gate Valves for Fire-Protection Service*, 2004.

ANSI/UL 312, *Check Valves for Fire-Protection Service*, 2010.

UL 1091, *Butterfly Valves for Fire-Protection Service*, 2004.

Subject 258, *Outline of Investigation for Shutoff Valves for Trim and Drain Purposes*, 2004.

Main Drain Test

Purpose

The purpose of conducting a main drain test is to determine the adequacy of the connected water supply and to detect significant reductions that might adversely impact the system operation by comparing the results of the current test to a previous baseline test pressure. The test does not provide absolute assurance of an unobstructed waterflow or fully opened valves, but it provides a reasonable check against gross changes in the water supply conditions. This testing is required for each water supply lead-in to the building. Where a single lead-in supplies multiple risers, the conduct of a single main drain is acceptable, except that additional main drain tests must be conducted so that every system backflow preventer and/or pressure-reducing valve is exercised. These additional tests would be necessary for situations such as those that include individual floor control valves equipped with pressure-reducing valves.

Tools/Equipment

No special tools are required.

Procedure Steps

Systems Supplied by a Fire Pump

1. Prior to any testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is going to be conducted.
2. The pressure gauge readings collected on the suction side of the fire pump during the annual fire pump test can be used for comparison purposes at a common flow rate in lieu of conducting a separate annual main drain test.
    a. During the annual fire pump test, record the static pressure (no flow) reading on the pressure gauge on the suction side of the fire pump.
    b. During the rated flow (or other common flow rate) of the annual fire pump test, allow the pressure to stabilize and then record the residual pressure reading on the pressure gauge on the suction side of the fire pump.
3. Where the sole supply of water to the fire pump is through a backflow preventer and/or pressure-reducing valve requiring a quarterly main drain test, the test should be conducted in accordance with the following procedure with the fire pump in the operating position.
    a. Check the area surrounding the main drain outlet to ensure that there are no obvious conditions that would prevent water from being discharged safely or cause direct damage in the immediate vicinity. Where the discharge of water is to an area subject to potential freezing conditions, the facility representative should be advised of the potential for icing conditions.
    b. On systems where the main drain is connected to an alarm valve or other arrangement where the flow of water from the main drain will result in the activation of an alarm device or water motor gong, the shutoff valve (where equipped) in the connection to the alarm sensing line should be closed to avoid unnecessary sounding of the alarm.
    c. Record the static pressure (no flow) reading on the pressure gauge on the suction side of the fire pump.
    d. Open the main drain valve slowly until it has reached the fully open position initiating the fire pump operation. Allow the pressure to stabilize, then record the residual pressure reading on the pressure gauge on the suction side of the fire pump.
    e. Slowly close the main drain valve to avoid water hammer, record the time for the pressure to stabilize, and record the return static pressure reading on the pressure gauge on the suction side of the fire pump.
    f. Allow the fire pump to operate for 10 minutes for an electric fire pump, or 30 minutes for a diesel fire pump, followed by a shutdown of the fire pump and restoration of automatic operating condition.
    g. Return any shutoff valves in alarm sensing lines that were closed during Step 3b to the normal operating position.
4. Upon completion of all testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is complete. Reset the fire alarm system as necessary.

Systems Not Supplied by a Fire Pump

1. Prior to any testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is going to be conducted.
2. Check the area surrounding the main drain outlet to ensure that there are no obvious conditions that would prevent water from being discharged safely or cause direct damage in the immediate vicinity. Where the discharge of water is to an area subject to potential freezing conditions, the facility representative should be advised of the potential for icing conditions.
3. On systems where the main drain is connected to an alarm valve or other arrangement where the flow of water from the main drain will result in the activation of an alarm device or water motor gong, the shutoff valve (where equipped) in the connection to the alarm sensing line should be closed to avoid unnecessary sounding of the alarm.

4. Record the static pressure reading on the supply pressure gauge. Note that gauge readings are to be taken at a supply water gauge on the supply side of any alarm valves or check valves on the system riser.
5. Open the main drain valve slowly until it has reached the fully open position. Allow the pressure to stabilize, and then record the residual pressure reading on the supply pressure gauge.
6. Slowly close the main drain valve to avoid water hammer, record the time for the pressure to stabilize, and record the return static pressure reading on the supply pressure gauge.
7. Return any alarm valve and shutoff valves in alarm sensing lines that were closed during Step 3 to the normal operating position.
8. Upon completion of all testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is complete. Reset the fire alarm system as necessary.

Evaluation of Results

The recorded results of the residual pressure reading on the supply pressure gauge during the main drain test, or the gauge on the suction side of the fire pump, should be compared to the baseline reading from the original acceptance test of the system or previously performed tests. Where the main drain residual test pressure is found to be more than 10 percent less than the baseline test pressure, the conditions warrant further investigation and correction as necessary. Additionally, a slow return in static pressure reading after the closing of the main drain valve could also be indicative of a water supply issue, such as a partially closed valve. It is important to note the differences between a degraded water supply resulting from a closed or partially closed valve or an obstruction in the piping from that occurring as a result of normal water system fluctuations. For example, a partially closed valve or obstruction will result in an increased drop between the static and residual pressure readings during the main drain test. However, a water system fluctuation might result in both a lowered static and residual pressure but might have a similar drop in pressure under flowing conditions during the main drain test.

The procedure(s) outlined above is not mandated by NFPA 25 and represents only one approach to conducting this test.

Waterflow Alarm Device Test

Purpose

The purpose of conducting a test of the waterflow alarm device is to ensure the operability of the device and initiation of an alarm condition. Waterflow alarm devices include two separate types: a mechanical waterflow device, and an electronic waterflow alarm device. A mechanical waterflow device, such as a water motor gong, uses a mechanical action created by water flow to create an audible signal. An electronic waterflow alarm device, such as a vane-type or pressure switch-type device, transmits an electronic signal upon water flow.

The testing of such devices is performed by simulating the flow that would result from system operation. This can be accomplished by a number of methods. The most common method for a wet pipe system is the opening of the inspector's test connection. However, the use of the alarm test line on an alarm valve, dry pipe valve, preaction valve, or deluge valve is also quite common and advisable for those systems where a trip of the system is not desirable or for those systems that are not equipped with an inspector's test connection. Additionally, the alarm test line is required to be used where the discharge of water during freezing weather or under other conditions prohibits the use of the inspector's test connection.

Tools/Equipment

A timing device is needed to measure the time between flow initiation and establishment of an alarm condition.

Procedure Steps

Wet System: Mechanical Water Motor Gong / Pressure Switch-Type Alarm Device / Vane-Type Alarm Device Using the Inspector's Test Connection

1. Prior to any testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is going to be conducted.
2. Locate the inspector's test connection and check the area surrounding the discharge location for the released water from this operation. Do this to ensure that there are no obvious conditions that would prevent water from being discharged safely or cause direct damage in the immediate vicinity. Where the discharge of water is to an area subject to potential freezing conditions, the facility representative should be advised of the potential for icing conditions.
3. Where connected to a fire alarm system, check the fire alarm panel or remote annunciator to determine that the waterflow alarm device is not currently active on the system.
4. Temporarily place any connected fire pumps in the "off" position.
5. Open the inspector's test valve until it has reached the fully open position and note the time of valve operation. Allow the flow to continue until an alarm condition is established; this could be the sounding of the water motor gong, or the alarm bell, or the transmission of an alarm signal to the fire alarm control panel or remote annunciator.
6. Record the time between the operation of the inspector's test valve and the establishment of an alarm condition.
7. Close the inspector's test valve.
8. Return any fire pumps that were placed in the "off" position in Step 4 to the automatic position.
9. Upon completion of all testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is complete. Reset the fire alarm system as necessary.

Wet or Dry System: Mechanical Water Motor Gong / Pressure Switch-Type Alarm Device Using Alarm Test Line

1. Prior to any testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is going to be conducted.
2. Locate the alarm test line on the alarm/dry pipe/preaction/deluge valve. Check the area surrounding the discharge location for the released water from operation to ensure that there are no obvious conditions that would prevent water from being discharged safely or cause direct damage in the immediate vicinity. Where the discharge of water is to an area subject to potential freezing conditions, the facility representative should be advised of the potential for icing conditions.
3. Where connected to a fire alarm system, check the fire alarm panel or remote annunciator to determine that the waterflow alarm device is not currently active on the system.
4. Temporarily place any connected fire pumps in the "off" position.
5. Open the alarm test valve until it has reached the fully open position and note the time of valve operation. Allow the flow to continue until an alarm condition is established; this could be the sounding of the water motor gong, or the alarm bell, or the transmission of an alarm signal to the fire alarm control panel or remote annunciator.
6. Record the time between the operation of the alarm test line and the establishment of an alarm condition.
7. Close the alarm test valve.
8. Return any fire pumps that were placed in the "off" position in Step 4 to the automatic position.
9. Upon completion of all testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is complete. Reset fire alarm system as necessary.

Wet System: Vane-Type Alarm Device Using Re-Circulating Pump

1. Prior to any testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is going to be conducted.
2. Where connected to a fire alarm system, check the fire alarm control panel or remote annunciator to determine that the waterflow alarm device is not currently active on the system.
3. Operate the re-circulating pump, flowing water in a loop past the vane pressure switch, and note the start time of re-circulating pump operation. Allow the re-circulating pump to continue operating until an alarm condition is established; this could be the sounding of the alarm bell or the transmission of an alarm signal to the fire alarm control panel or remote annunciator.
4. Record the time between the start of operation of the re-circulating pump and the establishment of an alarm condition.
5. Shut off the re-circulating pump operation.
6. Upon completion of all testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is complete. Reset the fire alarm system as necessary. A verification of the receipt of initiated signals with the fire department and/or the alarm monitoring company, where so connected, would be appropriate as part of this effort.

Evaluation of Results

The recorded time for establishment of an alarm condition must be less than 5 minutes for a local alarm per NFPA 13, *Standard for the Installation of Sprinkler Systems*, or 90 seconds for a remotely monitored alarm condition per *NFPA 72®*, *National Fire Alarm and Signaling Code®*. Alarm activation times that exceed these values require further investigation, adjustment, and/or corrective action as necessary.

References

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2019 edition.

NFPA 72®, National Fire Alarm and Signaling Code®, 2019 edition.

The procedure(s) outlined above is not mandated by NFPA 25 and represents only one approach to conducting this test.

Testing Procedures for 13.2.5.2

Gauge Accuracy Test

Purpose

The purpose of conducting an accuracy test on the pressure gauges is to ensure a reasonable level of accuracy of the gauge reading. Comparative tests are made against a calibrated pressure gauge to achieve accuracy within a 3 percent range of the full scale of the gauge consistent with the maximum original accuracy tolerances for the manufactured gauge.

Tools/Equipment

- A test pressure gauge[1] is required.
- Wrenches are required for pressure gauge installation or removal.

Procedure Steps

1. Prior to any testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is going to be conducted.
2. For pressure gauge connections equipped with a gauge test valve, close the valve, remove the ¼ in. (6 mm) plug from the test outlet, and install the calibrated test gauge. Reopen the valve, and note the readings on each gauge.
3. Repeat this process for each pressure gauge to be tested, except that where multiple pressure gauges are located at the same elevation and are installed within piping connected to a common water source (i.e., multiple risers connected to a common manifold without intervening check valves), only one pressure gauge needs be tested, where all of the installed pressure gauges have readings within 3 percent of the full gauge scale of one another.
4. Close the valve on the gauge test valve and remove the calibrated test gauge. Reinstall the ¼ in. (6 mm) plug in the test outlet, and reopen the valve.
5. Upon completion of all testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is complete. Reset the fire alarm panel as necessary.

Evaluation of Results

Pressure gauges found to have a reading of more than 3 percent of the full scale of the gauge difference from the calibrated test gauge need to be recalibrated or replaced. For example, a pressure gauge having a 200 psi (13.8 bar) full scale range would be allowed a pressure reading difference of ±6 psi (0.4 bar) from the calibrated test gauge.

References

American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990.

ASME B40.100, *Pressure Gauges and Gauge Attachments*, 2013 edition.

1 Test-quality gauges should be used in accordance with ASME B40.100, *Pressure Gauges and Gauge Attachments,* having an accuracy of ±1%. The use of quality test gauges produces results that are considered reasonably accurate within the scope of the test procedure. Care should be taken to protect the gauges from rough handling. Gauges should be calibrated at least annually by means of a dead-weight or calibrated tester throughout the range of operation before a test series is begun. Calibration sheets should be kept for each gauge and correction factors affixed to the back of each gauge.

The procedure(s) outlined above is not mandated by NFPA 25 and represents only one approach to conducting this test.

Valve Status Test

Purpose

The purpose of completing a valve status test is to verify that the control valves upstream of the valve status test connection are not closed. This test is conducted by flowing water from a point downstream of the control valves being checked after they have been returned to their normal open position. The test does not provide an absolute assurance of an unobstructed water flow or a fully opened valve, but it provides a reasonable check against a fully closed valve or dropped valve gate within the water supply upstream of the test.

Tools/Equipment

No special tools are required.

Procedure Steps

1. Prior to any testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is going to be conducted.
2. Locate a suitable valve status test connection downstream of the control valve being checked. Such suitable connections might include the main drain, fire pump test header, backflow preventer forward flow test connection, fire hydrant, and other similar locations. Where these devices are not available, an inspector's test connection or other similar, small drain connection can be used, provided the connection discharges to a suitable location. The selection of the larger available valve status test connections listed above is preferable, since they allow for a greater flow rate and are more likely for observation of potential valve closure conditions as opposed to the smaller inspector's test or smaller drain connections. Check the area surrounding the discharge location for the released water from this operation to ensure there are no obvious conditions that would prevent water from being discharged safely or cause direct damage in the immediate vicinity. Where the discharge of water is to an area subject to potential freezing conditions, the facility representative should be advised of the potential for icing conditions.
3. Open the selected valve status test connection fully, allow the flow to stabilize, and observe the flow conditions noting the character of such. Note that this operation can result in the operation of connected fire pumps. If a main drain connection is used for this purpose, it is suggested that the main drain test procedure be followed to allow for measurable results as to character of the flow conditions.
4. Slowly close the valve status test connection to avoid water hammer.
5. Allow any fire pumps that might have automatically operated to run for 10 minutes for an electric fire pump, or 30 minutes for a diesel fire pump, followed by a shutdown of the fire pump and restoration of automatic operating condition.
6. Upon completion of all testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is complete. Reset the fire alarm system as necessary.

Evaluation of Results

The evaluation of the results, other than a main drain test, is purely subjective, where the flow of water is the confirmation that the valve is not closed. A partially closed valve might not be identifiable using this test method, and it is not intended for such purpose. Observed water flow conditions that raise concern about the position of all control valves should be verified, and the valve status test should be repeated. Conditions that persist should be investigated and corrected, as required.

The procedure(s) outlined above is not mandated by NFPA 25 and represents only one approach to conducting this test.

Control Valve Test

Purpose

The purpose of completing a test of the control valves is to exercise valves that control the water supply to fire protection systems through the full range of operation and to ensure the valve is in the open position.

Tools/Equipment

A special wrench is needed for the operation of a post indicator valve or roadway box valve. The wrench for a post indicator valve is commonly found attached to the body of the post.

Procedure Steps

OS&Y Valve and Indicating Butterfly Valve (IBV)

1. Prior to any testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is going to be conducted.
2. Note the position of the valve status indicator (e.g., valve stem, position paddle). The valve position indicated should be fully open for water supply control valves.
3. Turn the valve handle or operating wheel through the full operating range of the valve, noting the position movement of the valve status indicator (e.g., valve stem, position paddle) from open to closed and back. OS&Y valves must be backed off one-quarter turn from the fully open position to prevent jamming. Excessive operating force requiring additional applied mechanical force is indicative of the need for maintenance and/or repairs.
4. A valve status test must be conducted downstream of the closed valve in accordance with 13.3.3.4.
5. Upon completion of all testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is complete. Reset the fire alarm system as necessary.

Post Indicator Valve (PIV) and Wall Post Indicator Valve (WPIV)

1. Prior to any testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is going to be conducted.
2. Note the position of the "target" indicator within the view window. The valve position should be indicated as fully open for water supply control valves.
3. Using the appropriate wrench or the operating wheel, turn the valve through the full operating range of the valve, noting the number of turns to fully close and reopen the valve. Additionally, note the position movement of the valve position indicator "target" within the view window from open to closed and back. The number of turns to fully close and open a gate valve should be equal to three times the valve diameter, plus two or three additional turns. Valves that do not open upon the anticipated number of turns, or that involve excessive operating force requiring additional applied mechanical force, are indicative of needing additional maintenance and/or repairs.
4. Reopening the valve must be continued until a resistance spring or torsion is felt and then must be backed off one-quarter turn from the fully open position to prevent jamming. Valve closure that does not result in a spring back or continues to turn in the open direction needs maintenance and/or repairs.
5. A valve status test must be conducted downstream of the closed valve in accordance with 13.3.3.4.
6. Upon completion of all testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is complete. Reset the fire alarm control panel as necessary.

Nonindicating Roadway Box Valve

1. Prior to any testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is going to be conducted.
2. Using the appropriate wrench (T-wrench), turn the valve through the full operating range of the valve, noting the number of turns to fully close and reopen the valve. The number of turns to fully close and open a gate valve should be equal to three times the valve diameter plus two or three additional turns. Valves that do not open upon the anticipated number of turns, or that involve excessive operating force requiring additional applied mechanical force, are indicative of needing maintenance and/or repairs.
3. After reopening the valve, it must then be backed off one-quarter turn from the fully open position to prevent jamming.
4. A valve status test must be conducted downstream of the closed valve in accordance with 13.3.3.4.
5. Upon completion of all testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is complete. Reset the fire alarm panel as necessary.

Evaluation of Results

The control valve should cycle through the full range of operation without excessive operating force or disengagement as indicated in the test procedure above. Abnormal conditions require further investigation and corrective action as necessary.

The procedure(s) outlined above is not mandated by NFPA 25 and represents only one approach to conducting this test.

Deluge/Preaction Valve Trip Test

Purpose

The purpose of completing a trip test (partial or full) for a deluge/preaction valve is to ensure the system operates in a manner consistent with the original design application. The operation and testing of the valve must follow the manufacturer's instructions. A full trip test of the deluge valve also verifies that the operating water pressures at the deluge valve and most remote nozzle/sprinkler are consistent with the original design application. As a result, the original design basis must be known for an evaluation of the test results for these types of systems. Additionally, a comparative assessment of the water delivery time during the full trip test of a double interlock preaction and combined dry pipe/preaction system can reveal significant delays in system operation.

The primary automatic releasing means for deluge/preaction valves is generally one of two types that follow, pilot line (wet or dry) or electronic:

- The pilot line contains either pressurized water or gas (air or nitrogen) which, in combination with the valve trim, holds the valve in the closed position with a specific drop in pressure, allowing for the release of the valve. This drop in pressure is designed to occur automatically with the fusing of an installed pilot sprinkler head on the pilot line. These systems will typically also contain a means of manually releasing pressure in the pilot line.
- The electronic release using an installed detection system, such as heat, smoke, or ultraviolet/infrared (UV/IR), is connected to a fire alarm/releasing panel. Upon operation, this will cause the release of the valve, typically through the opening of a solenoid valve in the deluge/preaction valve trim.

A preaction system can generally be designed in one of the three manners that follow:

1. Single/non-interlock preaction system — designed for release of the valve by the operation of the pilot/electronic release mechanism.
2. Double interlock preaction system — designed for release of the valve by a combination of the operation of the pilot/electronic release mechanism along with the release of gas (air or nitrogen) pressure in the preaction system piping.
3. Combined dry pipe/preaction system — designed to release in the same manner as the single/non-interlock preaction, except that the valve will also release upon a loss of gas pressure in the preaction system piping alone, similar to a conventional dry pipe system.

Prior to any testing of these systems, a thorough knowledge of the system type and original design basis should be known. Additionally, since the specific trim for the valve and associated operation/reset procedures vary between manufacturers, the manufacturers' data sheets should be reviewed and followed.

Full trip testing of deluge valves must only be conducted during periods of warm weather. Some system designs include the operation of multiple valves simultaneously requiring the operational testing of deluge valves at the same time.

In addition to the completion of the procedure steps continued herein, for electronic release deluge/preaction systems, complete testing in accordance with the manufacturer's instructions and *NFPA 72®, National Fire Alarm and Signaling Code®,* must be completed for the supporting detection system.

Tools/Equipment

1. A timing device is needed to measure the trip and water delivery times for full trip tests for the double interlock preaction and preaction/dry pipe systems.
2. Various wrenches and tools are required to facilitate the reset of the deluge/preaction valve.

Procedure Steps

Deluge System Trip Test

1. Prior to any testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is going to be conducted.
2. Check the area surrounding the discharge points for the main drain and wet pilot line inspector's test (if so installed) to ensure that there are no obvious conditions that would prevent water from being discharged safely or cause direct damage in the immediate vicinity.
3. Temporarily place any connected fire pumps in the "off" position. Note that, for systems where the sole source of water supply is from the fire pump, the pump might be required to remain in the automatic position.
4. Where a partial trip test is to be conducted:
    a. Fully open the main drain valve to clean any accumulated scale or foreign material from the supply water piping. Note that if the fire pump remains in the automatic position, this will result in the operation of connected fire pumps.
    b. Slowly close the system control valve to the point where additional closure cannot provide flow through the entire area of the drain outlet.
5. Where a full trip test is to be conducted:
    a. Verify with the facility representative that the location of system discharge has been properly prepared for the release of water. Check the vicinity surrounding the discharge area to ensure that there are no obvious conditions that would prevent water from being discharged safely or cause direct damage in the immediate vicinity. Take appropriate caution to ensure personnel and property are protected from the resulting discharge, including runoff.

Deluge/Preaction Valve Trip Test *(Continued)*

b. Install, or verify the installation of, a test gauge at or near the hydraulically most remote nozzle/sprinkler. Note that provisions for the installation of a test gauge should have been included as part of the system design or installation.

c. Fully open the main drain valve to clean any accumulated scale or foreign material from the supply water piping and slowly reclose the main drain valve. Note that if the fire pump remains in the automatic position, this will result in the operation of connected fire pumps. Where this occurs, allow any fire pumps that might have automatically operated to run for 10 minutes for an electric fire pump, or 30 minutes for a diesel fire pump, followed by a shutdown of the fire pump and restoration of automatic operating condition.

6. Record the water pressure on the supply side of the deluge valve.

7. Where a full trip test is to be conducted, return any fire pumps that might have been shut off in Step 3 to the automatic position.

8. Trip the deluge valve by operating the releasing system. For pilot line operated valves, release gas (air or nitrogen) or water pressure from the pilot line by completely opening the inspector's test connection or other appropriate outlet. For electrically operated valves, simulate an alarm activation at the fire alarm/releasing panel.

9. Where a partial trip test is to be conducted:

   a. Verify the trip of the deluge valve.

   b. Immediately close the system control valve, close the priming water line, and fully open the main drain valve to minimize the amount of water entering the system piping.

10. Where a full trip test is to be conducted:

    a. Verify the trip of the deluge valve.

    b. Ensure all the operating pressures stabilize.

    c. Read and record the operating pressure at the deluge valve gauge.

    d. Read and record the operating pressure at the gauge at or near the hydraulically most remote nozzle/sprinkler.

    e. Observe the discharge patterns from all of the nozzles/sprinklers to verify that the patterns provide complete unobstructed coverage of the protected area and that the nozzles/sprinklers are correctly aimed and are free of any plugging.

    f. Close the system control valve, close the priming water line, and fully open the main drain valve to drain the system.

11. Allow any fire pumps that might have automatically operated to run for 10 minutes for an electric fire pump, or 30 minutes for a diesel fire pump, followed by a shutdown of the fire pump and restoration of automatic operating condition.

12. Close any drain valves, inspector's test connections, or other equipment that was opened during the test.

13. Reset the deluge valve, and return the system to service in accordance with the manufacturer's instructions.

14. Open the system control valve.

15. Repeat Step 6 through Step 14, except:

    a. The trip of the deluge valve in Step 8 is to be initiated by operating the manual release mechanism for the system.

    b. In addition to opening the main drain valve, open all auxiliary/low point drains until the flow of water stops prior to reset of the deluge valve.

    c. Check any drainage weep holes to ensure free drainage.

    d. After the system is reset, recheck for accumulation of water at the auxiliary/low point drains as needed.

16. Return any fire pumps that still remain in the "off" position to the automatic position.

17. A valve status test must be conducted downstream of the closed control valves, in accordance with 13.3.3.4, using the main drain valve.

18. Upon completion of all testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is complete. Reset the fire alarm system as necessary.

Single/Non-Interlock Preaction System Trip Test

1. Prior to any testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is going to be conducted.

2. Check the area surrounding the discharge points for the main drain, system inspector's test connection, and wet pilot line inspector's test (if so installed) to ensure that there are no obvious conditions that would prevent water from being discharged safely or cause direct damage in the immediate vicinity.

3. Temporarily place any connected fire pumps in the "off" position. Note that for systems where the sole source of water supply is from the fire pump, the pump might be required to remain in the automatic position.

4. Where a partial trip test is to be conducted:

   a. Fully open the main drain valve to clean any accumulated scale or foreign material from the supply water piping. Note that if the fire pump remains in the

automatic position, this will result in the operation of connected fire pumps.

b. Slowly close the system control valve to the point where additional closure cannot provide flow through the entire area of the drain outlet.

5. Where a full trip test is to be conducted:

   a. Fully open the main drain valve to clean any accumulated scale or foreign material from the supply water piping, and slowly reclose the main drain valve. Note that if the fire pump remains in the automatic position, this will result in the operation of connected fire pumps. Where this occurs, allow any fire pumps that might have automatically operated to run for 10 minutes for an electric fire pump, or 30 minutes for a diesel fire pump, followed by a shutdown of the fire pump and restoration of automatic operating condition.

6. Record the water pressure on the supply side of the preaction valve, and if supervisory pressure is used on the system, record the gas (air or nitrogen) pressure.

7. Where a full trip test is to be conducted, return any fire pumps that might have been shut off in Step 3 to the automatic position.

8. Trip the preaction valve by operating the releasing system. For pilot line operated valves, release gas (air or nitrogen) or water pressure from the pilot line by completely opening the inspector's test connection or other appropriate outlet. For electrically operated valves, simulate an alarm activation at the fire alarm/releasing panel.

9. Where a partial trip test is to be conducted:

   a. Verify the trip of the preaction valve.

   b. Immediately close the system control valve, close the priming water line, and fully open the main drain valve to minimize the amount of water entering the system piping.

10. Where a full trip test is to be conducted:

    a. Verify the trip of the preaction valve, and allow the system pressure to stabilize.

    b. Close the system control valve, close the priming water line, and fully open the main drain valve to drain the system.

11. Allow any fire pumps that might have automatically operated to run for 10 minutes for an electric fire pump, or 30 minutes for a diesel fire pump, followed by a shutdown of the fire pump and restoration of automatic operating condition.

12. Close any drain valves, inspector's test connections, or other equipment that was opened during the conduct of the test.

13. Reset the preaction valve, and return the system to service in accordance with the manufacturer's instructions.

14. Open the system control valve.

15. Repeat Step 6 through Step 14, except:

    a. The trip of the preaction valve in Step 8 is to be initiated by operation of the manual release mechanism for the system.

    b. In addition to opening the main drain valve, open all auxiliary/low point drains until the flow of water stops prior to reset of the preaction valve.

    c. After the system is reset, recheck for accumulation of water at the auxiliary/low point drains at drain as needed.

16. Return any fire pumps that still remain in the "off" position to the automatic position.

17. A valve status test must be conducted downstream of the closed control valves, in accordance with 13.3.3.4, using the main drain valve.

18. Upon completion of all testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is complete. Reset the fire alarm system as necessary.

Double Interlock Preaction System Trip Test

1. Prior to any testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is going to be conducted.

2. Check the area surrounding the discharge points for the main drain, system inspector's test connection, and wet pilot line inspector's test to ensure that there are no obvious conditions that would prevent water from being discharged safely or cause direct damage in the immediate vicinity.

3. Temporarily place any connected fire pumps in the "off" position. Note that, for systems where the sole source of water supply is from the fire pump, the pump might be required to remain in the automatic position.

4. Where a partial trip test is to be conducted:

   a. Fully open the main drain valve to clean any accumulated scale or foreign material from the supply water piping. Note that if the fire pump remains in the automatic position, this will result in the operation of connected fire pumps.

   b. Slowly close the system control valve to the point where additional closure cannot provide flow through the entire area of the drain outlet.

   c. Where installed, close the valve controlling the quick opening device.

Deluge/Preaction Valve Trip Test *(Continued)*

5. Where a full trip test is to be conducted:
    a. Fully open the main drain valve to clean any accumulated scale or foreign material from the supply water piping, and slowly reclose the main drain valve. Note that if the fire pump remains in the automatic position, this will result in the operation of connected fire pumps. Where this occurs, allow any fire pumps that might have automatically operated to run for 10 minutes for an electric fire pump, or 30 minutes for a diesel fire pump, followed by a shutdown of the fire pump and restoration of automatic operating condition.
6. Record gas (air or nitrogen) pressure, along with the water pressure on the supply side of the preaction valve.
7. Where a full trip test is to be conducted, return any fire pumps that might have been shut off in Step 3 to the automatic position.
8. Initiate the operation of the releasing system. For pilot line operated valves, release gas (air or nitrogen) or water pressure from the pilot line by completely opening the inspector's test connection or other appropriate outlet. For electrically operated valves, simulate an alarm activation at the fire alarm/releasing panel.
9. Verify that the preaction valve does not trip, but that the solenoid valve on the releasing line has engaged. This can be done by listening for an audible engagement of the solenoid or checking for the presence of operating voltage at the solenoid.
10. Where a partial trip test is to be conducted:
    a. Open the condensate drain or priming water test level valve on the preaction system to release the internal gas (air or nitrogen) pressure.
    b. Verify the trip of the preaction valve, noting the gas (air or nitrogen) pressure at which the valve trips.
    c. Immediately close the system control valve, close the priming water line, and fully open the main drain valve to minimize the amount of water entering the system piping.
    d. Where installed, test the quick opening device in accordance with the manufacturer's instructions.
11. Where a full trip test is to be conducted:
    a. Completely open the inspector's test valve of the preaction system to release the internal gas (air or nitrogen) pressure, noting the start time when the valve is fully open.
    b. Verify the trip of the preaction valve, noting the gas (air or nitrogen) pressure at which the valve trips and the time for the valve to trip from the time the inspector's test connection is fully opened.
    c. Allow the system flow to continue. Note the time at which a steady stream of water issues from the inspector's test connection from the time the inspector's test connection is fully opened.
    d. Close the system control valve, close the priming water line, and fully open the main drain valve to drain the system.
12. Allow any fire pumps that might have automatically operated to run for 10 minutes for an electric fire pump, or 30 minutes for a diesel fire pump, followed by a shutdown of the fire pump and restoration of automatic operating condition.
13. Close any drain valves, inspector's test connections, or other equipment that was opened during the conduct of the test.
14. Reset the preaction valve and associated quick opening device, if installed, and return the system to service in accordance with the manufacturer's instructions.
15. Open the system control valve.
16. Repeat Step 6 through Step 15, except:
    a. The trip of the preaction valve in Step 8 is to be initiated by operation of the manual release for the system.
    b. In addition to opening the main drain valve, open all auxiliary/low point drains until the flow of water stops prior to the reset of the preaction valve.
    c. After the system is reset, recheck for accumulation of water at the auxiliary/low point drains as needed.
17. Return any fire pumps that still remain in the "off" position to the automatic position.
18. A valve status test must be conducted downstream of the closed control valves, in accordance with 13.3.3.4, using the main drain valve.
19. Upon completion of all testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is complete. Reset the fire alarm system as necessary.

Combined Dry Pipe/Preaction System Trip Test

1. Prior to any testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is going to be conducted.
2. Check the area surrounding the discharge points for the main drain, inspector's test connection, and wet pilot line inspector's test to ensure that there are no obvious conditions that would prevent water from being discharged safely or cause direct damage in the immediate vicinity.

3. Temporarily place any connected fire pumps in the "off" position. Note that, for systems where the sole source of water supply is from the fire pump, the pump might be required to remain in the automatic position.
4. Where a partial trip test is to be conducted:
    a. Fully open the main drain valve to clean any accumulated scale or foreign material from the supply water piping. Note that if the fire pump remains in the automatic position, this will result in the operation of connected fire pumps.
    b. Slowly close the system control valve to the point where additional closure cannot provide flow through the entire area of the drain outlet.
5. Where a full trip test is to be conducted, fully open the main drain valve to clean any accumulated scale or foreign material from the supply water piping, and slowly reclose the main drain valve. Note that if the fire pump remains in the automatic position, this will result in the operation of connected fire pumps. Where this occurs, allow any fire pumps that might have automatically operated to run for 10 minutes for an electric fire pump, or 30 minutes for a diesel fire pump, followed by a shutdown of the fire pump and restoration of automatic operating condition.
6. Record gas (air or nitrogen) pressure along with the water pressure on the supply side of the preaction valve.
7. Where a full trip test is to be conducted, return any fire pumps that might have been shut off in Step 3 to the automatic position.
8. Trip the combined dry pipe/preaction valve by operating the releasing system. For pilot line operated systems, release gas (air or nitrogen) or water pressure from the pilot line by completely opening the inspector's test connection or other appropriate outlet. For electrically operated systems, simulate an alarm activation at the fire alarm/releasing panel.
9. Where a partial trip test is to be conducted:
    a. Verify the trip of the combined dry pipe/preaction valve.
    b. Immediately close the system control valve, close the priming water line, and fully open the main drain valve to minimize the amount of water entering the system piping.
10. Where a full trip test is to be conducted:
    a. Verify the trip of the combined dry pipe/preaction valve and allow pressures to stabilize.
    b. Close the system control valve, close the priming water line, and fully open the main drain valve to drain the system.
11. Allow any fire pumps that might have automatically operated to run for 10 minutes for an electric fire pump, or 30 minutes for a diesel fire pump, followed by a shutdown of the fire pump and restoration of automatic operating condition.
12. Close any drain valves, inspector's test connections, or other equipment that might have opened during the conduct of the test.
13. Reset the combined dry pipe/preaction valve and associated quick opening device, if installed, and return the system to service in accordance with the manufacturer's instructions.
14. Open the system control valve.
15. Repeat Step 6 through Step 14, except the trip of the combined dry pipe/preaction valve in Step 8 is to be initiated by operation of the manual release for the system.
16. Where a partial trip test is to be conducted:
    a. Where installed, close the valve controlling the quick opening device.
    b. Open the condensate drain or priming water test level valve on the combined dry pipe/preaction system to release the internal gas (air or nitrogen) pressure.
    c. Verify the trip of the combined dry pipe/preaction valve, noting the gas (air or nitrogen) pressure at which the valve trips.
    d. Immediately close the system control valve, close the priming water line, and fully open the main drain valve to minimize the amount of water entering the system piping.
    e. Where installed, test the quick opening device in accordance with the manufacturer's instructions.
17. Where a full trip test is to be conducted:
    a. Completely open the inspector's test connection of the preaction/dry pipe system to release the internal gas (air or nitrogen) pressure, noting the start time when the valve is fully open.
    b. Verify the trip of the combined dry pipe/preaction valve, noting the gas (air or nitrogen) pressure at which the valve trips and the time for the valve to trip from the time the inspector's test connection is fully opened. Note that this operation will result in the operation of connected fire pumps.
    c. Allow the system flow to continue, and note the time at which a steady stream of water discharges from the inspector's test connection from the time the inspector's test connection is fully opened.
    d. Close the system control valve, close the priming water line, and fully open the main drain valve and all auxiliary drains for the system until the flow of water stops prior to the reset of the system.

Deluge/Preaction Valve Trip Test *(Continued)*

18. Allow any fire pumps that might have automatically operated to run for 10 minutes for an electric fire pump, or 30 minutes for a diesel fire pump, followed by a shutdown of the fire pump and restoration of automatic operating condition.
19. Reset the combined dry pipe/preaction valve and associated quick opening device, if installed, and return the system to service in accordance with the manufacturer's instructions.
20. Recheck for accumulation of water at the auxiliary/low point drains as needed.
21. Open the system control valve.
22. Return any fire pumps that still remain in the "off" position to the automatic position.
23. A valve status test must be conducted downstream of the closed control valves, in accordance with 13.3.3.4, using the main drain valve.
24. Upon completion of all testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is complete. Reset the fire alarm system as necessary.

Evaluation of Results

Instances where the deluge, preaction, or combined dry pipe/preaction valve fails to operate at the specified points in the test procedure or where it cannot be properly reset should be investigated and corrective action taken as necessary.

During a full trip (discharge) of a deluge valve, any nozzles/sprinklers that are found to be misaligned, obstructed, or plugged require adjustment or other corrective action as necessary. The operating pressure readings at the deluge valve and at or near the hydraulically most remote nozzle/sprinkler must be compared to the hydraulic design pressures for the system, to ensure the performance meets or exceeds that required by the original design. Pressures found to be less than the required design pressures should be investigated and corrective action taken as necessary.

During a full trip test of a double interlock preaction valve, a comparative assessment of the water delivery time to the inspector's test connection should be conducted. With the wide range of acceptable water delivery times, it is not the intent of NFPA 25 to reverify any specific time limits with the full flow trip test. Rather, it is the intent of NFPA 25 to reveal substantial delays for the water delivery time of these systems, since significant differences from one test to another are an indication of possible operational problems with the system. A drastic increase in the water delivery time from one full flow trip test to the next is of major concern, because such an increase is most likely due to corrosion of the system piping. An increase in delivery time might also indicate that physical changes have been made to the system, such as a revision in the piping layout. It might also indicate that the water supply characteristics have changed. Any substantial change in water delivery time from one test to another is cause for investigation into the source of the problem.

Double interlock preaction systems and combined dry pipe/preaction systems are limited in size by the time needed for the system to deliver water to the inspector's test connection. For example, NFPA 13, *Standard for the Installation of Sprinkler Systems,* places no time limit on water delivery for double interlock preaction systems with a volume of 500 gal (1893 L) or less, because systems of these sizes typically deliver the water in a relatively short time. Double interlock preaction systems with a volume greater than 500 gal (1893 L) must deliver water in not more than 60 to 70 seconds, be calculated with a listed calculation program, or the water discharge must be verified by an appropriately sized test manifold (see Exhibit 13.25). Combined dry pipe/preaction systems must deliver water in not more than 1 minute for each 400 ft (122 m) of common feed main in a system, with a maximum time not to exceed 3 minutes.

References

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2019 edition.

NFPA 72®, National Fire Alarm and Signaling Code®, 2019 edition.

The procedure(s) outlined above is not mandated by NFPA 25 and represents only one approach to conducting this test.

Dry Pipe Valve Trip Test

Purpose

The purpose of completing a trip test (partial or full) for a dry pipe valve is to ensure the functionality of the system to operate. The operation and testing of the valve must follow the manufacturer's instructions. The full trip test of a dry pipe system allows for a comparative assessment of the water delivery time that can reveal significant delays in system operation. Full trip testing of dry pipe valves must only be conducted during periods of warm weather.

Tools/Equipment

1. A timing device is needed to measure the trip and water delivery times for full trip tests of the dry pipe valve.
2. Various wrenches and tools are required to facilitate the reset of the dry pipe valve.

Procedure Steps

1. Prior to any testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is going to be conducted.
2. Record gas (air or nitrogen) pressure along with the water pressure on the supply side of the dry pipe valve.
3. Check the area surrounding the discharge points for the main drain and system inspector's test connection to ensure that there are no obvious conditions that would prevent water from being discharged safely or cause direct damage in the immediate vicinity.
4. Temporarily place any connected fire pumps in the "off" position. Note that, for systems where the sole source of water supply is from the fire pump, the pump might be required to remain in the automatic position.
5. Where a partial trip test is to be conducted:
    a. Fully open the main drain valve to clean any accumulated scale or foreign material from the supply water piping. Note that if the fire pump remains in the automatic position, this will result in the operation of connected fire pumps.
    b. Slowly close the system control valve to the point where additional closure cannot provide flow through the entire area of the drain outlet.
    c. Where installed, close the valve controlling the quick opening device.
6. Where a full trip test is to be conducted:
    a. Fully open the main drain valve to clean any accumulated scale or foreign material from the supply water piping, and slowly reclose the main drain valve. Note that if the fire pump remains in the automatic position, this will result in the operation of connected fire pumps. Where this occurs, allow any fire pumps that might have automatically operated to run for 10 minutes for an electric fire pump, or 30 minutes for a diesel fire pump, followed by a shutdown of the fire pump and restoration of automatic operating condition.
7. Where a partial trip test is to be conducted:
    a. Open the priming water test level valve on the dry pipe valve to release the internal gas (air or nitrogen) pressure.
    b. Verify the trip of the dry pipe valve, noting the gas (air or nitrogen) pressure at which the valve trips.
    c. Immediately close the system control valve, close the priming water line, and fully open the main drain valve to minimize the amount of water entering the system piping.
    d. Where installed, test the quick opening device in accordance with the manufacturer's instructions.
8. Where a full trip test is to be conducted:
    a. Return any fire pumps that might have been shut off in Step 4 to the automatic position.
    b. Completely open the inspector's test valve of the dry pipe system to release the internal gas (air or nitrogen) pressure, noting the start time when the valve is fully open.
    c. Verify the trip of the dry pipe valve, noting the gas (air or nitrogen) pressure at which the valve trips and the time for the valve to trip from the time the inspector's test connection is fully opened. Note that this will allow the system flow to continue, and note the time at which a steady stream of water discharges from the inspector's test connection from the time the inspector's test connection is fully opened.
    d. Close the system control valve, and fully open the main drain valve.
9. Allow any fire pumps that might have automatically operated to complete an elapsed run time of 10 minutes for an electric fire pump, or 30 minutes for a diesel fire pump, followed by a shutdown of the fire pump and restoration of automatic operating condition.
10. Fully open all auxiliary/low point drains for the system until the flow of water stops.
11. Close any drain valves, inspector's test connections, or other equipment that might have opened during the conduct of the test.
12. Reset the dry pipe valve and associated quick opening device, if installed, and return the system to service in accordance the manufacturer's instructions.
13. Starting from the initial gas (air or nitrogen) pressure required to set the valve clapper, observe the duration required to return the system pressure to its normal

Dry Pipe Valve Trip Test *(Continued)*

setting. Note that any installed air maintenance devices should have the bypass valves in the open position to allow for the maximum available fill rate from the gas (air or nitrogen) source.

14. Recheck for accumulation of water at the auxiliary/low point drains at drain as needed.
15. Open the system control valve.
16. Return any fire pumps that still remain in the "off" position to the automatic position.
17. A valve status test must be conducted downstream of the closed control valves, in accordance with 13.3.3.4, using the main drain valve.
18. Upon completion of all testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is complete. Reset the fire alarm system as necessary.

Evaluation of Results

Instances where the dry pipe valve fails to operate or where it cannot be properly reset should be investigated and corrective action should be taken as necessary. During a full trip test of the dry pipe valve, a comparative assessment of the water delivery time to the inspector's test connection should be conducted. With the wide range of acceptable water delivery times, it is not the intent of NFPA 25 to reverify any specific time limits with the full flow trip test. Rather, it is the intent of NFPA 25 to reveal substantial delays for the water delivery time of these systems, since significant differences from one test to another are an indication of possible operational problems with the system. A drastic increase in the water delivery time from one full flow trip test to the next is of major concern, because such an increase is most likely due to corrosion of the system piping. An increase in delivery time might also indicate that physical changes have been made to the system, such as a revision in the piping layout or the orifice size of sprinklers. It might also indicate that the water supply characteristics have changed. Any substantial change in water delivery time from one test to another is cause for investigation into the source of the problem.

Dry pipe systems are limited in size by the time needed for the system to deliver water to the inspector's test connection. For example, NFPA 13, *Standard for the Installation of Sprinkler Systems,* places no time limit on water delivery for dry pipe systems with a volume of 500 gal (1893 L) or less, or for systems of 750 gal (2839 L) or less that are equipped with a quick opening device; this is because systems of these sizes typically deliver the water in a relatively short time. Dry pipe systems with a volume greater than 750 gal (2839 L) must deliver water in not more than 60 seconds, be calculated with a listed calculation program, or the water discharge must be verified by an appropriately sized test manifold (see Exhibit 13.25).

The time required to refill the system with normal gas (air or nitrogen) is not to exceed 30 minutes. Longer refill durations require further investigation and corrective action as necessary.

References

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2019 edition.

The procedure(s) outlined above is not mandated by NFPA 25 and represents only one approach to conducting this test.

Testing Procedures for 13.4.5.2.6

Dry Pipe System Low Air Pressure Switch Test

Purpose

The purpose of conducting a test of the low air pressure switch is to ensure the operability of the device to signal a low air condition prior to reaching the trip pressure for the dry pipe valve. Some devices might also include a feature to monitor the system for high-pressure conditions. While not specifically mandated by NFPA 25, the testing of this feature is advisable and is included as part of the procedure below, should a test of this feature be desired.

Tools/Equipment

No special tools are required.

Procedure Steps

1. Prior to any testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is going to be conducted.
2. Check the fire alarm control panel or remote annunciator to determine that the low air supervisory device is not currently active on the system.
3. Close the control valve for the dry pipe system to ensure that any low gas pressure condition does not result in an unintended trip of the dry pipe valve.
4. Where installed, close the control valve to the quick opening device.
5. Shut off the gas supply (air or nitrogen) to the system.
6. Slowly bleed off pressure to the low air pressure switch until activation of the low air switch. Some dry pipe valves include a trim feature to allow the pressure to be released at the low air pressure switch independently, while others require the entire system pressure to be reduced.
7. Observe and record the pressure at which the low air switch activates and transmits to the fire alarm panel or remote annunciator. Should a pressure drop of more than 10 psi (0.7 bar) occur without an activation of the low air switch, terminate the test to avoid a potential trip of the dry pipe valve.
8. Open the gas supply (air or nitrogen) to the system, and return the system to normal operating pressure.
9. Where high-pressure monitoring is provided:
    a. Continue to slowly increase the system pressure until activation of the switch. Note that this might require an adjustment of pressure settings such as the compressor or regulator on the gas (air or nitrogen) supply or opening of the bypass valve on air maintenance devices to achieve higher pressures, and in some cases it might not be possible due to the limited capacity of the gas (air or nitrogen) supply.
    b. Observe and record the pressure at which the switch activates and transmits to the fire alarm control panel or remote annunciator. Should a pressure rise of more than 10 psi (0.7 bar) occur without an activation of the switch, terminate the test to avoid potentially damaging the dry pipe valve.
    c. Bleed off system pressure to return the system to normal operating pressure.
10. Where installed, open the control valve to the quick opening device.
11. Open the control valve for the dry pipe system.
12. A valve status test must be conducted downstream of the closed control valves in accordance with 13.3.3.4.
13. Upon completion of all testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is complete. Reset the fire alarm system as necessary.

Evaluation of Results

The recorded pressure drop/rise for activation of the low air switch from the normal operating pressure is to be not more than 10 psi (0.7 bar). Pressure drops/increases in excess of 10 psi (0.7 bar) without activation of the low air switch require further investigation, adjustment, and/or corrective action as necessary.

The procedure(s) outlined above is not mandated by NFPA 25 and represents only one approach to conducting this test.

Testing Procedures for 13.4.5.2.9

Dry Pipe System Gas Leakage Test

Purpose

The purpose of completing a gas leakage test is to ensure the dry pipe system is reasonably tight and free of excessive leakage. Two methods are presented for such a determination.

Tools/Equipment

A timing device is needed to measure the specified duration indicated by the procedure.

Procedure Steps

Leakage Rate Test

1. Prior to any testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is going to be conducted.
2. Close the control valve for the dry pipe system to ensure that any low gas pressure condition does not result in an unintended trip of the dry pipe valve. Note that the closure of the system control valve requires the establishment of impairment procedures in accordance with Chapter 15.
3. Adjust the gas pressure (air or nitrogen) on the system to a minimum of 40 psi (2.75 bar).
4. Shut off the gas supply (air or nitrogen) to the system.
5. Record the start time and gas pressure (air or nitrogen) of the test, and allow the system to sit for 2 hours.
6. Record the stop time of the test and the gas (air or nitrogen) pressure.
7. Open the gas supply (air or nitrogen) to the system, and allow the system gas pressure to return to normal.
8. Return the control valve for the dry pipe system to the open position.
9. Conduct a valve status test downstream of the closed control valves in accordance with 13.3.3.4.
10. Upon completion of all testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is complete. Reset the fire alarm system as necessary.

Low Air Supervisory Switch Activation Test

1. Prior to any testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is going to be conducted.
2. Close the control valve for the dry pipe system to ensure that any low gas pressure condition does not result in an unintended trip of the dry pipe valve. Note that the closure of the system control valve requires the establishment of impairment procedures in accordance with Chapter 15.
3. Check the gas pressure (air or nitrogen) on the system to ensure that it is at normal system pressure.
4. Check the fire alarm panel or remote annunciator to determine that the low air supervisory switch is not currently active on the system.
5. Shut off the gas supply (air or nitrogen) to the system.
6. Record the start time, and allow the system to sit for 4 hours.
7. Record the stop time of the test.
8. Check the fire alarm panel or remote annunciator to determine if a low air supervisory signal has been received for the tested dry pipe system.
9. Open the gas supply (air or nitrogen) to the system, and allow the system gas pressure to return to normal.
10. Return the control valve for the dry pipe system to the open position.
11. Conduct a valve status test downstream of the closed control valves in accordance with 13.3.3.4.
12. Upon completion of all testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is complete. Reset the fire alarm system as necessary.

Evaluation of Results

Testing completed using the air leakage rate method above that results in a loss of more than 3 psi (0.2 bar) over the 2 hour test duration requires further investigation and/or repair. Testing completed using the low air supervisory switch activation method above that results in the activation of the system low air supervisory switch over the 4 hour test duration requires further investigation and/or repair.

The procedure(s) outlined above is not mandated by NFPA 25 and represents only one approach to conducting this test.

System Pressure Reducing Valve Test

Purpose

The purpose of conducting a full flow test of the system pressure-reducing valve is to ensure the operability of the device in maintaining downstream system pressures to less than the pressure rating of the system components on the system side of the valve. Sprinkler systems are typically rated for a maximum of 175 psi (12.1 bar). However, there are systems equipped with components — including the sprinklers — that are rated for pressures higher than 175 psi (12.1 bar). These valves should be set with an outlet pressure of 10 psi (0.7 bar) below the maximum working pressure for the system, to allow a pressure differential between the controlled outlet pressure and that of the installed pressure relief, and to allow for reaction time for the valve.

Tools/Equipment

No special tools are required.

Procedure Steps

1. Prior to any testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is going to be conducted.
2. Locate a drain connection or other suitable discharge connection on the outlet side of the pressure-reducing valve. Check the area surrounding the discharge location for the released water from operation thereof to ensure that there are no obvious conditions that would prevent water from being discharged safely or cause direct damage in the immediate vicinity. Where the discharge of water is to an area subject to potential freezing conditions, the facility representative should be advised of the potential for icing conditions.
3. Open the drain or other suitable connection slowly until it has reached the fully open position, allowing for the establishment of automatic operation of any fire pumps. Observe the inlet and outlet pressures on the pressure-reducing valve to ensure the outlet pressures remain less than the pressure rating of the system components throughout the range of flow. Allow the pressure to stabilize, then record the residual pressure on both the inlet and outlet side of the pressure-reducing valve. Note that system pressure-reducing valve installations should include an inlet and outlet pressure gauge; however, where such gauges are not provided, the use of field installed gauges would be required.
4. Slowly close the drain or other suitable discharge connection to avoid water hammer. Record the return pressure on both the inlet and outlet side of the pressure-reducing valve.
5. Allow any fire pumps that might have automatically operated to run for 10 minutes for an electric fire pump, or 30 minutes for a diesel fire pump, followed by a shutdown of the fire pump and restoration of automatic operating condition.
6. Upon completion of all testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is complete. Reset the fire alarm system as necessary.

Evaluation of Results

The pressure-reducing valve outlet pressures should remain at least 10 psi (0.7 bar) less than the pressure rating of the system components through the full ranges of test flows. Higher pressures require further investigation, adjustment, and/or corrective action as necessary.

The procedure(s) outlined above is not mandated by NFPA 25 and represents only one approach to conducting this test.

Hose Connection Pressure-Regulating Device Test

Purpose

The purpose of conducting a test of the hose connection pressure-regulating device is to ensure the operability of the device in maintaining downstream pressures to not more than 100 psi (6.9 bar) for small hose connections [1½ in. (40 mm) diameter] and not more than 175 psi (12.1 bar) for connections for heavy hose [2½ in. (65 mm) diameter]. These devices are separated into the following two types: pressure-restricting and pressure-reducing. The pressure-restricting device is designed to reduce the downstream water pressure under flowing (residual) conditions only; whereas the pressure-reducing device is designed to reduce the downstream pressure under both flowing (residual) pressure and non-flowing (static) pressure conditions.

Tools/Equipment

1. Sufficient hose lengths with the appropriate thread connection are required to allow for the connection of the tested hose connection to a suitable discharge location. Typically, a 2½ in. (65 mm) hose with a coupling that has a thread pattern matching that of the hose outlet is used for this purpose. The number and length(s) of hose will depend on the specific location and the distance from the tested outlet to a suitable location.
2. An in-line flow measurement test device[2] or nozzles to permit flow measurement from the tested hose connection are needed. In-line flow measurement devices are best suited for this test; however, other approved test nozzles can be selected where an exterior discharge location is used. The flow characteristics of the test device must be known.
3. Where an exterior flow with test nozzles is used, a pitot tube together with a test-pressure gauge[1] suitable for the pressures to be expected is needed. [Usually, a 60 psi (4.1 bar) gauge is satisfactory.]
   - A pitot-tube-and-gauge assembly is indispensable in conducting flow tests from nozzles. The small opening at the end of the tube — not more than 1/16 in. (1.6 mm) in diameter — is inserted in the center of the stream, in a direct line with the flow, at a distance in front of the opening equal to one-half the opening diameter. Velocity pressure is registered on the gauge attached to the tube.
   - Some available test nozzles include an integral pitot tube or pitotless flow measuring feature with an attached test gauge[1] allowing for direct measurement of flows without the use of a separate pitot tube.
4. Pressure gauges[1] are needed to measure the upstream and downstream pressures on the pressure-regulating device.
5. Various wrenches and tools are needed to facilitate the necessary connections.

Procedure Steps

1. Prior to any testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is going to be conducted.
2. Set up a flow test connection from the hose connection being tested. See Exhibit 13.33 for an example of such a connection. This usually includes the following steps:
   a. Install a pressure gauge at the upstream and downstream side of the pressure-regulating valve. The downstream pressure gauge can be installed using an adapter connected to the hose connection outlet. The installation of an upstream pressure gauge on newer standpipe systems is allowed through the mandated installation of a valved gauge connection outlet; however, older systems might not include such connections, making the installation of an upstream gauge impracticable.
   b. Connect and route a fire hose from the valve connection to a proper discharge location, including the connection to a suitable flow measuring device and control valve to allow for measurement of the flow rate. For convenience, the flow measurements are best done using an in-line flow measurement device at the hose outlet but can also be done with discharge flow measure devices at the point of discharge. Standpipes installed in compliance with the 1993 or newer edition of NFPA 14, *Standard for the Installation of Standpipe and Hose Systems,* will include a 3 in. (75 mm) drain riser specifically for testing of hose connection pressure-regulating devices and should be used for the discharge during the flow test contained herein. Other standpipes require that the discharge be routed to suitable locations. This typically includes routing to the exterior of the building. Alternatively, where a second standpipe is available in the building, it can be isolated and taken out of service to be used as a temporary drain pipe with an extension for drainage to the exterior through one of the ground level hose connections using an additional length of fire hose. This would require that the hose connection pressure-regulating valves in the path of intended drainage within that temporary drain standpipe be removed and replaced with a standard hose connection.
3. Check the area surrounding the discharge point for a drain outlet or the connected discharge devices to ensure that there are no obvious conditions that would prevent water from being discharged safely or cause direct damage in the immediate vicinity. Take appropriate caution to ensure personnel and property are protected from the resultant high pressure hose stream discharge. The use of a flow diffuser can aid in breaking the directed stream and

managing the resultant energy of the discharge. Where the discharge of water is to an area subject to potential freezing conditions, the facility representative should be advised of the potential for icing conditions.

4. Ensure the control valve in the established test connection apparatus installed in Step 2 is in the closed position.
5. Fully open the hose connection valve.
6. Where installed, initiate the operation of the fire pump, and allow pressures to stabilize.
7. Observe and record the reading on the pressure gauge installed on the inlet (if it were possible to install such a gauge) and outlet side of the hose connection.
8. Slowly open the valve in the test connection apparatus installed in Step 2, measuring the flow rate and adjusting until the flow rate of 100 gpm (379 L/min) is established if testing a 1½ in. (40 mm) connection, or 250 gpm (946 L/min) if testing a 2½ in. (65 mm) hose connection. Record the flow rate.
9. Observe and record the reading on the pressure gauge installed on the inlet (if it were possible to install such a gauge) and outlet side of the hose connection.
10. Slowly close the valve in the test connection apparatus installed in Step 2 to avoid water hammer. Read the return pressure on both the inlet and outlet side of the pressure-reducing valve.
11. Allow any fire pumps that might have automatically operated to run for 10 minutes for an electric fire pump, or 30 minutes for a diesel fire pump, followed by a shutdown of the fire pump and restoration of automatic operating condition.
12. Close the hose connection valve, remove the test apparatus connection, and replace the cap on the hose connection.
13. Repeat this process for every pressure-regulating valve on the system.
14. Upon completion of all testing, notify the fire department and/or the alarm monitoring company, as well as the facility representatives, that testing is complete. Reset the fire alarm system as necessary.

Evaluation of Results

The pressure-regulating valve performance is based on the class of standpipe system provided and operating conditions as follows:

- For 1½ in. (40 mm) hose connections, the flowing (residual) pressure is not to exceed 100 psi (6.9 bar).
- For 1½ in. (40 mm) hose connections subject to a static pressure upstream of the pressure-regulating device of more than 175 psi (12.1 bar), both the non-flowing (static) and flowing (residual) pressure on the downstream side of the pressure-regulating device are not to exceed 100 psi (6.9 bar). Where a gauge can be installed on the upstream side of the pressure-regulating device, this static pressure reading can be taken directly. However, where the gauge connection is not possible, a determination of static pressure at another location within the system would be required, with necessary elevation adjustments made to determine the static pressure at the test location.
- For 2½ in. (65 mm) hose connections subject to a static pressure upstream of the pressure-regulating device of more than 175 psi (12.1 bar), both the non-flowing (static) and flowing (residual) pressure on the downstream side of the pressure-regulating device are not to exceed 175 psi (12.1 bar). Where a gauge can be installed on the upstream side of the pressure-regulating device, this static pressure reading can be taken directly; however, where the gauge connection is not possible, a determination of static pressure at another location within the system would be required, with necessary elevation adjustments made to determine the static pressure at the test location.

Instances where pressure conditions are found to be in excess of those stated above require further investigation, adjustment, and/or corrective action as necessary.

References

American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990.

ASME B40.100, *Pressure Gauges and Gauge Attachments*, 2013 edition

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 2019 edition.

The procedure(s) outlined above is not mandated by NFPA 25 and represents only one approach to conducting this test.

NFPA



14

INTERNAL PIPING CONDITION AND OBSTRUCTION INVESTIGATION

Chapter 14 of NFPA 25 addresses the need for continued operability of water-based fire protection systems by providing requirements for monitoring the interior condition of the piping system and conducting obstruction investigations. Metal piping systems can lose structural integrity due to corrosion and can become obstructed due to corrosion by-products such as pipe scale. The requirements for periodic internal inspections of the system piping are intended to address this issue. Any type of system that uses piping can become inoperative when the pipe is filled with obstructing material. Sprinkler systems are no exception. Any maintenance program must include means for revealing potential obstructions and removing any obstructions that are found. Obstructions are addressed in this chapter. Section 14.3 provides a list of potential causes of piping obstructions and identifies what type of situation requires an obstruction investigation when any of the listed conditions occur.

Historical Note

The title of this chapter was modified in 2014 because the 2011 edition title addressed only one of the two major concepts that are tackled in this chapter. Internal assessments of piping, referred to as inspections in the 2011 edition, are different from obstruction investigations. This was not clear in the 2011 chapter title, which was simply called "Obstruction Investigations." In the 2014 edition, both concepts were spelled out in the title to clarify that these are two different activities.

14.1* General.

This chapter shall provide the minimum requirements for conducting investigations of fire protection system piping for possible sources of materials that could cause pipe blockage or internal corrosion of system components.

A.14.1 For obstruction investigation and prevention, see Annex D.

14.2 Assessment of Internal Condition of Piping.

14.2.1* An assessment of the internal condition of piping shall be conducted on a frequency determined by 14.2.1.1 or 14.2.1.2 for the purpose of inspecting for the presence of foreign organic and inorganic material.

FAQ Does 14.2.1 apply to only dry sprinkler systems?

The requirement in 14.2.1 applies to all four types of sprinkler systems — wet, dry, preaction, and deluge — as well as foam-water sprinkler systems.

Tip for Owners

By requiring an *assessment* rather than an *inspection,* as mandated in previous editions of NFPA 25, the owner now has options available to find the most efficient method for determining the condition of the system piping. The intent of 14.2.1 is to place the smallest burden possible on the property owner by providing these options. For example, if the inspection option is exercised, it can be coordinated with the internal inspection requirement of system valves, such as is required by 13.4.1.2 for alarm valves; it can also be conducted during system renovations or maintenance.

Historical Note

It is important to note that requirements in NFPA 25 for periodic internal inspection of fire protection piping systems have changed over the years. They were first included in the 2002 edition in an attempt to prevent the destruction of piping systems by microbiologically influenced corrosion (MIC), which is shown in Exhibit 14.1. The 2008 edition of the standard modified this requirement to specifically indicate that 14.2.1 requires an inspection, not a complete (and subsequently, expensive) obstruction investigation. This periodic inspection was intended to reveal the presence of MIC, zebra mussels, or inorganic material such as rust and scale. The 2014 edition made even further changes and no longer specifically requires an inspection but rather an *assessment*, which can be conducted in accordance with either 14.2.1.1 or 14.2.1.2.

EXHIBIT 14.1 *Example of Internal Corrosion. (Courtesy of Byron Blake and SimplexGrinnell)*



Δ **A.14.2.1** It is the intent of 14.2.1 to provide a reasonable assurance that corrosion and obstruction issues within fire protection systems are identified. It is not the intent to require verification that every piece of pipe in the system is free from corrosion and obstructions. An assessment of the internal condition of piping can be accomplished by several methods that meet the intent of this section. These methods include the following:

Assessments can reveal the presence of inorganic types of obstructing material such as work gloves, weld coupons, and other material. When these types of obstructions are found, all feed and cross mains should be inspected. Exhibit 14.2 and Exhibit 14.3 show inorganic obstructions found in system piping.

(1) Fire sprinkler systems, foam systems, and water mist systems as follows:
   (a) Opening a flushing connection at the end of one main and removing the end fitting or piece of branch line or a sprinkler for the purpose of inspecting for the presence of foreign organic and inorganic material, including the following:



EXHIBIT 14.2 *Work Gloves Removed from System Piping. (Courtesy of John Jensen)*



EXHIBIT 14.3 *Weld Coupons Found in System Piping.*

(i) In dry pipe systems and preaction systems, the branch line inspected should be the most remote one from the source of water that is not equipped with the inspector's test valve.

After a dry pipe or preaction system has been tripped, the end of the system has the greatest potential for collecting the most scale and sediment. The branch line with the inspector's test connection, however, is expected to allow the material to flush out of that portion of the system. Examining the branch line adjacent to the branch line containing the inspector's test connection can provide a more realistic portrayal of the amount of material to be expected.

(ii) When performing normal maintenance that involves draining down a system to modify a system such as for tenant fit out or building renovations, or when removing or replacing piping, this inspection can be performed as described and properly recorded at that time. The time interval would then start for the next assessment of that system at the frequency determined by 14.2.1.1 or 14.2.1.2.

(iii) When possible, investigative work should be focused at those areas most prone to experiencing accelerated corrosion rates. These areas include high points of wet systems where trapped air accumulates, low points of dry and preaction systems where water will be trapped, and any bulk piping that sees frequent high volume flow of fresh water (i.e., bulk supply piping near a fire pump).

(iv) If a sprinkler is removed to perform this inspection, 5.4.1.1 requires a new sprinkler matching the characteristics of the replaced sprinkler.

FAQ How can the presence of MIC be detected without an inspection?

In the absence of an inspection and field or laboratory tests, MIC is usually revealed by the presence of a pinhole leak, like the one shown in Exhibit 14.4. Unfortunately, by the time such a leak develops and is noticed, it is usually too late to save the affected pipe. It might even be too late to salvage much of the system.

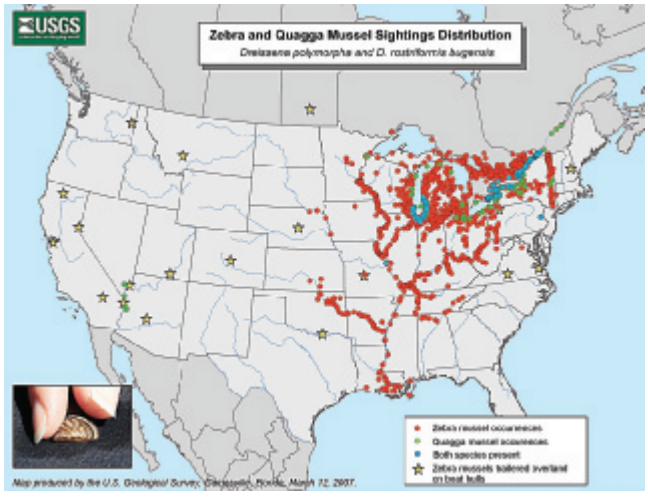
Yet, even if there is an inspection, MIC might not be detected. For example, an internal inspection that is poorly conducted or conducted too soon following the filling of a system might not reveal the presence of MIC.

Case In Point

Zebra mussels and quagga mussels can enter system piping when the fire protection system is supplied by a natural source of water, such as a river or lake. The photo below shows a typical zebra mussel, which is named for the stripes on the shell. The mussels can enter the piping as larvae or young adults and then can grow into obstructions. The zebra mussel species has become invasive in the last few years. They entered the United States through the Great Lakes, attached to the hulls of foreign ships. The mussels then spread throughout the Great Lakes region and beyond. The map below illustrates the extent of zebra mussel infestation.



Zebra Mussel. (Courtesy of Michigan Sea Grant)



Zebra Mussel Map. (Courtesy of Michigan Sea Grant)

FAQ What steps should be taken if MIC is found in the fire protection system?

Test kits and services are available to analyze test samples for the presence of microbes affiliated with the development of MIC. If MIC is found, special equipment and flushing services are available for treatment. For more information on MIC and other causes of obstruction, see Annex D. See Exhibit 14.5 and Exhibit 14.6 for examples of the effects of MIC in fire protection system piping.



EXHIBIT 14.4 *Example of Internal Corrosion. (Courtesy of Wiginton Fire Protection Engineering)*

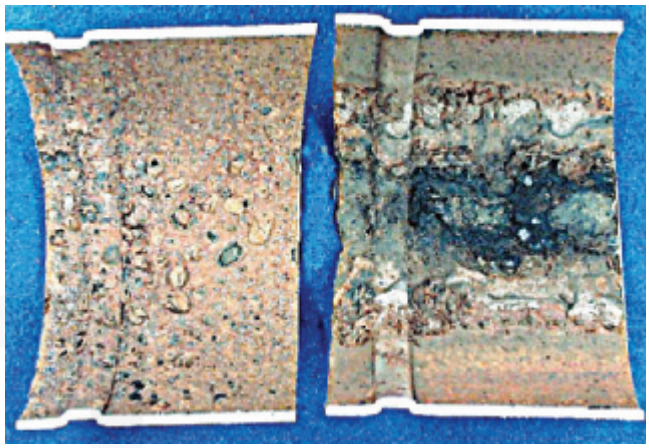


EXHIBIT 14.5 *Pipe Severely Corroded by MIC.*

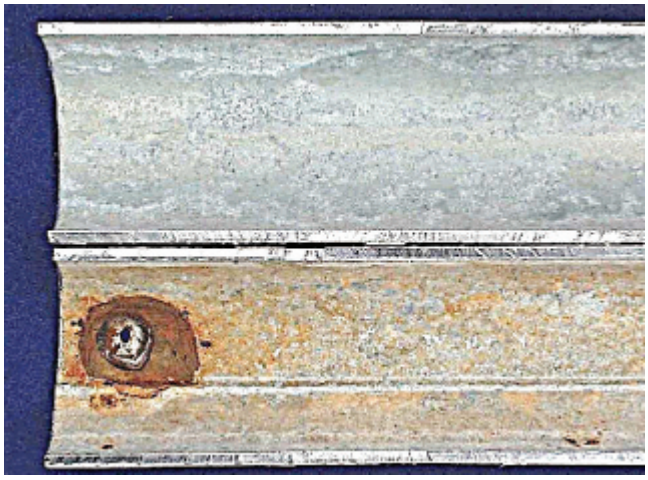


EXHIBIT 14.6 *Localized Corrosion Caused by MIC.*

(b) Utilizing alternative examination methods such as the following:

i. Using video inspection equipment that is inserted into the system at strategic points to observe the internal condition of pipes. This equipment provides a visual exam of the pipes using a camera and lighting system on the end of a push cable. Video inspection equipment can be inserted in alarm, dry, and preaction valves for a look into risers, feed mains, some cross mains, and some branch lines, depending on the system

configuration. The push cable can also be inserted in a check valve when performing the 5-year internal inspection required by 13.4.2.1 to view additional areas of a system, and in the fire department connection to perform the interior inspection required by 13.8.3.

ii. Ultrasonic or similar technology that allows the pipe wall to be tested to determine the extent of any deterioration due to microbiologically influenced corrosion (MIC) or other forms of corrosion. This method would not typically be used for the internal inspection of piping required by this section because it might not detect the presence of solid material in the piping, such as wood, plastic, or other foreign obstructions, that are not a by-product of corrosion, because only small representative sections of pipe are examined.

iii. A laboratory analysis of water samples obtained from the fire protection system, combined with collecting and inspecting solid material from fire protection system water discharged from a main drain, and an inspector's test connection, can provide an indication of the presence of corrosion, MIC, and/or foreign materials. If a high level of MIC is identified, or if a significant amount of foreign materials is found, further investigation might be warranted to verify the extent of corrosion, MIC, or other obstructions in the system. The solid materials should be collected with an appropriately sized strainer. If inspection of the solid materials identifies excessive rust, black water color, or sulfur (i.e., rotten egg) odors, an obstruction investigation as described in Section 14.3 is warranted.

iv. A laboratory analysis of a pipe sample taken from a system location most prone to experiencing accelerated corrosion rates can identify the root-cause of metal loss that has occurred and provide the building owner quantifiable data on the severity of the metal loss. This information would allow corrective action to be taken before the development of failures (i.e., leaks) in the system occur. Such locations include high points of wet systems where trapped air accumulates, low points of dry and preaction systems where water will be trapped, and any bulk piping that sees frequent high-volume flow of fresh water (i.e., bulk supply piping near a fire pump).

Case In Point

The traditional method for conducting the required internal assessment includes draining the system piping, opening up the piping, and looking inside. This tried-and-true method provides the inspector with an opportunity to obtain a visual account of the internal condition of the pipe and take samples of any organic growth found within the piping. This approach does require the system to be taken off line for a period of time, however, which can lead to a level of business interruption that is unacceptable to owners of some constantly operating facilities such as hospitals and power plants. Furthermore, this approach can be costly in high-rise buildings where each floor is considered a separate "system" and must undergo an independent internal evaluation.

As identified in A.14.2.1, draining the system and opening a flushing connection is not the only means for conducting the internal assessment. This section specifically states that nondestructive or noninvasive methods for conducting the assessment are permitted. One such nondestructive approach involves the use of ultrasound, or ultrasonic, technology. Ultrasonic technology allows an assessment to be performed without shutting the system down as the testing is being conducted. By applying ultrasonic transducers to the pipe's exterior surface, as shown in the photo below on the left, internal conditions can be identified quickly and accurately. Pulse echo and guided wave technology are two types of ultrasound that have been used in the sprinkler industry for years with great success. The photo below on the right shows a field technician looking at the test output data on the portable display screen.

Pulse echo ultrasonic technology works by measuring the amount of time it takes for an ultrasonic straight beam signal to travel through the wall of the pipe and reflect off the back

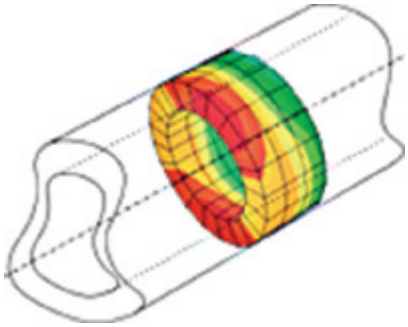
wall, resulting in a "remaining wall thickness" measured down to 1/1000 of an inch. Guided wrap wave (or lamb wave) ultrasonic technology travels around the circumference of the pipe, exposing the internal surface conditions. The concept of a circumferential wave concept is displayed in the diagram below. The wave generated by the pipe being tested, also referred to as the "real-time wave," is then compared to a "signature wave," which is a representation of a pristine pipe in the form of "energy." These energy data represent how an ultrasonic surface wave would travel through a piece of pipe of the same material and wall thickness. Discrepancies between the signature wave and the real-time wave signify that there has been a change in the internal condition of the piping. The output data are available as the test is being conducted on the portable device. Differences between these two waves could represent degradation of the pipe wall, ice plugs, MIC, material corrosion, scaling, or any other change that could modify the flow characteristics of the piping. The photo below shows an ice plug identified using ultrasonic technology.



Inspector Conducting Ultrasound Inspection. (Courtesy of David Martinez, Sonic Inspection Corporation)



Real-Time Wave Captured on Portable Display Unit. (Courtesy of David Martinez, Sonic Inspection Corporation)



Circumferential Wave. (Courtesy of David Martinez, Sonic Inspection Corporation)



Ice Plug Detected by Ultrasonic Technology. (Courtesy of David Martinez, Sonic Inspection Corporation)

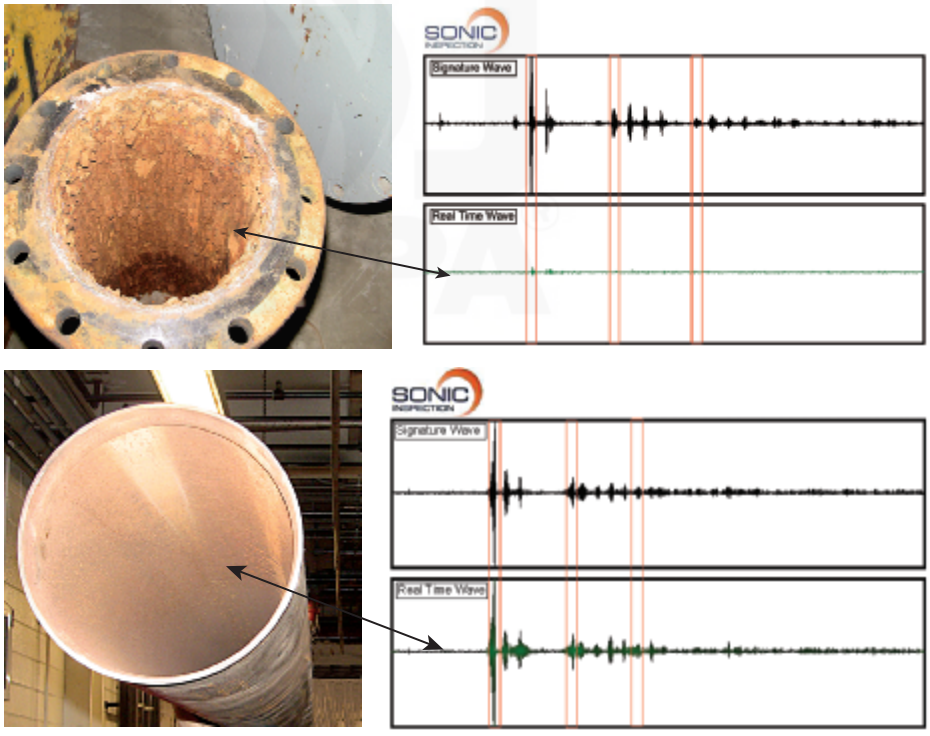
(*continues*)

Case In Point

Two sets of output data and corresponding photos of the pipes being inspected are shown below. The top photo (a) shows a piece of severely corroded pipe. Note how the green real-time wave in the diagram does not match the signature wave above it. The vast differences in these two waves would indicate to the person conducting the test that there is a significant problem inside of the pipe. The photo in (b) shows a clean piece of pipe. The real-time wave and signature wave in the diagram look very similar, which tells the inspector that the pipe is in good condition.

While A.14.2.1 states that this technology might not be appropriate for all internal assessments because only "small representative sections of pipe are examined," a larger, more comprehensive study using ultrasonic technology can be conducted as a means for compliance with this section. The next page shows a diagram of a building that has been inspected at dozens of locations. The green, yellow, and red markers identify varying levels of severity in the output data from the test. An assessment of this scope and magnitude provides the owner, inspector, and the authority having jurisdiction (AHJ) with a great deal of knowledge about the internal condition of the piping.

Once the change in the piping is identified by comparing the two waves, the owner and the fire sprinkler contractor can then look at solutions for resolving the conditions identified. The use of this technology as a means for conducting the required internal assessment can be beneficial as a cost-effective, noninvasive means for establishing the internal condition of system piping without causing any business interruption. An example of this situation is presented in the following case study that involves the use of this technology.



Output Data from Internal Inspections Using Guided Wrap Wave Technology: (a) Pipe Shows No Lamb Wave Reflections and Should Be Taken Out of Service; (b) Pipe Shows Excellent Lamb Wave Reflections and Will Be Left in Service. (Courtesy of David Martinez, Sonic Inspection Corporation)

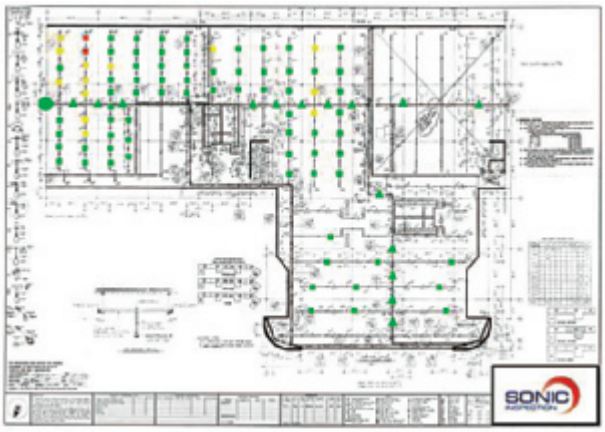


Diagram Identifying Pipe Inspection Locations and Results. (Courtesy of David Martinez, Sonic Inspection Corporation)

CASE STUDY

Problem

The fire sprinkler piping for a dry system in a large data center was not properly pitched. This improper pitch allowed water to be trapped in low areas, causing corrosion, wall thinning (see photo below), and obstructions. Originally the entire piping network was scheduled to be replaced at a substantial cost to the owner.

Solution

An ultrasonic inspection program was implemented using guided wave technology to identify wall thinning, corrosion, obstructions, and water trapped in the low areas. All of this work was conducted while the system was fully operational, which allowed the data center to function as normal. Only the problematic pipe was identified as needing to be replaced, and the pipe that was still in good working order was not touched and required no further internal inspection.

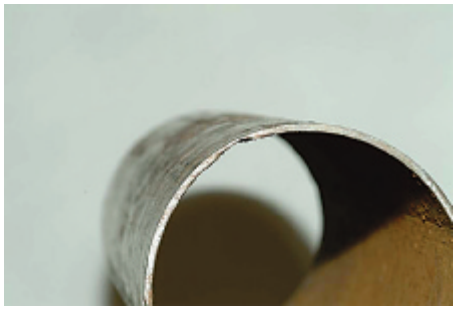
Resolution

The local fire sprinkler contractor was able to remove the bad pipe that was identified and flagged by ultrasonic inspection personnel. The contractor redesigned a more robust system by deploying a large nitrogen dryer, installing Schedule 40 hot dipped galvanized seamless pipe, and laser-pitching lines from the mains to risers with a positive 1 percent fall.

The inspection team retained specimens for the newly installed pipe at its headquarters for future reference. These specimens will now be used as the data center's benchmark for future testing. Specimens are measured to 1/1000 of an inch so future testing can be monitored for wall loss against the benchmark.

Savings to the Data Center

The use of this technology saved the organization $600,000. It also reduced the operational impacts of the pipe replacement project by limiting the number of pipes being replaced and the number of impacted zones.



Pipe Wall Thinning Detected by Ultrasound Technology. (Courtesy of David Martinez, Sonic Inspection Corporation)

(2) Standpipe and hose systems as follows:
   (a) Opening a flushing connection or fitting at the end of one main, removing a remote hose connection fitting, and removing the end fitting of horizontal branch line (if present) for the purpose of inspecting for the presence of foreign organic and inorganic material, including the following:
      i. When performing normal maintenance that involves draining down a system to modify a system such as for tenant fit out or building renovations, or when removing or replacing piping, this inspection can be performed as described and properly recorded at that time. The time interval would then start for the next assessment of that system at the frequency determined by 14.2.1.1 or 14.2.1.2.
   (b) Utilizing alternative examination methods such as the following:
      i. Using video inspection equipment that is inserted into the system at strategic points to observe the internal condition of pipes. This equipment provides a visual exam of the pipes using a camera and lighting system on the end of a push cable. Video inspection equipment can be inserted in valves for a look into risers, feed mains, some cross mains, and some branch lines, depending on the system configuration. The push cable can also be inserted in a check valve when performing the 5-year internal inspection required by 13.4.2.1 to view additional areas of a system, and in the fire department connection to perform the interior inspection required by 13.8.3.
      ii. Ultrasonic or similar technology that allows the pipe wall to be tested to determine the extent of any deterioration due to microbiologically influenced corrosion (MIC) or other forms of corrosion. This method would not typically be used for the internal inspection of piping required by this section because it might not detect the presence of solid material in the piping, such as wood, plastic, or other foreign obstructions, that are not a by-product of corrosion, because only small representative sections of pipe are examined.
      iii. A laboratory analysis of water samples obtained from the fire protection system, combined with collecting and inspecting solid material from fire protection system water discharged from a main drain, and an inspector's test connection, can provide an indication of the presence of corrosion, MIC, and/or foreign materials. If a high level of MIC is identified, or if a significant amount of foreign materials is found, further investigation might be warranted to verify the extent of corrosion, MIC, or other obstructions in the system. The solid materials should be collected with an appropriately sized strainer. If inspection of the solid materials identifies excessive rust, black water color, or sulfur (i.e., rotten egg) odors, an obstruction investigation as described in Section 14.3 is warranted.
      iv. A laboratory analysis of a pipe sample taken from a system location most prone to experiencing accelerated corrosion rates can identify the root-cause of metal loss that has occurred and provide the building owner quantifiable data on the severity of the metal loss. This information would allow corrective action to be taken before the development of failures (i.e., leaks) in the system occur.
(3) Private fire service mains, as follows:
   (a) Opening an accessible point on one main for the purpose of inspecting for the presence of foreign organic and inorganic material, including the following:
      i. When performing normal maintenance that involves draining down a system to modify a system such as for tenant fit out or building renovations, or when removing or replacing piping, this inspection can be performed as described and properly recorded at that time. The time interval would then start for the next assessment of that system at the frequency determined by 14.2.1.1 or 14.2.1.2
   (b) Utilizing alternative examination methods such as the following:
      i. Using video inspection equipment that is inserted into the system at strategic points to observe the internal condition of pipes. This equipment provides a

visual exam of the pipes using a camera and lighting system on the end of a push cable. Video inspection equipment can be inserted in alarm, dry, and preaction valves for a look into the private main depending on the system configuration. The push cable can also be inserted in a check valve when performing the 5-year internal inspection required by 13.4.2.1 to view additional areas of a system, and in the fire department connection to perform the interior inspection required by 13.8.3.

ii. Ultrasonic or similar technology that allows the pipe wall to be tested to determine the extent of any deterioration due to microbiologically influenced corrosion (MIC) or other forms of corrosion. This method would not typically be used for the internal inspection of piping required by this section because it might not detect the presence of solid material in the piping, such as wood, plastic, or other foreign obstructions, that are not a by-product of corrosion, because only small representative sections of pipe are examined.

iii. A laboratory analysis of water samples obtained from the fire protection system, combined with collecting and inspecting solid material from fire protection system water discharged from a main drain, and an inspector's test connection, can provide an indication of the presence of corrosion, MIC, and/or foreign materials. If a high level of MIC is identified, or if a significant amount of foreign materials is found, further investigation might be warranted to verify the extent of corrosion, MIC, or other obstructions in the system. The solid materials should be collected with an appropriately sized strainer. If inspection of the solid materials identifies excessive rust, black water color, or sulfur (i.e., rotten egg) odors, an obstruction investigation as described in Section 14.3 is warranted.

iv. A laboratory analysis of a pipe sample taken from a system location most prone to experiencing accelerated corrosion rates can identify the root-cause of metal loss that has occurred and provide the building owner quantifiable data on the severity of the metal loss. This information would allow corrective action to be taken before the development of failures (i.e., leaks) in the system occur.

14.2.1.1 An assessment of the internal condition of piping shall be conducted at a minimum of every 5 years or in accordance with 14.2.1.2 for the purpose of inspecting for the presence of foreign organic and inorganic material.

14.2.1.2* Where an assessment frequency has been established by an approved risk analysis, the assessment shall be performed at a frequency determined by the approved risk analysis.

A.14.2.1.2 The purpose of the assessment of the internal condition of piping is to identify whether foreign organic and inorganic material is present, since the presence of such material can potentially be detrimental to the performance of the sprinkler system. Corrosion, which includes general corrosion as well as microbiologically influenced corrosion (MIC), can be prevalent in sprinkler piping, but not necessarily in all systems, buildings, or geographic locations. Therefore, the risk analysis should be based upon evidence noted and/or data obtained from proximate sprinkler systems, known problems from the water supply, as well as other factors that could affect the integrity of the system piping such as the use of nitrogen generators on dry and preaction systems and nitrogen inerting with vents on wet systems. The decision of when, how often, and which method to use to conduct an assessment should also consider the risk of emptying and refilling the sprinkler system with water, which could adversely impact the sprinkler system by introducing foreign or inorganic material into the sprinkler system.

When determining an acceptable frequency based on a risk analysis, as permitted by 14.2.1.2, it is important that the analysis be performed by a qualified entity or person, such as a registered engineer, loss control consultant, or others possessing sufficient training and knowledge in system piping obstructions. It is important to note that the risk analysis must

Tip for Owners

The requirements in 14.2.1.1 and 14.2.1.2 address the frequency of the assessment required by 14.2.1. The 5-year minimum frequency is intended to limit the burden placed on the owner by aligning the assessment with the 5-year internal inspection requirement for check valves.

be *approved,* and any frequencies greater than 5 years should be approved by the AHJ. Prior to the 2011 edition, NFPA 25 did not specifically state that an alternative internal inspection or assessment frequency could be developed through a risk assessment. However, the opportunity to develop "performance-based frequencies" was available. As such, this concept is not entirely new, as many building owners had previously revised the internal inspection frequency by using a performance-based approach.

14.2.1.3 Tubercules or slime, if found, shall be tested for indications of microbiologically influenced corrosion (MIC).

14.2.1.4* If the presence of sufficient foreign organic or inorganic material is found to obstruct pipe or sprinklers, an obstruction investigation shall be conducted as described in Section 14.3.

Internal assessments and obstruction investigations are different activities; however, it is not uncommon for the findings of an internal assessment to be the catalyst for an obstruction investigation. Exhibit 14.7 shows a pipe found in a sprinkler system during an internal assessment filled with dirt and sediment that is significant enough to warrant an obstruction investigation.

A.14.2.1.4 Most piping systems contain some foreign material or other evidence of corrosion but not sufficient to trigger an obstruction investigation. Furthermore, an internal inspection is primarily an inspection for determining corrosion of the pipe, but it can result in finding the presence of material that would be an obstruction to piping or sprinklers. If such is found, an obstruction investigation in Section 14.3 would be required.

Small amounts of scale or soft sediment are often found within a sprinkler system. The presence of such scale should not necessarily trigger an obstruction investigation; however, significant corrosion, such as the internal corrosion shown in Exhibit 14.8, should trigger an investigation. It is important to remember that where a significant amount of sediment or corrosion is present in the piping, much of the deposits will settle in sprinkler drops and outlets. Whether it is MIC or corrosion due to material degradation, it is not uncommon for sprinklers to become plugged like the sprinkler shown in Exhibit 14.9.



EXHIBIT 14.7 *Pipe Obstructed With Dirt and Sediment. (Courtesy of Byron Blake and SimplexGrinnell)*

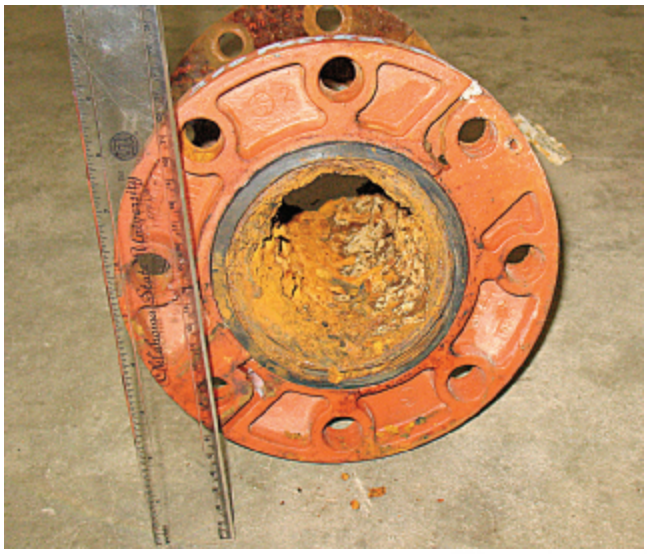


EXHIBIT 14.8 *Example of Interior Corrosion. (Courtesy of Byron Blake and SimplexGrinnell)*



EXHIBIT 14.9 *Example of Plugged Sprinkler. (Courtesy of Wiginton Fire Protection Engineering)*

14.2.1.5 Nonmetallic pipe shall not be required to comply with Section 14.2.

Corrosion is associated with metal pipe. Since nonmetallic piping is corrosion resistant, it is not necessary to perform internal inspections for this type of pipe. However, nonmetallic piping systems are subject to the requirements regarding obstruction investigations as mandated in Section 14.3.

FAQ Are systems using copper pipe excluded from the requirements of Section 14.2?

Although copper pipe is less prone to some of the most common forms of corrosion, it is still required to be assessed in accordance with this chapter.

14.2.2* In buildings having multiple wet pipe systems, every other system shall have an assessment of the internal condition of piping as described in 14.2.1.

A.14.2.2 In large warehouses, high-rise buildings, and other buildings having multiple systems, it is reasonable to perform the assessment on half of the systems, and conclude that these are representative of all systems in the building. The systems in the building not assessed during one frequency cycle should be assessed during the next one. As long as there is no evidence of any foreign organic and/or inorganic material found in any of the systems being assessed, every other system would be assessed once every frequency cycle. However, if foreign organic and/or inorganic material is found in any system in the building during the frequency cycle, all systems must would then be assessed during that frequency cycle.

14.2.2.1 During the next inspection frequency required by 14.2.1.1 or 14.2.1.2, the alternate systems not assessed during the previous assessment shall be assessed as described in 14.2.1.

Case In Point

During the revision cycle that generated the 2013 edition of NFPA 13, *Standard for the Installation of Sprinkler Systems*, the technical committee responsible for the definition of the term *sprinkler system* modified that definition to essentially define a system as the piping network downstream of a control valve, water source, flow switch, and drain. In the case of high-rise buildings, the system piping that is downstream of a floor control valve assembly (FCVA), is now defined as a *sprinkler system*.

Putting this new concept into practice, consider a 50-story building that is sprinklered throughout. The entire building was once considered to be protected by a single sprinkler system. With the revised definition, the building is now considered to have 50 sprinkler systems, with one on each floor.

The NFPA 13 definition for *sprinkler system* was added to the 2014 edition of NFPA 25. The impact of this change is that wherever the standard requires an inspection, testing, and maintenance (ITM) task to be completed for a "system," it will need to be done for each floor of the building that has an FCVA or each portion of a building that is sectioned off by a control valve, flow switch, and drain. The greatest impact for the application of this definition would be the internal assessment required by 14.2.1 and 14.2.2, where every other floor of a high-rise building would need to have an internal assessment every 5 years. In previous editions of the standard, the common application of this provision was to open the system and conduct an internal inspection in two or three areas of the building. This approach is no longer appropriate due to the modification of the definition, which would now require the system to be opened up on every other floor as described in 14.2.2.

Owners who do not wish to conduct the assessment on every other floor of a building every 5 years would need to illustrate an alternative assessment plan that is appropriate through a risk assessment.

14.2.2.2 If foreign organic and/or inorganic material is found in any system in a building, all systems shall be assessed.

This paragraph correlates with 14.2.2, which permits alternate systems to be internally assessed when they meet the definition of *system* in Chapter 3. In essence, it removes the allowance for inspecting every other system when obstructive material is found during the internal assessment.

14.3 Obstruction Investigation and Prevention.

Tip for Owners

The results of an internal assessment may trigger the need for an internal obstruction investigation. A building's sprinkler system may be compromised by obstructions that were caused by activities on the water supply upstream of the owner's building. This is one of the reasons why regularly scheduled ITM activities in accordance with NFPA 25 are so important.

Obstruction investigations are different from the assessment required by 14.2.1. They are more extensive and do not have a specified frequency. Obstruction investigations are triggered by specific events or conditions that can occur either within the system itself or within the water supply infrastructure for the system. Fifteen events or conditions are listed in 14.3.1 that would warrant an obstruction investigation.

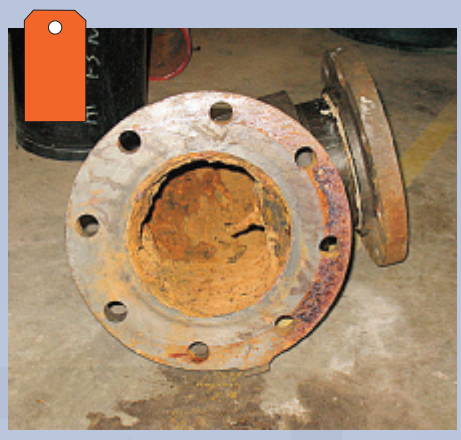
14.3.1* obstruction investigation shall be conducted for system or yard main piping wherever any of the following conditions exist:

(1) Defective intake for fire pumps taking suction from open bodies of water
(2) The discharge of obstructive material during routine water tests
(3) Foreign materials in fire pumps, in dry pipe valves, or in check valves
(4) Foreign material in water during drain tests or plugging of inspector's test connection(s)
(5) Unknown materials are heard in the system piping during draining, refilling, or otherwise flowing water through the system

(6) Plugged sprinklers
(7) The presence of sufficient foreign organic or inorganic material is found in the pipe
(8) Failure to flush yard piping or surrounding public mains following new installations or repairs

System Tagging

Typically, this level of internal corrosion or organic growth would be discovered during an internal assessment or obstruction investigation conducted in accordance with Chapter 14. Corrosion or organic growth that has developed to this point would impact the flow characteristic and pressure loss in this piping, which makes this a critical deficiency. If an examination of adjacent sections of pipes reveals additional corrosion or growth that is equally widespread or becomes worse, this could be considered an impairment.



(Courtesy of Byron Blake and SimplexGrinnell)


Noncritical Deficiency


Critical Deficiency


Impairment

(9) A record of broken public mains in the vicinity

The intent of this trigger is to ensure that obstructive material did not somehow enter the system during a repair to a public main following a break. Sometimes gravel and other material can find their way into the pipe during these events and can cause problems downstream. A certain level of judgment is necessary, as the requirement for "in the vicinity" is not defined.

(10) Abnormally frequent false tripping of a dry pipe valve(s)
(11) A system that is returned to service after an extended shutdown (greater than 1 year)
(12) There is reason to believe that the sprinkler system contains sodium silicate or highly corrosive fluxes in copper systems
(13) A system has been supplied with raw water via the fire department connection
(14) Pinhole leaks
(15) A 50 percent increase in the time it takes water to travel to the inspector's test connection from the time the valve trips during a full flow trip test of a dry pipe sprinkler system when compared to the original system acceptance test

FAQ Is there a pass/fail point for water delivery time when conducting full flow trip tests of dry pipe valves in accordance with 13.4.5.2?

As with most tests required by NFPA 25, there is no pass/fail. Most often, unsatisfactory test results drive additional requirements. In this case, if the results indicate a 50 percent increase in water delivery time as compared to the original acceptance, then an obstruction investigation is triggered.

A.14.3.1 Most piping systems contain some foreign material or other evidence of corrosion but not sufficient to trigger an obstruction investigation. Furthermore, an internal inspection is primarily an inspection for determining corrosion of the pipe, but it can result in finding the presence of material that would be an obstruction to piping or sprinklers. If such is found, an obstruction investigation in Section 14.3 would be required. For obstruction investigation procedures, see Section D.3. The type of obstruction investigation should be appropriately selected based on the observed condition. For instance, ordering an internal obstruction investigation would be inappropriate where the observed condition was broken public mains in the vicinity. On the other hand, such an investigation would be appropriate where foreign materials are observed in the dry pipe valve.

14.3.2* Systems shall be examined for internal obstructions where conditions exist that could cause obstructed piping.

A.14.3.2 For obstruction prevention program recommendations, see Section D.4.

14.3.2.1 If the condition has not been corrected or the condition is one that could result in obstruction of the piping despite any previous flushing procedures that have been performed, the system shall be examined for internal obstructions every 5 years.

Obstruction investigations are only required to be repeated on a 5-year basis when the cause of the obstruction cannot be corrected, such as with a zebra mussel infestation. In all other cases, an obstruction investigation is required only when one of the conditions listed in 14.3.1 is found. An obstruction investigation is not intended to be a routinely scheduled activity.

14.3.2.2* Internal examination shall be performed at the following minimum four points:

(1) System valve
(2) Riser
(3) Cross main
(4) Branch line

One of the keys to conducting a thorough obstruction investigation is to look in the system where obstructions are likely to be found. The requirements of 14.3.2.2 are minimum requirements and are not meant to limit the examination to these particular points.

FAQ How many pipes have to be examined if obstructions in the system are suspected?

The intent of 14.3.2.2 is for each of the main system components to be visually examined. If an obstruction is found in one of these main areas of the system, it would be good practice to open a few other areas of the system to verify whether the obstruction is an isolated incident. For branch lines, the intent is to open a representative number of branch lines rather than open every branch line in the system.

A.14.3.2.2 The indicated locations are presented as the minimum basis for determining the need for the initiation of a more extensive obstruction investigation effort. Additional points of examination can be appropriately dictated to assess the extent and severity of the obstructing material as determined by the observed conditions at these locations. See Section D.3 for further discussion.

14.3.2.3* Alternative nondestructive examination methods shall be permitted.

System Tagging

Internal assessments and obstruction investigations often yield varying levels of corrosion. These images show the inside of an outside screw and yoke (OS&Y) and fire department connection with internal corrosion. Table A.3.3.8 considers internal conditions like this to be a critical deficiency. In other instances however, where the corrosion is more widespread, it can be considered an impaired system.





(Courtesy of Byron Blake and SimplexGrinnell)

Noncritical Deficiency Critical Deficiency Impairment

Δ **A.14.3.2.3** Alternative examination methods can include the following:

(1) Using video inspection equipment that is inserted into the system at strategic points to observe the internal condition of pipes. This equipment provides a visual exam of the pipes using a camera and lighting system on the end of a push cable. Video inspection equipment can be inserted in alarm, dry, and preaction valves, in the risers, and into cross mains and branch lines, depending on the system configuration. This equipment can also be used to determine the results of any flushing that was performed.

(2) Ultrasonic or similar technology that allows the pipe wall to be externally tested to determine the extent of any deterioration due to MIC or other forms of corrosion. This method has advantages, including allowing the system to be left in service while performing the examination and pinpointing where pipes are about to fail before the actual failure occurs, allowing preventive action to be taken. This technology does have its limitations, and to be thorough all pipes would require access, even those in concealed spaces such as those above ceilings. This technology can detect the presence of a buildup of sludge, scale, or other by-products of corrosion, but cannot quantify the severity of the potential obstruction. It can detect existing air pockets in wet systems as well as trapped sections of pipe in dry systems that aren't adequately drained. This technology cannot determine the corrosion mechanisms responsible for pipe damage, but can determine the severity of the metal loss. In most cases this technology will not detect the presence of solid material in the piping such as wood, plastic, or other foreign obstructions that are not a by-product of corrosion, because only small representative sections of pipe are examined.

14.3.3* If an obstruction investigation indicates the presence of sufficient material to obstruct pipe or sprinklers, a complete flushing program shall be conducted by qualified personnel.

A.14.3.3 For obstruction investigation flushing procedures, see Section D.5.

The flushing procedures outlined in Section D.5 of Annex D are intended to be carried out with water. However, in cases where the obstruction investigation has identified severe MIC, chemical scouring might be necessary. This process is highly specialized and should be attempted only by professionals who are thoroughly experienced in the procedure. Chemicals should not be added to the water or used for flushing without first determining the possible effects on the sprinkler and valve seats or other sprinkler system components.

14.3.4 Tubercules or slime, if found during an obstruction investigation, shall be tested for indications of microbiologically influenced corrosion (MIC).

14.4 Ice Obstruction.

Dry pipe or preaction sprinkler system piping that protects or passes through refrigerated spaces maintained at temperatures below 32°F (0°C) shall be inspected internally on an annual basis for ice obstructions at the point where the piping enters the refrigerated area.

The inspection described in Section 14.4 should be conducted regularly to ensure that piping is not obstructed with ice and that fittings are not fractured due to ice buildup. Exhibit 14.10 shows piping with ice buildup.

EXHIBIT 14.10 *Dry System with Ice Buildup. (Courtesy of Byron Blake and SimplexGrinnell)*



14.4.1 Alternative nondestructive examinations shall be permitted.

The alternative nondestructive examination methods in 14.4.1 include the use of ultrasound, X-ray, and remote video camera technology.

14.4.2 All penetrations into the refrigerated spaces shall be inspected and, if an ice obstruction is found, additional pipe shall be examined to ensure that no additional ice obstructions or ice blockages exist.

References Cited in Commentary

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2019 edition.



15

IMPAIRMENTS

The requirements in Chapter 15 cover all the important aspects of a suitable impairment program. An impairment is a condition where a water-based fire protection system or a portion thereof will not function during a fire event. A formal impairment program establishes procedures for ensuring that system control valves remain in their correct position. Furthermore, implementation of an impairment program can help minimize the length of time that a system is out of service. This chapter provides the basic requirements for such an impairment program.

The success of any impairment program is determined by the support it receives from those responsible for implementing it. Often, the best way to ensure that an impairment program is properly set up is to review it with the authority having jurisdiction (AHJ), which can be the fire department, the insurance company, or other officials. If any situations arise that are not covered by the impairment program, it is good practice to seek the advice of the AHJ. The key point to remember in any impairment program is the vulnerability of the building and its occupants during these events.

15.1 General.

The most common impairments involve closed water-control valves, but other examples can include conditions such as a nonfunctioning fire pump, painted sprinklers, heavily corroded sprinklers, or a broken hose valve. (See A.3.3.8 for more examples of potential impairments.)

This chapter deals primarily with preplanned impairments — those impairments in which the system or a portion thereof is out of service due to work, such as modifications to the water supply or sprinkler system piping that has been planned in advance. In reality, an effective impairment program is one that is established and understood well in advance of any impairment and can be implemented in the event of an emergency impairment, as well. Note that the appointment of an impairment coordinator (see Section 15.2) does not necessarily coincide with the actual impairment. In fact, 4.1.11.1 directs the user to this chapter whenever an impairment occurs or is identified.

Rarely is a facility more exposed to a potentially catastrophic fire loss than when a fire protection system or portion of a system is out of service. Many devastating fires could have been mitigated had a proper impairment program been in place and adhered to. Whether an impairment is preplanned or occurs in an emergency situation seems to have little bearing

on its tendency to lead to catastrophe. A major factor in previous large-loss fires included the failure to do the following:

- Recognize the risks created by the impairment.
- Establish a fire watch and provide backup fire protection.
- Control ignition sources and/or shut down hazardous processes.
- Expedite repairs.
- Ensure that the fire protection system is properly placed back into service.

15.1.1 Minimum Requirements.

Δ **15.1.1.1** This chapter shall provide the minimum requirements for a fire protection system impairment program.

15.1.1.2 Measures shall be taken during the impairment to ensure that increased risks are minimized and the duration of the impairment is limited.

15.2 Impairment Coordinator.

15.2.1 The property owner or designated representative shall assign an impairment coordinator to comply with the requirements of this chapter.

Prior to removing a system from service, the impairment coordinator should ensure that the necessary tools, equipment, and replacement parts are on hand to minimize the duration of the impairment. This typically involves coordinating with the contractor or service provider who is scheduled to perform the work that necessitates the shutdown of the system. As stated earlier, the building and its occupants are at higher risk when fire protection systems are impaired. Thus, the role of the impairment coordinator in performing this important function should not be understated.

15.2.2 In the absence of a specific designee, the property owner or designated representative shall be considered the impairment coordinator.

15.2.3 Where the lease, written use agreement, or management contract specifically grants the authority for inspection, testing, and maintenance of the fire protection system(s) to the tenant, management firm, or managing individual, the tenant, management firm, or managing individual shall assign a person as impairment coordinator.

Tip for Owners

The impairment coordinator is usually someone from the building maintenance department. In larger facilities, the coordinator might be a member of the safety or loss control department. The impairment coordinator should be someone who is on site and thoroughly familiar with the building layout, operations, and systems. In addition, he or she should have the authority and means to initiate proper notification when a system impairment is planned. This notification includes, but is not limited to, the fire department, insurance carrier, alarm company, property owner, area supervisors, and tenants.

15.3 Tag Impairment System.

Many jurisdictions have requirements to identify the system's operational status. These often include tags that are placed at the system riser or other specified locations to indicate that inspection, testing, and maintenance (ITM) has been performed and whether or not there were any deficiencies or impairments found. System status tagging programs often use color-coded tags for this purpose. For more information on color-coded system status tagging programs, see Annex G. Those programs, and the tags they utilize, are not typically part of the requirements of Chapter 15. For example, a system that was found to have impairments during inspection or testing may be tagged as such by the qualified person conducting the ITM, but that simply triggers the implementation of the requirements found in Chapter 15. The impairment coordinator would then place the impairment tags as required by Section 15.3.

15.3.1* A tag shall be used to indicate that a system, or part thereof, has been removed from service.

A.15.3.1 A clearly visible tag alerts building occupants and the fire department that all or part of the water-based fire protection system is out of service. The tag should be weather resistant, plainly visible, and of sufficient size [typically 4 in. × 6 in. (100 mm × 150 mm)]. The tag should identify which system is impaired, the date and time impairment began, and the person responsible. Figure A.15.3.1 illustrates a typical impairment tag.

Anyone who is shutting down a system should use tagging procedures even if the owner does not. Tags should also be itemized in a list to facilitate proper restoration of the system to working order. Once retrieved, a tag can also be used for verification that a valve or system has been restored to service. Exhibit 15.1 illustrates a valve that has been closed for testing purposes and has an impairment tag attached.

ATTACH TO VALVE
• READ INSTRUCTIONS ON OTHER SIDE •

SPRINKLER VALVE

SHUT

THIS VALVE CONTROLS SPRINKLERS IN BUILDING(S):

SHUT BY (SIGNATURE)	DATE

After valve is opened, make 2 in. (50 mm) drain test. Drop in pressure should be normal. If pressure drop is extreme and does not build up, the system is impaired and immediate investigation is necessary.

DRAIN TEST RESULTS

STATIC PRESSURE psi (bar)	FLOWING PRESSURE psi (bar)

DRAIN TEST MADE BY (SIGNATURE)	DATE

FIGURE A.15.3.1 *Sample Impairment Tag.*

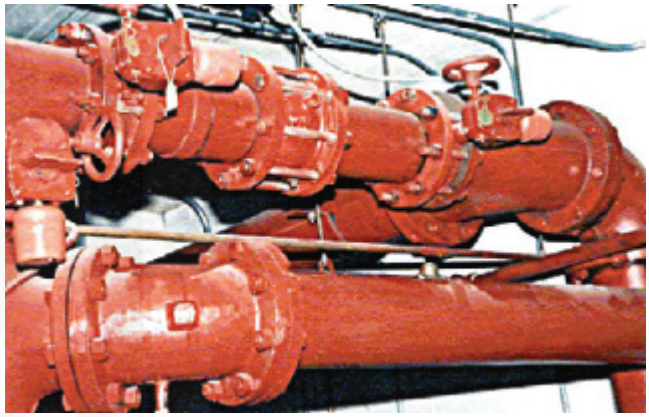


EXHIBIT 15.1 *Closed and Tagged Valve.*

15.3.2* The tag shall be posted at each fire department connection and the system control valve, and other locations required by the authority having jurisdiction, indicating which system, or part thereof, has been removed from service.

A.15.3.2 An impairment tag should be placed on the fire department connection to alert responding fire fighters of an abnormal condition. An impairment tag that is located on the system riser only could go unnoticed for an extended period if fire fighters encounter difficulty in gaining access to the building or sprinkler control room.

15.4 Impaired Equipment.

15.4.1 The impaired equipment shall be considered to be the water-based fire protection system, or part thereof, that is removed from service.

15.4.2 The impaired equipment shall include, but shall not be limited to, the following:

(1) Sprinkler systems
(2) Standpipe systems
(3) Fire hose systems
(4) Underground fire service mains
(5) Fire pumps
(6) Water storage tanks
(7) Water spray fixed systems
(8) Foam-water sprinkler systems
(9) Water mist systems
(10) Fire service control valves
(11) Water supply

Historical Note

Due to the modification to the scope of the technical committee that prepares NFPA 25, water mist systems were added in the 2014 edition to the list of systems that must be considered impaired. Historically, NFPA 750, *Standard on Water Mist Fire Protection Systems,* had provided the maintenance requirements for water mist systems, and NFPA 25 simply extracted the concepts from that standard. The NFPA Standards Council clarified the scopes of these technical committees in 2012, and all of the ITM-related tasks associated with water mists systems, including impairments, were put into NFPA 25.

15.5* Preplanned Impairment Programs.

A.15.5 The need for temporary fire protection, termination of all hazardous operations, and frequency of inspections in the areas involved should be determined. All work possible should be done in advance to minimize the length of the impairment. Where possible, temporary feedlines should be used to maintain portions of systems while work is completed.

Water-based fire protection systems should not be removed from service when the building is not in use. Where a system that has been out of service for a prolonged period, such as in the case of idle or vacant properties, is returned to service, qualified personnel should be retained to inspect and test the systems.

15.5.1 All preplanned impairments shall be authorized by the impairment coordinator.

15.5.2 Before authorization is given, the impairment coordinator shall be responsible for verifying that the following procedures have been implemented:

(1) The extent and expected duration of the impairment have been determined.
(2) The areas or buildings involved have been inspected and the increased risks determined.
(3) Recommendations to mitigate any increased risks have been submitted to management or the property owner or designated representative.

(4) Where a fire protection system is out of service for more than 10 hours in a 24-hour period, the impairment coordinator shall arrange for one of the following:
   (a) Evacuation of the building or portion of the building affected by the system out of service
   (b)* An approved fire watch

A.15.5.2(4)(b) A fire watch should consist of trained personnel who continuously patrol the affected area. Ready access to fire extinguishers and the ability to promptly notify the fire department are important items to consider. During the patrol of the area, the person should not only be looking for fire, but making sure that the other fire protection features of the building such as egress routes and alarm systems are available and functioning properly.

Tip for Owners

The building owner, through the impairment coordinator or other designated personnel, is responsible for arranging a fire watch. The fire watch is imperative from both a life safety and property protection perspective. It is also important that egress routes and alarm systems be maintained to ensure the safety of the building occupants.

FAQ What are the qualifications and responsibilities of the fire watch?

Fire watch personnel should be trained to understand the hazards at the job site and the nature of hot work where hot work operations are used. They should ensure that safe conditions are maintained during all hot work operations and should have the authority to stop work if unsafe conditions develop. Fire-extinguishing equipment should be readily available, and fire watch personnel should be trained in its use. The fire watch personnel should be familiar with the facilities and procedures for sounding an alarm in the event of a fire.

Fire watch personnel should be trained in proper incipient fire response procedures, such as notifying the fire department and persons in the fire area before attempting to extinguish a fire. They should attempt to extinguish a fire only if it is obviously within the capacity of the equipment available. It is important to note that many AHJs have specific requirements that fire watch personnel must meet. Fire watch personnel may be allowed to perform additional tasks, but those tasks should not distract them from their watch responsibilities. For additional guidance on fire watch operations, see NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*.

For torch-applied roofing operations, a fire watch must be posted for the duration of the work and for 60 minutes thereafter.

   (c)* Establishment of a temporary water supply

A.15.5.2(4)(c) Temporary water supplies are possible from a number of sources, including use of a large-diameter hose from a fire hydrant to a fire department connection, use of a portable tank and a portable pump, or use of a standby fire department pumper and/or tanker.

Temporary water supplies can be established through the use of existing systems or portions of systems that are not involved in the maintenance or repair activity. Exhibit 9.9 shows one type of temporary water supply in the form of portable bladder tanks. Exhibit 15.2 shows another type of temporary water supply where a hard-piped connection was made to the fire department connection (FDC) in order to bypass work on the main water supply. Furthermore, the temporary water supply for fire protection should be available as soon as existing fire protection systems are shut down for maintenance or repair.

In situations involving automatic sprinklers, the system should be returned to service as soon as possible. The operation of sprinkler control valves should be limited to properly authorized personnel only. Where the sprinkler protection is regularly turned off and on to facilitate connection of newly repaired segments, the sprinkler control valves should be checked at the end of each work shift. Additionally, the impairment program should be followed to verify that protection is in service. If at all possible, sprinkler systems should be isolated from standpipes in order to keep the standpipe system in service and readily available for manual fire fighting.

EXHIBIT 15.2 *Temporary Water Supply Connection to FDC.*



(d)* Establishment and implementation of an approved program to eliminate potential ignition sources and limit the amount of fuel available to the fire

An approved fire prevention program, as referred to in 15.5.2(4)(d), should include the following:

1. Good housekeeping
2. On-site security
3. Immediate activation of new or repaired fire protection systems as construction and repairs allow
4. Preservation of existing fire protection systems during building construction or renovation
5. Development of a prefire plan with the local fire department
6. Accurate and rapid communication process
7. Consideration of any special hazards resulting from construction operations
8. Protection of existing structures and equipment from exposure fires resulting from construction, alteration, and demolition operations

Temporary fire extinguishers should be provided in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*. At least one approved fire extinguisher should be provided in plain sight on each floor at each usable stairway. Access to permanent, temporary, or portable fire equipment should be maintained at all times.

A.15.5.2(4)(d) Depending on the use and occupancy of the building, it could be enough in some circumstances to stop certain processes in the building or to cut off the flow of fuel to some machines. It is also helpful to implement "No Smoking" and "No Hot Work" (cutting, grinding, or welding) policies while the system is out of service because these activities are responsible for many fire ignitions.

Tip for Owners

Hot work is a common cause of nonresidential fires and resulting property damage. Should welding or cutting be necessary during system repair, these activities should be carried out in accordance with NFPA 51B. OSHA 29 CFR 1910.252, "Welding, Cutting, and Brazing, General," references NFPA 51B and ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*, so the requirements of those two documents must be followed for OSHA compliance.

FAQ Is welding of pipe and pipe supports permitted?

Although shop welding of pipe is preferred, welding of pipe and pipe supports is permitted by NFPA 13, *Standard for the Installation of Sprinkler Systems*, provided that welding operations are conducted in accordance with NFPA 51B. In some areas, a permit issued by the local AHJ might be required.

(5) The fire department has been notified.

Although many fire departments might not require a permit for maintenance activities, notification to the department that a system or a portion of a system is out of service is still required. This notification of an impaired system serves two purposes, as follows:

1. It assists fire department pre-incident planning should an emergency response to the affected property be necessary.
2. It allows the fire department to monitor progress in repairs and avoid a system impairment that is longer than necessary.

(6) The insurance carrier, the alarm company, property owner or designated representative, and other authorities having jurisdiction have been notified.

Notifying the insurance carrier, the alarm company, the property owner or manager, and other AHJs is important for the following reasons:

1. In addition to ensuring that the alarm company does not inadvertently initiate a fire department response to an alarm signal, alarm companies often require an estimated time period for the impairment and will respond if the system is not placed in service at the end of the specified time period.
2. Insurance companies might have requirements or recommendations for temporary protection during impairments and provide assistance in monitoring the impairment. Many insurance companies have specific tag impairment systems that must be used during impairments.
3. Water or health departments might have special requirements when systems are shut off and brought back on line, such as testing of backflow prevention devices.

(7) The supervisors in the areas to be affected have been notified.
(8) A tag impairment system has been implemented. *(See Section 15.3.)*

Prior to any scheduled inspection or testing that could impair the system, the contractor or service company should consult with the property owner or impairment coordinator. The following issues should be discussed and agreed upon by all parties prior to the start of any work:

1. Any requirements for advance notification to the building occupants
2. Coordination of any business interruption
3. Procedures for the evacuation or for the restoration of protection
4. Any additional related issues

(9) All necessary tools and materials have been assembled on the impairment site.

Tip for Owners

Anyone who might be affected by fire protection system testing in a protected premises should be notified that testing will take place. This notification should include, but might not be limited to, the property owner, property manager, switchboard operator, building engineer, building or floor fire wardens, and building maintenance personnel. In addition, the fire department communication center (if required), the alarm supervising station, and building occupants should also be notified.

Effective methods of notification for the building occupants include emails, bulletin board postings, public address announcements, and lobby signs.

15.6* Emergency Impairments.

A.15.6 Emergency impairments include, but are not limited to, system leakage, interruption of water supply, frozen or ruptured piping, equipment failure, or other impairments found during inspection, testing, or maintenance activities.

15.6.1 Emergency impairments shall include, but are not limited to, interruption of water supply, frozen or ruptured piping, and equipment failure, and includes impairments found during inspection, testing, or maintenance activities.

FAQ What is an emergency impairment?

An emergency impairment is a condition in which the water-based fire protection system or a portion thereof is out of service due to an unexpected occurrence. Such an impairment might occur as the result of a successful system operation during a fire.

Following a fire, sprinklers that have operated must be replaced and the system must be returned to service. The replacement of sprinklers illustrates the importance of the sprinkler cabinet inspections required by Chapter 5, since the impairment time can be substantially reduced if replacement sprinklers are on site.

15.6.2* The coordinator shall implement the steps outlined in Section 15.5.

The impairment coordinator can use an emergency impairment notice, such as the one shown in Exhibit 15.3, to coordinate emergency repairs of a fire protection system.

A.15.6.2 When one or more impairments are discovered during inspection, testing, and maintenance activities, the owner or owner's authorized representative should be notified in writing. See Figure A.15.6.2 for an example of written notification.



EXHIBIT 15.3 *Impairment Tag. (Courtesy of Liberty Mutual Commercial Markets)*

IMPAIRMENT NOTICE

DURING A RECENT INSPECTION OF YOUR FIRE PROTECTION SYSTEM(S), AN ***EMERGENCY IMPAIRMENT*** WAS DISCOVERED AND INDICATED ON THE INSPECTION REPORT. AS DEFINED BY NFPA 25, AN ***EMERGENCY IMPAIRMENT*** IS "A CONDITION WHERE A WATER-BASED FIRE PROTECTION SYSTEM OR PORTION THEREOF IS OUT OF ORDER DUE TO AN UNEXPECTED OCCURRENCE, SUCH AS A RUPTURED PIPE, OPERATED SPRINKLER, OR AN INTERRUPTION OF WATER SUPPLY TO THE SYSTEM." NFPA 25 FURTHER STATES, "EMERGENCY IMPAIRMENTS INCLUDE BUT ARE NOT LIMITED TO SYSTEM LEAKAGE, INTERRUPTION OF WATER SUPPLY, FROZEN OR RUPTURED PIPING, AND EQUIPMENT FAILURE."

WE RECOMMEND THAT IMMEDIATE STEPS BE TAKEN, AS DESCRIBED IN THE ATTACHED COPY OF CHAPTER 15 OF NFPA 25, TO CORRECT THE FOLLOWING IMPAIRMENT(S) TO YOUR FIRE PROTECTION SYSTEM(S):

- ❑ CONTROL VALVE SHUT. SYSTEM OUT OF SERVICE.
- ❑ LOW WATER PRESSURE DURING FLOW TEST. POSSIBLE OBSTRUCTION IN WATER SUPPLY OR PARTIALLY SHUT VALVE.
- ❑ PIPE(S) FROZEN.
- ❑ PIPE(S) LEAKING.
- ❑ PIPE(S) ARE OBSTRUCTED.
- ❑ SYSTEM PIPING OR PORTIONS OF SYSTEM PIPING ARE DISCONNECTED.
- ❑ FIRE DEPT. CONNECTION MISSING OR DAMAGED OR OBSTRUCTED.
- ❑ DRY PIPE VALVE CANNOT BE RESET.
- ❑ DRY PIPE SYSTEM QUICK-OPENING DEVICE IS OUT OF SERVICE.
- ❑ SPRINKLERS ARE PAINTED, CORRODED, DAMAGED, OR LOADED.
- ❑ FIRE PUMP IS OUT OF SERVICE.
- ❑ DETECTION/ACTUATION SYSTEM IS OUT OF SERVICE.
- ❑ OTHER:_____

FIGURE A.15.6.2 *Sample Impairment Notice.*

15.7* Restoring Systems to Service.

When all impaired equipment is restored to normal working order, the impairment coordinator shall verify that the following procedures have been implemented:

(1) Any necessary inspections and tests have been conducted to verify that affected systems are operational. The appropriate chapter of this standard shall be consulted for guidance on the type of inspection and test required.

The most common tests required following a system repair include the hydrostatic pressure test and the main drain test. The hydrostatic pressure test verifies that the piping system will not leak, and the main drain test verifies that all water supply control valves have been returned to their full open positions. Other tests, such as a running test for fire pumps and flow or alarm tests to check the functioning of replaced components, are required when components are repaired or replaced. The specific actions required for placing a system or system component in service following repair, replacement, or other corrective actions can be found in the appropriate chapter in the standard.

(2) Supervisors have been advised that protection is restored.
(3) The fire department has been advised that protection is restored.
(4) The property owner or designated representative, insurance carrier, alarm company, and other authorities having jurisdiction have been advised that protection is restored.

All parties involved in the original impairment notification should be advised when protection is restored. See the commentary following 15.5.2(5) for further information.

(5) The impairment tag has been removed.

Impairment tags are required to be removed and should be accounted for. As stated in the commentary following A.15.3.1, counting these tags can be a means of verifying that all system control valves have been returned to their proper operating position and the system is fully operational.

A.15.7 Occasionally, fire protection systems in idle or vacant buildings are shut off and drained. When the equipment is eventually restored to service after a long period of not being maintained, it is recommended that qualified personnel or a qualified contractor perform the work. The following is an example of a procedure:

(1) All piping should be traced from the extremities of the system to the main connections with a careful check for blank gaskets in flanges, closed valves, corroded or damaged sprinklers, nozzles, or piping, insecure or missing hangers, and insufficient support. Proper repairs or adjustments should be made, and needed extensions or alterations for the equipment should be completed.
(2) An air test at low pressure (40 psi) should be conducted prior to allowing water to fill the system. When the piping has been proven tight by passing the air test, water can be introduced slowly into the system, with proper precautions against damage by escape of water from previously undiscovered defects. When the system has been filled under normal service pressure, drain valve tests should be made to detect any closed valve that possibly could have been overlooked. All available pipes should be flushed, and an obstruction investigation completed to make sure that the system is clear of debris.
(3) Where the system was known to have been damaged by freezing or where other extensive damage might have occurred, a full hydrostatic test can be performed in accordance with NFPA 13 to determine whether the system integrity has been maintained.

(4) Dry pipe valves, quick-opening devices, alarm valves, and all alarm connections should be examined, put in proper condition, and tested.
(5) Fire pumps, pressure and gravity tanks, reservoirs, and other water supply equipment should receive proper attention before being placed in service. Each supply should be tested separately and then together if they are designed to work together.
(6) All control valves should be operated from the closed to fully open position and should be left sealed, locked, or equipped with a tamper switch.

References Cited in Commentary

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 10, *Standard for Portable Fire Extinguishers*, 2018 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2019 edition.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, 2019 edition.

NFPA 750, *Standard on Water Mist Fire Protection Systems,* 2019 edition.

American Welding Society, 8669 NW 36 Street, #130, Miami, FL 33166-6672.

ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes*, 2012 edition.

U.S. Government Publishing Office, 732 North Capitol Street, NW, Washington, DC 20401-0001.

Title 29, Code of Federal Regulations, Part 1910.252, "Welding, Cutting, and Brazing, General."



16

SPECIAL REQUIREMENTS FROM OTHER NFPA DOCUMENTS

Chapter 16 was added to the 2014 edition of NFPA 25 to provide guidance for the inspection, testing, and maintenance (ITM) of systems installed in buildings that had not previously been addressed by the standard. In that edition, this chapter included references to the ITM of sprinkler systems installed in small residential board and care facilities in accordance with NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*. These ITM requirements were extracted directly from NFPA *101®*, *Life Safety Code®*, which permitted the systems to be installed in these occupancies. Because NFPA 25 excludes systems installed in accordance with NFPA 13D from its scope, and because these systems are used in occupancies other than typical one- and two-family dwellings, NFPA *101* established some ITM requirements. For the 2017 edition, these extracts were removed from the code by the NFPA Standards Council due to scoping and correlating issues between the documents in different revision cycles. This chapter is now intended to direct the user of NFPA 25 to those appropriate documents for the requirements.

16.1 General.

16.1.1 Application.

16.1.1.1* This chapter shall include the inspection, testing, and maintenance requirements for water-based fire protection systems found in other NFPA standards that are different from those included in this standard.

A.16.1.1.1 There are numerous NFPA documents that have special requirements for the inspection, testing, and maintenance of water-based fire protection systems that are different from those in NFPA 25. In many cases those documents reference NFPA 25 and could have either more stringent or even less stringent requirements than those in NFPA 25.

16.1.1.2* The requirements of this chapter shall be extracted from the other referenced standards.

A.16.1.1.2 These requirements are not written by or able to be amended by the technical committee of this standard, and therefore the text is an extract from the document that has the requirements.

16.1.1.3 Where the requirements of the referenced standard differ from the requirements of this standard, the referenced standard shall take precedence.

Tip for Owners

An owner of a board and care facility needs to refer to NFPA *101* for the ITM requirement of a NFPA 13D sprinkler system. All other NFPA 13D systems are excluded from the scope of NFPA 25.

16.1.2 Definitions.
For terms not defined in Chapter 3, the definitions of the reference standard shall apply.

16.2 Small Residential Board and Care Occupancies.

Because there are very minimal maintenance requirements for sprinkler systems installed in accordance with NFPA 13D, and because the scope of NFPA 25 excludes NFPA 13D sprinkler systems, 33.2.3.5.8 of NFPA *101* specifies a series of testing and maintenance requirements for such systems where installed in small board and care occupancies. Where NFPA 13D is utilized outside its originally intended scope (one- and two-family dwellings and manufactured homes), NFPA *101* supplements the requirements of NFPA 13D to ensure a high level of reliability, because the system is either a mandatory system or it is being used to modify some other requirement.

The testing and maintenance requirements of 33.2.3.5.8 in NFPA *101* are not onerous. Several of the provisions, such as monthly visual inspection of control valves, can be accomplished by the facility's owner or operator. Such routine visual inspection will help to ensure a control valve is not inadvertently closed, which could lead to the system's failure in the event of a fire.

16.2.1 The requirements in this section shall only apply to residential board and care facilities with sprinkler systems installed in accordance with NFPA 13D as described in NFPA *101*.

16.2.1.1 Systems installed in accordance with NFPA 13D shall be inspected, tested, and maintained in accordance with NFPA *101*.

This subsection, together with 1.1.5, establishes that only those systems installed in accordance with NFPA 13D in these particular occupancies are addressed by NFPA 25. All other NFPA 13D systems are excluded. Those requirements for the ITM of systems in small residential board and care occupancies from NFPA *101* have been provided below for reference. Note that references to the 2017 edition of NFPA 25 have been updated to the 2020 edition where needed.

EXTRACTS FROM NFPA *101*-2018

33.2.3.5.8 Systems installed in accordance with NFPA 13D shall be inspected, tested, and maintained in accordance with 33.2.3.5.8.1 through 33.2.3.5.8.15, which reference specific sections of NFPA 25. The frequency of the inspection, test, or maintenance shall be in accordance with this *Code*, whereas the purpose and procedure shall be from NFPA 25.

33.2.3.5.8.1 Control valves shall be inspected monthly in accordance with 13.3.2 of NFPA 25.

33.2.3.5.8.2 Gauges shall be inspected monthly in accordance with 13.2.7.1.1 *[13.2.5.1.1]* of NFPA 25.

33.2.3.5.8.3 Alarm devices shall be inspected quarterly in accordance with 5.2.4 of NFPA 25.

33.2.3.5.8.4 Alarm devices shall be tested semiannually in accordance with 5.3.2 of NFPA 25.

33.2.3.5.8.5 Valve supervisory switches shall be tested semiannually in accordance with 13.3.3.5 of NFPA 25.

33.2.3.5.8.6 Visible sprinklers shall be inspected annually in accordance with 5.2.1 of NFPA 25.

33.2.3.5.8.7 Visible pipe shall be inspected annually in accordance with 5.2.2 of NFPA 25.

33.2.3.5.8.8 Visible pipe hangers shall be inspected annually in accordance with 5.2.3 of NFPA 25.

33.2.3.5.8.9 Buildings shall be inspected annually prior to the onset of freezing weather to ensure that there is adequate heat wherever water-filled piping is run in accordance with 4.1.2 of NFPA 25.

33.2.3.5.8.10 A representative sample of fast-response sprinklers shall be tested once the sprinklers in the system are 20 years old in accordance with 5.3.1.1.1.3 of NFPA 25.

(A) If the sample fails the test, all of the sprinklers represented by that sample shall be replaced.

(B) If the sprinklers pass the test, the test shall be repeated every 10 years thereafter.

33.2.3.5.8.11 A representative sample of dry-pendent sprinklers shall be tested once the sprinklers in the system are 10 years old in accordance with 5.3.1.1.1.6 *[note that 2020 edition of NFPA 25 has revised the time from 10 years to 15 years]* of NFPA 25.

(A) If the sample fails the test, all of the sprinklers represented by that sample shall be replaced.

(B) If the sprinklers pass the test, the test shall be repeated every 10 years thereafter.

33.2.3.5.8.12 Antifreeze solutions shall be tested annually in accordance with 5.3.3 *[5.3.4]* of NFPA 25.

33.2.3.5.8.13 Control valves shall be operated through their full range and returned to normal annually in accordance with 13.3.3.1 of NFPA 25.

33.2.3.5.8.14 Operating stems of OS&Y valves shall be lubricated annually in accordance with 13.3.4 of NFPA 25.

33.2.3.5.8.15 Dry-pipe systems that extend into the unheated portions of the building shall be inspected, tested, and maintained in accordance with 13.4.5 of NFPA 25.

Water flow alarm devices and valve supervision are not typically found on sprinkler systems installed in accordance with NFPA 13D. As with other NFPA 25 requirements, nothing in 33.2.3.5.8.3, 33.2.3.5.8.4, 33.2.3.5.8.5 of NFPA *101* requires the presence of these items, only that they be inspected, tested, and maintained in systems where they are provided.

Existing systems incorporating non-listed antifreeze solutions, such as glycerine or propylene glycol, can be dangerous to the occupants of the building. Owners should consider all risks and evaluate the possibility of conditioning the space where piping is installed to protect it from freezing, replacing non-listed antifreeze with a listed antifreeze solution, or replace the system with a small dry pipe system. See 5.3.4 for the most recent requirements on how to address antifreeze systems in existing systems.

References Cited in Commentary

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*, 2019 edition.

NFPA *101*®, *Life Safety Code*®, 2018 edition.

NFPA



ANNEX A

EXPLANATORY MATERIAL

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

Annex material is useful information that is included in this standard solely to help the user understand the intent of the requirements by providing further information, diagrams, examples, or other details.

The Annex A material is not only explanatory material to specific sections of NFPA 25, but it is voted on by the document's technical committee along with the rest of NFPA 25.

The commentary in this handbook differs from the annex material in that it reflects the opinions of the editors of and the contributors to this handbook — not the committee — to help further explain provisions in the document.

For the convenience of the readers of this handbook, Annex A text is inserted after the appropriate paragraphs in Chapter 1 through Chapter 16 and, therefore, is not repeated here.

NFPA

ANNEX B

FORMS AND REPORTS FOR INSPECTION, TESTING, AND MAINTENANCE

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

B.1 General.

Forms need to be complete with respect to the requirements of NFPA 25 for the system being inspected, tested, or maintained, or any combination thereof. Because water-based fire protection systems comprise many components, it could be necessary to complete more than one form for each system. Reports translate the results of the inspection, testing, and maintenance process to the building owner and the authority having jurisdiction where applicable. The inspection form could also serve as the inspection report if the form contains the information suggested by the report guidance in Section B.4.

Authorities having jurisdiction are legitimately concerned that the forms used are comprehensive. Therefore, they could develop their own forms or utilize those already developed and reviewed by their jurisdiction.

NFPA has developed a series of customizable electronic forms specific to the inspection, testing, and maintenance (ITM) requirements throughout NFPA 25. These forms — available at www.nfpa.org — include open fields the inspector can fill in and modify for most of the ITM recommendations in Section B.4. This handbook also contains several examples of sample forms that can be used for recording system information or documenting an ITM task that has been completed.

B.2 Inspection, Testing, and Maintenance Forms.

At least five formats can be used and are described as follows:

(1) One form in which all requirements for NFPA 25 are specified and large sections of information do not apply to most systems
(2) Individual forms that provide requirements corresponding to each chapter of NFPA 25 and address the following:
    (a) Sprinkler systems
    (b) Standpipe systems

(c) Private fire service mains
(d) Fire pumps
(e) Storage tanks
(f) Water spray systems
(g) Foam-water sprinkler systems

(3) Forms that include information from the specific system chapter: Chapter 1, Chapter 13, and Chapter 14
(4) A series of forms similar to option (2) but with a more detailed breakdown of system types. For example, fire sprinkler systems are divided into the following five forms:
(a) Wet pipe fire sprinkler systems
(b) Dry pipe fire sprinkler systems
(c) Preaction fire sprinkler systems
(d) Deluge fire sprinkler systems
(e) Foam-water sprinkler systems
(5) Separate forms for each individual component of each fire protection system

Any forms that are used for checking a fire protection system must comply with the reporting requirements of NFPA 25. Note that NFPA 25 does not have a specific form or series of forms that must be used when conducting ITM tasks. There is a common misconception that the inspector must fill out "the NFPA 25 form," but the standard has no forms that are required to be used. This allows the owner and inspector to develop custom forms for their properties based on the systems that are present.

There are several electronic reporting systems that are also available. Any system that meets the minimum reporting requirements of the standard can be used.

B.3 Sample Forms.

Sample forms are available for downloading at www.nfpa.org, www.nfsa.org, and www.firesprinkler.org. Additional forms might be available through commercial insurance carriers.

B.4 Recommendations for Inspection, Testing, and Maintenance Reports.

Where reports are generated from the inspection, testing, and maintenance requirements of NFPA 25, consistent information should be included in the report. All inspection, testing, and maintenance reports developed for building owners and authorities having jurisdiction where applicable should include, at a minimum, the following information:

(1) Administrative information
(a) Name of property (if applicable)
i. Address, including city, state and zip code
ii. Name of property owner or designated representative
iii. Job title
iv. Voice phone
v. Fax
vi. Email address
(b) Inspection and testing organization/office locator
i. Address, including city, state and zip code
ii. Voice phone
iii. Fax
(c) Name of lead inspector performing inspection/testing
(d) Applicable licenses and certifications
(e) Start date of inspection/testing

(f) Completion date of inspection/testing
(g) Report issuance date

(2) Frequency of activity and summary of fire protection systems
(a) As defined in Section 3.6, the type of each water-based fire protection system being inspected, tested, or maintained should be recorded.
(b) For each system being inspected, tested, or maintained, the frequency of inspection, testing, and maintenance applicable for the inspection should be recorded consistent with Section 3.7.
(c) Where a premise being inspected, tested, or maintained has more than one type or multiples of one type of system, the number of each system inspected should also be recorded.

(3) Notifications for testing or maintenance
(a) If multiple notifications are required (e.g., to the fire department, authority having jurisdiction, and the alarm receiving facility), each notification should be recorded.
(b) The name of the property owner or designated representative who made the notification before testing or maintenance, the time notification was made, and to whom the notification was made should be recorded.
(c) The name of the property owner or designated representative who made the notification after testing or maintenance was completed, the time notification was made, and to whom the notification was made should be recorded.

(4) Impairments and deficiencies
(a) Forms and reports that are used for recording the activities and results of inspections, testing, and maintenance, should contain a section that specifically identifies any deficiencies and impairments that were observed. It is recommended that the section be clearly marked and formatted in a way that is easy for the property owner or the designated representative to identify each impairment and deficiency, and, if applicable, where the deficiencies and impairments are located. If required by the jurisdiction, impairments and deficiencies should be organized by classification, that is, critical, noncritical, or impairment.
(b) Where the authority having jurisdiction has mandated specific requirements regarding timelines for addressing deficiencies, it is helpful to include these in the reporting format. For many deficiencies, it is beneficial to attach a photograph or digital image of the deficiency, particularly where the property owner or the designated representative is not familiar with the water-based fire protection system.
(c) Where an impairment is found while performing inspection, testing, and maintenance, the property owner or designated representative should be notified in writing. *(See A.15.6.2.)*

(5) Signatures section
(a) Signature of property owner or designated representative
(b) Signature of lead inspector
i. It is recommended that signatures for the lead inspector and property owner, or their designated representatives, be placed at the end of the report. Placing signatures at the end of the report indicates that all activities in the preceding sections of the report have been performed and their completion has been verified by the property owner or designated representative.

NFPA



ANNEX C

POSSIBLE CAUSES OF PUMP TROUBLES

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

This annex is extracted from NFPA 20.

The information provided in Annex C is intended to assist the user in troubleshooting fire pump problems. Figure C.1 supplements the text of Annex C by identifying potential problems with fire pumps and determining the likely causes of those problems in an easy-to-read, concise matrix format. Figure C.1 illustrates that a given problem can be attributed to a variety of causes in various components and locations in piping associated with the fire pumps.

C.1 Causes of Pump Troubles.

This annex contains a partial guide for locating pump troubles and their possible causes *(see Figure C.1)*. It also contains a partial list of suggested remedies. *(For other information on this subject, see Hydraulic Institute Standards for Centrifugal, Rotary and Reciprocating Pumps.)* The causes listed here are in addition to possible mechanical breakage that would be obvious on visual inspection. In case of trouble, it is suggested that those troubles that can be inspected easily should be corrected first or eliminated as possibilities.

C.1.1 Air Drawn into Suction Connection Through Leak(s). Air drawn into suction line through leaks causes a pump to lose suction or fail to maintain its discharge pressure. Uncover suction pipe and locate and repair leak(s).

C.1.2 Suction Connection Obstructed. Examine suction intake, screen, and suction pipe and remove obstruction. Repair or provide screens to prevent recurrence.

Exhibit C.1 shows a playground ball that was drawn in through the suction piping and obstructed the intake into the pump.

C.1.3 Air Pocket in Suction Pipe. Air pockets cause a reduction in delivery and pressure similar to an obstructed pipe. Uncover suction pipe and rearrange to eliminate pocket.

C.1.4 Well Collapsed or Serious Misalignment. Consult a reliable well drilling company and the pump manufacturer regarding recommended repairs.

	Suction				Pump																Driver and/or Pump					Driver						
Fire pump troubles	Air drawn into suction connection through leak(s)	Suction connection obstructed	Air pocket in suction pipe	Well collapsed or serious misalignment	Stuffing box too tight or packing improperly installed, worn, defective, too tight, or incorrect type	Water seal or pipe to seal obstructed	Air leak into pump through stuffing boxes	Impeller obstructed	Wearing rings worn	Impeller damaged	Wrong diameter impeller	Actual net head lower than rated	Casing gasket defective, permitting internal leakage (single-stage and multistage pumps)	Pressure gauge is on top of pump casing	Incorrect impeller adjustment (vertical shaft turbine-type pump only)	Impellers locked	Pump is frozen	Pump shaft or shaft sleeve scored, bent, or worn	Pump not primed	Seal ring improperly located in stuffing box, preventing water from entering space to form seal	Excess bearing friction due to lack of lubrication, wear, dirt, rusting, failure, or improper installation	Rotating element binds against stationary element	Pump and driver misaligned	Foundation not rigid	Engine-cooling system obstructed	Faulty driver	Lack of lubrication	Speed too low	Wrong direction of rotation	Speed too high	Rated motor voltage different from line voltage	Faulty electrical circuit, obstructed fuel system obstructed steam pipe, or dead battery
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Excessive leakage at stuffing box					X													X					X								
Pump or driver overheats				X	X	X		X			X				X			X	X	X	X	X	X	X		X		X	X	X	
Pump unit will not start				X	X										X	X	X				X					X	X					X
No water discharge	X	X	X					X											X												
Pump is noisy or vibrates				X	X			X		X								X			X	X	X	X			X				
Too much power required				X	X			X	X		X		X		X			X			X	X	X	X			X		X	X	X	
Discharge pressure not constant for same gpm	X				X	X	X																								
Pump loses suction after starting	X	X	X			X	X													X												
Insufficient water discharge	X	X	X			X	X	X	X	X	X	X	X		X													X	X		X	
Discharge pressure too low for gpm discharge	X	X	X		X	X	X	X	X	X	X	X	X	X														X	X		X	

FIGURE C.1 *Possible Causes of Fire Pump Troubles.*

C.1.5 Stuffing Box Too Tight or Packing Improperly Installed, Worn, Defective, Too Tight, or of Incorrect Type. Loosen gland swing bolts and remove stuffing box gland halves. Replace packing.

C.1.6 Water Seal or Pipe to Seal Obstructed. Loosen gland swing bolt and remove stuffing box gland halves along with the water seal ring and packing. Clean the water passage to and in the water seal ring. Replace water seal ring, packing gland, and packing in accordance with manufacturer's instructions.

C.1.7 Air Leak into Pump Through Stuffing Boxes. Same as possible cause in C.1.6.

C.1.8 Impeller Obstructed. Does not show on any one instrument, but pressures fall off rapidly when an attempt is made to draw a large amount of water.



EXHIBIT C.1 *Obstructed In take. (Courtesy of Damon Pietraz-Underwood Fire Equipment)*

For horizontal split-case pumps, remove upper case of pump and remove obstruction from impeller. Repair or provide screens on suction intake to prevent recurrence.

For vertical shaft turbine-type pumps, lift out column pipe and pump bowls from wet pit or well and disassemble pump bowl to remove obstruction from impeller.

For close-coupled, vertical in-line pumps, lift motor on top pull-out design and remove obstruction from impeller.

Exhibit C.2 and Exhibit C.3 show obstructions to suction through the impeller.

C.1.9 Wearing Rings Worn. Remove upper case and insert feeler gauge between case wearing ring and impeller wearing ring. Clearance when new is 0.0075 in. (0.19 mm). Clearances of more than 0.015 in. (0.38 mm) are excessive.

C.1.10 Impeller Damaged. Make minor repairs or return to manufacturer for replacement. If defect is not too serious, order new impeller and use damaged one until replacement arrives.

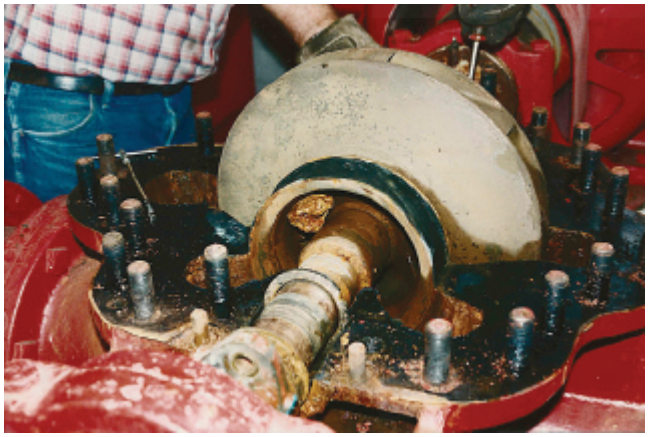


EXHIBIT C.2 *Horizontal Split Case Fire Pump with Large Rocks Obstructing Suction Through the Impeller. (Courtesy of Damon Pietraz-Underwood Fire Equipment)*



EXHIBIT C.3 *Pieces of a Failed Backflow Preventer Obstructing Suction Through the Impeller. (Courtesy of Damon Pietraz-Underwood Fire Equipment)*

C.1.11 Wrong Diameter Impeller. Replace with impeller of proper diameter.

C.1.12 Actual Net Head Lower than Rated. Check impeller diameter and number and pump model number to make sure correct head curve is being used.

C.1.13 Casing Gasket Defective, Permitting Internal Leakage (Single-Stage and Multistage Pumps). Replace defective gasket. Check manufacturer's drawing to see whether gasket is required.

C.1.14 Pressure Gauge Is on Top of Pump Casing. Place gauges in correct location.

C.1.15 Incorrect Impeller Adjustment (Vertical Shaft Turbine-Type Pump Only). Adjust impellers according to manufacturer's instructions.

C.1.16 Impellers Locked. For vertical shaft turbine-type pumps, raise and lower impellers by the top shaft adjusting nut. If this adjustment is not successful, follow the manufacturer's instructions.

For horizontal split-case pumps, remove upper case and locate and eliminate obstruction.

C.1.17 Pump Is Frozen. Provide heat in the pump room. Disassemble pump and remove ice as necessary. Examine parts carefully for damage.

C.1.18 Pump Shaft or Shaft Sleeve Scored, Bent, or Worn. Replace shaft or shaft sleeve.

C.1.19 Pump Not Primed. If a pump is operated without water in its casing, the wearing rings are likely to seize. The first warning is a change in pitch of the sound of the driver. Shut down the pump.

For vertical shaft turbine-type pumps, check water level to determine whether pump bowls have proper submergence.

C.1.20 Seal Ring Improperly Located in Stuffing Box, Preventing Water from Entering Space to Form Seal. Loosen gland swing bolt and remove stuffing box gland halves along with the water-seal ring and packing. Replace, putting seal ring in proper location.

C.1.21 Excess Bearing Friction Due to Lack of Lubrication, Wear, Dirt, Rusting, Failure, or Improper Installation. Remove bearings and clean, lubricate, or replace as necessary.

C.1.22 Rotating Element Binds Against Stationary Element. Inspect clearances and lubrication and replace or repair the defective part.

C.1.23 Pump and Driver Misaligned. Shaft running off center because of worn bearings or misalignment. Align pump and driver according to manufacturer's instructions. Replace bearings according to manufacturer's instructions.

C.1.24 Foundation Not Rigid. Tighten foundation bolts or replace foundation if necessary.

In 6.4.1 of NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, the pumps and driver are required to be mounted on a common grouted base plate. The use of rubber footings or mats, as shown in Exhibit C.4 and Exhibit C.5, does not comply with NFPA 20 and can lead to differential movement between pump components, which can lead to failure.



EXHIBIT C.4 *Flexible Mat Installed Under Base Plate — Not in Compliance with NFPA 20. (Courtesy of Indonesian Fire & Rescue Foundation)*



EXHIBIT C.5 *Rubber Mounting Underneath the Base Plate — Not in Compliance with NFPA 20. (Courtesy of Indonesian Fire & Rescue Foundation)*

C.1.25 Engine-Cooling System Obstructed. Heat exchanger or cooling water systems too small. Cooling pump faulty. Remove thermostats. Open bypass around regulator valve and strainer. Inspect regulator valve operation. Inspect strainer. Clean and repair if necessary. Disconnect sections of cooling system to locate and remove possible obstruction. Adjust engine-cooling water-circulating pump belt to obtain proper speed without binding. Lubricate bearings of this pump.

If overheating still occurs at loads up to 150 percent of rated capacity, contact pump or engine manufacturer so that necessary steps can be taken to eliminate overheating.

C.1.26 Faulty Driver. Inspect electric motor, internal combustion engine, or steam turbine, in accordance with manufacturer's instructions, to locate reason for failure to start.

Exhibit C.6 shows a diesel engine that has seized up.



EXHIBIT C.6 *A Seized Diesel Engine that Was Found to Have Antifreeze in the Oil. (Courtesy of Damon Pietraz-Underwood Fire Equipment)*

C.1.27 Lack of Lubrication. If parts have seized, replace damaged parts and provide proper lubrication. If not, stop pump and provide proper lubrication.

C.1.28 Speed Too Low. For electric motor drive, confirm that rated motor speed corresponds to rated speed of pump, voltage is correct, and starting equipment is operating properly.

Low frequency and low voltage in the electric power supply prevent a motor from running at rated speed. Low voltage can be due to excessive loads and inadequate feeder capacity or (with private generating plants) low generator voltage. The generator voltage of private generating plants can be corrected by changing the field excitation. When low voltage is from the other causes mentioned, it can be necessary to replace transformer taps or increase feeder capacity.

Low frequency usually occurs with a private generating plant and should be corrected at the source. Low speed can result in older type squirrel-cage-type motors if fastenings of copper bars to end rings become loose. The remedy is to weld or braze these joints.

For steam turbine drive, confirm that valves in steam supply pipe are wide open; boiler steam pressure is adequate; steam pressure is adequate at the turbine; strainer in the steam supply pipe is not plugged; steam supply pipe is of adequate size; condensate is removed from steam supply pipe, trap, and turbine; turbine nozzles are not plugged; and setting of speed and emergency governor is correct.

For internal combustion engine drive, confirm that setting of speed governor is correct; hand throttle is opened wide; and there are no mechanical defects such as sticking valves, timing off, or spark plugs fouled, and so forth. The latter can require the services of a trained mechanic.

C.1.29 Wrong Direction of Rotation. Instances of an impeller turning backward are rare but are clearly recognizable by the extreme deficiency of pump delivery. Wrong direction of rotation can be determined by comparing the direction in which the flexible coupling is turning with the directional arrow on the pump casing.

With polyphase electric motor drive, two wires must be reversed; with dc driver, the armature connections must be reversed with respect to the field connections. Where two sources of electrical current are available, the direction of rotation produced by each should be inspected.

C.1.30 Speed Too High. See that pump- and driver-rated speed correspond. Replace electric motor with one of correct rated speed. Set governors of variable-speed drivers for correct speed. Frequency at private generating stations can be too high.

C.1.31 Rated Motor Voltage Different from Line Voltage. For example, a 220 or 440 V motor on 208 or 416 V line. Obtain motor of correct rated voltage or a larger size motor.

C.1.32 Faulty Electric Circuit, Obstructed Fuel System, Obstructed Steam Pipe, or Dead Battery. Inspect for break in wiring open switch, open circuit breaker, or dead battery. If circuit breaker in controller trips for no apparent reason, make sure oil is in dash pots in accordance with manufacturer's specifications. Make sure fuel pipe is clear, strainers are clean, and control valves open in fuel system to internal combustion engine. Make sure all valves are open and strainer is clean in steam line to turbine.

C.2 Warning.

Chapters 6 and 7 of NFPA 20 include electrical requirements that discourage the installation of disconnect means in the power supply to electric motor–driven fire pumps. This requirement is intended to ensure the availability of power to the fire pumps. When equipment connected to those circuits is serviced or maintained, the employee can have unusual exposure

to electrical and other hazards. It can be necessary to require special safe work practices and special safeguards, personal protective clothing, or both.

C.3 Maintenance of Fire Pump Controllers After Fault Condition.

C.3.1 Introduction. In a fire pump motor circuit that has been properly installed, coordinated, and in service prior to the fault, tripping of the circuit breaker or the isolating switch indicates a fault condition in excess of operating overload.

It is recommended that the following general procedures be observed by qualified personnel in the inspection and repair of the controller involved in the fault. These procedures are not intended to cover other elements of the circuit, such as wiring and motor, which can also require attention.

C.3.2 Caution. All inspections and tests are to be made on controllers that are de-energized at the line terminal, disconnected, locked out, and tagged so that accidental contact cannot be made with live parts and so that all plant safety procedures will be observed.

C.3.2.1 Enclosure. Where substantial damage to the enclosure, such as deformation, displacement of parts, or burning has occurred, replace the entire controller.

C.3.2.2 Circuit Breaker and Isolating Switch. Examine the enclosure interior, circuit breaker, and isolating switch for evidence of possible damage. If evidence of damage is not apparent, the circuit breaker and isolating switch can continue to be used after the door is closed.

If there is any indication that the circuit breaker has opened several short-circuit faults, or if signs of possible deterioration appear within either the enclosure, circuit breaker, or isolating switch (e.g., deposits on surface, surface discoloration, insulation cracking, or unusual toggle operation), replace the components. Verify that the external operating handle is capable of opening and closing the circuit breaker and isolating switch. If the handle fails to operate the device, this would also indicate the need for adjustment or replacement.

C.3.2.3 Terminals and Internal Conductors. Where there are indications of arcing damage, overheating, or both, such as discoloration and melting of insulation, replace the damaged parts.

C.3.2.4 Contactor. Replace contacts showing heat damage, displacement of metal, or loss of adequate wear allowance of the contacts. Replace the contact springs where applicable. If deterioration extends beyond the contacts, such as binding in the guides or evidence of insulation damage, replace the damaged parts or the entire contactor.

C.3.2.5 Return to Service. Before returning the controller to service, inspect for the tightness of electrical connections and for the absence of short circuits, ground faults, and leakage current.

Close and secure the enclosure before the controller circuit breaker and isolating switch are energized. Follow operating procedures on the controller to bring it into standby condition.

Reference Cited in Commentary

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, 2019 edition.

NFPA

ANNEX D

OBSTRUCTION INVESTIGATION

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

Annex D outlines sources of obstruction, treatment strategies, and flushing procedures for piping and discharge outlets in fire protection systems. While Chapter 14 of NFPA 25 provides the enforceable requirements for conducting an obstruction investigation, this annex provides a recommended systematic approach to correcting obstruction problems.

In addition to the methods discussed in Annex D, new technologies employing ultrasonic examination and remote video are now available for interior piping investigations. Methods other than those mentioned here for cleaning obstructed pipe (e.g., flushing with chemical solutions) are also available.

D.1 General.

For effective control and extinguishment of fire, automatic sprinklers should receive an unobstructed flow of water. Although the overall performance record of automatic sprinklers has been very satisfactory, there have been numerous instances of impaired efficiency because sprinkler piping or sprinklers were plugged with pipe scale, corrosion products, including those produced by microbiologically influenced corrosion, mud, stones, or other foreign material. If the first sprinklers to open in a fire are plugged, the fire in that area cannot be extinguished or controlled by prewetting of adjacent combustibles. In such a situation, the fire can grow to an uncontrollable size, resulting in greater fire damage and excessive sprinkler operation and even threatening the structural integrity of the building, depending on the number of plugged sprinklers and fire severity.

Keeping the inside of sprinkler system piping free of scale, silt, or other obstructing material is an integral part of an effective loss prevention program.

D.1.1 While this chapter provides minimum requirements for the investigation and prevention of obstructions, authorities having jurisdiction must also consider regional, local, and project-specific propensities and histories to determine reasonable testing and obstruction mitigation measures.

D.2 Obstruction Sources.

D.2.1 Pipe Scale. Loss studies have shown that dry pipe sprinkler systems are involved in the majority of obstructed sprinkler fire losses. Pipe scale was found to be the most frequent

obstructing material (it is likely that some of the scale was composed of corrosion products, including those produced by microbiologically influenced corrosion). Dry pipe systems that have been maintained wet and then dry alternately over a period of years are particularly susceptible to the accumulation of scale. Also, in systems that are continuously dry, condensation of moisture in the air supply can result in the formation of a hard scale, microbiological materials, and corrosion products along the bottom of the piping. When sprinklers open, the scale is broken loose and carried along the pipe, plugging some of the sprinklers or forming obstructions at the fittings.

The development of scaling within dry pipe systems highlights the need to properly drain a system after water is introduced into the piping network. Although NFPA 25 does not require a check of the pitch on dry system piping, insufficiently pitched piping can lead to internal corrosion and scaling that can create obstructions. In instances where obstructions due to scaling have been identified, the owner should consider having an assessment of pipe pitch conducted. This assessment would occur outside of the scope of NFPA 25 and as such would not be part of a contract of services for inspectors complying with this standard. Exhibit D.1 shows internal corrosion in a dry system due to water not properly draining from the pipe after it was charged.

D.2.2 Careless Installation or Repair. Many obstructions are caused by careless workers during installation or repair of yard or public mains and sprinkler systems. Wood, paint brushes, buckets, gravel, sand, and gloves have been found as obstructions. In some instances, with welded sprinkler systems and systems with holes for quick-connect fittings, the cutout discs or coupons have been left within the piping, obstructing flow to sprinklers.

Paragraph 7.5.2.4.8(2) of NFPA 13, *Standard for the Installation of Sprinkler Systems*, requires that discs removed prior to attachment of a welded outlet be retrieved. This procedure can



EXHIBIT D.1 *Corrosion Due to Improperly Pitched Pipe. (Courtesy of M. Steven Welsh, Koffel Associates, Inc.)*

be verified by attaching the disc to the system at the point from which it was removed. Exhibit D.2 shows discs attached to the system from which they were cut. Exhibit D.3 shows weld coupons that were not properly retrieved and presented an obstruction to the system piping. Exhibit D.4 shows work gloves and other obstructive material removed from an underground pipe in a system water supply.

D.2.3 Raw Water Sources. Materials can be sucked up from the bottoms of rivers, ponds, or open reservoirs by fire pumps with poorly arranged or inadequately screened intakes and then forced into the system. Sometimes floods damage intakes. Obstructions include fine, compacted materials such as rust, mud, and sand. Coarse materials, such as stones, cinders, cast-iron tubercles, chips of wood, and sticks, also are common.

In addition to the solid, inorganic objects mentioned in D.2.3, bodies of raw water are commonly the place where organic materials, such as the ones mentioned in D.2.4, are introduced into a system.

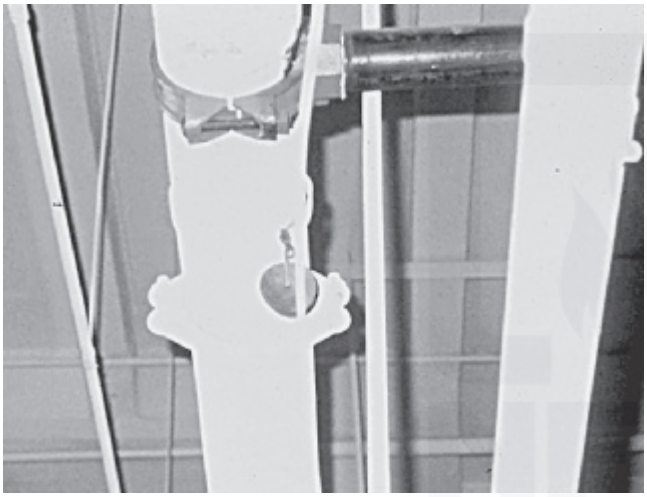


EXHIBIT D.2 *Discs Attached to Piping from Which They Were Cut. (Source: Automatic Sprinkler Systems Handbook, 2010, Exhibit 6.24)*



EXHIBIT D.3 *Weld Coupons Found in Early Suppression Fast-Response (ESFR) Sprinkler Main During Obstruction Investigation.*



EXHIBIT D.4 *Work Gloves and Other Obstructive Material. (Courtesy of John Jensen)*

D.2.4 Biological Growth. Biological growth has been known to cause obstructions in sprinkler piping. The Asiatic clam has been found in fire protection systems supplied by raw river or lake water. With an available food supply and sunlight, these clams grow to approximately ⅜ in. to 7⁄16 in. (9 mm to 11 mm) across the shell in 1 year and up to 2⅛ in. (54 mm) and larger by the sixth year. However, once in fire mains and sprinkler piping, the growth rate is much slower. The clams get into the fire protection systems in the larval stage or while still small clams. They then attach themselves to the pipe and feed on bacteria or algae that pass through.

Originally brought to Washington state from Asia in the 1930s, the clams have spread throughout at least 33 states and possibly are present in every state. River areas reported to be highly infested include the Ohio River, Tennessee River Valley, Savannah River (South Carolina), Altamaha River (Georgia), Columbia River (Washington), and Delta-Mendota Canal (California).

In addition to the Asian clam, the zebra mussel can create obstructions to fire protection piping systems. Since their introduction to the Great Lakes in the mid-1980s, zebra mussels have spread throughout the Great Lakes into many inland waterways, including the Mississippi Delta to the south and the Hudson River to the northeast. Like the Asian clam, the zebra mussels can enter the fire protection system in the larval stage or as young adults.

The mussel attaches to the inner surface of a pipe and feeds on algae or bacteria. Exhibit D.5 shows a 2 in. (50 mm) diameter pipe infested with zebra mussels. Exhibit D.6 shows the relative size of a zebra mussel. Exhibit D.7 indicates the extent of zebra mussel infestation in the United States and Canada.

The presence of zebra mussels can be revealed by reduced flow or discharge of the mussels or shells from the inspector's test or main drain test connections. If reduced flow or the discharge of obstructive material is observed, a complete obstruction investigation is required per Section 14.3.

A strainer listed for use in a fire protection system can help to combat the problem of clams and mussels obstructing piping. However, in the larval stage, these creatures can certainly pass through the ⅛ in. (3.2 mm) perforations typically found in such devices. If clams or mussels are known to be present, the strainer must be cleaned more often than once a year.

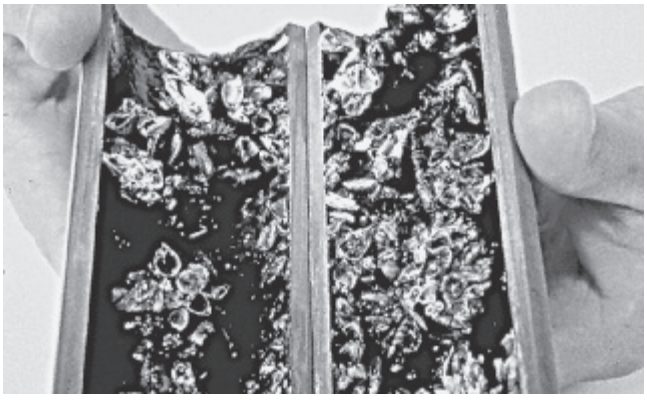


EXHIBIT D.5 *Pipe Infested with Zebra Mussels. (Source: Michigan Sea Grant)*



EXHIBIT D.6 *Relative Size of Adult Zebra Mussel. (Source: Michigan Sea Grant)*

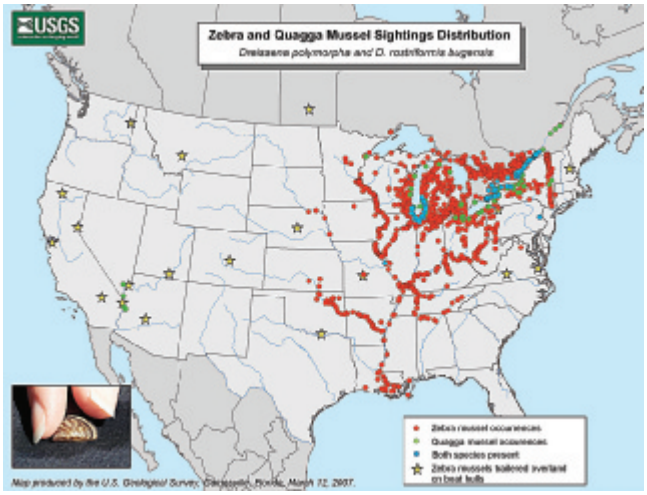


EXHIBIT D.7 *Extent of Zebra Mussel Infestation. (Courtesy of the U.S. Geological Survey)*

The use of potassium and heat has led to high mortality rates in zebra mussel populations. However, the use of more common chemicals, such as chlorine, should be considered for treatment of system water supplies. To prevent repopulation of systems with mussels or clams, flushing and testing in excess of the minimum requirements of the standard should be avoided.

D.2.5 Sprinkler Calcium Carbonate Deposits. Natural freshwaters contain dissolved calcium and magnesium salts in varying concentrations, depending on the sources and location of the water. If the concentration of these salts is high, the water is considered hard. A thin film composed largely of calcium carbonate, $CaCO_3$, affords some protection against corrosion where hard water flows through the pipes. However, hardness is not the only factor to determine whether a film forms. The ability of $CaCO_3$ to precipitate on the metal pipe surface also depends on the water's total acidity or alkalinity, the concentration of dissolved solids in the water, and its pH. In soft water, no such film can form.

In automatic sprinkler systems, the calcium carbonate scale formation tends to occur on the more noble metal in the electrochemical series, which is copper, just as corrosion affects the less noble metal, iron. Consequently, scale formation naturally forms on sprinklers, often plugging the orifice. The piping itself could be relatively clear. This type of sprinkler obstruction cannot be detected or corrected by normal flushing procedures. It can be found only by inspection of sprinklers in suspected areas and then removed.

Most public water utilities in very hard water areas soften their water to reduce consumer complaints of scale buildup in water heaters. Thus, the most likely locations for deposits in sprinkler systems are where sprinklers are not connected to public water but supplied without treatment directly from wells or surface water in areas that have very hard water. These areas generally include the Mississippi basin west of the Mississippi River and north of the Ohio River, the rivers of Texas and the Colorado basin, and other white areas in Figure D.2.5(a). (The water of the Great Lakes is only moderately hard.)

Within individual plants, the sprinklers most likely to have deposits are located as follows:

(1) In wet systems only.
(2) In high temperature areas, except where water has unusually high pH *[see Figure D.2.5(b)]*. High temperature areas include those near dryers, ovens, and skylights or at roof peaks.
(3) In old sprinkler systems that are frequently drained and refilled.
(4) In pendent sprinklers that are located away from air pockets and near convection currents.

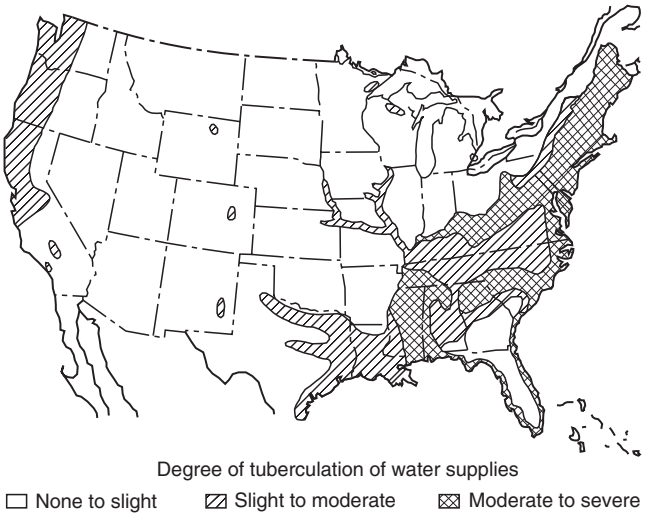


FIGURE D.2.5(a) *Map of Hard Water Areas. (Provided by Cast Iron Pipe Research Association. Used with permission.)*

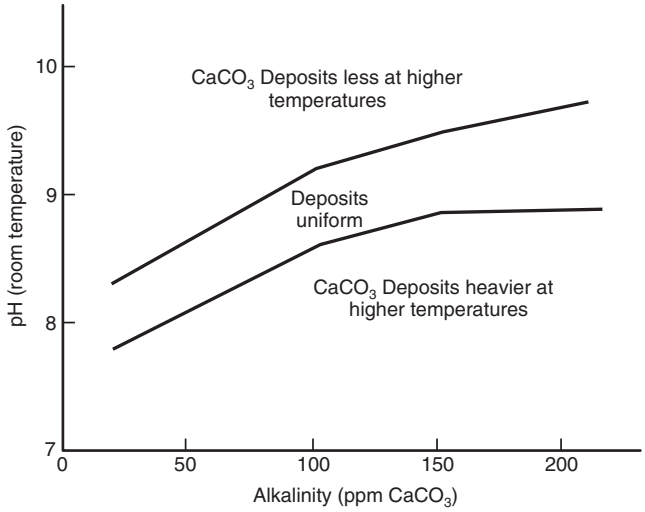
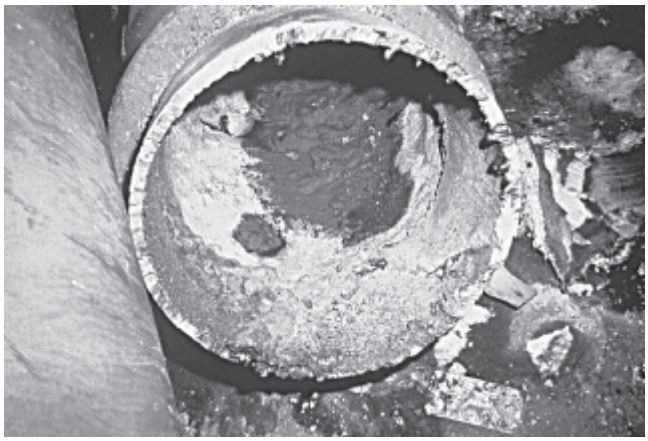


FIGURE D.2.5(b) *Scale Deposition as Function of Alkalinity/pH Ratio.*

Section D.2 describes where the requirements to perform a main drain test (see Chapter 13), flow test (see Chapter 7), and records retention (see Chapter 4) come into play. This annex section describes working examples of the requirements from the standard, including the requirement for a main drain test.

Although the main drain test is primarily intended to reveal the presence of a closed or partially closed valve, a comparison of results from one year to the next, or to the results obtained from the acceptance test, can be valuable. A periodic flow test can also be used for comparison purposes. A gradual decrease in available residual pressures from either test might indicate a buildup of tuberculation from calcium carbonate ($CaCO_3$) deposits. Although a slight deterioration can be expected over time, deterioration to the point where the water supply can no longer adequately supply the fire protection system must result in corrective action. Exhibit D.8 illustrates a pipe severely affected by $CaCO_3$ deposits. The effective diameter of this pipe has been substantially reduced to the point where the pipe was removed from service.

EXHIBIT D.8 *Pipe Affected by $CaCO_3$ Deposits.*



D.2.6 Forms of Corrosion. Corrosion is defined as the deterioration of a material, usually a metal, resulting from a chemical or electrochemical reaction. The eight main forms of corrosion include (1) uniform corrosion, (2) pitting, (3) galvanic corrosion, (4) crevice corrosion, (5) selective leaching (parting), (6) erosion corrosion, (7) environmental cracking, and (8) intergranular corrosion. Microbiologically influenced corrosion (MIC) is included herein as a ninth form of corrosion, although it is usually a secondary factor that accelerates or exacerbates the rate of another form of corrosion. Definitions of the different forms of corrosion are discussed next.

(1) *Uniform (or general) corrosion:* A regular loss of a small quantity of metal over the entire area or over a large section of the total area, which is evenly distributed within a pipe(s).
(2) *Pitting:* A localized form of corrosion that results in holes or cavities in the metal. Pitting is considered to be one of the more destructive forms of corrosion and is often difficult to detect. Pits can be covered or open and normally grow in the direction of gravity — for example, at the bottom of a horizontal surface.

Exhibit D.9 shows the interior of a pipe that has been affected by pitting. Pitting often can go undetected due to the relatively small size of the cavities and the potential for corrosion to obstruct the view of the cavities. Unlike pinhole leaks, which might require non-emergency maintenance or replacement, pitting often leads to catastrophic pipe failure, since the cavities can form in a line and create a perforation in the pipe. This linear perforation can cause the pipe to rupture and could require emergency pipe replacement that could render a system ineffective or impaired.



EXHIBIT D.9 *Effects of Pitting on Pipe. (Courtesy of Wiginton Fire Systems)*

(3) *Galvanic corrosion:* An electric potential exists between dissimilar metals in a conductive (corrosive) solution. The contact between the two materials allows electrons to transfer from one metal to the other. One metal acts as a cathode and the other as an anode. Corrosion usually occurs at anodic metal only.
(4) *Crevice corrosion:* A localized form of corrosion that occurs within crevices and other shielded areas on metal surfaces exposed to a stagnant corrosive solution. This form of corrosion usually occurs beneath gaskets, in holes, surface deposits, in thread and groove joints. Crevice corrosion is also referred to as gasket corrosion, deposit corrosion, and under-deposit corrosion.
(5) *Selective leaching:* The selective removal of one element from an alloy by corrosion. A common example is dezincification (selective removal of zinc) of unstabilized brass, resulting in a porous copper structure.

(6) *Erosion corrosion:* Corrosion resulting from the cumulative damage of electrochemical reactions and mechanical effects. Erosion corrosion is the acceleration or increase in the rate of corrosion created by the relative movement of a corrosive fluid and a metal surface. Erosion corrosion is observed as grooves, gullies, waves, rounded holes, or valleys in a metal surface.

(7) *Environmental cracking:* An acute form of localized corrosion caused by mechanical stresses, embrittlement, or fatigue.

(8) *Integranular corrosion:* Corrosion caused by impurities at grain boundaries, enrichment of one alloying element, or depletion of one of the elements in the grain boundary areas.

(9) *Microbiologically influenced corrosion (MIC):* Corrosion initiated or accelerated by the presence and activities of microorganisms, including bacteria and fungi. Colonies (also called bio-films and slimes) are formed in the surface of pipes among a variety of types of microbes. Microbes deposit iron, manganese, and various salts into the pipe surfaces, forming nodules, tubercles, and carbuncles. The formation of these deposits can cause obstruction to flow and dislodge, causing blockage (plugging) of system piping, valves, and sprinklers.

Microbiologically influenced corrosion (MIC) is not limited to water-based fire protection systems but can be found in many types of piping systems. MIC is thought to be responsible for 10 to 30 percent of corrosion in all piping systems in the United States.

Generally, two types of bacteria are responsible for MIC: sulfate-reducing bacteria (SRB) and acid-producing bacteria (APB). SRB are anaerobic (not requiring oxygen) and are typically found in carbon steel systems. APB are also anaerobic but can survive in aerated environments as well as in anaerobic environments. APB produce acids that stimulate the growth of SRB.

MIC can survive in a variety of environments from 0 to 100 percent oxygen-saturated water and in water with a pH from 1 to 10. MIC can be recognized by the presence of a gray or black mud-like slime (typical of anaerobic bacteria) or a brown or rusty color (typical of aerobic bacteria).



EXHIBIT D.10 *Pipe Sample Showing Effect of Nodule Formation. (Courtesy of Bioindustrial Technologies, Inc.)*

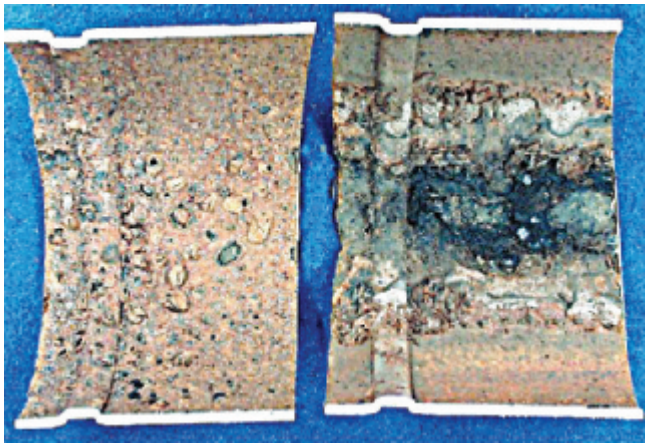


EXHIBIT D.11 *Pipe Sample Showing Effect of Severe Nodule Formation and Corrosion. (Courtesy of Bioindustrial Technologies, Inc.)*

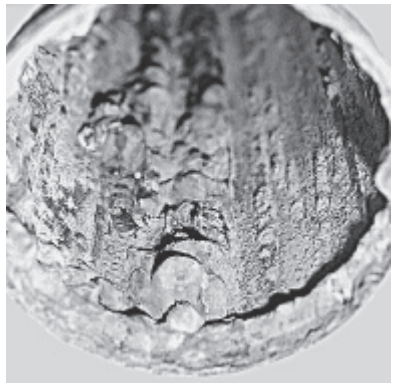


EXHIBIT D.12 *Close-Up View of Nodules. (Courtesy of Bioindustrial Technologies, Inc.)*

Once established, MIC creates nodules on the inner surface of pipe. If left untreated, this can result in pitting of the pipe wall and eventual pinhole leaks (although pinhole leaks can be caused by other factors). Nodules can also increase in size, causing obstruction of water flow. Exhibit D.10 through Exhibit D.12 illustrate pipe with nodules caused by MIC.

If the presence of MIC is suspected, water samples should be taken and analyzed before treatment is initiated. In cases of extreme pitting, the affected pipe should be replaced. In addition, the water supplying the system should be treated with a biocide, such as chlorine, to prevent recurrence of the MIC.

Exhibit D.13 and Exhibit D.14 illustrate pipe with moderate to severe pitting, and Exhibit D.15 illustrates copper pipe with pitting. Where pitting is not extensive, flushing the entire system with a chemical cleaning agent to remove nodules is recommended. After flushing, the system should be refilled with treated water to prevent recurrence of MIC.

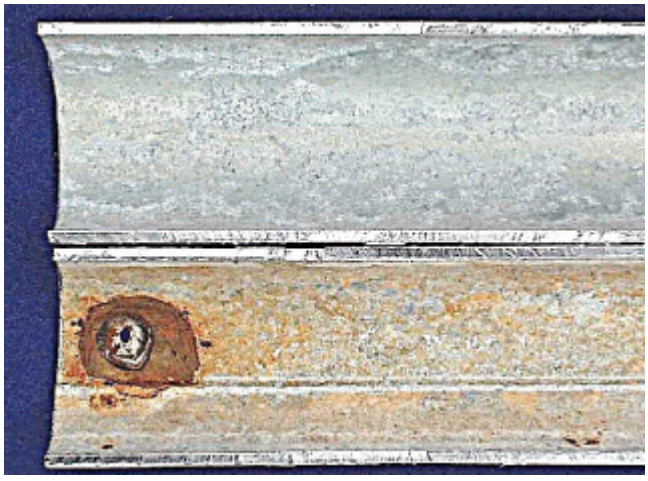


EXHIBIT D.13 *Pipe Sample with Pinhole Leak. (Courtesy of Bioindustrial Technologies, Inc.)*



EXHIBIT D.14 *Pipe Sample with Severe Pitting. (Courtesy of Bioindustrial Technologies, Inc.)*

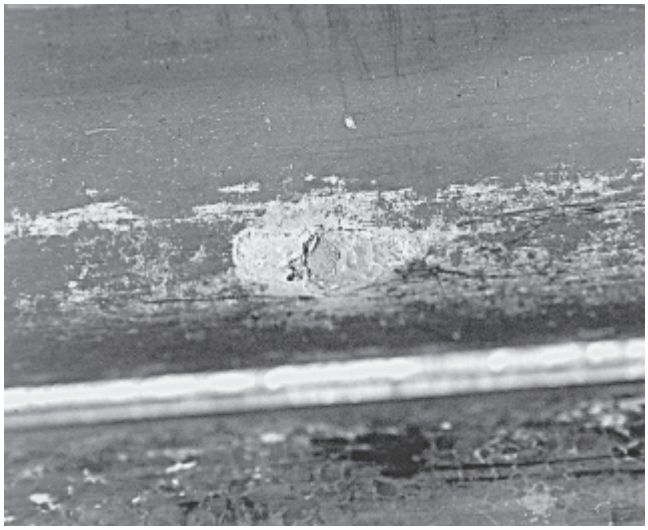


EXHIBIT D.15 *Copper Pipe with Localized Pitting. (Courtesy of Bioindustrial Technologies, Inc.)*

Δ **D.2.7 Microbiologically Influenced Corrosion (MIC).** The most common biological growths in sprinkler system piping are those formed by microorganisms, including bacteria and fungi. These microbes produce colonies (also called bio-films, slimes) containing a variety of types of microbes. Colonies form on the surface of wetted pipe in both wet and dry systems. Microbes also deposit iron, manganese, and various salts onto the pipe surface, forming discrete deposits (also termed nodules, tubercles, and carbuncles). These deposits can cause obstruction to flow and dislodge, causing plugging of fire sprinkler components. Subsequent under-deposit pitting can also result in pinhole leaks.

Microbiologically influenced corrosion (MIC) is corrosion influenced by the presence and activities of microorganisms. MIC is almost always a secondary form of corrosion driven by oxygen corrosion activity. MIC starts as microbial communities (also called bio-films, slimes) growing on the interior surface of the wetted sprinkler piping components in both wet and dry systems. The microbial communities contain many types of microbes, including slime formers, acid-producing bacteria, iron-depositing bacteria, and sulfate-reducing bacteria. The microbes deposit iron, manganese, and various salts onto the pipe surface, forming discrete deposits (also termed nodules, tubercles, and carbuncles). These deposits can cause obstruction to flow and dislodge, causing plugging of fire sprinkler components.

MIC of copper and copper alloys occurs as discrete deposits of smaller size, which are green to blue in color. Blue slimes can also be produced in copper piping or copper components (e.g., brass heads).

MIC is often first noticed as a result of pinhole leaks after only months to a few years of service. Confirmation of MIC can be made by examination of interior of pipes for deposits and under-deposit corrosion with pit morphology consistent with MIC (cup-like pits within pits and striations).

The occurrence and severity of MIC is enhanced by the following:

(1) Using untreated water to test and fill sprinkler piping. This is made worse by leaving the water in the system for long periods of time.
(2) Introduction of new and untreated water containing oxygen, microbes, salts, and nutrients into the system on a frequent basis (during repair, renovation, and/or frequent flow tests).
(3) Leaving dirt, debris, and especially oils, pipe joint compound, and so forth in the piping. These provide nutrients and protection for the microbes, often preventing biocides and corrosion inhibitors from reaching the microbes and corrosion sites.

Once the presence of MIC has been confirmed, the system should be assessed to determine the extent and severity of MIC. Severely affected portions should be replaced or cleaned to remove obstructions and pipe not meeting minimal mechanical specifications.

D.3 Investigation Procedures.

If unsatisfactory conditions are observed as outlined in Section 14.3, investigations should be made to determine the extent and severity of the obstructing material. From the fire protection system plan, determine the water supply sources, age of underground mains and sprinkler systems, types of systems, and general piping arrangement. Consider the possible sources of obstruction material.

Examine the fire pump suction supply and screening arrangements. If necessary, have the suction cleaned before using the pump in tests and flushing operations. Gravity tanks should be inspected internally, with the exception of steel tanks that have been recently cleaned and painted. If possible, have the tank drained and determine whether loose scale is on the shell or if sludge or other obstructions are on the tank bottom. Cleaning and repainting could be in order, particularly if it has not been done within the previous 5 years.

Investigate yard mains first, then sprinkler systems.

Where fire protection control valves are closed during investigation procedures, the fire protection impairment precautions outlined in Chapter 15 should be followed.

Large quantities of water are needed for investigation and for flushing. It is important to plan the safest means of disposal in advance. Cover stock and machinery susceptible to water damage, and keep equipment on hand for mopping up any accidental discharge of water.

Subsections D.3.1 through D.3.5 provide direction on how to conduct various investigation procedures. These procedures should be used as guidelines on how to conduct an investigation, but they might not consider all types of system arrangements. Additional system assessment might be required in addition to what is provided below to properly investigate certain systems or certain portions of systems.

D.3.1 Investigating Yard Mains. Flow water through yard hydrants, preferably near the extremes of selected mains, to determine whether mains contain obstructive material. It is preferable to connect two lengths of 2½ in. (65 mm) hose to the hydrant. Attach burlap bags to the free ends of the hose from which the nozzles have been removed to collect any material flushed out, and flow water long enough to determine the condition of the main being investigated. If there are several water supply sources, investigate each independently, avoiding any unnecessary interruptions to sprinkler protection. In extensive yard layouts, repeat the tests at several locations, if necessary, to determine general conditions.

If obstructive material is found, all mains should be flushed thoroughly before investigating the sprinkler systems. *(See Section D.5.)*

D.3.2 Investigating Sprinkler Systems. Investigate dry systems first. Tests on several carefully selected, representative systems usually are sufficient to indicate general conditions throughout the plant. If, however, preliminary investigations indicate the presence of obstructing material, this justifies investigating all systems (both wet and dry) before outlining needed flushing operations. Generally, the system can be considered reasonably free of obstructing material, provided the following conditions apply:

(1) Less than ½ cup of scale is washed from the cross mains.
(2) Scale fragments are not large enough to plug a sprinkler orifice.
(3) A full, unobstructed flow is obtained from each branch line inspected.

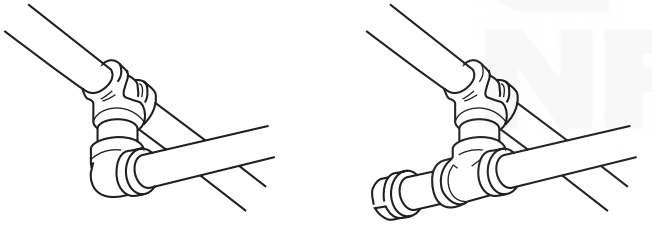
Where other types of foreign material are found, judgment should be used before considering the system unobstructed. Obstruction potential is based on the physical characteristics and source of the foreign material.

In selecting specific systems or branch lines for investigation, the following should be considered:

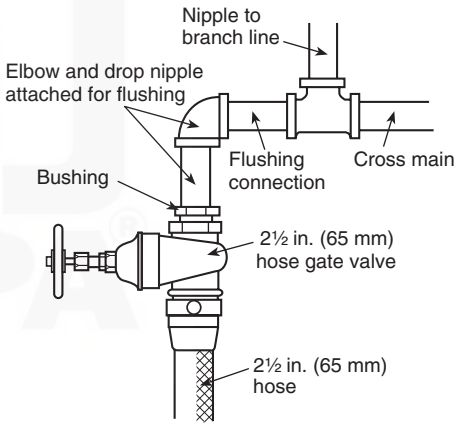
(1) Lines found obstructed during a fire or during maintenance work
(2) Systems adjacent to points of recent repair to yard mains, particularly if hydrant flow shows material in the main

Tests should include flows through 2½ in. (65 mm) fire hose directly from cross mains *[see Figure D.3.2(a) and Figure D.3.2(b)]* and flows through 1½ in. (40 mm) hose from representative branch lines. Two or three branch lines per system is a representative number of branch lines where investigating for scale accumulation. If significant scale is found, investigation of additional branch lines is warranted. Where investigating for foreign material (other than scale), the number of branch lines needed for representative sampling is dependent on the source and characteristic of the foreign material.

If provided, fire pumps should be operated for the large line flows, since maximum flow is desirable. Burlap bags should be used to collect dislodged material as is done in the investigation of yard mains. Each flow should be continued until the water clears (i.e., a minimum of 2 to 3 minutes at full flow for sprinkler mains). This is likely to be sufficient to indicate the condition of the piping interior.



Δ ***FIGURE D.3.2(a)*** *Replacement of Elbow at End of Cross Main with Flushing Connection Consisting of 2 in. (50 mm) Nipple and Cap.*



Δ ***FIGURE D.3.2(b)*** *Connection of 2½ in. (65 mm) Hose Gate Valve with 2 in. (50 mm) Bushing and Nipple and Elbow to 2 in. (50 mm) Cross Main.*

D.3.3 Investigating Dry Pipe Systems. Flood dry pipe systems one or two days before obstruction investigations to soften pipe scale and deposits. After selecting the test points of a dry pipe system, close the main control valve and drain the system. Check the piping visually with a flashlight while it is being dismantled. Attach hose valves and 1½ in. (40 mm) hose to the ends of the lines to be tested, shut the valves, have air pressure restored on the system, and reopen the control valve. Open the hose valve on the end branch line, allowing the system to trip in simulation of normal action. Any obstructions should be cleared from the branch line before proceeding with further tests.

After flowing the small end line, shut its hose valve and test the feed or cross main by discharging water through a 2½ in. (65 mm) fire hose, collecting any foreign material in a burlap bag.

After the test, the dry pipe valve should be cleaned internally and reset. Its control valve should be locked open and a drain test performed.

D.3.4 Investigating Wet Pipe Systems. Testing of wet systems is similar to that of dry systems, except that the system should be drained after closing the control valve to permit installation of hose valves for the test. Slowly reopen the control valve and make a small hose flow as specified for the branch line, followed by the 2½ in. (65 mm) hose flow for the cross main.

In any case, if lines become plugged during the tests, piping should be dismantled and cleaned, the extent of plugging noted, and a clear flow obtained from the branch line before proceeding further.

Perform similar tests on representative systems to indicate the general condition of the wet systems throughout the plant, keeping a detailed record of the procedures performed.

D.3.5 Other Obstruction Investigation Methods. Other obstruction investigation methods, such as technically proven ultrasonic and x-ray examination, have been evaluated and if applied correctly, are successful at detecting obstructions.

The sources of the obstructing material should be determined and steps taken to prevent further entrance of such material. This entails work such as inspection and cleaning of pump suction screening facilities or cleaning of private reservoirs. If recently laid public mains appear to be the source of the obstructing material, waterworks authorities should be requested to flush their system.

D.4 Obstruction Prevention Program.

D.4.1 Dry Pipe and Preaction Systems — Scale.

(1) Dry pipe and preaction systems using noncoated ferrous piping should be thoroughly investigated for obstruction from corrosion after they have been in service for 15 years, for 25 years, and every 5 years thereafter.
(2) Dry pipe systems with noncoated ferrous piping should be kept on air year-round, rather than on air and water alternately, to inhibit formation of rust and scale.

D.4.2 Flushing Connections. Sprinkler systems installed in accordance with recent editions of NFPA 13 should have provisions for flushing each cross main. Similarly, branch lines on gridded systems should be capable of being readily "broken" at a simple union or flexible joint. Property owners of systems installed without these provisions should be encouraged to provide them when replacement or repair work is being done.

D.4.3 Suction Supplies.

(1) Screen pump suction supplies and screens should be maintained. Connections from penstocks should be equipped with strainers or grids, unless the penstock inlets themselves are so equipped. Pump suction screens of copper or brass wire tend to promote less aquatic growth.
(2) Extreme care should be used to prevent material from entering the suction piping when cleaning tanks and open reservoirs. Materials removed from the interior of gravity tanks during cleaning should not be allowed to enter the discharge pipe.
(3) Small mill ponds could need periodic dredging where weeds and other aquatic growth are inherent.

D.4.4 Asian Clams. Effective screening of larvae and small-size, juvenile Asian clams from fire protection systems is very difficult. To date, no effective method of total control has been found. Such controls can be difficult to achieve in fire protection systems.

D.4.5 Calcium Carbonate. For localities suspected of having hard water, sample sprinklers should be removed and inspected yearly. Subsection D.2.5 outlines sprinkler locations prone to the accumulation of deposits where hard water is a problem. Sprinklers found with deposits should be replaced, and adjacent sprinklers should be inspected.

D.4.6 Zebra Mussels. Several means of controlling the zebra mussel are being studied, including molluscicides, chlorines, ozone, shell strainers, manual removal, robotic cleaning, water jetting, line pigging, sonic pulses, high-voltage electrical fields, and thermal backwashing. It is believed that these controls might need to be applied only during spawning periods when water temperatures are 57°F to 61°F (14°C to 16°C) and veligers are present. Several silicon grease-based coatings also are being investigated for use within piping systems.

While it appears that the use of molluscicides could provide the most effective means of controlling the mussel, these chemicals are costly. It is believed that chlorination is the best available short-term treatment, but there are problems associated with the use of chlorine, including strict Environmental Protection Agency regulations on the release of chlorine into lakes and streams. The use of nonselective poison, such as chlorine, in the amounts necessary to kill the mussels in large bodies of water could be devastating to entire ecosystems.

To provide an effective means of control against zebra mussels in fire protection systems, control measures should be applied at the water source, instead of within the piping system. Effective controls for growth of the zebra mussel within fire protection systems include the following:

(1) Selecting a water source that is not subject to infestation. This could include well water or potable or pretreated water.
(2) Implementing a water treatment program that includes biocides or elevated pH, or both.
(3) Implementing a water treatment program to remove oxygen, to ensure control of biological growth within piping.
(4) Relying on a tight system approach to deny oxygen and nutrients that are necessary to support growth.

D.5 Flushing Procedures.

D.5.1 Yard Mains. Yard mains should be flushed thoroughly before flushing any interior piping. Flush yard piping through hydrants at dead ends of the system or through blow-off valves, allowing the water to run until clear. If the water is supplied from more than one direction or from a looped system, close divisional valves to produce a high-velocity flow through each single line. A velocity of at least 10 ft/sec (3 m/sec) is necessary for scouring the pipe and for lifting foreign material to an aboveground flushing outlet. Use the flow specified in Table D.5.1 or the maximum flow available for the size of the yard main being flushed.

Connections from the yard piping to the sprinkler riser should be flushed. These are usually 6 in. (150 mm) mains. Although flow through a short, open-ended 2 in. (50 mm) drain can create sufficient velocity in a 6 in. (150 mm) main to move small obstructing material, the restricted waterway of the globe valve usually found on a sprinkler drain might not allow stones and other large objects to pass. If the presence of large size material is suspected, a larger outlet is needed to pass such material and to create the flow necessary to move it. Fire department connections on sprinkler risers can be used as flushing outlets by removing the clappers. Yard mains also can be flushed through a temporary Siamese fitting attached to the riser connection before the sprinkler system is installed. *[See Figure D.5.1.]*

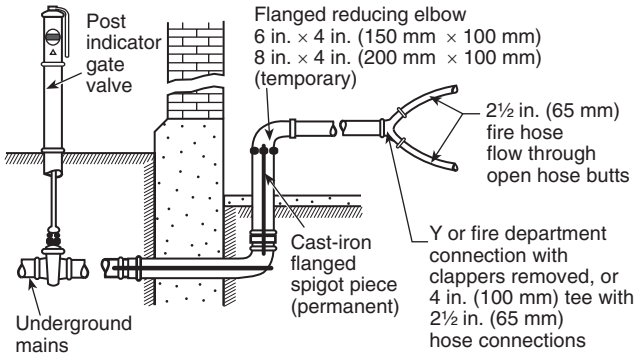


FIGURE D.5.1 *Arrangement for Flushing Branches from Underground Mains to Sprinkler Risers.*

Δ ***TABLE D.5.1*** *Flushing Rates to Accomplish Flow of 10 ft/sec (3 m/sec)*

	Steel			*Copper*				*Polybutylene*	
Pipe Size (in.)	*SCH 10 (gpm)*	*SCH 40 (gpm)*	*XL (gpm)*	*K (gpm)*	*L (gpm)*	*M (gpm)*	*CPVC (gpm)*	*CTS (gpm)*	*IPS (gpm)*
¾	—	—	—	14	15	16	19	12	17
1	29	24	30	24	26	27	30	20	27
1¼	51	47	52	38	39	41	48	30	43
1½	69	63	70	54	55	57	63	42	57
2	114	105	114	94	96	99	98	72	90
2½	170	149	163	145	149	152	144	—	—
3	260	230	251	207	212	217	213	—	—
4	449	396	—	364	373	379	—	—	—
5	686	623	—	565	582	589	—	—	—
6	989	880	—	807	836	846	—	—	—
8	1665	1560	—	1407	1460	1483	—	—	—
10	2632	2440	—	2185	2267	2303	—	—	—
12	—	3520	—	—	—	—	—	—	—

For SI units, 1 gpm = 3.785 L/min.

D.5.2 Sprinkler Piping. Two methods commonly are used for flushing sprinkler piping:

(1) The hydraulic method
(2) The hydropneumatic method

The hydraulic method consists of flowing water from the yard mains, sprinkler risers, feed mains, cross mains, and branch lines, respectively, in the same direction in which water would flow during a fire.

The hydropneumatic method uses special equipment and compressed air to blow a charge of about 30 gal (114 dm^3) of water from the ends of branch lines back into feed mains and down the riser, washing the foreign material out of an opening at the base of the riser.

The choice of method depends on conditions at the individual plant and the type of material installed. If examination indicates the presence of loose sand, mud, or moderate amounts of pipe scale, the piping generally can be flushed satisfactorily by the hydraulic method. Where the material is more difficult to remove and available water pressures are too low

for effective scouring action, the hydropneumatic method generally is more satisfactory. The hydropneumatic method should not be used with listed CPVC sprinkler piping.

In some cases, where obstructive material is solidly packed or adheres tightly to the walls of the piping, the pipe needs to be dismantled and cleaned by rodding or other means.

Dry pipe systems should be flooded one or two days before flushing to soften pipe scale and deposits.

Successful flushing by either the hydraulic or hydropneumatic method is dependent on establishing sufficient velocity of flow in the pipes to remove silt, scale, and other obstructive material. With the hydraulic method, water should be moved through the pipe at least at the rate of flow indicated in Table D.5.1.

Where flushing a branch line through the end pipe, sufficient water should be discharged to scour the largest pipe in the branch line. Lower rates of flow can reduce the efficiency of the flushing operation. To establish the recommended flow, remove the small end piping and connect the hose to a larger section, if necessary.

Where pipe conditions indicate internal or external corrosion, a section of the pipe affected should be cleaned thoroughly to determine whether the walls of the pipe have seriously weakened. Hydrostatic testing should be performed as outlined in NFPA 13.

Pendent sprinklers should be removed and inspected until it is reasonably certain that all are free of obstruction material.

Painting the ends of branch lines and cross mains is a convenient method for keeping a record of those pipes that have been flushed.

D.5.3 Hydraulic Method. After the yard mains have been thoroughly cleaned, flush risers, feed mains, cross mains, and finally the branch lines. In multistory buildings, systems should be flushed by starting at the lowest story and working up. Branch line flushing in any story can immediately follow the flushing of feed and cross mains in that story, allowing one story to be completed at a time. Following this sequence prevents drawing obstructing material into the interior piping.

To flush risers, feed mains, and cross mains, attach 2½ in. (65 mm) hose gate valves to the extreme ends of these lines *[see Figure D.5.3]*. Such valves usually can be procured from the manifold of fire pumps or hose standpipes. As an alternative, an adapter with 2½ in. (65 mm) hose thread and standard pipe thread can be used with a regular gate valve. A length of fire hose without a nozzle should be attached to the flushing connection. To prevent kinking of the hose and to obtain maximum flow, an elbow usually should be installed between the end of the sprinkler pipe and the hose gate valve. Attach the valve and hose so that no excessive strain will be placed on the threaded pipe and fittings. Support hose lines properly.

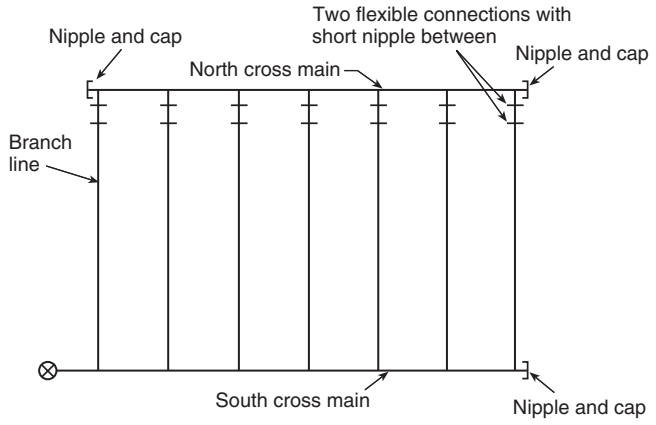


FIGURE D.5.3 *Gridded Sprinkler System Piping.*

Where feed and cross mains and risers contain pipe 4 in., 5 in., and 6 in. (100 mm, 125 mm, and 150 mm) in diameter, it could be necessary to use a Siamese with two hose connections to obtain sufficient flow to scour this larger pipe.

Flush branch lines after feed and cross mains have been thoroughly cleared. Equip the ends of several branch lines with gate valves, and flush individual lines of the group consecutively. This eliminates the need for shutting off and draining the sprinkler system to replace a single hose line. The hose should be 1½ in. (40 mm) in diameter and as short as practicable. Branch lines can be permitted to be flushed in any order that expedites the work.

Branch lines also can be permitted to be flushed through pipe 1½ in. (40 mm) in diameter or larger while extended through a convenient window. If pipe is used, 45 degree fittings should be provided at the ends of branch lines. Where flushing branch lines, hammering the pipes is an effective method of moving obstructions.

Figure D.5.3 shows a typical gridded piping arrangement prior to flushing. The flushing procedure is as follows:

(1) Disconnect all branch lines and cap all open ends.
(2) Remove the cap from the east end of the south cross main, flush the main, and replace the cap.
(3) Remove the cap from branch line 1, flush the line, and replace the cap.
(4) Repeat step (3) for the remaining branch lines.
(5) Reconnect enough branch lines at the west end of the system so that the aggregate cross-sectional area of the branch lines approximately equals the area of the north cross main. For example, three 1¼ in. (32 mm) branch lines approximately equal a 2½ in. (65 mm) cross main. Remove the cap from the east end of the north cross main, flush the main, and replace the cap.
(6) Disconnect and recap the branch lines. Repeat step (5), but reconnect branch lines at the east end of the system and flush the north cross main through its west end.
(7) Reconnect all branch lines and recap the cross main. Verify that the sprinkler control valve is left in the open and locked position.

D.5.4 Hydropneumatic Method. The apparatus used for hydropneumatic flushing consists of a hydropneumatic machine, a source of water, a source of compressed air, 1 in. (25 mm) rubber hose for connecting to branch lines, and 2½ in. (65 mm) hose for connecting to cross mains.

The hydropneumatic machine *[see Figure D.5.4(a)]* consists of a 30 gal (114 dm^3) (4 ft^3) water tank mounted over a 185 gal (700 dm^3) (25 ft^3) compressed air tank. The compressed air tank is connected to the top of the water tank through a 2 in. (50 mm) lubricated plug cock. The bottom of the water tank is connected through hose to a suitable water supply. The compressed air tank is connected through suitable air hose to either the plant air system or a separate air compressor.

To flush the sprinkler piping, the water tank is filled with water, the pressure is raised to 100 psi (6.9 bar) in the compressed air tank, and the plug cock between tanks is opened to put air pressure on the water. The water tank is connected by hose to the sprinkler pipe to be flushed. The lubricated plug cock on the discharge outlet at the bottom of the water tank then is snapped open, allowing the water to be "blown" through the hose and sprinkler pipe by the compressed air. The water tank and air tank should be recharged after each blow.

Outlets for discharging water and obstructing material from the sprinkler system should be arranged. With the clappers of dry pipe valves and alarm check valves on their seats and cover plates removed, sheet metal fittings can be used for connection to 2½ in. (65 mm) hose lines or for discharge into a drum [maximum capacity per blow is approximately 30 gal (114 dm^3)]. If the 2 in. (50 mm) riser drain is to be used, the drain valve should be removed and a direct hose connection made. For wet pipe systems with no alarm check valves, the riser should be taken apart just below the drain opening and a plate inserted to prevent foreign

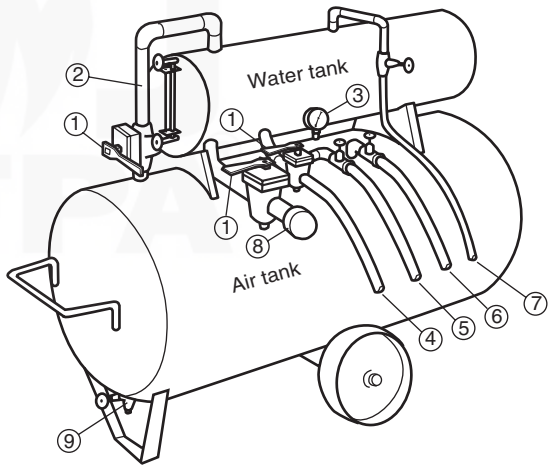
material from dropping to the base of the riser. Where dismantling of a section of the riser for this purpose is impractical, the hydropneumatic method should not be used.

Before starting a flushing job, each sprinkler system to be cleaned should be studied and a schematic plan prepared showing the order of the blows.

To determine that the piping is clear after it has been flushed, representative branch lines and cross mains should be investigated, using both visual examination and sample flushings.

(1) *Branch Lines.* With the yard mains already flushed or known to be clear, the sprinkler branch lines should be flushed next. The order of cleaning individual branch lines should be laid out carefully if an effective job is to be done. In general, the branch lines should be flushed, starting with the branch closest to the riser and working toward the dead end of the cross main. *[See Figure D.5.4(b).]* The order for flushing the branch lines is shown by the circled numerals. In this example, the southeast quadrant is flushed first, then the southwest, followed by the northeast, and, finally, the northwest. Air hose 1 in. (25 mm) in diameter is used to connect the machine with the end of the branch line being flushed. This hose air pressure should be allowed to drop to 85 psi (5.9 bar) before the valve is closed. The resulting short slug of water experiences less friction loss and a higher velocity and, therefore, cleans more effectively than if the full 30 gal (114 dm^3) of water were to be used. One blow is made for each branch line.

(2) *Large Piping.* Where flushing cross mains, fill the water tank completely and raise the pressure in the air receiver to 100 psi (6.9 bar) (690 kPa). Connect the machine to the end of the cross main to be flushed with no more than 50 ft (15.2 m) of 2½ in. (65 mm) hose. After opening the valve, allow air pressure in the machine to drop to zero (0). Two to six blows are necessary at each location, depending on the size and length of the main.



1 Lubricated plug cocks
2 Pipe connection between air and water tanks (This connection is open when flushing sprinkler system.)
3 Air pressure gauge
4 1 in. (25 mm) rubber hose (air type) (Used to flush sprinkler branch lines.)
5 Hose connected to source of water (Used to fill water tank.)
6 Hose connected to ample source of compressed air (Used to supply air tank.)
7 Water tank overflow hose
8 2½ in. (65 mm) pipe connection [Where flushing large interior piping, connect woven jacket fire hose here and close 1 in. (25 mm) plug cock hose connection (4) used for flushing sprinkler branch lines.]
9 Air tank drain valve

FIGURE D.5.4(a) *Hydropneumatic Machine.*

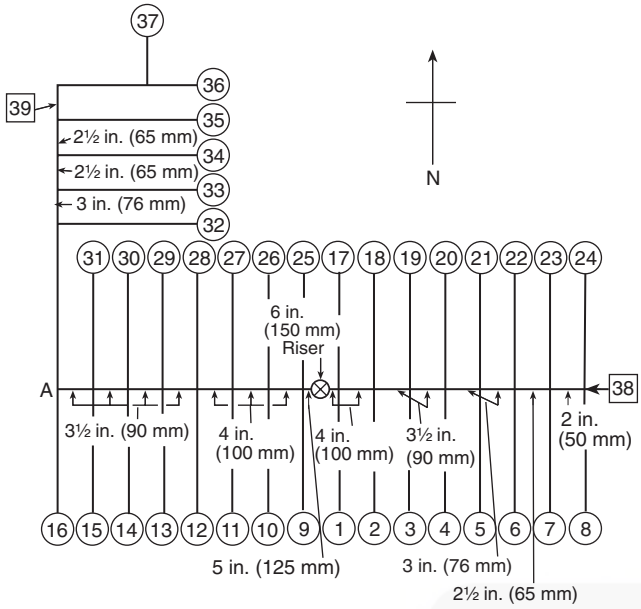


FIGURE D.5.4(b) *Schematic Diagram of Sprinkler System Showing Sequence To Be Followed Where Hydropneumatic Method Is To Be Utilized.*

In Figure D.5.4(b), the numerals in squares indicate the location and order of the cross main blows. Because the last branch line blows performed were located west of the riser, clean the cross main located east of the riser first. Where large cross mains are to be cleaned, it is best, if practical, to make one blow at 38, one at 39, the next again at 38, then again at 39, alternating in this manner until the required number of blows has been made at each location.

(3) Where flushing cross mains and feed mains, arrange the work so that the water passes through a minimum of right-angle bends. In Figure D.5.4(b), blows at 38 should be adequate to flush the cross mains back to the riser. Do not attempt to clean the cross main from location A to the riser by backing out branch line 16 and connecting the hose to the open side of the tee. If this were to be done, a considerable portion of the blow would pass northward up the 3 in. (76 mm) line supplying branches 34 to 37, and the portion passing eastward to the riser could be ineffective. Where the size, length, and condition of cross mains necessitate blowing from a location corresponding to location A, the connection should be made directly to the cross main corresponding to the 3½ in. (90 mm) pipe so that the entire flow travels to the riser. Where flushing through a tee, always flush the run of the tee after flushing the branch. Note the location of blows 35, 36, and 37 in Figure D.5.4(b). Gridded systems can be flushed in a similar fashion. With branch lines disconnected and capped, begin flushing the branch line closest to the riser (branch line 1 in Figure D.5.3), working toward the most remote line. Then flush the south cross main in Figure D.5.3 by connecting the hose to the east end. Flushing the north cross main involves connecting the hose to one end while discharging to a safe location from the other end.

Reference Cited in Commentary

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2019 edition.

NFPA



ANNEX E

HAZARD EVALUATION FORM

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

Δ E.1 Conducting Hazard Evaluations.

This annex provides one example of a hazard evaluation form. A hazard evaluation is not part of a system inspection. (*See Figure E.1.*)

The property owner or the designated representative must not make changes in the occupancy, the use or process, or the materials used or stored in the building without evaluation of the fire protection systems for their capability to protect the new occupancy, use, or materials. While this evaluation is required by 4.1.6, it is not considered a part of the normal inspection, testing, and maintenance (ITM) required by the standard.

Historical Note

Prior editions of NFPA 25 included the requirement in 4.1.6 and 4.1.7 for the need to address changes in hazard, but there was no specific trigger for the need to conduct a hazard evaluation. As a result, such evaluations were rare even though they are extremely important, and there was a common misunderstanding that these evaluations took place during the course of a normal system inspection. In response, a new hazard evaluation form was added for the 2011 edition of the standard to assist in differentiating between a system inspection and a system hazard evaluation. When such an evaluation is considered appropriate, the owner or authority having jurisdiction (AHJ) can ask an individual qualified to address system design issues to use this form as part of the evaluation.

This form provides a focus and is intended to assist the user in considering factors that are not directly related to the system but may impact system performance, such as occupancy changes; process or material changes such as metal stamping to molded plastics; building revisions such as relocated walls, added mezzanines, and ceilings added below sprinklers; and removal of heating systems in spaces with piping subject to freezing.

The form is also intended to be used as a tool for meeting the requirements of 4.1.6 and 4.1.7.

FIRE SPRINKLER SYSTEM HAZARD EVALUATION

Changes in building occupancy, use, or process, or material used or stored, create the need for evaluation of the installed fire protection systems. This form is intended to identify and evaluate such changes and should be completed only by an individual properly qualified in the area of system design.

Owner: _____ Owner's address: _____

Property being evaluated: _____

Property address: _____

Date of work: _____

(All responses refer to the current hazard evaluation performed on this date.)

Section 1. Identification of Sprinklered Occupancy and Storage Hazards

(Use additional pages as needed.)

Area of Property (List nonsprinklered areas separately in Section 3.)	Type of System and Sprinklers	Design Capability of System	Hazard Protected (Uses or storage arrangements, including commodity)	Improvements Needed to Address Hazard
1.				
2.				
3.				
4.				
5.				

© 2019 National Fire Protection Association

Δ ***FIGURE E.1*** *Sample of Fire Sprinkler Hazard Evaluation.*

FIRE SPRINKLER SYSTEM HAZARD EVALUATION *(continued)*

Section 2. Evaluation of Protection

For each area of the property evaluated in Section 1, please answer the following questions with a "yes," "no," "N/A," or "?," and explain all "no" and "?" responses below by row and column identification:

Answer the following for each identified property area:	**1**	**2**	**3**	**4**	**5**
a. Are all sprinklers the correct type for their application?					
b. Are the obstructions to sprinklers in all areas within acceptable limits for the specific types of sprinklers used?					
c. Are hazards associated with all occupancy areas consistent with hazards typical for that occupancy hazard classification?					
d. Are stockpiles of combustibles located within occupancy areas limited to appropriate heights?					
e. Are miscellaneous and dedicated storage areas properly identified and managed?					
f. Are all dedicated storage areas protected in accordance with the proper storage configuration and commodity classification?					
g. Is the storage or use of flammable liquids, combustible liquids, or aerosol products in any area properly addressed?					
h. Is all idle pallet storage properly protected?					
i. Is there any presence of nitrate film, pyroxylin plastic, compressed or liquefied gas cylinders, liquid or solid oxidizers, or organic peroxide formulations except where specifically addressed by appropriate protection measures?					
j. Are all sprinklers spaced appropriately for the hazard and the type of sprinkler?					
k. Do the available sources of heat and cooling appear adequate for the type of system and temperature rating of sprinklers?					

Explanation of "no" and "?" answers:

Examples:
b2 – no – Obstructions to ESFR sprinklers exceed currently accepted standards
e3 – ? – Owner must provide information on type of plastic involved in product before evaluation can be finalized.

© 2019 National Fire Protection Association

Δ ***FIGURE E.1*** *Continued*

FIRE SPRINKLER SYSTEM HAZARD EVALUATION *(continued)*

Section 3. Evaluation of Unsprinklered Areas

Area of Property for Which Protection Is Not Provided	Basis of Lack of Protection (if known)	Basis for Omission Under Current Codes/Standards
1.		
2.		
3.		
4.		
5.		

Section 4. Water Supply Evaluation

If this hazard evaluation is the result of a reduction in the residual pressure during routine inspections, explain the results of the investigation made to determine the reasons for this change:

Explain the basis of continued acceptability of the water supply or proposed improvements:

© 2019 National Fire Protection Association

Δ ***FIGURE E.1*** *Continued*

FIRE SPRINKLER SYSTEM HAZARD EVALUATION *(continued)*

Section 5. Hazard Evaluator's Information and Certification

Evaluator: _____

Company: _____

Company address: _____

I state that the information on this form is correct at the time and place of my review of my evaluation.

Is this hazard evaluation completed? (Note: All "?" must be resolved.) ❑ Yes ❑ No

Explain if answer is not "yes":

_____

_____

Have deficiencies in protection been identified that should be improved or corrected? ❑ Yes ❑ No

Summarize improvements of corrections needed:

_____

_____

_____

_____

Signature of Evaluator: _____ Date: _____

License or Certification Number (if applicable): _____

© 2019 National Fire Protection Association NFPA 25 (p. 4 of 4)

Δ ***FIGURE E.1*** *Continued*

NFPA

ANNEX F

CONNECTIVITY AND DATA COLLECTION

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

F.1 Scope.

F.1.1 This annex covers considerations relating to the collection of inspection, test, maintenance, and monitoring data.

Inspection, testing, and maintenance (ITM) frequencies are currently based on anecdotal evidence related to the committee's experience and expertise with incidents that are frequently sighted. To extrapolate historical data for a performance-based approach, performance data needs to be collected and collated more systematically. This requires a more uniform electronic reporting of performance data by a significant number of service providers. NFPA 20, *Standard for the Installation of Stationary Fire Pumps for Fire Protection,* added Annex C, Fire Pump Controller Connectivity, beginning with the 2016 edition, which provides for uniform reporting of fire pump performance, including Modbus register assignments. Annex F of NFPA 25 is intended to move this standard in the same direction, recognizing that NFPA 25 covers a much wider range of systems and components than NFPA 20.Future versions of this annex might expand on this concept to review existing and potential future reporting mechanisms and develop advisory standardized input and data storage for the most promising electronic reporting systems. Ideally, the electronic collection system should not add to, but actually reduce, the time required for ITM.

A side benefit of systematic analysis of performance data may be to identify issues with new technology or product changes much earlier.

F.1.2 Potential use of accessible information includes remote supervision, remote monitoring that may include specific components for failure forecasting/component replacement, reliability analysis for owner, manufacturer, and NFPA or similar group for obtaining information only. No remote operation nor remote changing of any controller settings should be permitted.

F.1.3 Connectivity is for remote monitoring and data gathering. It does not replace any of the alarm and signaling requirements of this or other standards.

F.1.4 This annex is intended to be complementary to Annex D in NFPA 20 and relies on that annex for common concerns and elements.

F.1.5 Although none of the clauses in this annex are enforceable, future editions of this standard might incorporate requirements for connectivity and data collection into the enforceable portion of this standard. Public review and comment are encouraged.

F.2 Internet Protocol (IP).

See Annex D of NFPA 20.

F.3 Possible Configurations.

F.3.1 Standalone Laptop Computers, Tablets, Smart Cell Phones.

F.3.1.1 The devices could be provided with software or connected to a control panel for downloading data, plugged into data recording equipment, or used for manual data entry.

F.3.2 Control Panels.

F.3.2.1 These devices could have direct access to a network — the network could be local WAN or Internet.

F.3.2.2 These devices could be standalone devices and require a direct connection to download data.

F.3.2.3 Data collection capability is almost universal in modern fire pump controllers. Manual (user) intervention is required to access (read or download).

F.3.3 User Connection. See Annex D of NFPA 20.

F.4 Security Concerns.

See Annex D of NFPA 20.

F.5 Recommended Requirements.

F.5.1 Separate access protocols should be used for different access levels.

F.5.1.1 Level 1 allows read-only access to performance information for user benefit.

F.5.1.2 Level 2a allows access for statistical analysis by an independent body. Information that identifies the user should be transformed to conceal the user's identity and should provide a GPS location that identifies latitude and longitude within 100 miles.

F.5.1.3 Level 1 allows access for manufacturer analysis with the owner's permission.

F.5.1.4 Level 2b allows access for manufacturer analysis without the owner's permission. Information that identifies the user should be transformed to conceal the user's identity and should provide a GPS location that identifies state and latitude and longitude within 100 miles.

F.5.1.5 Level 2c allows access for manufacturer analysis of the control panel.

F.5.1.6 Level 2d allows access for remote testing, with an alarm to be triggered if the control panel is not restored to automatic mode within eight hours.

F.5.2 Information Recorded for External Access.

TABLE F.5.2(a) *Inspection, Test, Maintenance, and Repair Record Layout*

Category	*Item Format*	*Format*	*Possible Values*
Basic information	Type of record	String (48)	Inspection, test, and maintenance
	Facility name	String (96)	Alphanumeric
	Location — GPS coordinates (longitude)	Number	−183333330° to +180°
	Location — GPS coordinates (latitude)	Number	−90° to +90°
	Location — GPS coordinates (elevation)	Number	Feet or meters
	Location adjusted for privacy — GPS coordinates (longitude)	Number	−180° to +180°
	Location adjusted for privacy — GPS coordinates (latitude)	Number	−90° to +90°
	Location adjusted for privacy — GPS coordinates (elevation)	Number	Feet or meters
	Reporting units pressure	Character	(1) psi (2) bar (3) Pascals (4) other
	Reporting units flow	Character	(1) gpm (2) L/min (3) L/sec (4) m^3/min (5) ft^3/min (6) Other
	Type of inspection or test	Character	(I) Inspection (T) Test (M) Maintenance (R) Repair
Item inspected, tested, maintained, or repaired — repeat for each item	Start of record marker for item	String (16)	Record start
	Unit type identifier (develop list)	String (48)	Alphanumeric
	Passed; failed; passed, but needs attention	Character	(P) Passed (F) Failed (A) Passed, but needs attention
	See Table F.2.5(d).		See Table F.2.5(d).
	Passed visual inspection	Character	(Y) Yes (N) No (A) Not Applicable
	Maintenance required	Number	≥ 0
	Maintenance done	Character	(1) Not applicable (2) Completed (3) Ordered but not completed (4) Not ordered
	End of item record marker	String (16)	Record end
End of ITC record	End of ITC (all components reported)	String (48)	End of inspection, test, and maintenance report

TABLE F.5.2(b) *Equipment Repair Data Record Layout*

Equipment repair data	*Type of record*	*String (48)*	*Repair*
	Facility name	String (96)	Alphanumeric
	Location — GPS coordinates (longitude)	Number	−180° to +180°
	Location — GPS coordinates (latitude)	Number	−90° to +90°
	Location — GPS coordinates (elevation)	Number	Feet or meters
	Location adjusted for privacy — GPS coordinates (longitude)	Number	−180° to +180°
	Location adjusted for privacy — GPS coordinates (latitude)	Number	−90° to +90°
	Location adjusted for privacy — GPS coordinates (elevation)	Number	Feet or meters
	Repair date	Date	Year/month/day
	Common data		See Table F.5.2(c).
	Repair preventative or result of failure	Character	(P) Preventative (F) Failure
	Failure mode (develop list)	5 Characters	Correspond to list
	Failure impaired fire protection system	Character	(I) Impaired (P) Partially functional (N) Not impaired
	Repair code (develop list)	5 Characters	Correspond to list
	Component replaced (develop list)	5 Characters	Correspond to list
	Repair description	String (96)	Alphanumeric
	Component replacement date	Date	Year/month/day
	End of repair record	String (48)	End of repair

TABLE F.5.2(c) *Common Equipment Data*

Category	*Item*	*Format*	*Possible Values*
	Manufacturer (develop list)	String (48)	Alphanumeric
	Model number	String (48)	Alphanumeric
	Size	String (48)	Alphanumeric
	Serial number	String (48)	Alphanumeric
	Year manufactured	4 Characters	xxxx (year)
	Device/component identifier tag	String (48)	Alphanumeric

Δ ***TABLE F.5.2(d)*** *Item Information*

Item	*Item Component*	*Format*	*Possible Values*
Air compressor	Common data		See Table F.5.2(c).
	Type of system served	Character	(1) Dry (2) Non-interlock preaction (3) Single interlock preaction (4) Double interlock preaction (5) Other
	Filled system in 30 minutes or less	Character	(Y) Yes (N) No (3) N/A

Δ ***TABLE F.5.2(d)*** *Continued*

Item	*Item Component*	*Format*	*Possible Values*
Alarm check valve	Common data		See Table F.5.2(c).
	Operated satisfactorily	Character	(Y) Yes (N) No (3) N/A
Alarm device	Common data		See Table F.5.2(c).
	Operated satisfactorily	Character	(Y) Yes (N) No (3) N/A
Alarm valves	Common data		See Table F.5.2(c).
	Operated satisfactorily	Character	(Y) Yes (N) No (3) N/A
Antifreeze solution	Unit type identifier	String (48)	
	Type of antifreeze	Character	(1) Glycerin (2) Ethylene glycol (3) Other
	Tested satisfactorily	Character	(Y) Yes (1) Concentration too low/high (2) Antifreeze dirty (3) Other
Auxiliary drains	Operated satisfactorily	Character	(Y) Yes (N) No (3) N/A
Backflow preventer	Common data		See Table F.5.2(c).
	Type		(1) DC (2) DDC (3) RPZ (4) RPZDC (5) Air gap (6) Check valve (7) Single-check DC (8) Other
	Nonflow upstream pressure	Number	Two decimal places
	Nonflow intermediate chamber pressure	Number	Two decimal places
	Nonflow downstream pressure	Number	Two decimal places
	ITC flow upstream pressure	Number	Two decimal places
	ITC flow intermediate chamber pressure	Number	Two decimal places
	ITC flow downstream pressure	Number	Two decimal places
	Demand test flow rate	Number	Two decimal places
	Demand flow upstream pressure	Number	Two decimal places
	Demand flow intermediate chamber pressure	Number	Two decimal places
	Demand flow downstream pressure	Number	Two decimal places
Balancing valve diaphragm	Common data		See Table F.5.2(c).
	Operated satisfactorily	Character	(Y) Yes (N) No (3) N/A

(continues)

Δ ***TABLE F.5.2(d)*** *Continued*

Item	*Item Component*	*Format*	*Possible Values*
Ball drip (automatic type) drain valves	Common data		See Table F.5.2(c).
	Operated satisfactorily	Character	(Y) Yes (N) No (3) N/A
Bladder tank	Common data		See Table F.5.2(c).
	Fill level OK	Character	(Y) Yes (N) No (3) N/A
	Operated satisfactorily	Character	(Y) Yes (N) No (3) N/A
	Comment if needed	String (80)	Alphanumeric
Spare head cabinet	Unit type identifier	String (48)	Alphanumeric
	Adequate stock of spare sprinklers	Character	(Y) Yes (N) No (3) N/A
	Comment if needed	String (80)	Alphanumeric
Check valve(s)	Common data		See Table F.5.2(c).
	Type	Character	(1) Flanged swing (2) Grooved swing (3) Sprinkler-loaded flanged swing (4) Spring-loaded grooved swing (5) Spring-loaded duo-wafer (6) Spring-loaded duo-grooved (7) Spring-loaded duo-flanged (8) Other
	Prevents backflow	Character	(Y) Yes (N) No (3) N/A
	Nonflow upstream pressure	Number	≥0
	Nonflow downstream pressure	Number	≥0
	Demand test flow rate	Number	≥0
	Demand flow upstream pressure	Number	≥0
	Demand flow downstream pressure	Number	≥0
	Unit type identifier	String (48)	Alphanumeric
	Where installed	Character	(1) On fire pump discharge (2) Loop piped back to suction
	Operated satisfactorily	Character	(Y) Yes (N) No (3) N/A

Δ ***TABLE F.5.2(d)*** *Continued*

Item	*Item Component*	*Format*	*Possible Values*
Control valve(s)	Common data		See Table F.5.2(c).
	Type of valve	Character	(1) OS&Y (2) Butterfly (3) Ball (4) NRS gate (5) Post indicator gate (6) Post indicator butterfly (7) Wall indicator gate (8) Wall indicator butterfly (9) Other
	Nominal valve size [in. (mm)]	Number	≥0
	Original position of valve	Character	(1) Normally open valve, open (N) Normally open valve, closed (3) Normally closed valve, closed (4) Normally closed valve, open (5) Valve partially closed
	Stops flow of water when closed	Character	(Y) Yes (2) Minor leakage (3) No (4) Not tested for flow
	Obstructs flow of water when open	Character	(Y) Yes (N) No (3) Not tested for flow
	Operated satisfactorily	Character	(Y) Yes (N) No (3) N/A
Deluge/preaction valve	Common data		See Table F.5.2(c).
	Type of system	Character	(1) Deluge (2) Non-interlock preaction (3) Single interlock preaction (4) Double interlock preaction (5) Other
	Activation mechanism	Character	(1) Pilot line (2) Heat detection (3) Smoke detection (4) Manual (5) Other
	Automatic actuation OK	Character	(Y) Yes (N) No (3) Not tested (4) N/A
	Manual actuation OK	Character	(Y) Yes (N) No (3) Not tested (4) N/A
	Operated satisfactorily	Character	(Y) Yes (N) No (3) N/A
	See Backflow Prevention Devices.		

(continues)

Δ ***TABLE F.5.2(d)*** *Continued*

Item	*Item Component*	*Format*	*Possible Values*
Detector check valve	Common data		See Table F.5.2(c).
	Nozzle size [in. (mm)]	Number	≥0
	Flowed without obstruction	Character	(Y) Yes (2) Minor obstructed nozzles (3) Significant obstructions
	Flowed at or above system design	Character	(Y) Yes (N) No (3) Not determined
	Concentrate percentage correct	Character	(Y) Yes (N) No
Drain riser	Operated satisfactorily	Character	(Y) Yes (N) No (3) N/A
Dry pipe valve	Common data		See Table F.5.2(c).
	Accelerator	Character	(Y) Yes (N) No
	Time to trip with accelerator (sec)	Number	≥0
	Water delivery time with accelerator (sec)	Number	≥0
	Time to trip without accelerator (sec)	Number	≥0
	Water delivery time without accelerator (sec)	Number	≥0
	System passed	Character	(Y) Yes (N) No
Accelerator	Common data		See Table F.5.2(c).
	Time to trip with accelerator (sec)	Number	≥0
	System passed	Character	(Y) Yes (N) No
Enclosure (during cold weather)	Adequate heat	Character	(Y) Yes (N) No
Fire department connection	Connection supplies	Character	(1) Sprinkler (2) Standpipe (3) Standpipe and sprinkler (4) Other
	Connection flushed	Character	(Y) Yes (N) No
	Connection tested	Character	(Y) Yes (N) No
	System passed	Character	(Y) Yes (N) No
Fire hose	Hydrostatically tested within last 5 years	Character	(Y) Yes (N) No
Fire pumps	See NFPA 20 and Table F.5.2(e).		
Fittings — except those with rubber gaskets	Indication of leakage present	Character	(1) No (2) Minor (3) Significant

Δ ***TABLE F.5.2(d)*** *Continued*

Item	*Item Component*	*Format*	*Possible Values*
Fittings — those with rubber gaskets	Indication of leakage present	Character	(1) No (2) Minor (3) Significant
Foam concentrate	Manufacturer	String (48)	Alphanumeric
	Type	String (48)	Alphanumeric
	Adequate quantity	Character	(Y) Yes (N) No
	Samples submitted for testing	Character	(Y) Yes (N) No
	Samples tested satisfactory	Character	(Y) Yes (N) No
Foam concentrate strainer(s)	Strainer clear initial	Character	(Y) Yes (N) No
Foam concentrate tank	Tank full	Character	(Y) Yes (N) No
	Protective coating (mineral oil) on top of foam concentrate OK	Character	(Y) Yes (N) No
Foam-water solution	Foam percentage	Number	≥0
	Solution passed	Character	(Y) Yes (N) No
Gauges	Gauge on	Character	(1) System side, wet pipe system (2) Supply side, wet pipe system (3) Air side, dry pipe system (4) Supply side, dry pipe system (5) Air side, preaction system (6) Supply side, preaction system (7) Fire pump suction (8) Fire pump discharge (9) Water mist system (10) Pressure tank (11) Water storage tank (12) Other
	Gauges reading correctly	Character	(Y) Yes (N) No
General information sign	Required signs provided	Character	(Y) Yes (N) No
	Signs readable and correct	Character	(Y) Yes (N) No
Gravity tanks	Water level OK	Character	(Y) Yes (N) No
	Adequate heat provided	Character	(Y) Yes (N) No
Hanger/pipe supports	Passed visual inspection	Character	(Y) Yes (N) No

(continues)

Δ ***TABLE F.5.2(d)*** *Continued*

Item	*Item Component*	*Format*	*Possible Values*
High and low air pressure switch	Common data		See Table F.5.2(c).
	Sends low air signal at the appropriate pressure setting	Character	(Y) Yes (N) No
	Sends high air signal at the appropriate pressure setting	Character	(Y) Yes (N) No
Hose houses	Properly equipped and maintained	Character	(Y) Yes (N) No
Hose nozzle	Type of nozzle	Character	(1) Straight stream (2) Fog (3) Other
	Properly maintained	Character	(Y) Yes (N) No
Hose racks	Properly maintained	Character	(Y) Yes (N) No
Hose storage device	Properly maintained	Character	(Y) Yes (N) No
Hose valve (non–pressure-regulating)	Properly maintained	Character	(Y) Yes (N) No
Hose valve pressure-regulating devices	Common data		See Table F.5.2(c).
	Inlet pressure while flowing	Character	(Y) Yes (N) No
	Outlet pressure while flowing	Character	(Y) Yes (N) No
	Test flow rate	Number	≥0
	Passed test	Character	(Y) Yes (N) No
Hydrants (dry barrel and wall)	Common data		See Table F.5.2(c).
	Hydrant opened and closed	Character	(Y) Yes (N) No
	Hydrant barrel drained	Character	(Y) Yes (N) No
	Hydrant shows need of maintenance	Character	(Y) Yes (N) No
Hydrants (wet barrel)	Common data		See Table F.5.2(c).
	Hydrant opened and closed	Character	(Y) Yes (N) No
	Hydrant shows need of maintenance	Character	(Y) Yes (N) No
Hydraulic design, information sign, and hydraulic placards	Required signs/placards provided	Character	(Y) Yes (N) No
	Signs readable and correct	Character	(Y) Yes (N) No

Δ ***TABLE F.5.2(d)*** *Continued*

Item	*Item Component*	*Format*	*Possible Values*
Identification signs	Required signs/placards provided	Character	(Y) Yes (N) No
	Signs readable and correct	Character	(Y) Yes (N) No
Information sign	Required signs/placards provided	Character	(Y) Yes (N) No
	Signs readable and correct	Character	(Y) Yes (N) No
Inspector's test connection	Flowed without obstruction	Character	(Y) Yes (N) No
	Activated alarm	Character	(Y) Yes (N) No
Low-point drains (dry pipe system)	Drained without obstruction	Character	(Y) Yes (N) No
	Passed visual inspection	Character	(Y) Yes (N) No
	Excessive water at drain	Character	(Y) Yes (N) No
Main drain	Static pressure	Number	≥0
	Residual pressure	Number	≥0
Main drain valves	Free of corrosion and damage	Character	(Y) Yes (N) No
Mainline strainers	Strainer without excessive debris and damage	Character	(Y) Yes (N) No
Manual actuation device(s)	Passed test	Character	(Y) Yes (N) No
Mist system compressed gas cylinder	Cylinders full	Character	(Y) Yes (N) No
Mist system control equipment	Passed test	Character	(Y) Yes (N) No
Mist system plant air, compressors, and receivers	Operated satisfactorily	Character	(Y) Yes (N) No
Mist system pneumatic valves, cylinder valves, and master release valves	Passed test	Character	(Y) Yes (N) No
Mist system standby pump	Passed test	Character	(Y) Yes (N) No
Mist system water storage cylinder (additive storage cylinder)	Passed test	Character	(Y) Yes (N) No
Mist system water storage cylinder (high pressure)	Passed test	Character	(Y) Yes (N) No

(continues)

Δ ***TABLE F.5.2(d)*** *Continued*

Item	*Item Component*	*Format*	*Possible Values*
Mist system water storage cylinder (high pressure), filters on refill connection	Passed test	Character	(Y) Yes (N) No
Mist system water storage cylinder (high pressure), support frame/restraints	Passed visual inspection	Character	(Y) Yes (N) No
Mist system water storage cylinder (high pressure), vent plugs at refilling	Operated satisfactorily	Character	(Y) Yes (N) No
Mist system water storage cylinder (high pressure), water level (load cells)	Passed test	Character	(Y) Yes (N) No
Mist system water storage tank	Tank full without leaks	Character	(Y) Yes (N) No
Mist system water storage tank, all valves and appurtenances	Passed test	Character	(Y) Yes (N) No
Mist system water storage tank, sight glass valves (confirm open)	Operated satisfactorily	Character	(Y) Yes (N) No
Mist system water storage tank, water level (supervised)	Passed test	Character	(Y) Yes (N) No
Monitor nozzles	Passed test	Character	(Y) Yes (N) No
Pipes (above ground)	Type of system	Character	(1) Wet pipe sprinkler (2) Dry pipe sprinkler (3) Preaction (4) Deluge (5) Water mist (6) Other
	Environment	Character	(1) Indoors, heated (2) Indoors, unheated (3) Covered, exposed to exterior atmosphere (4) Covered, exposed to exterior, salt air (5) Exposed, exterior (6) Exposed, exterior, salt air (7) Hostile chemical (8) Other
	Free of leads and excessive corrosion	Character	(Y) Yes (N) No
Fittings (above ground)	Type of system	Character	(1) Wet pipe sprinkler (2) Dry pipe sprinkler (3) Preaction (4) Deluge (5) Water mist (6) Other

Δ ***TABLE F.5.2(d)*** *Continued*

Item	*Item Component*	*Format*	*Possible Values*
	Environment	Character	(1) Indoors, heated (2) Indoors, unheated (3) Covered, exposed to exterior atmosphere (4) Covered, exposed to exterior, salt air (5) Exposed, exterior (6) Exposed, exterior, salt air (7) Hostile chemical (8) Other
	Free of leaks and excessive corrosion	Character	(Y) Yes (N) No
Pipes and fittings (underground)	Environment	Character	(1) Sandy soil (2) Clay soil (3) Corrosive soil (4) Other
	Unit type identifier	String (48)	Alphanumeric
	Type of pipe	Character	(1) Ductile iron (2) Steel (3) CPVC (4) Polyethylene (5) Other
	Pipe encasement	Character	(1) Polyethylene wrap (2) Culvert (3) None
	Water supply source	Character	(1) From municipal system (2) From water storage tank (3) From pond, lake, river, etc. (4) Other
	Free of excessive leakage	Character	(Y) Yes (N) No
	Excessive friction loss	Character	(Y) Yes (N) No
Pipe stands	Passed visual inspection	Character	(Y) Yes (N) No
Post indicator and wall indicator valves	Opened and closed	Character	(Y) Yes (N) No
	Stopped flow of water when closed	Character	(Y) Yes (N) No (3) Not verified
Low flow pressure relief valves (e.g., sprinkler system)	Relief pressure	Number	≥0
	Functioning properly	Character	(Y) Yes (N) No

(continues)

Δ ***TABLE F.5.2(d)*** *Continued*

Item	*Item Component*	*Format*	*Possible Values*
High flow pressure relief valves (e.g., fire pump)	Common data		See Table F.5.2(c).
	Type	Character	(1) Pilot-operated (2) Spring-loaded (3) Other
	Discharge to…	Character	(1) Atmosphere (2) Tank (3) Fire pump suction (4) Other
	Relief pressure	Number	≥0
	Shutoff pressure	Number	≥0
	Functioning properly	Character	(Y) Yes (N) No
Pressure reducing valves	Common data		See Table F.5.2(c).
	Type	Character	(1) Pilot-operated (2) Spring-loaded (3) Other
	Installation with other pressure reducing valves	Character	(1) Standalone (2) Series upstream (3) Series downstream (4) Parallel, with smaller (5) Parallel, with larger (6) Parallel, same size (7) Combination series and parallel (8) Other
	Static inlet pressure	Number	≥0
	Static outlet pressure	Number	≥0
	Residual low flow inlet pressure	Number	≥0
	Residual low flow outlet pressure	Number	≥0
	Residual low flow inlet pressure	Number	≥0
	Residual low flow outlet pressure	Number	≥0
	Functioning properly	Character	(Y) Yes (N) No
Pump suction control valves	Common data		See Table F.5.2(c).
	Type	Character	(1) Pilot-operated (2) Spring-loaded (3) Other
	Set suction pressure	Number	≥0
	Static inlet pressure	Number	≥0
	Static outlet pressure	Number	≥0
	Inlet pressure at 100 percent rated pump capacity	Number	≥0
	Outlet pressure at 100 percent rated pump capacity	Number	≥0
	Inlet pressure at 150 percent rated pump capacity	Number	≥0
	Outlet pressure at 150 percent rated pump capacity	Number	≥0

Δ ***TABLE F.5.2(d)*** *Continued*

Item	*Item Component*	*Format*	*Possible Values*
	Functioning properly	Character	(Y) Yes (N) No
Pressure tanks	Air pressure (supervised)	Character	(Y) Yes (N) No
	Air pressure	Number	≥0
	Water level OK	Character	(Y) Yes (N) No
	Air pressure water level normal	Character	(Y) Yes (N) No
Pressure vacuum vents	Functioning correctly	Character	(Y) Yes (N) No (3) Not verified
Proportioning system(s)	Common data		See Table F.5.2(c).
	Functioning properly	Character	(Y) Yes (N) No
Reduced-pressure detectors	Common data		See Table F.5.2(c).
	Functioning properly	Character	(Y) Yes (N) No
Retainer glands	No visible leakage or damage	Character	(Y) Yes (N) No
Sight glass	No visible leakage or damage	Character	(Y) Yes (N) No
Spare sprinklers	Adequate number of each type	Character	(Y) Yes (N) No
	Visible leakage or damage	Character	(Y) Yes (N) No
Sprinkler systems	Visible leakage or significant corrosion or damage	Character	(Y) Yes (N) No
Sprinklers	Manufacturer	String (48)	Alphanumeric
	SIN	String (48)	Alphanumeric
	Quick response	Character	(Y) Yes (N) No
	Year manufactured	4 Characters	xxxx (year)
	Approximate number of sprinkler	Number	≥0
	Visible leakage or significant corrosion or damage	Character	(Y) Yes (N) No
	Approximate percent substandard	Number	0–100
Sprinklers (dry)	Manufacturer	String (48)	Alphanumeric
	SIN	String (48)	Alphanumeric
	Quick response	Character	(Y) Yes (N) No
	Year manufactured	4 Characters	xxxx (year)
	Approximate number of sprinkler	Number	≥0
	Visible leakage or significant corrosion or damage	Character	(Y) Yes (N) No
	Approximate percent substandard	Number	0–100

(continues)

Δ ***TABLE F.5.2(d)*** *Continued*

Item	*Item Component*	*Format*	*Possible Values*
Sprinklers (extra-high or greater temperature solder type)	Manufacturer	String (48)	Alphanumeric
	SIN	String (48)	Alphanumeric
	Quick response	Character	(Y) Yes (N) No
	Year manufactured	4 Characters	xxxx (year)
	Approximate number of sprinkler	Number	≥0
	Visible leakage or significant corrosion or damage	Character	(Y) Yes (N) No
	Approximate percent substandard	Number	0–100
	Approximate percent substandard	Number	0–100
Sprinklers (in harsh environments)	Manufacturer	String (48)	Alphanumeric
	SIN	String (48)	Alphanumeric
	Quick response	Character	(Y) Yes (N) No
	Year manufactured	4 Characters	xxxx (year)
	Approximate number of sprinkler	Number	≥0
	Visible leakage or significant corrosion or damage	Character	(Y) Yes (N) No
	Approximate percent substandard	Number	0–100
	Approximate percent substandard	Number	0–100
Sprinklers and automatic spray nozzles protecting commercial cooking equipment and ventilation systems	Manufacturer	String (48)	Alphanumeric
	SIN	String (48)	Alphanumeric
	Quick response	Character	(Y) Yes (N) No
	Year manufactured	4 characters	xxxx (year)
	Approximate number of sprinkler	Number	≥0
	Visible leakage or significant corrosion or damage	Character	(Y) Yes (N) No
	Approximate percent substandard	Number	0 –100
	Approximate percent substandard	Number	0 –100
Suction tanks	Tank full	Character	(Y) Yes (N) No
Supervisory device	Functioned correctly	Character	(Y) Yes (N) No
Supports	Correctly installed	Character	(Y) Yes (N) No

Δ ***TABLE F.5.2(d)*** *Continued*

Item	*Item Component*	*Format*	*Possible Values*
System pressure-regulating devices	Functioned correctly	Character	(Y) Yes (N) No
Tank alarm and supervisory component, enclosure temperature	Connected to constantly monitored location	Character	(Y) Yes (N) No
	Functioned correctly	Character	(Y) Yes (N) No
Tank alarm and supervisory component, high and low water level	Connected to constantly monitored location	Character	(Y) Yes (N) No
	Functioned correctly	Character	(Y) Yes (N) No
Tank alarm and supervisory component, low water temperature alarms	Connected to constantly monitored location	Character	(Y) Yes (N) No
	Functioned correctly	Character	(Y) Yes (N) No
Tank alarm and supervisory component, temperature alarms	Connected to constantly monitored location	Character	(Y) Yes (N) No
	Functioned correctly	Character	(Y) Yes (N) No
Tank alarm and supervisory component, valve supervision	Connected to constantly monitored location	Character	(Y) Yes (N) No
	Functioned correctly	Character	(Y) Yes (N) No
Tank alarm and supervisory component, water level alarms	Connected to constantly monitored location	Character	(Y) Yes (N) No
	Functioned correctly	Character	(Y) Yes (N) No
Tank alarm and supervisory component, water temperature	Connected to constantly monitored location	Character	(Y) Yes (N) No
	Functioned correctly	Character	(Y) Yes (N) No
Tank catwalks and ladders	Passed visual inspection	Character	(Y) Yes (N) No
Tank check valves	Functioned correctly	Character	(Y) Yes (N) No (3) Not verified

TABLE F.5.2(e) *Fire Pump Information and Testing*

Item	*Item Component*	*Item*	*Item*
Basic information (should be supplied by the fire pump package integrator)	Common equipment data		See Table F.5.2(c).
	Fire pump type	String (40)	P
	Rated flow	Number	>0
	Rated pressure	Number	>0
	Rated speed	Number	>0
	Rated horsepower	Number	>0
	Factory test pressure	Number	>0
	Design net churn pressure	Number	>0
	Design net 150 percent pressure	Number	>0
Basic information	Pump start pressure	Number	>0
	Pump reset pressure	Number	>0
	Design suction pressure	Number	>0
	Design discharge pressure	Number	>0
	Electric motor manufacturer	String (40)	Alphanumeric
	Electric motor type	String (40)	Alphanumeric
	Electric motor serial number	String (40)	Alphanumeric
	Electric motor model number	String (40)	Alphanumeric
	Electric motor date in service	Date	Year/month/day
	Nominal system voltage	Number	>0
	Electric motor rated horsepower	Number	>0
	Electric motor rated speed	Number	>0
	Motor rated FLA at the system nominal voltage	Number	>0
	Motor service factor	Number	>0
	Motor starting code	ASCII	A–H
	Nameplate full load amps	Number	>0
	Diesel engine manufacturer	String (40)	Alphanumeric
	Diesel engine serial number	String (40)	Alphanumeric
	Diesel engine model number	String (40)	Alphanumeric
	Diesel engine date in service	Date	Year/month/day
	Diesel engine rated horsepower	Number	>0
	Diesel engine rated speed	Number	>0
	Controller manufacturer	String (40)	Alphanumeric
	Controller type	String (40)	Alphanumeric
	Controller serial number	String (40)	Alphanumeric
	Controller model number	String (40)	Alphanumeric
	Controller date in service	Date	Year/month/day
	Jockey pump manufacturer	String (40)	Alphanumeric
	Jockey pump type	String (40)	Alphanumeric
	Jockey pump serial number	String (40)	Alphanumeric
	Jockey pump model number	String (40)	Alphanumeric
	Jockey pump date in service	Date	Year/month/day
	Jockey pump horsepower	Number	>0
	Jockey pump start pressure	Number	>0
	Jockey pump reset pressure	Number	>0
	Jockey pump controller manufacturer	String (40)	Alphanumeric
	Jockey pump controller type	String (40)	Alphanumeric

TABLE F.5.2(e) *Continued*

Item	*Item Component*	*Item*	*Item*
	Jockey pump controller serial number	String (40)	Alphanumeric
	Jockey pump controller model number	String (40)	Alphanumeric
	Jockey pump controller date in service	Date	Year/month/day
	Maximum system flow demand (at pump discharge flange)	Number	>0
	Maximum system pressure demand (at pump discharge flange)	Number	>0
Continuously monitored data	Fire pump power status	Number	(0) Off (1) On
	Fire pump running status		(0) Off (1) Running
	Fire pump test running		(0) No (1) Yes
	Suction pressure [psi (bar)]	Number	>0
	System pressure [psi (bar)]	Number	>0
	Pump discharge pressure [psi (bar)]	Number	>0
	Water temperature in pump casing	Number	>0
	Room temperature	Number	>0
	Last pump start date	Date	Year/month/day
	Last pump start time	Time	Hour(n)/min(n)/sec(n)
	Pressure at pump start	Number	>0
	Type of start		(1) Automatic demand (2) Automatic test (3) Manual
	Last pump shutdown date	Date	Year/month/day
	Last pump shutdown time	Time	Hour(n)/min(n)/sec(n)
	System pressure at pump shutdown	Number	>0
	Type of shutdown	Number	(1) Automatic demand (2) Automatic test (3) Manual (4) Overspeed (5) Other trouble
	Loss of power	Number	(1) Power on (2) Power off
	Transfer of power	Number	(1) Normal power (2) Standby power
	Fuel tank level (0-Above 2/3, 1-below 2/3)	Number	>0
	Fuel tank level (percentage full)	Number	>0
	Fuel maintenance system status	Number	(1) On (2) Off (3) Needs maintenance
Nonflow test data sets — 10 sets maintained in local equipment	Last nonflow monitoring reset date	Date	Year/month/day
	Last nonflow monitoring reset time	Time	Hour(n)/min(n)/sec(n)
	Total number of nonflow tests during monitored period	Number	>0
	Total pump test run time during monitored period (minutes)	Number	>0

(continues)

TABLE F.5.2(e) Continued

Item	*Item Component*	*Item*	*Item*
	Nonflow test date start	Date	Year/month/day
	Nonflow test time start		Hour(n)/min(n)/sec(n)
	Nonflow test date end	Date	Year/month/day
	Nonflow test time end		Hour(n)/min(n)/sec(n)
	Nonflow test reference identifier	Number	>0
	Nonflow test data set reference identifier	Number	>0
	Nonflow test suction pressure [psi (bar)]	Number	>0
	Nonflow test system pressure [psi (bar)]	Number	>0
	Nonflow test pump discharge pressure [psi (bar)]	Number	>0
	Nonflow test net pressure [psi (bar)]	Number	>0
	Nonflow test water temperature in pump casing	Number	>0
	Nonflow test room temperature	Number	>0
	Nonflow test pump start date	Date	Year/month/day
	Nonflow test pump start time	Time	Hour(n)/min(n)/sec(n)
	Nonflow test pressure at pump start	Number	>0
	Nonflow test minimum transducer pressure	Number	>0
	Nonflow test type of start (1-automatic demand, 2-automatic test, 3-manual)	Number	>0
	Nonflow test pump shutdown time	Number	>0
	Nonflow test system pressure at pump shutdown	Number	>0
	Nonflow test type of shutdown	Number	(1) Automatic demand (2) Automatic test (3) Manual (4) Overspeed (5) Other trouble
	Nonflow test RPM	Number	>0
	Nonflow test voltage, Phase A–B	Analog signal converted to number	>0
	Nonflow test voltage, Phase B–C	Analog signal converted to number	>0
	Nonflow test voltage, Phase C–A	Analog signal converted to number	>0
	Nonflow test amperage, Phase 1	Analog signal converted to number	>0
	Nonflow test amperage, Phase 2	Analog signal converted to number	>0
	Nonflow test amperage, Phase 3	Analog signal converted to number	>0
Acceptance test data set (percentage) — permanent — 0, 25, 50, 75, 100, 125, and 150	Test date acceptance test	Date	Year/month/day
	Test reference identifier acceptance test	Number	>0
	Data set reference identifier acceptance test	Number	>0
	Suction pressure acceptance test	Number	>0
	System pressure acceptance test	Number	>0
	Discharge pressure acceptance test	Number	>0

TABLE F.5.2(e) Continued

Item	*Item Component*	*Item*	*Item*
	Net pressure	Number	>0
	Water temperature in pump casing acceptance test	Number	>0
	Room temperature — acceptance test	Number	>0
	Initial pump start date — acceptance test	Date	Year/month/day
	Initial pump start time — acceptance test	Time	Hour(n)/min(n)/sec(n)
	Final pump stop date — acceptance test	Date	Year/month/day
	Final pump stop time — acceptance test	Time	Hour(n)/min(n)/sec(n)
	Pump start dates — acceptance test (record up to 10)	Date	Year/month/day
	Pump start times — acceptance test (record up to 10)	Date	Year/month/day
	Pump stop dates — acceptance test (record up to 10)	Date	Year/month/day
	Pump Stop Times — acceptance test (record up to 10)	Number	>0
	Pressure at pump start acceptance test	Number	>0
	Type of start acceptance test	Number	(1) Automatic demand (2) Automatic test (3) Manual
	Minimum transducer pressure at startup acceptance test	Number	>0
	Number of starts and stops during acceptance test	Number	>0
	Final pump shutdown time acceptance test	Number	>0
	System pressure at final pump shutdown	Number	>0
	Type of shutdown		(1) Automatic demand (2) Automatic test (3) Manual (4) Overspeed (5) Other trouble
	Loss of power (for transfer) date	Date	Year/month/day
	Loss of power (for transfer) time	Time	Hour(n)/min(n)/sec(n)
	Transfer of power date	Date	Year/month/day
	Transfer of power time	Time	Hour(n)/min(n)/sec(n)
	Day power restored to normal	Date	Year/month/day
	Time power restored to normal	Time	Hour(n)/min(n)/sec(n)
	Date readings recorded	Date	Year/month/day
	Time readings recorded	Time	Hour(n)/min(n)/sec(n)
	RPM	Number	>0
	Voltage Phase A–B acceptance test	Analog signal converted to number	>0
	Voltage Phase B–C acceptance test	Analog signal converted to number	>0
	Voltage Phase C–A acceptance test	Analog signal converted to number	>0
	Amperage Phase 1 acceptance test	Analog signal converted to number	>0

(continues)

TABLE F.5.2(e) Continued

Item	*Item Component*	*Item*	*Item*
	Amperage Phase 2 acceptance test	Analog signal converted to number	>0
	Amperage Phase 3 acceptance test	Analog signal converted to number	>0
	Nozzle coefficient acceptance test, up to 20 per test	Number	>0
	Nozzle size acceptance test, up to 20 per test [in. (mm)]	Number	>0
	Nozzle pitot pressure acceptance test, up to 20 per test	Number	>0
	Fuel tank level acceptance test (0-Above 2/3, 1-below 2/3)	Number	>0
	Fuel tank level acceptance test (percentage full)	Number	>0
	Flow through pump acceptance test	Number	>0
	RPM adjusted net pressure acceptance test	Number	>0
	RPM adjusted flow acceptance test [gpm (L/min)]	Number	>0
	Percentage of factory-certified curve acceptance test	Number	>0
	Hours on diesel engine or electric motor at start of acceptance test	Number	>0
	Hours on diesel engine or electric motor at conclusion of acceptance test	Number	>0
	Pump passed initial acceptance test	Character	(Y) Yes (N) No
	Pump could supply maximum system demand acceptance test	Number	(1) Yes (2) No (3) Demand not known
	Pump was significantly impaired acceptance test	Character	(Y) Yes (N) No
	Pump was partially impaired acceptance test	Character	(Y) Yes (N) No
	Pump passed after adjustments acceptance test	Character	(Y) Yes (N) No
	Failure mode acceptance test (See Standardized List.)	Number	>0
	Explanation of failure acceptance test	String (80)	Alphanumeric
Current performance test data set (percentage) — permanent — 0, 25, 50, 75, 100, 125, and 150	Test date — current performance test	Date	Year/month/day
	Test reference identifier — current performance test	Number	>0
	Data set reference identifier — current performance test	Number	>0
	Suction pressure — current performance test	Number	>0

TABLE F.5.2(e) Continued

Item	*Item Component*	*Item*	*Item*
	System pressure — current performance test	Number	>0
	Discharge pressure — current performance test	Number	>0
	Net pressure	Number	>0
	Water temperature in pump casing — current performance test	Number	>0
	Room temperature — current performance test	Number	>0
	Initial pump start date — current performance test	Date	Year/month/day
	Initial pump start time — current performance test	Time	Hour(n)/min(n)/sec(n)
	Final pump stop date — current performance test	Date	Year/month/day
	Final pump stop time — current performance test	Time	Hour(n)/min(n)/sec(n)
	Pump start dates — current performance test (record up to 10)	Date	Year/month/day
	Pump start times — current performance test (record up to 10)	Time	Hour(n)/min(n)/sec(n)
	Pump stop dates — current performance test (record up to 10)	Date	Year/month/day
	Pump stop times — current performance test (record up to 10)	Time	Hour(n)/min(n)/sec(n)
	Pressure at pump start — current performance test	Number	>0
	Type of start — current performance test	Number	(1) Automatic demand (2) Automatic test (3) Manual
	Minimum transducer pressure at startup — current performance test	Number	>0
	Number of starts and stops during — current performance test	Number	>0
		Number	>0
	System pressure at final pump shutdown	Number	>0
	Type of shutdown	Number	(1) Automatic demand (2) Automatic test (3) Manual (4) Overspeed (5) Other trouble
	Loss of power (for transfer) date	Date	Year/month/day
	Loss of power (for transfer) time	Time	Hour(n)/min(n)/sec(n)
	Transfer of power date	Date	Year/month/day
	Transfer of power time	Time	Hour(n)/min(n)/sec(n)
	Day power restored to normal	Date	Year/month/day
	Time power restored to normal	Time	Hour(n)/min(n)/sec(n)
	Date readings recorded	Date	Year/month/day
	Time readings recorded	Time	Hour(n)/min(n)/sec(n)

(continues)

TABLE F.5.2(e) Continued

Item	*Item Component*	*Item*	*Item*
	RPM	Number	>0
	Voltage Phase A–B current performance test	Analog signal converted to number	>0
	Voltage Phase B–C current performance test	Analog signal converted to number	>0
	Voltage Phase C–A current performance test	Analog signal converted to number	>0
	Amperage Phase 1 current performance test	Analog signal converted to number	>0
	Amperage Phase 2 current performance test	Analog signal converted to number	>0
	Amperage Phase 3 current performance test	Analog signal converted to number	>0
	Nozzle coefficient — current performance test, up to 20 per test	Number	>0
	Nozzle size — current performance test, up to 20 per test [in. (mm)]	Number	>0
	Nozzle pitot pressure — current performance test, up to 20 per test	Number	>0
	Fuel tank level — current performance test (0-Above 2/3, 1-below 2/3)	Number	>0
	Fuel tank level — current performance test (percentage full)	Number	>0
	Flow through pump — current performance test	Number	>0
	RPM adjusted net pressure — current performance test	Number	>0
	RPM adjusted flow — current performance test [gpm (L/min)]	Number	>0
	Percentage of factory-certified curve — current performance test	Number	>0
	Hours on diesel engine or electric motor at start of current performance test	Number	>0
	Hours on diesel engine or electric motor at conclusion of current performance test	Number	>0
	Pump passed initial — current performance test	Character	Y/N
	Pump could supply maximum system demand — current performance test	Number	(1) Yes (2) No (3) Demand not known
	Pump was significantly impaired — current performance test	Character	Y/N
	Pump was partially impaired — current performance test	Character	Y/N
	Pump passed after adjustments — current performance test	Character	Y/N
	Failure mode — current performance test	Number	See Standardized List.
	Explanation of failure — current performance test	String(80)	Alphanumeric

TABLE F.5.2(e) *Continued*

Item	*Item Component*	*Item*	*Item*
Previous performance test data set (percentage) — static — 0, 25, 50, 75, 100, 125, and 150	Test date — previous performance test	Date	Year/month/day
	Test reference identifier — previous performance test	Time	Hour(n)/min(n)/sec(n)
	Data set reference identifier — previous performance test	Number	>0
	Suction pressure — previous performance test	Number	>0
	System pressure — previous performance test	Number	>0
	Discharge pressure — previous performance test	Number	>0
	Net pressure	Number	>0
	Water temperature in pump casing — previous performance test	Number	>0
	Room temperature — previous performance test	Number	>0
	Initial pump start date — previous performance test	Date	Year/month/day
	Initial pump start time — previous performance test	Time	Hour(n)/min(n)/sec(n)
	Final pump stop date — previous performance Test	Date	Year/month/day
	Final pump stop time — previous performance test	Time	Hour(n)/min(n)/sec(n)
	Pump start dates — previous performance test (record up to 10)	Date	Year/month/day
	Pump start times — previous performance test (record up to 10)	Time	Hour(n)/min(n)/sec(n)
	Pump stop dates — previous performance test (record up to 10)	Date	Year/month/day
	Pump stop times — previous performance test (record up to 10)	Time	Hour(n)/min(n)/sec(n)
	Pressure at pump start — previous performance test	Number	>0
	Type of start — previous performance test (1-automatic demand, 2-automatic test, 3-manual)	Number	>0
	Minimum transducer pressure at startup — previous performance test	Number	>0
	Number of starts and stops —previous performance test	Number	>0
	Final pump shutdown time — previous performance test	Number	>0
	System pressure at final pump shutdown	Number	>0
	Type of shutdown	Number	(1) Automatic demand (2) Automatic test (3) Manual (4) Overspeed (5) Other trouble

(continues)

TABLE F.5.2(e) Continued

Item	*Item Component*	*Item*	*Item*
	Loss of power (for transfer) date	Date	Year/month/day
	Loss of power (for transfer) time	Time	Hour(n)/min(n)/sec(n)
	Transfer of power date	Date	Year/month/day
	Transfer of power time	Time	Hour(n)/min(n)/sec(n)
	Day power restored to normal	Date	Year/month/day
	Time power restored to normal	Time	Hour(n)/min(n)/sec(n)
	Date readings recorded	Date	Year/month/day
	Time readings recorded	Time	Hour(n)/min(n)/sec(n)
	RPM		>0
	Voltage Phase A–B previous performance test	Analog signal converted to number	>0
	Voltage Phase B–C previous performance test	Analog signal converted to number	>0
	Voltage Phase C–A previous performance test	Analog signal converted to number	>0
	Amperage Phase 1 previous performance test	Analog signal converted to number	>0
	Amperage Phase 2 previous performance test	Analog signal converted to number	>0
	Amperage Phase 3 previous performance test	Analog signal converted to number	>0
	Nozzle coefficient — previous performance test, up to 20 per test	Number	>0
	Nozzle size — previous performance test, up to 20 per test [in. (mm)]	Number	>0
	Nozzle pitot pressure — previous performance test, up to 20 per test	Number	>0
	Fuel tank level previous performance test (0-Above 2/3, 1-below 2/3)	Number	>0
	Fuel tank level — previous performance test (percentage full)	Number	>0
	Flow through pump — previous performance test	Number	>0
	RPM adjusted net pressure — previous performance test	Number	>0
	RPM adjusted flow — previous performance test [gpm (L/min)]	Number	>0
	Percentage of factory-certified curve — previous performance test	Number	>0
	Hours on diesel engine or electric motor at start of previous performance test	Number	>0
	Hours on diesel engine or electric motor at conclusion of previous performance test	Number	>0
	Pump passed initial — previous performance test	Character	Y/N
	Pump could supply maximum system demand — previous performance test	Number	(1) Yes (2) No (3) Demand not known

TABLE F.5.2(e) Continued

Item	*Item Component*	*Item*	*Item*
	Pump was significantly impaired — previous performance test	Character	Y/N
	Pump was partially impaired — previous performance test	Character	Y/N
	Pump passed after adjustments — previous performance test	Character	Y/N
	Failure mode — previous performance test	Number	See Standardized List.
	Explanation of failure — previous performance test	String (80)	Alphanumeric
Repair maintenance data (20 sets)	Date of maintenance/repair	Date	Year/month/day
	Maintenance/repair identifier	Number	>0
	Routine maintenance/repair	Character	Y/N
	Pump out of service during maintenance/repair	Character	Y/N
	Date pump out of service	Date	Year/month/day
	Time pump out of service	Time	Hour(n)/min(n)/sec(n)
	Date pump restored to service	Date	Year/month/day
	Time pump restored to service	Time	Hour(n)/min(n)/sec(n)
	Date pump maintenance/repair completed	Date	Year/month/day
	Part replaced (1)	String (40)	Alphanumeric
	Description of maintenance, repair, and/or Part 1 replacement	String (80)	Alphanumeric
	Part replaced (2)	String (40)	Alphanumeric
	Description of maintenance, repair, and/or Part 2 replacement	String (80)	Alphanumeric
	Part replaced (3)	String (40)	Alphanumeric
	Description of maintenance, repair, and/or Part 3 replacement	String (80)	Alphanumeric
	Part replaced (4)	String (40)	Alphanumeric
	Description of maintenance, repair, and/or Part 4 replacement	String (80)	Alphanumeric
	Routine maintenance or repair	String (40)	Alphanumeric
	Date repair completed	Date	Year/month/day
	Fuel tank level — current performance test	Number	(0) Above 2/3 (1) Below 2/3
	Fuel tank level — current performance test (percentage full)	Number	>0
	Fuel maintenance system status	Number	(1) In service (2) Out of service (3) Needs maintenance
	19 additional repair maintenance data sets		S
Jockey pump operation	Last jockey pump monitoring reset date	Date	Year/month/day
	Last jockey pump monitoring reset time	Time	Hour(n)/min(n)/sec(n)
	Total number of starts (since reset)	Number	>0
	Total jockey pump run time (minutes since last reset)	Number	>0
	Jockey Pump start pressure (most recent)	Number	>0
	Jockey pump stop pressure	Number	>0
	Most recent run time (seconds)	Number	>0

(continues)

TABLE F.5.2(e) Continued

Item	*Item Component*	*Item*	*Item*
Fire pump operation	Last fire pump monitoring reset date	Date	Year/month/day
	Last fire pump monitoring reset time	Time	Hour(n)/min(n)/sec(n)
	Fire pump start date and time (last 10 times)	Date	Year/month/day
	Fire pump stop date and time (last 10 times)	Time	Hour(n)/min(n)/sec(n)
	Fire pump start pressure (most recent)	Number	>0
	Fire pump stop pressure (most recent)	Number	>0
	Stop automatic or manual (most recent)	Number	>0
	Total number of starts since reset	Number	>0
	Total run time since reset (minutes)	Number	>0
	Date loss of electrical power with switch in "on" position since last reset (50 sets)	Number	>0
	Time loss of electrical power with switch in "on" position since last reset (50 sets)	Number	>0
	Date power restored after loss of power with switch in "on" position since last reset (50 sets)	Date	Year/month/day
	Time power restored after loss of power with switch in "on" position since last reset (50 sets)	Time	Hour(n)/min(n)/sec(n)
	Date power switch turned off (50 sets)	Date	Year/month/day
	Time power switch turned off (50 sets)	Time	Hour(n)/min(n)/sec(n)
	Date power switch turned back on (50 sets)	Date	Year/month/day
	Time power switch turned back on (50 sets)	Time	Hour(n)/min(n)/sec(n)

F.5.2.1 The data formats shown in Table F.5.2.1 are used in Table F.5.2(a), Table F.5.2(b), Table F.5.2(c), and Table F.5.2(d).

TABLE F.5.2.1 *Data Formats*

Reference Name	*Format*	*Possible Values*			
Bit		0 or 1			
Byte	8 bits	0–256			
Character	1 byte	0–256 (These can be interpreted as letters, numbers, or symbols using ASCII convention.)			
Integer	2 bytes	0–65,534 (During interpretation, a decimal place may be assumed. When using an assumed decimal place for a number in which the first digit might exceed 5, the number is limited to four digits.)			
Number	5 bytes	Byte	Value	Number	Power of 10
		1st byte	0	Positive	Positive
			1	Positive	Negative
			2	Negative	Positive
			3	Negative	Negative
		2nd–4th bytes	0–16,777,216		
		5th byte	0–255 (10^n)		
String	Multibytes as specified [e.g., String (80) is 80 bytes]	Any letters, numbers, or symbols represented in the ASCII convention			
Date	8 characters	xxxx (year) xx (month) xx (day)			
Time	3 bytes	n (hours, 0–24) n (minutes, 0–60) n (seconds, 0–60)			

F.5.2.2 All inspection, test, and maintenance data should be recorded in the format provided in Table F.5.2(a). All repair data should be recorded in the format provided in Table F.5.2(b).

F.5.2.3 All recorded information should be protected in accordance with F.5.1 and/or other appropriate security to limit access to appropriate entities.

Reference Cited in Commentary

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 20, *Standard for the Installation of Stationary Fire Pumps for Fire Protection,* 2019 edition.

NFPA



ANNEX G

COLOR-CODED TAGGING PROGRAM

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

G.1 Tagging Program.

To assist with the enforcement and application of NFPA 25, some authorities having jurisdiction (AHJs) adopt color-coded system status tagging programs. The purpose of these programs varies, but the typical goal is to promote the timely determination of the following:

(1) Have the inspections and tests required by this standard been completed at their designated frequencies?
(2) Were the systems inspected and/or tested in compliance with this standard at the time of the inspections and tests?

While NFPA 25 does not mandate system status tagging, it is desirable that a certain level of consistency exist between programs. With that in mind, AHJs using a color-coded system status tagging program are urged to consider the following:

(1) *Overall Goal of the Program.* Once that is determined, questions to ask about the program might include the following:
    (a) Does the presence of a particular color tag indicate that all tasks are completed at the required frequency, and, if so, how often are the tags placed? For example, if a green tag is meant to signify compliance with NFPA 25, which frequency does that compliance correspond to? (NFPA 25 establishes frequencies from daily through 5 years and beyond.) Additionally, what should happen when a more frequent inspection (daily/weekly/monthly/quarterly/etc.) reveals no deficiencies, but later, during the annual frequency inspection, deficiencies are found?
    (b) Is the goal to inform fire department inspectors, emergency responders, and others?
(2) *Benefits and Pitfalls of a Color-Coded Tagging Program.* These might include the following:
    (a) Benefit: Quicker recognition of a system with deficiencies would promote a quicker response to system deficiencies by the owner and trigger a more in-depth review of ITM records.
    (b) Pitfalls: The presence of a tag indicating compliance with the standard might give a false sense of security if question (1)(a) is not addressed adequately, or it might create confusion between the owner and sprinkler contractor(s) if repair work is not done thoroughly; tags are not filled out completely, accurately, and consistently; or multiple contractors are employed for corrections/repairs on a single tag.

(3) *The Type and Amount of Information Contained on the Tag.* ITM records are comprehensive and contain much more information than could be condensed onto a tag. With that in mind, information required to be written on a tag should include the following as a minimum:
   (a) Identification of the system that the information on the tag represents
   (b) Employer of the technician who performed inspections, tests, or maintenance and any license or certification information required by the AHJ.
   (c) Date inspections, tests, or maintenance was performed
   (d) Type and frequency of inspections, tests, or maintenance

(4) *The Four Conditions.* This standard identifies four conditions as follows:
   (a) No deficiencies or impairments
   (b) Noncritical deficiencies
   (c) Critical deficiencies
   (d) Impairments

(5) *The Tag Colors and What the Colors Represent.* A color-coded tagging system that mirrors the standard would include the following tags:
   (a) Green tag — No deficiencies or impairments found when inspections and tests performed at the required frequency were completed as indicated on the ITM report provided to the owner
   (b) Yellow tag — Noncritical deficiencies found and recorded on the ITM report
   (c) Orange tag — Critical deficiencies found and recorded on the ITM report
   (d) Red tag — Impairments found and recorded on the ITM report (The color-coded tagging program should be kept separate from the impairment tag and other requirements outlined in Chapter 15.)
   (e) White tag — Correction/repair tag (placed along with color-coded tag after work to correct/repair deficiencies or impairments has been completed) indicating specifically which corrections or repairs were made.

(6) *How to Address Corrections or Repairs.* A tag that indicates deficiencies or impairments were corrected and when and by who is important. A green tag should only be placed on a system when inspections and tests at the required frequency have been performed and no deficiencies have been found. Many times this is not part of the work done following corrections and repairs. Following completion of corrections or repairs, a white tag should be placed, along with the yellow, orange, or red tag, briefly describing what was done to correct or repair the deficiencies or impairments. Also, all corrections and repairs should include the appropriate inspections and tests as outlined in Tables 5.5.1, 6.5.1, 7.5.1, 8.6.1, 9.6.1, 10.5.1, and 11.5.1 before they are tagged as completed.

(7) *How Long Tags Should Remain.* Subsection 4.3.5 outlines a timeline for record retention. Consideration should be given to coordinating those requirements with tagging programs.

(8) *Who Can Place or Remove Tags.* The standard requires that persons who perform ITM work must be qualified. Consideration should be given to only permitting those who are qualified to place or remove tags.

All tags should be made of durable, weatherproof, colorfast materials and should be securely affixed to the main control valve of each system. If the main control valve is not accessible, as with underground piping, the tag should be attached at a point as close as possible to the main control valve, but still visible and accessible, as on a system pressure gauge or for an underground system on a hydrant.

These are just a few of the most common points for an AHJ to consider, but this is certainly not a complete list. A well-thought-out program will be more likely to succeed than one that leaves questions unanswered.

Many jurisdictions currently utilize a color-coded system-status tagging program, and many others will follow suit in the future. Prior to the 2017 edition, NFPA 25 was silent on the concept, so there was no guidance from the technical committee for authorities having jurisdiction (AHJs) considering such a program. While the inclusion of this annex does not mean that a tagging program is required by NFPA 25, the added guidance provides a framework intended to provide consistency to programs and technical committee guidance to AHJs seeking input.

This annex was developed by an NFPA 25 technical committee task group. The task group used a report prepared by the Fire Protection Research Foundation (FPRF) in the development of this tagging methodology. The focus of the FPRF study was to collect data on all known tagging programs in the United States. The review considered tagging programs applied at both the state and municipal level. The complete report is available at nfpa.org/News-and-Research.

G.2 Sample Tags.

Figure G.2(a), Figure G.2(b), Figure G.2(c), Figure G.2(d), and Figure G.2(e) illustrate typical color-coded tags.

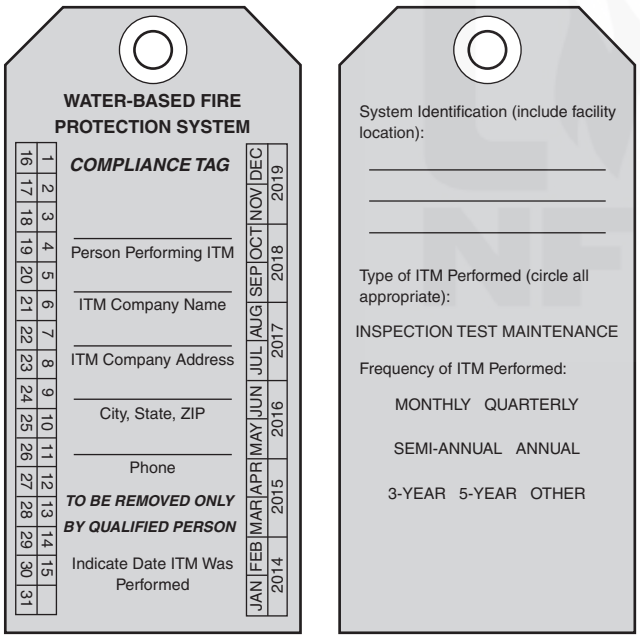


FIGURE G.2(a) *Sample Compliance Tag (Green Tag).*

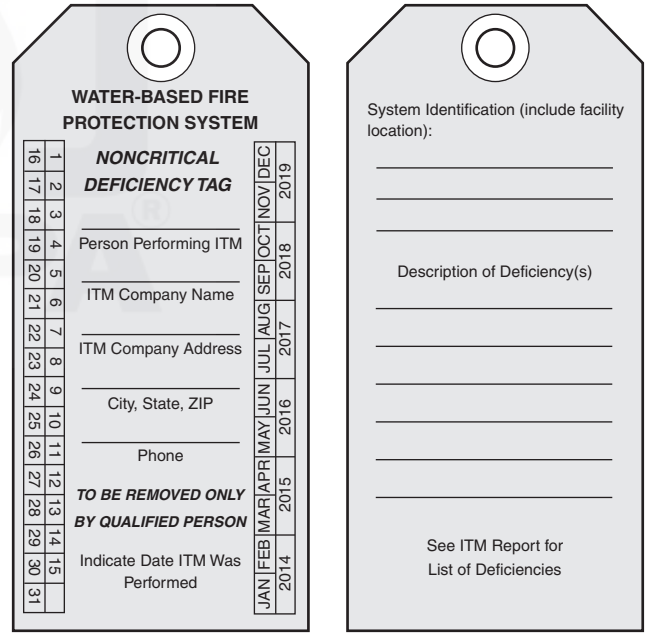


FIGURE G.2(b) *Sample Noncritical Deficiency Tag (Yellow Tag).*

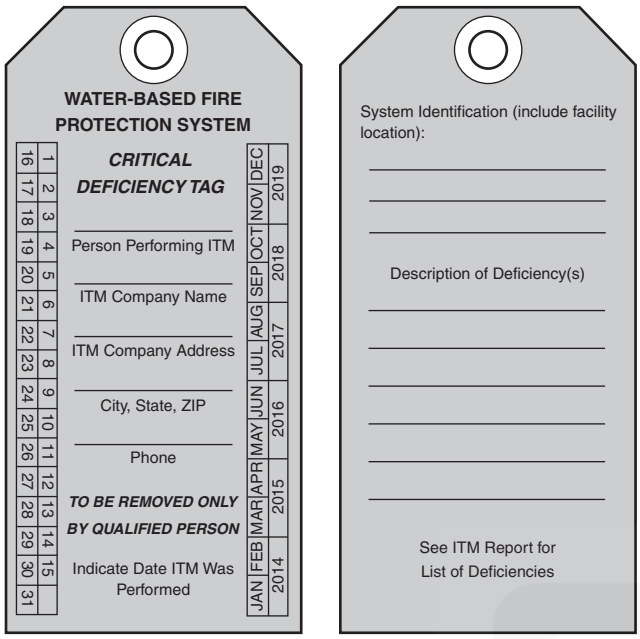


FIGURE G.2(c) *Sample Critical Deficiency Tag (Orange Tag).*

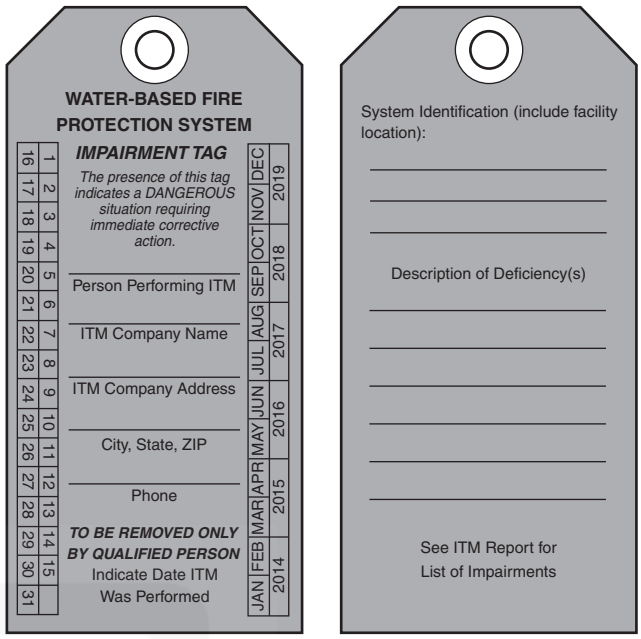


FIGURE G.2(d) *Sample Impairment Tag (Red Tag).*

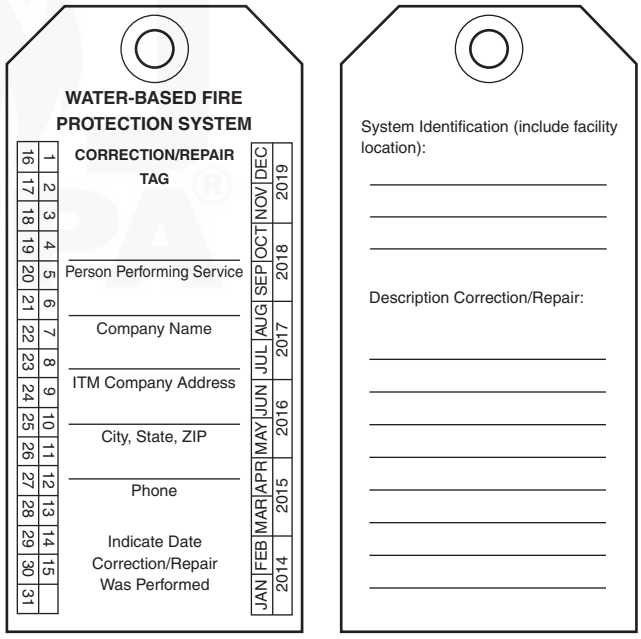


FIGURE G.2(e) *Sample Correction/Repair Tag (White Tag).*



ANNEX H

INFORMATIONAL REFERENCES

H.1 Referenced Publications.

The documents or portions thereof listed in this annex are referenced within the informational sections of this standard and are not part of the requirements of this document unless also listed in Chapter 2 for other reasons.

Δ **H.1.1 NFPA Publications.** National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2019 edition.

NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*, 2019 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 2019 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 2017 edition.

NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*, 2019 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, 2019 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection*, 2018 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, 2019 edition.

NFPA 70E®, *Standard for Electrical Safety in the Workplace®*, 2018 edition.

NFPA 72®, *National Fire Alarm and Signaling Code®*, 2019 edition.

NFPA 110, *Standard for Emergency and Standby Power Systems*, 2019 edition

NFPA 291, *Recommended Practice for Fire Flow Testing and Marking of Hydrants*, 2019 edition.

NFPA 551, *Guide for the Evaluation of Fire Risk Assessments*, 2019 edition.

NFPA 750, *Standard on Water Mist Fire Protection Systems*, 2019 edition.

NFPA 780, *Standard for the Installation of Lightning Protection Systems*, 2020 edition.

NFPA 1962, *Standard for the Care, Use, Inspection, Service Testing, and Replacement of Fire Hose, Couplings, Nozzles, and Fire Hose Appliances*, 2018 edition.

Antifreeze Systems in Home Fire Sprinkler Systems — Literature Review and Research Plan, Fire Protection Research Foundation, June 2010.

Antifreeze Systems in Home Fire Sprinkler Systems — Phase II Final Report, Fire Protection Research Foundation, December 2010.

Antifreeze Solutions Supplied through Spray Sprinklers — Interim Report, Fire Protection Research Foundation, February 2012.

"Fire Pump Field Data Collection and Analysis Report," available for download at www.nfpa.org/Foundation, 2011.

NFPA's Future in Performance Based Codes and Standards, July 1995.

NFPA Performance Based Codes and Standards Primer, December 1999.

H.1.2 Other Publications.

H.1.2.1 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

IEEE/ASTM-SI-10, *American National Standard for Metric Practice,* 2016.

H.1.2.2 AWWA Publications. American Water Works Association, 6666 West Quincy Avenue, Denver, CO 80235.

AWWA *Manual of Water Supply Practices — M42 Steel Water-Storage Tanks*, 2013.

N **H.1.2.3 BSI Publications.** British Standards Institution, 389 Chiswick High Road, London, W4 4AL, United Kingdom.

EN 12259-1, *Fixed firefighting systems – Components for sprinkler and water spray systems – Part 1: Sprinklers*, 1999 edition.

N **H.1.2.4 FM Publications.** FM Approvals LLC, 1151 Boston-Providence Turnpike, P.O. Box 9102, Norwood, MA 02062.

FM Approvals Standard 5560, *Water Mist Systems*, 2012 edition.

N **H.1.2.5 CGA Publications.** CGA Publications. Compressed Gas Association, 14501 George Carter Way, Suite 103, Chantilly, VA 20151.

CGA C-6, *Standard for Visual Inspection of Steel Compressed Gas Cylinders*, 2013.

H.1.2.6 Hydraulic Institute Publications. Hydraulic Institute, 9 Sylvan Way, Parsippany, NJ 07054.

Hydraulic Institute Standards for Centrifugal, Rotary and Reciprocating Pumps, 14th edition, 1983.

N **H.1.2.7 UL Publications.** Underwriters Laboratories, Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

UL 2167, *Standard for Water Mist Nozzles for Fire Protection Service*, 2017.

N **H.1.2.8 IMO Publications.** International Maritime Organization, 4 Albert Embankment, London SE1 7SR.

MSC.1/Circular 1432, *Guidelines for the Maintenance and Inspection of Fire Protection Systems and Appliances*, 2012.

H.1.2.9 SFPE Publications. Society of Fire Protection Engineers, 9711 Washington Blvd., Suite 380 W, Gaithersburg, MD, 20878.

SFPE *Engineering Guide: Fire Risk Assessment*, 2006.

SFPE *Engineering Guide to Performance-Based Fire Protection*, 2nd edition, 2007.

SFPE *Handbook of Fire Protection Engineering*, 5th edition, 2016.

N **H.1.2.10 U.S. Government Publications.** U.S. Government Publishing Office, 732 North Capitol Street, NW, Washington, DC 20401-0001.

Department of Defense Handbook MIL-HDBK-695D, *Rubber Products: Recommended Shelf Life*, 23 May 2005.

Title 49, Code of Federal Regulations.

H.1.2.11 Other Publications. Edward K. Budnick, P.E., "Automatic Sprinkler System Reliability," *Fire Protection Engineering*, SFPE, Winter 2001.

Fire Protection Equipment Surveillance Optimization and Maintenance Guide, Electric Power Research Institute, July 2003.

Kenneth W. Dungan, P.E., "Performance-Based Inspection, Testing, and Maintenance," *Fire Protection Engineering*, SFPE, Quarter 4, 2016.

William E. Koffel, P.E., *Reliability of Automatic Sprinkler Systems*, Alliance for Fire Safety.

H.2 Informational References.

The following documents or portions thereof are listed here as informational resources only. They are not a part of the requirements of this document.

H.2.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 1, *Fire Code*, 2018 edition.
Water-Based Fire Protection Systems Handbook, 2020 edition.

H.2.2 Other Publications.

H.2.2.1 AWWA Publications. American Water Works Association, 6666 West Quincy Avenue, Denver, CO 80235.

AWWA D101, *Inspecting and Repairing Steel Water Tanks, Standpipes, Reservoirs, and Elevated Tanks, for Water Storage*, 1986.

N **H.2.2.2 SSPC Publications.** Society for Protective Coatings, 800 Trumbull Drive, PA 15205.

SSPC Chapter 3, "Special Pre-Paint Treatments," 1993.
SSPC-PA 1, *Shop, Field, and Maintenance Coating of Metals*, 2016.
SSPC PA 9, *White (or Colored) Vinyl Paint*, 2015.
SSPC-SP 6, *Commercial Blast Cleaning*, 2007.
SSPC-SP 8, *Pickling*, 2004.
SSPC-SP 10, *Near-White Blast Cleaning*, 2007.

H.2.2.3 U.S. Government Publications. U.S. Government Publishing Office, Washington, DC 20402.

Bureau of Reclamation Specification VR-3.
Federal Specification TT-P-86, *Specifications for Vinyl Resin Paint*, M-54, 1995.

H.3 References for Extracts in Informational Sections.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2019 edition.
NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 2019 edition.
NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 2017 edition.
NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, 2019 edition.
NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, 2019 edition.
NFPA 1142, *Standard on Water Supplies for Suburban and Rural Fire Fighting*, 2017 edition.

NFPA

PART 2

Supplements

In addition to the 2020 edition of NFPA 25 and the commentary presented in Part 1, the NFPA 25 Handbook: ITM of Water-Based Fire Protection Systems includes five supplements. The supplements included in Part 2 of this handbook are not part of NFPA 25; they are included as additional information for handbook users. The supplements in Part 2 are as follows:

1. Conducting Fire Pump Flow Tests
2. ITM Roles and Responsibilities
3. Role of the Inspector
4. Role of the Owner or Designated Representative
5. Role of the Authority Having Jurisdiction

NFPA



SUPPLEMENT 1

CONDUCTING FIRE PUMP FLOW TESTS

By Bruce H. Clarke

Editor's Note: *In many buildings, the fire pump is a critical element for delivering a sufficient amount of water to a sprinkler or standpipe system. It is imperative that, where a pump is installed, it is properly maintained and that the functional performance of the pump is confirmed through the required flow tests in Chapter 8. This supplement looks at the process for conducting these tests, and more importantly, how the information ascertained during the testing should be interpreted to confirm pump functionality.*

NFPA 25 does not provide a specific procedure or set of steps that must be followed to conduct a flow test in accordance with Chapter 8. Chapter 8 simply provides a requirement that the test must be conducted. The following sections provide an approach for conducting these flow tests. It is important to keep in mind that the approaches shown below are not mandated by NFPA 25 and might not be appropriate for all installations. The types and models of system components installed vary greatly from installation to installation; therefore, specific procedures outlined in the manufacturer's literature should also be reviewed.

Sample Testing Procedure

Purpose

The following is a description of the testing procedures necessary to conduct the annual test required in 8.3.3.1. This test allows the owner/inspector to determine the fire pump's capability based on its current operating condition. The owner/inspector can then compare the current data to the certified shop test curve to quantify the pump degradation since its installation.

Tools/Equipment

The test equipment required should be in good working condition and of such quality as to not be questioned should a flow test fail. All gauges used in the test (i.e., those for the suction and discharge sides of the pump as well as the pitot tube) should have recent calibration within the past 6 to 12 months. Gauges should be calibrated at least annually by means of a dead-weight or calibrated tester throughout the range of operation. Calibration sheets should be kept for each gauge and correction factors affixed to the back of each gauge before a test series is begun. The flow characteristics of the test nozzles should be known, as well. While listed play pipes have standard flow performance curves, some proprietary flow devices, such as hose monster test nozzles, have equipment specific flow charts. If flow meters are used, they require pre-test calibration. Typical tools and equipment used in the annual pump flow testing are as follows:

1. A handheld tachometer[1] is required to measure the operating speed of the fire pump and verify it on the engine.
2. A pitot tube together with a test-pressure gauge[2], suitable for the pressures to be expected, is required.

[Usually, a 60 psi (4 bar) gauge is satisfactory.] Test-quality gauges should be used in accordance with ASME B40.100, *Pressure Gauges and Gauge Attachments,* having an accuracy of ±1 percent. The use of quality test gauges produces results that are considered reasonably accurate within the scope of the testing procedure. Care should be taken to protect the gauges from rough handling. While pitot tubes for fire protection flow testing are not listed, the gauges used should be listed and should be acceptable for water or water/air systems and not only air systems.

A pitot-tube-and-gauge assembly, such as the one shown in Exhibit S1.1, is indispensable in conducting flow tests from hydrants and nozzles. The small opening at the end of the tube — not over 1/16 in. (1.6 mm) in diameter — is inserted in the center of the stream, in a direct line with the flow, at a distance in front of the opening equal to one-half the opening diameter. Velocity pressure is registered on the gauge attached to the tube. Some available test nozzles, including an integral pitot tube, are pitotless flow measuring features; they come with an attached test gauge that allows for the direct measurement of flows without the use of a separate pitot tube.

3. Test-pressure gauges suitable for measurement of expected suction and discharge pressures on the fire pump are required. Note that the gauge used on the suction side of the fire pump should be a compound pressure. The vacuum gauge should have a pressure range of at least twice the static pressure available from the suction supply. The gauge used on the discharge side of the fire pump should have a range of at least twice the rated working pressure of the fire pump.
4. A sufficient number of test nozzles are required, including hoses for connection to test headers where needed [typically 50 ft (15.2 m) lengths of lined 2½ in. (65 mm) hose might be used for this purpose], to permit the measurement of a flow rate up to 150 percent of the rated capacity of the fire pump. Test nozzles can include UL play pipes or other approved test nozzles. The flow characteristics of the test nozzles must be known.
5. The various wrenches and other specific tools necessary to allow for required adjustments during the test and for the installation of required test equipment are required.
6. For electric pump tests, a multimeter and/or clamp-on ammeter is required for taking voltage and amperage readings.
7. A timing device is required to measure the duration of the fire pump run (on acceptance tests).
8. A form for recording test data is required.
9. While not required for the actual pump test data collections, approved hearing protection and personal protective equipment (PPE) are typically required. If PPE is not handy, then the start of pump testing can often be delayed while the PPE is being located.



EXHIBIT S1.1 *Typical Pitot Tube Assembly.*

Positive Displacement Pump Flow Tests. The pump flow for positive displacement pumps is completed to meet the specified rated performance criteria. Typically, one performance point is required to establish positive displacement pump performance. Many positive displacement pumps also have special applications, such as a component in foam or water mist systems. For these types of pumps, manufacturers' data should be referenced. The pump flow test for foam positive displacement pumps typically is completed using a flowmeter or orifice plate installed in a test loop back to the foam concentrate tank or the inlet side of a water pump. The flowmeter reading or discharge pressure should be recorded and should be in accordance with the pump manufacturer's flow performance data. If orifice plates are used, the orifice size and corresponding discharge pressure to be maintained on the upstream side of the orifice plate should be made available to the authority having jurisdiction (AHJ). Flow rates should be as specified while operating at the system design pressure.

In addition to manufacturers' recommendations, systems with positive displacement pumps should reference ANSI/Hydraulic Institute 3.6, *Rotary Pump Tests,* and Chapter 12, Chapter 13, and Annex C of NFPA 750, *Standard on Water Mist Fire Protection Systems.* ANSI/Hydraulic Institute 3.6 applies to industrial rotary positive displacement pumps; it also includes detailed procedures on the setup and methods for conducting hydrostatic test and performance tests of such pumps.

Steam-Driven Turbine Fire Pumps. While Chapter 13 of NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, is dedicated to these types of pumps, they are rarely installed today due to maintenance and reliability

concerns both on the driver and steam source. A steam turbine driver for a fire pump should always be kept "warmed up" to permit instant operation at full rated speed. The automatic starting of the turbine should not be dependent on any manual valve operation or period of low-speed operation, and this should be verified as part of the test. Steam turbines are provided with governors to maintain a predetermined speed, with some adjustment for higher or lower speeds. Desired speeds below this range can be obtained by adjusting the main throttle valve.

Vertical Turbine and Horizontal Split Case Pump Flow Tests. As required by 8.3.3.1, pump flow and pressure, as well as drive shaft speed (rpm), is measured at a minimum of three points: churn (no flow), rated (100 percent flow), and peak/overload (150 percent flow).

Procedure Steps

Pre-Flow Activities/Planning.

1. If the site has a fire alarm system, notify the alarm monitoring company and place the fire alarm system on test.
2. Notify all facility representatives that testing is going to be conducted. In some cases, the amount of water flowing on the ground might require extra maintenance personnel. Or, suction pressure requirements could affect site production equipment (e.g., site cooling towers could trip off line due to low supply pressure, and so forth).
3. Notify the local fire department and/or any other AHJ that might want to attend, such as property insurance representatives.
4. Complete the required inspection activities in Section 8.2 to ensure pump system readiness for full flow testing. This maintenance should include checking battery electrolyte levels and specific gravity, inspecting cable conditions, and checking for any corrosion on pipes and other system equipment.
5. Review the fire pump assembly nameplates, noting the following:
   a. Voltage rating (electric pumps)
   b. Rated speed
   c. Rated capacity (flow)
   d. Churn pressure
   e. Rated pressure
   f. Overload pressure
6. Ensure all valves are in the proper position. Normally, pump discharge valves that supply site fire systems or fire system loops should be kept fully open throughout both weekly testing and the annual pump test. These are closed sometimes due to concern that the "high pump pressure" or "pressure fluctuations" might damage the fire system where pipe integrity is a concern. However, if fire mains are subject to damage due to pump pressures, it is best to discover this during an annual test rather than an actual fire. Where the pump churn pressure will significantly exceed the rated pressure for the system, the fire pump discharge control valve might be closed prior to the operation of the fire pump to limit the exposure of the connected systems. Consideration might be given to closure of the fire pump discharge control valve prior to conducting the test. This could limit the exposure of the connected systems to the resultant pressure surge during the start-up of the fire pump. Another method to avoid potential water hammer effects is to partially open a test header outlet at start-up, and then close it for the churn pressure reading.
7. Replace suction and discharge pressure gauges with the appropriate calibrated test gauges. (For a vertical turbine fire pump, there will only be a discharge gauge.)
8. Install flow test equipment on the test header as required, to allow for the maximum flow rate. This might include the use of hoses connected to the test header and extending them to flow measurement devices, such as listed play pipes or other test nozzles.
9. Confirm that all test equipment, such as play pipes, hoses, play pipe test stands, and so forth, are adequately secured or protected against movement. Manually securing play pipes (i.e., by hand holding) is not acceptable and could cause serious personal damage. Swivel elbows, if installed on test headers, must be locked in place with set screws to avoid spinning during testing, which could cause serious personal damage. In some cases, the connection of flow test equipment — such as play pipes — can be made directly to the test header. The use of a flow diffuser can aid in preventing movement, as well as breaking the directed stream.
10. For testing using hose-connected flow-measuring devices or UL play pipes directly connected to the test header, ensure that the individual hose connection valves on the test header are in the closed position. Then, slowly open the main test header control valve pressurizing the test header. For other flow measuring devices directly connected to the test header, ensure that the main test header control valve is closed. Then, fully open a single hose connection valve, readying the arrangement for the first flow point, with the flow being controlled by the main test header control valve. Any time the use of an additional hose connection valve is required with this latter arrangement, the additional hose connection valves are to be fully opened and the flow again controlled by the position of the main test header control valve rather than the individual hose connection valves.
11. Check the surrounding area for potential uncontrolled water flow that could cause damage — plugged drain pipes, local construction with open pits, berms subject to hydraulic erosion, and so forth. Check any relief valve or cooling water discharge outlets as well as the discharge points for the fire pump flow to ensure that there are no

obvious conditions that would prevent water from being discharged safely or cause direct damage in the immediate vicinity. Where the discharge of water is to an area subject to potential freezing conditions, the facility representative should be advised of the potential for icing conditions.

12. Check the fire pump packing glands for a slight discharge (slow drip) of water, adjusting the packing gland nuts as needed to achieve approximately 1 drip per second. If the packing is completely dry before start-up, it could overheat and fail once the pump is turned for the pump test. The overheating of bearings could also quickly occur. For safety purposes, the adjustment of the packing gland should be made while the pump is not running. Care should be exercised to ensure the glands are not tightened to the point of breaking.
13. For vertical turbine pumps, make sure the pump is completely primed.
14. In cases where a handheld tachometer will be used, verify where the point readings will be taken from and that reflective tape is installed as required. Some handheld tachometers require advance preparation prior to the test for proper measurement, such as the application of a reflective tape on the shaft. Care should be taken not to apply reflective tape on a shaft that already has it applied, because false "double readings" might occur. Since a reading will be required at each point during the actual test, care should be taken where the location tape is applied, considering the proximity to casing spray, hot engine exhaust, accessibility to the sides of a rotating shaft, and so forth.

Flow Test Activities/Planning.

1. For pressure-actuated fire pump controllers, simulate an automatic start for the fire pump by creating a pressure drop in the sensing line to the fire pump controller. This is typically accomplished by slowly opening the drain valve on the sensing line located near the fire pump controller until the fire pump starts automatically. The use of the "start" button on the fire pump controller is not acceptable for the purpose of simulating an automatic start. Note the start time of the fire pump, and record the starting pressure.

   For pressure-actuated fire pump controllers that use an automatic timer, an automatic opening of a solenoid valve in the sensing line to the fire pump controller might be used to simulate the automatic start of the fire pump. These systems must include a record of the pressure drop on the pressure recorder for the controller.

   For non-pressure-actuated fire pump controllers, the automatic start can be simulated by other means.
2. Check the fire pump packing gland for a slight discharge (slow drip) of water, adjusting the packing gland nuts as needed to achieve approximately 1 drip per second. For safety purposes, the adjustment of the packing gland should be made while the pump is not running. Care should be exercised to ensure the glands are not tightened to the point of breaking.
3. Monitor the fire pump operation for any unusual noise, vibration, or other signs of malfunction.
4. For electric-driven pumps, verify that the operation of the circulation (casing) relief valve has a steady stream of water to ensure proper cooling of the pump case.
5. Check the packing gland box, shaft bearings, and pump casing for overheating approximately every 5 minutes during the test. The packing gland box and shaft bearings might be warm to the touch, but the pump casing should remain cool throughout the test.
6. If the fire pump is equipped with a main pressure relief valve, verify the operation of the pressure relief valve such that outlet pressures do not exceed the pressure rating of the piping downstream of the fire pump. Usually, this rating is 175 psi (12.1 bar); however, some systems might be designed for higher pressures.
7. For electric-driven pumps, the motor voltage and current on all phases (lines) should be recorded from an external readout screen. Where no external screen exists, energized controller doors should not be opened; other tests' results should be used to determine if an issue exists with voltage or current. If a controller door must be opened, it should be done so by individuals trained and qualified in electrical hazards and equipped with the needed safety equipment as outlined in *NFPA 70E®*, *Standard for Electrical Safety in the Workplace®*. Also see 8.3.3.14 and Section 4.9, along with the associated commentary, for additional guidance.
8. Record the suction and discharge pressures. Note that only the discharge pressure is recorded for vertical turbine pumps.
9. Record the operating speed (rpm) of the motor.
10. The data recorded in Step 8 and Step 9 should be noted as the churn test point.
11. Initiate the flow of the fire pump by slowly opening either hose control valves on the test header or by slowly opening the main test header control valve, depending on the arrangement selected. As the valve is opened, take flow measurements to determine the flow rate, adjusting each valve position until a combined flow rate equal to the rated capacity from the nameplate on the fire pump is achieved. Where the flow rate with the valve fully open is inadequate to meet this rated capacity, additional hose valves must be opened and adjustments made until the total measured flow rate equals the rated capacity. For systems equipped with a main pressure relief valve, this should now be verified as closed and not flowing water. If it is flowing water, adjust the pressure relief valve to temporarily close.
12. Repeat Step 8 and Step 9.

13. The data recorded in Step 11 and Step 12 should be noted as the rated (or 100 percent flow) test point.
14. Continue to open hose valves and/or the main test header control valve, as in Step 11, and take flow measurements to determine the flow rate. Also, adjust the valve(s) position until a flow rate equal to the 150 percent of the rated capacity from the nameplate on the fire pump is achieved, or until the maximum available flow rate is achieved, whichever is lower. Care must be taken to ensure that the suction pressure (at the point of the city connection) does not fall below an acceptable level. NFPA 20 allows a suction pressure of 0 psi (0 bar) for fire pumps connected to municipal supplies and –3 psi (–0.2 bar) for fire pumps taking suction from a grade level tank. Some local water authorities might require a higher maintained pressure [typically 20 psi (1.4 bar) where this is a regulation], as the flow rate is increased to 150 percent.
15. Repeat Step 8 and Step 9.
16. The data recorded in Step 14 and Step 15 should be noted as the overload (or 150 percent flow) test point.
17. Shut down the flow by slowly closing the main test header control valve to avoid water hammer.
18. If the run time for the fire pump has not reached 10 minutes, then allow the fire pump to continue operating until a total run time of 10 minutes is reached. Recheck for overheating periodically during the test, and then shut it down manually upon completion of the test.
19. Plot the test data against the manufacturer's specifications *before* removing test equipment to verify a retest is not required due to bad data recording and other reasons.
20. Remove all attached test equipment from the test header, restore the closed position of all hose connection valves, and reinstall the hose caps. In locations subject to freezing, check that the test header properly drains or pumps out as necessary.
21. Remove the calibrated gauges, and reinstall the original gauges on the suction and discharge side of the fire pump. Any gauges found out of calibration should be replaced.
22. Inspect and clean any installed intake screens.
23. Verify that all of the fire pump supervisory signals (e.g., fire pump running, loss of power, phase reversal) required by NFPA 20 and NFPA 25 (see 8.3.3.13) have been indicated at the fire pump controller as well as being transmitted to any connected fire alarm panels.
24. Verify the main pressure relief valve is properly set and adjusted.
25. Verify the fire pump start-stop settings (see below).
26. If closed, reopen the fire pump discharge control valve, and conduct a valve status test downstream of the closed valve in accordance with 13.3.3.4.
27. Restore the fire pump to the automatic operating position.
28. Complete a coupling alignment check.
29. Upon completion of all testing, notify the fire department and/or the alarm monitoring company (as needed), as well as the facility representatives, that testing is complete. Reset the fire alarm system as necessary.
30. Complete the pump test data analysis to determine compliance with 8.3.3.1 and 8.3.7.1.

    At each flow test point, the quantity of water discharging from the fire pump test assembly should be stabilized as best as possible before taking pitot readings. When using multiple outlets for pitot readings, final readings on all outlets cannot accurately be made until all adjustments are completed. Due to hydraulic principles, each time one test header outlet is adjusted, the flow on others will be affected. That is, opening an additional test header will cause the flow (and related pitot readings) on others flowing to drop to a different number than the reading taken before the additional valve was opened.

Fire Pump Operational Settings. The fire pump system, when started by pressure drop, should be arranged as follows:

1. The jockey pump stop point should equal the pump churn pressure plus the minimum static supply pressure.
2. The jockey pump start point should be at least 10 psi (0.7 bar) less than the jockey pump stop point.
3. The fire pump start point should be 5 psi (0. 4 bar) less than the jockey pump start point. Use 10 psi (0.7 bar) increments for each additional pump.
4. Where minimum run timers are provided, the pump will continue to operate after attaining these pressures. The final pressures should not exceed the pressure rating of the system.
5. Where the operating differential of pressure switches does not permit these settings, the settings should be as close as equipment will permit. The settings should be established by pressures observed on test gauges.

Evaluation of Results

The text following this Testing Procedure section provides an in-depth review of interpreting the results of the annual flow test and determining if the pump has seen more than a 5 percent degradation when compared to the certified shop test curve.

References

1. American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990.
2. ASME B40.100, *Pressure Gauges and Gauge Attachments*, 2013.
3. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.
4. NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection,* 2019 edition.

5. *NFPA 70E®, Standard for Electrical Safety in the Workplace®,* 2018 edition.
6. NFPA 750, *Standard on Water Mist Fire Protection Systems,* 2019 edition.
7. Hydraulic Institute, 6 Campus Drive First Floor North, Parsippany, NJ 07054-4406.
8. ANSI/Hydraulic Institute 3.6, *Rotary Pump Tests,* 2010 edition.

Endnotes

1. All test equipment should be calibrated by an approved testing laboratory within 12 months prior to the test.
2. Test-quality gauges should be used in accordance with ASME B40.100, *Pressure Gauges and Gauge Attachments,* having an accuracy of ±1%. The use of quality test gauges produces results that are considered reasonably accurate within the scope of the testing procedure. Care should be taken to protect the gauges from rough handling. Gauges should be calibrated at least annually by means of a dead-weight or calibrated tester throughout the range of operation before a test series is begun. Calibration sheets should be kept for each gauge and correction factors affixed to the back of each gauge.

The procedure(s) outlined above is not mandated by NFPA 25 and represents only one approach to conducting this test.

Fire Pump Flow Test Analysis

The inspection, testing, and maintenance (ITM) tasks outlined in Chapter 8 of NFPA 25 are intended to ensure that a fire pump, when installed, will function at or near (within 5 percent of the original specification documentation) the performance criteria the pump was installed for. Confirming functionality is achieved by properly maintaining the equipment and conducting the necessary tests to perform a quantifiable analysis of the pump's capability based on the data gathered during the test. NFPA 25 has two specific data analysis requirements for pump flow performance after conducting an annual fire pump test to determine pump acceptance. These are as follows:

1. Determine if a fire pump net performance, relative to the original design/installation, is acceptable.

Per 8.3.7.2.3, pump *net performance* adjusted for rated speed must be graphically plotted and evaluated with a comparison to the net pressure curve from owner documents, copies of original manufacturers pump curves, pump nameplate data, or pump retrofit/rebuild documents. Additionally, per 8.3.7.2.3(3), when graphically plotted the annual net pump performance flow should be no less than 95 percent of the original pump performance across the complete flow performance curve (i.e., churn through 150 percent of rated flow).

2. Determine if a fire pump gross performance, relative to connected fire protection system demands, is acceptable.

Per 8.3.7.2.3, pump *gross performance* not adjusted for speed must be graphically plotted and evaluated with a comparison to owner-provided fire system demands. And when graphically plotted, the annual gross pump performance flow should not be less than the system requirement demands of all water-based fire protection supplied by the fire pump.

3. Determine if the fire pump supplies 100 percent of rated flow.

There are many more actions for ITM that are required as part of an acceptable annual fire pump test, but these three items listed are the requirements for engineering analysis of the actual pump data. Both are required to determine a "pass/fail" for the test. Other requirements include inspecting general pump room conditions, including heating and cooling systems; inspecting and testing control valves and controller alarm signals; testing controller start-stop pressures; and inspecting and testing numerous mechanical performance features such as master relief valves, circulating relief valves, and heat exchanger solenoid valves. These requirements are covered throughout NFPA 25, primarily in Chapter 8.

Whenever deficiencies are found during ITM procedures, the owner (or designee) is responsible for repairs per 4.1.5. Supplemental action after repair might be required per summary tables in each chapter, including Table 8.6.1 for fire pump systems. To help ensure a quick repair, it is also required that any deficiencies and abnormalities observed during inspection or testing be reported promptly to the property owner or designated representative by the test contractor per 8.4.1. Additionally, any documented performance issues should be formally recorded and retained for future reference per Section 4.3. Thus, deficiencies must be formally reported and presented to building owners, or those designated as responsible for initiating repairs, and not simply verbally communicated.

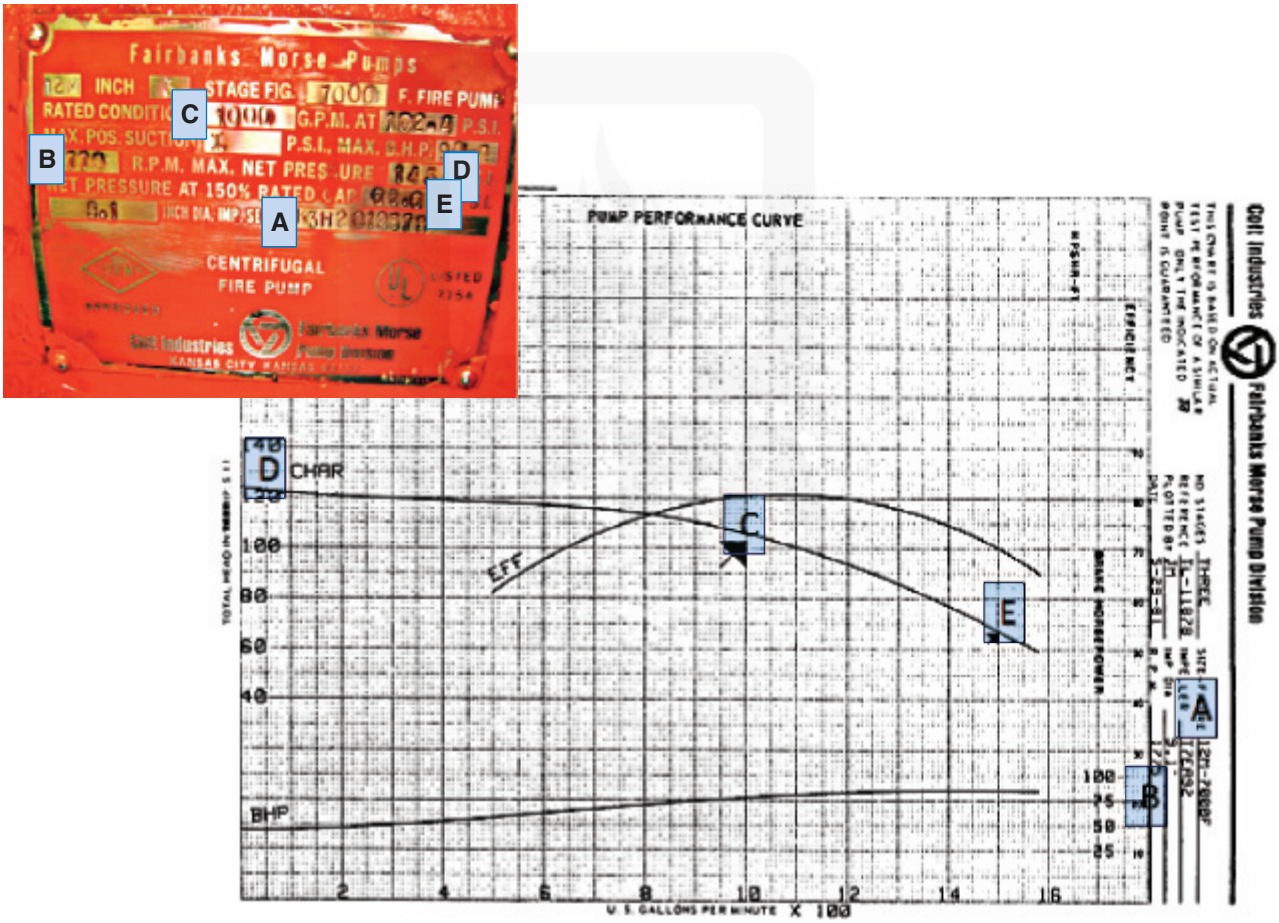
Data analysis is also required for electric-driven fire pumps regarding recorded current and voltage readings per 8.3.7.2.8 for pump tests to be considered acceptable — but this is not part of the flow test analysis.

For data analysis requirement 1, per 8.3.7.2.3, a test must be compared to the original pump performance. The original pump performance data is available typically from a manufacturer's pump curve. It can also be recorded from a fire pump design placard or nameplate. Data on these should be the same, as the nameplate data is usually stamped directly from the pump curve data.

Paragraph 8.3.7.1.3 of NFPA 25 requires that, where applicable, the speed-adjusted data be compared to the original pump performance. Net speed-adjusted data can be compared to the owner document pressure curves, copies of the original manufacturer's pump curves, pump nameplate data, or pump retrofit/rebuild documents per 8.3.7.2.3.

Original factory-new performance data, to use in comparison, can come from (or be generated from) numerous sources, as now listed. All four acceptable sources now listed should contain the exact same data, because all should be generated from the original manufacturer's pump curve. The term *certified* was removed from the requirement because this was never an NFPA 25–defined term. In relation to technical documents, the term typically implies that something is official, is recognized by an authority having jurisdiction, and is based upon a review relative to a specific and recognized quality standard. While it could be said that pumps are designed to be listed and meet the requirements of NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection,* the certified pump curves have always only been self-certified by manufacturers, representing the performance of the pump at the factory that should be seen once installed. Since these curves are not reviewed and approved by an AHJ or outside authority at the factory, the term could have been misleading when used with pump curve documents. A certified manufacturer's curve is the same as an original manufacturer's pump curve.

On pumps where this information is missing, original manufacturers can be contacted for this information. Manufacturers typically keep original pump curve data stored by pump serial numbers. If pump serial numbers cannot be located, many times information can be located by manufacturers based on the address of the pump installation. Exhibit S1.2 shows the relationship between a manufacturer's curve and placard.



A: Serial number: Unique to each pump. Curve and placard must match.
B: RPM: Pump and curve must match.
C: Rated point:
D: Churn pressure
E: 150% rated capacity

EXHIBIT S1.2 *Relationship Between Pump Placard and Manufacturer's Certified Pump Curve. (Courtesy of Liberty Mutual Insurance Fire Lab)*

Before an annual test can be completed, as implied by the two primary data analysis requirements, some design information is required. This information should be collected, reviewed, and analyzed before the annual fire pump test is scheduled and made available to those responsible for the analysis. This evaluation includes original pump performance data system requirement demands of all water-based fire protection systems supplied by the fire pump. It is also helpful to have recent and historical copies of past water supply test results.

Fire Pump Testing Analysis Walkthrough

The following sections of this supplement use a real-world scenario to walk through a fire pump testing analysis.

Site Information

For this example, assume the following data have been collected, reviewed for accuracy, and are available before the test (see Exhibit S1.3):

Original Pump Performance Data (Determined from One of the Means in 8.3.7.2.3).

Driver type: Diesel

Rated flow: 1000 gpm

Rated pressure: 85 psi

Rated rpm: 1760 rpm

Churn pressures (i.e., maximum net pressure): 97.0 psi

Net pressure at 150 percent: 56.2 psi

Building Sprinkler System Placard Design Information (Water-Based Fire Protection Systems Supplied by the Fire Pump).

System 1, Office Area:

Design: 0.10 gpm/ft^2 over 1500 ft^2

Demand for design (including hoses): 268 gpm at 78 psi

System 2, Manufacturing Area:

Design: 0.28 gpm/ft^2 over 2500 ft^2

Demand for design (including hoses): 1254 gpm at 102 psi

System 3, Warehouse Area:

Design: ESFR sprinkler system

Demand for design (including hoses): 1440 gpm at 63 psi

Pump Suction Water Supply Test Data (from City Fire Hydrant Test or a Hydrant on the Fire Pump Suction Supply).

Static pressure: 45 psi

Residual pressure at flow: 35 psi

Flow: 1250 gpm



EXHIBIT S1.3 *Manufacturer's Original Pump Performance Data Placard. (Courtesy of Liberty Mutual Insurance Fire Lab)*

2014 Annual Fire Pump Recoded Raw Test Data. The information shown in Table S1.1 should be recorded directly during the pump test. As noted in 8.3.3.10(2), if testing an electric-driven fire pump, the voltage and current should also be recorded for the power supply analysis.

The plotting of hydraulic water data is typically completed using N$^{1.85}$ graph paper. When plotted, the flow characteristics of water flow — such as from a fire hydrant — visually appear as a curve. Contrary to common sense where "two points make a line," for water flow, two points make a curve. The hydraulic relationship between flow and pressure results in a curve, and the more that is flowed, exponentially more friction loss occurs and exponentially less corresponding pressure is available. Thus, when using standard graph paper to plot water supply tests, the results appear more as a "curve" than a line. This can be complicated for water supply analysis because several points must be plotted, and those drawing the plot points must be competent in using French curves.

By using the N$^{1.85}$ semi-exponential log paper, the lines on the vertical axis remain constant, but the lines on the horizontal axis increase inwards as the grid moves from left to right, with N$^{1.85}$ taking the curve out of the line. This allows accurate analysis to be achieved easily and with only two points. Exhibit S1.4 and Exhibit S1.5 illustrate water supply test data plotted on straight-line graph paper and N$^{1.85}$ paper. Exhibit S1.6 and Exhibit S1.7 also show the straight-line graph paper and N$^{1.85}$ paper, this time with both water supply and pump test data being plotted.

While the benefits of using N$^{1.85}$ graph paper for water supply analysis do not transfer to fire pump net performance, it is recommended for fire pump gross performance analysis; it is especially useful if questionable pump test results require a suction supply review. And, if used for fire pump net analysis, secondary plots are not required for fire pump gross analysis.

TABLE S1.1 *Pressure and Flow Data for Fire Pump Testing*

Test	Test Flow Info	Pitot Reading	S (rpm)	Q (gpm)	P_s (psi)	P_d (psi)	P_v (psi)	P_n (psi)	Q_N (gpm)	P_N (gpm)
1-Churn	No flow	n/a	1777	0	45	140				
2-Rated	2-1.75 in. play pipes	32, 32	1763	1028	38	121				
3-150% Rated	3-1.75 in. play pipes	32, 32, 32	1731	1542	29	84				

S = pump speed — typically recorded at pump shaft with tachometer

Q = pump discharge flow — combined pitot tube pressure readings converted to flow for given orifice

P_s = pump suction pressure — from reading suction flange gauge at flow

P_d = pump discharge pressure — from reading discharge flange gauge at flow

P_v = pump velocity head — correction calculated based on suction and discharge pipe sizes

P_n = pump net discharge — total pump discharge performance accounting for P_v

Q_N = pump flow — gross pump flow adjusted for speed

P_N = pump pressure — gross pump pressure adjusted for speed

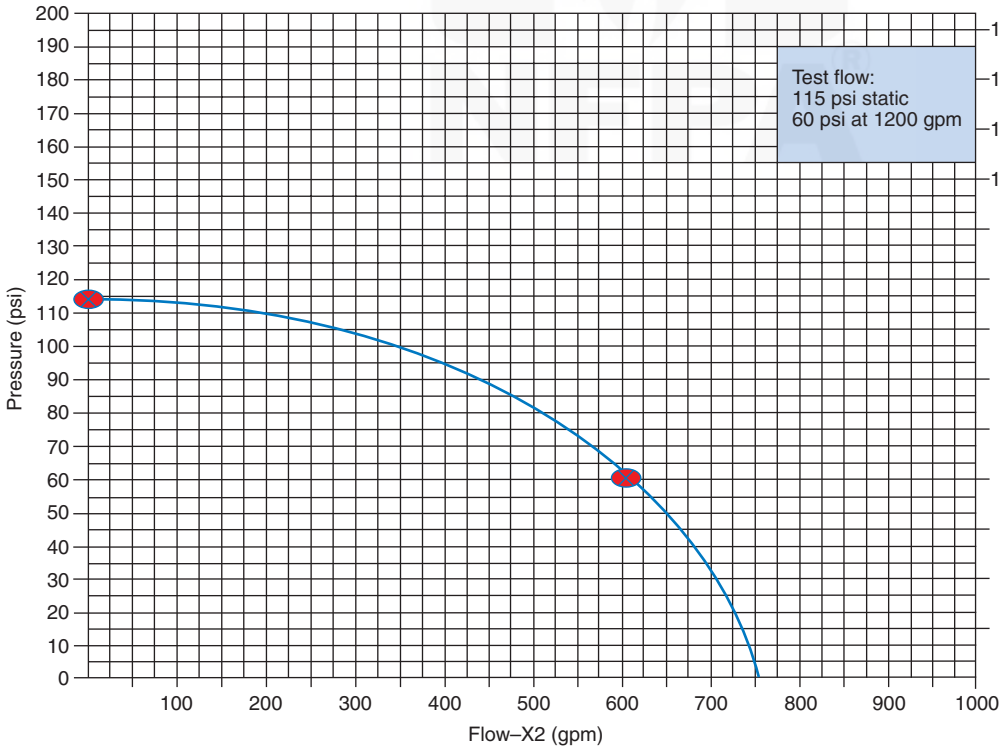


EXHIBIT S1.4 *Water Supply Test Plotted on Straight-Line Graph Paper.*

EXHIBIT S1.5 *Water Supply Test Plotted on $N^{1.85}$ Graph Paper.*

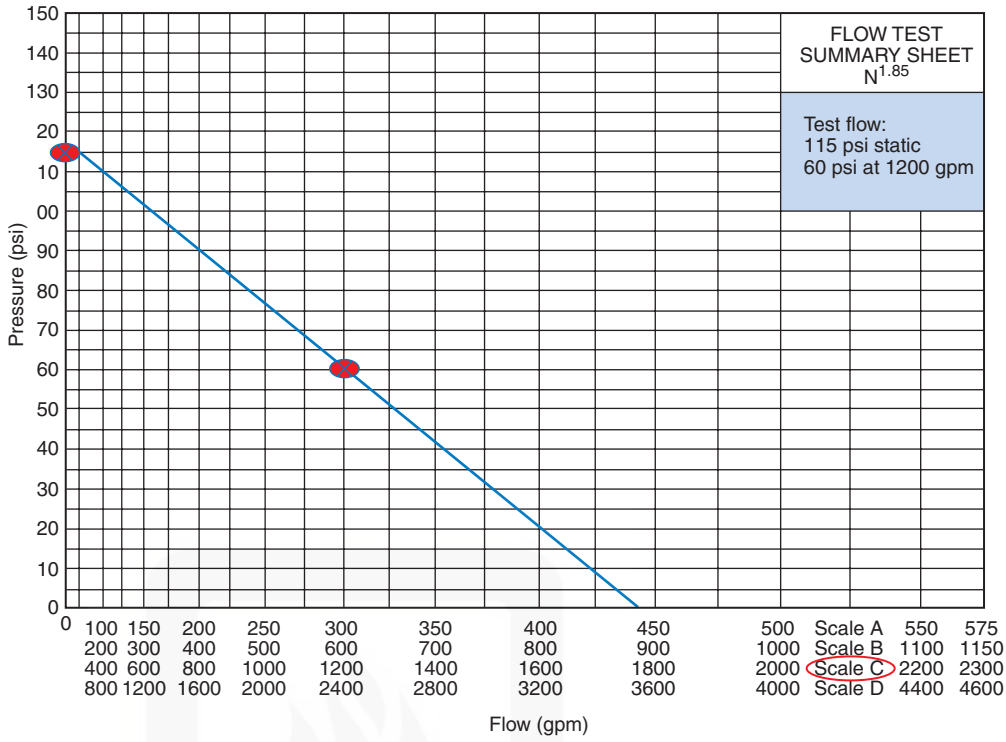
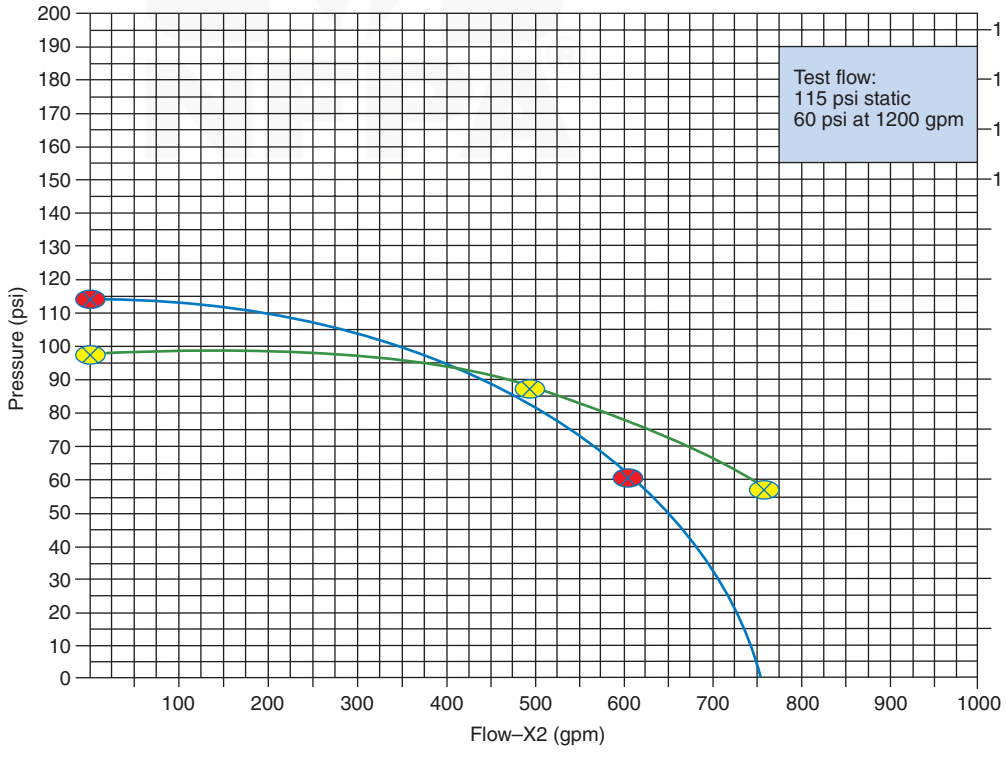


EXHIBIT S1.6 *Water Supply and Pump Test Plotted on Straight-Line Graph Paper.*



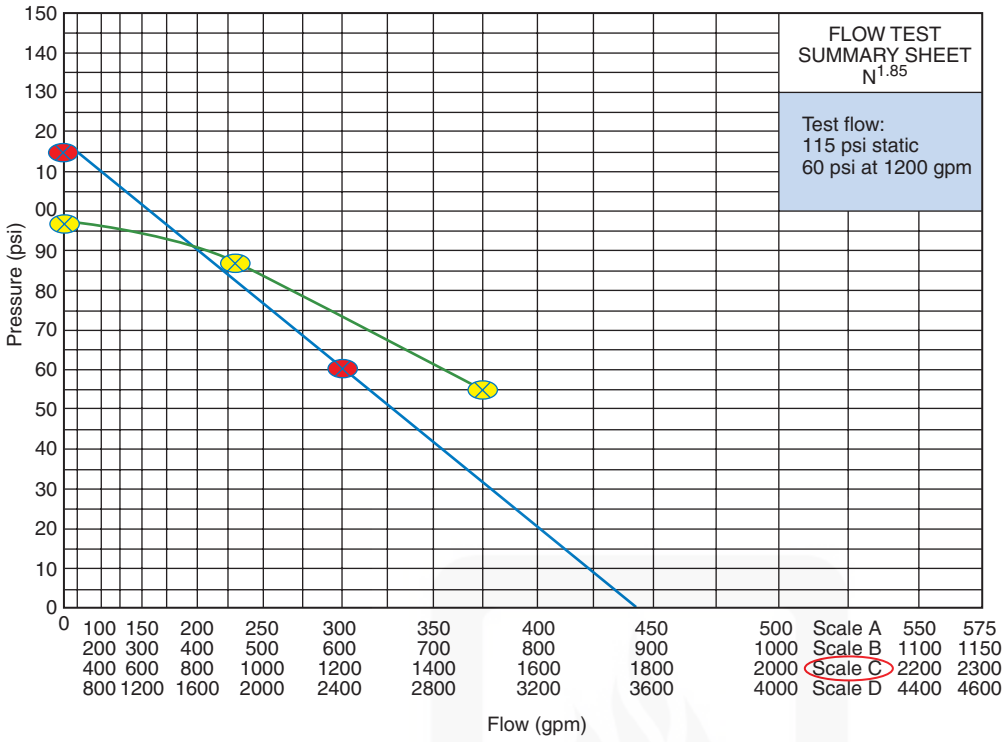


EXHIBIT S1.7 *Water Supply and Pump Test Plotted on $N^{1.85}$ Graph Paper.*

There are drawbacks to using the $N^{1.85}$ graph paper, too. A water supply might not exactly follow the set exponential relationship, such as in cities where municipal pumps are phased on to meet added demands. In these types of cases, no matter which graph paper is used for analysis, systematic and detailed analysis is required. Secondly, $N^{1.85}$ paper can make reading flow points on the curve somewhat difficult, but this would only typically account for a 1 psi (0.07 bar) to 3 psi (0.2 bar) difference at most.

Analysis 1

The purpose of the first analysis is to look at the overall fire pump output to confirm that it will support the necessary demand.

Determine if a fire pump gross performance, relative to connected fire protection system demands, is acceptable.

Step 1: Plot gross fire pump performance, which is "*Q*" at the associated "P_d". (See Exhibit S1.8.)

Step 2: Plot all provided fire system demands. (See Exhibit S1.9.)

Step 3: Make a determination for the final report if a fire pump gross (unadjusted) performance, relative to the original design/installation, is acceptable.

This analysis is completed by closely reviewing the data in the gross pump test with system demands, as shown in Exhibit S1.9. If the gross pump discharge has a flow and pressure that exceeds what each fire system demand needs, the test is considered acceptable. From the example plot shown in Exhibit S1.9, all fire system demands fall under the gross test data and thus appear acceptably supplied by the fire pump.

Figure A.8.3.7.2.3(2)(b) shows another example of a pump test result plotted and compared with system demands. That figure shows that the actual pump discharge can meet system demands. Some things to consider in this analysis are as follows:

1. Sprinkler system demands are not always calculated to the pump. If the pump is significantly detached from the sprinkler system, this could be an issue. Many are only calculated to the base of the riser. Thus, this information must be known.

   For example, if the System 2 design as listed on the placard was only calculated to the base of the riser, there could easily be another 5 psi (0.34 bar) to 20 psi (1.38 bar) pressure loss between what was plotted with the gross pump discharge and what is available for the fire protection system. In the plot example shown, there is only an approximate buffer of 3 psi (0.2 bar). After analysis, this could mean the pump test is not acceptable and that fire system reinforcement or a pump replacement is warranted.
2. Sprinkler system demands are not always calculated to include hose allowances per NFPA 13, *Standard for the*

Installation of Sprinkler Systems. Also, data shown on riser placards do not always include the sprinkler system demand with hose allowances included. Thus, this information must be known.

For example, if the System 2 design listed on the riser placard was calculated without hose allowance requirements, there could be another 100 gpm (379 L/min) to 750 gpm (2835 L/min) required to be added to the system demand. Also, in the example shown, there is only an approximate 45 gpm (170 L/min) buffer. After analysis, this could mean the pump test is not acceptable and that fire system reinforcement or a pump replacement is warranted.

3. Fire pump water supply fluctuations (P_s) directly affect fire pump discharge (P_d). As a municipal water supply pressure drops, so does the fire pump gross performance. Municipal supply pressures can fluctuate for various reasons. Some cities now cycle or adjust municipal pump pressures down to force water conservation in areas that experience drought. Less pressure relates to less flow. In turn, this creates less household and industry consumption. Pressure fluctuations can also occur on shared water mains where heavy equipment or landscape irrigation drops the total system pressure.

For this example, if the pump test were completed in the late afternoon when the water supply from a city was the highest, or if the same test was completed in the morning or during the highest demand hours, the results could have indicated that System 2 only had an acceptable water supply from the installed fire pump at certain times of the day.

Any significant drop in gross pump output, as shown in Exhibit S1.10, should always be a concern and should be investigated, since this can also be an indication of a hidden closed valve somewhere on the suction supply leading to the fire pump. This is why it is recommended that historical water supply data, such as from past city fire hydrant tests or hydrant flow tests on the fire pump suction supply, be maintained and available during the pump test for comparison.

Analysis 2

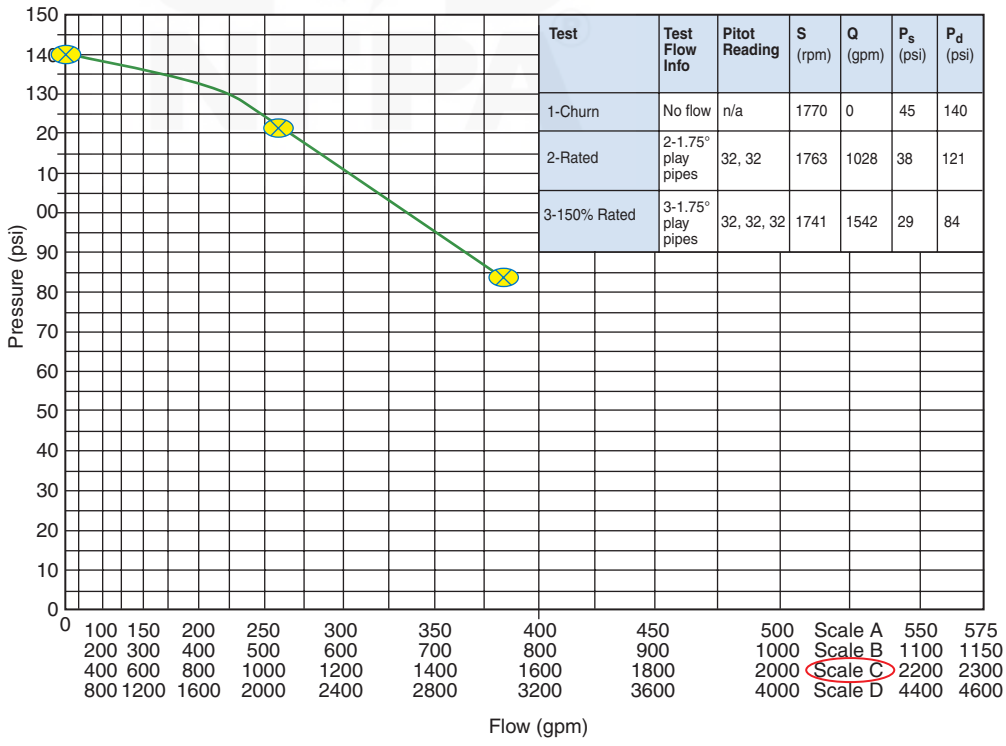
This analysis of the pump's capabilities will examine the functionality of the pump when compared to the performance of the pump during acceptance testing conducted in accordance with NFPA 20.

Determine if a fire pump net performance, relative to the original design/installation, is acceptable.

Step 1: Determine velocity head adjustment relative to net pressure (P_n).

The pump test data analysis should include velocity head correction. Velocity head is created when the discharge pipe

EXHIBIT S1.8 *Pump Gross Test Data Plotted on $N^{1.85}$ Graph Paper.*



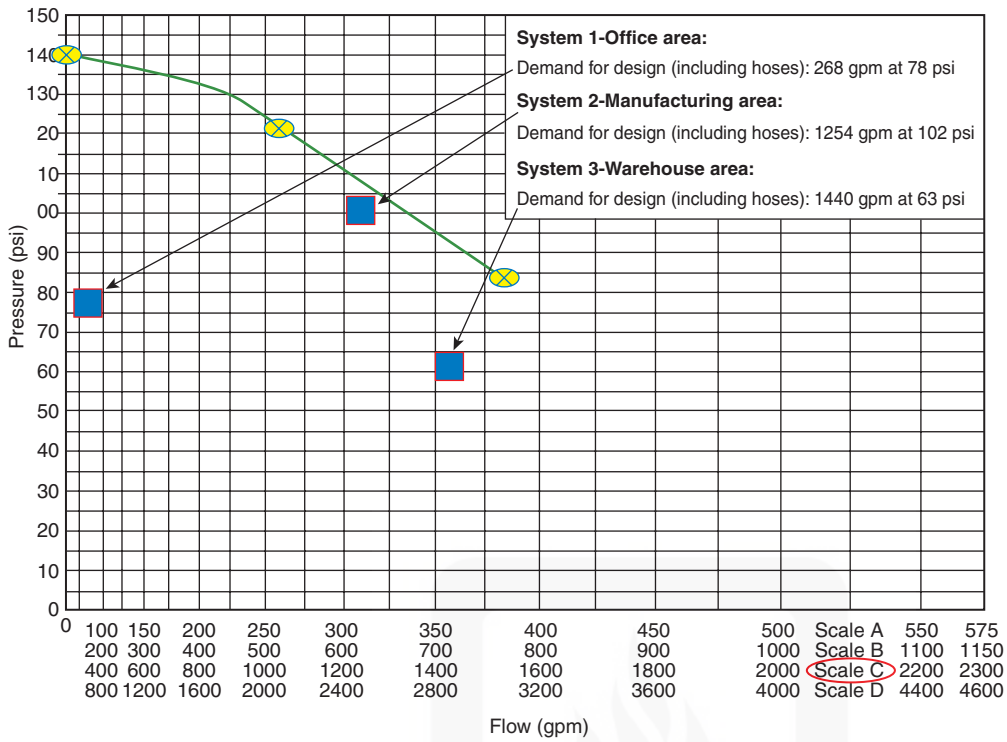


EXHIBIT S1.9 *Pump Gross Test Data with System Demand Plotted on $N^{1.85}$ Graph Paper.*

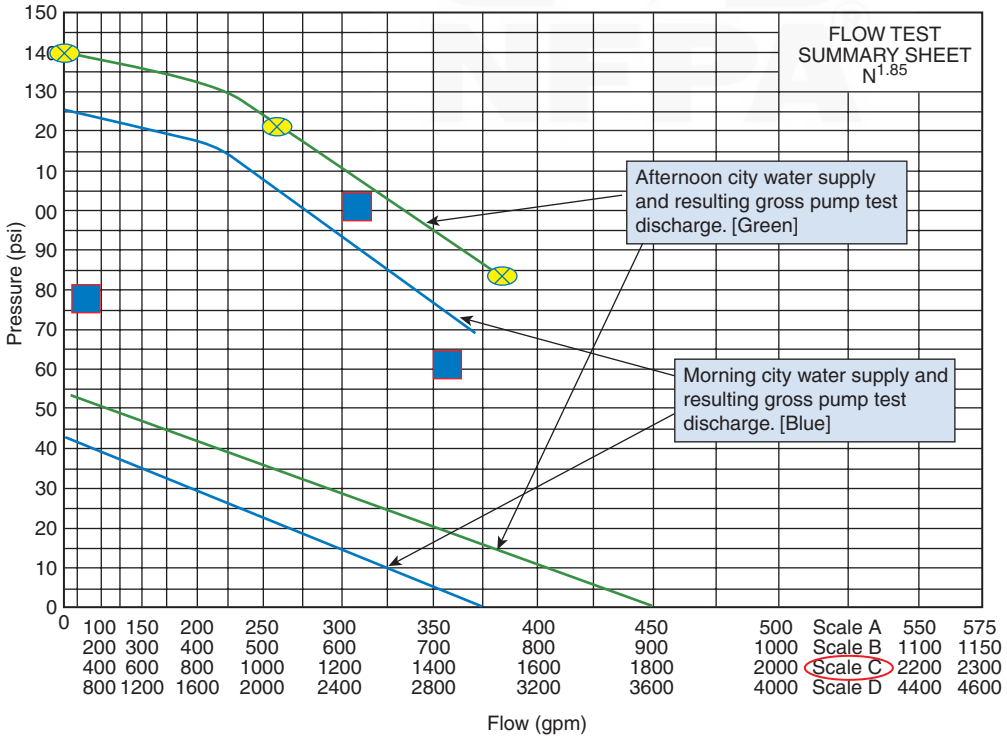


EXHIBIT S1.10 *Pump Gross Test Data Plotted on $N^{1.85}$ Graph Paper.*

size leading to a fire pump differs from the suction pipe size. Changes in pipe size change velocity. Since water is an incompressible fluid, when the pipe size increases or decreases without compression as an option, the velocity must change.

For fire pump analysis purposes, the following calculation can be applied:

P_n: $(P_d - P_s) + (P_v)$

where:

P_n = pump net discharge — total pump discharge performance accounting for P_v

P_d = pump discharge pressure — from reading discharge flange gauge at flow

P_s = pump suction pressure — from reading suction flange gauge at flow

P_v = pump velocity head — correction calculated based on suction and discharge pipe sizes

To mathematically calculate velocity head, the following calculation can be applied:

$$P_v = 0.001123\, Q^2(1/D_d^4 - 1/D_s^4)$$

where:

P_v = velocity pressure (psi)

Q = measured flow (gpm)

D_d = suction pipe diameter measured at gauge attachment flange (inches)

D_s = discharge pipe diameter measured at gauge attachment flange (inches)

However, while velocity head can be worth noting in some cases, such as for very small pumps with small pipes, this adjustment is negligible and can be ignored for almost all standard fire protection pump installations. For this reason, most contractor pump test sheets do not even have a column to record this calculation.

For example, for installations where both suction and discharge pipes or flanges (measured where gauges are mounted) are the same, this can always be disregarded, since there is no velocity head potential. Additionally, most fire pumps have between 6 in. (150 mm) and 10 in. (255 mm) pipes where, even if sizes change, the P_v created is typically negligible — less than 2 psi (0.14 bar). For example, a pump with an 8 in. (200 mm) suction pipe and 10 in. (255 mm) discharge flowing 2000 gpm (7570 L/min) and a pump flowing 500 gpm (1890 L/min) with a 4 in. (100 mm) suction and a 6 in. (150 mm) discharge would both result in less than a 1 psi (0.07 bar) adjustment. For this reason, P_v should be considered to be 0 psi, as is the typical industry practice. And therefore, P_n is simply calculated as follows:

$P_n = (P_d - P_s)$

where:

P_n = pump net discharge — total pump discharge performance accounting for P_v

P_d = pump discharge pressure — from reading discharge flange gauge at flow

P_s = pump suction pressure — from reading suction flange gauge at flow

Calculating Vertical Turbine Pump Adjustments. One other adjustment must also be accounted for on vertical turbine pumps. Since vertical turbine pumps have impellers that are typically submerged in a static water source and must lift the water up to the discharge piping, there are no suction gauges, and therefore, there is no P_s. For vertical turbine pumps, pressure loss due to the required lift, or P_e, must also be included, and P_n is as follows:

$P_n = P_d + P_e$

where:

$P_e = E \times 0.433$

P_n = pump net discharge — total pump discharge performance accounting for P_v

P_d = pump discharge pressure — from reading discharge flange gauge at flow

P_e = pump negative pressure (loss) due to elevation head

E = distance (ft) between pump discharge gauge and suction water level

In the rare instances where a vertical turbine pump is connected to a pressurized water main, the adjustment methodology discussed for horizontal split case pumps must be used with the required elevation adjustments. See Table S1.2.

Step 2: Determine speed-adjusted net flow and pressure (Q_N and P_N).

A mathematical adjustment must be made for the correction of recorded test data to the original pump rated speed (it may also include a velocity head adjustment); it must be applied when determining flow test performance relative to the original pump performance. These corrections are shown in Table S1.2.

The three data points on a manufacturer's pump curve and placard are generated as part of the manufacturing quality assurance process, such that each pump is tested for flow and pressure at the speed listed on the manufacturer's pump curve or placard. At each pump manufacturing site, when a manufacturer's curve is generated, the pump is connected to a test driver and the driver is manually adjusted to the same speed at each test point before flow is recorded. So, on the manufacturer's curve the churn, rated, and 150 percent flow points are all taken at the exact same speed, which is listed as the pump speed (rpm) at rated flow and pressure. In the same way a car does not maintain the same speed along each hill and valley, a pump and driver that are installed in the field do not really maintain the same speed across all flow points.

In a real installation, for most diesel drivers (and to a smaller degree, for some electric drivers), the more work the pump does (i.e., more flow), the more work or load is required of the driver. As with most drivers, an increased work load results in decreased speed. This is similar to what is seen

TABLE S1.2 *Fire Pump Output Data with Velocity Head and Speed Corrections*

Test	Test Flow Info	Pitot Reading	S (rpm)	Q (gpm)	P_s (psi)	P_d (psi)	P_v (psi)	P_n (psi)	Q_N (gpm)	P_N (gpm)
1-Churn	No flow	n/a	1777	0	45	140	0	95		
2-Rated	2-1.75 in. play pipes	32, 32	1763	1028	38	121	0	83		
3-150% Rated	3-1.75 in. play pipes	32, 32, 32	1731	1542	29	84	0	55		

S = pump speed — typically recorded at pump shaft with tachometer

Q = pump discharge flow — combined pitot tube pressure readings converted to flow for given orifice

P_s = pump suction pressure — from reading suction flange gauge at flow

P_d = pump discharge pressure — from reading discharge flange gauge at flow

P_v = pump velocity head — correction calculated based on suction and discharge pipe sizes

P_n = pump net discharge — total pump discharge performance accounting for P_v

Q_N = pump flow — gross pump flow adjusted for speed

P_N = pump pressure — gross pump pressure adjusted for speed

in automobiles. A vehicle towing a heavy load has a slower speed than the same vehicle towing nothing unless more fuel is supplied via the gas pedal.

For this reason, to make an equal comparison of a fire pump installed in the field to a test flow to that on a manufacturer's pump curve, the test data (both flow and pressure) must be mathematically adjusted to the pump's rated speed (or rpm).

Adjusting flow and pressure mathematically for speed related to fire pump analysis is typically completed using the Affinity Laws as follows:

1. For flow: $Q_N = Q$ [rated speed (rpm)/measured speed (S)]
2. For pressure: $P_N = P_n$ [rated speed (rpm)/measured speed (S)]^2

For our case, placard data indicates the pump speed rating is 1760 rpm. Therefore, the following applies:

Churn:

$Q_N = 0$ gpm

$P_N = 95 \text{ psi} \times (1760/1777)^2 = 93 \text{ psi}$

Rated:

$Q_N = 1028 \text{ gpm} \times (1760/1763) = 1028 \text{ gpm}$

$P_N = 83 \times (1760/1763)^2 = 83 \text{ psi}$

150 percent:

$Q_N = 1542 \text{ gpm} \times (1760/1731) = 1569 \text{ gpm}$

$P_N = 55 \times (1760/1731)^2 = 57 \text{ psi}$

This data is summarized in Table S1.3.

Step 3: Make a determination for the final report if a fire pump net (adjusted) performance, relative to the original design/installation, is acceptable.

This calculation is completed by comparing the manufacturer's performance curve plot with the adjusted flow and pressure plot (three *QN* and *PN* points), with judgment relative to meeting the requirements of 8.3.7.2. If both curves run within +/- 5 percent of each other, the test is acceptable. This is shown in our final plot of Exhibit S1.11.

Figure A.8.3.7.2.3(2)(a) shows another example of a net pump test plotted and compared to an original pump manufacturer's test curve. Adjusted results of this test closely overlap (i.e., the pump is performing at or above 95 percent of the original design specifications per the manufacturer's performance curve), which indicate the pump is performing close to the way it did when it was factory new. Also, this plot is a good indication that the internal parts of the pump are functioning well and the driver is operating as required for the attached pump.

A final step in any pump test is a written evaluation of the conclusions. Per 8.4.1, and 8.4.1.1, the property owner or designated representative must be given a written copy of the data analysis (i.e., interpretation of results) with the test results as part of an annual pump test that includes any noted abnormalities. Any documented performance issues must be recorded and retained for future comparison purposes.

This analysis leads to one final question: What must be done if a fire pump does not pass an annual test? If the failure is in the associated Analysis 1, this must be addressed immediately. Without further engineering review, a failed test

TABLE S1.3 *Gross Pump Output Data Following Adjustments for Speed*

Test	Test Flow Info	Pitot Reading	S (rpm)	Q (gpm)	P_s (psi)	P_d (psi)	P_v (psi)	P_n (psi)	Q_N (gpm)	P_N (gpm)
1-Churn	No flow	n/a	1777	0	45	140	0	95	0	93
2-Rated	2-1.75 in. play pipes	32, 32	1763	1028	38	121	0	83	1028	83
3-150% Rated	3-1.75 in. play pipes	32, 32, 32	1731	1542	29	84	0	55	1569	57

S = Pump speed — typically recorded at pump shaft with tachometer

Q = pump discharge flow — combined pitot tube pressure readings converted to flow for given orifice

P_s = pump suction pressure — from reading suction flange gauge at flow

P_d = pump discharge pressure — from reading discharge flange gauge at flow

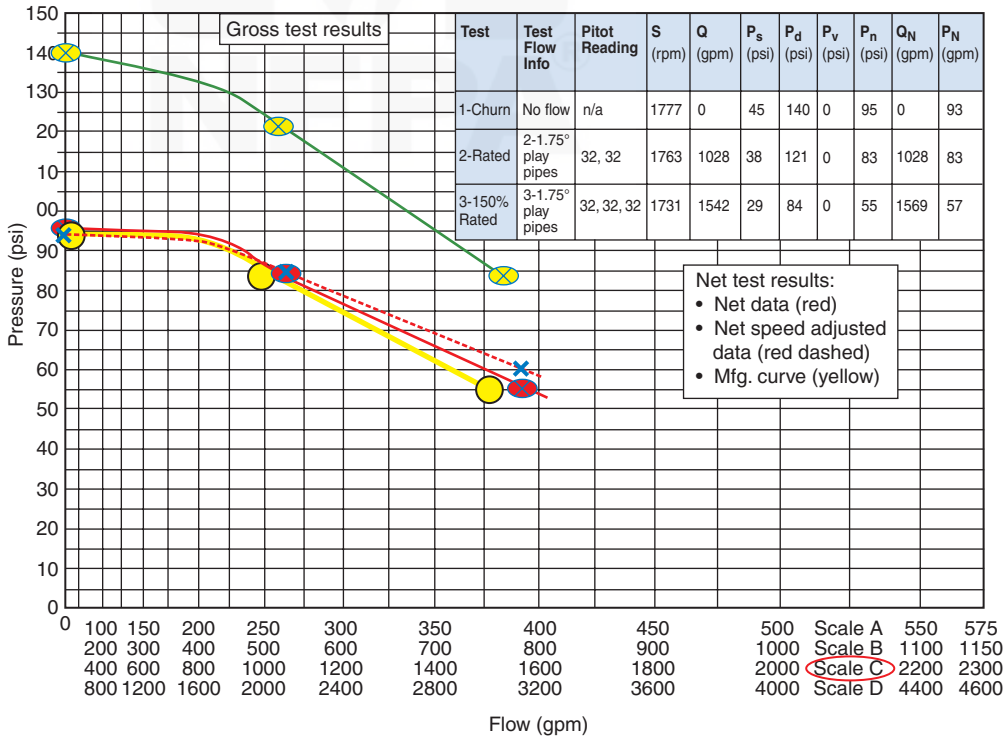
P_v = pump velocity head — correction calculated based on suction and discharge pipe sizes

P_n = pump net discharge — total pump discharge performance accounting for P_v

Q_N = pump flow — gross pump flow adjusted for speed

P_N = pump pressure — gross pump pressure adjusted for speed

EXHIBIT S1.11 *Pump Plot: Gross vs. Net Data Plotted on $N^{1.85}$ Graph Paper.*



would indicate that in the event of a fire, there might not be an adequate water supply to acceptably supply the fire systems connected to the fire pump. This translates to the potential of an uncontrolled fire and, potentially, extended loss of life and property.

The solutions are varied and a complete engineering analysis must be completed, but a logical first step is to verify that all gauges and flow measuring devices are properly calibrated and working. This might also involve a pump retest to verify the results.

If results still show a failed pump test, a possible solution would be replacement of the fire pump with a larger unit. Since the driver size is based on pump size, this will likely mean a newer, more powerful driver as well. Additionally, since controller components, power supply transformers, and wiring for electric drivers are sized based on motor size, this could also mean that a new transformer, a new controller, and rewiring are required.

The flow also must be evaluated to see if the issue is with a water supply source. As previously discussed, a water supplier could be purposely decreasing a municipal water supply for reasons related to fire protection, such as forced water conservation. In these cases, a request can be made to increase the pump suction water supply. Reduced flow could also be the result of a valve partially closed downstream of the pump. Thus, these are the reasons a full engineering analysis must be completed.

In some cases, the solution is connecting the pump to another water supply source or parallel source to counter frictional loss, such as from a recent backflow apparatus installation. In extreme cases, this could also mean adding a fire pump suction tank as a new source of site water. And in this case, an entirely new fire pump and driver would likely also be required.

In completing the evaluation for Analysis 2, a failed test per 8.3.7.2.3(3) that required further investigation is pump flow performance degradation in excess of 5 percent. While the causes for failure here could be different from those for Analysis 1, they could also be the same or related. Thus, a full engineering analysis must be completed for this, along with following the same logic and process of issue investigations. A logical first step would also be to verify that all gauges and flow measuring devices were properly calibrated and working. A pump retest to verify the results would also be recommended. If results are confirmed, maintenance involving taking apart the pump for visual inspection is then typically required. Poor performance indicated here is usually the result of a damaged impeller or blocked impeller vane.

The following are some examples of poor net pump test curves and possible problems.

Exhibit S1.13 shows a failed test because there is more than a 5 percent performance degradation. The test shown in Exhibit S1.13 is not a failed test per NFPA 25; however, an investigation is still warranted. This test, taken as plotted, would mean the pump and driver actually improved performance by almost 10 percent from when it was factory new. This is not likely. This would most likely be the result of test equipment not calibrated correctly or poor test data recording. In either case, the test has to be questioned as "too good to be true."

There are numerous reasons for a test, as shown in Exhibit S1.12. Exhibit S1.10 shows a gross test plot with the water supply. Any significant drop in gross pump output per Exhibit S1.10 should always be a concern and should be investigated, since this can also be an indication of a hidden closed valve somewhere on the suction supply leading to the fire pump. This is why it is recommended that historical water supply data such as from past city fire hydrant tests or hydrant flow tests on a fire pump suction supply be maintained and available during the pump test for comparison. Of course, since Exhibit S1.12 only looks at net performance, this would not be detected if only one of the two analyses were completed. This could be the result of impeller wear, uncalibrated gauges reading low, or using the wrong flow device pitot reading chart. It could also be from a pressure relief valve stuck open in a certain position.

Exhibit S1.14 is a failure for the same reason as Exhibit S1.12. However, this might not be as big of a concern, because performance is within the requirements at the rated and 150 percent point. This result could simply be a pressure relief valve closing as flow increases, as should be the case. For testing, it should be ensured that this valve closes as soon as water flow through the header is started, so as not to affect the performance curve data.

Exhibit S1.15 is a failure for the same reason as Exhibit S1.12 and Exhibit S1.14. Also, this is much more critical, as the flow region with the poor performance is typically where most sprinkler system demands would fall on the graph. Reviewing the pump affinity laws, pressure is exponentially affected relative to flow. This can be attributed to a partially closed valve on the suction side of a fire pump or, more likely, an impeller that is damaged or has foreign material lodged in it.

EXHIBIT S1.12 *Example of Failed Test.*

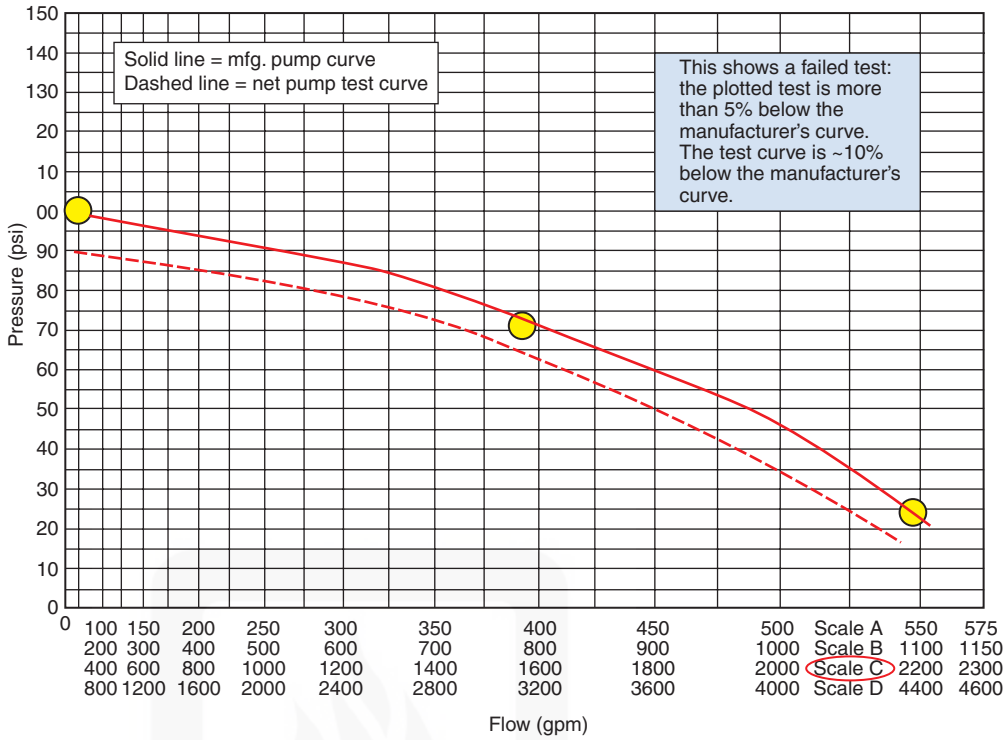
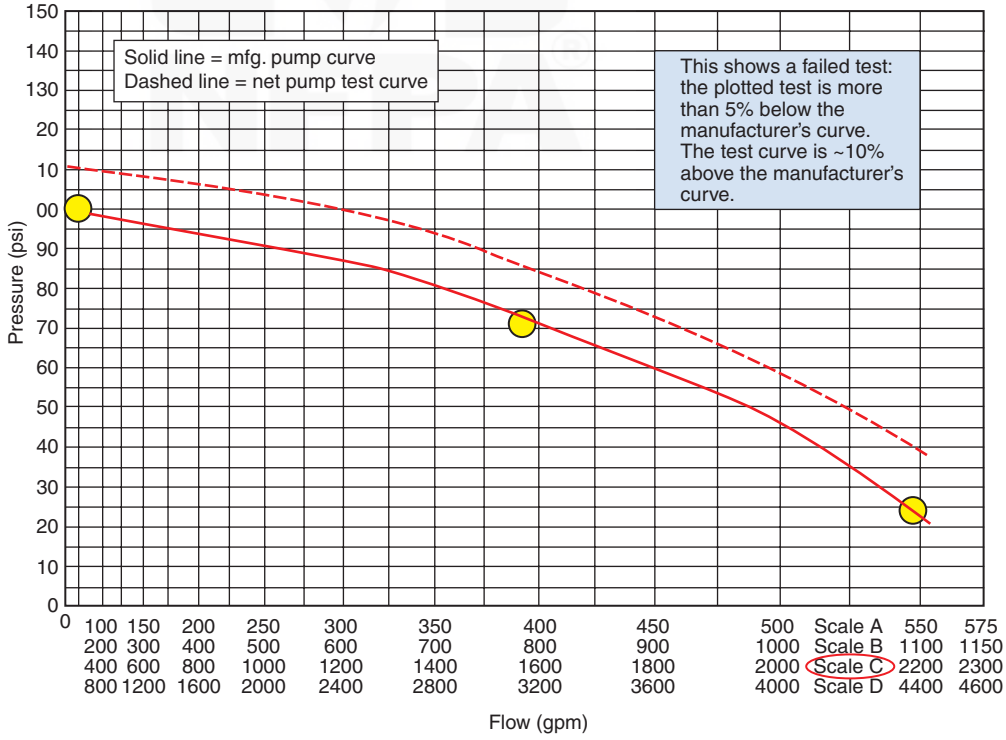


EXHIBIT S1.13 *Example of Test Results That Would Trigger an Investigation.*



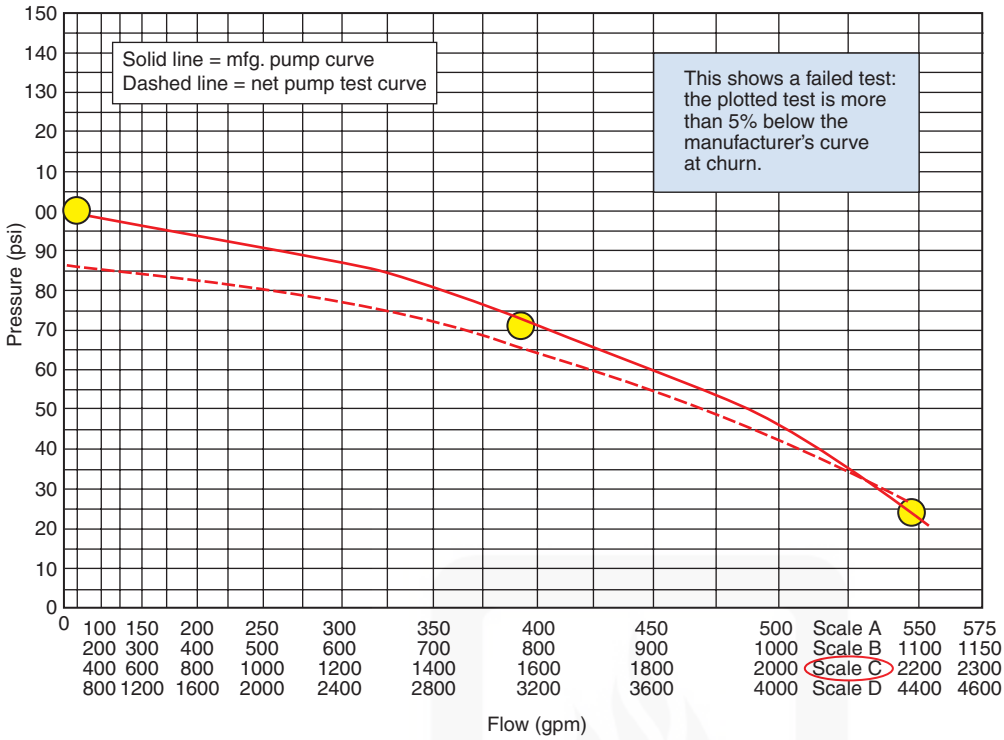


EXHIBIT S1.14 *Example of Failed Test Data.*

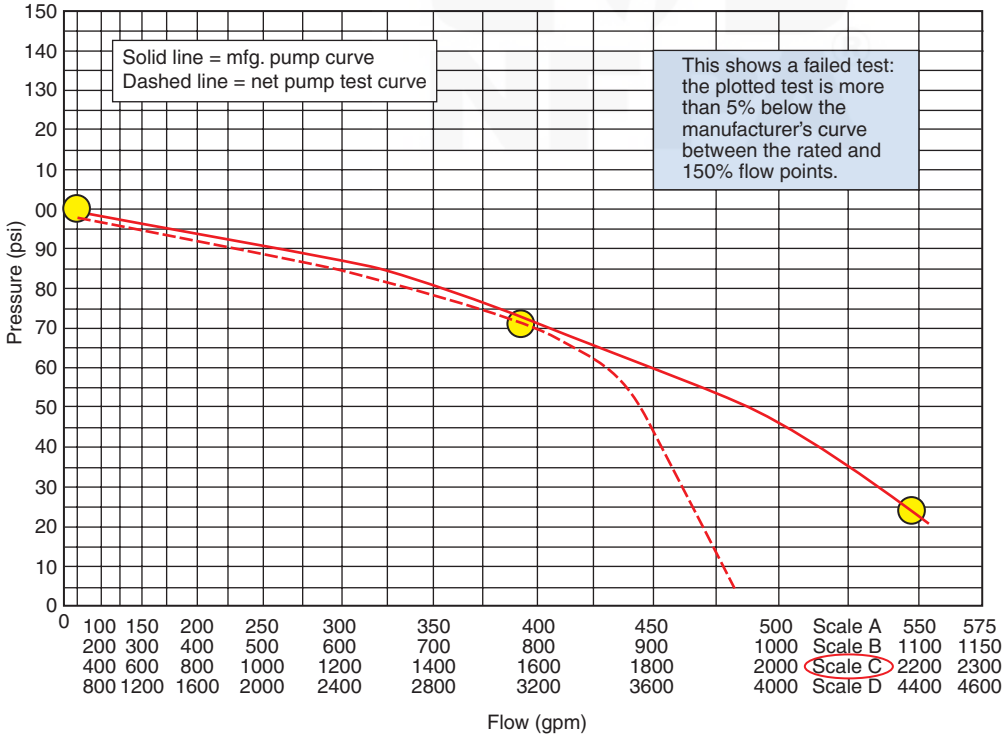


EXHIBIT S1.15 *Example of Failed Test Data.*

Summary

Confirming a fire pump's ability to provide the required flow and pressure based on system demand is imperative to maintaining the level of life safety anticipated for a given property. Properly conducting fire pump flow tests to quantify a pump's functionality is a critical step to making this confirmation. In addition to confirming that the pump will supply the necessary pressure and flow, it is important to assess the performance of the pump against its original performance data. Degradation in pump output over time can lead to a system impairment; it can also be a sign of potential issues with the pump, suction piping, or water supply.

References Cited

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2019 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, 2019 edition.



SUPPLEMENT 2

ITM ROLES AND RESPONSIBILITIES

By Rich Ray, Russell Leavitt, and John A.M. Lake

Editor's Note: *This supplement is included in the handbook to provide the reader with a snapshot of some of the roles and responsibilities associated with several key players in the water-based system inspection, testing, and maintenance (ITM) process.*

The inspector, owner, and authority having jurisdiction (AHJ) are key cogs in the ITM machine. For these individuals to be effective in executing ITM activities, it is important for them to understand not only *what* they need to be doing, but also *why* they are doing it. The following table summarizes many of their responsibilities for a series of tasks that are associated with the ITM process. This table is not intended to be all-inclusive, but rather to hit the high points and basic principles for each of the tasks outlined. For a more detailed look at the role of the inspector, owner, and AHJ, refer to the full-length narrative supplements that are provided as follows: Supplement 3, Role of the Inspector; Supplement 4, Role of the Owner or Designated Representative; and Supplement 5, Role of the Authority Having Jurisdiction.

Roles and Responsibilities of Key Stakeholders

Responsibility	*Role*
Overall ITM Program	**Inspector** ▪ Provide information to all interested AHJs and the property owner regarding the requirements of NFPA 25. ▪ Provide competitive pricing to the building owner for the services necessary to comply with NFPA 25. ▪ Conduct the tasks outlined in NFPA 25 in accordance with the scope of the document, which addresses wear and tear issues.
	Owner ▪ Ensure that the systems are inspected, tested, and maintained. ▪ Provide access to system components as needed, have needed repairs and corrections completed, and keep records. ▪ Evaluate the adequacy of existing systems if changes are made to the building, its use, or other conditions that could impact system performance. ▪ Understand and comply with any local requirements regarding qualifications for performing inspections, tests, and maintenance along with reporting and record keeping. ▪ Put procedures in place to address any impairments that occur, whether planned or unplanned.

Responsibility	*Role*
Overall ITM Program (continued)	**AHJ** ▪ Determine if an existing situation involves a distinct hazard to life or property that requires inspection, testing, and maintenance methods in excess of those required by the standard. ▪ Approve alternative programs. ▪ Enforce the requirements of a code or standard or approve equipment, materials, an installation, or a procedure. ▪ Educate the property owner of the requirements of the various codes and standards that affect the facility. ▪ Review the fire protection system as it compares to the original installation by requesting copies of the original design documentation from the owner to help identify any changes that might inhibit the effectiveness of the system. ▪ Know the requirements of NFPA 25, recognize its limited scope for AHJs, and know where to obtain the information necessary to ensure the protection system will operate correctly.
Qualification/ Competency of ITM Personnel	**Inspector** ▪ Become completely and exhaustively familiar with the scope of NFPA 25 and what NFPA does *not* require of an inspecting company. ▪ Obtain credentials to be deemed "qualified" in the jurisdiction where work is being performed, and become familiar with all types of system components from fire pumps to pressure switches. Some states require specific credentials, such as the National Institute for Certification in Engineering Technologies (NICET) Certification or Academy Exam Certification through the Academy of Fire Sprinkler Technology. ▪ Be aware if there are other agencies that impose regulations regarding qualifications and competency.
	Owner ▪ Understand that NFPA 25 is, by design, quite generic regarding qualifications for those that will perform inspections, testing, and maintenance. ▪ Know that the owner (or owner's personnel) can perform many of the NFPA 25 tasks, particularly inspections. However, many inspections and tests require a progressively higher level of technical competence. ▪ Exercise sound judgment when determining whether inspections, tests, and maintenance are to be performed by in-house personnel. ▪ Be aware of any state and local jurisdictions that have strict qualification requirements for conducting any inspection, test, or maintenance of a water-based suppression system.
	AHJ ▪ Approve the right personnel for the task, such as those who have the following qualifications: • Factory trained and certified for the specific type and brand of system being inspected • Certified by a nationally recognized fire protection certification organization • Registered, licensed, or certified by a state or local authority • Employed and qualified by an organization listed by a nationally recognized testing laboratory for the servicing of fire protection systems ▪ Determine specific qualifications and competencies found throughout the standard. The requirements are often found in the text, such as in the specification of "qualified" for performing particular functions. ▪ Know the areas in the standard where the need for qualified personnel becomes an issue for the AHJ.
Equipment Accessibility	**Inspector** ▪ Inform the property owner of the items to which access must be made available, such as the pump and valve rooms, test valves, and tenant spaces. ▪ Notify the owner of the scheduled inspection in a timely fashion to allow the owner ample time to prepare for the inspection and testing activities.
	Owner ▪ Provide access to all components requiring ITM. While NFPA 25 places this responsibility with the owner, it can be problematic for properties such as apartments, hotels, and multi-unit condominiums. ▪ Coordinate access with tenants and occupants, and know that the standard gives no exceptions to the accessibility requirement except in some instances where access might be unsafe. ▪ Understand that not performing inspections, tests, or maintenance in an area because it might be inconvenient is not a valid reason for the owner to defer required tasks.

Responsibility	*Role*
Equipment Accessibility (continued)	**AHJ** ▪ Understand that in NFPA 25, the AHJ has a limited role in relation to accessibility to equipment. ▪ Know that the AHJ has a more significant role in the installation phase where decisions on the fire protection equipment locations are discussed and approved. When initial plans are submitted for review, the AHJ should review the design for operational aspects as well as the need to gain access to the equipment for inspection, repair, and replacement. ▪ Remember that, when looking at the installation, there are standards other than NFPA 25 that apply to accessibility. One example would be the requirement for a controller for a fire pump in 10.2.4 of NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, where it states that "Working clearances around controllers shall comply with *NFPA 70,* Article 110."
Notification of Impairment	**Inspector** ▪ Identify any impaired conditions found while conducting an inspection, and document the impairment. Where possible, the inspector should identify impairments to the owner during or shortly after the inspection, rather than waiting to file a written report days later. ▪ Be ready and willing to assist the owner by helping to identify the approximate duration of the shutdown and impairment until repairs can be made. ▪ Know that the notification of impairment may apply to the inspector provided that individual has the competency to make such a determination. If not, this might become the duty of another segment of the inspecting contractor's firm.
	Owner ▪ Notify all the interested stakeholders when an impairment occurs, including the fire department, insurance carrier, alarm company, and other AHJs. ▪ Coordinate notifications with the service provider when a provider — such as a contractor — is employed by the owner. ▪ Verify that all required notifications were completed in cases where the service provider makes the notifications.
	AHJ ▪ Understand that NFPA 25 requires the AHJ to be notified of impairments to the fire protection system. ▪ Request specific information to determine what the nature of the impairment is and whether or not there are additional notifications or investigations that need to take place. The level of response from the AHJ will directly relate to the type of impairment and the length of time it will take to correct. ▪ Require standby fire personnel or an approved fire watch when potentially hazardous conditions or a reduction in a life safety feature exist due to impairment to the fire protection system. ▪ Know that when a fire protection system is out of service for more than 10 hours in a 24-hour period, the AHJ has the ability to require the building to be evacuated or an approved fire watch to be provided for all portions left unprotected by the fire protection system shutdown until the fire protection system has been returned to service.
Notification of System Shutdown	**Inspector** ▪ Understand that notifying interested AHJs of system shutdowns is the responsibility of the property owner. ▪ Assist the owner with tasks, as specifically requested and directed by the owner; this could include tasks such as providing fire watches, assisting in tagging equipment affected by the shutdown as "out of service," and providing temporary water supplies.
	Owner ▪ Understand that a majority of all system failures are the result of a shut water control valve. ▪ Notify the fire department and alarm receiving company when a system is to be shut down, and know that NFPA 25 provides strict and detailed instructions for this notification. When a service provider is employed by the owner, often the service provider will assist with the notifications. ▪ Verify that notifications were performed as needed, since the responsibility of the notification rests with the owner.

Responsibility	*Role*
Notification of System Shutdown (continued)	**AHJ** ▪ Develop a facility-specific plan with the AHJ and stakeholders to address emergency response prior to responding to the need to shut down a fire protection system. These plans should include a response with a partially or fully impaired fire protection system. ▪ Know that the role and responsibility of the AHJ is the same for a system shutdown as it is for impairment. ▪ Ask simple questions, such as: • Why is the system being shut down? • How long will it be shut down? ▪ Determine and establish procedures for the type and level of response that can be initiated after the AHJ receives the required information.
Changes in Occupancy, Use, Process, or Material	**Inspector** ▪ Understand that these changes cannot be handled by the everyday inspector — a higher level of education and training is necessary, such as that of a licensed professional fire protection engineer. ▪ Know that the "more qualified" person could assist the property owner in determining the effect that such changes will have in regard to the fire sprinkler system. ▪ Understand that, in instances where the inspector becomes aware of a change in occupancy or hazard during an inspection and chooses to notify the owner, it should be done on a separate report with a disclaimer that this information is beyond the scope of an NFPA 25 inspection and does not establish the fact that a full design evaluation has been conducted.
	Owner ▪ Conduct an evaluation of existing systems whenever changes to a building or its use are contemplated. ▪ Understand that the evaluation is not a part of the normal ITM required by the standard and must be performed by someone who is qualified. ▪ Make whatever corrections are necessary to ensure that the system will perform as needed if the evaluation finds that the existing system is inadequate to protect the building or the hazard. ▪ Request that a service provider perform an evaluation of the fire protection systems if many existing buildings have had numerous changes to the original layout or use. ▪ Know that many contractors have personnel that are qualified to do this evaluation or can assist the owner in finding a qualified consultant or engineer.
	AHJ ▪ Evaluate the system using NFPA 25 and the installation standard for the year the system was installed. By using both standards, the AHJ can reasonably be assured that the fire protection system will function correctly. ▪ Determine if any changes have been made to the fire protection system. The standard assumes that the original system design and installation have not changed and the water supply or building use is the same as originally constructed. This is an incorrect assumption that should not be perpetuated. ▪ Conduct an evaluation of any proposed building changes before any change is incorporated. Permits must be applied for, and the required plans must be submitted for approval prior to making any changes. ▪ Be aware that the standard provides that if a property owner is contemplating changing a process or material, then it is the owner's responsibility to arrange for the evaluation of the fire protection system. However, there might be changes that the property owner is not aware of, including the following: • Moving stock from one area to another (change of commodity in a given area) • Increase in storage height (change in volume of combustibles) • Component material changes not by the property owner (commodity class change) • Material stored (material owner is not the same as the property owner) ▪ Communicate with the property owner on a regular basis and make visits to the facility; visit with the responding fire station that performs the preplanning for the facility. The engine crews can provide valuable information to the AHJ, gather important information for response, and participate in the preparation of response plans (in case of impairment or system shutdown), as well as help the owner with questions that might arise. ▪ Look at the fire protection system as it compares to the original installation. Wherever any device, equipment, system, condition, arrangement, level of protection, fire-resistive construction, or any other feature is changed, notify the property owner of the need to correct the deficiency.

Responsibility	*Role*
Records Retention	**Inspector** ▪ Assist the owner by explaining the requirements of NFPA 25 as they pertain to record keeping. ▪ Suggest methods to organize and store records, and ensure the owner is aware that he or she is responsible for maintaining records. ▪ The inspector might choose to keep a set of records to make future inspection and tests easier, but the inspector is not responsible for retaining the documents for other parties.
	Owner ▪ Maintain records of inspection, testing, and maintenance of water-based systems. ▪ Keep records of the original acceptance tests, as-built drawings, and other close-out documents. The standard allows the keeping of these records electronically, and many service providers maintain records for owners that can be accessed at any time using the Internet. ▪ Verify that the owner retains ownership of the records, should the owner choose to change service providers.
	AHJ ▪ Retain acceptance test records for the life of the system, and refer to these records when performing a facility inspection. Use the records to compare the existing conditions with the original installation to determine if any changes have been made that will affect the fire protection system. ▪ Require the ITM service to provide copies of their reports, and incorporate these reports into the AHJ's property file for the facility. It is recommended that the AHJ request copies of the inspection reports from all the ITM service providers in their jurisdiction. ▪ Give a specific timeline to the ITM service for providing the reports so that the report can be evaluated and deficiencies can be corrected in a timely fashion. ▪ Require that a log book be kept at the facility containing the original plans, acceptance test documents, and any inspection or repair documents.
Inspection Frequency	**Inspector** ▪ Strictly follow the requirements of NFPA 25 as they pertain to the frequency of inspections. ▪ Educate the AHJs and property owner with what NFPA 25 requires in regard to inspection frequency. ▪ Note that other agencies might impose regulations regarding inspection frequencies that differ from NFPA 25. These should be considered only when they are more stringent than the frequencies in NFPA 25.
	Owner ▪ Follow the inspection frequencies provided in NFPA 25, and understand that there is nothing to restrict more frequent inspections. ▪ Know that if the owner desires to perform inspections less frequently, a performance-based program can be instituted that involves the owner, demonstrating that less frequent inspections will not decrease the reliability of the system below acceptable standards. ▪ Ensure all performance-based programs are approved. ▪ Use a performance-based program only after following a methodology such as that outlined in Section 4.7.
	AHJ ▪ Evaluate the inspection reports to determine if the inspections are being performed in accordance with the standard and, if not, formulate an action plan to address the deficiency. ▪ Note that jurisdictions might allow the inspection frequency to be modified to less than those listed in the standard. These modifications are based on a well-documented performance-based inspection schedule. Copies of this documentation should be maintained in the facility log book, as well as in the AHJ's property record. ▪ Document any undocumented variance to the standard's inspection frequencies as a failure of the system. ▪ Evaluate what has been presented and determine if the schedule is acceptable. However, if the AHJ feels uncomfortable approving the performance-based schedule, he or she can always require a third-party expert to evaluate the schedule, the costs of which are borne by the proponent of the design.
Tools and Safety Equipment	**Inspector** ▪ Keep tools and testing equipment — hoses, gauges, amp/volt meters, diffusers, and so forth — clean, calibrated, and in good working condition. ▪ Wear the proper personal protective equipment (PPE) — safety glasses, hard topped boots, and gloves — as part of a daily routine. ▪ Comply with the requirements of *NFPA 70E®, Standard for Electrical Safety in the Workplace®,* for fire pump testing, including arc-protection PPE such as insulated gloves, rubber boots, face shields, and body aprons; many older controllers require the inspector to directly measure amp and volt readings while the controller is fully energized.

Responsibility	*Role*
Tools and Safety Equipment (continued)	**Owner** ▪ Maintain strict safety protocols — they must be followed by employees and vendors. ▪ Ask for confirmation or evidence that service providers comply with state and federal Occupational Safety and Health Administration (OSHA) requirements, along with site-specific safety needs. ▪ Inform the service providers of any hazard materials that might be encountered, along with the current safety data sheets (SDS).
	AHJ ▪ Understand that the typical municipal AHJ working for the building or fire department has a limited role in the preparation of tools and safety equipment for the ITM inspector. ▪ Be aware that there might be several different AHJs for an activity, since the numbers of regulations for the various activities have different enforcers. ▪ Determine the level of involvement needed. The local AHJ might be involved in permitting and inspection of work sites, such as confined space entry, or in an inspection that involves entry into an area that requires use of respiratory protection.
System ITM Activities	**Inspector** ▪ Always be prompt, professional, and proficient in his/her job (the three *P*s). ▪ Explain what you are doing, and always ask the owner if an escort is required. ▪ Clearly explain the results and findings of inspections and tests. ▪ Think ahead of time where the water will travel to prior to performing any given test that involves the discharge of water. ▪ Be respectful of the owner's property and inform all occupants and tenants of any alarms that will be sounding and any other ancillary building systems that might be affected during the testing.
	Owner ▪ Determine the level of involvement. When the owner contracts ITM tasks to a service provider, the level of involvement for many items is subject to the discretion of the owner, such as whether or not to accompany those performing ITM. ▪ Require direct involvement by the owner for the items that follow: • Providing access to all system components that require ITM • Notifying all persons occupying the property of any alarms, flowing water, or other potential disruptions associated with ITM • Ensuring that all required impairment procedures are performed
	AHJ ▪ For the most part, the AHJ does not attend or conduct the ITM activities outlined in NFPA 25. These activities are performed by employees of fire protection contractors, who are contracted by the property owner to comply with the requirements of specific law. ▪ The reports generated by these inspections are useful tools to identify deficiencies in the fire protection equipment.
ITM Reports/ Forms	**Inspector** ▪ Make sure all reports, forms, and any written correspondence is clear, legible, and well-written. ▪ Submit all reports in a timely manner. ▪ Note all deficiencies and refer to the appropriate section(s) of NFPA 25.
	Owner ▪ Make sure that all required records are complete and legible when using a service provider. ▪ Verify that all reported tasks were completed. ▪ Understand all reports or forms before signing, as many terms, descriptions, or deficiencies might be unfamiliar to the owner. ▪ Ask for and refer to a copy of NFPA 25 to be certain that all required work was performed.
	AHJ ▪ Require a copy of the ITM reports. ▪ Evaluate the report to determine if any corrective actions are needed to ensure that the protection system is operational. ▪ Request copies of all the inspection reports, with specific timelines for providing the reports; do this to ensure that the deficiencies are corrected as quickly as possible. ▪ Review the inspection report to make sure it includes a detailed explanation of every deficiency and an indication of whether the inspection frequency is a weekly, monthly, quarterly, or annual inspection.

Responsibility	*Role*
Corrective Actions for Deficiencies and Impairments	**Inspector** ▪ Provide a proposal for making any necessary corrections. ▪ Make sure these proposals are competitive, clear in scope, and provided in a timely manner. ▪ Clearly identify any long lead time items. ▪ Note what equipment or building areas will need to be accessed to perform the work.
	Owner ▪ Correct any deficiencies identified during ITM. ▪ Verify that the person or entity making corrections or repairs is qualified to do so, and ensure that any jurisdictional requirements for licensing or the certification of those making corrections are followed. ▪ Understand that while simple corrections can be made by the owner's personnel, such as locking a control valve in the appropriate position, more complex corrections might require a contractor. ▪ Note that there is no requirement for the inspecting entity to make corrections.
	AHJ ▪ Contact all of the ITM service providers in the jurisdiction, and request copies of the inspection reports. ▪ Provide a specific timeline to the ITM service provider for completing the reports, so there is time for the report to be evaluated and deficiencies to be corrected in accordance with the policies of the jurisdiction. ▪ Investigate the cause of any impairments to ensure that other systems in the area are not affected by the same issues. ▪ Take the necessary action to ensure a level of response commensurate with the decrease in protection provided by the impaired system. ▪ Determine the level of protection for a facility and the level of protection required in the event a system is impaired.
System Tagging	**Inspector** ▪ Assist the owner with tagging procedures and in complying with Chapter 15. ▪ Note that the inspecting firm can also provide assistance with the tags and help establish the most effective wording.
	Owner ▪ Understand that NFPA 25 has limited tagging requirements. ▪ Attach tags to the system components, showing the date of inspections, tests, or maintenance, along with other information. ▪ Ensure that tags have been properly completed and placed in cases where a jurisdiction requires the use of tags.
	AHJ ▪ Use fire protection system tags as an initial indication of a system's condition, but do not rely solely on the information. ▪ Review the inspection report to identify the information needed to determine system readiness. ▪ Remember that the inspection report and tagging of the fire protection system relates strictly to the NFPA 25 inspection and does not look at all of the conditions that could cause a fire protection system to fail. ▪ Remind the property owner of the scope of the NFPA 25 inspection, and educate them on the other conditions that could cause failure.
Follow-Up on Corrective Actions	**Inspector** ▪ Perform the inspection and testing activities as outlined in NFPA 25 again. ▪ For examples, see Table 8.6.1 for fire pumps and Table 5.5.1 for fire sprinkler systems.
	Owner ▪ Make all corrective actions and repairs as directed. ▪ Verify that all corrections have been completed and documentation has been provided to the appropriate authorities when using a service provider.
	AHJ ▪ Enforce the provisions of NFPA 25 if the AHJ has adopted the appropriate enabling document, such as NFPA 1, *Fire Code*. ▪ Contact the ITM service provider when a report that lists deficiencies is received, and determine if the repairs have been made. ▪ Determine the level of deficiency and severity of hazard if the repairs have not been made. ▪ Contact the facility owner/agent if the deficiency is a relatively low hazard, and request a timeline for repair or a fire safety improvement plan.

Responsibility	*Role*
Planned Impairment Programs	**Inspector** ▪ Assist the owner by providing fire watches, establishing temporary water supplies, and determining the duration of impairment. ▪ Assemble and procure the needed materials, tools, manpower, and equipment to perform any needed repairs *prior* to commencing the planned impairment.
	Owner ▪ Ensure that all steps listed in Chapter 15 are completed, as these are the minimum requirements for impairment programs. ▪ Obtain assistance from service providers in implementing an impairment program. ▪ Ensure that a system is complying with the insurer's requirements, as many insurance companies have strict impairment procedures. ▪ Notify the fire department that a system is impaired, and obtain approval from the fire department when using alternative water supplies, fire watches, and other impairment activities that could impact fire department response and fire-fighting tactics.
	AHJ ▪ Note that when the ITM service provider has determined that a fire protection system must be taken out of service, the provisions of the facility emergency plan and policies of the AHJ should be discussed; those portions of the plans should be implemented prior to taking the system out of service. The planned impairment might also require plans to be submitted and a permit obtained. ▪ Where a fire protection system is out of service for more than 10 hours in a 24-hour period, the impairment coordinator must arrange for one of the following: • Evacuation of the building or portion of the building affected by the system out of service • An approved fire watch • Establishment of a temporary water supply • Establishment and implementation of an approved program to eliminate potential ignition sources and limit the amount of fuel available to the fire
Emergency Impairments	**Inspector** ▪ Assist the owner, at the owner's specific direction, by providing fire watches, establishing temporary water supplies, and determining the duration of impairment. ▪ Assemble and procure the needed materials, tools, manpower, and equipment to perform any needed repairs once authorized to do so.
	Owner ▪ Know the importance of having a plan to follow when an unplanned impairment occurs. ▪ Have someone on site at all times who is knowledgeable about the system(s), including the location and operation of water supply control valves and drain valves. ▪ Make sure the water supply is shut off promptly and drains are opened to significantly reduce water damage when an unplanned water discharge occurs, such as a broken sprinkler. ▪ Maintain spare sprinklers, because acquiring specialized or hard-to-obtain critical components can lengthen the time a system is out of service and increase the associated costs.
	AHJ ▪ Preplanned actions need to be discussed with the ITM service provider in all cases involving impairments to ensure a consistent level of protection for the property. ▪ Discuss policies involving the disabling of any fire protection system prior to that system being taken out of service. ▪ Provide contact information that will allow the ITM service provider to notify the appropriate authorities any time a system is taken out of service. ▪ Determine what level of alternative protection must be provided once the AHJ or designee is notified that a system is out of service. Part of that evaluation might include the following: • Level of impairment • Amount of time the system might be out of service • Type of hazard without protection • Potential for an uncontrolled fire • Risk to the community

Responsibility	*Role*
Restoring System to Service	**Inspector** ▪ Perform the inspection and testing activities as delineated in NFPA 25 again. ▪ Assist the owner with removing all tags and informing interested AHJs of the system status.
	Owner ▪ Ensure that systems are back in service. ▪ Ask for documentation that all required tests were performed if a service provider is used. ▪ Ensure tags are removed and that the fire department, other AHJs, and the alarm receiving station are notified. ▪ Ensure that all required tasks are completed either by the service provider or owner's representative.
	AHJ ▪ Consider requiring that the fire protection systems be evaluated to ensure that the design addresses the hazards. ▪ Consider having the work performed by a qualified contractor. ▪ Inspect the fire protection system after being notified that a repair to the system is complete to ensure it is operational. ▪ Keep in mind that NFPA 25 provides for a certain level of inspection to be performed. However, depending on the level of repair, the AHJ might require additional inspection/testing to be conducted.
Obstruction Investigations	**Inspector** ▪ Clearly explain the importance of obstruction investigations and the procedures that will be followed in performing the investigation, such as what system components will need to be accessed, which areas of the facility will be disrupted, and so forth. ▪ Clearly identify and take precautionary efforts regarding where the water will travel. ▪ Identify and communicate to the owners and AHJ the duration of all system shutdowns, and assist the owner in complying with NFPA 25 regarding the shutdown. ▪ Explain all the findings of the investigation; this includes submitting a detailed report complete with pictures, as necessary. ▪ Note that some of what is outlined here might be the duty of the actual inspector, while some might be that of another entity of the inspecting firm.
	Owner ▪ Follow a prescribed frequency, or determine the frequency of internal pipe inspections, by completing a risk assessment. The owner should not take this assessment lightly and should have a qualified individual or entity conduct it. A 5-year inspection frequency for internal pipe inspections is designed to keep the cost at a minimum by having the inspection correspond to the internal inspection of check valves, which are also on a 5-year frequency. ▪ Conduct an obstruction investigation when an inspection or other issues reveal the potential for obstructions. Section D.3 contains procedures for conducting an obstruction investigation.
	AHJ ▪ Note that an obstruction investigation should be viewed similar to an impairment. The AHJ should be notified of obstruction investigations and to what degree the fire protection system will be impaired. ▪ Request specific information to determine what the nature of the investigation is, and whether or not there are additional notifications or investigations that need to take place. ▪ Determine a level of response, but note that it will directly relate to the type of obstruction found. ▪ Consider impairment procedures if the fire protection system is going to be out of service. The fire department must be able to respond accordingly to a particular incident.
Performance-Based ITM Programs	**Inspector** ▪ Inform and educate owners and AHJs of alternative means and methods of complying with NFPA 25. ▪ Provide variances on costs, activities to be performed, equipment to be accessed, and so forth. ▪ Make sure the owner and AHJ clearly understand the advantages and disadvantages associated with differing means of complying with NFPA 25.
	Owner ▪ Understand that although NFPA 25 gives the owner the option to use a performance-based ITM program, great care should be exercised in doing so. ▪ Include the fire department and other interested AHJs when developing a performance-based program. ▪ Determine a failure rate that is acceptable to all stakeholders. ▪ Note that performance-based programs are generally suitable to owners with large numbers of properties and/or components in order to develop a database large enough to make a realistic assessment of potential frequencies and failure rates.

Responsibility	*Role*
	AHJ ▪ Evaluate performance-based options as a means to provide a greater degree of safety and, potentially, a lower cost to the facility owner. ▪ Look to provide the highest level of protection with the lowest degree of risk when developing the program to provide an alternative means of compliance. ▪ Evaluate testing programs using a method that is acceptable to the AHJ and appropriate for the conditions. Each design should be realistic and apply to conditions found in the facility.

References Cited

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 1, *Fire Code,* 2018 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, 2019 edition.

NFPA 70®, *National Electrical Code®*, 2020 edition.

NFPA 70E®, *Standard for Electrical Safety in the Workplace®*, 2018 edition.



SUPPLEMENT 3

ROLE OF THE INSPECTOR

By Terry L. Victor

Editor's Note: *In an effort to assist those involved in training inspectors and those who are being trained, this supplement has been included in the handbook to outline the training needs, safety equipment, basic duties, and the approach to the performance of work for the professional inspector. It includes information for the training and education of the professional water-based fire protection systems inspector. This supplement can be used for formal training classes or for individual study. It is not part of NFPA 25 and is not intended to be an enforceable part of the standard.*

The inspection and testing of a fire protection system requires specialized knowledge of system components, including valves, piping, hangers, test connections, and sprinklers. This specialized knowledge includes recognition of different types of components, their intended use, manufacturer's testing requirements, and Underwriters Laboratories' listing criteria. The inspection and testing of a water-based fire protection system requires expertise that is not usually associated with building engineers or building maintenance personnel, and 4.1.1.2 states that "Inspection, testing, and maintenance shall be performed by qualified personnel."

Therefore, many property owners and occupants rely on and contract with fire protection contractors who offer inspection and testing services. Although NFPA 25 requires some training and experience for personnel involved in performing the tasks required by the standard, it cannot dictate the exact training and experience for every situation in which the standard might be adopted and used. For example, some jurisdictions might require licensing for individuals providing professional inspection, testing, and maintenance (ITM) services, whereas other jurisdictions do not.

This supplement is intended to offer examples illustrating the role and duties of the inspector. It is not intended to be an all-inclusive list of responsibilities, but rather an outline of the background and qualifications necessary to perform the work. The discussion of preplanning, tools and equipment, and the approach to an inspection is intended to provide the inspector and property owner with a basic plan for inspecting any building or system.

Many activities in NFPA 25 require only a visual inspection to determine the status and/or the condition of a component or system. These activities can be taught to on-site personnel and require a minimal amount of training. Most of the weekly and monthly inspection requirements fall into this category, and training on-site personnel might be the most cost-effective way to comply with the standard. This supplement deals primarily with the activities of the inspectors employed by fire protection contractors and the methods used to conduct the inspection and/or tests required by NFPA 25. Methods used to compile and record results are also addressed. For those who feel they are qualified to perform this work, proceed with caution and have the telephone number of a reputable contractor in your area available, in case you are unable to silence the fire alarms, reset the dry pipe valve, or restore the fire pump to normal service.

Inspector Responsibilities

The purpose of periodic inspection and testing of fire protection systems is to provide a reasonable amount of assurance that, at that moment in time, the system will operate as intended during a fire emergency. Note the following in A.1.2 of NFPA 25:

History has shown that the performance reliability of a water-based fire protection system under fire-related conditions increases where comprehensive inspection, testing, and maintenance procedures are enforced.

The contract with a fire protection contractor to perform the ITM of a water-based fire protection system is not an insurance policy or an engineering evaluation. If the property owner is ever uncertain whether the fire protection system, as installed, will provide the minimum protection required by the applicable codes, the owner should contact a fire protection engineer or qualified contractor to perform an analysis of the building, the building occupancy, the commodity classification of any storage present, the system design criteria, and the water supply.

The inspection and testing of a fire protection system in accordance with NFPA 25 is *not* equivalent to any of the following:

1. An engineering or authority having jurisdiction (AHJ) review or evaluation of the adequacy of the system to control or extinguish a fire in the protected occupancy.
2. An engineering or AHJ review or evaluation of the adequacy of the water supply, including water tanks and fire pumps, to provide the necessary water flow and pressure needed to meet the fire protection system demand as designed.
3. An engineering or AHJ review or evaluation of the hazards present in the facility to determine the required system criteria for minimum protection levels.
4. An engineering or AHJ review, evaluation, acceptance, inspection, or test of the fire protection system to determine whether the system was designed and installed in accordance with the applicable installation standard, including NFPA 13, *Standard for the Installation of Sprinkler Systems*; NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*; NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*; NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*; NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*; NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*; NFPA 22, *Standard for Water Tanks for Private Fire Protection*; and NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances.*
5. An engineering or AHJ review or evaluation of all areas of the facilities to determine whether all areas of the facility are protected in accordance with the original applicable installation standard.

The NFPA Technical Committee on Inspection, Testing, and Maintenance of Water-Based Systems has made it clear that the role of the inspector performing the inspection and testing activities in accordance with NFPA 25 is not that of a fire protection engineer or an AHJ. The inspector is not required to be a fire protection engineer, nor is the inspector required to have detailed knowledge of the fire protection system installation requirements in the applicable NFPA standards. Therefore, when property owners contract with a fire protection contractor, they should not expect the inspector to provide an engineering analysis detailing the adequacy of the system design when compared to the hazard, or evaluate the accuracy and completeness of the installation.

The inspector is not required to perform the following functions:

- Review the design criteria for the system to determine whether it is adequate for the commodity or hazard
- Review the installation shop drawing to make sure all pipes are correctly sized and the sprinklers are the correct type, orifice size, and temperature rating
- Perform a water supply analysis to determine whether the water supply is sufficient to provide the required gallons per minute at the required pounds per square inch for the system
- Perform a complete building inspection to determine whether closets, blind spaces, attics, crawl spaces, and all other special building features are adequately protected in accordance with the version of the installation standard in force at the time of the installation
- Recognize that storage commodities and/or arrangements are different from those anticipated when the system was designed and installed
- Research the installation contract files to determine whether special requirements were needed by the AHJ

Inspector Qualifications and Training

The inspector of a water-based fire protection system — whether an employee of the property owner, the owner's authorized representative, or an employee of a fire protection contractor — has a tremendous responsibility. Water-based fire protection systems protect both life and property. These systems have a history of reliability that exceeds most other mechanical systems. In those instances when a water-based fire protection system fails to extinguish or control a fire, poor maintenance and shut water control valves are the most frequent reasons for the failures. Although a properly conducted ITM program cannot guarantee the performance of a water-based fire protection system, the chances of timely system operation and fire control during a fire emergency are increased dramatically. The inspector is responsible for conducting inspections and tests in accordance with NFPA 25, industry-accepted practices, and manufacturer's recommendations. Given the importance of these systems, the choice

of whom to hire and train as an inspector should be given careful consideration.

Inspector Qualifications

A person hired as an inspector who has little or no knowledge of fire protection systems will obviously have a more difficult time during training than someone who has worked in or around the fire protection sprinkler industry and has knowledge of these systems. The inspector-in-training with little or no knowledge of fire protection systems will have to learn the systems and components, as well as the requirements of NFPA 25, and the proper ways to conduct an inspection and/or test.

Whatever the background of the individual hired as a water-based fire protection systems inspector or trainee, several personal traits must be considered as well. The role of the inspector is to properly perform the activities required by NFPA 25, which are meant to provide the highest level of assurance that systems will respond as expected during a fire emergency. An individual who lacks a certain work ethic and sense of responsibility will not carry out these activities as accurately or as thoroughly as expected or, in some cases, will not carry them out at all. The following sections describe the desired personal traits of the person hired to perform inspection and testing activities and allow the reader to fully understand the total scope of competency and training required of the NFPA 25 inspector.

Basic Traits. There are some basic traits that an inspector should possess to do the job completely, accurately, efficiently, and professionally. Aside from related work experience, the person hired to be an inspector should meet the following minimum qualifications.

Conscientiousness and Motivation. An inspector must be conscientious and aware of the importance of the job being performed. The need to perform every inspection completely and thoroughly must be the number one priority of the inspector. An inspector must possess a good work ethic, be self-motivated, and have the ability to self-supervise. Some contractors schedule their inspectors and even set up appointments to have systems inspected, whereas others rely on the inspectors to establish their own schedule and make their own appointments. Whichever is the case, the inspector needs to be at the property when scheduled. The owner, the owner's authorized representative, and/or the occupants expect the inspection to take place as scheduled. The monitoring station and the local authorities might expect alarms to be tested at certain times. An inspector who is aware of schedules and appointments shows regard for the other individuals involved in supervising and maintaining water-based fire protection systems.

Dexterity. An inspector should be mechanically inclined. Some of the activities that must be performed by an inspector include resetting or restoring to service dry valves, preaction valves, deluge valves, accelerators, exhausters, air compressors, fire pumps, controllers, alarm switches, and numerous other system components. The inspector must also be able to interpret test results, perform basic troubleshooting, and make recommendations to correct deficiencies or impairments found.

Education. An inspector must be educated and have legible writing. Local codes as well as NFPA 25 must be read, understood, and applied as inspections are performed. The inspector must have the ability to read the manufacturer's maintenance information and follow the instructions. Inspection forms must be filled out so that those responsible for system maintenance can read them and correct any deficiencies found. In recent years, computer programs have been developed to aid in the inspection process. These programs include question sets that correspond to the activities required by NFPA 25. In addition, the programs provide standardized descriptions of, and describe corrective actions for, impairments and deficiencies. If computers are used as part of the inspection process, then computer skills are also necessary.

Communication Skills. An inspector must be able to communicate well, both orally and in writing. Once an inspection is complete, the inspector must be able to translate the results of the inspection and/or test onto the inspection report. These results must then be explained to the owner or the owner's authorized representative. For most fire protection contractors, the inspector works face-to-face with the customer more than anyone else in the company; therefore, the inspector's relationship with the customer reflects the attitude and professionalism of the contractor.

Organization. An inspector must be organized and have an organized office behind the scenes. Keeping track of the names and addresses of the properties to be inspected, the testing frequencies required for the types of systems and components in each building or structure, and the previous inspection reports requires organized tracking methods. Some contractors rely entirely on the inspector to keep these records organized, whereas others provide office staff to assist.

Appearance and Hygiene. An inspector should be neat in appearance and have good personal hygiene. The inspector has to interact with owners, owners' authorized representatives, building occupants, building engineers, approving authorities, and other inspectors. Having a neat appearance is especially important for the inspector who works for a fire protection contractor, as he or she represents the professionalism of the contractor. Having good personal hygiene is a common courtesy to those who have to work with the inspector. The pride that an inspector has in himself or herself is usually reflected in the quality of the work they do.

Character and Background. Any inspector, whether working for a fire protection contractor or directly employed by the property owner, must also possess the personal characteristics necessary to perform work without being influenced by those who may not want the inspections or tests done properly. Every inspector should approach the inspection and testing of a water-based fire protection system as the most important job he or she has ever had. Lives and property are at stake. Therefore, the inspector should be public safety–oriented, self-motivated, responsible, a good communicator, thorough, organized, ethical, and honest (i.e., would not falsify a report for any reason). Many facilities being inspected require security clearance and background checks of their own employees, as well as contractor employees entering their sites. In turn, most fire protection contractors perform background checks on candidates before hiring an inspector or inspector trainee.

The candidate who does not have the complete set of minimum qualifications and basic traits described here will struggle in the performance of the responsibilities of an inspector. Some of the traits described, such as communication skills, appearance, and education level, can be learned. The others, such as organizational ability or character, are inherent for the most part, and either cannot be taught or are taught with much difficulty and effort.

Experience. Many inspectors working for fire protection contractors have previous experience with water-based fire protection systems either as a sprinkler fitter, an engineering technician, a fire service inspector, or an insurance underwriter. Inspectors with previous experience in these fields have a varied range of knowledge of water-based fire protection systems and how these systems should operate during a fire emergency.

The sprinkler fitter who installed fire protection systems knows how to read installation shop drawings, knows different system configurations, and knows all of the standard system components. An inspector with this background also knows the methods of concealing piping systems, which is useful in locating pipes when inspecting a system for the first time. Many valves and system components that need to be inspected or tested are concealed behind access panels in walls or above ceilings. The sprinkler fitter who serviced and repaired water-based fire protection systems has a more thorough knowledge of how these systems work and what the possible reasons are for bad test results or failures. The service sprinkler fitter has replaced the gaskets in dry pipe valves, rebuilt exhausters and accelerators, and cleared obstructions from all parts of a system, from mains to branch lines to trim piping.

The engineering technician has a good theoretical knowledge of systems and their components. The layout of a fire protection system involves the ability to visualize how the pipe, fittings, and hangers fit in the building or structure. All of the various valves and system components are detailed on the shop drawings. With a background in performing and translating hydraulic calculations for various types of systems, the engineering technician should be able to better interpret main drain test and fire pump test results.

The fire service inspector has experience and skills that closely parallel those needed by the inspector of water-based fire protection systems. Knowledge of applicable codes and the ability to interpret them is required in both positions. The fire service inspector has performed a visual walkthrough of entire systems to ensure that they were installed in accordance with the approved shop drawings and has witnessed the testing of systems conducted by the installing contractor.

The insurance underwriter has performed the same inspections and tests that the fire service inspector has and has seen firsthand how the systems perform. The insurance underwriter has been on the scene after a fire emergency and has documented how problems in a water-based fire protection system, such as a painted sprinkler or a clogged branch line, have impaired the system's ability to control fires. The insurance underwriter has also been involved in the rating of properties with and without fire systems and therefore knows the financial benefit of properly maintaining these systems.

Training the Inspector

Inspector training is a process of teaching skills to individuals over a period of time until a minimum competency level is obtained that will allow the inspector to perform basic inspection and test activities. However, training does not stop at this point, unless the inspector is limited to performing basic activities such as inspecting and testing wet and dry systems for the remainder of his or her career. In reality, the training process never stops. As the requirements of NFPA 25 change, as new types of systems and components are developed for the industry, and as more sophisticated inspection and testing equipment are introduced, additional training will be necessary.

A program developed for the training of inspectors should address the various levels of experience of the individuals being trained. If the individual is new to the fire protection industry, training must start at a rudimentary level. Terminology within the fire protection industry is somewhat specialized and the knowledge of the components that make up a fire protection system must first be taught. Training seminars are available from several organizations, such as NFPA, National Fire Sprinkler Association (NFSA), and American Fire Sprinkler Association (AFSA). Internet-based training is also available. Some colleges and universities have also developed curriculums specific to training inspectors of water-based fire protection systems.

Certifications

The National Institute for Certification in Engineering Technologies (NICET) sponsors certification programs for inspectors of water-based fire protection systems, in addition to other fire protection subfields. NICET certification can be used to determine the competency of inspectors in the application of NFPA 25 and other standards and practices used in the field. The following three levels of certification are available, based on written verification of the individual's experience and ability to pass a written exam:

- Level I — less than 2 years of experience
- Level II — 2 to 5 years of experience
- Level III — over 5 years of experience

Once certified, inspectors must maintain their certification by accumulating professional development points from on-the-job experience, by attending training seminars, or by participating in specific industry-related activities. Inspectors must accumulate 90 professional development points every three years to maintain an active certification. For more information regarding NICET certification, see www.nicet.org. Many states and local jurisdictions now require NICET certification for the licensing of fire protection contractors and/or inspectors. Contact the state or local jurisdiction for their licensing requirements.

Training should be documented, not only for the advancement of personnel but also to protect against possible lawsuits. If the individual has a background in fire protection, knows the industry terminology, and can identify system types and components, training can concentrate on the actual inspection and test activities. In today's world, any incident that involves a loss of life or property becomes a target for lawsuits. One way to defend against lawsuits that attempt to prove negligence is to submit training records and personnel records that prove the competency of both the contractor and the individual inspectors. Maintaining high standards in hiring practices and providing continuous training is necessary if legal problems are to be avoided.

Before Conducting an Inspection and/or Test

Conducting an inspection and/or test for the first time in a building will require more time than will subsequent inspections and/or tests. The initial inspection will require that the inspector meet the owner or the owner's authorized representative for the first time. The inspector must become familiar with the building, the systems installed in the building, the system components, and the records of the previous inspections and tests performed. The inspector must then determine the necessary inspection and test tools, equipment, and instruments needed. The inspector must also plan the inspection and test sequence and prepare the inspection reports. Subsequent inspections and tests take less time because the building and systems are known and the inspector can focus on inspecting and testing the systems and components.

Written Agreements

An inspection agreement and its specifications should be read carefully by both the owner and the occupant. Paragraph 4.1.1.3 of NFPA 25 states the following:

> Where the property owner or designated representative is not the occupant, the property owner or designated representative shall be permitted to delegate the authority for inspecting, testing, maintenance, and the managing of impairments of the fire protection system to a designated representative.

As with any contract for services, a properly executed document removes any ambiguities, misunderstandings, or confusion. More importantly, the inspection agreement defines the financial responsibilities and liabilities of the owner and the fire protection contractor.

An inspection/test agreement describes the activities provided by a fire protection contractor for the owner, occupant, management firm, or managing individual. These agreements normally include the following information:

Building address
Description and quantity of the system(s) being inspected/tested
Frequency of the inspection/test activities
Reports
Annual cost of the agreement
Payment terms
Renewal terms
Limits of liability
Signature space

Other specifications, include:

Criteria
Notification
Working hours
Cancellation
Access

Building Address. Referencing the street address of the building being inspected is necessary to avoid any misunderstandings by the property owner, the fire protection contractor, and the inspector(s). Also, a building's name, owner, or management company might change, making it difficult to maintain a historical record of inspections and tests of the fire protection systems. The building's street address generally remains a consistent point of reference.

Description and Quantity of the System(s) Being Inspected/Tested. As in any contract, the services being provided for the price indicated must be clearly defined. Many buildings have several fire protection systems that are required to be inspected and tested by NFPA 25. For instance, a typical high-rise office building will have a backflow prevention device, one or more fire pumps, a standpipe system, wet pipe sprinkler systems on each floor, and dry pipe systems in the parking garage and mechanical penthouse. There might even be one or more preaction systems in computer rooms and a fixed water spray system in a cooling tower. Does the contract include all water-based fire protection systems in the building? Even if the intent of the contract is to include all systems in the building at the time the contract is executed, it is still advisable to include a list of all systems in the building. Systems can be added or changed, which will affect the contract price.

NFPA 25 contains a series of tables that describe what action must be performed on systems and/or components when corrective action is taken to address a deficiency or impairment. Each table is referenced in the subsection in which it appears, for example: "Whenever a component in a [type of] system is adjusted, repaired, reconditioned, or replaced, the action required in Table 5.5.1 shall be performed." Many of the actions required include reinspecting and/or retesting of systems or components after they are adjusted, repaired, reconditioned, or replaced. The fire protection contractor might be contacted to reinspect and/or retest the system or component, and the inspector might be called to return to the facility to perform the inspection or test. These inspections and tests are performed separately from those conducted on a periodic basis per NFPA 25. The agreement should specify if these additional inspections and/or tests are included in the contract price. Because the types of reinspections or retests required or the frequency of these inspections and tests cannot accurately be determined ahead of time, most contracts will not include them. The fire protection contractor can price and provide these inspections and tests on an as-needed basis.

Frequency of the Inspection/Test Activities. NFPA 25 requires that certain activities be performed at prescribed frequencies. However, rarely does an inspection and test agreement assign all of these activities and frequencies to a fire protection contractor. To comply fully, an implied partnership is formed between the owner or the owner's representative and the fire protection contractor. All of the requirements of NFPA 25 are the responsibility of the owner, and the fire protection contractor relies on the owner to perform all inspections and tests not specified in the agreement.

A common agreement for a wet sprinkler system will specify that the fire protection contractor enter the building on a quarterly or semiannual basis to inspect the gauges, control valves, alarm devices, hydraulic nameplate, and the fire department connection, as well as to test some of the alarm devices. In addition to these activities, flow switches and valve tamper switches will be tested semiannually; the building, pipe hangers, pipes, fittings, and spare sprinklers will be inspected annually; and the main drain will be tested annually. Such an agreement would specify a quarterly or semiannual inspection and test in accordance with NFPA 25. All other weekly and monthly activities are expected to be performed by the owner, occupant, management firm, or managing individual.

Unless specified in the agreement, all other less-frequent activities are not included, such as testing gauges every 5 years; testing sprinklers every 5, 10, 20, or 50 years; and internally inspecting pipes, alarm valve, check valves, strainers, filters, and orifices every 5 years. These activities are normally performed by the fire protection contractor but are invoiced as additional periodic services.

Reports. Records of ITM activities are to be maintained by the property owner. The fire protection contractor generally provides reports of the inspection and test activities performed at each visit. Many local jurisdictions require that such reports be kept at the site. Local ordinances might also require that a copy of any reports be submitted directly to the AHJ.

Reports come in as many versions as there are contractors providing services. Many forms are still filled out by hand, although computerized programs with printed reports are becoming more and more popular. The electronic reports are more professional and legible. When preprinted report forms are filled out by hand, multiple copies can be provided on the spot using multi-sheet forms or the occupant's copy machine. Some companies provide printers for technicians using computer-based inspection programs; however, the more common practice is to input the test results off-site, create the report in the office, and e-mail it to the customer.

The inspector or the office administrator should be able to reference the agreement to determine who has been authorized by the owner or the owner's representative to receive the inspection report forms.

Annual Cost of the Agreement. Of course, the most important part of any agreement is the price. A typical agreement is priced for a one-year term. The price can be broken down into quarterly payments and, in some cases, per system. However, most agreements state a lump sum that covers all described activities and frequencies.

Payment Terms. Payment terms are extremely important to both the fire protection contractor and the owner. The owner needs to know when to expect billing for budgeting purposes, and the fire protection contractor needs to meet payroll and expense needs. Typically, one of two types of payment terms is used in the majority of agreements.

The first type stipulates that the full annual amount is invoiced up front and paid before any inspection or test activities begin. This ensures that the fire protection contractor will have the necessary funds available to meet payroll and expense needs throughout the term of the agreement and creates less paperwork for both parties. There is one invoice, one accounts payable transaction, one check posting, and no collection effort.

The second type stipulates that invoicing is done after each inspection in an amount equal to the work being performed. Many agreements with quarterly inspection frequencies invoice one-fourth of the annual amount after each inspection/test. This payment arrangement usually forces the fire protection contractor to wait until the last inspection of the agreement term to perform any time-intensive activities, such as tripping dry pipe valves and flow testing fire pumps. The owner might be able to budget more favorably with this payment schedule, but it requires four times the office work: four invoices, four accounts payable transactions, and four check postings. Another downside to invoicing quarterly after each inspection is that any delay in the payment of one of the invoices can affect the schedule for the subsequent inspections. Good business practices dictate that a fire protection contractor does not perform additional work if payment is late for the previous work performed.

Many other payment term options, such as one-twelfth invoiced per month, are commonly used by local governments on large agreements, but this option is the exception to the norm.

Renewal Terms. Every agreement should spell out the renewal terms. Typically, an annual agreement renews automatically each year with a cost of living increase tied to the federal index or to pre-described increase percentages per year. Most agreements can be cancelled by either party with thirty days' written notice, provided all payments have been paid for services rendered.

Some agreements require special action on the part of the owner and/or fire protection contractor. The owner might require a new agreement each year, including any revised pricing, or a separate purchase order might have to be issued each year. These provisions should be spelled out in the agreement.

Limits of Liability. Every agreement should state the limits of liability for the fire protection contractor. This legal terminology protects the fire protection contractor for losses that are beyond the fire protection contractor's control and responsibility. No one can guarantee that a water-based fire protection system will work as designed and installed at any given time. As previously stated, fire protection systems are more reliable than just about any other mechanical system, and the fire protection industry has an excellent track record. However, unexpected and improbable occurrences do happen. A clogged sprinkler cannot be detected during an inspection or test, nor can an inspector predict when a leak in a pipe is going to develop.

Despite the difficulty of predicting every potential problem or failure of a system, litigation is very common for a loss event that is associated with a fire protection system, in an attempt to assign blame to everyone from the architect, to the engineer, to the general contractor, to the installing sprinkler contractor, to the fire protection contractor performing inspections and tests. The unanticipated loss could cost any of these parties hundreds of thousands of dollars to defend, unless contractual language exists in the agreement limiting this exposure.

Signature Space. The agreement is a contractual document and therefore must be signed to be legally binding. The agreement should include designated lines at the end of the document for the fire protection contractor and the owner or the owner's authorized representative to sign, print their name and title, and insert the date. An unsigned agreement is not legally considered an agreement.

Agreement Specifications

Specifications are a binding part of an agreement when referenced as an attachment in the body of the agreement. Specifications normally include the more detailed requirements of a contract. Some specifications include the following:

- *Criteria* indicate which specific NFPA 25 requirements are included.
- *Notification* describes who is responsible for notifying occupants of an inspection or test.
- *Working hours* are the hours during which the inspection/test activities can be performed.
- *Cancellation* refers to a cancellation clause in the agreement.
- *Access* refers to the buyer's responsibility to provide access to the inspector.

Communication with the Property Owner

The fire protection contractor is required by NFPA 25 to communicate with the property owner or owner's authorized representative, or the occupant, management firm, or managing individual, as described in the agreement, to obtain certain information concerning changes in occupancy, use, or layout of the building.

Communication with the owner or owner's authorized representative, or the occupant, management firm, or managing individual, is also necessary to schedule an inspection or test. Throughout the inspection and testing process, communication will be both verbal and written. Once an executed contract exists, communication then involves the actual performance of the inspection and/or test.

In some cases, arrangements are made so the inspector can arrive at the property without an appointment and perform the inspection and/or test. However, in a case like this, the owner or the owner's authorized representative, or the occupant, management firm, or managing individual, must be available either in person or by phone to answer questions on the inspection report. The inspector must be provided with the necessary keys and access codes to inspect throughout the protected areas of the property.

Safety Laws and Regulations

Generally, it is the responsibility of the property owner to advise anyone working in the building of specific hazards present. The inspector should, however, request copies of such items as a material safety data sheet (MSDS); they should also determine whether any confined spaces or other hazardous conditions exist.

Tools and Equipment

Essentially, three categories of tools and equipment are necessary to properly inspect and/or test a fire protection system: safety equipment, standard inspection tools and equipment, and standard test equipment.

Safety Equipment. Safety must be a matter of primary importance and should be second nature to the inspector. Federal and state regulations require compliance with safety laws. Common sense dictates that care and caution must be taken to ensure the safety of the inspector, and those working around the inspector, from certain hazards inherent in inspection and test procedures. As a minimum, federal Occupational Safety and Health Administration (OSHA) regulations must be adhered to. If not, employee safety is at risk. OSHA levies stiff fines on companies whose employees do not follow these national regulations. If violations are repeated, the fines increase exponentially.

Table S3.1 describes examples of the safety equipment needed and some general uses for each.

Inspection Tools and Equipment. Table S3.2 lists some of the inspection tools and equipment commonly used by inspectors.

Test Equipment. Table S3.3 lists some of the standard test equipment for the inspection and testing of water-based fire protection equipment.

Inspection Procedure

NFPA 25 does not prescribe how to perform an inspection or test. However, the standard does list the systems and components that are to be inspected and tested, spell out the acceptance criteria, and identify the corrective action requirements.

TABLE S3.1 *Safety Equipment*

Safety Equipment	General Use for Equipment
Hard hat	Hard hats are required when head injury is a possibility from climbing, crawling through confined spaces, or falling objects.
Safety shoes	Safety shoes are required in most industrial and manufacturing plants and at any location where foot injury is possible from stepping on sharp objects or from heavy objects falling on the feet.
Proper clothing	Loose clothing is not to be worn around machinery. In some plants, fire and/or chemical protective clothing must be worn.
Eye protection	Safety glasses should always be worn when inspecting or testing fire protection systems.
Hearing protection	Hearing protection should be a part of the standard safety equipment worn by inspectors. Many areas in industrial occupancies post signs where hearing protection must be worn.
Safety harness	See OSHA regulations for the requirements for safety harnesses. Safety harnesses are required when inspectors must be on ladders or lifts above a certain height.
Confined space equipment	Confined space equipment requirements are not limited to pits or cellars but can also extend to more common spaces, such as unventilated attics, crawl spaces, concealed spaces, and vaults. See OSHA regulations for the requirements for confined space entry.

The actual inspection process is unique to each facility, building, and system. The NFPA 25 report forms available from NFPA's website, if followed line by line, lead the inspector through the process in one way. However, if these report forms or any other report forms are followed line by line, duplication of effort and doubling back over the same parts of the same systems will occur.

This section describes one method of performing an inspection. However, as each system is unique, so is each inspector. What works for one will be inefficient for another. Inspectors must develop their own processes. However, certain bare essentials are universal. Before the experienced inspector can put together a game plan to perform the activities in the most efficient and comprehensive way possible, certain

TABLE S3.2 Standard Inspection Tools and Equipment

Tool	General Use and Notes
Ladders	The inspector should use the right height ladder at all times, to avoid overextending his or her reach. When using extension ladders, always follow the "1 to 4 rule," setting the base of the ladder 1 ft (0.3 m) away from the wall for every 4 ft (1.2 m) in height. The inspector must follow all other safety rules concerning ladders as detailed in OSHA and local requirements, including safety harnesses and fall protection.
Flashlight	A flashlight is particularly useful when working in confined spaces.
Binoculars	Binoculars are typically used for examination of sprinklers from the floor level. The inspector is not expected to climb a ladder to inspect each sprinkler, but binoculars can be helpful when inspecting sprinklers for leakage, corrosion, foreign materials, loading, paint, physical damage, or improper orientation.
Tape measure or folding rule	The size of some pipes or components might not be evident, and the inspector might need to measure the size to provide an accurate report.
Assorted hand tools	To perform certain internal inspections, the inspector will have to remove face plates from valves or remove sprinklers or flushing connections. Screwdrivers, a socket set, crescent wrench, hammer, and a set of open-end wrenches should be included in the inspector's toolkit.

***TABLE S3.3** Standard Test Equipment*

Equipment	General Notes on Use
12 in. pipe wrench	
Crescent wrench	
Calibrated test gauges	
Volt meter	Primarily used during the annual fire pump test. Proper safety equipment should be worn while using this equipment.
Amp meter tachometer	
Hydrometer or refractometer	Used to measure the concentration of antifreeze.
Pitot tube	Used to measure velocity pressure during flow and fire pump tests. (See Chapters 6 and 8.)
Stopwatch	A watch that reads in minutes and seconds. Used to measure trip times for dry pipe systems.
Heat lamp	Used to activate heat detection systems on water spray fixed systems.
Digital gauges	
Water analysis kit	Used when performing the five-year obstruction inspection if tubercles or slime are found in the piping.

information must be reviewed. This information can be divided into three basic areas: preparation for the test, performance of the test, and post-test processing of information.

Preparing for the Test

Familiarity with the Contract. The inspector needs to know the entire scope of the agreement and the types of systems being inspected. He or she must become familiar with the layout of the building and identify where the system controls and valves are.

Scope. The inspector must know how many systems are to be inspected and tested, what type of systems they are, and the frequency of the inspections to be performed. With this information, the inspector can plan the time it will take to perform the inspection or test, and determine the equipment needed to perform these activities. The terms and conditions of the contract must be reviewed at this time to determine whether the inspection and test activities are to be performed during off-hours, whether there are special payment terms, and whether there are any other special requirements that will affect the inspection and test process.

Property to Be Inspected. The inspector should review any as-built drawings available or should, as a minimum, review previous inspection reports or sketches that are retained in the owner's inspection file.

Contact Information. Usually, the inspection contract will have contact information. A scheduled appointment might be necessary prior to performing the inspection; contact with the property owner or owner's representative, or the occupant, management firm, or managing individual, should be made at this time.

Planning. Based on the inspection contract and the types of systems involved, the NFPA 25 inspection and test requirements should be reviewed prior to entering the building. Preplanning will save time and can reveal components or systems that require special attention.

Preplanning will reveal the specific inspection and test tasks that need to be performed; this, in turn, will dictate the types of tools and equipment needed to perform them. Preplanning will also highlight the needed report forms.

Before the Inspection/Test

The following procedures represent normal practices used when performing a sprinkler inspection and/or test.

Walk the Perimeter. Upon arrival at the location, the inspector should drive or walk the exterior perimeter of the building to become familiar with the building layout. This helps to determine some of the features of the fire protection systems and the location of many of the components being inspected and tested. The perimeter walk enables the inspector to locate the fire department connection, motor water gong, main valve room, inspector's test valves, main drains, any outside valves [i.e., post indicator valve (PIV), wall post indicator valve (WPIV)], fire pump header — which also indicates the approximate size of the pump — and any specific conditions that the inspector needs to be aware of before flowing any water.

Meet the Owner or the Owner's Authorized Representative. Upon entering the building, the inspector should report to the owner or owner's representative, or the occupant, management firm, or managing individual. The inspector should provide company identification, which includes the inspector's name. Then, the inspector should explain the purpose of the visit, including the steps involved in performing the inspection. The inspector should then ask a series of questions that deal with occupancy changes, content changes, building changes, and system(s) status, filling out the inspection report forms as responses are provided. The inspector should also ask to be directed to the room housing the interior valves controlling the fire protection system(s). Generally, a conscientious inspector will observe the areas being passed through on the way to the valve room and make note of anything that is pertinent to the inspection.

Locate Systems and Equipment. At the system valve room, the following steps are to be taken before starting any actual testing:

- Note the type, manufacturer, size, and number of systems to be inspected and/or tested.
- Note the location, type, manufacturer, size, and quantity of any flow switches or tamper switches.
- Alert the building occupants. Determine whether the alarms are monitored through the building fire alarm system and, if so, warn the building occupants of a possible alarm.
- Locate the fire alarm panel. Verify accessibility to the fire alarm equipment and determine whether the system is monitored by a central station.
- Notify the monitoring company. If it is monitored, call the central station and the appropriate local fire response authorities.
- Verify that an authorized building engineer or in-house user is on site to reset any alarm systems.
- Notify the AHJ/local fire department. Every inspector's worst nightmare is hearing sirens wailing as the fire trucks pull up in front of the building while conducting a flow test of a fire protection system. Not only is this embarrassing, but a false alarm can be costly to all parties involved. A false alarm could potentially divert a fire department from a real emergency. The owner, or the fire protection contractor, or both, can be fined by the fire department for causing a false alarm. The business at the property loses productivity because of the disruption. The inspector loses valuable time while meeting with the fire officials to assure them it was a mistake and not intentional. Finally, after the fire engines leave, the building occupants return to work, and the alarm company is properly notified, the test can continue. Do not depend on the central station, the property owner, or anyone else to notify local fire response authorities. Write down the names of individuals that were notified and the times they were notified.

Conducting the Inspection or Test

Inspect/Test. Once the preparatory steps have been taken, actual inspection and testing can begin. The activities described here are for an annual inspection and test (with the exception of full flow tripping dry, preaction, or deluge systems). The requirements in NFPA 25 should be followed for these specific activities and for inspections and tests during other frequencies.

Perform a Visual Inspection. The purpose of a walkthrough is to visually inspect all areas in the building visible from the floor level. It is the owner's responsibility to declare any such added areas or rooms when answering the general questions at the beginning of the inspection. However, during the walkthrough the inspector should look for areas of the building that are not protected by the fire protection system, such as new additions, new rooms, or new mezzanines. These should be brought to the owner's attention and recorded, as a courtesy to the owner, not as an obligation of the agreement or as a requirement of NFPA 25.

Additional observations and testing that must be conducted include the following:

- Perform a visual inspection of the alarm, dry, preaction and/or deluge system valve, and all associated trim. Look for any signs of leakage, rust, and any unusual problems or conditions.
- Determine where test water will discharge. Verify that the water from the main drain will discharge in a safe location.
- Conduct a main drain test, which includes the following steps:
  1. Note and record the static pressure on the supply side of the system valve.
  2. Conduct the main drain test by opening the main drain valve fully.
  3. Note and record the residual pressure with the valve wide open.
  4. Observe the water discharging from the main drain test fitting and note any kind of debris or restrictions.
  5. Flow water through the main drain until the water stream is clear.
  6. Close the main drain valve and record the gauge readings.
  7. Note and record the static pressure after the valve is fully closed.
- Verify the operation of the water motor alarm (if applicable). On a wet system it will ring during the main drain test. On dry, preaction, and deluge systems, it will ring when the test valve in the system valve trim is opened.
- Close and fully open all control valves to verify proper operation. Test the tamper devices if applicable.
- Locate and flow all the inspector's test valves for the required 90 seconds and verify alarm activation. Reset any alarms and continue with the walkthrough.
- Look for proper coverage and orientation of sprinklers. Also, observe sprinklers for evidence of loading, paint, corrosion, damage, and any physical obstructions to discharge patterns.
- Observe any exposed system piping and hangers for corrosion, leakage, misalignment, and physical damage.
- Record all conditions observed during the walkthrough. When this has been done, the inspection is complete.

Note that the inspector is not required by NFPA 25 to determine whether the fire protection system, as installed, provides adequate coverage in the building or whether all areas of the building are protected in accordance with the original applicable installation standard. The installation codes change every three to five years, and what is required in the most recent code might not have been required in earlier versions, and vice versa. The inspector is not required to examine concealed spaces, closets, attic spaces, or any other building feature to determine whether the fire protection system extends into those areas. If the property owner is ever uncertain whether the fire protection system, as installed, will provide the minimum protection required by the applicable codes, the owner should contact a fire protection engineer or qualified contractor to perform an analysis of the building, the building occupancy, the commodity classification of any storage present, the system design criteria, and the water supply.

Compile Results. Many inspectors fill out inspection and test reports as they perform the activities. Others compile results, observations, and deficiencies on a separate piece of paper. Then, they transfer the information to the actual report at the end of the inspection. Either method is acceptable. Using the inspection form as the inspection and test is performed helps to eliminate missed activities and aids in establishing a systematic process.

Complete Reports. All pressures, trip times, flows, and other recorded results are to be written in the report. All deficiencies are to be clearly detailed, and corrective action recommended.

Many inspectors employed by fire protection contractors started their fire protection careers in other areas of the industry, so they have specific knowledge of codes and standards other than NFPA 25. Because of this specific knowledge, these inspectors might observe potential problems with the water-based fire protection systems, to other fire protection systems, or to general safety requirements that are unrelated to the NFPA 25 inspection being performed. Examples of some problems typically observed include the following:

- Sprinklers appear to be too far from walls or appear inadequately spaced.
- Sprinklers appear too close to building construction features that could obstruct spray patterns.
- Emergency exits are chained and locked.
- Flammable liquids are present and not stored properly.
- New kitchen cooking equipment has been added and is not protected by the hood suppression system.
- Fire extinguishers are discharged or are missing.
- Fire alarm zones are out of service.
- Fire doors are propped open.

Inspectors are often conscientious, so they are compelled to alert the owner or owner's representative, or the occupant, management firm, or managing individual, of their observations. The inspector should not note these observations on the NFPA 25 inspection form. Instead, the inspector should provide a separate attachment describing the observations. The inspector should then advise the owner or owner's representative to have them checked out by the appropriate fire protection system or building code professional.

Completing the Inspection and/or Test

To complete the inspection or test, many of the processes required to start these activities must be repeated in reverse. It is just as important to go through the following steps upon the completion of the inspection or test as it was before starting.

- All systems are to be returned to normal service.
- Test and drain valves are to be closed tightly until no water flow or dripping is observed. All flow and tamper switches are to be returned to normal settings.
- All alarm panels are to be returned to their normal condition. To do this, confirm that all alarm, trouble, or supervisor signals have been verified at the panel, and then reset the panel.
- Fill out any tags provided and/or required.

Some jurisdictions have a visual tag procedure that the inspector must follow. A green tag indicates the system did not have any deficiencies or impairments. A yellow tag indicates one or more deficiencies were found and therefore the application of one or more components is not within its designed limits or specifications, but there were no impairments found. A red tag indicates one or more impairments were found and the system might not function as intended during a fire emergency. If a red tag is issued, the owner or owner's representative, or the occupant, management firm, or managing individual, must be notified immediately so emergency impairment procedures can be initiated.

Advise Occupants. If occupants were notified of the test, notify them that the test is complete.

Notify the AHJ/Local Fire Department. Notify the proper authorities that the test is complete and the system has been returned to normal service. Write down the name of the individual who received the notification and the time of notification.

Notify the Monitoring Company. Notify the monitoring company, if applicable, that the test is complete. Ensure the individual performs a system check to verify they are receiving the proper signals. Write down the name of the individual who performed the system check and the time of notification.

Review Reports. After all systems are back in service and all notifications have been made, meet with the owner or owner's authorized representative, or the occupant, management firm, or managing individual, and review the results of the inspection and test. The report should be explained line by line, and any unusual readings or findings discussed. Deficiencies should be clearly explained, and, if necessary, show them the deficiencies. Explain the requirements of NFPA 25 pertaining to acceptable results and corrective action that must be taken to address deficiencies.

Follow Impairment Procedures, if Applicable. If impairments are found, impairment procedures must be implemented by the owner. It is important for the owner to tag systems and/or components that are not working properly, especially those impaired. The inspector should advise the owner of the impairments and the steps required by NFPA 25 to correct those impairments.

Sign Reports. When the inspector has completely explained the inspection and test results with the owner, or the owner's authorized representative and is satisfied that the results and deficiencies have been clearly explained, the report is to be signed and dated by both parties. The owner or the owner's representative should be given a copy of the signed report.

After the Inspection

Inspection Follow-Up. An inspection and/or test performed without proper follow-up is useless. Protection of lives and property is dependent on properly operating water-based fire protection systems. By contracting with a reputable fire protection contractor, the owner has made a commitment to the employees, the insurance company, stockholders, and the community at large that the system(s) is in proper working order. The fire protection contractor has an obligation to follow up with the inspection in a timely fashion.

Notification Process. Although not required by NFPA 25, it is good practice to directly notify the property owner upon completion of an inspection and/or test. In most cases, the owner is not the individual who meets with the inspector on site and reviews the report after the inspection. NFPA 25 does require that the owner maintain records of all inspections and tests for a period of time. Therefore, the fire protection contractor should send a copy of each report to the owner.

In addition, it is a good practice, as well as a preferred legal procedure, to attach a cover letter to any report that contains deficiencies or impairments. The cover letter should clearly explain all the deficiencies and/or impairments and should detail the requirements of NFPA 25 to have them corrected. If the fire protection contractor is also in the repair and installation business, an offer to make the corrections and the price for those corrections can be included in the letter. For liability reasons, it is a common practice to send cover letters that describe impairments by certified mail and to call the owner to notify them of the impairment. Should a fire emergency occur between the time the impairment is discovered and the time the owner is notified of the impairment, lawsuits might be filed as insurance companies assess blame for the system failure.

Corrective Action. When an owner performs repairs to the system, or contracts the repair to a fire protection contractor, the date the repairs were made and the corrective action taken should be recorded. This information is then passed to

the inspector at the next inspection and noted on the new inspection report.

Component Replacement Action Requirements. NFPA 25 includes a series of tables describing what action must be performed on systems and/or components when corrective action is taken to address a deficiency or impairment. Each table is referenced in the subsection in which it appears, for example: "Whenever a component in a [type of] system is adjusted, repaired, reconditioned, or replaced, the action required in Table 5.5.1 shall be performed." Many of the actions required include reinspecting and/or retesting of systems or components after they are adjusted, repaired, reconditioned, or replaced. The fire protection contractor might be contacted to reinspect and/or retest the system or component, and the inspector might be called to return to the facility to perform the inspection or test. These inspections and tests are performed separately from those conducted on a periodic basis per NFPA 25, and the results should be recorded on a separate inspection/test report. These additional reports should be retained by both the owner and the fire protection contractor for future reference.

Maintaining Inspection Files. Proper filing of reports by the fire protection contractor is necessary to provide ongoing inspection and test services to the customer. The reports must be accessible for reference should the property owner call with questions about the reports or if an additional copy is needed for the AHJ or insurance underwriter. The inspector will also need copies of previous reports when the next inspection is performed. Comparisons between current test results and previous test results must be made to determine whether degradation of water supplies, system piping, fire pump performance, and so forth is taking place.

Code Enforcement

Laws enacted by local, city, and state legislatures allow for the enforcement of building codes as well as NFPA codes, including NFPA 25. Many of these codes are modified by local ordinances, with some mandating more stringent requirements and some relaxing requirements. Each jurisdiction adopts those sections of a code that meet its needs and the needs of the community. Noncompliance with these laws can result in fines, loss of a business license, and in some cases, businesses being shut down. In the case of NFPA 25, the inspection and testing requirements might be adopted without exception, but some frequencies might be amended to require fewer inspections and/or tests per year. If requirements are relaxed by local ordinance, the fire protection contractor might decide to still comply with NFPA 25 frequencies. NFPA 25 is a minimum standard, and therefore, many fire protection contractors make the business decision to fully comply with NFPA 25 requirements even though they are not required to do so by local ordinances.

References Cited

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2019 edition.

NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies,* 2019 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems,* 2019 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection,* 2017 edition.

NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems,* 2019 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection,* 2019 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection,* 2018 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances,* 2019 edition.

NFPA



SUPPLEMENT 4

ROLE OF THE OWNER OR DESIGNATED REPRESENTATIVE

By Russell Leavitt and J. William Sheppard

Editor's Note: *In an effort to assist building owners in selecting the right inspector or in training their employees in inspection procedures, this supplement has been included in the handbook to outline the training needs, safety equipment, and basic duties and approach to the performance of an inspection or test of a water-based fire protection system. This supplement is intended to illustrate the methods for in-house inspection, testing, and maintenance of water-based extinguishing systems and the use of reporting forms to document the required activities in NFPA 25. A sample dry pipe sprinkler system — complete with a fire pump — is used as an example of the systems being maintained.*

Owner's Responsibility

Choosing Personnel for Training

There are many instances where an owner or designated representative has qualified personnel and equipment to adequately perform the inspection and testing of water-based extinguishing systems. Furthermore, the owner or designated representative might have the capability to perform the necessary maintenance required to correct any deficiencies noted as a result of the inspection or test.

The qualifications for this in-house performance can be a result of "skilled trades" training in mechanical and electrical issues, training of employees by the installing contractor using the manufacturers' documentation of the equipment, and other outside training materials and methods that are available.

In-house expertise is not always available. However, where the talent is available, the primary consideration is the cost to perform tasks effectively and to ensure that satisfactory inspection, testing, and maintenance (ITM) of the systems and components are accomplished.

The personnel responsible for the inspections, testing, and maintenance should be mechanically and electrically trained. Some of the activities that must be performed include resetting or restoring to service dry valves, preaction valves, deluge valves, accelerators, exhausters, air compressors, fire pumps, controllers, alarm switches, and numerous other system components.

Some of the basic skills that the owner or designated representative should look for in a candidate for this training include critical thinking ability, familiarity with codes and standards, communication skills, and organizational ability.

Critical Thinking. In-house personnel must have the ability to read the manufacturer's maintenance information and follow the instructions. They must also be able to interpret test results, perform basic troubleshooting, and make recommendations to correct deficiencies or impairments found.

Familiarity with Codes and Standards. Inspection personnel must understand and apply local codes, as well as NFPA 25, as inspections are performed. Inspection forms must be filled out completely so that those responsible for system maintenance can read them and correct any deficiencies noted. In recent years, computer programs have been developed to aid in the inspection process. These programs include question sets that correspond to the activities required by NFPA 25. In addition, the programs provide standardized descriptions and corrective actions for impairments and deficiencies. If computers are used as part of the inspection process, then computer skills are also necessary.

Communication Skills. An inspector must be able to communicate well, both orally and in writing. Once an inspection is complete, the inspector must be able to translate the results of the inspection and/or test onto the inspection report. These results must then be explained to the facility or maintenance staff responsible for corrective action.

Organizational Ability. An inspector must be organized. Keeping track of the testing frequencies and the previous inspection reports required for all of the types of systems and components in each building or structure requires organized tracking methods. Some owners or designated representatives rely entirely on the inspector to keep these records organized, whereas others provide office staff for this purpose.

The candidate who does not have the minimum qualifications as described will struggle in the performance of the responsibilities of an inspector. Communication skills and education level can be improved. The other characteristics, however, are for the most part inherent and either cannot be taught or are taught with much difficulty and effort.

Training and Certification of Personnel

There are many activities stated in NFPA 25 that require only a visual inspection to determine the condition of the equipment. Training of in-house personnel by the installing contractor is often the most cost-efficient method to ensure that the program is effective. In addition to the "skilled trades" and contractor training that might be available, there are various programs available — such as those provided by the National Fire Protection Association (NFPA), the National Fire Sprinkler Association (NFSA), and the American Fire Sprinkler Association (ASFA). Further, Internet-based training is also available. Some colleges and universities have also developed curriculums specific to training personnel to inspect and test water-based fire protection systems.

Finally, a certification program is offered by the National Institute of Certification in Engineering Technologies (NICET) for Inspection and Testing of Water-Based Systems. This three-level certification program is designed for engineering technicians in the automatic fire sprinkler industry who are engaged in the physical and mechanical aspects of the ITM of water-based systems.

More information on training programs is available at the websites for each of these organizations.

If the individual has a background in fire protection, knows the industry terminology, and can identify system types and components, training can concentrate on the actual inspection and test activities.

Conducting an Inspection and/or Test

Conducting an inspection and/or test for the first time in a building will require more time than will subsequent inspections and/or tests. The inspector must become familiar with the building, the systems installed in the building, the system components, and the records of the previous inspections and tests that have been performed. The inspector must also determine the necessary inspection and test tools, equipment, and instruments needed, plan the inspection and test sequence, and prepare the inspection reports. Subsequent inspections and tests will take less time to complete because the building and systems are known, and the inspector can focus on inspecting and testing the systems and components.

Many buildings have several fire protection systems that are required to be inspected and tested by NFPA 25. For instance, a typical large facility might have a backflow prevention device, one or more fire pumps, yard main systems including hydrants and valves, a standpipe system, wet pipe sprinkler systems and control valves on each floor, and dry pipe systems or antifreeze systems for some processes or areas of the facility. There might even be one or more preaction systems in computer rooms or electrical service rooms and fixed water spray systems for cooling towers and other processes. In addition, depending upon the facility and occupancy, there might be standpipe systems employed for hose stream application.

NFPA 25 contains a series of tables that describe an action that must be performed on systems and/or components when corrective action is taken to address a deficiency or impairment. Each table is referenced in the subsection in which it appears, for example: "Whenever a component in a [type of] system is adjusted, repaired, reconditioned, or replaced, the action required in Table 5.5.1 shall be performed." Many of the actions required include reinspecting and/or retesting of systems or components after they are adjusted, repaired, reconditioned, or replaced. These inspections and tests are performed separately from those conducted on a periodic basis per NFPA 25.

Frequency for Common Inspection and Testing Activities

An example of a common approach for a wet sprinkler system is to arrange for the following steps as required by NFPA 25:

Quarterly. Inspect the gauges, control valves, alarm devices, hydraulic nameplate, and the fire department connection, and test some of the alarm devices.

Semiannually. Test flow switches and valve tamper switches.

Annually. Manually inspect the building, pipe hangers, pipes, fittings, and spare sprinklers, and test the main drain.

All other less-frequent activities are not normally included in the inspection program, including testing gauges every 5 years; testing sprinklers every 5, 10, 20, or 50 years; and internally inspecting piping, alarm valves, check valves, strainers, filters, and orifices every 5 years.

These activities are normally performed by a fire protection contractor. However, depending upon the experience level, these activities may be performed by the in-house inspector.

Reports

Records of ITM activities are to be maintained by the building owner or designated representative. Many local jurisdictions require that such reports be kept at the site. Local ordinances might also require that a copy of any reports be submitted directly to the authority having jurisdiction (AHJ).

Reports are not standardized and come in many versions. Many forms are still filled out by hand, although computerized programs with printed reports are becoming more and more popular. The electronic reports tend to be more professional and legible.

Tools and Equipment

Essentially, three categories of tools and equipment are necessary to properly inspect and/or test a fire protection system: safety equipment, standard inspection tools and equipment, and standard test equipment.

Safety Equipment. Safety must be a matter of primary importance and be second nature to the inspector. Federal and state regulations require compliance with safety laws. Common sense dictates that care and caution must be taken to ensure the safety of the inspector, and those working around the inspector, from certain hazards inherent with performing inspection and test procedures. As a minimum, federal Occupational Safety and Health Administration (OSHA) regulations must be adhered to. If not, employee safety is at risk.

Table S4.1 describes examples of the safety equipment needed and some general uses for each.

TABLE S4.1 *Safety Equipment*

Safety Equipment	General Use for Equipment
Hard hat	Hard hats are required when head injury is a possibility from climbing, crawling through confined spaces, or falling objects.
Safety shoes	Safety shoes are required in most industrial and manufacturing plants and at any location where foot injury is possible from stepping on sharp objects, or from heavy objects falling on the feet.
Proper clothing	Loose clothing is not to be worn around machinery. In some plants, fire and/or chemical protective clothing must be worn.
Eye protection	Safety glasses should always be worn when inspecting or testing fire protection systems.
Hearing protection	Hearing protection should be a part of the standard safety equipment worn by inspectors. Many areas in industrial occupancies post signs where hearing protection must be worn.
Safety harness	See OSHA regulations for the requirements for safety harnesses. Safety harnesses are required when inspectors must be on ladders or lifts above a certain height.
Confined space equipment	Confined space equipment requirements are not limited to pits or cellars but can also extend to more common spaces, such as unventilated attics, crawl spaces, concealed spaces, and vaults. See OSHA regulations for the requirements for confined space entry.

Inspection Tools and Equipment. Table S4.2 lists some of the inspection tools and equipment commonly used by inspectors.

TABLE S4.2 *Standard Inspection Tools and Equipment*

Tool	General Use and Notes
Ladders	The inspector should use the right height ladder at all times to avoid overextending his or her reach. When using extension ladders, always follow the "1 to 4 rule," setting the base of the ladder 1 ft (0.3 m) away from the wall for every 4 ft (1.2 m) in height. The inspector must follow all other safety rules concerning ladders as detailed in OSHA and local requirements, including safety harnesses and fall protection.
Flashlight	A flashlight is particularly useful when working in confined spaces.
Binoculars	Binoculars are typically used for examining sprinklers from the floor level. The inspector is not expected to climb a ladder to inspect each sprinkler, but binoculars can be helpful when inspecting sprinklers for leakage, corrosion, foreign materials, loading, paint, physical damage, or improper orientation.
Tape measure or folding rule	The size of some pipes or components might not be evident, and the inspector might need to measure the size to provide an accurate report.
Assorted hand tools	To perform certain internal inspections, the inspector will have to remove face plates from valves or remove sprinklers or flushing connections. Screwdrivers, a socket set, crescent wrench, hammer, and a set of open-end wrenches should be included in the inspector's tool kit.

Test Equipment. Table S4.3 lists some of the standard test equipment for the inspection and testing of water-based fire protection equipment.

TABLE S4.3 *Standard Test Equipment*

Equipment	*General Notes on Use*
12 in. pipe wrench	
Crescent wrench	
Calibrated test gauges	
Volt meter	Primarily used during the annual fire pump test. Proper safety equipment should be worn while using this equipment.
Amp meter tachometer	
Hydrometer or refractometer	Used to measure the concentration of antifreeze.
Pitot tube	Used to measure velocity pressure during flow and fire pump tests. (See Chapters 6 and 8.)
Stopwatch	A watch that reads in minutes and seconds. Used to measure trip times for dry pipe systems.
Heat lamp	Used to activate heat detection systems on water spray fixed systems.
Digital gauges	
Water analysis kit	Used when performing the five-year obstruction inspection if tubercules or slime are found in the piping.

Inspection Procedure

NFPA 25 does not prescribe how to perform an inspection or test. The systems and components that are to be inspected and tested are listed, the acceptance criteria are spelled out, and the corrective action requirements are clear.

The owner or designated representative must realize that the actual inspection process is unique to each facility, building, and system. The NFPA 25 report forms available from NFPA's website, if followed line by line, lead the inspector through the process.

As each system is unique, so is each inspector. What works for one will be inefficient for another. Inspectors must develop their own processes. However, certain essentials are universal. Before the experienced inspector can put together a game plan to perform the activities in the most efficient and comprehensive way possible, certain information must be reviewed. The inspector needs to know the types of systems being inspected. He or she must become familiar with the layout of the building and identify where the system controls and valves are.

The following describes one method of performing an inspection.

Locate Systems and Equipment

At the system valve room, the following steps are taken before starting any actual inspection or testing:

- Note the type, manufacturer, size, and number of systems to be inspected and/or tested.
- Note the location, type, manufacturer, size, and quantity of any flow switches or tamper switches.
- Alert the building occupants. Determine whether the alarms are monitored through the building fire alarm system and, if so, warn the building occupants of a possible alarm.
- Locate the fire alarm panel. Verify accessibility to the fire alarm equipment and determine whether the system is monitored by a proprietary or central station.
- Notify the monitoring company or, if the systems are monitored within the premises, the personnel monitoring the proprietary alarm system.
- If the local procedures at the facility require it, notify the AHJ or local fire department.

Performing the Inspection and/or Test

Once the preparatory steps are taken, the actual inspection and testing can begin. The activities described in this section are for an annual inspection and test, with the exception of full flow tripping dry, preaction, or deluge systems. The requirements in NFPA 25 should be followed for the specific activities that follow and for inspections and tests during other frequencies.

- Perform a visual inspection of the alarm, dry, preaction and/or deluge system valve, and all associated trim. Look for any signs of leakage, rust, and any unusual problems or conditions.
- Determine where the test water will discharge. Verify that the water from the main drain will discharge in a safe location.
- Conduct a main drain test, including the following steps:
  1. Note and record the static pressure on the supply side of the system valve.
  2. At least annually, conduct the main drain test by opening the main drain valve fully.
  3. Note and record the residual pressure with the valve wide open.
  4. Observe the water discharging from the main drain test fitting and note any debris or restrictions of any kind.
  5. Flow water through the main drain until the water stream is clear.
  6. Close the main drain valve and record the gauge readings.
  7. Note and record the static pressure after the valve is fully closed.

- Verify the operation of the water motor alarm (if applicable). On a wet system it will ring during the main drain test. On dry, preaction, and deluge systems, it will ring when the test valve in the system valve trim is opened.
- Close and fully open all control valves to verify proper operation. Test the tamper devices if applicable.
- Locate and flow all the inspector's test valves for the required 90 seconds, and verify alarm activation. Reset any alarms and continue with the walkthrough.
- Look for proper coverage and orientation of sprinklers. Also, observe sprinklers for evidence of loading, paint, corrosion, damage, and any physical obstructions to discharge patterns.
- Observe any exposed system piping and hangers for corrosion, leakage, misalignment, and physical damage.
- Record all conditions observed during the walkthrough. When this has been done, the inspection is complete.

Compile Results. Many inspectors fill out inspection and test reports as they perform the activities. Others compile results, observations, and deficiencies on a separate piece of paper and transfer the information to the actual report at the end of the inspection. Either method is acceptable. Using the inspection form as the inspection and test is performed helps to eliminate missed activities and aids in establishing a systematic process.

Complete Reports. All pressures, trip times, flows, and other recorded results are written in the report. All deficiencies are to be clearly detailed and corrective action recommended.

Completing the Inspection and/or Test

To complete the inspection or test, many of the processes required to start these activities must be repeated in reverse. It is just as important to go through these steps upon the completion of the inspection or test as it was before starting. Some of the steps that should be undertaken in completing the inspection or test are as follows:

- All systems are to be returned to normal service.
- Test and drain valves are to be closed tightly until no water flow or dripping is observed. All flow and tamper switches are to be returned to normal settings.
- All alarm panels are to be returned to their normal condition. To do this, confirm that all alarm, trouble, or supervisor signals have been verified at the panel, and then reset the panel.
- Fill out any tags provided and/or required.

Tags. Some jurisdictions have a visual tag procedure that the inspector must follow. A green tag indicates the system did not have any deficiencies or impairments. A yellow tag indicates one or more deficiencies were found, and therefore the application of one or more components is not within its designed limits or specifications, but there were no impairments found. A red tag indicates one or more impairments were found, and the system might not function as intended during a fire emergency. If one or more impairments are found, impairment procedures must be initiated as necessary, until the impaired condition is properly corrected. Table A.3.3.8 of NFPA 25 provides guidance on determining the severity of the deficiency for the purposes of providing the correct tag.

Advise Occupants. If occupants were notified of the test, notify them that the test is complete.

Notify the AHJ/Local Fire Department. Notify the proper authorities that the test is complete and the system has been returned to normal service. Write down the name of the individual who received the notification and the time of notification.

Notify the Monitoring Company. Notify the monitoring company, if applicable, that the test is complete. Ensure the individual performs a system check to verify that they are receiving the proper signals. Write down the name of the individual who performed the system check and the time of notification.

Review Reports. After all systems are back in service and all notifications have been made, review the results of the inspection and test. The report should be explained line by line. Any unusual readings or findings should be discussed with the appropriate management representative. Deficiencies should be clearly explained. Review the requirements of NFPA 25 pertaining to acceptable results and the corrective action that must be taken to address deficiencies.

Follow Impairment Procedures, if Applicable. As previously stated, if impairments are found, impairment procedures must be implemented as required by NFPA 25 for prompt corrective action. It is important to tag systems and/or components that are not working properly, especially those that are impaired.

After the Inspection

Inspection Follow-Up. An inspection and/or test performed without proper follow-up is useless. Protection of lives and property is dependent on properly operating water-based fire protection systems. The owner or designated representative has made a commitment to the employees, the insurance company, stockholders, and the community at large to have the system(s) in proper working order.

Corrective Action. When an owner or designated representative performs repairs to the system, or contracts the repair to a fire protection contractor, the date the repairs were made and the corrective action taken should be recorded. This information is then processed for the subsequent inspection.

Component Replacement Action Requirements. NFPA 25 includes a series of tables that describe what action must be performed on systems and/or components when corrective action is taken to address a deficiency or impairment. Each table is referenced in the subsection in which it appears, for example: "Whenever a component in a [type of] system is adjusted, repaired, reconditioned, or replaced, the actions required in Table 5.5.1 shall be performed." Many of the actions required include reinspecting and/or retesting systems or components after they are adjusted, repaired, reconditioned, or replaced. These inspections and tests are performed separately from those conducted on a periodic basis per NFPA 25, and the results should be recorded on a separate inspection/test report. These additional reports should be retained by the owner or designated representative for future reference.

Maintaining Inspection Files. Proper filing of reports is necessary to provide ongoing inspection and test services. The reports must be accessible for possible distribution to the AHJ or insurance underwriter. The inspector will also need copies of previous reports when the next inspection is performed. Comparisons between current test results and previous test results must be made to determine whether the degradation of water supplies, system piping, fire pump performance, and so forth is taking place.

Sample Documentation

The following is an example of documentation for the practices described in this supplement. Both the contractor's material and test certificate for aboveground piping and the contractor's material and test certificate for underground piping must be kept on file by the property owner or designated representative for the life of the system.

The material and test certificates provide a basis for many of the subsequent inspections and tests required for their respective systems. Subsequent ITM forms must be kept on file by the property owner or designated representative for a period of one year after the activity is repeated.

This supplement provides a sample form that can be used by the owner. Exhibit S4.1 illustrates the reporting requirements necessary to demonstrate compliance with Chapter 8 for fire pumps.

The annual activities or activities that require specialized training and equipment might be conducted by a qualified fire protection contractor. Some jurisdictions require the licensing of inspectors, and such licensing laws are commonly addressed to those involved in the business of providing such services. In most cases, the licensing of an employee of the property owner or designated representative is not required for "in-house" work. This should be verified with the local jurisdiction if an employee of the property owner or designated representative is qualified to perform this type of work.

A file of all reports must be kept on the premises as stated in Chapter 4 of NFPA 25. This file provides direct evidence of compliance with NFPA 25, and a review of this file can be requested by the AHJ during an inspection. An accurate and complete file will lead to a brief and successful review.

FIRE PUMP ANNUAL PERFORMANCE TEST

Contractor Information

Name: ACME Fire Protection

Address: 42 Milky Way

Phone: 555-555-5555

Fax: 555-555-5333

Job Name: ACME Warehouse

Job No.: 123456

Test Date: 8/29/2019

Test performed for:

ACME Warehouse, 45 Galaxy Lane, Stardust, CA

Test location:

Warehouse

Test Method:

☑ Test header ☑ Flow meter to drain or suction reservoir ☑ Flowmeter back to suction (closed-loop metering)

Pump Nameplate Information:

Make: A-C Fire Pump

Model: 10x8x20F-S

Stages: Single

Coupling:

SN: 20-06515-03-03-7E7

Imp. Diam.:

Speed: 1785

Rating Capacity: 2000

Rated Pressure: 145

Motor Nameplate Information:

Make:

SN:

Volts:

Amps:

Frame:

Speed:

HP:

Water Supply Type:

Pump Controller Nameplate Information:

Make:

Model:

SN:

Time set for minutes

Turns on at:

Turns off at:

NFPA 25 Handbook (p. 1 of 6)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT S4.1 *Sample Annual Performance Tests for Fire Pumps.*

FIRE PUMP ANNUAL PERFORMANCE TEST (Continued)

Pressure Maintenance Pump Nameplate Information:	Pressure Maintenance Pump Controller Nameplate Information:
Make:	Make:
Model:	Model:
SN:	SN:
Speed:	Turns on at:
HP:	Turns off at:
Volts:	

Flow Test

A. Is a copy of the manufacturer's certified pump test curve attached?	☑ Yes	❑ No
B. Test results compared to the manufacturer's certified pump test curve?	☑ Yes	❑ No
C. Gauges and other test equipment calibrated?	☑ Yes	❑ No
D. No vibrations that could potentially damage any fire pump component?	☑ Yes	❑ No
E. The fire pump performed at all conditions without objectionable overheating of any component?	☑ Yes	❑ No

F. For each test, record the required information for each load condition using the following formulas (or other acceptable methods) and tables:

$$P_{Net} = P_{Discharge} - P_{Suction}$$

$$Q = 29.83\ cd^2P^{0.5}$$

$$Pv = 0.43352V^2/(2g) = (Q^2)/(890.47D^4)$$

where:

P_{Net}	= net pump pressure (psi)
$P_{Discharge}$	= total pressure at the pump discharge (psi)
$P_{Suction}$	= total pressure at the pump suction (psi)
Q	= flow through a circular orifice (gpm)
c	= nozzle discharge coefficient
d	= nozzle orifice diameter (in.)
P	= pressure measured on gauge (pitot)
Pv	= velocity pressure (psi)
V	= velocity of liquid (ft/sec)
g	= gravitational constant (32.174 ft/sec)
D	= internal pipe diameter (in.)

NFPA 25 Handbook (p. 2 of 6)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT S4.1 *Continued.*

FIRE PUMP ANNUAL PERFORMANCE TEST (Continued)

Test	Pump speed (rpm)	Suction pressure (psi)	Discharge pressure (psi)	Nozzle size (in.) 2.5 Nozzle coefficient 0.9 Pitot readings (psi) 1	2	3	4	5	6	Flow (gpm)	Net pressure (psi)	Rpm adjusted net pressure	Rpm adjusted flow (psi)	Suction velocity pressure (psi)[1]	Discharge velocity pressure (psi)[1]	Velocity adjusted pressure (psi)[1]	Oil pressure (psi)[2]	Exhaust back pressure (in. Hg)[2]	Diesel water temperature[2]	Cooling loop pressure (psi)[2]
0%	1795	10	190							0	180	178	0			178				
25%																				
50%	1792	8	176	9	9					1007	168	166.7	1003			166.9				
75%	1790	7	168	20	20					1501	149	160.1	1497			160.5				
100%	1789	5	154	9	9	9	9			2014	161	148.3	2009			149				
125%																				
150%	1786	1	122	20	20	20	20			2999	121	119.6	2998			121				
0%																				
100%																				
150%																				

Pump is ☑ constant speed ❑ variable speed

Notes:
[1]Velocity pressure adjustments provide a more accurate analysis in most cases and as a minimum should be included whenever the pump suction and discharge diameters are different and the pump fails by a narrow margin. The actual internal diameter of the pump suction and discharge should be obtained from the manufacturer.
[2]These readings are applicable to diesel engine pumps only. Recording these readings is not specifically required in Chapter 14.

NFPA 25 Handbook (p. 3 of 6)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT S4.1 *Continued.*

FIRE PUMP ANNUAL PERFORMANCE TEST (Continued)

For electric motor–driven pumps also record:

Test	Voltage			Amperes		
	L1-L2	L2-L3	L1-L3	L1	L2	L3
0%	499	491	497	133	131	135
25%						
50%	496	486	492	190	168	196
75%	493	490	491	221	199	227
100%	492	485	492	247	226	258
125%						
150%	495	487	493	274	253	285
0%						
100%						
150%						

G. For electric motors operating at rated voltage and frequency, is the ampere demand less than or equal to the product of the full load ampere rating times the allowable service factor as stamped on the motor nameplate? ☑ Yes ❑ No ❑ N/A

H. For electric motors operating under varying voltage:

1. Was the product of the actual voltage and current demand less than or equal to the product of the rated full load current times the rated voltage times the allowable service factor? ☑ Yes ❑ No ❑ N/A
2. Was the voltage always less than 5% above the rated voltage during the test? ☑ Yes ❑ No ❑ N/A
3. Was the voltage always less than 10% above the rated voltage during the test? ☑ Yes ❑ No ❑ N/A

I. Did engine-driven units operate without any signs of overload or stress? ❑ Yes ❑ No ☑ N/A

J. Was the engine overspeed emergency shutdown tested? ❑ Yes ❑ No ☑ N/A

K. Was the governor set to properly regulate the engine speed at rated pump speed? ❑ Yes ❑ No ☑ N/A

L. Did the gear drive assembly operate without excessive objectionable noise, vibration, or heating? ❑ Yes ❑ No ☑ N/A

M. Was the fire pump unit started and brought up to rated speed without interruption under the conditions of a discharge equal to peak load? ☑ Yes ❑ No ❑ N/A

N. Did the fire pump performance equal the manufacturer's factory curve within the accuracy limits of the test equipment? ☑ Yes ❑ No ❑ N/A

O. Did the electric motor pumps pass phase reversal test on normal and alternate (if provided) power? ☑ Yes ❑ No ❑ N/A

NFPA 25 Handbook (p. 4 of 6)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT S4.1 *Continued.*

FIRE PUMP ANNUAL PERFORMANCE TEST (Continued)

Multiple Pump Operation

A. _____ fire pumps are required to operate _____ in series _____ in parallel ☑ N/A to meet the maximum fire protection demand.

B. Record the following information for each of the pumps operating simultaneously

Test	Pump speed (rpm)	Suction pressure (psi)	Discharge pressure (psi)	Nozzle size (in.) _____ Nozzle coefficient _____ Pitot readings (psi) 1	2	3	4	5	6	7	8	9	10	11	12	Net pressure (psi)	Total flow (gpm)	Flow through this pump (gpm)	Rpm adjusted net pressure	RPM adjusted flow (psi)	Suction velocity pressure (psi)	Suction velocity pressure (psi)	Velocity adjusted net pressure (psi)
0%																							
25%																							
50%																							
75%																							
100%																							
125%																							
150%																							
0%																							
100%																							
150%																							
Pump is ☑ constant speed ❑ variable speed																							

C. Did the fire pump performance equal the manufacturer's factory curve within the accuracy limits of the test equipment during the multiple test? ❑ Yes ❑ No ❑ N/A

Additional Tests			Transfer Switch
☑ Yes	❑ No	❑ N/A	Simulate power failure while pump is operating at peak load
☑ Yes	❑ No	❑ N/A	Power transferred to alternate power source
☑ Yes	❑ No	❑ N/A	Pump performed for 2 minutes on alternate power
☑ Yes	❑ No	❑ N/A	Record the following while the pump is operating at peak load and alterate power - Voltage where an external means is provided on the controller - Amperage where an external means is provided on the controller - RPM - Suction Pressure ____psi - Discharge Pressure ___psi
☑ Yes	❑ No	❑ N/A	Pump reconnects to normal power source
☑ Yes	❑ No	❑ N/A	Alarm indicating (visual and audible) functions correctly
❑ Yes	❑ No	☑ N/A	Suction screens inspected and cleared of any debris
☑ Yes	❑ No	❑ N/A	ECM sensors (primary and redundant) function correctly

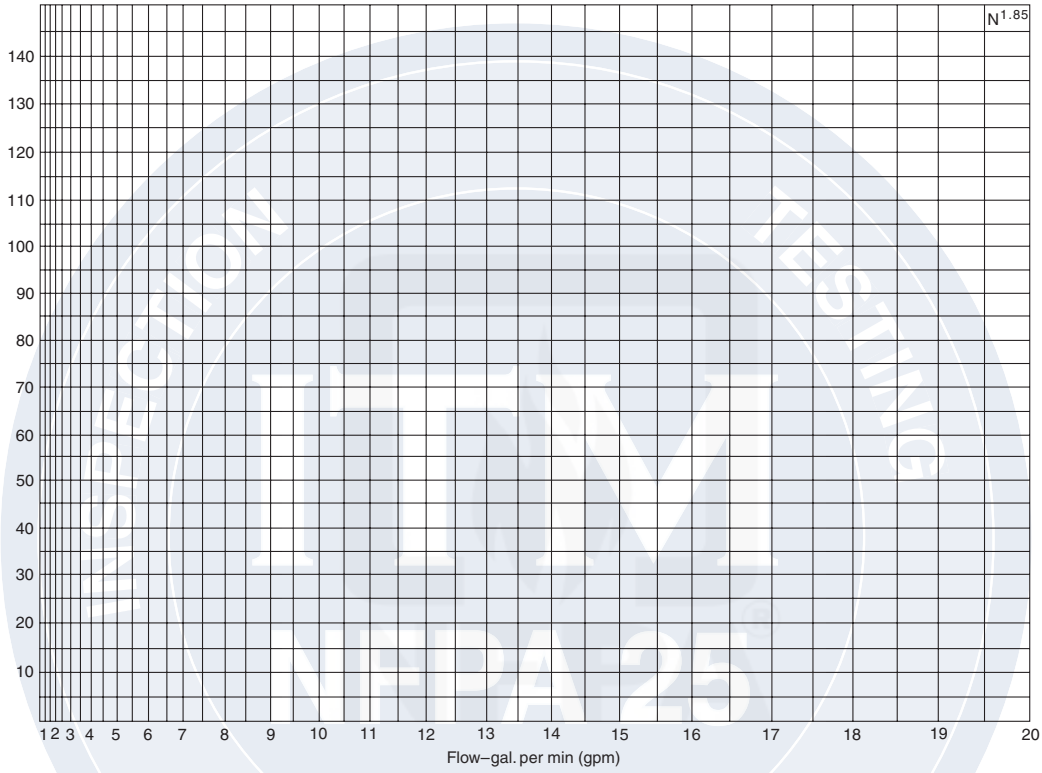
NFPA 25 Handbook (p. 5 of 6)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT S4.1 *Continued.*

FIRE PUMP ANNUAL PERFORMANCE TEST (Continued)

☑ Yes	❑ No	❑ N/A	Pump room temperature control is functioning and being maintained at appropriate temperatures
☑ Yes	❑ No	❑ N/A	Parallel and angular alignment of the pump verified
☑ Yes	❑ No	❑ N/A	Fire pump supplies 100 percent of the rated flow
☑ Yes	❑ No	❑ N/A	Net pressure at each flow point is at least 95% of either the original manufacturers pump curve, original unadjusted field test curve, or test curve generated from the fire pump nameplate.



Comments

Controller: Work shall be completed, to the extent that such work can be completed without opening an energized electric motor-driven fire pump controller.

NFPA 25 Handbook (p. 6 of 6)

© 2019 National Fire Protection Association. This form may be copied for individual use other than for resale. It may not be copied for commercial sale or distribution. No other reproduction or transmission in any form permitted without written permission of NFPA. For inquiries or to report unauthorized use, contact licensing@nfpa.org.

EXHIBIT S4.1 *Continued.*



SUPPLEMENT 5

ROLE OF THE AUTHORITY HAVING JURISDICTION

By John A.M. Lake

Editor's Note: *In an effort to assist authorities having jurisdiction (AHJs) in identifying their roles and responsibilities in the inspection, testing, and maintenance (ITM) process, this supplement has been included in the handbook to provide a quick reference on several different topics. This supplement is intended to describe some best practices that AHJs can follow to ensure that the buildings in their jurisdiction are safe — not only for the building occupants, but also for first responders. This supplement describes some of the interactions the AHJ may have with other people in the ITM process and also how to address impaired systems.*

The role of the AHJ in the ITM process is largely misunderstood. In most instances, when an AHJ is responsible for enforcing a standard, the AHJ is required to be present at system testing or actively reviewing and approving system documentation. In the NFPA 25 ITM realm, the AHJ is not asked to attend tests or inspections and is not generating test reports or retaining documents. However, the role of the AHJ in the process is critical, and therefore, it is entirely appropriate for an AHJ to make sure the property owners in the jurisdiction are actively taking care of their systems. Some of the most common reasons for water-based system failure are closed valves and lack of maintenance. Deficiencies and impairments that arise due to these conditions can be dangerous, not only for building occupants, but also for responding personnel. The following sections of this supplement elaborate on the topics addressed in the Roles and Responsibilities of Key Stakeholders table provided in Supplement 2.

Overview of the ITM Program

The role of the AHJ in the ITM inspection and the use of NFPA 25 is unique, because it depends on whom the AHJ represents. Because of the broad definition of an AHJ, the view and scope of interest will be as varied as the AHJ's motivation. The motivation for most fire officials is the protection of life and property, whereas the motivation for an insurance company might be to reduce the maximum probable loss. The following information is presented from the perspective of a fire official. In many jurisdictions, the AHJ does not use NFPA 25 as the primary manual for the ITM of water-based fire protection systems. The AHJ usually references a fire or building code that gives the appropriate authority to enforce the provisions of the standard. In looking at those provisions, the AHJ usually has a different view on how a fire protection system should be maintained.

The NFPA Technical Committee on Inspection, Testing, and Maintenance of Water-Based Systems has made it clear that the role of the inspector performing the inspection and testing activities in accordance with NFPA 25 is not all-inclusive. The ITM inspector is not required to have detailed knowledge of the fire protection system installation requirements in the applicable NFPA standards. However, this is not the case when the inspector works for the AHJ. In many cases, the AHJ has a different role; the AHJ looks at the facility from the perspectives of the responding agency and the enforcement agency in the event of an emergency. When a facility and the protection features required are considered,

the fire protection system must meet the requirements to protect the hazard present. Upon review of the other applicable NFPA standards, it can be determined that compliance with NFPA 25 might not provide assurance that the fire protection system will work appropriately. This is further complicated by the fact that the installation documents provide minimal guidance beyond requiring compliance with NFPA 25.

It is the responsibility of the inspectors to identify any issues that might cause a fire suppression system to not function properly. This includes many issues that are not covered by NFPA 25. In trying to identify the role of the AHJ in administering the provisions of NFPA 25, the standard does not require the AHJ to have detailed knowledge of the fire protection system installation requirements. In fact, NFPA 25 does not provide any language requiring the enforcement authority to have the requisite knowledge. However, NFPA 25 does provide requirements that give the AHJ the responsibility to do the following:

- Determine that an existing situation involves a distinct hazard to life or property and permitting him/her to require ITM methods in excess of those required by the standard (1.2.2).
- Approve alternative programs (1.3.2).
- Enforce the requirements of a code or standard or for approving equipment, materials, installation, or procedure (3.2.2).
- Determine if the person or company is competent and capable and that they have met the requirements and training for a given field to perform the inspection (3.3.36).
- Approve alternative means of compliance for components and systems inspection, testing, and maintenance (4.7).
- Approve the recognized testing laboratory where sample sprinklers are submitted for field service testing (5.3.1.1).
- Approve an appropriate location for the standpipe flow test when the hydraulically most remote outlet(s) is not practical (6.3.1.1.1).
- Determine where the additional flow can be taken when the 250 gpm (946 L/min) cannot be flowed from each additional standpipe (6.3.1.2.2).
- Determine the standpipe system demand where the standpipe system demand cannot be determined by the inspector (6.3.1.4.1).
- Approve a location or manner where records indicating the date the preaction or deluge valve was last tripped and the tripping time, as well as the individual and organization conducting the test and providing information on procedures and policies for maintenance of all backflow prevention assemblies (13.4.3.2.10).

NFPA 25 does *not* require that the AHJ do the following:

- Review or evaluate the adequacy of the system to control or extinguish a fire in the protected occupancy.
- Review or evaluate the adequacy of the water supply, including water tanks and fire pumps, to provide the necessary water flow and pressure needed to meet the fire protection system demand as designed.
- Review or evaluate the hazards present in the facility to determine the required system criteria for minimum protection levels.
- Conduct a review, evaluation, acceptance testing, inspection, or other test of the fire protection system to determine whether the system was designed and installed in accordance with the applicable installation standard, including NFPA 13, *Standard for the Installation of Sprinkler Systems*; NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*; NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*; NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*; NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*; NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*; NFPA 22, *Standard for Water Tanks for Private Fire Protection*; NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*; and NFPA 750, *Standard on Water Mist Fire Protection Systems*.
- Review or evaluate all areas of the facility to determine whether those areas are protected in accordance with the original applicable installation standard.
- Review the design criteria for the system to determine whether it is adequate for the commodity or hazard.
- Review the installation shop drawing to make sure all pipes are correctly sized and the sprinklers are the correct type, orifice size, and temperature rating.
- Perform a water supply analysis to determine whether the water supply is sufficient to provide the required gallons per minute at the required pounds per square inch for the system.
- Perform a complete building inspection to determine whether closets, blind spaces, attics, crawl spaces, and all other special building features are adequately protected in accordance with the version of the installation standard in force at the time of the installation.
- Recognize that storage commodities and/or arrangements are different from those anticipated when the system was designed and installed.
- Research the installation contract files to determine whether special requirements were required.

This lack of specific requirements for enforcing the provisions of NFPA 25 requires that the AHJ go to other codes

and standards to find that authority. Some of the installation standards provide information that requires the system be maintained at least to the same level of performance and protection as designed. The standard then refers the AHJ back to NFPA 25, which does not require the AHJ to perform an analysis of the system to assure the system will function as required to protect the hazard that is present. For those facilities that are inspected using only NFPA 25, the facility and its occupants are at an increased risk, due to the focus on maintenance issues and the failure to address problems that can significantly impact these systems. (See the NFPA report, "U.S. Experience with Sprinklers," for more information.)

The standard does require that the property owner address changes to use, process, or materials by mandating an evaluation of the fire protection system for its capability to protect the new occupancy, use, or material. In the case of a facility that has had changes over a significant period of time, the provision does little to address the potential issues that can arise from a change that is not recognized as such by the property owner. A classic example of this would be a warehouse that has stored materials that are classified as noncombustible, and over a period of decades, the warehouse now includes combustible materials. The owner might not recognize that the change in product could have an impact on their fire protection system. Without expert intervention, the property owner might never know something is wrong until there is a fire.

An issue can also arise when a space is reconfigured resulting in improper sprinkler spacing and obstructions to discharge. The use, process, or materials have not changed, so the owner does not know that an evaluation needs to be done. Again, without expert intervention there is a potential for a significant loss in a property that was considered "protected."

In the case of fire sprinkler systems, it is widely held that the majority of issues related to the failure of these systems can be resolved with an ITM program that deals with shut valves and maintenance. This is an incorrect supposition, as the "U.S. Experience with Sprinklers" report shows that shut valves account for 59 percent and maintenance accounts for only 10 percent of sprinkler system failures. While it is agreed that the majority of failures relate to shut valves, when it comes to the other categories, there are significantly more failures in systems where the water supply is inadequate (12 percent). When coupled with obstructions to distribution (10 percent) and inappropriate systems (9 percent), the grouping almost equals the same percentage as shut valves. All of these items can be identified by a properly trained inspector. The inspector working for the AHJ must identify these issues and require modification to the system to correct the deficiencies and protect the hazards present.

The installation standards provide some guidance to the AHJ, but they ultimately refer back to NFPA 25. The provisions for ITM in the related standards are as follows:

- NFPA 13, Section 31.1, General.
  A sprinkler system installed in accordance with this standard shall be properly inspected, tested, and maintained by the property owner or their authorized representative in accordance with NFPA 25 to provide at least the same level of performance and protection as designed.
- NFPA 13R, Section 11.3, Inspection, Testing, and Maintenance.
  Sprinkler systems shall be inspected, tested, and maintained in accordance with NFPA 25.
- NFPA 14, Section 13.10, System Inspection, Testing, and Maintenance.
  A standpipe system installed in accordance with this standard shall be properly inspected, tested, and maintained by the property owner or an authorized representative in accordance with NFPA 25 to provide at least the same level of performance and protection as originally designed.
- NFPA 15, 11.1.1.
  A water spray system installed in accordance with this standard shall be properly inspected, tested, and maintained in accordance with NFPA 25 and *NFPA 72*.
- NFPA 16, Section 9.3, Inspection, Testing, and Maintenance Frequency.
  Foam-water sprinkler systems shall be tested and inspected in accordance with NFPA 25.
- NFPA 20, Section 14.4, Periodic Inspection, Testing, and Maintenance.
  Fire pumps shall be inspected, tested, and maintained in accordance with NFPA 25.
- NFPA 22, Section 18.1, General.
  Tanks shall be periodically inspected, tested, and maintained in accordance with NFPA 25.
- NFPA 24, Section 14.1, General.
  A private fire service main and its appurtenances installed in accordance with this standard shall be properly inspected, tested, and maintained in accordance with NFPA 25 to provide at least the same level of performance and protection as designed.
- NFPA 750, 15.1.1.
  Water mist systems, other than those installed in one- and two-family dwellings, shall be inspected, tested, and maintained in accordance with NFPA 25.

In each of these cases, the installation standard does not require the system to be maintained in accordance with the installation standard; instead it refers back to NFPA 25, so as the saying goes, "you can't get there from here."

From the perspective of the AHJ, the facility and the protection system must be maintained to address any changes in the protected property that might affect the operation of the protection system. A fire in a protected property that is not controlled reflects poorly on the industry and creates barriers to the installation of protection systems. To minimize the potential for failure of fire protection systems, the AHJ must take on the role of educator, engineer, and enforcer.

First and foremost, the AHJ must educate the property owner/manager. Far too often, the property owner has not been properly informed of the requirements of the various codes and standards that affect his/her facility. This is sometimes due to changes in ownership or management where the information has not been passed on. The AHJ has a unique opportunity to help the owner understand the myriad of regulations and provide guidance on how best to protect the owner's property. This can be accomplished at any point from the preconstruction meetings through permitting, to the change of occupancy discussions, to referrals from the fire department through preplans. By defining the regulations and roles of various inspectors in advance, the AHJ can mitigate some of the common confusion issues.

In the role of engineer, the AHJ must look at the fire protection system as it compares to the original installation. Requiring the property owner to have copies of the original design documentation will help to identify any changes that might inhibit the effectiveness of the system. A review of this documentation and of items such as preplans will help when reviewing process and/or commodity changes. Additional guidance in this area is provided in NFPA 1, *Fire Code*:

> **1.3.6.3** Repairs, renovations, alterations, reconstruction, change of occupancy, and additions to buildings shall conform to this *Code,* NFPA *101*, and the building code.
>
> **1.3.6.4** Newly introduced equipment, materials, and operations regulated by this *Code* shall comply with the requirements for new construction or processes.

NFPA 1 gives the AHJ the ability to look at all issues that might affect the operation of the fire protection system and require modification of that system to address those changes. This concept is further discussed in NFPA *101®, Life Safety Code®*:

> **4.5.8.1** Whenever or wherever any device, equipment, system, condition, arrangement, level of protection, fire-resistive construction, or any other feature is required for compliance with the provisions of this *Code,* such device, equipment, system, condition, arrangement, level of protection, fire-resistive construction, or other feature shall thereafter be continuously maintained. Maintenance shall be provided in accordance with applicable NFPA requirements or requirements developed as part of a performance-based design, or as directed by the AHJ. [***101:***4.6.12.1]
>
> **4.5.8.6** Any device, equipment, system, condition, arrangement, level of protection, fire-resistive construction, or any other feature requiring periodic testing, inspection, or operation to ensure its maintenance shall be tested, inspected, or operated as specified elsewhere in this *Code* or as directed by the AHJ. [***101:***4.6.12.4]

As the enforcer, the AHJ must have the ability to assure that a fire protection system will function correctly. Yet, NFPA 25 does not provide the authority or guidance (see A.4.1.6) on how to accomplish this. As an example, in 1.2.2, NFPA 25 states the following:

> In those cases where it is determined that an existing situation involves a distinct hazard to life or property, the authority having jurisdiction shall be permitted to require inspection, testing, and maintenance methods in excess of those required by the standard.

This leads to questions, such as: "Which methods?" or "Which standards?" Without a clear tie to some code or standard, this section can be politically sensitive and difficult to enforce.

The AHJ must go to other codes or standards to address the issues of function and operation of the systems. The *International Fire Code* provides clear guidance to the AHJ in the provisions of 901.4, which state the following:

> Fire protection systems shall be maintained in accordance with the original installation standards for that system. Required systems shall be extended, altered, or augmented as necessary to maintain and continue protection whenever the building is altered, remodeled, or added to. Alterations to fire protection systems shall be done in accordance with applicable standards.

NFPA 1 also provides the following clear direction to the AHJ on maintenance of fire protection systems:

> **1.6 Enforcement.** This *Code* shall be administered and enforced by the AHJ designated by the governing authority.

In addition, NFPA 1 provides guidance in dealing with changes to the building and/or processes and who enforces the code:

> **1.3.6.3** Repairs, renovations, alterations, reconstruction, change of occupancy, and additions to buildings shall conform to this *Code*, NFPA *101*, and the building code.

> **1.3.6.4** Newly introduced equipment, materials, and operations regulated by this *Code* shall comply with the requirements for new construction or processes.

This requirement gives the AHJ the ability to look at all issues that might affect the operation of the fire protection system and require modification of that system to address those changes. There are additional provisions found in NFPA 1, such as the following, which address maintenance, inspection, and testing and provide enforceable language:

> **4.5.8.1** Whenever or wherever any device, equipment, system, condition, arrangement, level of protection, fire-resistive construction, or any other feature is required for compliance with the provisions of this *Code*, such device, equipment, system, condition, arrangement, level of protection, fire-resistive construction, or other feature shall thereafter be continuously maintained. Maintenance shall be provided in accordance with applicable NFPA requirements or requirements developed as part of a performance-based design, or as directed by the AHJ. [***101:***4.6.12.1]

NFPA 25 is a valuable tool in the maintenance of water-based fire protection system; however, it does not provide the necessary language for the AHJ to ensure the installation will function correctly and provide the level of protection required. The AHJ must look at the requirements of this document, recognize its limited scope, and know where to obtain the information necessary to ensure the protection system will operate correctly.

Determining Qualification or Competency of ITM Personnel

In determining the qualifications or competency as outlined in 3.3.36, the AHJ should look to personnel who are factory-trained and certified for the specific type and brand of system being inspected, personnel who are certified by nationally recognized fire protection certification organizations such as the National Institute for Certification in Engineering Technologies (NICET), personnel who are registered, licensed, or certified by a state or local authority, and personnel who are employed and qualified by an organization listed by a nationally recognized testing laboratory for the servicing of fire protection systems.

The AHJ has responsibilities for determining qualifications or competencies found throughout NFPA 25. More often than not, the requirements are found in the text, such as in the specification of the term *qualified* for performing particular functions. It must be noted that the AHJ, for one portion of a system, might not be the AHJ for another portion of the system. An example might involve 13.7.2, where the AHJ for the sprinkler system is the fire marshal and the AHJ for the backflow preventer is the local utility or health department. Both have a distinct interest in the water supply but for very different reasons. An example of language defining *qualified* is as follows in the Florida State Statute:

> The State Fire Marshal shall require the National Institute of Certification in Engineering Technologies (NICET), Sub-Field of Inspection and Testing of Fire Protection Systems Level II or equivalent training and education as determined by the division as proof that the permit holders are knowledgeable about nationally accepted standards for the inspection of fire protection systems.

The areas in NFPA 25 where the term *qualified* must be considered by the AHJ are as follows:

> **3.3.36 Qualified.** A competent and capable person who has met the requirements and training for a given field acceptable to the AHJ. [**96,** 2017]

> **A.1.1.1.2** This standard does not address all of the inspection, testing, and maintenance requirements of the electrical components of a water-based fire protection system that are addressed by *NFPA 72*. However, there are times when a single inspection or test can meet the requirements of both NFPA 25 and *NFPA 72* (e.g., operation of a tamper switch). This standard does not necessarily require that two separate inspections or tests be conducted on the same component, provided the inspection or test meets the requirements of both standards and the individual performing the inspection or test is ***qualified*** to perform the inspection or test required by both standards.

> **A.3.3.22 Impairment.** The use of the phrase *fire protection system or unit* is a broad reference to those terms used in titles of Chapters 5 through 12. Some fire protection features are referred to as systems in the installation standards (e.g., sprinkler, standpipe, water spray, foam-water, and water mist), or are referred to as units (e.g., fire pumps), and others use neither term (e.g., private service fire mains and water tanks). For the purpose of this standard, the term *unit* refers to a fire pump and its connections required by NFPA 20, or a water storage tank and its connections required by NFPA 22, or a private service fire main and its connections required by NFPA 24. The use of the term *unit* in the definitions of impairment, deficiency, critical deficiency, and noncritical deficiency is not referring to an individual component such as a sprinkler, valve, fitting, switch, piece of pipe, and so forth.

Temporarily shutting down a system as part of performing the routine inspection, testing, and maintenance on that system while under constant attendance by ***qualified*** personnel, and where the system can be restored to service quickly, should not be considered an impairment. Good judgment should be considered for the hazards presented.

A.3.3.25 Inspection, Testing, and Maintenance Service. This program includes logging and retention of relevant records. Any portion or all of the inspection, testing, and maintenance can be contracted with an inspection, testing, and maintenance service. Similarly, any portion or all of the inspection, testing, and maintenance can be performed by ***qualified*** personnel employed by the property owner or designated representative.

4.1.1.2 Inspection, testing, and maintenance shall be performed by ***qualified*** personnel.

A.4.1.5.1 System deficiencies not explained by normal wear and tear, such as hydraulic shock, can often be indicators of system problems and should be investigated and evaluated by a ***qualified*** person or engineer.

4.1.5.2 Corrections and repairs shall be performed by **qualified** maintenance personnel or a **qualified** contractor.

A.4.1.6 The inspections and tests specified in this standard do not address the adequacy of design criteria or the capability of the fire protection system to protect the building or its contents. It is assumed that the original system design and installation were appropriate for the occupancy and use of the building and were approved by all applicable authorities having jurisdiction. If no changes to the water supply or to the building or its use have transpired since it was originally occupied, no evaluation is required. If changes are contemplated, it is the owner's responsibility to arrange for the evaluation of the fire protection system(s). In such a case, Figure A.4.1.6 provides an example of a questionnaire that the owner could use. Where the inspections and tests specified in the standard have been contracted to a ***qualified*** inspection provider or contractor, it is not the role of the inspector or contractor to determine if any changes have been made or the subsequent evaluation of the fire protection system. The evaluation of any building changes should be conducted before any proposed change is incorporated and should utilize the appropriate installation standard and input from applicable authorities having jurisdiction.

Fire protection systems should not be removed from service when the building is not in use; however, where a system that has been out of service for a prolonged period (such as in the case of idle or vacant properties) is returned to service, it is recommended that a responsible and experienced contractor be retained to perform all inspections and tests.

4.4 Water Supply Status. During inspection, testing, and maintenance, water supplies, including fire pumps, shall remain in service unless under constant attendance by ***qualified*** personnel or unless impairment procedures in Chapter 15 are followed.

5.3.4.4.1(2) Antifreeze systems with concentrations in excess of 30 percent but not more than 40 percent propylene glycol by volume and 38 percent but not more than 50 percent glycerine by volume shall be permitted based upon an approved deterministic risk assessment prepared by a ***qualified*** person approved by the authority having jurisdiction.

A.8.3.1.1.2 The risk analysis should be prepared and reviewed by ***qualified*** people. Increased test frequencies might be desirable when high impact losses could result from an uncontrolled fire. Examples where increased fire pump test frequencies can be considered could include high piled storage facilities and buildings where the predominant occupancy is protected by an extra hazard density sprinkler system.

A.8.3.1.2.4 The risk analysis should be prepared and reviewed by ***qualified*** people. Increased test frequencies can be desirable when high impact losses could result from an uncontrolled fire. Examples where increased fire pump test frequencies can be considered could include high piled storage facilities and buildings where the predominant occupancy is protected by an extra hazard density sprinkler system.

8.3.2.7.1 The use of the automatic timer allowed in 8.3.2.6 shall not eliminate the requirement of 8.3.2.7 to have ***qualified*** personnel present during the test.

8.3.3.1 Except as permitted in 8.3.3.4, an annual test of each constant speed pump assembly shall be conducted by ***qualified*** personnel under no-flow (churn), rated flow, and 150 percent of the pump rated capacity flow of the fire pump by controlling the quantity of water discharged through approved test devices.

8.3.7.1.2 ***Qualified*** individuals shall interpret the test results.

9.5.2.1 Maintenance of all automatic tank fill valves shall be conducted by a ***qualified*** person following the manufacturer's instructions in accordance with the procedure and policies of the authority having jurisdiction.

13.2.4.7 Fire pumps shall not be taken out of service during testing unless constantly attended by ***qualified*** personnel, or all impairment procedures contained in Chapter 15 are followed.

13.7.3 Maintenance. Maintenance of all backflow prevention assemblies shall be conducted by a ***qualified*** individual following the manufacturer's instructions in accordance with the procedure and policies of the authority having jurisdiction.

14.3.3 If an obstruction investigation indicates the presence of sufficient material to obstruct pipe or sprinklers, a complete flushing program shall be conducted by ***qualified*** personnel.

A.15.5 The need for temporary fire protection, termination of all hazardous operations, and frequency of inspections in the areas involved should be determined. All work possible should be done in advance to minimize the length of the impairment. Where possible, temporary feedlines should be used to maintain portions of systems while work is completed.

Water-based fire protection systems should not be removed from service when the building is not in use. Where a system that has been out of service for a prolonged period, such as in the case of idle or vacant properties, is returned to service, ***qualified*** personnel should be retained to inspect and test the systems.

A.15.7 Occasionally, fire protection systems in idle or vacant buildings are shut off and drained. When the equipment is eventually restored to service after a long period of not being maintained, it is recommended that ***qualified*** personnel or a ***qualified*** contractor perform the work.

C.3.1 Introduction. In a fire pump motor circuit that has been properly installed, coordinated, and in service prior to the fault, tripping of the circuit breaker or the isolating switch indicates a fault condition in excess of operating overload.

It is recommended that the following general procedures be observed by ***qualified*** personnel in the inspection and repair of the controller involved in the fault. These procedures are not intended to cover other elements of the circuit, such as wiring and motor, which can also require attention.

Accessibility to Equipment

In NFPA 25, the AHJ has a limited role in relation to accessibility to equipment. The AHJ has a more significant role in the installation phase where decisions on the fire protection equipment locations are discussed and approved. When initial plans are submitted for review, the AHJ should review the design for operational aspects as well as the need to gain access to the equipment for inspection, repair, and replacement. When considering the installation of equipment, the AHJ needs to remember that there are standards other than water-based fire protection that apply to accessibility, such as a controller for a fire pump, as shown in the following requirement from NFPA 20:

10.2.4 Working clearances around controllers shall comply with *NFPA 70*, Article 110.

The following provisions found in NFPA 1, *Fire Code,* provide for accessibility to the fire protection system:

13.1.4 Obstructions shall not be placed or kept near fire hydrants, fire department inlet connections, or fire protection system control valves in a manner that would prevent such equipment or fire hydrants from being immediately visible and accessible.

13.1.5 A minimum 36 in. (915 mm) of clear space shall be maintained to permit access to and operation of fire protection equipment, fire department inlet connections, or fire protection system control valves. The fire department shall not be deterred or hindered from gaining immediate access to fire protection equipment.

Notification of Impairment

The specific notification requirements found in NFPA 25 require the AHJ to be notified of impairments to the fire protection system. The AHJ should request specific information to determine what the nature of the impairment is and whether or not there are additional notifications or investigations that need to take place. The level of response from the AHJ will directly relate to the type of impairment and the length of time it will take to correct the impairment. The fire department must be able to respond accordingly to a particular incident. For occupancies of a hazardous nature or where special hazards exist, the AHJ should consider requiring additional safeguards. These safeguards include additional fire safety equipment (including fully staffed apparatus), more than one type of fire safety equipment, or special systems suitable for the protection of the hazard involved.

If the impairment is due to debris in the system, it might be due to a past break in the integrity of the supply system. This could mean other fire protection systems on the same

service could also be affected. The AHJ should contact the utility or service provider to determine what occurred, where it occurred, and what other systems are on that supply; then, they should request that those systems be evaluated.

The AHJ has the ability to require standby fire personnel or an approved fire watch when potentially hazardous conditions or a reduction in a life safety feature exist due to impairment to the fire protection system. As per 13.3.3.6.5.2 of NFPA 1, when a fire protection system is out of service for more than 10 hours in a 24-hour period, the AHJ has the authority to require that the building be evacuated or that an approved fire watch be provided for all portions left unprotected by the fire protection system shutdown until the fire protection system has been returned to service.

Notification of System Shutdown

Prior to responding to the need to shut down a fire protection system, the AHJ and stakeholders should develop a facility-specific plan to address emergency response. These plans should include response with a partially or fully impaired fire protection system.

The role and responsibility of the AHJ is the same for a system shutdown as it is for impairment. Simple questions need to be asked, such as: Why is the system being shut down? How long will it be shut down? What is the hazard associated with the system or portion of the facility being shut down? Once the AHJ receives the information, procedures for the type and level of response can be initiated.

Standby fire personnel or an approved fire watch might be part of that response. In some cases, if the hazard is determined to be high due to the potential for loss of life or significant property loss, the AHJ might require that the building be evacuated and all processes be shut down until the fire protection system is restored.

Changes in Occupancy, Use, Process, or Material

The inspections and tests specified in NFPA 25 do not address the adequacy of design criteria or the capability of the fire protection system to protect the building or its contents. The standard assumes that the original system design and installation have not changed and the water supply or building use is the same as originally constructed. This is an incorrect assumption that should not be perpetuated. The AHJ should evaluate the system using NFPA 25 and the installation standard for the year the system was installed. By using both standards, the AHJ can reasonably be assured that the fire protection system will function correctly.

It is the role of the inspector who works for the local AHJ to determine if any changes have been made to the fire protection system. The evaluation of any proposed building changes should be conducted before any change is incorporated. Permits must be applied for and the required plans must be submitted for approval prior to making any changes.

The standard requires that if a property owner is contemplating changing a process or material, then it is the owner's responsibility to arrange for the evaluation of the fire protection system. The concern is to identify any changes that the property owner might not be aware of. Some of these changes can include moving stock from one area to another (change of commodity in a given area), increase in storage height (volume of combustibles), component material changes not by the property owner (commodity class change), or material stored (material owner is not the same as the building owner). All of these items can negatively affect the function of the fire protection system. The standard requires that an expert evaluate the conditions and advise the property owner if there is a need to either modify the conditions or return the facility to the original permitted condition. In most cases, the property owner is not that expert and should not be relied upon to make those judgments.

The AHJ can help in this process by communicating with the property owner on a regular basis. This communication can be accomplished either by regular site visits or by using surrogates, such as the responding fire station performing preplans, to visit the facility. The engine crews can provide valuable information to the AHJ, gather important information for response, and participate in preparation of response plans (in case of impairment or system shutdown), as well as help the facility owner with questions that might arise.

The AHJ must look at the fire protection system as it compares to the original installation, and whenever or wherever any device, equipment, system, condition, arrangement, level of protection, fire-resistive construction, or any other feature is changed, the AHJ must notify the property owner of the need to correct the deficiency.

NFPA 25 does provide some guidance in 4.1.6, but states in 4.1.6.1 that such an evaluation is not part of the "normal" ITM required by the standard. The owner must know that there is a change to cause the evaluation. In most cases, the owners look to the experts to identify those changes and provide them with guidance to protect their property.

Records Retention

Acceptance test records should be retained for the life of the system. The AHJ will frequently refer to these records when performing a facility inspection. The AHJ will use these records to compare the existing conditions with the original installation to determine if any changes have been made that will affect the fire protection system.

The standard requires that all ITM records must be provided upon request. In many cases, the AHJ will require the ITM contractor to provide copies of their reports. The reports can be incorporated into the AHJ's property file for the facility.

It is recommended that the AHJ contact all of the ITM contractors providing services in their jurisdiction and request copies of the inspection reports. It is also recommended that a specific timeframe be given to the ITM contractor for providing the reports so that there is adequate time for the report to be evaluated and for any deficiencies to be corrected. If the jurisdiction has adopted NFPA 1, then the property owner is also required to maintain detailed records documenting all systems and equipment testing and maintenance. If the AHJ requires documentation to be maintained for review during inspections, the property owner should be notified as part of the original approval process. Such notification ensures that the property owner is aware of these requirements and will have the documentation when it is needed.

The AHJ might also require that a log book be kept at a facility. The log book would contain the original plans, acceptance test documents, and any inspection or repair documents. The AHJ will review the log book to determine if there are any outstanding deficiencies. If the ITM report contains severe violations, then the AHJ can take action to assure the deficiency is corrected. Subsequent test records should be retained for a period of 1 year after the next test. The comparison of these records and the log book can help determine any deterioration of the system's performance or condition and the need for further testing or maintenance.

NFPA 25 allows records to be maintained electronically. The AHJ should provide an e-mail address or some other means to allow the ITM contractor to send reports electronically. This change makes it easier to provide the records required by the standard.

Records retention might also be governed by a different AHJ. In many cases, state and local governments require different record retention schedules than those provided in the standard. It is recommended that the AHJ become aware of these requirements and retain the records in accordance with those policies. These requirements might also affect the ITM contractor if the facility being inspected is covered under this records retention schedule.

Determining Inspection Frequency

When addressing the testing frequencies, reliance should be placed on the provisions of NFPA 25. The AHJ should evaluate the inspection reports to determine if the inspections are being performed in accordance with the standard; if they are not being performed in accordance with the standard, the AHJ should formulate an action plan to address the deficiency. Many inspectors will review the inspection reports to verify that the inspection frequencies are being met, and if not, they will discuss the excessive intervals between ITM tasks with the property owner.

Jurisdictions might allow the inspection frequency to be modified to fewer than those listed in the standard. These modifications are based on a well-documented performance-based inspection schedule. Copies of this documentation should be maintained in the facility log book as well as in the AHJ's property record. Any variance to the standard's inspection frequencies should be well-documented as a failure of the system, because a variance in the inspection schedule can lead to litigation. If the AHJ feels uncomfortable approving the performance-based schedule, a third-party expert can be required by the AHJ to evaluate the schedule. The costs for the third-party evaluator are borne by the proponent of the design. Ultimately, the AHJ must evaluate what has been presented and determine if the schedule is acceptable.

Preparing and Providing Tools and Safety Equipment

The typical AHJ working as a building official or fire marshal has a limited role in the preparation of tools and safety equipment for the ITM inspector. There might be several different AHJs for this activity since the numbers of regulations for the various activities have different enforcers. Many of the issues related to the tools and safety equipment are under the jurisdiction of agencies such as the Occupational Safety and Health Administration (OSHA) and state occupational safety and labor departments. These agencies regulate many of the activities that relate to worker safety.

In some cases, the local AHJ might be involved in permitting and the inspection of work sites, such as confined space entry. The AHJ might require a site visit and, in some cases, a standby rescue crew. The local AHJ might also be involved in an inspection that involves entry into an area that requires use of respiratory protection. This is to ensure that the necessary emergency response personnel are available in case of an incident. If the AHJ determines the hazard to be high enough, standby personnel might be required.

Conducting and Attending System ITM Activities

For the most part, the AHJ does not attend or conduct the ITM activities outlined in NFPA 25. These activities are performed by employees of fire protection contractors, who are contracted by the property owner to comply with the requirements of specific law or rule. The reports generated by these inspections are a useful tool to identify deficiencies in the fire protection equipment.

Preparing ITM Reports

The AHJ role, in preparing the ITM report, is to simply require a copy of the report. The AHJ should evaluate the report to determine if any corrective actions are needed to ensure the protection system is operational. The AHJ should request copies of all inspection reports along with specific deadlines

for providing the reports. This will ensure that the deficiencies are corrected as quickly as possible.

The AHJ should review the inspection report to make sure it includes a detailed explanation of every deficiency and an indication of the inspection frequency, such as whether it is a weekly, monthly, quarterly, or annual inspection. The inspection report should include the name of the permitted water-based fire protection inspector, the inspector permit number, the inspector's signature, the date and time of the inspection, and the signature of the owner or the owner's representative.

Some jurisdictions have provided regulatory language to require the reports, such as in Florida Statute 633.082 or 69A-46.041(7) Florida Administrative Code that follows, which covers inspection of fire control systems, fire hydrants, and fire protection systems:

> **69A-46.041(7) Florida Administrative Code.** The contractor or his or her permitted Water-Based Fire Protection Inspector shall complete in detail the inspection reports as required in NFPA 25, as adopted in Rule Chapter 69A-3, F.A.C. that outlines all points of the inspection, test, and maintenance as required by the applicable NFPA standards. A copy of the inspection report shall be provided to the owner at the completion of each inspection performed.
>
> **Reporting FS 633.082.** The inspecting contractor shall provide to the building or hydrant owner and the local authority having jurisdiction a copy of the applicable inspection report established under this chapter. The maintenance of fire hydrant and fire protection systems as well as corrective actions on deficient systems is the responsibility of the owner of the system or hydrant. Equipment requiring periodic testing or operation to ensure its maintenance shall be tested or operated as specified in the *Fire Prevention Code*, *Life Safety Code*, National Fire Protection Association standards, or as directed by the agency having jurisdiction, provided that such agency shall not require a sprinkler system not required by the *Fire Prevention Code*, *Life Safety Code*, or National Fire Protection Association standards to be removed regardless of its condition. This section does not prohibit governmental entities from inspecting and enforcing fire safety codes.

Corrective Actions for Deficiencies and Impairments

This area is where the AHJ can have the most impact. As previously stated in the reporting section, it is recommended that the AHJ contact all of the ITM contractors providing services in the jurisdiction and request copies of the inspection reports. It is also recommended that a specific time frame be given to the ITM contractor for providing the reports, so that there is adequate time for the report to be evaluated and for any deficiencies to be corrected in accordance with the policies of the jurisdiction. In the case of impairments, the AHJ should investigate the cause of the impairment to ensure that other systems in the area are not affected by the same issues. The AHJ should also take the necessary action to ensure a level of response commensurate with the decrease in protection resulting from the impaired system.

An evaluation of the current operating condition of the fire protection system should be weighed against the potential for loss in the facility. In some high-risk cases, the AHJ might require a full complement of fire equipment and manpower to protect a facility for as long as the fire protection system is not fully operational. This is where communication with the ITM inspection contractors is essential. The ITM contractors need to be aware that notification of system impairment or deficiencies that will affect the system's protection of the facility need to be addressed in the time frame set by the AHJ. It is the responsibility of the AHJ to determine the level of protection for a facility and the level of protection required in the event that a system is impaired.

System Tagging

Many jurisdictions require a fire protection system to be tagged to indicate the readiness condition of the system. The AHJ can use the tag as an initial indication of the system's condition but should not rely solely on this information. A review of the inspection report will reveal the information needed to determine system readiness. The AHJ should remember that the report and tagging of the fire protection system relates strictly to the NFPA 25 inspection and does not consider all of the conditions that might cause a fire protection system to fail.

The AHJ should review the inspection reports to determine the condition of the system as it relates to NFPA 25. In some cases, the tag will relate information on system deficiencies. NFPA 25 provides guidance for the actions the inspector should take for particular types of deficiencies. The AHJ can review the information provided in Annex A, but since this information is annex material and therefore not mandatory but explanatory in nature, the jurisdiction would need to adopt the information.

When many inspectors see a red tag, it might mean the system is not operational and the appropriate emergency actions must be put into effect. This might not be the case, and a review of the inspection report might provide the information necessary for the AHJ to determine what actions, if any, need to be performed. Conversely, an inspector might see a green tag and think the system is operational and that

no action is necessary. Again, this might be an inappropriate action because the system might not have an adequate water supply; for example, sprinkler heads might be obstructed or there could be other deficiencies.

The AHJ should remember that the property owner might see a green tag on a riser and receive a report from the ITM inspector that indicates the system is compliant with NFPA 25, but the system might not function correctly to control a fire in the facility. The AHJ must remind the facility owner of the scope of the NFPA 25 inspection and educate them on the other conditions that could cause failure. Then the inspector for the AHJ must inspect the facility, evaluate all of the conditions that might keep the system from performing correctly, and note any deficiencies.

In many cases, the AHJ will provide regulations on the tagging system. This can include everything from the size and color, to the information contained on the tag, to the size of the lettering. The following provisions of 69A-46.041(2), (3), and (4) Florida Administrative Code are an example of these requirements:

Inspection Requirements for Fire Protection Systems

Each system that has been inspected, tested, or maintained by a fire protection contractor, or his or her permitted Water-Based Fire Protection Inspector, shall have a record tag of durable and weather resistant material placed on the riser.

Inspection Tags

After inspection and testing, an inspection tag shall be completed indicating all work that has been done, and then attached to the system riser in such a position as to permit convenient inspection and not hamper activation or operation. A new inspection tag shall be attached to the system riser each time an inspection and test service is performed.

Inspection tags must be a minimum dimension of 5¼ inches (133 mm) in height and 3½ inches (89 mm) in width, and a maximum dimension of 7 inches (178 mm) in height and 4 inches (102 mm) in width.

Inspection tags shall bear the following information in an easily read format:

'DO NOT REMOVE BY ORDER OF THE STATE FIRE MARSHAL.'

- This particular information shall be in a minimum of 10 pt type and in all capital letters
- The licensed Fire Protection System Contractor I or II's name and licensed physical address
- The license number of the Fire Protection System Contractor I or II
- The permit number of the Water-Based Fire Protection Inspector
- The permitted Water-Based Fire Protection Inspector's signature
- The day, month and year
- The facility name and address

The reverse of the noncompliant tag shall include at least four separate boxes for the listing of repair work as follows:

a. Date of Repair
b. Repaired by (Signature)
c. Print Name
d. Type of Repair
e. Permit Number (If repair is made by a Water-Based Fire Protection Inspector, Permit Number must be noted.)

Compliance and Noncompliance Tag

If a fire protection system is found to be in compliance with the applicable NFPA standards, a GREEN Compliance Tag shall be attached to either the main riser or main control valve in such a manner as to be plainly visible and not more than 60 inches above the finished floor.

If a fire protection system is found to have deficiencies and is not in compliance with the applicable NFPA standards, a completed RED Noncompliance Tag shall be attached to the main control valve of the system to indicate that corrective action is necessary. If the system is operational but not in compliance with the applicable NFPA standards, the building owner or authorized representative and occupant shall be notified by copy of the NFPA 25 inspection report within 30 days of the inspection. If the system is not operational, the contractor or inspector shall notify the building owner or authorized representative, the occupant, and the authority having jurisdiction within 24 hours of the time of the inspection.

Pursuant to the provisions of [*Local Jurisdiction's regulation*], it is the owner's responsibility to maintain the fire protection system. Affixing an inspection tag as required herein does not invalidate responsibility nor shall a transfer of risk be construed.

Follow-Up on Corrective Actions

If the AHJ has adopted the appropriate enabling document, such as NFPA 1, then the AHJ has the ability to enforce the provisions of NFPA 25. The AHJ and ITM inspector should be communicating on a regular basis concerning inspection reports. When a report is received that lists deficiencies, the AHJ can contact the ITM contractor and determine if the repairs have been made. If the repairs have not been made, then the AHJ should determine the level of deficiency and severity of the hazard. If the deficiency is a relatively low hazard, then the facility owner or owner's representative should be requested to provide a time frame for repair or for a fire safety improvement plan. If the hazard is such that

immediate action in necessary, the AHJ should take the steps necessary to mitigate the hazard. These steps might include requiring a fire watch, shutting down hazardous operations, or evacuating the building.

Planned Impairment Programs

In a situation where the ITM contractor has determined that the fire protection system must be taken out of service, the provisions of the facility emergency plan and policies of the AHJ should be discussed and those portions of the plans should be implemented prior to taking the system out of service. The planned impairment might also require plans to be submitted and a permit obtained. The provisions of 15.5.2(4) in NFPA 25 provide guidance to the ITM inspector as follows:

> Where a fire protection system is out of service for more than 10 hours in a 24-hour period, the impairment coordinator shall arrange for one of the following:

(a) Evacuation of the building or portion of the building affected by the system out of service
(b) An approved fire watch
(c) Establishment of a temporary water supply
(d) Establishment and implementation of an approved program to eliminate potential ignition sources and limit the amount of fuel available to the fire

However, if the jurisdiction is governed by the provisions of NFPA 1 or NFPA *101*, then the following provisions apply:

> Whenever impairments, critical deficiencies, or non-critical deficiencies are identified in water-based fire protection systems maintained in accordance with NFPA 25, they shall be corrected in a time frame approved by the AHJ. [**1:**13.1.9]

The decisions to evacuate a building, require a fire watch, or establish any alternative programs must be discussed and approved by the AHJ. These decisions in consultation with the fire protection agency, will determine the level of response for a given facility based on the hazard analysis and response plans.

The AHJ should verify that the appropriate actions have been taken and that the system has been tagged at all of the required points. The AHJ should also make sure that the response personnel have updated their response plans to include the potential lack of fire protection at the site of the impairment.

Upon notification that the system has been restored to operational, the AHJ needs to inform the appropriate response personnel that the system is back in service. The AHJ should also verify that the ITM contractor has removed all the warning tags and that the system has been restored to operational.

Emergency Impairments

In all cases involving impairments, preplanned actions need to be discussed with the ITM contractor to ensure there is a consistent level of protection for the property. The AHJ should meet and discuss policies involving the disabling of any fire protection system prior to that system being taken out of service. The AHJ should make available contact information that will allow the ITM contractor to notify the appropriate authorities any time a system is taken out of service.

Once the AHJ is notified that a system is out of service, the AHJ should determine what level of alternative protection must be provided. Part of that evaluation might include the level of impairment, the amount of time the system might be out of service, the type of hazard without protection, the potential for an uncontrolled fire, and the risk to the community. After evaluating the hazard, the AHJ might require actions that include everything from establishing a fire watch to requesting standby fire fighters with apparatus. When a water-based fire protection system is out of service for more than 10 hours in a 24-hour period, the AHJ can require that the building be evacuated or an approved fire watch be provided for all portions left unprotected by the fire protection system shutdown until the fire protection system has been returned to service.

Restoring Systems to Service

When fire protection systems in idle or vacant buildings are being restored to service, it is usually due to the building being reoccupied. In this case, most jurisdictions require permitting and a re-evaluation of the fire protection features to ensure that the installed systems will protect the hazards being introduced into the building. During the inspection process, the AHJ should require that the fire protection systems be evaluated to make certain that the design addresses the hazards. It is recommended that a qualified contractor perform the work.

A sample review note that can be used in a jurisdiction is as follows:

> Interior renovations can affect the sprinkler protection provided by any existing fire sprinkler system(s). A licensed fire sprinkler contractor should be contacted to determine if alterations to any existing fire sprinkler system will be required to comply with the coverage requirements of NFPA 13. Any existing sprinkler system shall cover all areas required. Alteration of any existing sprinkler system (if required) will require a separate permit by a licensed fire sprinkler contractor.

When the AHJ is notified that a repair to the fire protection system is complete, the system should be inspected to

ensure it is operational. NFPA 25 provides for a certain level of inspection to be performed; however, depending on the level of repair, the AHJ might want to take the inspection to a higher level. The AHJ should look over the facility to verify that the area protected has not been modified and that the system design is appropriate for the hazard present. The authority to perform this type of inspection is not found in NFPA 25 but is covered in NFPA 1. This will assure that when the AHJ leaves the facility, the fire protection system will function correctly and protect the occupants and property in accordance with the design.

The AHJ should also make sure that all of the systems associated with the fire protection system are operational. In many cases, when a fire sprinkler system is taken out of service the fire alarm is also removed from service to avoid potential false alarms. Thus, verification of the alarm service should be performed, including contact through the dispatch service.

Obstruction Investigations

An obstruction investigation should be handled similarly to an impairment. The AHJ should be notified of obstruction investigations and to what degree the fire protection system will be impaired. The AHJ should request specific information to determine what the nature of the investigation is and whether or not there are additional notifications or investigations that need to take place. The level of response from the AHJ will directly relate to the type of obstruction found. The AHJ should request that the ITM inspector provide information on what was found and, if possible, the circumstances surrounding the obstruction. This information will help the AHJ determine if other systems might be affected and what steps to take to correct any potential issues. If the fire protection system is going to be out of service, then impairment procedures should be considered. The fire department must be able to respond accordingly to a particular incident. For occupancies of a hazardous nature or where special hazards exist, the AHJ should consider requiring additional safeguards consisting of additional fire safety equipment (including fully staffed apparatus), more than one type of fire safety equipment, or special systems suitable for the protection of the hazard involved.

Performance-Based ITM Programs

Performance-based test and inspection methods proposed as an alternative means of compliance for testing frequencies require significant involvement of the AHJ. The performance-based options should be evaluated as a means to provide a greater degree of safety and potentially a lower cost to the facility owner. In developing the program to provide the alternative means of compliance, the AHJ should always look to provide the highest level of protection with the lowest degree of risk.

The verification process starts with the submittal to the AHJ. If the AHJ does not consider itself qualified to perform an adequate review of the performance-based design, the AHJ might specify a qualified third-party reviewer. A detailed process for evaluation is outlined in the *SFPE Engineering Guide to Performance-Based Fire Protection Analysis and Design of Buildings*. Additional information on reviewing performance-based design can be found in the *SFPE Enforcer's Guide to Performance-Based Design Review*.

In reviewing the verification process, the AHJ needs to identify a clear set of goals and objectives. Attention must be paid to both those objectives that apply to the facility as a whole and those that apply only to limited aspects of the facility. The purpose of this review is to determine whether the objectives of the designer and the owner are commensurate with the community's objectives.

The AHJ should review the objectives for consistency and judiciousness. The objectives must form a realistic and comprehensive package. Assumptions need to be reasonable, consistent, comprehensive, cohesive, and supported by adequate references.

Ultimately, the interest is in determining whether the designer did a credible job and if there is a sufficient margin of safety acceptable to the AHJ. Because of the complexity involved in this process, considerable discussions should be planned between the AHJ, the designer, and, if used, the third-party reviewer.

Testing programs must be evaluated using a method acceptable to the AHJ and appropriate for the conditions. Each design should be realistic and apply to conditions found in the facility. System components must be evaluated using products that are similar if not the same. If the testing is too general, the results might be inaccurate, since the quality for one manufacturer's product might be different from another. Failure rates for products and components typically follow specific production lots and manufacturers.

All aspects of the design must be documented. The format and content of the documentation must be acceptable to the AHJ. Sufficient documentation must be supplied to support the validity, accuracy, relevance, and precision of the proposed methods. The engineering standards, calculation methods, and other forms of scientific information provided must be appropriate for the application and methodologies used. It is imperative that the AHJ be involved with the development of the performance-based program from its inception. The development of the program, including all of the required documents, requires the AHJ's approval.

Frequencies must not be arbitrarily extended or reduced without a suitable basis and rationale. Failure to properly evaluate, document, and obtain approval for modifications of the testing requirements can result in enforcement actions being taken. Depending on circumstances, the enforcement actions might be taken against the owner of the facility or the

ITM provider. It is recommended that the inspector review the local jurisdiction's laws, rules, and codes for requirements on servicing fire protection equipment.

A performance-based program provides that a maximum allowable failure rate be established and approved by the AHJ in advance of implementation. The use of historical system and component fire system inspection records can be used to determine failure rates. The design team and the AHJ should develop a process for reviewing the failure rates and increasing or decreasing the frequency of testing.

Ultimately, if the AHJ has been involved in the entire development process, then approval of the program should be relatively simple. Approval of the process used to determine test frequencies and the final design must be obtained in advance of any alterations to the test program.

References Cited

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 1, *Fire Code,* 2018 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2019 edition.

NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*, 2019 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 2019 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 2017 edition.

NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*, 2019 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*, 2019 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection*, 2018 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, 2019 edition.

NFPA 70®, *National Electrical Code®*, 2017 edition.

NFPA 72®, *National Fire Alarm and Signaling Code*, 2019 edition.

NFPA *101®*, *Life Safety Code®,* 2018 edition.

NFPA 750, *Standard on Water Mist Fire Protection Systems,* 2019 edition.

The SFPE Engineering Guide to Performance-Based Fire Protection Analysis and Design of Buildings, 2000 edition.

"U.S. Experience with Sprinklers," Marty Ahrens, July 2017.

International Code Council, 500 New Jersey Avenue, NW, 6th Floor, Washington, DC 20001.

International Fire Code, 2018 edition.

Society of Fire Protection Engineers, 7315 Wisconsin Ave., Bethesda, MD, 20814.

SFPE Enforcer's Guide to Performance-Based Design Review, 2003 edition.

Florida State Statute 633.082, "Inspection of Fire Control Systems, Fire Hydrants, and Fire Protection Systems," Title XXXVII, Chapter 633, 2012.

Florida Administrative Code, 69A-46.041(2), (3), (4), and (7), "Inspection Requirements for Fire Protection Systems."

INDEX

A

Accessibility, 4.1.3, 13.2.2, A.4.1.3, A.13.2.2
Adjust (definition), 3.3.1
Adjustments *see* Repairs, reconditioning, replacements, or adjustments
Alarm devices, Table 5.1.1.2, Table F.5.2(d); *see also* Supervisory signal devices; Valve supervisory devices; Waterflow alarm devices
  Fire pumps, Table 8.1.1.2, 8.1.4(4), 8.3.3.13, A.8.3.3.13, A.8.3.3.13.1
  Foam-water sprinkler systems, Table 11.1.1.2, Table 11.5.1
  Private fire service mains, Table 7.5.1
  Sprinkler systems, Table 5.1.1.2, 5.2.4, 5.3.3, Table 5.5.1, Table A.3.3.8, A.5.3.3.2
  Standpipe and hose systems, Table 6.1.1.2, 6.3.3, Table 6.5.1
  Valves, 13.2.4, 13.4.3.2.11, 13.4.3.2.12, 13.4.3.3.1, 13.4.4.2.14, 13.4.4.3.1, 13.4.5.2.6, 13.4.5.2.7, 13.4.5.2.9(2), Table 13.11.1, A.13.2.4.8
  Water spray systems, Table 10.5.1
  Water tanks *see* Water tanks
Alarm receiving facility, 4.1.4
  Definition, 3.3.2, A.3.3.2
Alarm valves, Table 13.1.1.2, 13.4.1, Table A.3.3.8, A.13.1, A.13.4.1.1, A.13.4.1.2, Table F.5.2(d)
Annual frequency (inspections, testing, and maintenance), A.4.1.1
  Alarm devices, 13.2.6.2, 13.4.3.1.2, 13.4.3.2.12, 13.4.4.1.2, 13.4.5.2.6, 13.4.5.2.7
  Antifreeze systems, 5.3.4
  Backflow prevention devices, 13.7.2.1, A.13.7.1.3
  Definition, 3.7.1.6
  Fire department connections, 13.8.2
  Fire pumps, Table 8.1.1.2, 8.1.1.2.1 to 8.1.1.2.6, 8.1.1.2.8 to 8.1.1.2.11, 8.1.1.2.13 to 8.1.1.2.22, 8.3.1.3, 8.3.3, 8.3.4, Table 8.6.1, Table A.3.3.8, Table A.8.1.1.2, A.8.3.3.1 to A.8.3.3.16, Fig. A.8.4.1
  Foam-water sprinkler systems, Table 11.1.1.2, 11.2.8.5.2.2(3), 11.3.4
  Low temperature alarms, 13.4.4.2.14
  Pressure-regulating devices, 13.5.2.1, 13.5.2.3, 13.5.3.1, 13.5.3.3, 13.5.4.3
  Private fire service mains, Table 7.1.1.2
  Sprinkler systems, Table 5.1.1.2, 5.2.1.1, 5.2.1.4, 5.2.2, 5.2.3, 5.2.5, 5.2.7 to 5.2.9, 5.4.1.7, 14.4
  Standpipe and hose systems, Table 6.1.1.2, 6.2.1, 6.2.2, 6.2.3.1, 6.2.4.1, 6.2.5.1, 6.2.6.1, 6.2.7.1, 6.2.8.1, 7.2.2.3.2, 7.2.2.4, 7.2.2.5, 7.2.2.6.5, 7.3.2, 7.3.3.2, 7.4.2.1, 7.4.3
  Supervisory signal devices, 13.2.6.2
  Valves, Table 13.1.1.2, 13.3.3.1, 13.3.4.1, 13.4.3.1.2, 13.4.3.2.7, 13.4.3.2.12, 13.4.3.2.13, 13.4.3.3.2, 13.4.4.1.2, 13.4.4.2.3, 13.4.4.2.4, 13.4.4.2.9, 13.4.4.2.10, 13.4.4.2.14, 13.4.4.2.15, 13.4.4.3.2, 13.4.5.1.3, 13.4.5.2.2, 13.4.5.2.6 to 13.4.5.2.8, 13.4.5.3.1, 13.5.6.2.3, 13.6.2.1
  Water mist systems, Table 12.1.1.2, 12.2.1.2, 12.2.3.1, 12.2.4.1, 12.2.5.1.2, 12.2.5.3, 12.2.5.4.3, 12.2.5.6, 12.2.5.7, 12.2.5.9, 12.2.8.3, 12.2.8.4, 12.3.7.2, 12.3.11, 12.3.13.2, 12.3.14.2, 12.3.15, 12.3.16, 12.3.17.2, 12.3.20, 12.4.1.7, 12.4.1.8
  Water spray systems, Table 10.1.1.2, 10.3.5
  Water tanks, Table 9.1.1.2, 9.2.4.3 to 9.2.4.5, 9.3.5, Table 9.5.1.1, Table 9.6.1
Antifreeze sprinkler systems, 4.1.9.2(3), 5.3.4, Table A.3.3.8, A.5.3.4 to A.5.3.4.4.1(2), Table F.5.2(d)
  Antifreeze solution, 4.1.2, Table 5.1.1.2, 5.3.4, Table 5.5.1, A.4.1.2, A.5.3.4, A.5.3.4.4.1(2)
  Definition, 3.6.4.1
  Information signs *see* Information signs
  Premixed antifreeze solution, 5.3.4.2.2
    Definition, 3.6.4.1.1
Application of standard, 1.3, A.1.3
Approved (definition), 3.2.1, A.3.2.1
Asian clams, obstruction by, D.2.4, D.4.4
Authority having jurisdiction (definition), 3.2.2, A.3.2.2
Automated inspection and testing, 4.6.1.1, 4.6.1.2, 4.6.6, A.4.6.6
  Definition, 3.3.3
Automatic bulb-type sprinklers, 5.4.1.7.1
Automatic detection equipment, Table 10.1.1.2, 10.3.3.1.2, 10.3.3.2, 10.4.2, Table 11.1.1.2, 11.3.2.1, 12.3.8, 13.4.4.2.15, 13.9
  Component action requirements, Table 5.5.1, Table 10.5.1, Table 11.5.1
  Definition, 3.3.4, A.3.3.4
Automatic operation, 8.3.6.3
  Definition, 3.3.5, A.3.3.5
Automatic standpipe systems *see* Standpipe and hose systems
Automatic transfer switches, 8.3.3.12, 8.3.6.2
  Definition, 3.3.6

B

Backflow prevention assemblies, Table 10.1.1.2, Table 11.1.1.2, Table 13.1.1.2, 13.2.3.2, 13.7, Table 13.11.1, Table A.3.3.8, A.13.1, Fig. A.13.1(a), A.13.7.1.3, A.13.7.2.1, Table F.5.2(d)
  Reduced-pressure principle backflow prevention assemblies (RPBA), 13.7.1.1, A.13.1, A.13.1(a)
    Definition, 3.3.38
Ball valves, 11.4.4.1, Table 11.5.1, A.13.1, Table F.5.2(d)
Biological growth, obstruction caused by, D.2.4; *see also* Microbiologically influenced corrosion (MIC)
Bladder tank proportioners, Table 11.1.1.2, 11.2.8.5.2, 11.4.5, Table 11.5.1, Table A.3.3.8, A.11.2.8.5.2.1, A.11.4.5.2, Table F.5.2(d)
  Definition, 3.3.35.1, Fig. A.3.3.35.1

Braces, Table 5.1.1.2, 5.2.3, Table 6.5.1, Table 10.1.1.2, 10.2.3.2, Table 10.5.1, Table 11.1.1.2, 11.2.3, Table 11.5.1, 12.2.4, Table A.3.3.8, A.5.2.3, A.10.2.3.2, A.12.2.4.4
Butterfly valves, A.13.1, Fig. A.13.1(b)

C

Calcium carbonate, obstruction by, D.2.5, D.4.5
Changes
In hazard, 4.1.7, A.4.1.7
In occupancy, use, process, or materials, 4.1.6, A.4.1.6
Check valves, Table 9.1.1.2, Table 10.1.1.2, Table 11.1.1.2, Table 13.1.1.2, 13.4.2, 13.7.2.1.1, Table 13.11.1, 14.3.1(3), A.13.1, Fig. A.13.1(c), Table F.5.2(d); *see also* Detector check valves
Double check valve assembly (DCVA), Fig. A.13.1(a)
Definition, 3.3.10
Churn *see* No flow (churn, shutoff)
Circulation relief valves *see* Relief valves
Clean (ing)
Battery terminals, 8.1.1.2.15(2)
Definition, 3.3.7
Fire pumps, Table A.8.1.1.2, Table A.8.3.3.2.9, A.8.5.1
Foam-water systems discharge devices/piping, 11.3.2.6.2
Nozzles, 10.3.3.3.2
Piping, 10.3.3.3.2, A.13.4.5.2.2.3, C.1.6, D.2.7, D.3.4, D.5.2, D.5.4
Proportioners, 11.4.4.1, 11.4.5.1
Pumps, C.1.21, C.1.25, C.1.32, D.3, D.3.4
Robotic, D.4.6
Sprinklers, A.5.2.1.1.1
Strainers, 7.2.2.3.1, Table 9.5.1.1, 9.5.2.3, 10.2.1.6, 10.2.6.2, 10.2.6.3, 11.2.6.3, Table 13.11.1, Table A.8.1.1.2
Suction screens, Table A.8.1.1.2
Tanks, 8.3.4.2, 9.4.6.2, A.8.3.4.2
Valves, 13.4.1.3.1, 13.4.2.2, 13.4.3.3.2, 13.4.4.2.4.3, 13.4.4.3.2, 13.4.5.3.1, A.13.4.5.2.2.2, D.3.3
Water mist system filters, 12.4.1.6
Yard mains, D.5.3
Cold weather *see* Freezing conditions or cold weather
Combined standpipe and sprinkler systems (definition), 3.6.1
Commercial-type cooking equipment, sprinklers and nozzles for, 5.4.1.7
Concealed spaces
Sprinkler system components in, 5.2.1.1.3, 5.2.2.3, 5.2.3.3, 5.2.3.4, A.5.2.1.1.3, A.5.2.2.3, A.5.2.3.3
Water mist nozzles in, 12.2.1.1.4
Concealed sprinklers, 5.2.1.1.5, Table A.5.3.4.4.1(2)
Definition, 3.3.42.1.1
Confined spaces, entry to, 4.9.2
Connections
Fire department *see* Fire department connections
Flushing, D.5.1
Hose *see* Hose connections
Test, Table 5.5.1, Table 11.5.1
Connectivity, for remote monitoring and data collection, Annex F
Controllers, pump, 4.9.6, Table 8.1.1.2, 8.1.8, 8.2.2(4), 8.3.2.6.1 to 8.3.2.6.3, A.4.9.6, A.8.1.8, C.3
Control mode specific application (CMSA) sprinklers, A.5.2.1.2.3
Definition, 3.3.42.2, A.3.3.42.2
Control valves, 4.1.9.1, 13.3, A.13.3.1 to A.13.3.3.5, Table F.5.2(d); *see also* Pressure-reducing valves
Component action requirements, Table 6.5.1, Table 13.11.1
Definition, 3.5.1, A.3.5.1
Impairments, signs indicating, 10.1.6.2
Information signs *see* Information signs
Inspection, Table 5.1.1.2, Table 6.1.1.2, Table 9.1.1.2, Table 10.1.1.2, Table 11.1.1.2, Table 12.1.1.2, Table 13.1.1.2, 13.3.2, Table A.3.3.8, A.13.3.2.2
Maintenance *see* Maintenance, valves
Obstruction investigations, closure during, D.3
Testing *see* Testing, valves
Conventional pin rack *see* Hose storage devices
Cooking equipment, sprinklers protecting, Table 5.1.1.2
Corrective action, 4.1.5, 4.1.7.2, 4.1.7.3, 4.2, A.4.1.5; *see also* Repairs, reconditioning, replacements, or adjustments
Corrosion *see also* Microbiologically influenced corrosion (MIC)
Corrosive atmospheres or water supplies, 5.3.1.1.2, A.5.3.1.1.2
Foam-water sprinkler systems, Table 11.1.1.2, 11.4.4.4, 11.4.6.1, 11.4.6.2, 11.4.7.4, 11.4.8.4
Obstruction due to corrosion products, 14.3.1(12), D.1, D.2.1, D.2.6, D.2.7, D.5.2
Piping, 7.2.2.1.2(3), 7.2.2.3.2, 14.1, 14.2.1.3, 14.3.4, A.14.2.1.2, A.14.2.1.4, A.14.3.1
Sprinkler systems, 5.2.1.1.1(2), 5.2.2.1, A.5.2.1.1.1, A.5.2.2
Water mist systems, 12.2.1.1.1(2), 12.2.3.2
Water spray systems, 10.2.3.1(2), 10.2.6.4, 10.3.6.1.1
Water tanks, 9.2.5.3, 9.2.5.4, 9.2.6(3), 9.2.6(5)
Corrosion-resistant sprinklers, A.5.4.1.6
Definition, 3.3.42.3
Critical deficiency *see* Deficiency

D

Daily frequency (inspections, testing, and maintenance), A.4.1.1
Definition, 3.7.1.1
Valves, Table 13.1.1.2
Water tanks, Table 9.1.1.2, 9.2.2.2, Table 9.5.1.1
Deficiency
Critical, A.4.1.5, G.1, Fig. G.2(c)
Definition, 3.3.8.1, A.3.3.8
Definition, 3.3.8, A.3.3.8
Noncritical, A.4.1.5, G.1, Fig. G.2(b)
Definition, 3.3.8.2, A.3.3.8
Definitions, Chap. 3
Deluge sprinkler systems, Table 5.1.1.2; *see also* Deluge valves
Definition, 3.6.4.2
Foam-water sprinkler and foam-water spray systems (definitions), 3.4; *see also* Foam-water sprinkler systems
Deluge valves, 10.3.3.4.2, Table 13.1.1.2, 13.4.4, Table 13.11.1, Table A.3.3.8, A.13.1, Fig. A.13.1(d), A.13.4.4.2.3 to A.13.4.4.3.3, Table F.5.2(d)
Definition, 3.5.2, A.3.5.2
Foam-water sprinkler systems, Table 11.1.1.2, 11.2.1
Water spray systems, Table 10.1.1.2, 10.2.1.5, 10.2.2
Detection equipment, automatic *see* Automatic detection equipment
Detector check valves, Table 10.1.1.2, Table 11.1.1.2, A.13.1, Fig. A.13.1(c), Table F.5.2(d)
Differential pressure *see* Pressure (pump), net pressure (differential pressure)
Discharge devices
Definition, 3.3.9
Foam-water, Table 11.1.1.2, 11.2.4, Table 11.5.1, Table A.3.3.8, A.11.2.4, A.11.2.4.4

Discharge patterns
Foam-water sprinkler systems, 11.3.2.6
Water mist systems, 12.3.16.5, A.12.3.16.5
Water spray systems, 10.3.3.3, A.10.3.3.3
Discharge pressure *see* Pressure (pump)
Discharge time
Foam-water sprinkler systems, 11.3.2.5
Water mist systems, 12.3.16.4
Water spray systems, 10.3.3.2
Double check assembly (DCA), A.13.1
Double check detector assembly (DCDA), A.13.1
Double check valve assembly (DCVA), Fig. A.13.1(a)
Definition, 3.3.10
Drainage
Foam-water sprinkler systems, Table 11.1.1.2, 11.2.7; *see also* Strainers
Obstructions, 14.3.1(5)
Water spray nozzles, Table 10.1.1.2
Water spray systems, 10.2.7, 10.3.6.1, Table A.3.3.8
Drains
Auxiliary, 4.1.9.2(2), 4.6.3, Table 6.5.1, Table 10.5.1, Table 11.5.1, 13.4.3.3.3, 13.4.5.1.1, A.13.4.3.3.3, Table F.5.2(d)
Component action requirements, Table 5.5.1, Table 6.5.1, Table 10.5.1, Table 11.5.1
Low point, Table 5.1.1.2, 10.3.6.1, Table F.5.2(d)
Main *see* Main drains
Sectional (definition), 3.3.11.2, A.3.3.11.2
Tests, 14.3.1(4)
Drip valves, 11.4.4.1, Table 11.5.1, A.13.1, Table F.5.2(d)
Driver, pump, 8.1.7
Dry barrel hydrants, Table 7.1.1.2, 7.2.2.4, 7.3.2.3, 7.3.2.6, Table A.3.3.8, Fig. A.3.3.13.1, Table F.5.2(d)
Definition, 3.3.13.1, A.3.3.13.1
Dry hydrants
Definition, 3.3.13.2, A.3.3.13.2, Fig. A.3.3.13.2
Inspection, 7.2.2.6, A.7.2.2.6
Testing, 7.2.2.6.5, A.7.2.2.6.5
Dry pipe sprinkler systems, 4.1.9.1, 4.1.9.2(2); *see also* Dry pipe valves
Accelerator, Fig. A.13.1(f)
Control valve information sign *see* Information signs
Definition, 3.6.4.3
Inspection, Table 5.1.1.2
Maintenance, Table 5.1.1.2, 5.4.2, A.5.4.2
Obstructions, 14.3.1(15), 14.4, D.2.1, D.3.2, D.3.3, D.4.1, D.5.2
Testing, 14.3.1(15), Table A.3.3.8
Dry pipe valves, Table 13.1.1.2, 13.4.5, Table 13.11.1, 14.3.1(3), 14.3.1(10), Table A.3.3.8, A.13.1, Fig. A.13.1(e), A.13.4.5.2.1 to A.13.4.5.3.2, Table F.5.2(d)
Dry sprinklers, Table 5.1.1.2, 5.3.1.1.1.6, 5.4.1.5.3, A.5.3.1.1.1.6, Table F.5.2(d)
Definition, 3.3.42.4
Dry standpipe systems *see* Standpipe and hose systems

E

Early suppression fast-response (ESFR) sprinkler, 5.3.4.4.3, A.5.2.1.2.3, A.5.3.1.1.1.3, A.5.4.1.5.6.1(1)
Definition, 3.3.42.5
Electrically operated sprinklers
Definition, 3.3.42.6
Maintenance, 5.4.1.8
Testing, 5.3.2
Electrical safety, 4.9.6, 8.3.3.14, A.4.9.6
Electric motors, pump *see* Fire pumps
Emergency impairments, 15.6, A.15.6
Definition, 3.3.22.1, A.3.3.22.1
Exposed piping, private fire service mains
Inspection, Table 7.1.1.2, 7.2.2.1, Table A.3.3.8
Testing, Table 7.1.1.2, 7.3.1, Table A.3.3.8, A.7.3.1
Extended coverage sprinklers, A.5.2.1.2.1, Table A.5.3.4.4.1(2)
Definition, 3.3.42.7

F

Fall protection, 4.9.3
Fast-response sprinkler elements, Table 5.1.1.2, 5.3.1.1.1.3, Table A.3.3.8, A.5.3.1.1.1.3; *see also* Early suppression fast-response (ESFR) sprinkler; Quick-response (QR) sprinklers; Residential sprinklers
Fire department connections, Table 5.1.1.2, 6.3.2.1, Table 13.1.1.2, 13.8, 14.3.1(13), A.6.3.2.1, A.13.8.1(9), Table F.5.2(d)
Component action requirements, Table 5.5.1, Table 10.5.1, Table 11.5.1, Table 13.11.1
Definition, 3.3.12
Flushing outlets, used as, D.5.1
Impairments, signs indicating, 10.1.6.2
Inspections *see* Inspections
Maintenance *see* Maintenance
Testing *see* Testing
Fire hose *see* Hose
Fire hydrants, Table 7.5.1
Definition, 3.3.13, A.3.3.13, Fig. A.3.3.13(a), Fig. A.3.3.13(b)
Dry *see* Dry hydrants
Dry barrel *see* Dry barrel hydrants
Maintenance, Table 7.1.1.2, 7.4.2, A.7.4.2.2
Monitor nozzle (definition), 3.3.13.3, A.3.3.13.3, Fig. A.3.3.13.3
Testing *see* Testing
Wall *see* Wall hydrants
Wet barrel *see* Wet barrel hydrants
Fire pumps, Chap. 8, 14.3.1(1), 14.3.1(3), Table F.5.2(d)
Auxiliary equipment, 8.1.4, A.8.1.4
Batteries, Table 8.1.1.2, 8.1.1.2.15, 8.2.2(4), Table A.8.1.1.2
Controllers, 4.9.6, 8.1.8, Table 8.6.1, A.4.9.6, A.8.1.8, C.3, Table F.5.2(e)
Definitions, 3.6.2, A.3.6.2.4 to A.3.6.2.6.2
Diesel engine systems, Table 8.1.1.2, 8.2.2(1), 8.2.2(4), 8.3.1.1, 8.3.2.4, 8.3.2.9(1), 8.3.2.9(3), 8.3.3.10(4), 8.3.4, Table 8.6.1, Table 10.1.1.2, Table A.3.3.8, A.8.1, Table A.8.1.1.2, A.8.3.1.1, A.8.3.1.1.2, A.8.3.2.1.2.1, A.8.3.2.1.2.2, Table A.8.3.2.9, A.8.3.4.1.1, A.8.3.4.2, Table F.5.2(e)
Electrical system, Table 8.1.1.2, 8.1.1.2.2, 8.1.1.2.16, 8.2.2(3), 8.3.1.2, 8.3.2.3, 8.3.2.9(2), Table 8.6.1, Table A.3.3.8, A.8.1.1.2.2.1, A.8.1.1.2.2.2, Table A.8.1.1.2, A.8.3.1.2
Electric motors, 4.9.6, Table 8.1.1.2, 8.1.1.2.3, 8.1.7, 8.2.2(1), 8.3.1.2, 8.3.2.1.3.2, 8.3.2.9(1), 8.3.2.9(2), 8.3.3.10, 8.3.3.14, 8.3.7.2.5 to 8.3.7.2.9, Table 8.6.1, Table 10.1.1.2, Table 12.1.1.2, A.4.9.6, A.8.1, Table A.8.1.1.2, A.8.3.1.1.2, A.8.3.3.10(3), C.1.26, C.1.28 to C.1.32, C.2, Table F.5.2(e)
Emergency or standby power generators, 8.3.6.1, A.8.3.6.1
Energy source, 8.1.6, 8.3.6.1, A.8.3.6.1
Engine speed, 8.3.7.2.2
Foam-water sprinkler systems, Table 11.1.1.2, 11.1.2, 11.2.5.1
Impairments, 5.3.3.5, 8.1.9
Inspections *see* Inspections
Maintenance *see* Maintenance
No flow (churn, shutoff) *see* No flow (churn, shutoff)
Testing *see* Testing
Fire watch, 15.5.2(4)(b), A.15.5.2(4)(b)
Fittings *see* Piping

Five years frequency (inspections, testing, and maintenance)
Backflow prevention assemblies, 13.7.1.3
Definition, 3.7.1.8
Fire pumps, Table 8.1.1.2, 8.1.1.2.23
Foam-water sprinkler systems, Table 11.1.1.2
Pressure-regulating devices, 13.5.2.2, 13.5.3.2, A.13.5.2.2
Sprinklers, 5.3.1.1.1.4, 5.3.1.1.1.5, 5.3.1.1.2, A.5.3.1.1.1.4
Standpipe and hose systems, Table 6.1.1.2
Underground and exposed piping, 7.3.1
Valves, Table 13.1.1.2, 13.4.3.1.2.1, 13.4.3.1.3, 13.4.4.1.2.1, 13.4.4.1.3, 13.5.1.2
Water mist systems, Table 12.1.1.2, 12.3.1.2, 12.3.1.3, 12.3.10.1, 12.4.3
Water spray systems, Table 10.1.1.2
Water tanks, Table 9.1.1.2, 9.2.5.1.2, Table 9.5.1.1
Fixed nozzle systems *see* Water spray systems
Flow tests
Backflow prevention assemblies, 13.7.2.1, Table 13.11.1, Table A.3.3.8, A.13.7.2.1
Fire pumps, 8.3.1.3, 8.3.3, 8.3.5, 8.3.7.1, Table A.3.3.8, A.8.3.3.1 to A.8.3.3.16, A.8.3.7.1
Foam-water sprinkler systems, Table 11.1.1.2, 11.2.4.3, 11.2.6.5, 11.3, Table 11.5.1, A.11.3
Obstruction investigation, 14.3.1(15)
Pressure-regulating devices, 13.5.2.2, 13.5.2.3, 13.5.3.2, 13.5.3.3, 13.5.4.2, 13.5.4.3, Table 13.11.1, A.13.5.2.2, A.13.5.4.2
Pressure relief valves, 13.5.6.2.3
Private fire service mains, Table 7.1.1.2, 7.3.1, 7.3.2, Table 7.5.1, 7.5.3, A.7.2.2.2, A.7.3.1, A.7.5.3
Standpipe and hose systems, Table 6.1.1.2, 6.3.1
Valves, 13.4.3.2.3, 13.4.4.2.1 to 13.4.4.2.5, 13.4.5.2.2.3, 13.5.1.2, 13.5.1.3, A.13.4.4.2.3 to A.13.4.4.2.12, A.13.4.5.2.2.2, A.13.4.5.2.2.3
Water spray systems, Table 10.1.1.2, 10.2.4.3, 10.2.6.1, 10.2.6.2, 10.3.6, Table 10.5.1, A.10.2.4
Flushing procedures, 11.4.4.2, 11.4.6.3, 11.4.7.3, 11.4.8.3, 14.3.1(8), A.11.4.4.2, A.14.2.1, D.4.2, D.5
Flush sprinklers, 5.2.1.1.5
Definition, 3.3.42.1.2
Foam concentrates, Table 11.5.1, Table F.5.2(d)
Definition, 3.3.14, A.3.3.14
Pumps *see* Pumps
Strainers *see* Strainers
Tanks *see* Tanks
Testing, 11.3.5
Foam discharge devices, 11.2.4, A.11.2.4, A.11.2.4.4
Definition, 3.3.15
Foam-water spray systems (definition), 3.4.1; *see also* Foam-water sprinkler systems
Foam-water sprinkler systems, Chap. 11, Table F.5.2(d)
Component action requirements, 11.5
Definition, 3.4.2
Impairments, 11.1.6
Inspections *see* Inspections
Maintenance, 11.1, 11.4, A.11.4
Proportioners *see* Proportioners
Return to service after testing, 11.3.6
Testing *see* Testing
Freezers, systems protecting, 13.4.3.2.5, 13.4.5.2.2.1, 14.4
Freezing conditions or cold weather, 4.1.2, A.4.1.2; *See also* Antifreeze sprinkler systems
Ice obstruction prevention, 14.4
Private fire service mains, 7.3.2.6
Standpipe and hose systems, 6.3.3.2
Valves, 13.4.3.3.3, 13.4.4.3.3, 13.4.5.3.2, A.13.4.4.2.3, A.13.4.5.3.2
Water spray systems, 10.3.6.1.1
Water tanks, 9.2.3, 9.2.4.2(3), 9.3.3, 9.4.3, A.9.2.1.1
Frequency of inspections, testing, and maintenance *see* Inspection, testing, and maintenance (ITM) task frequencies
Frostproof hydrants *see* Dry barrel hydrants
Fuel tanks, Table 8.1.1.2, 8.1.1.2.7, 8.1.1.2.9, 8.1.1.2.10, 8.2.2(4), Table F.5.2(e)

G

Gauges, Table 13.1.1.2, Table F.5.2(d)
Component action requirements, Table 5.5.1, Table 6.5.1, Table 7.5.1, Table 10.5.1, Table 11.5.1, Table 13.11.1
Fire pumps, Table 8.1.1.2, 8.1.1.2.22, 8.1.4(1), 8.1.5.2, 8.2.2(2), 8.2.2(5), 8.3.2.1.2.1, 8.3.2.8, 8.3.2.9, 8.3.3.5.1, 8.3.3.5.2, Table A.8.1.1.2, A.8.3.2.1.2.1, A.8.3.2.9
Sprinkler systems, Table 5.1.1.2, Table A.3.3.8
Standpipe and hose systems, Table 6.1.1.2, 6.3.1.6.2
Valves, Table 13.1.1.2, 13.2.5, 13.4.1.1(1), Table A.3.3.8, A.13.2.5.1, A.13.2.5.1.1
Water tanks, Table 9.1.1.2, Table 9.6.1, A.9.3.1

H

Hangers, Table F.5.2(d)
Component action requirements, Table 10.5.1
Foam-water sprinkler systems, Table 11.1.1.2, 11.2.3, Table 11.5.1, Table A.3.3.8
Sprinkler systems, Table 5.1.1.2, 5.2.3, Table A.3.3.8, A.5.2.3
Standpipe and hose systems, Table 6.5.1
Water mist system, 12.2.4, A.12.2.4.4
Water spray systems, Table 10.1.1.2, 10.2.3.2, Table A.3.3.8, A.10.2.3.2
Hazard evaluations, 4.1.7.1, 4.1.7.2, Annex E
Hazardous materials, 4.9.5, A.4.9.5
Hazards, 4.1.7, 4.9.4, A.4.1.7
Heat tape, 4.1.9.2(4), Table A.3.3.8
Heat tracing, Table 5.1.1.2, 5.2.6
Horizontal rack *see* Hose storage devices
Hose *see also* Standpipe and hose systems
Fire, Table 6.5.1, 7.1.4, Table F.5.2(d)
Fire pumps, Table 8.1.1.2, 8.1.1.2.11
Water mist systems, 12.3.10
Hose connections, 5.1.5, 8.2.2(2)
Definition, 3.3.16
Pressure-reducing valves, Table 13.1.1.2, Table A.3.3.8
Pressure-regulating devices, 13.5.2, A.13.5.2.2
Standpipe and hose systems, Table 6.1.1.2, 6.2.3, A.6.3.1.1
Hose houses, Table 7.1.1.2, 7.2.2.8, Table 7.5.1, Table A.3.3.8, Fig. A.3.3.17(a) to Fig. A.3.3.17(c), Table F.5.2(d)
Definition, 3.3.17, A.3.3.17
Hose nozzles, Table 6.1.1.2, 6.2.6, Table A.3.3.8, Table F.5.2(d)
Definition, 3.3.18
Hose rack assembly pressure-reducing valves *see* Pressure-reducing valves
Hose reel *see* Hose storage devices

Hose stations, 3.3.44.2, 3.3.44.3, 6.3.1.5, 13.6.2.2, 13.7.2.2
Definition, 3.3.19
Hose storage devices, Table 6.1.1.2, 6.2.7, Table 6.5.1, Table A.3.3.8, Table F.5.2(d)
Conventional pin rack (definition), 3.3.20.1, Fig. A.3.3.20.1
Horizontal rack (definition), 3.3.20.2, Fig. A.3.3.20.2
Hose reel (definition), 3.3.20.3, A.3.3.20.3, Fig. A.3.3.20.3
Semiautomatic hose rack assembly (definition), 3.3.20.4, A.3.3.20.4, Fig. A.3.3.20.4
Hose valves, Table 6.1.1.2, Table 13.1.1.2, 13.3.1.5, 13.6, Table 13.11.1, Table A.3.3.8, A.6.3.1.2, A.13.6.2.1, A.13.6.2.2, Table F.5.2(d)
Definition, 3.5.3
Hydrants, fire *see* Fire hydrants
Hydraulic design information signs *see* Information signs
Hydraulic placards, Table 6.5.1, Table 11.5.1, Table F.5.2(d)
Hydrostatic tests, Table 6.1.1.2, 6.3.2, Table 11.1.1.2, 11.4.4.4, 11.4.5.2, Table A.3.3.8, A.6.3.2.1, A.11.4.5.2
Definition, 3.3.21

I

Ice obstruction prevention, 14.4; *see also* Freezers, systems protecting; Freezing conditions or cold weather
Identification signs *see* Information signs
Impairment coordinator, 15.2, 15.5
Impairments, 4.1.11, 5.1.4, Chap. 15, B.4; *see also* System shutdown
Coordinator, 15.2
Definition, 3.3.22, A.3.3.22
Emergency, 15.6, A.15.6
Definition, 3.3.22.1, A.3.3.22.1
Equipment involved, 15.4
Fire pumps, 5.3.3.5, 8.1.9
Foam-water sprinkler systems, 11.1.6
Preplanned programs, 15.5, A.15.5
Definition, 3.3.22.2
Private fire service mains, 7.1.5
Restoring systems to service, 15.7, A.15.7
Sprinkler systems, 5.1.4, 5.3.3.5
Tag system *see* Tag system
Water spray systems, 10.1.6, A.10.1.6
Water tanks, 9.1.4
Indicating valves, A.13.1
Indicator posts, A.13.1, Fig. A.13.1(g)
Information signs, 4.1.9, Table 5.1.1.2, 5.2.7 to 5.2.9, Table 5.5.1, Table 6.5.1, Table 7.5.1, 10.1.6.2, Table 10.5.1, Table 11.5.1, 13.3.1, 13.4.5.1.1, 13.4.5.2.5, Table 13.11.1, Table A.3.3.8, A.4.1.9, A.5.2.8, A.13.3.1, Table F.5.2(d)
Antifreeze, 4.1.10, 5.2.9
Hydraulic design, Table 5.1.1.2, 5.2.5, Table 5.5.1, Table 6.1.1.2, 6.2.2, Table A.3.3.8, A.5.2.5, A.6.2.2, Table F.5.2(d); *see also* Hydraulic placards
Tag system *see* Tag system
In-line balanced pressure proportioners, Table 11.1.1.2, 11.2.8.5.5, 11.4.8, Table A.3.3.8, A.11.2.8.5.5(1), A.11.2.8.5.5(2)
Definition, 3.3.35.2, A.3.3.35.2, Fig. A.3.3.35.2
In-rack sprinklers, 5.2.1.2.5
Inspection, testing, and maintenance data collection, Annex F
Inspection, testing, and maintenance service (definition), 3.3.25, A.3.3.25
Inspection, testing, and maintenance (ITM) task frequencies, 4.5, 4.6.1.1, 4.6.1.2, 4.6.2, 5.1.1.2, A.4.5, B.4
Definitions, 3.7, A.3.7.1
Fire pumps, 8.1.1.2, 8.3.1.1.1, 8.3.1.2.1 to 8.3.1.2.3, 8.3.1.3, 8.3.3, A.8.1.1.2, A.8.3.1.2.3, A.8.3.3.1 to A.8.3.3.16
Small residential board and care occupancies, 16.2.1.1
Water mist systems, A.12.2.1.1.1(5) to A.12.2.5.2
Inspections, 4.5, A.4.5; *see also* Impairments
Automated, 4.6.6, A.4.6.6
Backflow prevention assemblies, 13.7.1, A.13.7.1.3
Data collection, Annex F
Definition, 3.3.24
Fire department connections, 13.8, Table A.3.3.8, A.13.8.1(9)
Fire pumps, 8.1, Table 8.1.1.2, 8.2, Table 10.1.1.2, 10.2.5.1, Table 12.1.1.2, Table 13.1.1.2, Table A.3.3.8, A.8.1, A.8.2.2
Foam-water sprinkler systems, 11.1, Table 11.1.1.2, 11.2, Table A.3.3.8, A.11.2.4 to A.11.2.8.5.6(2), A.14.2.1(1)
Forms for, Annex B
Obstructions, 14.2, A.14.2.1, A.14.2.2
Owner/occupant responsibilities, 4.1.1 to 4.1.4, 4.9.5.2, A.4.1.1 to A.4.1.3
Performance-based programs, 4.7, A.4.7 to A.4.7.1
Pressure-regulating devices, 13.5.2.1, 13.5.3.1, 13.5.4.1, A.13.5.4.1(1)
Private fire service mains, 7.1, 7.2, 10.2.5.1, 11.2.5.1, Table A.3.3.8, A.7.2.2, A.14.2.1(3)
Records *see* Records
Return to service, 4.1.11.2
Safety, 4.9, A.4.9.5, A.4.9.6
Sprinklers, Table 5.1.1.2, 5.2.1, A.5.2.1.1 to A.5.2.1.3
Sprinkler systems, 5.1, 5.2, 16.2.1.1, Table A.3.3.8, A.5.2 to A.5.2.8
Standpipe and hose systems, 6.1, Table 6.1.1.2, 6.2, Table A.3.3.8, A.6.2.2, A.14.2.1
Steam system conditions, 8.2.2(5), A.8.2.2(5)
Valves, Table 5.1.1.2, 5.1.2, 8.1.2, 9.1.2, 10.1.5, Table 12.1.1.2, 13.1.1.1, Table A.3.3.8
Alarm, 13.4.1, A.13.4.1.1, A.13.4.1.2
Automatic tank fill valves, 9.5.1
Check, 13.4.2.1
Deluge, 13.4.4.1
Dry pipe/quick opening devices, 13.4.5.1
Hose, 13.6.1
Preaction, 13.4.3.1
Pressure-reducing, 13.5.1, 13.5.5.1
Water mist systems, 12.1, 12.2, A.14.2.1(1)
Water spray systems *see* Water spray systems
Water supply status, 4.4
Water tanks, 9.1, 9.2, 9.5.1, Table 10.1.1.2, 10.2.5.1, Table A.3.3.8, A.9.1, A.9.2.1.1 to A.9.2.5.5
Inspector's test connections, 14.3.1(4), 14.3.1(15), Table F.5.2(d)

L

Large drop sprinklers, A.5.2.1.2.3
Line proportioners, Table 11.1.1.2, 11.2.8.5.3, 11.4.6, Table A.3.3.8, A.11.2.8.5.3(1), A.11.2.8.5.3(2)
Definition, 3.3.35.3, A.3.3.35.3, Fig. A.3.3.35.3
Listed (definition), 3.2.3, A.3.2.3
Lowest permissible suction pressure, 8.1.5.1, 8.3.3.4
Definition, 3.3.26, A.3.3.26

M

Main drains, Table 13.11.1, A.7.2.2.3, Table F.5.2(d)
Component action requirements, Table 5.5.1, Table 6.5.1, Table 10.5.1
Definition, 3.3.11.1
Test, Table 5.1.1.2, Table 6.1.1.2, 6.3.1.6, 7.5.3, Table 10.1.1.2, Table 10.5.1, Table 11.5.1, Table 13.1.1.2, 13.2.3, Table A.3.3.8, A.7.5.3, A.13.2.3
Mainline strainers, Table F.5.2(d)
Foam-water sprinkler systems, Table 11.1.1.2, 11.2.6.1
Private fire service mains, Table 7.1.1.2, 7.2.2.3, Table 7.5.1, Table A.3.3.8, A.7.2.2.3
Water mist systems, 12.2.2, 12.3.3
Water spray systems, 10.2.1.7, 10.2.6.1
Mains *see also* Private fire service mains
Broken, 14.3.1(9), A.14.3.1
Flushing, 14.3.1(8)
Yard, D.3, D.3.1, D.5.1, D.5.4
Maintenance, 4.8; *see also* Impairments; Repairs, reconditioning, replacements, or adjustments
Backflow prevention assemblies, 13.7.3
Data collection, Annex F
Definition, 3.3.27, A.3.3.27
Fire hydrants, Table 7.1.1.2, 7.4.2, A.7.4.2.2
Fire pumps, 8.1, Table 8.1.1.2, 8.3.4, 8.5, Table 10.1.1.2, 10.2.5.1, Table 12.1.1.2, Table 13.1.1.2, A.8.1, A.8.3.4.1.1, A.8.3.4.2, A.8.5.1
Foam-water sprinkler systems, 11.1, 11.2.5.1, 11.4, A.11.4
Forms for, Annex B
Heat tracing, 5.2.6
Owner/occupant responsibilities, 4.1.1 to 4.1.4, 4.9.5.2, A.4.1.1 to A.4.1.5.1.2
Performance-based programs, 4.7, A.4.7
Private fire service mains, 7.1, 7.4, 10.2.5.1, 11.2.5.1, A.7.4.2.2
Records *see* Records
Safety, 4.9, A.4.9.5, A.4.9.6
Sprinklers, 5.4.1, A.5.4.1.2 to A.5.4.1.9.1
Sprinkler systems, 5.1, 5.4, 16.2.1.1, A.5.4.1.2 to A.5.4.3
Standpipe and hose systems, 6.1, Table 6.1.1.2, 6.4
Valves, Table 5.1.1.2, 5.1.2, Table 6.1.1.2, 8.1.2, 9.1.2, 10.1.5, Table 12.1.1.2, 13.1.1.1
Alarm, 13.4.1.3
Automatic tank fill valves, 9.5.2
Check, 13.4.2.2
Control, Table 9.1.1.2, Table 12.1.1.2, 13.3.4
Deluge, 13.4.4.3
Dry pipe/quick-opening devices, 13.4.5.3, A.13.4.5.3.2
Hose, 13.6.3
Preaction, 13.4.3.3, A.13.4.3.3.3
Water mist systems, 12.1, Table 12.1.1.2, 12.4
Water spray systems *see* Water spray systems, inspection and maintenance procedures
Water supply status, 4.4
Water tanks, 9.1, Table 9.1.1.2, 9.4, 9.5.2, 10.2.5.1, Table 12.1.1.2, A.9.1
Manual operation, Table F.5.2(d)
Definition, 3.3.28
Deluge valves, 13.4.4.2.9
Foam-water sprinkler systems, Table 11.1.1.2, 11.3.4, Table 11.5.1
Preaction valves, 13.4.3.2.7
Standpipe and hose systems, 6.3.2.1, A.6.3.2.1
Definition, 3.3.43.3
Water spray systems, Table 10.1.1.2, 10.3.3, 10.3.5, Table 10.5.1, A.10.3.3.1 to A.10.3.3.3.1
Manufacturers
Heat tracing, inspection and maintenance requirements for, Table 5.1.1.2, 5.2.6
Modifications by, 4.2, 5.3.1.3.1
Manufacturer's data sheets, 4.3.4
Manufacturer's instructions, 4.1.1.1
Marine sprinkler systems, 5.4.3, A.5.4.3
Definition, 3.6.4.4
Master pressure-reducing valves (definition), 3.5.5.1, A.3.5.5.1
Master pressure-regulating devices, 13.5.4, A.13.5.4.1(1), A.13.5.4.2
Materials, changes in, 4.1.6, A.4.1.6
Measurement, units of, 1.4, A.1.4
Microbiologically influenced corrosion (MIC), 14.2.1.3, 14.3.4, A.14.2.1.2, D.1, D.2.7
Monitoring data, collection of, Annex F
Monitor nozzle hydrant (definition), 3.3.13.3, A.3.3.13.3, Fig. A.3.3.13.3
Monitor nozzles
Component action requirements, Table 7.5.1
Definition, 3.3.29.1, A.3.3.29.1, Fig. A.3.3.29.1(a), Fig. A.3.3.29.1(b)
Inspection, Table 7.1.1.2, 7.2.2.7, Table A.3.3.8
Maintenance, Table 7.1.1.2, 7.4.3
Testing, Table 7.1.1.2, 7.3.3, Table A.3.3.8, Table F.5.2(d)
Monthly frequency (inspections, testing, and maintenance), Table 13.1.1.2
Definition, 3.7.1.3
Fire pumps, 8.3.1.2.2, 8.3.1.2.3, Table A.8.1.1.2
Foam-water sprinkler systems, Table 11.1.1.2
Valves, Table 13.1.1.2, 13.2.5.1.1, 13.2.5.1.3, 13.2.5.1.4, 13.3.2.1.1, 13.4.3.1.1, 13.4.4.1.1, 13.4.5.1.2
Water mist systems, Table 12.1.1.2, 12.2.8.2.1, 12.2.9
Water spray systems, Table 10.1.1.2, 10.4.2
Water tanks, Table 9.1.1.2, 9.2.1.2, Table 9.5.1.1, 9.5.1.2
Multiple systems, testing, 10.3.4, 11.3.3, 12.3.16.7, 13.4.4.2.8

N

Net pressure *see* Pressure (pump)
No flow (churn, shutoff), 8.3.1.1, 8.3.1.2, 8.3.2, 8.3.3.1, 8.3.3.2, 8.3.3.10(1), A.8.3.1.1, A.8.3.1.2, A.8.3.2.1.2.1 to A.8.3.2.9
Definition, 3.6.2.4, A.3.6.2.4
Noncritical deficiency *see* Deficiency
Nonrising stem (NRS) gate valves, A.13.1, Fig. A.13.1(h)
Notification, out of service, 15.5.2(5) to 15.5.2(7)
Sprinkler system, 4.1.4
Water spray systems, 10.1.6.1
Nozzles
Definition, 3.3.42.8
Hose *see* Hose nozzles
Monitor *see* Monitor nozzles
Water mist, 12.2.1, 12.3.1, 12.3.2, 12.4.2, A.12.2.1.1(5), A.12.3.1.1 to A.12.3.2.5, A.12.4.2.1 to A.12.4.2.4
Water spray *see* Water spray nozzles

O

Obstructions
Ice, 14.4
Inspection, 14.2, A.5.2.1.3, A.14.2.1, A.14.2.2
Investigations, Table 5.1.1.2, 5.1.3, 7.1.3, 14.3, A.14.3.1 to A.14.3.3, Annex D
Fire pumps, 8.1.3
Foam-water sprinkler systems, 11.1.5
Procedure, D.3
Sources of obstruction, D.2
Water mist systems, 12.3.16.5.3
Water-spray fixed systems, 10.1.4
Water tanks, 9.1.3
Prevention, 10.2.5.2, 11.2.5.2, 14.3, A.10.2.5.2, A.11.2.5.2, A.14.3.1 to A.14.3.3, D.4

Occupancy, changes in, 4.1.6, A.4.1.6
Old-style/conventional sprinklers, 5.4.1.2.1, A.5.4.1.2.1
Definition, 3.3.42.9
Open sprinkler (definition), 3.3.42.10
Operation
Automatic, 8.3.6.3
Definition, 3.3.5, A.3.3.4
Manual *see* Manual operation
Orifice plate proportioning, 11.2.8.5.6, Table A.3.3.8, A.11.2.8.5.6(1), A.11.2.8.5.6(2)
Definition, 3.3.30
Ornamental/decorative sprinklers, 5.4.1.6, A.5.4.1.6
Definition, 3.3.42.11
Outside screw and yoke (OS&Y) gate valves, A.13.1, Fig. A.13.1(i)
Owner/occupant responsibilities, 4.1, 4.9.5.2, 8.3.7.2.4(1), 12.3.6.2, 12.3.18.4, 13.2.1, 15.2, 15.5.2(3), A.4.1.1 to A.4.1.9

P

Painted sprinklers, 5.2.1.1.1(6), 5.4.1.6, A.5.4.1.6
Peak load (pump) *see* Pumps
Pendent sprinklers, 5.2.1.1.6, A.5.2.1.2.1, Table A.5.3.4.4.1(2), A.5.4.1.2.1, A.5.4.1.5.6.1(1), D.2.5, D.5.2
Definition, 3.3.42.1.3
Performance-based programs, 4.7, A.4.7
Definition, 3.3.31
Piers, sprinklers for, 5.4.1.2.3
Piping, Table F.5.2(d)
Flushing, 14.3.1(8), A.14.2.1, D.4.2, D.5
Foam-water sprinkler systems, Table 11.1.1.2, 11.2.2, 11.2.5.1, 11.2.5.2, Table 11.5.1, Table A.3.3.8, A.11.2.5.2
Obstructions *see* Obstructions
Private fire service mains, Table 7.5.1, Table A.3.3.8
Exposed *see* Exposed piping, private fire service mains
Underground, Table 7.1.1.2, 7.2.2.2, 7.3.1, A.7.2.2.2, A.7.3.1
Sprinkler systems, Table 5.1.1.2, 5.2.2, Table 5.5.1, Table A.3.3.8, A.5.2.2, A.14.2.1, D.3 to D.5, Table F.5.2(d)
Standpipe and hose systems, Table 6.1.1.2, 6.2.4, Table 6.5.1, Table A.3.3.8
Water mist systems, 12.2.3
Water spray systems, Table 10.1.1.2, 10.2.3, 10.2.5.2, 10.3.6.1.1, Table 10.5.1, Table A.3.3.8, A.10.2.3, A.10.2.5.2
Positive displacement pumps, 8.3.2.1.3, 8.3.5, Table 8.6.1
Preaction sprinkler systems, 4.1.9.1, 4.1.9.2(2), Table 5.1.1.2
Control valve information sign *see* Information signs
Definition, 3.6.4.5
Obstructions, 14.4, D.4.1
Preaction valves, Table 11.1.1.2, Table 13.1.1.2, 13.4.3, Table 13.11.1, Table A.3.3.8, A.13.4.3.2.1 to A.13.4.3.3.3, Table F.5.2(d)
Premixed antifreeze solution, 5.3.4.2.2
Definition, 3.6.4.1.1
Preplanned impairments, 15.5, A.15.5
Definition, 3.3.22.2
Pressure (pump)
Discharge pressure, 8.1.4(3), 8.3.2.1.2, 8.3.2.8(1), 8.3.2.9(1), 8.3.3.9.1.1, 8.3.3.9.2, 8.3.3.9.3.1, 8.3.3.10(2), 8.3.3.11, 8.3.3.12(3), 8.3.5.4, 8.3.5.5, 8.4.1.1(1), A.8.3.1.1, A.8.3.3.11, A.8.3.7.2.3(2), A.11.3.2.7, C.1.1, Table F.5.2(e)
Definition, 3.6.2.6.1
Net pressure (differential pressure), 8.3.7.1.3, Table F.5.2(e)
Definition, 3.6.2.6.2, A.3.6.2.6.2
Rated pressure, 8.3.3.11.2.1, Table F.5.2(e)
Definition, 3.6.2.6.3
Suction pressure, 8.3.3.9.1.1, 8.3.3.9.2, 8.3.3.12(3), Table A.8.2.2, A.8.3.7.2.3(2), Table F.5.2(e)
Definition, 3.6.2.6.4
Pressure control valves
Definition, 3.5.4
Standpipe and hose systems, Table 6.1.1.2
Pressure maintenance (jockey) pumps, 8.1.4(6), 8.2.2(3), Table F.5.2(e)
Pressure readings
Deluge and preaction systems, 13.4.4.2.7
Foam-water sprinkler systems, 11.3.2.7, A.11.3.2.7
Water spray systems, 10.3.3.4
Pressure-reducing valves, Table 6.1.1.2, Table 13.1.1.2, 13.2.3.2, 13.5, A.13.5.2.2 to A.13.5.4.2, Table F.5.2(d); *see also* Pressure-regulating devices; Relief valves
Definition, 3.5.5, A.3.5.5.1
Fire pumps, Table 13.1.1.2
Hose connection, Table 13.1.1.2, Table A.3.3.8
Hose rack assembly, Table 13.1.1.2, Table A.3.3.8
Master pressure reducing valves (definition), 3.5.5.1, A.3.5.5.1
Sprinkler, Table 13.1.1.2, 13.5.1, Table A.3.3.8
Standpipe and hose systems, 6.3.1.5
Pressure-regulating devices, Table 6.1.1.2, 6.3.1.5, Table 6.5.1; *see also* Pressure control valves; Pressure-reducing valves; Relief valves
Component action requirements, Table 13.11.1
Definition, 3.3.32, A.3.3.32
Hose connection, 13.5.2, A.13.5.2.2
Hose rack assembly, 13.5.3
Master, 13.5.4, A.13.5.4.1(1), A.13.5.4.2
Pressure relief valves *see* Relief valves
Pressure-restricting devices (definition), 3.3.33
Pressure vacuum vents, Table 11.1.1.2, 11.2.8.5.3(2), 11.2.8.5.4(2), 11.2.8.5.5(2), 11.2.8.5.6(2), 11.4.9, A.11.2.8.5.3(2), A.11.2.8.5.4(2), A.11.2.8.5.5(2), A.11.2.8.5.6(2)
Definition, 3.3.34, A.3.3.34, Fig. A.3.3.34
Private fire service mains, Chap. 7
Component action requirements, 7.5, A.7.5.3
Definition, 3.6.3, A.3.6.3, Fig. A.3.6.3
Impairments, 7.1.5
Inspections *see* Inspections
Maintenance *see* Maintenance
Obstructions, A.14.2.1(3)
Testing *see* Testing
Problems, possible causes of, Annex C
Process, changes in, 4.1.6, A.4.1.6
Proportioners, Table 11.1.1.2, 11.2.8, Table 11.5.1, Table A.3.3.8, A.11.2.8
Definitions, 3.3.35.1 to 3.3.35.5, A.3.3.35, Fig. A.3.3.35
Pumps *see also* Fire pumps; Positive displacement pumps
Foam concentrate, Table 11.1.1.2, 11.4.7.1, 11.4.7.2, 11.4.8.1, Table 11.5.1
No flow (churn, shutoff) *see* No flow (churn, shutoff)
Peak load, 8.3.3.12, Table 8.6.1, Table A.3.3.8
Definition, 3.6.2.5, A.3.6.2.5
Pressure *see* Pressure (pump)
Unadjusted field test curve, 8.3.7.2.3(3), A.8.3.7.2.3(2)
Definition, 3.6.2.11
Water mist systems, Table 12.1.1.2
Purpose of standard, 1.2, A.1.2

Q

Qualified (definition), 3.3.36
Quarterly frequency (inspections, testing, and maintenance), A.4.1.1
Alarm devices, 5.2.4, 5.3.3.1, 13.2.4.3.1, 13.2.4.3.2, 13.2.4.4.1, 13.2.6.1, 13.4.3.2.11, 13.4.4.2.13, 13.4.5.2.1
Definition, 3.7.1.4
Fire department connections, 13.8.1
Fire pumps, Table 8.1.1.2, 8.1.1.2.7, 8.1.1.2.12, Table A.8.1.1.2
Foam-water sprinkler systems, Table 11.1.1.2
Gauges, 13.2.5.1.2, 13.2.5.1.3.2
Pressure-regulating devices, 13.5.4.2
Private fire service mains, Table 7.1.1.2, 7.2.2.6, 7.2.2.8
Sprinkler systems, Table 5.1.1.2, 5.2.4, 5.3.3.1
Valves, Table 13.1.1.2, 13.2.3.2, 13.4.1.1, 13.4.3.2.1, 13.4.5.2.1, 13.4.5.2.4, 13.5.1.1, 13.5.4.2, 13.6.1.1, A.13.4.5.2.4, A.13.5.4.2
Water mist systems, Table 12.1.1.2, 12.2.5.1.1, 12.2.5.5.1, 12.2.7.1, 12.2.8.2.2, 12.2.10.1, 12.3.9.2
Water spray systems, Table 10.1.1.2, 10.2.7
Water tanks, Table 9.1.1.2, 9.2.1, 9.2.2.1, 9.2.3.2, 9.2.4.1, 9.2.4.2, Table 9.5.1.1, 9.5.2.3
Quick-opening devices, Table 13.1.1.2, 13.4.5, Table 13.11.1, Table A.3.3.8, A.13.4.5.2.1 to A.13.4.5.3.2
Quick-response early suppression (QRES) sprinklers (definition), 3.3.42.12
Quick-response extended coverage sprinklers (definition), 3.3.42.13
Quick-response (QR) sprinklers, 5.4.1.4, Table A.3.3.8, A.5.3.1.1.1.3, A.5.4.1.4
Definition, 3.3.42.14

R

Rated flow (pump), 8.3.3.1, 8.3.3.4, A.8.3.3.1
Definition, 3.6.2.7
Rated pressure *see* Pressure (pump)
Rebuild *see also* Repairs, reconditioning, replacements, or adjustments
Definition, 3.3.37
Recessed sprinklers, 5.2.1.1.5
Definition, 3.3.42.1.4
Records, 4.3, 4.6.6.13, 13.4.3.2.10, A.4.3.1 to A.4.3.3, A.13.4.3.2.10
Owner/occupant responsibilities, 4.3.3, 12.3.6.3, 12.3.18.3, 12.3.18.4, A.4.3.3
Valves, 13.2.7
Reduced-pressure detector assembly (RPDA), Table 13.1.1.2, 13.7.1.1, A.13.1
Reduced-pressure principle backflow prevention assemblies (RPBA), 13.7.1.1, A.13.1, A.13.1(a)
Definition, 3.3.38
Reduced-pressure zone principle assembly (RPA), A.13.1
References, Chap. 2, Annex H
Refrigerated spaces, 5.4.2.2; *see also* Freezers; Freezing
Relief valves, Table 8.1.1.2, 8.3.2.1.1 to 8.3.2.1.3, 8.3.3.10(1), 8.3.3.11, Table 13.1.1.2, 13.5.6.2, Table 13.11.1, A.8.3.2.1.2.1, A.8.3.3.11, A.8.3.3.11.1, Table F.5.2(d)
Circulation relief, 8.1.4(1), 8.3.2.1.1.1, 8.3.2.1.1.2, 8.3.3.10(1), Table 13.1.1.2, 13.5.6.1, A.8.3.1.1
Definition, 3.5.6.1
Definition, 3.5.6
Remove (definition), 3.3.39
Repairs, reconditioning, replacements, or adjustments, 4.1.5, 4.1.7.2, 4.1.7.3, A.4.1.5; *See also* Maintenance
Data collection, Table F.5.2(a), Table F.5.2(b)
Definitions, 3.3.40, 3.3.41
Fire department connections, 13.8.3
Fire pumps, 8.6.1
Foam-water sprinkler systems, 11.5.1
Private fire service mains, 7.5.1
Sprinklers, 5.2.1.1.1, 5.3.1.1.1, 5.4.1.1 to 5.4.1.7, 5.4.1.7, A.5.2.1.1.1, A.5.3.1.1.1.3, A.5.3.1.1.1.4, A.5.4.1.2 to A.5.4.1.5.6.1
Sprinkler systems, 5.5.1
Standpipe and hose systems, 6.5.1
Tests, 4.6.5, A.4.6.5
Valves, 13.11.1
Water spray systems, 10.5.1
Water storage tanks, 9.6.1
Reports, 8.4, A.8.4.1
Residential sprinklers, 5.4.1.2.2, Table A.3.3.8, A.5.2.1.2.1, A.5.3.1.1.1.3, Table A.5.3.4.4.1(2), A.5.4.1.2.2, A.5.4.1.5.6.1(1)
Definition, 3.3.42.15
Response time
Foam-water sprinkler systems, 11.3.2.4
Water mist systems, 12.3.16.3
Water spray systems, 10.3.3.1, 10.4.5, A.10.3.3.1
Rubber tires, storage of, 5.2.1.2.4

S

Safety, 4.9, 8.3.3.14, A.4.9.5, A.4.9.6
Scope of standard, 1.1, A.1.1.1.2 to A.1.1.4
Sectional drains (definition), 3.3.11.2, A.3.3.11.2
Seismic bracing *see* Braces
Semiannual frequency (inspections, testing, and maintenance), A.4.1.1
Alarm devices, 5.3.3.2, 13.2.4.4.2
Definition, 3.7.1.5
Fire pumps, Table A.8.1.1.2
Private fire service mains, Table 7.1.1.2
Standpipe and hose systems, 7.2.2.7
Valves, Table 13.1.1.2, 13.3.3.5.1
Water mist systems, Table 12.1.1.2, 12.2.5.5.2, 12.2.6, 12.2.7.2, 12.2.10.2, 12.2.11, 12.3.12.2
Semiautomatic dry standpipe systems, 6.3.2.1, Table A.3.3.8, A.6.3.2.1
Definition, 3.3.43.4
Semiautomatic hose rack assembly *see* Hose storage devices
Shall (definition), 3.2.4
Should (definition), 3.2.5
Shutdown, system *see* Impairments; System shutdown
Shutoff *see* No flow (churn, shutoff)
Shutoff valves, 4.1.8
Sidewall sprinklers, A.5.2.1.2.1, Table A.5.3.4.4.1(2)
Definition, 3.3.42.1.5
Signs, information *see* Information signs
Small residential board and care occupancies, 16.2
Solder-type sprinklers, 5.3.1.1.1.4, A.5.3.1.1.1.4
Special requirements from other NFPA documents, Chap. 16, A.16.1.1, A.16.1.2
Special sprinklers, 5.2.1.2.3, 5.4.1.4, A.5.2.1.2.3, A.5.4.1.4
Definition, 3.3.42.16
Spray coating areas
Sprinklers protecting, 5.4.1.9
Water mist nozzles protecting, 12.4.2.5
Spray sprinklers, 5.4.1.2.1; *see also* Standard spray sprinklers
Definition, 3.3.42.17

Sprinklers *see also* Dry sprinklers; Pendent sprinklers; Quick-response (QR) sprinklers
Component action requirements, Table 5.5.1
Concealed spaces, in, 5.2.1.1.3, A.5.2.1.1.3
Control mode specific application (CMSA), A.5.2.1.2.3
Definition, 3.3.42.2, A.3.3.42.2
Corrosion-resistant, A.5.4.1.6
Definition, 3.3.42.3
Definitions, 3.3.42.1 to 3.3.42.18, A.3.3.42.2
Hazard evaluation form, Annex E
Inspections *see* Inspections
Installation orientation (definition), 3.3.42.1
Maintenance, 5.4.1, A.5.4.1.2 to A.5.4.1.9.1
Nozzles *see* Nozzles
Old-style/conventional, 5.4.1.2.1, A.5.4.1.2.1
Definition, 3.3.42.9
Plugged, 14.3.1(6)
Spare, Table 5.1.1.2, 5.2.1.4, 5.4.1.5, Table 5.4.1.5.2, Table A.3.3.8, A.5.4.1.5, Table F.5.2(d)
Spray, 5.4.1.2.1
Definition, 3.3.42.17
Standard spray, Table A.5.3.4.4.1(2)
Definition, 3.3.42.18
Testing *see* Testing
Sprinkler systems, Chap. 5; *see also* Foam-water sprinkler systems; Marine sprinkler systems
Combined standpipe and sprinkler (definition), 3.6.1
Component action requirements, 5.5
Definitions, 3.6.4, A.3.6.4
Flushing *see* Flushing procedures
Impairments, 5.1.4
Inspection *see* Inspections
Installation, 5.5.2
Maintenance, 5.1, 5.4, A.5.4.1.2 to A.5.4.3
Marine systems, 5.4.3, A.5.4.3
Obstructions, 14.3, A.14.3.1 to A.14.3.3
Piping *see* Piping
Testing *see* Testing
Standard (definition), 3.2.6
Standard balanced pressure proportioners, Table 11.1.1.2, 11.2.8.5.4, 11.4.7, Table A.3.3.8, A.11.2.8.5.4(1), A.11.2.8.5.4(2)
Definition, 3.3.35.4, A.3.3.35.4, Fig. A.3.3.35.4
Standard pressure proportioners, 11.2.8.5.1, 11.4.4, Table A.3.3.8, A.11.2.8.5.1.1, A.11.4.4.2
Definition, 3.3.35.5, A.3.3.35.5, Fig. A.3.3.35.5
Standard spray sprinklers, Table A.5.3.4.4.1(2)
Definition, 3.3.42.18
Standpipe and hose systems, Chap. 6
Automatic standpipe systems, 6.3.1.1, A.6.2.2
Definition, 3.3.43.1
Cabinets, Table 6.1.1.2, 6.2.8, Table 6.5.1
Class III system, 6.3.1.2, 13.6.2.1, Table A.3.3.8
Definition, 3.3.44.3
Class II system, 6.3.1.3, 13.6.2.2, Table A.3.3.8
Definition, 3.3.44.2
Class I system, 6.3.1.2, 13.6.2.1, Table A.3.3.8
Definition, 3.3.44.1
Combined sprinkler and standpipe system (definition), 3.6.1
Component action requirements, 6.5
Definition, 3.3.43, A.3.3.43
Dry standpipe system
Definition, 3.3.43.2
Semiautomatic, 6.3.2.1, Table A.3.3.8, A.6.3.2.1
Definition, 3.3.43.4
Inspections *see* Inspections
Maintenance, 6.1, Table 6.1.1.2, 6.4
Manual standpipe system, 6.3.2.1, A.6.3.2.1
Definition, 3.3.43.3
Obstructions, A.14.2.1(2)
Semiautomatic dry standpipe system
Definition, 3.3.43.4
Testing *see* Testing
Types of standpipe systems, 3.3.44.1, 3.3.44.2, 3.3.44.3
Wet standpipe system, 6.3.2.1.1
Definition, 3.3.43.5
Steam systems, Table 8.1.1.2, 8.2.2(5), 8.3.2.9(4), Table 8.6.1, Table A.3.3.8, A.8.1, A.8.2.2(5)
Storage, sprinkler clearance to, 5.2.1.2, A.5.2.1.2
Storage tanks *see* Water tanks
Strainers, 13.4.1.2, 13.4.3.1.3, 13.4.4.1.3, A.13.1, A.13.4.1.2
Definition, 3.3.45, A.3.3.45
Dry or preaction valves, 13.4.5.1.4
Foam concentrate, 11.2.6.4, Table 11.5.1, Table A.3.3.8, Table F.5.2(d)
Foam-water sprinkler systems, Table 11.1.1.2, 11.2.6, 11.2.8.5.3(1), 11.2.8.5.4(1), 11.2.8.5.5(1), 11.2.8.5.6(1), A.11.2.8.5.3(1), A.11.2.8.5.4(1), A.11.2.8.5.5(1), A.11.2.8.5.6(1), A.11.2.8.5.6(2)
Mainline *see* Mainline strainers
Nozzle, 10.2.1.6
Valves, Table 13.1.1.2, Table 13.11.1
Water spray nozzles, Table A.3.3.8
Water spray systems, Table 10.1.1.2, 10.2.6, A.10.2.6
Water tank automatic tank fill valves, 9.5.2.3
Suction pressure *see* Pressure (pump)
Suction screens, Table 8.1.1.2, 8.2.2(2), 8.3.3.15, Table A.8.1.1.2, A.8.3.3.15, A.8.3.3.16, C.1.2, D.3, D.4.3
Supervision (definition), 3.3.46
Supervisory signal devices, Table 5.1.1.2, 5.2.4, Table 6.1.1.2, 6.3.3, Table 8.1.1.2, 8.1.1.2.7, 8.1.1.2.8, Table 13.1.1.2, 13.2.6, 13.4.4.2.13, Table 13.11.1, Table F.5.2(d)
Supports, Table 5.1.1.2, 5.2.3, Table 10.1.1.2, 10.2.3.2, Table 11.1.1.2, 11.2.3, A.5.2.3, A.10.2.3.2, Table F.5.2(d)
Water mist system, 12.2.4
Switches, automatic transfer *see* Automatic transfer switches
System shutdown *see also* Impairments
Hanger, brace, and support inspection, 5.2.3.4
Notification of system shutdown, 4.1.4, 15.5.2(5) to 15.5.2(7)
Owner/occupant responsibilities, 4.1.4
Pipe and fittings inspection, 5.2.2.4
Restoring systems to service, 4.1.4.2, 14.3.1(11)
Shutoff valves, location of, 4.1.8
Sprinkler inspection, 5.2.1.1.4
System valves, 13.4, A.13.4.1.1 to A.13.4.5.3.2

T

Tag system, 4.1.11.1, 15.3, 15.5.2(8), 15.7(5), A.15.3.1, A.15.3.2, Annex G
Tanks *see also* Fuel tanks; Water tanks
Foam concentrate, Table 11.1.1.2, 11.4.4.2, 11.4.5.2, 11.4.6.1 to 11.4.6.3, 11.4.7.4, 11.4.8.4, Table 11.5.1, A.11.4.4.2, A.11.4.5.2, Table F.5.2(d)
Temporary fire protection, 15.5.2(4)(c), A.15.5.2(4)(c)
Test *see also* Valve status tests
Definition, 3.3.47
Unadjusted field test curve, 8.3.7.2.3(3), A.8.3.7.2.3(2)
Definition, 3.6.2.11

Testing, 4.6, A.4.6.4 to A.4.6.6.7; *see also* Flow tests; Hydrostatic tests; Impairments
Automated, 4.6.6, A.4.6.6
Backflow prevention assemblies, 13.7.2, A.13.7.2.1
Data collection, Annex F
Definition, 3.3.48, A.3.3.48
Fire hydrants, Table 7.1.1.2, 7.3.2
Fire pumps, 4.9.6, 8.1, Table 8.1.1.2, 8.3, 8.4, Table 10.1.1.2, Table 12.1.1.2, 12.3.9, Table 13.1.1.2, Table A.3.3.8, A.4.9.6, A.8.1, A.8.3, A.8.4.1, Table F.5.2(e)
Component replacement testing requirements, 8.6
Flow tests *see* Flow tests
At no-flow condition *see* No flow (churn, shutoff)
Results and evaluation, 8.3.7, A.8.3.7.1 to A.8.3.7.2.4
Foam-water sprinkler systems, 11.1, Table 11.1.1.2, 11.3, Table A.3.3.8, A.11.3 to A.11.3.2.7
Forms for, Annex B
Main drain test *see* Main drains
Owner/occupant responsibilities, 4.1.1 to 4.1.4, 4.9.5.2, A.4.1.1 to A.4.1.3
Performance-based programs, 4.7, A.4.7
Pressure-regulating devices, 13.5.2.2, 13.5.2.3, 13.5.3.2, 13.5.3.3, 13.5.4.2, 13.5.4.3, A.13.5.2.2, A.13.5.4.2
Private fire service mains, Table 7.1.1.2, 7.3, A.7.3.1
Records *see* Records
Return to service,, 4.1.11.2, 12.3.16.8
Safety, 4.9, A.4.9.5, A.4.9.6
Sprinklers, Table 5.1.1.2, 5.3.1, A.5.3.1 to A.5.3.1.2
Sprinkler systems, 5.1, 5.3, 16.2.1.1, A.5.3.1 to A.5.3.4.4.1(2)
Standpipe and hose systems, 6.1, Table 6.1.1.2, 6.3, Table A.3.3.8, A.6.3.1.1 to A.6.3.2.1
Valves, 5.1.2, Table 6.1.1.2, Table 7.1.1.2, 8.1.2, 9.1.2, 10.1.5, Table 11.1.1.2, 13.1.1.1, Table 13.1.1.2, 13.2.3, 13.3.3.4, 13.4.3.2.3, Table A.3.3.8, A.13.2.3
Automatic tank fill valves, 9.5.3
Control, Table 6.1.1.2, Table 12.1.1.2, 13.3.3, 13.4.3.2.2, Table A.3.3.8, A.13.3.2.2 to A.13.3.3.5
Deluge, 13.4.4.2, Table A.3.3.8, A.13.4.4.2.3 to A.13.4.4.2.12
Dry pipe/quick-opening devices, 13.4.5.2, Table A.3.3.8, A.13.4.5.2.1 to A.13.4.5.2.4
Hose, 13.6.2, A.13.6.2.1, A.13.6.2.2
Preaction, 13.4.3.2, Table A.3.3.8, A.13.4.3.2.1 to A.13.4.3.2.10
Pressure-reducing, 13.5.1, 13.5.5.2
Pressure relief, 13.5.6
Water mist systems, Table 12.1.1.2
Water spray systems, 10.4.4
Water mist systems, 12.1, 12.3
Water spray systems, 10.1, 10.2.1.3, 10.3, 10.4, Table A.3.3.8, A.10.1, A.10.3.2 to A.10.3.3.3.1
Water supply status, 4.4
Water tanks, 9.1, Table 9.1.1.2, 9.3, 9.5.3, Table 10.1.1.2, Table A.3.3.8, A.9.1, A.9.3.1, A.9.3.4
Three years frequency (inspections, testing, and maintenance), 4.6.1.1, 4.6.1.2, 4.6.6.4.2, 4.7.3
Definition, 3.7.1.7
Sprinkler systems, 5.3.3.4.2
Valves, 13.4.5.2.9
Water tanks, Table 9.1.1.2, 9.2.5.1.1

U

Ultra high-speed water spray systems, 10.4, Table A.3.3.8
Definition, 3.6.6.1
Unadjusted field test curve, 8.3.7.2.3(3), A.8.3.7.2.3(2)
Definition, 3.6.2.11
Underground piping, private fire service mains
Inspection, 7.2.2.2, A.7.2.2.2
Testing, 7.3.1, Table A.3.3.8, A.7.3.1
Units of measurement, 1.4, A.1.4
Upright sprinklers, A.5.2.1.2.1, Table A.5.3.4.4.1(2), A.5.4.1.2.1, A.5.4.1.5.6.1(1)
Definition, 3.3.42.1.6
Use, changes in, 4.1.6, A.4.1.6

V

Valves, Chap. 13, Table F.5.2(d); *see also* Alarm valves; Ball valves; Check valves; Control valves; Deluge valves; Drip valves; Dry pipe valves; Hose valves; Pressure-reducing valves; Relief valves
Air release, 8.1.4(1)
Antifreeze system, 4.1.10
Automatic tank fill valves, 9.5, Table 9.6.1
Component action requirements, Table 6.5.1, Table 9.6.1, Table 11.5.1, 13.11, Table 13.11.1, A.13.11.3
Definitions, 3.5, A.3.5.1 to A.3.5.5.1
Flushing, used for, D.5.3
Gauges, 13.2.5, A.13.2.5.1, A.13.2.5.1.1
Inspections *see* Inspections
Location, 4.1.8
Maintenance *see* Maintenance
Owner/occupant responsibilities, 13.2.1
Pneumatic, 12.2.6, 12.3.12, 12.3.13
Preaction, 13.4.3, Table A.3.3.8, A.13.4.3.2.1 to A.13.4.3.3.3
Pressure control
Definition, 3.5.4
Standpipe and hose systems, Table 6.1.1.2
Protection of, 13.2.2, A.13.2.2
Records, 13.2.7
Return to service after testing, 13.4.3.2.8, 13.4.4.2.10
Shutoff, 4.1.8
System, 13.4, A.13.4.1.1 to A.13.4.5.3.2
Testing *see* Testing
Test valves, 4.6.3
Water mist systems, Table 12.1.1.2, 12.1.2
Water-spray fixed systems, 10.1.5
Valve status test connection (definition), 3.3.50, A.3.3.50
Valve status tests, Table 6.1.1.2, Table 7.1.1.2, Table 9.1.1.2, Table 10.1.1.2, Table 11.1.1.2, Table 13.1.1.2, 13.3.3.4
Definition, 3.3.49
Valve supervisory devices, Table 5.1.1.2, Table 6.1.1.2, Table 11.5.1, Table 13.1.1.2, 13.3.3.5
Component action requirements, Table 5.5.1, Table 6.5.1, Table 7.5.1, Table 10.5.1
Water tanks, Table 9.6.1
Variable speed pump, 8.3.3.2, 8.3.3.3, A.8.3.3.2
Definition, 3.6.2.12
Ventilating systems, sprinklers for, 5.4.1.7
Vents, pressure vacuum, 11.4.9

W

Wall hydrants, Table 7.1.1.2, 7.2.2.4, 7.3.2.3, Table A.3.3.8, Fig. A.3.3.13.4, Table F.5.2(d)
Definition, 3.3.13.4, A.3.3.13.4, Fig. A.3.3.13.4

Waterflow alarm devices, Table 13.1.1.2, 13.2.4, A.13.2.4.8
Definition, 3.3.53
Foam-water sprinkler systems, Table 11.1.1.2, Table 11.5.1
Sprinkler systems, Table 5.1.1.2, 5.2.4, 5.3.3.2, Table 5.5.1, A.5.3.3.2
Standpipe and hose systems, Table 6.1.1.2, 6.3.3, Table 6.5.1
Water spray systems, Table 10.5.1
Waterflow detector check valves, A.13.1
Water mist systems, Chap. 12, Table F.5.2(d)
Definition, 3.6.5
Inspection, maintenance, and testing, 12.1, 12.2, 12.3, 12.4, A.12.2.1.1.1(5) to A.12.5.2, A.12.3.1.1 to A.12.3.18.1, A.12.4.1.5 to A.12.4.2.5.2, A.14.2.1(1)
Training, 12.5
Water spray (definition), 3.3.51, A.3.3.51
Water spray nozzles, Table 5.1.1.2, 5.4.1.7, Table 10.1.1.2, 10.2.4, 10.2.6.2, 10.3.3.3, 10.3.3.4, Table 11.1.1.2, Table A.3.3.8, A.10.2.4, A.10.3.3.3, Table F.5.2(d)
Component action requirements, Table 10.5.1
Definition, 3.3.29.2, A.3.3.29.2
Water spray systems, Chap. 10; *see also* Fire pumps; Ultra high-speed water spray systems; Water tanks
Component action requirements, 10.5
Definition, 3.6.6, A.3.6.6
Foam-water spray system (definition), 3.4.1; *see also* Foam-water sprinkler systems
Impairments, 10.1.6, A.10.1.6
Inspection and maintenance procedures, 10.1, Table 10.1.1.2, 10.2, Table A.3.3.8, A.10.2.3 to A.10.2.8.5.6(2)
Automatic detection equipment, 10.4.2
Deluge valves, 10.2.1.5, 10.2.2
Drainage, 10.2.7
Piping, 10.2.3, 10.2.5.2, A.10.2.3, A.10.2.5.2
Strainers, 10.2.6, A.10.2.6
Valves, 10.4.4
Water supply, 10.2.5, A.10.2.5.2
Manual operations, 10.3.5
Return to service after testing, 10.3.6
Testing *see* Testing
Water supply, 13.2.3, A.13.2.3
Definition, 3.3.52
Foam-water sprinkler systems, 11.2.5, A.11.2.5.2
Obstructions, Annex D
Temporary, 15.5.2(4)(c), A.15.5.2(4)(c)
Water mist systems, Table 12.1.1.2, 12.2.10, 12.3.20
Water spray systems, 10.2.5, 10.3.4, A.10.2.5.2
Water supply to pump suction, 8.1.5
Water tanks, Chap. 9, Table F.5.2(d)
Alarm devices, Table 9.1.1.2, 9.2.1, 9.2.2, 9.2.3.2, 9.3.3, 9.3.5, Table 9.6.1, A.9.2.1.1, A.9.3.5
Component action requirements, 9.6
Definition, 3.6.7
ESCF, maintenance of, Table 9.1.1.2, 9.4.6
Foam-water sprinkler systems, Table 11.1.1.2, 11.1.2, 11.2.5.1, Table 11.5.1
Heating systems, Table 9.1.1.2, 9.2.2, 9.3.2 to 9.3.4, Table 9.6.1, Table A.3.3.8, A.9.3.4
Impairments, 9.1.4
Inspections *see* Inspections
Maintenance *see* Maintenance
Obstruction investigations, D.3
Pressure tanks, Table 9.1.1.2, Table 10.1.1.2, Table A.3.3.8
Testing *see* Testing
Water mist systems, Table 12.1.1.2, 12.2.8, 12.3.17, 12.3.19, Table F.5.2(d)
Water spray systems, 10.2.9
Weekly frequency (inspections, testing, and maintenance), Table 13.1.1.2
Definition, 3.7.1.2
Fire pumps, Table 8.1.1.2, 8.2.2, 8.3.1.1.1, 8.3.1.2.1, Table 8.6.1, Table A.8.1.1.2
Pressure-regulating devices, 13.5.4.1
Valves, Table 13.1.1.2, 13.3.2.1, 13.5.4.1, 13.7.1.1
Water tanks, Table 9.1.1.2, 9.2.3.3, Table 9.5.1.1
Wet barrel hydrants, Table 7.1.1.2, 7.2.2.5, Table A.3.3.8, Table F.5.2(d)
Definition, 3.3.13.5, A.3.3.13.5, Fig. A.3.3.13.5
Wet pipe sprinkler systems
Definition, 3.6.4.6, A.3.6.4.6
Inspection, Table 5.1.1.2, 14.2, A.14.2.1, A.14.2.2
Obstructions, 14.2, A.14.2.1, A.14.2.2, D.2.5, D.3.2, D.3.4, D.5.4
Wet standpipe systems, 6.3.2.1.1
Definition, 3.3.43.5
Wharves, sprinklers for, 5.4.1.2.3

Y

Yard mains, 14.3.1(8), D.3, D.3.1, D.5.1, D.5.4

Z

Zebra mussels, obstruction by, D.4.6

IMPORTANT NOTICES AND DISCLAIMERS CONCERNING NFPA® STANDARDS

NOTICE AND DISCLAIMER OF LIABILITY CONCERNING THE USE OF NFPA STANDARDS

NFPA® codes, standards, recommended practices, and guides ("NFPA Standards"), of which the document contained herein is one, are developed through a consensus standards development process approved by the American National Standards Institute. This process brings together volunteers representing varied viewpoints and interests to achieve consensus on fire and other safety issues. While the NFPA administers the process and establishes rules to promote fairness in the development of consensus, it does not independently test, evaluate, or verify the accuracy of any information or the soundness of any judgments contained in NFPA Standards.

The NFPA disclaims liability for any personal injury, property or other damages of any nature whatsoever, whether special, indirect, consequential or compensatory, directly or indirectly resulting from the publication, use of, or reliance on NFPA Standards. The NFPA also makes no guaranty or warranty as to the accuracy or completeness of any information published herein.

In issuing and making NFPA Standards available, the NFPA is not undertaking to render professional or other services for or on behalf of any person or entity. Nor is the NFPA undertaking to perform any duty owed by any person or entity to someone else. Anyone using this document should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances.

The NFPA has no power, nor does it undertake, to police or enforce compliance with the contents of NFPA Standards. Nor does the NFPA list, certify, test, or inspect products, designs, or installations for compliance with this document. Any certification or other statement of compliance with the requirements of this document shall not be attributable to the NFPA and is solely the responsibility of the certifier or maker of the statement.

ADDITIONAL NOTICES AND DISCLAIMERS

Updating of NFPA Standards

Users of NFPA codes, standards, recommended practices, and guides ("NFPA Standards") should be aware that these documents may be superseded at any time by the issuance of new editions or may be amended from time to time through the issuance of Tentative Interim Amendments or corrected by Errata. An official NFPA Standard at any point in time consists of the current edition of the document together with any Tentative Interim Amendments and any Errata then in effect. In order to determine whether a given document is the current edition and whether it has been amended through the issuance of Tentative Interim Amendments or corrected through the issuance of Errata, consult appropriate NFPA publications such as the National Fire Codes® Subscription Service, visit the NFPA website at www.nfpa.org, or contact the NFPA at the address listed below.

Interpretations of NFPA Standards

A statement, written or oral, that is not processed in accordance with Section 6 of the Regulations Governing the Development of NFPA Standards shall not be considered the official position of NFPA or any of its Committees and shall not be considered to be, nor be relied upon as, a Formal Interpretation.

Patents

The NFPA does not take any position with respect to the validity of any patent rights referenced in, related to, or asserted in connection with an NFPA Standard. The users of NFPA Standards bear the sole responsibility for determining the validity of any such patent rights, as well as the risk of infringement of such rights, and the NFPA disclaims liability for the infringement of any patent resulting from the use of or reliance on NFPA Standards.

NFPA adheres to the policy of the American National Standards Institute (ANSI) regarding the inclusion of patents in American National Standards ("the ANSI Patent Policy"), and hereby gives the following notice pursuant to that policy:

> **NOTICE:** The user's attention is called to the possibility that compliance with an NFPA Standard may require use of an invention covered by patent rights. NFPA takes no position as to the validity of any such patent rights or as to whether such patent rights constitute or include essential patent claims under the ANSI Patent Policy. If, in connection with the ANSI Patent Policy, a patent holder has filed a statement of willingness to grant licenses under these rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such a license, copies of such filed statements can be obtained, on request, from NFPA. For further information, contact the NFPA at the address listed below.

Law and Regulations

Users of NFPA Standards should consult applicable federal, state, and local laws and regulations. NFPA does not, by the publication of its codes, standards, recommended practices, and guides, intend to urge action that is not in compliance with applicable laws, and these documents may not be construed as doing so.

Copyrights

NFPA Standards are copyrighted. They are made available for a wide variety of both public and private uses. These include both use, by reference, in laws and regulations, and use in private self-regulation, standardization, and the promotion of safe practices and methods. By making these documents available for use and adoption by public authorities and private users, the NFPA does not waive any rights in copyright to these documents.

Use of NFPA Standards for regulatory purposes should be accomplished through adoption by reference. The term "adoption by reference" means the citing of title, edition, and publishing information only. Any deletions, additions, and changes desired by the adopting authority should be noted separately in the adopting instrument. In order to assist NFPA in following the uses made of its documents, adopting authorities are requested to notify the NFPA (Attention: Secretary, Standards Council) in writing of such use. For technical assistance and questions concerning adoption of NFPA Standards, contact NFPA at the address below.

For Further Information

All questions or other communications relating to NFPA Standards and all requests for information on NFPA procedures governing its codes and standards development process, including information on the procedures for requesting Formal Interpretations, for proposing Tentative Interim Amendments, and for proposing revisions to NFPA standards during regular revision cycles, should be sent to NFPA headquarters, addressed to the attention of the Secretary, Standards Council, NFPA, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101; email: stds_admin@nfpa.org

For more information about NFPA, visit the NFPA website at www.nfpa.org. All NFPA codes and standards can be viewed at no cost at www.nfpa.org/docinfo.

FIRE-GAS

Website:Fire-gas.com

FIRE-GAS

مدرس ، طراح و مشاور سیستم های (آتش نشانی ، تهویه ، اگزاست و فشار مثبت)

دارای صلاحیت سازمان آتش نشانی

اخذ تاییده از سازمان آتش نشانی



اولین هند بوک سیستم اطفاء حریق و مدیریت دود در ایران

Handbook of Smoke Control Engineering

AUTHOR
QUILL PEN



طراحی سیستم های اطفا آبی ، گازی و فوم Sprinkler ,FM200,CO2,Foam

طراحی ، انتخاب ، تست و راه اندازی پمپ های آتش نشانی مطابق NFPA20

طراحی سیستم های اگزاست و تهویه پارکینگ ، فشار مثبت راه پله - آسانسور وآتریوم ها

SOFTWARE

نرم افزار کانتم Contam

نرم افزار پایروسیم و پاس فیدر Pyrosim ,Pathfinder

نرم افزار اتواسپرینک Autosprink

نرم افزار انتخاب فن، دمپرهای دود و آتش Sodeca Quick Fan & RF Damper

برای دریافت اطلاعات بیشتر کد روبرو را اسکن کنید

www.fire-gas.com

Aparat/fire-gas.com

02634411758

00989123280127

البرز گوهردشت خ۱۲ شرقی پ۸ ط اول واحد ۲

instagram/firegascom

t.me/fire_gas

info@fire-gas.com

youtube/firegas2447