FIRE PROTECTION SYSTEM INSPECTION, TESTING AND MAINTENANCE

Table of Contents

Page

List of Tables

1.0 SCOPE

This document provides guidance on inspection, testing, and maintenance (ITM) of privately-owned fire protection systems that automatically or manually discharge fire extinguishing agents (e.g., water, foam, gas, or dry chemical).

Refer to the applicable FM Global Property Loss Prevention Data Sheet for guidance on fire protection system design, installation, and acceptance (commission testing).

Refer to the applicable data sheet for guidance on ITM of non-agent discharging fire protection systems, including stand-alone fire detection systems (Data Sheet 5-48), and containment/drainage (Data Sheet 7-83).

Refer to Data Sheet 10-7, *Impairment Management*, for precautions to implement when a fire protection system is out of service.

1.1 Hazards

For a description of the hazards associated with the lack of inspection, testing, and maintenance of fire protection systems, see the following FM Global Understanding the Hazard (UTH) brochures:

- *Lack of Inspection, Testing and Maintenance of Water-Based Fire Protection Systems* (P0343)
- *Improperly Closed Valves* (P0035)
- *Dry-Pipe Sprinkler Flushing Investigations* (PO241)
- *Freeze* (P0148)
- *Ice Plugs* (P0118)
- *Ice Plugs in Dry Pendent Sprinklers in Freezers* (P0382)
- *Fire Pumps* (P0252)
- *Hot Work* (P0032)
- *Lack of Emergency Response* (P0034)
- *Lack of Pre-Incident Planning* (P0033)

1.2 Changes

October 2019. Interim revision. Added Appendix C, Fire Protection System Inspection Frequency Comparison.

2.0 LOSS PREVENTION RECOMMENDATIONS

2.1 Introduction

Automatic fire protection systems are a reliable and effective means of mitigating fire risk, provided the systems are properly designed, installed, and maintained. After system installation and acceptance testing, implementing an ITM program will help ensure the fire system can be depended on to protect your facility.

It is equally important that, when inspection, testing, and maintenance operations are carried out, proper planning and impairment procedures are followed to minimize the amount of time systems are out of service, and to have in place a means to readily return the system to service in the event of an emergency during these procedures. Coordination with the in-house emergency response team, as well as close supervision of any outside contractors performing these services, are essential to minimize the hazard involved and reduce the risk to the facility.

Tables 1-10 contain both frequency-based and event-driven ITM activities. Frequency-based activities are listed with a baseline frequency, and references to any additional technical detail are included in the tables.

Appendix D contains sample forms to serve as checklists and/or to document the results of ITM activities. These forms may be customized to meet the individual needs of a facility.

2.1.1 Fire Protection System Impairment Precautions

Routine inspection, testing, and maintenance of fire protection equipment can create an impairment to the system, and these impairments need to be properly managed. Whenever fire protection water supplies, sprinklers, fire pumps, or special protection is impaired, an unusual fire protection hazard exists and specific fire prevention procedures are necessary. Follow procedures based on the FM Global Red Tag Permit System (or equivalent) and as outlined Data Sheet 10-7, *Fire Protection Impairment Management*, to ensure complete precautionary measures are taken and ignition sources are controlled.

2.2 Inspection, Testing, and Maintenance Programs

2.2.1 Use trained personnel or qualified contractors to perform ITM.

2.2.1.1 Provide initial and annual refresher training for facility personnel performing ITM. Ensure personnel are knowledgeable on: location of critical system components (e.g., control valves); system operation; relevant procedures; and identifying abnormal conditions that may render a system inoperable. Train and maintain a competent group of back-up facility personnel in the event primary personnel suddenly become unavailable (e.g., illness or transfer).

2.2.1.2 Select qualified contractors who meet the requirements of local codes and authorities having jurisdiction. Supervise fire protection contractors performing ITM in accordance with Data Sheet 10-4, *Contractor Management*.

2.2.2 Document completed ITM activities. At a minimum, include the following in the documentation:

- Specific systems and equipment covered
- Type of ITM
- Results
- Comments or corrective actions needed

Retain ITM documentation for auditing by management and/or authorities having jurisdiction for a minimum of one year.

2.2.3 Audit the fire protection system ITM program.

A. Establish an audit frequency based on facility conditions, such as the past program audit results, but at least annually.

B. Review program documentation, including policies and procedures (to ensure they remain current); completed ITM documentation (for thoroughness and unresolved corrective actions); record retention; timeliness of ITM work-order completion and outstanding work-orders; and training.

C. Witness employees or contractors performing ITM activities.

2.3 General Inspection, Testing and Maintenance Practices

2.3.1 Use an impairment management program (FM Global Red Tag Permit System or equivalent) when protection is taken out of service to conduct ITM. Refer to Data Sheet 10-7 for examples of fire protection systems impaired during ITM.

2.3.2 Incorporate an impairment alert into ITM work orders, procedures, or contracts if the activity renders a protection system out of service.

2.3.3 Conduct alarm device testing that initiates fire alarms outside of normal operating or production hours to limit disruption within the facility. Prohibit the use of jumpers or forces to temporarily bypass an alarm device that initiates a fire or supervisory alarm to facilitate testing.

2.3.4 Conduct alarm device testing that initiates an automatic shutdown of building's system or process equipment during planned or unplanned maintenance outages. However, if bypassing an alarm device is unavoidable, either of the following alternatives are tolerable if an impairment management program is also used.

A. Install a lockable switch with exterior position indication (i.e., open or closed) in the alarm circuit. Locate the isolation switch near the alarm device, allowing for periodic inspection of the switch conditions (secured and closed position).

B. Use a jumper or force to temporarily bypass an alarm device.

2.3.5 Use an impairment management program (FM Global Red Tag Permit System or equivalent) when fire protection systems are discovered to be out of service through ITM. Inoperable components, poor system performance, and poor physical condition are instances in which a fire protection system may be considered out of service. See Data Sheet 10-7 for examples of fire protection systems discovered to be out of service through ITM.

2.4 Fire Protection System Inspsection, Test, and Maintenance Frequencies

2.4.1 General

Sections 2.4 through 2.12 contain recommendations for the scope and frequency of fire protection system ITM activities. Some of these activities may be modified based on positive or negative factors present at the facility. Clients of FM Global can discuss modifying ITM activities with an FM Global field engineer.

2.4.2 Fire Protection Control Valves in Automatic and Manual Fire Protection Systems

2.4.2.1 Perform control valve inspection and test activities for automatic and manual fire protection systems in accordance with Table 1.

Table 1. Control Valves in Automatic and Manual Fire Protection Systems

ID	*ITM Activity & Scope*	*Frequency*	*Details*
1a	Visually inspect indicating control valves for full-open, secured, and accessible conditions.	Weekly	Record visual inspection results on a form listing all control valves and their locations and areas. See Appendix D for a sample form.
1b	Inspect control valves installed in waterflow alarm sensing lines when the alarm actuates process or building interlocks for full-open and locked conditions.		
1c	Visually inspect enhanced security indicating control valves for full-open, secured, and accessible conditions.	Semiannually	Record visual inspection results on a form listing all control valves and their locations and areas. See Appendix D for a sample form.
2	Physically test control valves for full-open position.This includes post-indicating valves (PIV); wall-mounted post-indicating valves (WPIV); non-FM Approved indicating-butterfly valves (IBV); non-rising stem (NRS) valves; curb-box/road-way (CB/RW) valves; and non-indicating butterfly valves.	Monthly	Record physical inspection results on a form listing all control valves and their locations and areas. See Appendix D for a sample form.
3	Test control valve supervisory alarms and enhanced security control valves (e.g., tamper switches).	Semiannually	
4	Full-travel exercise all control valves recording number of turns-to-close and turns-to-reopen.	Annually	

2.4.2.3 Secure control valves using the following methods. Note that a control valve is considered secured when the valve operator is prevented from being manipulated more than one turn toward the closed position, or at all for quarter-turn valves (e.g., ball valves).

A. Secure each control valve separately with a dedicated lock and chain. Secure control valves with a sturdy, key-operated lock and chain capable of withstanding breakage except by heavy-duty bolt cutters or similar hand tools. Do not use combination locks. Do not use seals or breakaway locks except when valves are 1.5 in. (38 mm) nominal diameter or smaller, or control five or fewer sprinklers. Treat valves in the waterflow alarm sensing lines actuating process and building interlocks as control valves in automatic fire protection systems.

B. For a wall-mounted post-indicating valve, ensure the valve hand-wheel cannot be removed from the valve stem when the valve is secured.

C. For a curb-box/road-way valve, secure all operating wrenches with a sturdy lock and chain, and inspect valve sleeve for cover.

2.4.2.4 Limit the distribution of control valve keys to only individuals responsible for fire protection system ITM, and local management.

2.4.2.5 Ensure control valves remain accessible in case of an emergency. Additionally, verify the appropriate signage is in place to identify the control valve and, where necessary, signage is in place to quickly locate control valves not readily visible.

2.5 Automatic Sprinkler Systems

2.5.1 All Sprinkler Systems

2.5.1.1 Conduct the ITM activities recommended in Table 2a for all types of sprinkler systems (wet, dry, preaction, deluge, fixed water spray, antifreeze, and refrigerated area).

Table 2a. ITM Activities Applicable to All Types of Sprinkler Systems

ID	*Recommendation*	*Frequency*	*Details*
1	Inspect, test, and exercise control valves in automatic fire protection systems.	Per Table 1	Per Table 1
2	Test waterflow alarms (including flow switches) by flowing water through a system test connection.	Quarterly (Annually for antifreeze systems)	Verify the following: - Local notification devices (e.g., bell, horn, and/or strobe) activate. - Alarms register on remote fire alarm control panels in constantly attended locations or at central alarm monitoring stations.
3	Test building and/or process interlocks actuated by waterflow alarms to verify the desired system actions are initiated and achieved.	Annually	
4	Flow test from system main-drain to check for significant obstructions in the water supply upstream of each system riser.	Annually	If multiple system risers are manifolded together and supplied by a common lead-in, then one main-drain test will sufficiently evaluate the water supply available to all system risers fed from the manifold. Ideally, main-drain testing is completed after annual control valve exercising, as main-drain testing is often the final step in restoring system impairments such as valve closures.
5	Investigate systems for obstructive debris.	When obstructions suspected	See 2.5.1.2.
6	Conduct a complete system flushing. Physically remove obstructive deposits or replace piping.	When obstructions discovered (debris)	See 2.5.1.2.
7	Inspect system sprinklers, nozzles, piping, pipe support, and seismic protection for damage and/or other poor conditions.	Annually or more frequently based on the operating environment or facility experience. (see 2.5.1.3.2)	See 2.5.1.3.
8	Test a random sample of sprinklers with fusible elements rated for 360°F (180°C) or greater when subjected to prolonged exposures of around 300°F (149°C) or higher.	Every 3 years	
9	Test a random sample of recalled O-ring sprinklers.	Every 5 years	
10	Test a random sample of dry-type sprinklers (AKA dry pendent)	Every 15 years	
11	Replace all dry-type sprinklers manufactured prior to 2003 (AKA dry pendent).	When found	
12	Replace all non-operated sprinklers within a minimum of 20 ft (6 m) of any operated sprinklers.	After a fire	

2.5.1.2 Investigation for and Removal of Obstructive Debris

2.5.1.2.1 Investigate the feed main, a minimum of one cross main, and a minimum of three branch lines using one of the following methods:

A. Flushing investigation in accordance with Section 3.1.3

B. Videoscope inspection in accordance with Section 3.1.3

C. Ultrasonic localized guided wave evaluation in accordance with Section 3.1.3

2.5.1.2.2 When preparing the system for an investigation, collect any debris discharged from main or auxiliary drains.

2.5.1.2.3 Examine different portions of a system during subsequent investigations.

2.5.1.2.4 Treat the system as obstructed if any of the following conditions are present:

A. Approximately 1/2 cup (120 ml) or more of debris is found in a cross main.

B. Debris pieces found in piping are large enough to plug a sprinkler orifice.

C. Flow from a branch line is obstructed.

D. Analysis of the videoscope inspection or ultrasonic localized guided wave evaluation results determines the system is obstructed.

2.5.1.2.5 If the system is deemed obstructed by debris, conduct a complete system flushing in accordance with Section 3.1.3. Treat the system as impaired protection until system piping is completely flushed.

2.5.1.2.6 During ITM activities or pipe alterations, if deposits (tubercles) are found attached to internal pipe walls, physically remove the deposits or replace the affected sections of pipe. Additionally, refer to Data Sheet 2-1, *Corrosion in Automatic Sprinkler Systems*, and develop a solution to suppress the existing corrosion mechanism and prevent the tubercles from reforming.

2.5.1.3 Inspect sprinkler system components for damage and/or other poor conditions.

2.5.1.3.1 Conduct a close examination of sprinklers and nozzles to look for damage, including any of the following:

A. Leakage from the orifice button and seal as shown by green discoloration or white deposits.

B. Surface corrosion when exposed in or near atmospheres containing high humidity and temperature, caustic or acidic vapor, solvent vapor, or other corrosive agents.

C. Surface accumulations, including residue or dust.

D. Paint when not properly protected during painting operations, whether occurring at floor or ceiling level.

E. Exposure to temperatures within 50°F (28°C) of their temperature rating (e.g., located above ceiling-level heating equipment or near heated process equipment).

F. Indications of freeze damage, including reduced link tension, metal gaskets forced upward, bent hook pieces, tilted glass or metal buttons, badly dished or distorted diaphragms, or bent struts.

G. Mechanical impact shown by distorted deflector or frame.

H. Sealed concealed sprinklers that have been adhered to the ceiling.

I. Damage to any protective devices (e.g., concealed cover plates, cages, plastic bags) or factory-applied coatings.

2.5.1.3.2 Inspect piping, pipe supports, and seismic protection for physical damage or poor conditions, including the following: bent piping (e.g., from mechanical impact); leaking fittings or piping due to corrosion; missing, detached, corroded, or broken pipe hanger or seismic brace assemblies; and piping used to support wiring or other materials.

2.5.1.3.3 Tailor inspection frequency and scope based on facility experience (inspection results and/or past instances of sprinkler leakage), and consider if measures have been taken to reduce the susceptibility to sprinkler damage (wax-coatings or corrosion-resistant construction).

2.5.1.3.4 Complete piping inspections from floor level unless large sections of piping are obstructed from view or difficult to see (e.g., within combustible concealed spaces, automated storage retrieval systems or buildings with tall roofs).

2.5.1.3.5 If damage is discovered during inspections, perform the following:

A. Test a random sample of sprinklers or replace sprinklers in accordance with Data Sheet 2-0.

B. Test a random sample of nozzles or replace nozzles in accordance with Data Sheet 4-2.

C. Protect sprinklers/nozzles, or control the environmental conditions that caused the damage, in accordance with Data Sheets 2-0 and/or 4-2.

2.5.1.3.6 Increase the inspection frequency (from annually) when sprinklers/nozzles are exposed to harsh environmental conditions (corrosives, dirt, dust, oil) or prone to impact.

Examples of harsh environmental conditions include process equipment containing elevated temperatures and high humidity; caustic or acidic vapor, solvent vapor (e.g., dryers/ovens, oil cookers, paint-spray tunnels); and exhaust ventilation systems conveying particulates or gases/vapor.

Examples of locations where sprinklers/nozzles are prone to impact include in-rack sprinklers within warehouse racking and sprinklers positioned close to conveyor systems.

2.5.2 Wet Sprinkler Systems

2.5.2.1 For wet sprinkler systems, in addition to the ITM activities listed in Table 2a, conduct the ITM activities listed in Table 2b.

Table 2b. Wet Sprinkler Systems

ID	*Recommendation*	*Frequency*	*Details*
1	Test telescopic sprinkler assemblies installed in anechoic chambers.	Varies	See Data Sheet 1-53.
2	Check systems fed by an open water supply for obstructive debris regardless of pipe material.	Every 5 years	See Section 3.1.3.
3	Check systems for mineral deposits at sprinkler-pipe connections in areas known or suspected to have hard water.	Every 5 years	See Section 2.5.2.2.
4	For systems with antifreeze solutions, test the antifreeze solution.	Annually	- Determine the specific gravity and the corresponding concentration of antifreeze in the system. - Evaluate the adequacy of the antifreeze concentration in terms of both freeze protection (freeze point vs. ambient temperature) and fire hazard in accordance with Data Sheet 2-0. - Test the antifreeze solution prior to the cold weather season.

2.5.2.2 In systems where hard water is known or suspected, focus inspections at sprinkler-pipe connections in the following areas:

A. Water-filled piping exposed to high-temperatures, such as in or near heated equipment, or at roof peaks in warm climates.

B. Older sprinkler systems that have been frequently drained and refilled.

C. Pendent sprinklers located away from air pockets near convective currents (i.e., sprinklers and piping at the lower portions of a system).

2.5.2.2.1 Inspect a random sample of sprinklers on several branch lines. Remove at least five sprinklers from different branch lines and inspect the threaded pipe connection and sprinkler internals for deposits.

2.5.2.2.2 Document portions of the system investigated and the findings to ensure future investigations building on previous inspections including: refrain from re-inspecting sections of the system previously found free of deposits until the entire system is inspected; and revisit sections of the system where deposits have been found.

2.5.2.2.3 When deposits are discovered, replace sprinklers containing deposits and widen the scope of the investigation to include additional sprinklers and piping inspections.

2.5.3 Dry, Preaction, Vacuum, Deluge, Fixed-Water Spray and Refrigerated Area Sprinkler Systems

2.5.3.1 For dry, preaction, vacuum, deluge, fixed-water spray and refrigerated area sprinkler systems, in addition to the ITM activities listed in Table 2a, conduct the ITM activities listed in Table 2c. Items 1-16 apply to all dry, preaction, vacuum, deluge, fixed-water spray and refrigerated area sprinkler systems. Item 17 applies to preaction and vacuum systems. Items 18-20 apply to refrigerated area sprinkler systems. Items 21-24 apply to deluge and fixed-water spray systems.

Table 2c. Dry, Preaction, Vacuum, Deluge, Fixed-Water Spray, and Refrigerated Area Sprinkler Systems

ID	*Recommendation*	*Frequency*	*Details*
1	Check system valve air and water pressures (including for pilot lines).	Weekly	
2	Verify the quick-opening device for in-service conditions, including equalized air pressure and open control valves.	Weekly	
3	Confirm system valve enclosures are maintained above 40°F (5°C).	Weekly	
4	Verify the automatic drain valve is open and free to move.	Monthly	
5	Check priming-water level within the system valve.	Monthly	
6	Check the condition of the compressed air supply (including for pilot lines).	Monthly	
7	Visually check indicating desiccant in compressed air dryers for saturation (including for pilot lines).	Monthly	
8	Physically/visually check the condition of desiccant in compressed air dryers (including for pilot lines).	Every 3 years (Annually for systems protecting areas constantly maintained below freezing)	- Physically check non-indicating desiccant for saturation. - Visually inspect both indicating and non-indicating desiccants for deterioration/breakdown.
9	Test quick-opening devices (QOD) without tripping the system valve.	Annually if FM Approved devices; otherwise quarterly	
10	Determine the air leakage rate of the system (including for pilot lines).	Annually	Use leakage rates to: - identify systems prone to false trip during power outages (loss of compressed air supply). - determine when action is needed to reduce air leakage rate or improve the reliability of compressed air supply.
11	Test supervisory alarms for low air pressure (including for pilot lines) and low temperature in system valve enclosures.	Annually (Quarterly for systems protecting areas constantly maintained below freezing)	Verify supervisory alarms surface on system control panels, fire alarm control panels, and/or at remote monitoring stations.
12	Inspect and clean system valve internals and associated valve trim.	Annually	
13	Partial-flow trip test system valves.	Annually	Verify the system valve trip point (and trip time when possible) are in agreement with the last full-flow trip test results.

Table 2c. Dry, Preaction, Vacuum, Deluge, Fixed-Water Spray, and Refrigerated Area Sprinkler Systems (continued)

ID	*Recommendation*	*Frequency*	*Details*
14	Full-flow trip test, videoscope or ultrasonic localized guided wave evaluation of systems.	Every 3 years, or every 10 years for systems with nitrogen	Verify systems can deliver water to hydraulically remote areas within the specified time. The maximum water delivery time is 60 seconds unless stated otherwise in an FM Global data sheet specifically for the occupancy or hazard being protected. Use of videoscope or ultrasonic localized guided wave evaluation can determine if the piping is clear of debris and can be used as an alternative to confirm delivery of water.
15	Check systems (excluding refrigerated area systems and systems originally installed with nitrogen) containing black steel pipe for obstructive debris.	At 10 years, 20 years, and every 5 years thereafter	See Section 2.5.1.2.
16	Check the system for obstructive debris.	After the 3rd false trip in 12 months on open water supply	
For preaction and vacuum sprinkler systems, conduct items 1-16 and item 17.			
17	Test control panels, fire detectors, and backup power supplies used to actuate system valves.	Annually	See Data Sheets 5-40 and 5-48.
For refrigerated area sprinkler systems, conduct items 1-16 and items 18-20.			
18	Verify there is one duplex line in service supplying compressed air, and check the in-service duplex line for an ice plug.	Monthly	If ice is forming within the in-service duplex line, place the second duplex line into service, and remove ice from the first duplex line.
19	Inspect sprinklers and piping for exterior ice buildup.	Quarterly	Focus inspections on wall penetrations where warm moist air could enter the freezer, including above personnel and fork-truck doors, and conveyor openings.
20	Check systems and pilot sprinkler lines for ice plugs along with freeze damage to piping and sprinklers.	Semiannually and after every system trip	Visually inspect pipe internals for ice plugs by disassembly and visual inspection, videoscope or ultrasonic localized guided wave evaluation. Inspect each branch line and cross main to ascertain whether ice has formed. If an ice plug is discovered, treat the system as impaired until the ice plug is removed. Do not attempt to melt ice plugs using hot work as fire protection is impaired. Remove ice plugs by disassembling the subject piping and relocating the piping to a warm area.

Table 2c. Dry, Preaction, Vacuum, Deluge, Fixed-Water Spray, and Refrigerated Area Sprinkler Systems (continued)

ID	*Recommendation*	*Frequency*	*Details Scope*
For deluge and fixed-water spray systems, conduct items 1-16 and items 21-24.			
21	Test control panels, fire detectors, and backup power supplies used to actuate system valves.	Annually	See Data Sheets 5-40 and 5-48.
22	Disassemble and inspect system strainers.	Every 3 years	Inspect system strainers for holes and corrosion or mechanical damage.
23	Flush system strainers until clear.	After every system trip	
24	Remove a random sample of nozzles and inspect nozzles, pipe connections, and strainers for obstructive debris.	After Every System Trip	- Visually confirm waterflow and proper spray distribution from nozzles. - Compare base of riser and remote pressure measurements to design and/or acceptance results. - If obstructions are suspected, investigate using one of the following methods: a. Disassembly of piping and visual inspection. b. Full-trip test and nozzle inspection. c. Videoscope inspection in accordance with 3.1.3. d. Ultrasonic localized guided wave evaluation in accordance with 3.1.3. - If the system is deemed obstructed by debris, develop a plan to remove obstructions from piping. Treat the system as impaired protection until obstructions are removed.

2.6 Manual Fire Protection Systems

2.6.1 Fire Hydrants, Standpipe Systems, and Monitor Nozzles

2.6.1.1 For fire hydrants, standpipe systems, and monitor nozzles, conduct the ITM activities listed in Table 3.

Table 3. Fire Hydrants, Standpipe Systems, and Monitor Nozzles

ID	*Recommendation*	*Frequency*	*Details*
1	Inspect, test, and exercise control valves.	Annually	Per Table 1.
2	Check hydrants and standpipes for accessibility, leakage, and damage.	Monthly	
3	Check hydrant hose houses, standpipe valves and hose stations, and portable and fixed monitors for equipment availability, accessibility, and damage.	Quarterly	
4	Inspect and flow test fire hydrants.	Annually	
5	Inspect, exercise, and flow test monitors and nozzles.	Annually	Exercise monitors through their full range of travel, including sidetoside and upanddown.
6	Inspect, test, and maintain fire hose, hose couplings, and hose appliances per local jurisdictional requirements and/or the manufacturer's guidelines, whichever is more stringent.	Varies	
7	Inspect hydrant, standpipe hose and/or nozzles, and monitors and nozzles for damage, leaks, or debris lodged in nozzle strainers.	After every use	
8	Flow test standpipe systems, achieving design flow and hose valve pressure.	Every 5 years	

2.7 Flow and Pressure-Regulating Valves

2.7.1 Pressure-Reducing Valves

2.7.1.1 See Data Sheet 3-11, *Pressure Reducing Valves for Fire Protection Service*, for ITM recommendations.

2.7.2 Pressure-Relieving and Suction-Control Valves

2.7.2.1 For pressure-relieving and suction-control valves, conduct the ITM activities listed in Table 4.

Table 4. Pressure-Relieving and Suction-Control Valves

ID	*Recommendation*	*Frequency*	*Details*
1	Test pressure-relieving and suction-control valves in supply piping.	Annually	- Verify the operation of pressure-relieving and suction-control valves in supply piping by flowing the water downstream of the valve (from hydrants or a pump test header). - Verify proper valve modulation. - Confirm the regulating valve setpoint. For suction-control valves, confirming valve modulation and setpoints may not be possible, but at least verify the valve does not begin to throttle flow at or near sprinkler system demands or maximum fire pump design capacity. For example, verify the suction-control valve remains full open while flowing in excess of 150% fire pump capacity.

2.7.3 Backflow Preventers and Single Check Valves

2.7.3.1 For backflow preventers and single check valves, conduct the ITM activities listed in Table 5.

Table 5. Backflow Preventers and Single Check Valves

ID	*Recommendation*	*Frequency*	*Details*
1	Conduct a full-flow test in excess of the greatest sprinkler demand. Measure and record the flow rate during testing.	Annually	- A full-flow test can be completed by flowing water through a bypass line, hydrant or other outlet downstream of the backflow prevention or single check valve. - An alternative means of conducting a full-flow test is to reverse the check-valve in the fire department connection piping, flowing water through supply piping, and discharging out of the fire department connection. - Given the size of the fire service piping, the fire service connection flush will yield flow rates through a backflow preventer sufficiently close to sprinkler system demands.
2	Inspect valve internals for debris and damage.	Every 5 years	

2.8 Fire Service Mains

2.8.1 For fire service mains, conduct the ITM activities listed in Table 6.

Table 6. Fire Service Mains

ID	*Recommendation*	*Frequency*	*Details*
1	Inspect, test, and exercise control valves.	Per Table 1.	Per Table 1.
2	Disassemble and inspect supply strainers.	Annually	Inspect in-line supply strainers for holes, and corrosion or mechanical damage.
3	Check systems for obstructive debris or deposits.	When obstructions suspected	
4	Conduct a complete system flushing.	When obstructions (debris) discovered	- Flush mains and lead-in connections to system risers through hydrants at dead ends of the system or through accessible aboveground flushing outlets, allowing the water to run until clear. - If water is supplied from more than one source or from a looped system, close divisional valves to produce a high velocity flow through each single line.
5	Flush in-line supply strainers until clear.	After every significant flow	When a flow in excess of a main-drain test occurs, flush in-line supply strainers until clear. Examples of such flows include: hydrant flow testing; dry, preaction, or deluge system valve trip; or flushing obstruction investigation.

2.9 Fire Pumps

2.9.1 All Fire Pumps

2.9.1.1 For all types of fire pumps, conduct the ITM activities listed in Table 7. Items 1-9 apply to all fire pumps. Item 10 applies to electric fire pumps. Items 11-17 apply to diesel fire pumps.

Table 7. Fire Pumps

ID	Recommendation	Frequency	Details
1	Inspect, test, and exercise control valves.	Per Table 1.	Per Table 1.
2	Start the pump in automatic mode via pressure drop or waterflow alarm and allow the pump to churn, reaching normal operating conditions.	Monthly for electric pumps	See 2.9.2.
		Weekly for diesel pumps	See 2.9.3.
3	Inspect the pump room for satisfactory conditions.	Weekly	See 2.9.4.
4	Test pump performance and verify suction supply availability.	Annually	See 2.9.5.
5	Verify the pump controller is set for manual stop only.	Annually	
6	Verify automatic start and stop set points of pressure maintenance devices through testing.	Annually	
7	Test pump controller supervisory alarms.	Annually	See 2.9.6.
8	Test automatic fill systems on priming tanks when taking suction under lift.	Annually	
9	Check alignment of pumps and drivers that are coupled.	Annually	See 2.9.7.

Table 7. Fire Pumps (continued)

ID	Recommendation	Frequency	Details
For electric fire pumps, conduct items 1-9 and item 10.			
10	Inspect, test, and maintain primary and secondary power feeds, including automatic transfer switches to electric fire pumps.	Per Data Sheet 5-20.	Per Data Sheet 5-20.
For diesel fire pumps, conduct items 1-9 and 11-17.			
11	Check the condition of engine batteries.	Monthly	Check engine battery condition by determining the available cold-cranking amps using a battery tester. An alternative test method is to determine electrolyte specific gravity. Record test results for trending battery health.
12	Change engine oil and oil filter.	Per manufacturer’s specifications but at least annually	
13	Change oil in right-angle gear-drives.	Per manufacturer’s specifications but at least annually	
14	Test primary and backup electronic control modules (ECM) on electronic fuel injected engines.	Annually	
15	Drain water from the diesel tank sump.	Annually	
16	Replace biodiesel within diesel tanks.	Per supplier’s instructions, but at least every 2 years	
17	Replace engine batteries.	Every 2 years	Consider alternating battery replacement on an annual basis. For example, replace battery set A in year 1, then replace battery set B in year 2.

2.9.2 Electric Fire Pumps

2.9.2.1 Inspect and test electric fire pumps for the following conditions.

2.9.2.1.1 Prior to start-testing, do the following:

A. Confirm the pump controller is in automatic mode, and there are no trouble alarms registered on the controller.

B. Confirm the pump room temperature is maintained above 40°F (4°C).

C. Visually check the fire pump installation before starting the unit to identify:

1. Evidence of loose, rusted, corroded or damaged pump/driver securement bolts

2. Lack of guarding for the pump coupling or other exposed rotating components.

3. Evidence of filings/debris beneath the pump coupling unit indicating coupling deterioration.

4. Evidence of excessive corrosion of piping connected to the pump unit.

If any of the above conditions exist, investigate and resolve the issue before continuing with any testing.

2.9.2.1.2 Test the Electric Fire Pump

A. Test the pump in automatic mode via pressure drop or waterflow alarm, and allow the pump to churn for a minimum of 10 minutes.

B. At start and throughout the test:

1. Watch for any vibration or water leakage. Terminate churn or flow testing of fire pumps immediately if there are any indications of excess vibration, unusual loud noise, or excessive leakage from the pump packing, casing, or engine cooling system. Complete any repairs before resuming any churn/flow testing.

2. Verify waterflow through the pump seals is adequate (if packed seals are installed).

3. Verify flow from the circulation-relief valve.

4. Verify the pump casing is not overheating.

5. Record suction and discharge pressures.

C. Position properly trained facility personnel at the fire pump controller during any churn or flow testing to ensure prompt shutdown of the pump system if unusual conditions develop.

2.9.2.1.3 Following the churn-test:

A. Confirm the pump controller is in automatic mode.

B. If pumps are taking suction under lift, inspect the priming tank level and any fill controls.

2.9.3 Diesel Fire Pumps

2.9.3.1 Inspect and test diesel fire pumps for the following conditions.

2.9.3.1.1 Prior to start-testing:

A. Confirm the pump controller is in automatic mode, and there are no trouble alarms registered on the controller.

B. Confirm the pump room temperature is maintained above 40°F (4°C).

C. Check battery charger float current.

D. Check the battery electrolyte level.

E. Check oil level and quality.

F. Check air filter.

G. Confirm block heater is maintaining engine temperature above 90°F (32°C), or the pump room is maintained above 70°F (21°C).

H. If a right-angle gear-drive is installed, check gear oil level.

I. Visually check the fire pump installation before starting the unit to identify:

1. Evidence of loose, rusted, corroded or damaged pump/driver securement bolts

2. Lack of guarding for the pump coupling or other exposed rotating components.

3. Evidence of filings/debris beneath the pump coupling unit indicating coupling deterioration.

4. Evidence of excess corrosion of piping connected to the pump unit.

If any of the above conditions exist, investigate and resolve the issue before continuing with any testing.

2.9.3.1.2 Test the Diesel Fire Pump

A. Test the pump in automatic mode via pressure drop or waterflow alarm, and allow the pump to churn for a minimum of 30 minutes.

B. At start and throughout the test:

1. Look for any vibration or water leakage. Terminate churn or flow testing of fire pumps immediately whenever there are any indications of excess vibration, unusual loud noise, or excessive leakage from the pump packing, casing, or engine cooling system. Complete any repairs before resuming any churn/flow testing.

2. Verify waterflow through the pump seals is adequate (if packed seals are installed).

3. If the engine is heat exchanger-cooled, at start and throughout the test verify raw water is flowing through the engine heat exchanger.

4. If the engine is radiator-cooled, at start and throughout the test verify flow from the circulation-relief valve.

5. Verify the pump casing is not overheating.

6. If a main-relief valve is installed to protect against diesel engine overspeed, verify water is not discharging through the valve at churn.

7. If a right-angle gear-drive is installed, verify the gear-drive is not overheating (e.g., if water-cooled, water is flowing through the heat exchanger).

8. Record suction and discharge pressures.

9. Record engine panel conditions including RPM, oil pressure, and coolant temperature.

C. Position properly trained facility personnel at the fire pump controller during any churn or flow testing to ensure prompt shutdown of the pump system if unusual conditions develop.

2.9.3.1.3 Following the churn-test:

A. Confirm the pump controller is in automatic mode.

B. If the engine is heat exchanger cooled, inspect and clean the raw water cooling loop strainers as follows:

1. If fed by an open water source, inspect and clean the strainer in the automatic loop after each pump start test.

2. If fed by a potable/filtered water source, inspect and clean the strainer in the automatic loop at least semiannually.

3. Inspect and clean the strainer in the manual bypass cooling loop every time it is used.

4. Flushing connections on strainers can be used to clean strainers (weekly or semiannually); however, remove and visually inspect strainers for damage at least annually.

C. Verify the diesel tank is at least 3/4 full or capable of providing 8 hours of runtime at 100% rated engine load.

2.9.4 Fire Pump Room

2.9.4.1 Inspect the fire pump room for the following items:

A. Fire pump controller is in automatic mode, and there are no trouble alarms registered on the controller.

B. Pump room temperature is maintained above 40°F (4°C).

C. Floor drains are clear of any obstructions.

D. Ventilation louvers are operating freely.

E. Housekeeping is maintained, and room is free of combustible storage.

F. Electrical cabinets are shut and secured.

G. All valves are locked in the fully open position.

H. Piping is free of leaks.

I. Locks are secured on diesel tank discharge control valve and outdoor diesel tank fill caps.

J. Visually check the fire pump installation for the following:

1. Evidence of loose, rusted, corroded or damaged pump/driver securement bolts
2. Lack of guarding for the pump coupling or other exposed rotating components.
3. Evidence of filings/debris beneath the pump coupling unit indicating coupling deterioration.
4. Evidence of excess corrosion of piping connected to the pump unit.

2.9.5 Pump Performance

2.9.5.1 Evaluate pump performance and verify suction availability by discharging from a pump test connection.

2.9.5.1.1 Measurements

A. Record suction and discharge pressures and flow rate by flowing through a test header or through a flow meter to a tank or reservoir at a minimum of three test points: churn; rated pump capacity; and maximum pump capacity. If flowing through a flow meter, calibrate it every 3 years.

B. Record revolutions per minute (rpm) at each test point.

C. For electric pumps, record voltage and amperage at each test point (if available).

D. For diesel pumps, monitor and record coolant temperature and oil pressure, and record hours.

2.9.5.1.2 Evaluations

A. Compare the three test points to the manufacturer's pump curve and/or pervious test results, adjusting for driver rpm as needed.

B. For electric pumps, compare actual amperage at 150% pump capacity and the full-load current (FLC) listed on the motor nameplate (if available).

C. For diesel pumps, verify actual pump speed is within 10% of rated pump speed when the pump is flowing at rated capacity (i.e., 100%).

2.9.6 Remote Alarms

2.9.6.1 Test the following remote alarms (at a minimum) and verify local notification devices activate (e.g., bell, horn, and/or strobe), and alarms surface on pump controllers, fire alarm control panels, and/or at remote monitoring stations.

A. For electric fire pumps:

- Pump running
- Loss of AC power to controller
- Loss of phase (single-phasing)
- Phase reversal
- Controller connected to alternate power source (if provided)
- Drive failure (variable speed pump only)
- Bypass mode (variable speed pump only)
- Over-pressure (variable speed pump only)

B. For diesel fire pumps:

- Pump running (engine running)
- Controller main switch turned to ″OFF″ or ″MANUAL″
- Engine trouble
- Loss of AC power to controller
- Pump room trouble (when provided)

2.9.7 Fire Pump Alignment

2.9.7.1 Prior to starting the fire pump:

A. Visually check the fire pump installation for the following:

1. Evidence of loose, rusted, corroded or damaged pump/driver securement bolts
2. Lack of guarding for the pump coupling or other exposed rotating components
3. Evidence of filings/debris beneath the pump coupling unit indicating coupling deterioration
4. Evidence of excess corrosion of piping connected to the pump unit

Where any of the above conditions exist, investigate and resolve the issue before continuing.

B. Upon starting the pump, look for any vibration or water leakage. Terminate testing of the fire pump immediately whenever there are any indications of excess vibration, unusual loud noise, or excessive leakage from the pump packing, casing, or engine cooling system. Where any of the above conditions exist, investigate and resolve/repair the issue before continuing.

2.10 Water Sources

2.10.1 Open-Water Sources and Water Storage Tanks

2.10.1.1 For open-water sources, conduct the ITM activities listed in Table 8a. For water storage tanks conduct the ITM activities listed in Table 8b.

Table 8a. Open-Water Sources

ID	*Recommendation*	*Frequency*	*Details*
1	Inspect, test, and exercise control valves.	Per Table 1.	Per Table 1.
2	Verify the water level is sufficient.	Weekly ormonthly	Inspect open-water sources to verify the water level is sufficient to support fire protection system demands (flow and duration). Make these inspections weekly if the water source is not equipped with a supervised water level alarm. Inspect monthly if the water source is equipped with a supervisory water level alarm that has been tested (with satisfactory performance) at least annually.
3	Inspect and repair slopes of lined earth reservoirs for erosion.	Annually	
4	Inspect and repair liner surface of lined earth reservoirs above the water level for ultraviolet ray damage.	Annually	
5	Remove sediment, inspect and repair liner of lined earth reservoirs.	Every 5 years (or more frequently if warranted)	
6	Visually check wet-pit intake screens and bar racks, and suction strainers for debris clogs and damage.	Weekly	Remove debris and make repairs if needed. If not readily visible (e.g., from a walkway around or over the wet-pit), perform the check using a borescope, underwater camera, or diver.
7	Perform a closeup inspection and repair of wet-pit bar racks and screens, and suction strainers for holes, corrosion, or mechanical damage.	Annually	

Table 8b. Water Storage Tanks

ID	*Recommendation*	*Frequency*	*Details*
1	Inspect, test, and exercise control valves.	Per Table 1.	Per Table 1.
2	Inspect the water level in atmospheric storage tanks to verify they are full.	Weekly ormonthly	See 2.10.1.2.
3	Test water-level indicators and water-level supervisory alarms.	Annually	Test water-level indicators and water-level supervisory alarms on system control panels, fire alarm control panels, and/or at remote monitoring stations.
4	Verify pressure tank water and air pressure levels; verify/test air pressure source.	Weekly or monthly	Inspect the water level, air pressure, and air pressure source **weekly** if not equipped with supervised water level and air pressure alarms, or **monthly** if these alarms are provided and have been tested with satisfactory performance at least annually. Test the air pressure source if appropriate (i.e., it is a compressor).
5	Test all break tank automatic fill systems.	Monthly	- Maintain break tank automatic fill valves in accordance with the manufacturer's recommendations. - Test break tank automatic fill valves by opening the pipe well drain valve and flowing enough water until the automatic fill valve opens fully.
6	Verify the rate of inflow from break tank automatic and manual valves.	Annually	Per Data Sheet 3-2.
7	Visually check, inspect, and/or repair tank exteriors.	Monthly	- Identify obvious leaks, damage, erosion, obstructions, and exposures. - Repair any leaks and damage of foundations and anchors, exterior walls, ladders, roofs, gauges, etc. - Inspect embankments supporting fabric tanks for unusual erosion, and refill/replant as necessary. - Inspect and remove obstructions from vents and overflows. - Verify combustible yard storage, combustible waste, and vegetation is maintained at least 50 ft (15 m) from the tank.
8	During freezing weather, verify tanks and enclosures with tanks/piping are maintained above 40°F (4.5°C), and ice does not form on gravity tanks or structures beneath.	Daily ormore frequently if warranted	Verify the following: - Water temperature in tanks is being maintained at a minimum of 40°F (4.5°C). - The temperature inside pressure tank enclosures and other enclosures where freezing of pipes may occur is no lower than 40°F (4.5°C). - Gravity tanks, their supporting structures, and building roofs under them remain free of ice. - If the water in a tank/piping is frozen, provide an adequate emergency water supply for the fire protection system and follow the guidelines in Data Sheet 3-2.
9	Inspect and maintain tank heating systems.	Varies	See 2.10.1.3.
10	Visually inspect all systems and equipment that can be accessed without draining the tank, conducting an underwater evaluation, or disassembly.	Annually	Include the following items in the inspection: Tank; tower; piping; control and check valves; heating systems; water level indicator; pressure, temperature and water level alarms; expansion joint; frost proof casing; liner; insulation; overflow; screened or open vents, and all other accessories.
11	Investigate any tank supplied from an unfiltered source, and all dual-service water tanks, for sediment/ obstructions.	Annually(or more frequently if warranted)	Inspect for sediment/obstruction by opening the tank drain valve, flushing out sediment and inspecting the discharge. More frequent flushing may be needed, depending upon the amount of sediment.
12	Investigate tanks and supply piping when receiving untreated/raw water from bodies of water known to contain, or suspected of containing, fresh-water mussels or clams.	Annually	

Table 8b. Water Storage Tanks (continued)

ID	*Recommendation*	*Frequency*	*Details* *Table 8b. Water Storage Tanks (continued)*
ID	Recommendation	Frequency	Details
13	Inspect exterior coatings of steel and wood tanks for corrosion, rot, and insulation.	Every 2 years	- If the exterior of the tank is insulated, partially expose the tank to adequately assess it and replace the insulation afterwards. - Repaint/recoat steel and iron work, steel tank exteriors, and wood exteriors as necessary to prevent corrosion and rot.
14	Inspect coating of the exposed surface of embankment-supported fabric tanks for weathering.	Every 2 years (or more frequently if required by the tank manufacturer)	Repaint the exposed surface of the tank as necessary to protect it from weathering. Ensure all painting is in accordance with the manufacturer's recommendations.
15	Inspect the interior of the tank.	Every 5 years (or more frequently if warranted)	See 2.10.1.4.

2.10.1.2 Inspect the water level in atmospheric storage tanks weekly if the water source is not equipped with a supervised water-level alarm. Inspect monthly if the water source is equipped with a supervisory water-level alarm that has been tested (with satisfactory performance) at least annually. Suction, break, and gravity tanks are usually considered full when the water level is near the bottom of the overflow pipe inlet. However, a greater distance below the overflow pipe may be required in FM Global 50-year through 500-year earthquake zones to provide the necessary freeboard to accommodate water sloshing during a seismic event.

2.10.1.3 Inspect, test, and maintain tank heating systems per the following:

A. Flush out the water-circulating pipe and heater in the autumn before the heating season starts, and monthly during the heating season. After the first monthly flushing during the heating season, increase (to not more than two months) or decrease the flushing time interval depending on the rate of sedimentation. After flushing, make sure all valves are wide open, the drain valve closed, and the tank filled. If the tank level is checked by overflowing, do not let ice form on the tank or tower.

B. In the autumn before the heating season starts, test the tank heating system; check the accuracy of thermometers, pressure gauges, and low-water-temperature alarms, as well as the adjustment of relief valves, steam regulators, pressure-reducing valves, thermostats, and safety pilots.

C. At the end of the heating season, clean and overhaul heaters, traps, strainers, and other accessories as necessary. Take apart and renew gaskets of steam, electric, and hot water heaters. Wire brush the steel or iron heating surfaces of coal, fuel oil, or gas-fired heaters and coat them with oil. Follow the manufacturer's instructions regarding lubrication. Have gas- or oil-fired heaters serviced and inspected by a service organization during the summer.

D. Every five years, or at the interval recommended by the manufacturer, perform major inspection and maintenance on heaters, steam coils, etc. (e.g., clean pipes, replace badly corroded pipe) per the manufacturer's specifications.

2.10.1.4 Perform a thorough visual inspection of water storage tank interiors at an interval not exceeding five years. More frequent inspection may be necessary under certain conditions (e.g., a tank interior is not protected by coatings or a liner, paint is exposed to unusually corrosive water or atmospheric conditions, the 5-year inspection indicates deterioration of the tank interior is occurring, or liners or fabric tanks are nearing the end of their useful life).

Look for signs of debris, pitting, corrosion, spalling, rot, coating failure, liner or fabric tank weakness/failure, failure or water saturation of insulation, aquatic growth, etc. Inspect interior piping, anti-vortex plates, heater elements, ladders, etc. Inspect tank floors for evidence of voids beneath or leakage.

Perform at least every other inspection (i.e., at ten-year intervals) by draining the tank. Whenever the tank is to be drained, restrain the empty tank as necessary to resist wind forces (if wind anchorage is not provided). The inspection between these drained-tank inspections can be made by sending in a diver or remote-controlled submersible with a camera if the tank can be adequately assessed using these methods. Drain tanks that have internal heat exchangers to facilitate servicing those items.

Clean the tank interior and repair any deterioration as necessary. For steel tanks, if warranted by the visual inspection, determine the remaining dry film thickness on tank interior surfaces and/or expand the inspection to include nondestructive examination (e.g., ultrasonic testing) to evaluate for thinning of the tank walls. Repaint/recoat the tank interior if needed to prevent corrosion. Replace interior liners and insulation if required.

2.11 Special Protection Systems

2.11.1 Gaseous and Dry Chemical

2.11.1.1 For gaseous (clean agent, halon, CO_2) and dry chemical systems, conduct the ITM activities listed in Table 9a.

Table 9a. Gaseous and Dry Chemical Systems

ID	*Recommendation*	*Frequency*	*Detail Frequency or Scope*
1	Inspect, test, and exercise control valves.	Per Table 1.	Per Table 1.
2	Inspect the control panels.	Weekly	Verify control panels are: - Powered on. - In the "normal-ready" state. - In automatic mode. - No trouble or supervisory alarms. - Panel doors shut and locked.
3	Inspect automatic and manual initiating devices (i.e., fire detectors and pull stations).	Weekly	Verify automatic and manual initiating devices are: - In position. - Clear of obstructions including residues or deposits. - Appear to be undamaged.

4	Visually inspect extinguishing agent and expellant-gas storage containers.	Weekly	- Verify the extinguishing agent and expellant-gas storage containers are:
			  - Restrained
			  - Undamaged
			  - Full
			- Refill or replace containers of:
			  - Halocarbon clean agent if they show a weight loss of more than 5%, or loss in pressure (adjusted for temperature) of more than 10%.
			  - Inert gas clean agent, Halon, CO_2, or dry chemical if they show a loss in pressure (adjusted for temperature) of more than 5%.

5	Inspect release devices (actuators).	Weekly	Verify that release devices (actuators) are: - Attached to storage containers and piping. - In service (e.g., solenoid coils attached to solenoid-operated valves).
6	Inspect nozzles.	Weekly	Verify nozzles are: - Oriented properly. - Clear of obstructions, including residues or deposits. - Protective caps where needed are in place and operable.
7	Inspect protected areas.	Weekly	Verify protected areas or enclosures do not have: - Changes in occupancy/hazard. - Changes in the room envelope such as holes/penetrations. - Signs of recent or impending construction/alterations. - Other negative conditions that could render the special protection system ineffective.

Table 9a. Gaseous and Dry Chemical Systems (continued)

ID	*Recommendation*	*Frequency*	*Detail*
8	Test all operating components of the system exclusive of a full-discharge.	Annually	- Inspect and test all actuating, operating devices and alarms in accordance with the system manufacturer's DIOM. - Trip each automatic and manual initiating device (e.g., detectors and pull stations) and verify proper operation. - Local notification devices activate (e.g., bell, horn, and/or strobe). - Discharge and supervisory alarms register on remote fire alarm control panels in constantly attended locations or at central alarm monitoring stations. - Verify backup power supplies used to actuate systems (per Data Sheet 5-48). - Verify building and/or process fire-safe interlocks initiated by system discharge alarms.
9	Hydrostatically test flexible hoses conveying compressed gas extinguishing agent or expellant.	Every 5 years	
10	After discharge, inspect, hydrostatically test, and recharge pressurized extinguishing agent containers and/or pressurized expellant gas containers.	After 5 years of service, and prior to recharge	
11	Hydrostatically test system components.	Every 12 years	- Remove from service, inspect, perform hydrostatic test, and recharge pressurized extinguishing agent containers, and/or pressurized expellant gas containers. - Hydrostatically test, to the manufacturer's pressure specification, all of the following: - Dry chemical containers - Gaseous extinguishing agent - containers - Auxiliary pressure containers - Valve assemblies - Hoses and fittings - Check valves - Directional valves - Manifolds - Hoses
12	Check dry chemical agent stored in non-pressurized containers for free-flowing condition (no lumps).	Annually	
13	Check dry chemical agent stored in pressurized containers for free-flowing condition (no lumps).	Every 6 years	
14	Replace dry chemical extinguishing agent.	Every 12 years	
15	Purge dry chemical agent from all system piping and any hose lines.	After every system activation	

2.11.2 Water Mist System

2.11.2.1 For water mist systems, conduct the ITM activities listed in Table 9b.

Table 9b. Water Mist Systems

ID	Recommendation	Frequency	Details
1	Inspect, test, and exercise control valves.	Per Table 1.	Per Table 1.
2	Inspect and test the fire pump in automatic mode via pressure drop or waterflow alarm and allow the pump to churn, reaching normal operating conditions.	Per Table 7 for occupancy protection. Semiannually for equipment protection.	Per Table 7.
3	Inspect pneumatically operated standby pumps.	Varies	Per the manufacturer's DIOM.
4	Inspect the pump room for satisfactory conditions.	Weekly	Per 2.9.1.4.
5	Conduct an operational test of the water mist system.	Annually	Per 2.11.2.2.
6	Conduct a test of all hoses.	5 years	- Test all hose at 1-1/2 times the maximum container pressure at 130°F (54.4°C). Apply pressure at a rate-of-pressure rise to reach the test pressure within 1 minute. Maintain the test pressure for 1 full minute. - Observe and note any distortion or leakage. - Remove from service any hose that has failed testing. - Mark each hose assembly passing the hydrostatic test to show the date of test.
7	Inspect automatic and open nozzles.	Annually or more frequently based on the operating environment	Per 2.5.1.5.
8	Investigate systems for obstructive debris.	Every 5 years	- Perform a videoscope or ultrasonic localized guided wave evaluation of system piping and remove and inspect system nozzles. - Clean and retest piping and nozzles where obstructions occur.
9	Remove and inspect all nozzles for debris.	After every system activation	- Perform a videoscope or ultrasonic localized guided wave evaluation of system piping and remove and inspect system nozzles. - Clean and retest piping and nozzles where obstructions occur.
10	Inspect the interior of the tank.	Every 5 years (or more frequently if warranted)	Per Table 8.
11	Test a sample of in-service stored water prior to draining water storage tanks.	Annually	- Analyze the water sample for composition to ensure it meets the manufacturer's DIOM manual. - If water quality is found to be unacceptable, a full tank or water source inspection may be warranted.
12	Verify the water supply and fire service mains can meet system demands at base of system riser.	Annually	
13	Inspect and clean supply strainers and filters.	Annually	

Table 9b. Water Mist Systems (continued)

ID	*Recommendation*	*Frequency*	*Details*
14	Inspect, clean, and/or replace supply and system filters and strainers per the manufacturer's DIOM manual.	After Every System Activation	
15	Check preaction system air pressure and/or twin-fluid system compressed gas pressure.	Weekly	
16	Visually inspect the storage cylinder for external corrosion or damage.	Quarterly	
17	Visually inspect all compressed gas cylinders continuously in service without having been discharged.	Every 5 years, or more frequently if required.	- Visually inspect cylinders in accordance with Section 3 of the Compressed Gas Association, C-6, Standard for Visual Inspection of Steel Compressed Gas Cylinders. - The cylinders do not need to be emptied or stamped while under pressure. - Record all results.
18	Hydrostatically test pressurized cylinders.	Every 5 to 12 years	- Hydrostatically test cylinders before recharge if more than 5 years has elapsed from the date of the last test. - Discharge and hydrostatically test cylinders that have been in continuous service at 12-year intervals or in accordance with the manufacturer's DIOM manual.
19	Inspect system piping, hoses, tubing, fittings, hangers, braces, supports, pneumatic cylinder valves, and all cylinder mounting brackets to ensure they are securely fastened. Replace or refasten as needed.	Semiannually and after each system activation	
20	Visually inspect the cylinder, cylinder pressure and control valves to confirm they are in the proper position per the manufacturer's specifications.	Weekly	
21	Test control panels, fire detectors, and backup power supplies used to actuate system valves per Data Sheet 5-40 and 5-48.	Varies	
22	Check the condition of the compressed air supply.	Monthly	
23	Inspect the enclosure to ensure compliance with the original design.	Annually	
24	Test to confirm operation of all interlocks, including ventilation, fuel or lubrication systems, dampers, and door closures.	Annually	

2.11.2.2 Water Mist Operational Testing

2.11.2.2.1 Conduct an operational test from a test connection with an orifice equivalent to the friction loss for the total number of nozzles. In lieu of a test connection, an operational test can be conducted through the distribution piping and nozzles.

A. Observe the water discharge patterns from all the open water mist nozzles to ensure patterns are not impeded by plugged nozzles, nozzles are correctly positioned, and obstructions do not prevent discharge patterns from fully developing.

B. Where the nature of the protected property is such that water cannot be discharged, inspect the nozzles for proper orientation and test the system pneumatically (e.g., compressed air or inert gas) to ensure the nozzles are not plugged.

C. Conduct operational testing of pneumatic and electric solenoid valves (i.e., slave valves, valves intended to cycle on-off) both automatically and manually in accordance with the manufacturer's DIOM manual.

D. Verify that gauges are operable and not physically damaged.

2.11.2.2.2 Operate the detection system under test conditions:

- Record response times.
- Compare response times with those from the acceptance test.

2.11.2.2.3 Record pressure readings at the hydraulically most remote nozzle or test connection to ensure the waterflow has not been impeded by partially closed valves or by plugged strainers or piping. For water mist systems with a deluge valve, record a second pressure reading at the deluge valve to ensure the water supply is adequate. Compare readings 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. Where the hydraulically most remote nozzle is inaccessible, visually inspect nozzles without taking a pressure reading on the most remote nozzle. Where the reading taken at the riser indicates the water supply has deteriorated, place a gauge on the hydraulically most remote nozzle and compare the results with the required design pressure.

2.11.2.2.4 Simultaneously test the maximum number of systems expected to operate in case of fire to inspect the adequacy of the water supply.

2.11.2.2.5 After the operational test, return the water mist system to service in accordance with the manufacturer's DIOM manual.

2.11.3 Foam Systems

2.11.3.1 For foam systems, conduct the ITM activities listed in Table 9c.

Table 9c. Foam Sytems

ID	*Recommendation*	*Frequency*	*Details*
1	Inspect, test, and exercise control valves.	Per Table 1.	Per Table 1.
2	Inspect system sprinklers, piping, pipe support, and seismic protection for damage and/or other poor conditions.	Annually, or more frequently based on the operating environment (see 2.5.1.5.2)	See 2.5.1.5.
3	Start the foam concentrate pump in automatic mode and allow the pump to run with no system flow.	Weekly	Per Table 7.
4	Verify the foam concentrate pump is in service and operable with satisfactory pump room conditions.	Per Table 7.	Per Table 7.
5	Exercise water-driven positive-displacement proportioner pumps.	Monthly	
6	Verify the integrity of the bladder in the bladder tank against foam concentrate leakage.	Annually	Obtain a sample of water from between the tank wall and bladder, and determine if foam concentrate is present (i.e., an indication that the bladder may be leaking). Refer to the manufacturer's documentation for procedures on obtaining a sample and determining if foam concentrate is present in the tank wall water.
7	Test the automatic foam concentrate control valve.	Semiannually	
8	Inspect and clean system water strainers and filters, and foam concentrate strainers.	Annually	
9	Test a sample of in-service foam concentrate.	Annually	- Test foam concentrate for the following parameters: - appearance - stratification/sediment - refractive index - pH - density - viscosity - Consult the foam concentrate manufacturer's literature for any additional parameters to evaluate. - Compare the test results to the permissible ranges allowed by the foam concentrate manufacturer. - Trend results from each test to evaluate for degrading performance.
10	Investigate foam concentrate supplied by black steel piping for obstructive deposits.	Annually	- Investigate piping for: - Concentrate coagulation (degraded, semi-solid buildups) - Tubercles on walls of non-corrosion-resistant piping (e.g., black steel) - Replace piping that shows any obstructions or degradation with brass or stainless-steel piping.

Table 9c. Foam Sytems (continued)

ID	Recommendation	Frequency	Details
11	Test the foam concentrate proportioning system at the minimum and maximum flow for the demand area in the acceptance test.	Annually	Discharge test foam-concentrate proportioning systems across the flow range points (minimum proportioning flow, maximum hydraulic demands of downstream fire protection systems). See Data Sheet 4-12 for pass/fail proportioner results. Alternatives to flowing foam-water solution are discharge test methods, which include the following: - A water-equivalency method may be used if a baseline flow testing of foam-water solution and correlating water readings were completed at system acceptance. - A test liquid method may be used if the test liquid has been assessed as a surrogate for the foam concentrate. - FM Approved flowmeters can be used for the foam concentrate and water to calculate the percent injection for the water driven positive displacement foam concentrate portioning pump
12	Investigate systems with pre-primed foam-water solution for obstructive debris, including sediment accumulations.	Every 3 years	
13	Test discharge devices.	Semiannually	Test the following discharge devices: - High-expansion foam generators: Visually inspect foam generators for obstructions to the air inlets and impairment to moving parts. Test operability of louvers and dampers to allow for air flow to the high expansion foam generator(s). - Floor-level discharge devices: Visually inspect floor-level discharge devices (e.g., grate nozzles) for permanent obstructions and debris. - Monitors: Visually inspect monitors for permanent obstructions.
14	Inspect and clean system water strainers and filters.	After every system activation	
15	Purge foam concentrate and foam-water solution from system piping.	After every system activation	

2.12 Preventing Freeze-Up in Fire Protection Systems

2.12.1 Administrating the Freeze-Up Prevention Program

2.12.1.1 Develop a policy to prevent fire protection system freeze-ups.

2.12.1.2 Implement the policy in accordance with Section 2.2.

2.12.1.3 Implement precautions to prevent freeze-up in accordance with Tables 10a and 10b, and Data Sheet 9-18, Prevention of Freeze-Ups.

2.12.1.4 Schedule routine fire protection system ITM activities that involve waterflow (e.g., sprinkler system waterflow alarm testing) prior to and/or after periods of extreme cold, or when warm spells occur during the heating season. Water discharge during freezing temperatures can create hazardous work conditions for personnel depending on site conditions, while water can also freeze and damage piping or equipment (e.g., water motor gongs).

2.12.2 Freeze-Up Prevention During the Heating Season

2.12.2.1 During the heating season, conduct the ITM activities listed in Table 10a.

Table 10a. Prior To, During, and Following the Heating Season

ID	*Recommendation*	*Frequency*	*Details*
1	Disassemble, inspect, and clean accessible water storage tank heating system components.	Annually (following season)	- Dismantle and clean heaters, traps, strainers, and other accessories accessible from outside water storage tanks. - Clean furnace heat transfer surfaces within fuel-fired heaters. - Maintain heating systems in accordance with manufacturer guidelines.
2	Inspect and test fuel-fired water storage tank heater burners and fuel-train safeguards.	Annually (following season)	
3	Check enclosures containing system valves, fire pumps, and other wet-piping for proper insulation; weather sealing around enclosure penetrations; and in-service and operable heating systems.	Annually (prior to season)	
4	Check compressed air supply to dry, preaction, and deluge systems for condensate when supply piping runs outside heated enclosures.	Annually (prior to season)	
5	Check dry-barrel fire hydrants for trapped water.	After testing and prior to season	
6	Check insulation on the water storage tank, suction line, and refill line.	Annually (prior to season)	
7	Flush water storage tank circulation heater and associated piping.	Annually (prior to season)	
8	Test water storage tank and heating system temperature indicators, supervisory alarms, and heater controls.	Annually (prior to season)	
9	Test accessible water storage tank heating system components.	Annually (prior to season)	
10	Disassemble, inspect, and clean heaters, heat exchangers, and associated piping within water storage tanks.	Every 5 years (during internal tank inspection)	
11	Maintain an equipment log of fuel-fired heating systems for water storage tanks.	Daily (during the season)	
12	Check water storage tanks for in-service heating systems, and verify the tank, suction line, and fill line are maintained above 40°F (5°C).	Weekly (during the season)	
13	Check open water sources for in-service heating systems, if installed, and verify the suction line is maintained above 40°F (5°C), the suction inlet extends below the freeze line, and a vacuum breaker is maintained within the ice.	Weekly (during the season)	
14	Check enclosures containing system valves, fire pump rooms, and/or other wet-piping for in-service heating systems, and verify enclosures are maintained above 40°F (5°C).	Weekly (during the season)	
15	Verify fire pump diesel engine is maintained above 90°F (32°C).	Weekly (during the season)	
16	Purge condensate from dry and preaction system low-point/auxiliary drains.	Monthly (during the season)	
17	Flush water storage tank circulation heaters and associated piping.	Monthly (during the season)	

2.12.3 Freeze-Up Prevention During Periods of Extreme Cold

2.12.3.1 If the facility is exposed to periods of extreme cold, conduct the ITM activities listed in Table 10b. Extreme cold can be defined as temperatures 20°F (11°C) below normal low temperatures for more than a week.

Table 10b. Prior To and During Periods of Extreme Cold

ID	*Recommendation*	*Frequency*	*Details Frequency or Scope*
1	Evaluate if water-filled equipment or piping require additional freeze protection.	Prior to	Inspect the following to determine if additional freeze protection is warranted: - System riser enclosures - Pump rooms - Water storage tanks - Wet-pits - Exposed pipe runs
2	Develop a plan to maintain the diesel fire pump engine above 90°F (32°C) upon loss of electrical power.	Prior to	
3	Purge condensate from dry and preaction system low-point/auxiliary drains.	Prior to	
4	Check bar-racks and screens for ice blockage at the wet-pit intake.	Daily (during)	
5	Check the wet-pit to ensure the suction inlet extends below the freeze line.	Daily (during)	
6	Check the wet-pit to ensure a vacuum breaker is being maintained through the ice.	Daily (during)	
7	Check water storage tanks for in-service heating systems, and verify the tank, suction line, and fill line are maintained above 40°F (5°C).	Daily (during)	
8	Check for ice buildup in suction lines and water storage tank fill lines by flowing water.	Daily (during)	
9	Check enclosures containing system valves, fire pump rooms, and/or other wet-piping for in-service heating systems, and verify enclosures are maintained above 40°F (5°C).	Daily (during)	
10	Verify fire pump diesel engine is maintained above 90°F (32°C).	Daily (during)	
11	Purge condensate from dry and preaction system low-point/auxiliary drains.	Daily (during)	
12	Check for ice formation in fire service mains by conducting main-drain testing.	Weekly (during)	
13	Check for accessibility of hydrants, hose houses, and monitor nozzles (snow removal during winter).	Weekly (during)	

3.0 SUPPORT FOR RECOMMENDATIONS

3.1 Supplemental Information

3.1.1 Control Valve

In order for most fire protection systems to function adequately, control valves must be in the full-open position. A partially or completely closed control valve will likely prevent a fire protection system from effectively controlling a fire.

A control valve may be closed for well-intentioned reasons, such as maintenance, repairs/alterations, or during an emergency; or malicious ones, such as arson or incendiarism. In either case, safeguards should be in place to prevent unauthorized valve closures, and to ensure valves are promptly reopened after any work is completed.

To protect against arson, securing access to or manipulation of control valves remains the best defense, while implementing an impairment management program is the best way to prevent valves unknowingly being left closed after work or repairs have been completed. (For guidance on preventing improperly closed valves (ICVs), see Data Sheet 10-7, *Impairment Management*.) However, FM Global loss history involving ICVs shows that an impairment management program alone is not enough. Additional safeguards should be put in place to help prevent ICVs, including visual inspections and physical testing of control valves and supervisory alarms (tamper switches). A combination of impairment management, inspection and testing, and supervisory alarms can help reduce the likelihood of an ICV and the consequences of a large shut-valve fire.

3.1.1.1 Securement

Securement is intended to limit control valve access. When left unsecured or poorly secured, arsonists can disable fire protection systems by closing control valves and then setting fires in the now unprotected area. FM Global loss history indicates would-be arsonists can include the general public, disgruntled employees, and contractors. Restricting control valve access to individuals responsible for fire protection system ITM will help ensure fire protection systems remain in-service to defend against arson.

The preferred method for securing control valves is to install a sturdy, dedicated lock and chain on each valve in a manner that prohibits valve operator access and manipulation without heavy-duty tools.

3.1.1.2 Accessibility

Control valves should remain accessible for inspection and use during emergencies. Interior control valves may become inaccessible as interior furniture, work-in-process on a production floor, warehouse stock, or other moveable objects shift during normal operations at a facility or construction projects. To prevent blocking access, control valves should be clearly marked with signs or stripping, or protected with physical barriers such as guard-rails.

Exterior control valves are prone to similar accessibility concerns as interior valves in addition to a few hazards specific to them. In cold climates, snow removal efforts can block or cover valves, while roadway resurfacing or debris such as dirt and gravel can conceal curb-box/road-way valve covers. To help personnel maintain access, control valves should be clearly marked and, if warranted, provided with free-standing signs or poles to help identify valve locations and alert personnel to remove obstructions.

3.1.2 Valve Inspections

Even with an impairment management program in place and supervisory alarms installed on valve operators, long-duration ICVs still occur. The last line of defense against an ICV remains visual inspection and physical testing.

At most facilities, fire protection systems are not subject to regular use (operation or manipulation), not readily visible, and when visible, typically foreign to most building occupants.

Lack of regular control valve manipulation (closures) may be considered a positive quality given it reduces the chance a valve could be mistakenly left closed. However, valve closures do occur for various reasons. During these infrequent closures, personnel may be in a rush during an emergency (after the system has controlled a fire), or unfamiliar with the impairment management program. In either case, the impairment management program may fail to be implemented or precautions inadequately followed, resulting in an ICV.

The likelihood of a passer-by recognizing an ICV by chance is low, with fire protection control valves often hidden from sight and the inability of most building occupants to recognize a closed valve or other system abnormality.

In order to function reliably, supervisory alarms must be installed and adjusted properly, made tamper-resistant, tested periodically, and supervisory alarm signals not ignored. FM Global's ICV loss history indicates supervisory alarm systems do not always meet these guidelines.

Visual inspection verifies that most control valves are full-open as well as secured and accessible.

Physical testing is warranted on control valves where the position indicator is not intrinsic or reliably connected to the valve gate or disc, or where an external position indicator is not provided. These valves require visual inspection as well as less frequent physical testing to verify full-open position.

3.1.2.1 Physical Valve Testing

The lack of a position indicator (or the existence of an unreliable position indicator) warrants the valve full-open position to be verified by closing the valve two to three turns, then fully reopening the valve until resistance is felt in the valve operator at the end-of-travel.

Physically inspecting a valve includes the following steps: (1) unlocking the valve; (2) turning the handwheel or wrench in the full-open position direction; (3) turning in the closed direction three turns to ensure operable condition; (4) then a return to the full open position; (5) backing off approximately one-quarter turn to relieve the strain; and (6) relocking the valve.

If electronic valve supervision is provided, make arrangements to verify the tamper switch is operating properly during the physical inspection. Ensure that tamper switches operate when the valve is turned down a maximum of three turns.

When testing indicator posts, the "spring" or torsion of the rod will be felt when an attempt is made to turn it beyond the wide-open position. The spring may not be felt in older gate valves or gate valves left at end-of-travel for long periods (rather than backed-off a quarter turn from end-of-travel). The internal valve components can lose their elasticity or spring-feel, resulting in a hard stop at end-of-travel. In this case, apply sufficient force to ensure the gate is attached to the stem and in the full-open position.

Post indicator valve assemblies (PIVA), indicating butterfly valves (IBV), and outside screw and yoke (OS&Y) valves have fail-safe open position indicators, so they need to be physically tried only if there is doubt of their operable condition. Visual inspections are still necessary.

CAUTION: Do not spring-test butterfly valves because the end-of-travel is typically met with a hard stop and, if additional force is applied, may damage the valve operating mechanism.

At least once a year, operate all sprinkler control valves the full travel of their mechanisms to make sure they can be operated easily when necessary.

Maintain a record of the number of turns required to operate each valve from the full-open to full-shut position. This is valuable in determining whether a valve has "stuck" partially open.

After valves have been operated, relock them in the wide-open position and perform a drain test (see Section 2.5.1.3, Main-Drain Testing).

3.1.2.2 Valve Inspection Form

The valve inspection form is the basic guide for the person who makes each inspection. Ensure the form is complete and designed for the specific facility. It is essential that the inspector carry the form and use it as a checklist, filling it in as rounds are made rather than from memory after the inspection is completed. This procedure encourages thorough, conscientious inspections and avoids errors and omissions. At small facilities (one or two risers), the valve inspection form may be a tag attached to the valve or a placard on the wall near the valve.

A good valve inspection form lists each fire system control valve requiring inspection (including its number). Indicate the valve location and the area each valve controls, and provide space for recording whether the valve is open, shut, locked, or sealed. Provide space on the form for signatures of the valve inspector and the facility manager responsible for taking action to correct any deficiencies.

3.1.2.3 Valve Marking and Identification

Number the fire system control valves for identification and inspection purposes, and provide a sign indicating the sprinkler/fire protection systems or water supplies they control. Clearly mark the valves with the direction to open. If not marked by the valve manufacturer, paint the direction of opening on the valve, or on a nearby sign. For underground valves, the marking may be painted on the roadway box or on the sign describing what the valve controls. Post signs indicating distance and direction to curb box valves for locating under ice and snow.

3.1.2.4 Supervision of Valves

Central station supervision of valves definitely of value, but it is not a substitute for regular valve inspections.

Supervisory alarm systems do not prevent malicious tampering of control valves, but do detect and notify when a valve has been tampered with (i.e., typically within 2-3 turns toward the closed position). In order for a supervisory alarm to defend against malicious tampering during an arson fire, the supervisory alarm system itself must be tamper-resistant, while tamper alarm signals must be monitored and responded to by onsite personnel. The following is a list of supervisory alarm system considerations:

A. The supervisory device must be properly installed with tamper-resistant mounting and cover hardware.

B. The supervisory device cover must be monitored to alarm when removed.

C. The supervisory alarm signal must be monitored by the fire alarm control panel for device connectivity and health (periodic device polling).

D. The supervisory alarm signals must be monitored. Onsite monitoring is preferable at a constantly attended station such as a boiler house or guard shack to facilitate a prompt and reliable response.

E. A tamper response plan must be in place to investigate a supervisory alarm.

F. The supervisory alarm system must receive periodic testing to help ensure reliable operation.

Supervisory alarm systems are helpful at detecting control valves unknowingly left closed. However, the supervisory alarm system must receive periodic testing to help ensure the system remains in reliable operation.

Jumping a supervisory alarm should be avoided whenever possible. If unavoidable, an impairment management program should be implemented to ensure the alarm is returned to service upon completion of any corrective action.

3.1.2.5 Supervisory Alarms

Supervisory alarm systems do not prevent malicious tampering of control valves but do detect and notify when a valve has been tampered with (typically within 2 turns toward the closed position). In order for a supervisory alarm to defend against malicious tampering during an arson or other fire event, the supervisory alarm system itself must be tamper resistant. There are now two levels of FM Approved tamper resistance and reliability available in supervisory systems: Standard security and enhanced security. The supervisory alarm system itself must be tamper resistant, while tamper alarm signals must be monitored and responded to by onsite personnel. The following is a list of supervisory alarm system considerations for the two levels of security.

A. Standard Security Supervisory Device

- Should be of limited access such that specialized mechanical fasteners and tools are required for access to the field wiring terminations or interior of the device, or where removal of the cover results in a trouble or supervisory condition being communicated to the fire alarm control panel (FACP).

B. Enhanced Security Supervisory Device

- Should be arranged so that removal of the method of access to the field wiring terminations or the interior of the device results in a trouble or supervisory condition being communicated to the FACP.

- Should be arranged so that removal of the supervisory device from the valve to the extent that its monitoring capability is adversely affected results in a trouble or supervisory condition being communicated to the FACP.

- Should provide visual indication at the supervisory device when the device senses an off-normal valve condition, to facilitate quick identification of the off-normal condition. The visual indication should not be extinguished but latched on when the valve is restored to its normal condition and only extinguished and reset after the alarm is acknowledged at the FACP. For applications where each supervisory device can be identified individually by the FACP with an addressable interface, this indication is not required.

C. Smart Valve Monitor

- Where security of fire protection control valves or process control valves is paramount, and/or for large buildings, campuses, and processing sites, the coupling of FM Approved enhanced security supervisory devices (valve monitors) with FM Approved Wi-Fi devices and associated systems provides superior supervision of critical valves, as well as significant cost savings (eliminates costly hard wiring).

3.1.2.6 Common Valve Problem Troubleshooting

Common valve troubles requiring immediate attention are as follows:

A. Indicator posts may become inoperative from corrosion or freezing due to a leaking valve. They also may be broken from frost action or from being struck by vehicles.

B. Indicator post targets may be improperly adjusted and prevent full valve travel. Targets also may be accidentally adjusted to read OPEN when valves are closed.

C. Directional arrows on indicator post heads may have two points or may have the wrong point chiseled off.

D. Valve gates can become separated from the operating stems by corrosion or by excessive strain when forced in either direction against obstruction, heavy deposits, or friction.

3.1.3 Fire Protection System Obstructions

3.1.3.1 Obstruction Sources

A. Pipe Scale

Dry-pipe sprinkler systems are involved in the majority of obstructed sprinkler systems. Pipe scale was found to be the most frequent obstructing material. Dry-pipe systems that have been maintained wet or dry alternately over a period of years are particularly susceptible to the accumulation of scale. Also, in systems there are continuously dry, condensation of moisture in the air supply may result in the formation of a hard scale 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.

B. 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 are some materials that have been found as obstructions. In some instances, with welded sprinkler systems and systems with cut holes for quick connect fittings, the cutout disks or coupons have been left inside the piping, obstructing flow to sprinklers.

C. Raw Water Sources

Materials may be sucked up from the bottoms of rivers, ponds or open reservoirs by fire pumps with poorly arranged or inadequately screened intakes and 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. These materials can obstruct piping as well as accumulate in the orifices of pendent sprinklers.

D. Biological Growth

Biological growth has been known to cause obstructions in sprinkler piping. Data Sheet 2-1, *Corrosion in Automatic Sprinkler Systems*, covers the topic in detail.

E. Sprinkler Calcium Carbonate Deposits

Natural fresh water contains dissolved calcium and magnesium salts in varying concentrations, depending on source and location of the water. If the concentration of these salts is high, the water is called “hard.” A thin film composed largely of calcium carbonate, CaCO3, affords some protection against corrosion when hard water flows through the pipes. However, hardness alone is not the only factor to determine whether a film forms. Ability of CaCO3 to precipitate on the metal pipe surface also depends on the total acidity or alkalinity, the concentration of dissolved solids in the water and the pH. In “soft” waters, 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, copper, just as corrosion will affect the less noble metal, iron.

Consequently, scale formation naturally forms on sprinklers often plugging the orifice. The piping may be relatively clear. This type of sprinkler obstruction cannot be detected or corrected by normal flushing procedures. It can only be found by removal and inspection of sprinklers in suspected areas.

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 very hard water areas.

3.1.3.2 Obstruction Investigation Procedure

Conduct investigations to determine the extent and severity of obstructing material. From the fire protection system plan, determine water supply sources, age of 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 needed, have the suction cleaned before using the pump in tests and flushing operations. Inspect suction tanks internally. Determine whether loose scale is on the interior shell, or if sludge or other obstructions are on the tank bottom. Cleaning and repainting may be in order, particularly if it has not been done within the past five years.

There are several ways to investigate obstructions in the sprinkler system piping:

- Flushing investigation
- Videoscope inspection
- Ultrasonic localized guided wave evaluation

3.1.3.2.1 Flushing Investigation

A. Investigate Yard Mains

Flow through yard hydrants, preferably near the extremes of selected mains, to determine whether mains contain obstructive material. Preferably, connect two lengths of 2-1/2 in. (64 mm) hose to the hydrant. Attach burlap bags to 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 sources of water supply, investigate each independently, avoiding any unnecessary interruptions to sprinkler protection. On extensive yard layouts, repeat the tests at several locations, if necessary, to determine general conditions.

If obstructive material is found, thoroughly flush all mains before investigating sprinkler systems.

B. Investigate Sprinkler Systems

Investigate dry systems first. Tests on several carefully selected, representative systems usually are sufficient to indicate general conditions throughout the facility. If, however, preliminary investigations indicate obstructing material, this would justify investigating all systems (both wet and dry) before outlining needed flushing operations. Generally, the system can be considered reasonably free of obstructing material if (a) less than 1/2 cup of scale is washed from the crossmains, (b) scale fragments are not large enough to plug a sprinkler orifice, and (c) a full unobstructed flow is obtained from each branch line checked. When other types of foreign material are found, judgment is needed when determining whether the system is unobstructed. Obstruction potential is based on the physical characteristics and source of the foreign material.

Applying guidelines for determining whether the system is free from obstructing material is often a judgment based on the actual physical evidence obtained. Base the analysis on whether there appears to be sufficient material of sufficient size that could obstruct the flow of water through smaller branch lines and sprinklers.

In selecting specific systems or branch lines for investigating, consider the following:

- Lines found obstructed during a fire or during maintenance work.
- Systems adjacent to points of recent repair to yard mains, particularly if hydrant flow shows material in the main.

Include test flows through 2-1/2 in. (64 mm) fire hose directly from cross mains and flows through 1-1/2 in. (38 mm) hose from representative branch lines. Two or three branch lines per system is considered a representative number of branch lines when investigating for scale accumulation. If significant scale is found, investigate additional branch lines. When 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 the facility has a fire pump, ensure that it is in operation for all flows. Use burlap bags or equivalent to collect dislodged material as is done in the investigation of yard mains. Continue each flow until the water clears. Allow a minimum of 2 to 3 minutes at full flow for sprinkler mains.

1. Dry Pipe Systems

Flood dry-pipe systems one or two days before obstruction investigations to soften pipe scale and deposits. Having selected the test points of a dry-pipe system, close the main control valve and release air from the system. Check the piping visually with a flashlight while it is being dismantled. Attach hose valves and 1-1/2 in. (38 mm) hose to ends of lines to be tested, shut these valves and have air pressure restored on the system and the control valve reopened. Open the hose valve on the end branch line allowing the system to trip in simulation of normal action. Clear any obstructions 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 2-1/2 in. (64 mm) fire hose, collecting any foreign material in a burlap bag.

After the test, internally clean and reset the dry-pipe valve. Lock its control valve open and conduct a drain test.

2. Wet Pipe Systems

Testing wet systems is similar to testing dry systems except the system must be drained after closing the control valve to permit the installation of hose valves for the test. Slowly reopen the control valve and make a small hose flow as prescribed for the branch line, followed by the 2-1/2 in. (64 mm) hose flow for the cross main.

In any case, if lines become plugged during the tests, piping must be dismantled and cleaned, the extent of plugging noted and a clear flow obtained from the branch line before proceeding further.

Make similar tests on representative systems to indicate the general condition of the wet systems throughout the facility, keeping a detailed record of what is done.

3. Videoscope Inspection

An advantage to this technique is that it allows an investigation during cold weather, and if the results are not satisfactory, can indicate a direct need for full flushing without having to go through a flushing investigation during cold weather. Use of videoscopic techniques can result in time savings when used in an appropriate fashion.

The skill of the operator of the video scope equipment is definitely a factor in the final conclusions drawn. Experience in the traditional flushing investigation method is essential in selection of test points and in determining the number of representative points. When comparisons are made between the video image and the debris collected from the burlap bag, a mapping is created. After several systems are evaluated, this mapping becomes more evident. Without the prior knowledge of the traditional investigation method, it would be difficult to draw any comparison.

There may be cases that arise where a conclusion cannot be made based on video scope examination alone. The video scope method is most useful when the condition of the pipe is definitely bad or definitely good. In those cases, where the conclusion can not be reached, conduct a traditional flushing investigation.

4. Ultrasonic Localized Guided Wave Evaluation

The ultrasonic localized guided wave (ULGW) evaluation method uses a harmless ultrasonic pulse that is driven around the pipe wall to determine the presence and severity of internal pipe integrity issues such as obstruction (corrosion, ice), pitting, trapped air, and water pockets. ULGW is a low-risk inspection method that is more comprehensive than traditional ultrasonic thickness testing and is safe to use near sensitive equipment, fragile assets, food, and people.

While leaving the system operational, an ultrasonic wave is driven into the wall of the pipe by simply touching the ULGW probe to the pipe wall. The shape and magnitude of each resulting wave will be altered by internal conditions and captured in a database. Once all data points are collected and compiled through software, the waves are compared to baseline waves for a pristine pipe to determine internal pipe condition at each test location.

3.1.3.3 Flushing Procedure

If investigation indicates the presence of sufficient material to obstruct sprinklers, conduct a complete system flushing program. The work may be done either by qualified sprinkler contractors or by competent facility personnel. Determine the sources of the obstructing material and take steps to prevent further entrance of such material. This entails such work 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, request waterworks authorities to flush their system.

A. Yard Mains

Thoroughly flush yard mains before flushing any interior piping. With new installations, conduct flushing before connecting to sprinkler systems. 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/s (3 m/s) is necessary for scouring the pipe and for lifting foreign material to an aboveground flushing outlet. Use the flow specified in Table 11 or the maximum flow available for the size of the yard main being flushed.

Table 11. Waterflow Recommended for Flushing Piping

Size of Pipe		Flow		Size of Pipe		Flow	
in.	**(mm)**	**gpm**	**(L/min)**	**in.**	**(mm)**	**gpm**	**(L/min)**
¾	(19)	17	(65)	3-½	(89)	300	(1,135)
1	(25)	27	(100)	4	(100)	390	(1,475)
1-¼	(32)	47	(180)	5	(125)	620	(2,345)
1-½	(38)	63	(240)	6	(150)	880	(3,325)
2	(50)	105	(395)	8	(200)	1,560	(5,895)
2-½	(64)	149	(565)	10	(250)	2,440	(9,225)
3	(76)	220	(830)	12	(300)	3,520	(13,305)

Flush connections from yard piping to sprinkler risers. These are typically 6 in. (150 mm) mains. Although flow through a short open-ended 2 in. (50 mm) drain may 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 may not allow stones and other large objects to pass. If presence of large size material is suspected, a larger outlet will be needed to pass such material and to create the 750 gpm (2839 L/min) flow necessary to move it. Fire service connections on sprinkler risers can be used as flushing outlets by removing or inverting the check valve. Yard mains also can be flushed through a temporary fitting installed on the riser connection before the sprinkler system is installed.

B. Sprinkler Piping

Two methods are commonly used for flushing sprinkler piping: 1) the hydraulic method; and 2) the Hydro-pneumatic method.

The hydraulic method consists of flowing water progressively from the yard mains, sprinkler risers, feed mains, cross mains and finally the branch lines in the same direction in which it would flow during a fire.

The Hydro-pneumatic method uses special equipment and compressed air to blow a charge of about 30 gal (114 L) 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 facility. If examination indicates the presence of loose sand, mud or moderate amounts of pipe scale, the piping can generally be satisfactorily flushed by the hydraulic method. Where the material is more difficult to remove, and available water pressures are too low for effective scouring action, the Hydro-pneumatic method is generally more satisfactory.

In some cases, where obstructive material is solidly packed or adheres tightly to the walls of the piping, the pipe will have to be dismantled and cleaned by rodding or other means.

Flood dry-pipe systems with water one or two days before a flushing to soften pipe scale and deposits.

Successful flushing by either the hydraulic or Hydro-pneumatic method is dependent on establishing sufficient velocity of flow in the pipes to remove silt, scale and other obstructive material. With the Hydro-pneumatic method, this is accomplished by the air pressure behind the charge of water. With the hydraulic method, ensure waterflow rates are at least the rates of flow indicated in Table 11.

When flushing a branch line through the end pipe, sufficient water must be discharged to scour the largest pipe in the branch line. Lower rates of flow may reduce the efficiency of the flushing operation. To establish the recommended flow, remove small end piping and connect the hose to a larger section, if necessary.

Where pipe scale indicates internal or external corrosion, clean and measure the pipe wall thickness to determine if the walls of the pipe have weakened. Hydrostatically test the system as outlined in Data Sheet 2-0, Installation Guidelines for Automatic Sprinklers.

Remove several sample pendent sprinklers per system and inspect until it can be concluded that all sprinklers 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.

1. Hydraulic Method

After the yard mains have been thoroughly cleared, flush risers, feed mains, cross mains and finally the branch lines. In multi-story buildings, flush systems by starting at the lowest story and working up. Branch line flushing in any story may follow immediately the flushing of feed and cross mains in that story, allowing one story to be completed at a time. Following this sequence will prevent drawing obstructing material into the interior piping.

To flush risers, feed mains and cross mains, attach 2-1/2 in. (64 mm) hose gate valves to the extreme ends of these lines. Such valves usually can be procured from the manifold of fire pumps or hose standpipes.

As an alternative, an adapter with 2-1/2 in. (64 mm) hose thread and standard pipe thread can be used with a regular gate valve. Attach a length of fire hose without a nozzle to the flushing connection. To prevent kinking of the hose and to obtain maximum flow, install an elbow 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.

Where feed and cross mains and risers contain pipe 4, 5 and 6 in. (100, 125 and 150 mm) in diameter, it may 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 will eliminate the need for shutting off and draining the sprinkler system to change a single hose line. Use a minimum 1-1/2 in. (38 mm) hose diameter and keep it as short as practical. Branch lines may be flushed in any order that will expedite the work.

2. Hydro-Pneumatic Method

The apparatus used for hydro-pneumatic flushing consists of a hydro-pneumatic machine, a source of water, a source of compressed air, a 1 in. (25 mm) rubber hose, for connecting to branch lines and a 2-1/2 in. (64 mm) hose for connecting to cross mains.

The hydro-pneumatic machine consists of a 30 gal (114 L) water tank mounted over a 25 ft^3 (700 L) 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 a hose to a suitable water supply. The compressed air tank is connected through a suitable air hose to either the facility air system or a separate air compressor.

To flush the sprinkler piping, the water tank is filled with water, the pressure raised to 100 psi (690 kPa, 6.9 bar) in the compressed air tank, and the plug cock between tanks opened to put air pressure on the water. The water tank is connected by a hose to the sprinkler pipe to be flushed. Then the lubricated plug cock on the discharge outlet at the bottom of the water tank in snapped open, permitting the water to be “blown” through the hose and sprinkler pipe by the compressed air. The water tank and air tank must be recharged after each blow.

Outlets for discharging water and obstructing material from the sprinkler system must 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 2-1/2 in. (64 mm) hose lines or for discharge into a drum. (Maximum capacity per blow is about 30 gal [114 l]). If the 2 in. (50 mm) riser drain is to be used, remove the drain valve and make a direct hose connection. For wet-pipe systems with no alarm check valves, the riser must 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, do not use the hydro-pneumatic method.

Before starting a flushing job, each sprinkler system to be cleaned must be studied and a schematic plan prepared showing the order of the blows.

To determine the piping is clear after it has been flushed. Investigate representative branch lines and cross mains using both visual examination and sample flushing.

C. Branch Lines

With the yard mains already flushed or known to be clear, flush the sprinkler branch lines next. The order of cleaning individual branch lines must be carefully laid out if an effective job is to be done. In general, flush the branch lines starting with the branch closest to the riser and work toward the dead-end of the cross main. The order of flushing the branch lines is shown by the circled numerals. In this example, the southeast quadrant is flushed first, then the southwest, next the northeast, and last, 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. The hose should be as short as practical. When the blow is made, allow the air pressure to drop to 85 psi (586 kPa) (5.9 bar) before the valve is closed. The resulting short slug of water will have less friction loss and a higher velocity and hence do a more effective cleaning job than if the full 30 gal (114 L) of water is used. One blow is made for each branch line.

D. Large Piping

When flushing cross mains, completely fill the water tank and raise the pressure in the air receiver to 100 psi (690 kPa, 6.9 bar). Connect the machine to the end of the cross main to be flushed with not more than 50 ft (15.2 m) of 2-1/2 in. (64 mm) hose. After opening the valve, allow air pressure in the machine to drop to zero. Two to six blows are necessary at each location, depending on the size and length of the main.

3.1.4 Overheating

Overheating means subjecting sprinklers to temperatures in excess of the recognized safe maximum temperature in the absence of fire. It may result from hot processes, artificial heat, or lack of ventilation. If the temperature approaches the rated operating temperature even for a short period, it may cause sprinklers to open. If a solder-type sprinkler is exposed for a long time to a high temperature, although below its rated temperature, the soldered joint may gradually give way, with partial separation of the soldered members. This weakness will, in time, cause the sprinkler to operate.

Changes in occupancy that may affect room temperatures, such as increased drier temperatures, installation of new heat-producing equipment, overhead heating coils or unit heaters, frequently cause premature opening of sprinklers through overheating. When such changes are made, install sprinklers of higher ratings, if needed.

Nominally rated 360°F (182°C) solder-type sprinklers may fail to open after prolonged exposures to temperatures of approximately 300°F (149°C). The maximum allowable ambient temperature to which 360°F (182°C) sprinklers may be exposed is 300°F (149°C). The suspected cause of failure is the migration of tin from the high tin content solder alloy into the brass of the sprinkler link. Also, some of the brass's copper migrates into the solder. The result is a new, higher melting point alloy at the junction of the solder and brass. Sprinkler manufacturers have altered the design of the link in an attempt to reduce solder migration. It has not yet been determined whether this is an effective solution. Testing is recommended every three years to verify the condition of 360°F (182°C) sprinklers that are exposed to high temperatures.

Bulb-type sprinklers and those using a chemical compound having a sharp melting point do not have the "cold-flow" properties of solder and are not subject to danger of operation from long exposure to temperatures below that of normal operation. In a very few instances, bulbs of sprinklers manufactured prior to 1931 have developed minute cracks as a result of being repeatedly subjected to temperatures close to the operating point. This allows liquid to escape, making the sprinkler inoperative. Replace the sprinkler if a bulb-type sprinkler is observed with no liquid or less than the normal level of liquid in the bulb.

3.1.5 Corrosion

Corrosive atmospheres may build up deposits that prevent sprinklers from opening by attacking the solder so it is chemically changed or becomes hard and infusible.

Typical corrosive atmospheres are produced by chlorine, phosphine, sulfur dioxide, zinc chloride, ammonia, and hydrochloric, sulfuric and acetic acids. Corrosion of unprotected sprinklers can usually be detected by effects varying from an inconspicuous discoloration of the frame and gray powder on the solder, caused by acetic acid fumes, to the brilliant green caused by chlorine fumes.

External appearance is not always a sure guide, and badly corroded sprinklers may appear only slightly discolored. Corrosion, once started, is usually progressive and in time renders the sprinkler completely inoperative. A very thin hard corrosion on a sprinkler that has been in service 15 to 20 years is generally more harmful than a loose bulky deposit on a more recently installed sprinkler, even though the older sprinkler may appear to be in better condition.

All sprinklers are likely to become inoperative when hard deposits form around the valve-retaining members and pack tightly between the arms of the yoke.

3.1.5.1 Corrosion Prevention

FM Approved wax-coated, lead-coated, wax-over-lead coated, and stainless-steel sprinklers may be used in corrosive environments. Ensure the selection of sprinklers takes into consideration the corrosive environment and the compatibility with the sprinkler materials.

Care must be taken not to injure the coating during the installation of such sprinklers. If any of the wax is broken off, touch up the bare spots with a brush dipped in warm liquid wax. Bulb-type sprinklers are somewhat less susceptible to corrosion than other types, but metal parts need to be protected by wax.

A lead coating is effective against mild corrosion, but soldered links of lead-coated sprinklers require a wax coating.

3.1.5.2 Internal Pipe Corrosion

Limited corrosion is always present in water-based fire protection systems. The limiting of internal corrosion to even surface-level oxidation will result in a long service life of system piping and components.

There are several common conditions that can accelerate corrosion in any water-based fire protection system. They are:

- source water corrosivity.
- trapped air (air/water boundary).
- frequent introduction of oxygen rich water.
- dissimilar metals (galvanic).
- microbiological (MIC) based corrosion.

See Data Sheet 2-1, *Corrosion in Automatic Sprinkler Systems*, for additional guidance.

3.1.6 Dry-Pipe Systems

3.1.6.1 Dry-pipe Sprinkler System Maintenance

A. General

Dry-pipe sprinkler systems inherently require significantly higher levels of maintenance than wet pipe sprinkler systems due to the increased mechanical complexity, plugging or pipe damage from internal ice formation, and accelerated corrosion rates.

B. Air Supply

Air for dry-pipe systems may be supplied from individual compressors or from facility air systems. Locate air intakes to compressors where the atmosphere is as cold and dry as practical, avoiding warm, damp areas. Moisture introduced into dry system piping condenses and collects at low points where it may freeze. If air must be taken from a warm area, provide air dryers on the air supply to the dry-pipe systems or use a dry inert gas such as nitrogen. The use of inert gas can slow corrosion attack of the system internal surfaces.

C. Air Pressure

Unless otherwise specified by the dry-pipe valve manufacturer, maintain the air pressure within the system at approximately 20 psi (140 kPa, 1.4 bar) greater than the trip pressure of the dry-pipe valve based on the highest normal system water pressure. Ensure that air pressure never exceeds system water pressure.

Extremely high air pressure will delay the tripping of the valve. Too low air pressure may cause accidental tripping of the valve when fire pumps are started or pressure surges occur.

D. Trip Points

The trip point of a differential dry-pipe valve is usually about one-sixth of the water pressure. Trip points of mechanical dry-pipe valves are more or less independent of water pressure, ranging from 5 to 30 psi (35 to 200 kPa, 0.35 to 2 bar).

E. Trip Time

Ensure that the valve trips and water flows from the remote test connection within 60 seconds or less after opening the test connection. Times greater than 60 seconds may be as a result of system obstructions, valve mechanical problems, or improper installation. If the system is free of obstructions and the valve is functioning properly, accessory accelerators and exhausters can be employed to reduce the time required to trip the valve and exhaust the air in the piping.

F. Air Leak Testing

Dry-pipe systems, when pressurized with air to 40 psi (280 kPa, 2.8 bar), should not lose more than 1-1/2 psi (10 kPa, 0.1 bar) over a 24-hour period. Repair systems with excessive leakage.

Abnormal leakage of air may sometimes be found by filling the system with water by tripping the dry pipe valve. If there is danger of freezing, the system may be placed under approximately 50 psi (350 kPa 3.5 bar) air pressure and leaks located by painting joints with a glycerin and soap solution or by introducing oil of wintergreen at the compressor discharge and noting any odor along the piping.

Ultrasonic leak test devices that can pinpoint leaks from the high frequency sound they generate are now available.

3.1.6.2 Dry-Pipe System Inspections and Tests

To ensure maximum reliability, regularly inspect and test dry-pipe systems as part of a comprehensive fire protection inspection and maintenance program.

Number and list each dry-pipe valve on the inspection form. Provide spaces for recording (a) air and water pressure, (b) adequacy of temperature inside any dry-pipe valve enclosure, and (c) condition of quick-tripping devices, if any.

A. Weekly Inspection

(Daily inspections may be advisable during severe cold weather.)

1. System pressure. Check and record dry-pipe system air and water pressure.

2. Accelerators and exhausters. Inspect the quick-opening device condition if provided. Inspect quick-opening devices to make certain that (a) supply valves are open; (b) air pressure and system pressure are equalized; and (c) excess water is drained off.

3. Riser temperature. Check the temperature in the dry-pipe valve room during winter months. Maintain temperature at or above 40°F (5°C). Heat tape and steam tracing are not satisfactory substitutes for a heated room or enclosure.

B. Monthly Inspections and Tests

1. Automatic drain. Make sure the automatic drain from the dry-pipe valve intermediate chamber is free to move. With some valves, this requires lifting the rod that extends through the drain-valve opening, or insertion of a rod or pencil through the valve opening if the drain valve is not so equipped. Where the velocity-type of automatic drain valve is used, make sure by means of the push rod or by feeling through the discharge end of the valve with a finger that the clapper or ball is off its seat.

2. Priming water. Priming water must be retained over the air clapper to prevent air leakage and premature tripping of the valve. To test for priming water level, use the valve provided for that purpose. However, all dry-pipe valves are not trimmed in the same manner, and it may be necessary to use the priming water supply connection. Draw off excess water, which could prevent the dry-pipe valve from tripping.

3. Air leakage. Make sure no air leakage has been caused by operation of test valves. Such leakage can be detected by applying water or preferably soap solution to the valve stem at the packing nut. Check for leakage at valves in the air supply line; loss of air here also can cause premature tripping. Stop the leakage at valves by tightening the stuffing boxes.

4. Accelerators and exhausters. Check the operation of exhausters and accelerators (quick opening devices) when the design permits testing without tripping the dry-pipe valves. Post and follow test procedures based on the manufacturer's recommendations. A sudden drop in air pressure will actuate these devices and trip the dry-pipe valves. When it is necessary to reduce system air pressure, shut off or deactivate the quick opening device. After completing work, be certain the equipment is left in operating condition.

5. Low point drains. Just prior to and during freezing weather, test all low points by opening the drain valve to see that pipes are entirely free of water or ice. Depending on the amount of condensate in the piping, more frequent inspecting and draining may be necessary.

C. Quarterly Inspections and Tests

1. Alarms. Test alarms by admitting water through the test connections to the pressure switches and/or water motors. Test hydraulic alarms only when pipes and water motors are not subject to freezing. In prolonged cold spells see that moving parts are free and the pipes drained and clear of frost.

D. Annual Inspections and Tests

1. Trip Test

Annual trip testing of dry-pipe valves is recommended to ensure reliable operation. Record trip test records and compare with previous test results. Record details of the trip test such as static water pressure, system air pressure, and trip point air pressure and valve trip time after test valve air release. Testing is the best means of determining whether adjustments, repairs, or replacement of parts are needed. Valves that have not been operated for several years may fail or be very slow in action. Delayed tripping of a dry-pipe valve in event of fire could be disastrous.

Make annual trip tests during the season when there is no danger of freezing. Also, if possible, make trip tests when facility operations are shut down in the area controlled. If more than one valve can be worked on at a time, select alternate systems to avoid impairments to large areas where protection cannot be restored quickly. Before control valves are closed, follow the fire protection impairment precautions outlined in Section 3.1.1.

Before the tests, see that controlling valves are open, and make the usual flow test from the 2 in. (50 mm) drain. If there is evidence of foreign material in the yard mains, flush them clean before the starting other tests.

Examine automatic drip valves at the dry-pipe valve to make sure they are open, not obstructed with scale or dirt, and operative so far as can be determined. Ball drips may be taken apart for this inspection. Where there is central-station sprinkler supervisory service or flow alarms connected to the public fire service, make arrangements to avoid calling out fire apparatus or messengers.

Release the air through the system test valve at the end of the sprinkler system in order to simulate the operation of one sprinkler. Install a system test valve if one is not provided.

To prevent water from entering the sprinkler system, throttle the control valve to a position where flow from a 2 in. (50 mm) drain would maintain about 5 psi (30 kPa, 0.3 bar) under the dry-pipe valve. Immediately after the dry-pipe valve trips, close the control valve and open the drain valve. By keeping as much water as possible out of the piping, drainage is made easier, especially if there are many low points or pendent sprinklers.

Tripping dry-pipe valves with throttled water supplies will not completely operate some models that require a high rate of flow to complete the movements of the parts. In that case, a higher flow rate may be needed to ascertain that all parts are free to move and the valve trips properly.

After the test, thoroughly drain the system including low point drains and remove the cover plate from the valve. Examine the position of the parts, and determine whether or not operation has been normal. Thoroughly wash the inside of the body, and wipe the clappers dry with a clean cloth. Remove all dirt and scale, giving special attention to the small valves or ports to drains and alarm devices. Examine particularly for dirt under the clapper hinges; a large amount of dirt may indicate the system is obstructed.

If rubber rings or seats are deformed or otherwise in poor condition, replace them with new parts supplied by the valve manufacturer. Keep spare rubber on hand for quick replacement to avoid an extended impairment.

2. Pitch of Pipes

Dry systems may freeze-up as a of water collecting in improperly pitched pipes. Carefully check the pitch of all piping in dry-pipe systems each autumn, using a spirit level to detect dips and small pockets in the lines. Sagging floors and roofs may seriously interfere with drainage even if the pipes were properly pitched when installed. Replace broken, missing, or loose hangers, and otherwise restore the system to ensure good drainage. Install valved drains at all low points that cannot be eliminated.

3.1.7 Hydrants

To ensure that a hydrant will work correctly when it is needed, a periodic testing and maintenance program should be followed. AWWA Manual M17, Installation, Field Testing, and Maintenance of Fire Hydrants, outlines various points to check, lubrication repairs and record keeping procedures to carry out a meaningful inspection. Hydrants should be inspected yearly, and in locations of freezing climates, two inspections per year may be appropriate.

3.1.8 Monitors and Nozzles

When exercising monitors and nozzles, the manufacturers' recommendations for inspections, testing, and maintenance should be adhered to. At a minimum, the following should be checked:

A. Inspections

- Nozzle angle
- No obstructions in front of discharge path
- Fire detection: optical range clear, wires intact
- Signaling, alarm, and system activation: power active, activation panel lights green

B. Testing

- Range of motion functional test (i.e., not flowing water)
- Flow test: throw distance, flowrate, spray distribution,
- Fire detection
- Signaling, alarm, and system activation

C. Maintenance

- Lubrication
- Range of motion
- Mechanical stops are tight

3.1.9 Backflow Prevention Assemblies

When maintenance of backflow prevention assemblies is necessary, the following precautions should be taken to prevent impairments to protection:

A. Operation of valves should be done by or under the jurisdiction of the building owner or their representative, who should take appropriate precautions in connection with the impairment.

B. Where there are multiple fire-service connections from public mains, overhaul and clean one assembly at a time, leaving the others in service.

C. When there is only one connection from a public main and a secondary supply is from a fire pump, operate the pump to maintain pressure at the sprinklers while the public water connection is shut off. If the secondary supply is from a tank, see that it is full and that all tank control valves are open.

D. Open one check valve at a time, so that in the event of fire the cover can be replaced and protection restored with the least possible delay.

3.1.10 Water Storage Tanks with Flexible Liners

The visible parts of suction tank liners should be inspected yearly and the tank should preferably be drained (leaving a minimum of 2 in. [50 mm] of water to prevent liner movement) and the liner inspected thoroughly at intervals not exceeding five years. An indication of the life remaining in a tank liner should be estimated at each inspection. Subsequent tank internal inspection frequency intervals may need to be adjusted based on the estimated remaining life of the liner or the expiration of the manufacturer's warranty.

Above the water line, suction tank liners should be checked for: eyelet corrosion, failure of eyelets or punched-hole connectors, discoloration, shrinkage (e.g., notable increased membrane tension), brittleness, surface deterioration, cuts and tears. Below the water line check for discoloration, elongation, bulging, loss of flexibility and for signs of leaks, cuts and tears. Remove all sludge and debris without using sharp tools to prevent tearing and puncturing of the liner. Patching of a liner is an acceptable method of repair if the patch repair work matches the performance of the factory-built liner. Ensure the liner is in the correct position prior to refilling; this includes the positioning of the neoprene mat (where fitted) under the vortex plate bottom support.

3.1.11 Fire Pumps

3.1.11.1 Fire Pump Alignment

One of the most crucial steps of fire pump inspection is making sure the coupled fire pump and driver is properly aligned. There are many factors that can affect alignment, including thermal expansion and equipment maintenance. Coupled fire pumps and drivers that are misaligned are far more likely to fail and could cause disruption of service.

The alignment must be checked and correctly set when:

A pump and drive unit are initially installed (before grouting the baseplate, after grouting the baseplate, after connecting the piping, and after the first run).

After a unit has been serviced.

After changes have been made to the piping system in the fire pump room.

Annually, for coupled fire pumps as a preventive maintenance check of the alignment (see below).

If the pump is found to be misaligned after it was properly installed, the following are possible causes:

- Settling, seasoning or springing of the foundation
- Pipe stress distorting or shifting the pump
- Wear of the bearings

- Springing of the base plate due to temperature variations
- Shifting of the building structure due to variable loading or other causes

There are two forms of misalignment between the pump shaft and the driver shaft, as follows:

- Angular misalignment: shafts with axes concentric but not parallel.
- Parallel misalignment: shafts with axes parallel but not concentric.

3.1.11.2 Alignment Methods

Alignment is critical to pump and driver longevity and generally the better the alignment the longer the pump and driver bearing life. The three most prevalent and acceptable alignment methods are:

- Straight Edge and Feeler Gauges
- Dial Indicator
- Lasers-optic

3.1.11.2.1 Straight Edge and Feeler Gauges

The straight edge is laid across the flanges of the coupling hub and the feeler gauges are used between the faces of the coupling hubs. Shim changes are estimated, and the alignment is attained through a process of trial and error.

3.1.11.2.2 Dial Indicators

There are two basic dial indicator methods:

- The single indicator method uses a single dial indicator to take both the rim and face reading. Shim changes can then be calculated for the motor feet to correctly align the unit.
- The reverse indicator method uses a dial indicator on the pump shaft to read the motor shaft, and a dial indicator on the motor shaft to read the pump shaft. Mathematical formulas can then be used to calculate shim changes to correctly align the unit.

3.1.11.2.3 Laser Optic Devices

This system emits a pulsating laser beam that automatically determines relative shaft positions. The laser is especially helpful when aligning shafts that are separated by more than a few inches. The laser systems also have software that can calculate the shim changes required. The advantages of laser optic alignment devices far outweigh any possible initial cost advantages of older, more conventional methods.

3.1.12 Ice Plugs

3.1.12.1 Locating Ice Plugs

Ice plugs can form rapidly inside piping systems in freezers unless proper precautions are taken to prevent them. When warm air enters the freezer and rapidly cools, moisture present in the air condenses and accumulates in the interior of the piping. As the accumulation becomes larger, it can fill the entire section of the pipe preventing waterflow. Field examinations of existing freezers have shown ice plugs in over 50% of the freezers examined. The ice plugs are generally found in the feed main inside the freezer, at a distance of 10 to 15 ft (3 to 5 m) from the point where the pipe enters the freezer. Due to the tendency of moisture to migrate to the coldest part of the system, it also is possible to have frost accumulation near the evaporator coils, where the pipes may reach the coldest temperatures.

Data collected during inspections indicates ice is more likely to form in sprinkler systems that are not air tight and in in-rack sprinkler systems.

If a system has been flooded with water, such as during a test or false trip, potential for ice plugs exists in any area and any piping, but is most likely in low points and in undrained areas.

To locate ice plugs, the traditional method has been to disassemble the piping and visually inspect for internal ice formation. The piping also can be inspected using ultrasound technology without the need for disassembling the piping system. This method is both accurate and efficient.

3.1.12.1 Removing Ice Plugs

To remove ice plugs, piping should be disassembled and brought to a warm area to thaw. If ice plugs are small they can be broken up by hammering and then removed from the pipe. Some contractors have successfully used steam or hot water to remove ice without removing the pipe; with the sprinkler system depressurized, a hose is introduced into the piping; steam or hot water is fed into the frozen pipe and thaws the ice ahead of it. The water and thawed ice discharges through the open end of the pipe where the hose is inserted. Care must be taken to ensure all ice is removed and no blockages or blocked branches remain.

The use of torches, welders, or other electrical resistance heating methods should be prohibited due to the ignition source they represent.

4.0 REFERENCES

4.1 FM Global

Data Sheet 1-23, *Fire Barriers and Protection of Openings*
Data Sheet 2-0, *Installation Guidelines for Automatic Sprinklers*
Data Sheet 2-1, *Corrosion in Automatic Sprinkler Systems*
Data Sheet 3-7, *Fire Protection Pumps*
Data Sheet 3-10, *Installation/Maintenance of Private Fire Service Mains and Their Appurtenances*
Data Sheet 5-20, *Electrical Testing*
Data Sheet 5-40, *Fire Alarm Systems*
Data Sheet 5-48, *Automatic Fire Detection*
Data Sheet 7-83, *Drainage Systems for Ignitable liquids*
Data Sheet 9-18, *Prevention of Freeze-Ups*
Data Sheet 10-0, *The Human Factor of Property Conservation*
Data Sheet 10-3, *Hot Work Management*
Data Sheet 10-4, *Contractor Management*
Data Sheet 10-7, *Fire Protection Impairment Management*

Pocket Guide to Inspecting, Testing and Maintaining Fire Protection Equipment (P0418)
Managing Fire Protection System Impairments (P9006)
Hot Work Permit System Wall Hanger Kit (P9311K)
Fire Protection Control Valves (P9603)
Fire Pump Testing and Maintenance Checklist (P8217)
Freeze-up Checklist (P9521)
Understanding the Hazard: Lack of Inspection, Testing and Maintenance of Water-Based Fire Protection Systems (P0343)
Understanding the Hazard: Improperly Closed Valves (P0035)
Understanding the Hazard: Dry-Pipe Sprinkler Flushing Investigations (PO241)
Understanding the Hazard: Freeze (P0148)
Understanding the Hazard: Ice Plugs (P0118)
Understanding the Hazard: Ice Plugs in Dry Pendent Sprinklers in Freezers (P0382)
Understanding the Hazard: Fire Pumps (P0252)
Understanding the Hazard: Hot Work (P0032)
Understanding the Hazard: Lack of Emergency Response (P0034)
Understanding the Hazard: Lack of Pre-Incident Planning (P0033)

4.2 Other

Compressed Gas Association (CGA). CGA C-6, *Standards for Visual Inspection of Steel Compressed Gas Cylinders*.

APPENDIX A GLOSSARY OF TERMS

Actuator: The agent release means of a fire protection system

Automatic: An operation that occurs without human intervention.

Control valve: A valve controlling water or agent flow to a fire protection system. A zone valve is also considered a control valve.

Deluge valve: A control valve that automatically releases water to a piping system that supplies open nozzles.

DIOM: Design, installation, operation, and maintenance.

Dry-pipe valve: A control valve that, on loss of system air pressure, automatically releases water into a piping system that supplies closed nozzles.

Dry pendant sprinkler: A dry extension to a sprinkler's waterway that has an inlet seal that operates with the sprinkler fusible element in order to keep water a specified distance from a sprinkler that may be located in a freezing environment.

Enhanced security control valve: A valve fitted with or incorporating an FM Approved "Enhanced Security Supervisory Device," which has a greater level of tamper resistance and operational reliability than "Standard Security Supervisory Devices" per the new FM Approval Standard 3135.

Fire department connection: A connection to the fire protection system through which the fire service can pump supplemental water into the system.

Fire service: A term for firefighters in any area of the world. Includes fire departments, fire brigades, fire and emergency services, and fire/rescue.

Fire hydrant: A valved connection on a water main for the purpose of supplying water to fire hose or other fire protection equipment.

FM Approved: Products and services that have satisfied the criteria for FM Approval. Refer to the Approval Guide, an online resource of FM Approvals, for a complete listing of products and services that are FM Approved.

Foam concentrate: A liquid stored in a containment vessel that, when metered into a flowing water stream at a specific concentration, will generate a foam-water solution for firefighting purposes.

Flushing: The practice of flowing water or pneumatically blowing through a fire protection piping system for the purpose of removing obstructions.

Hose connection: A valve and connection method for fire hose.

Impairment: The planned or unplanned shutdown of a fire protection system.

Inspection: A visual examination that determines if a condition, device, equipment, or system is suitable for service.

Main drain (2-inch drain): The primary drain for a sprinkler system located on the system riser.

Maintenance: Work conducted to ensure continued satisfactory operation of a device or system.

Manual: An operation that requires human intervention.

Obstruction: Foreign material in a fire protection system that restricts or prevents flow.

Open water supply: Fire protection water source that is open to an outdoor environment (e.g., reservoirs, ponds, lakes, rivers).

Pre-action valve: A control valve that, upon some combination of detection of a fire and loss of system air pressure, automatically releases water into a piping system that supplies closed nozzles.

Pressure reducing valve: A valve that will reduce the downstream fire protection water pressure under both flowing and non-flowing conditions.

Scale: Thin surface deposits that develop on the interior of fire protection water pipe due to corrosion.

Smart valve monitor: An FM Approved "Enhanced Security Supervisory Device" fitted with an FM Approved wireless/Wi-Fi secure/encrypted device and associated system, that provides near real-time surveillance of control valves to any location/interface required.

Supervision: An automatic means of monitoring a system or a device status and indicating abnormal conditions.

Test: To physically operate a device or system for the purpose of verifying operational condition.

APPENDIX B DOCUMENT REVISION HISTORY

The purpose of this appendix is to capture the changes that were made to this document each time it was published. Please note that section numbers refer specifically to those in the version published on the date shown (i.e., the section numbers are not always the same from version to version).

October 2019. Interim revision. Added Appendix C, Fire Protection System Inspection Frequency Comparison.

July 2019. Interim revision. Minor editorial changes were made.

April 2019. This document has been completely revised. Major changes include the following:

A. Changed the title from *Fire Protection System Inspection Testing and Maintenance and other Fire Loss Prevention Inspections* to *Fire Protection System Inspection, Testing, and Maintenance.*

B. Relocated impairment management information to Data Sheet 10-7.

C. Relocated fire prevention inspections information to Data Sheet 10-0.

D. Incorporated ITM recommendations from the following data sheets:

- 3-1, *Tanks and Reservoirs for Interconnected Fire Service and Public Mains*
- 3-2, *Water Tanks for Fire Protection*
- 3-3, *Cross Connections*
- 3-4, *Embankment-Supported Fabric Tanks*
- 3-6, *Lined Earth Reservoirs for Fire Protection*
- 3-10, *Installation/Maintenance of Private Service Mains and Their Appurtenances*
- 3-11, *Pressure-Reducing Valves for Fire Protection Service*
- 4-0, *Special Protection Systems*
- 4-1N, *Fixed Water Spray Systems for Fire Protection*
- 4-2, *Water Mist Systems*
- 4-3N, *Medium and High Expansion Foam Systems*
- 4-4N, *Standpipe and Hose Systems*
- 4-7N, *Low Expansion Foam Systems*
- 4-8N, *Halon 1301 Fire Extinguishing Systems*
- 4-9, *Halocarbon and Inert Gas (Clean Agent) Fire Extinguishing Systems*
- *4-10, Dry Chemical Systems*
- 4-11N, *Carbon Dioxide Extinguishing Systems*
- 4-12, *Foam-Water Sprinkler Systems*

E. Modified the scope and frequency of ITM activities.

May 2018. Interim revision. The following changes were made:

A. Guidance for visual and physical inspection of fire pumps for signs of misalignment.

April 2017. Interim revision. Minor editorial changes were made.

April 2012. Terminology related to ignitable liquids has been revised to provide increased clarity and consistency with regard to FM Global's loss prevention recommendations for ignitable liquid hazards.

January 2008. Minor editorial changes were made.

April 2007. Revised recommendation 2.3.9 on main drain testing.

January 2007. The following changes were made:

1. Reorganized and reformatted the entire document.

2. Changed waterflow alarm testing frequency to quarterly from monthly.

3. Removed guidance on non-owned valve inspection frequency.

4. Changed obstruction investigation frequency for black steel pipe on dry systems from 15 years, 25 years and 5 years thereafter, to 10 years, 20 years and 5 years thereafter.

5. Clarified the need for flushing investigations every 5 years for all sprinkler systems fed from open bodies of water.

6. Added annual obstruction investigation requirement for dry and pre-action systems that trip frequently that take suction from open reservoirs.

7. Provided more specific guidance for special hazard protection systems (Table 8).

8. Removed guidance on non-OEM plating of sprinklers.

9. Added internal pipe corrosion guidance.

10. Clarified inspection frequency for hydrant control valves.

11. Clarified the water delivery time requirement of 60 seconds for dry system testing.

12. Added Zebra mussel obstruction information.

January 2006. Minor editorial changes were made for this edition of the data sheet.

September 2005. Minor editorial changes were made for this edition of the data sheet.

January 2003. Minor editorial changes were made for this edition of the data sheet.

January 2001. An FM Global comment has been added after Section 2.10, Condition of Sprinklers, outlining requirements for sprinkler testing contained in NFPA 25, ''Inspection, Testing and Maintenance of Water-based Fire Protection Systems'', and the FM Global position in that regard.

September 2000. This revision of the document has been reorganized to provide a consistent format.

July 1986. The following changes were made in:

1. The section entitled ''Precautions Against Freezing'' has been revised to include recommendations to establish an active cold weather readiness program. Additional cold weather precautions based on loss report recommendations have also been included.

2. The section on sprinkler system obstructions has been revised.

a) A recommendation has been included that all proposed preaction and dry systems should be installed using galvanized piping. Loss studies have shown that dry-pipe systems are involved in the majority of obstructed sprinkler system fire losses. Pipe scale was found to be the most frequent obstructing material.

b) The recommendation to flush dry system no more than 10 years after installation has been revised to 15 years, 25 years and every five years thereafter. Loss studies have better defined those systems most likely to be obstructed and to result in a large loss. The importance of flushing has been emphasized by listing conditions that ''do'' rather than ''may'' indicate the need for flushing.

c) Discussion with regard to Asiatic Clams has been added. Thus far the majority of problems associated with this clam have involved clogging of condensers, heat exchangers, pump impellers and other associated water systems for power utilities and industry. However, there has also been an instance reported to FM Global Research where two dry-pipe sprinkler valves failed to trip during testing due to ''several buckets of clam shells'' found on the wet side of the system. At several other locations, sprinkler piping has been found plugged with shells and clam growth found inside protection mains. To date, no effective method of controlling clam infestations has been established. The problem is still under investigation. It is suspected that chlorination is the most practical method. Should chlorination be used, it is suggested that clams within the fire protection system be exposed to a minimum residual chlorine concentration of 0.2 ppm continually for a minimum three-week period. For control, the treatment should be applied at least for one period in the spring and one period in the fall, the clam's primary spawning periods.

d) A recommendation regarding sprinkler cutouts (coupons) has been included. Originally, the problem became apparent after investigating a fire in a spray booth involving two obstructed sprinklers. About 37 cutouts ranging in size from 1 to 4 in. (2.5 to 10.0 mm) were recovered from the sprinkler piping. They had fallen into the pipe when the hole was cut for the welding operation. At least seven other locations have been discovered with the same problem.

APPENDIX C FIRE PROTECTION SYSTEM INSPECTION FREQUENCY COMPARISON

Table 12. Fire Protection System Inspection Frequency Comparison

Component	*FM Global Recommendation*	*FMDS 2-81 - 2019 Frequency*	*FMDS 2-81 - 2019 Reference*	*NFPA 25 - 2017 Frequency*	*NFPA 25 - 2017 Reference*
Control Valves in Automatic and Manual Fire Protection Systems	Visually inspect indicating control valves for full-open, secured, and accessible conditions.	Weekly	Table 1	Monthly/ Weekly	13.3.2.1
	Inspect control valves installed in waterflow alarm sensing lines when the alarm actuates process or building interlocks for full-open and locked conditions.	Weekly	Table 1	Quarterly	13.2.6.1
	Visually inspect enhanced security indicating control valves for full-open, secured, and accessible conditions.	Semiannually	Table 1	Quarterly	13.3.2.1.2
	Physically test control valves for full-open position when the valve does not have a position indicator or has a position indicator deemed unreliable.	Monthly	Table 1	Annually	13.3.3.1
	Test control valve supervisory alarms and enhanced security control valves (e.g., tamper switches).	Semiannually	Table 1	Semiannually	13.3.3.5.1
	Full-travel exercise all control valves recording number of turns-to-close and turns-to-re-open.	Annually	Table 1	Annually	13.3.3.1

Table 12. Fire Protection System Inspection Frequency Comparison

Component	*FM Global Recommendation*	*FMDS 2-81 - 2019 Frequency*	*FMDS 2-81 - 2019 Reference*	*NFPA 25 - 2017 Frequency*	*NFPA 25 - 2017 Reference*
General ITM activities applicable to all types of sprinkler systems	Inspect, test, and exercise control valves in automatic fire protection systems.	Varies	Table 2a	Varies	As above
	Test waterflow alarms (including flow switches) by flowing water through a system test connection.	QuarterlyAnnually: for antifreeze systems.	Table 2a	Quarterly/ Semi-Annually	5.3.2.1/.2
	Flow test from system main-drain to evaluate for significant obstructions in the water supply upstream of each system riser.	Annually	Table 2a	Annually	13.2.5
	Investigate systems for obstructive debris.	Obstructions Suspected	Table 2a	5 years	14.3.2.1
	Conduct a complete system flushing. Physically remove obstructive deposits or replace piping.	Obstructions Discovered (Debris)	Table 2a	Sufficient material discovered	14.3.3
	Inspect system sprinklers, nozzles, piping, pipe support, and seismic protection for damage and/or other poor conditions.	Annually or more frequently based on the operating environment or facility experience. (see 2.5.1.5.2)	Table 2a	Annually	5.2.1.1
	Test a random sample of sprinklers with fusible-elements rated for 360 F (180 C) or greater when subjected to prolonged exposures of around 300 F (149 C) or greater.	Every 3 Yrs.	Table 2a	5 years	5.3.1.1.1.4
	Test a random sample of dry-type sprinklers (a.k.a. dry pendants)	Every 15 Yrs	Table 2a	10 Years	5.3.1.1.1.6
Wet Sprinkler Systems	Investigate systems fed by and open water supply for obstructive debris regardless of pipe material.	Every 5 Yrs.	Table 2b	5 Years	14.3.2.1
	Investigate systems for mineral deposits at sprinkler-pipe connections in areas known to or suspected of having hard-water.	Every 5 Yrs.	Table 2b	Yearly	D.4.5
	For systems with antifreeze solution, test the antifreeze solution.	Annually	Table 2b	Annually	5.3.3

Table 12. Fire Protection System Inspection Frequency Comparison

Component	*FM Global Recommendation*	*FMDS 2-81 - 2019 Frequency*	*FMDS 2-81 - 2019 Reference*	*NFPA 25 - 2017 Frequency*	*NFPA 25 - 2017 Reference*
Dry, Preaction, Vacuum, Deluge, Fixed-Water Spray and Refrigerated Area Sprinkler Systems	Check system valve air and water pressures (including for pilot lines).	Weekly	Table 2c	Monthly/ Quarterly	13.2.7.1
	Verify the quick-opening device for in-service conditions including equalized air pressure and open control valves.	Weekly	Table 2c	Monthly (externally)	13.4.5.1.3
	Confirm system valve enclosures are maintained above 40F (5C).	Weekly	Table 2c	Weekly	13.4.5.1.1
	Check priming-water level within the system valve.	Monthly	Table 2c	Quarterly	13.4.3.2.1
	Check the condition of the compressed air supply (including for pilot lines).	Monthly	Table 2c	Annually	Table 12.1.2
	Test quick-opening devices (QOD) without tripping the system valve.	Annually: FM Approved Quarterly: Non-FM Approved	Table 2c	Quarterly	13.4.5.2.4
	Determine the air leakage rate of the system (including for pilot lines).	Annually	Table 2c	3 Years	13.4.5.2.9
	Test supervisory alarms for low-air pressure (including for pilot lines) and low-temperature in system valve enclosures.	Annually	Table 2c	Quarterly	13.4.3.2.10
	Inspect and clean system valve internals and associated valve trim.	Annually	Table 2c	Annually	13.4.3.3.2
	Partial-flow trip test system valves.	Annually	Table 2c	Annually	13.4.5.2.2
	Full-flow trip test, Videoscope or Ultrasonic Localized Guided Wave evaluation of systems.	Every 3 Yrs. Or Every 10 years for systems with Nitrogen	Table 2c	3 years	13.4.5.2.2.2
	Investigate systems (excluding refrigerated area systems and systems originally installed with Nitrogen) containing black steel pipe for obstructive debris.	At 10 Yrs, 20 Yrs and 5 years thereafter	Table 2c	5 years	14.2
Refrigerated Area Sprinkler Systems	Investigate systems and pilot sprinkler lines for ice plugs along with freeze damage to piping and sprinklers.	Semiannually and After Every System Trip	Table 2c	Annually	14.4
Deluge and Fixed-Water Spray Systems	Disassemble and inspect system strainers.	Every 3 Yrs.	Table 2c	5 Years	13.4.4.1.5

Table 12. Fire Protection System Inspection Frequency Comparison

Component	*FM Global Recommendation*	*FMDS 2-81 - 2019 Frequency*	*FMDS 2-81 - 2019 Reference*	*NFPA 25 - 2017 Frequency*	*NFPA 25 - 2017 Reference*
Fire Hydrants, Standpipe Systems and Monitor Nozzles	Check hydrant hose houses, standpipe valves and hose stations and portable and fixed monitors for equipment availability, accessibility, and damage.	Quarterly	Table 3	Quarterly	7.2.2.7
	Inspect and Flow test fire hydrants.	Annually	Table 3	Annually	7.3.2
	Inspect, Exercise and Flow test monitors and nozzles.	Annually	Table 3	Semi Annually/ Annually	7.2.2.6/7.3.3
Backflow Preventers and Single Check Valves	Conduct a full-flow test in excess of the greatest sprinkler demand. Measure and record the flow rate during testing.	Annually	Table 5	Annually	13.7.2.1
Fire Pumps	For Diesel Fire Pumps:Start the pump in automatic mode via pressure drop or waterflow alarm and allow the pump to churn reaching normal operating conditions.	Weekly	Table 7	Weekly	8.2.2/8.3.1.1
	For Electric Fire Pumps: Inspect and Test the pump in automatic mode via pressure drop or waterflow alarm and allow the pump to churn reaching normal operating conditions.	Monthly	Table 7	Weekly/ Monthly	8.2.2/8.3.1.2
	Inspect the pump room for satisfactory conditions.	Weekly	Table 7	Weekly	8.2.2 (1)
	Test pump performance and verify suction supply availability.	Annually	Table 7	Annually	8.3.3
	Check alignment of pumps and drivers that are coupled.	Annually	Table 7	Annually	8.3.6.4
Electric Fire Pumps	Inspect, test, and maintain primary and secondary power feeds including automatic transfer switches to electric fire pumps.	Varies	Table 7	Varies	Chapter 13
Diesel Fire Pumps	Check the condition of engine batteries.	Monthly	Table 7	Annually	8.1.1.2.15
	Change engine oil and oil filter.	Per manufacturer specifications but at Least Annually	Table 7	Per 50 hours of operation or annually	8.1.1.2.17/18
All water storage tanks and open-water sources	Verify atmospheric tanks are full and the water level for open-water sources is sufficient.	Weekly/ Monthly	Table 8	Monthly/ Quarterly	9.2.1
	Test water-level indicators, and water-level supervisory alarms.	Annually	Table 8	Annually/5 Years	9.3.5/9.3.1

Table 12. Fire Protection System Inspection Frequency Comparison

Component	*FM Global Recommendation*	*FMDS 2-81 - 2019 Frequency*	*FMDS 2-81 - 2019 Reference*	*NFPA 25 - 2017 Frequency*	*NFPA 25 - 2017 Reference*
Tanks (i.e., gravity, suction, break, and embankment-supported fabric tanks)	Verify pressure tank water and air pressure levels; verify/test air pressure source.	Weekly/ Monthly	Table 8	Monthly/ Quarterly	9.2.2.1/9.2.2.2
	Test all break tank automatic fill systems.	Monthly	Table 8	Annually	9.5.3
	Verify the rate of inflow from break tank automatic and manual valves.	Annually	Table 8	Annually	9.5.3
	Visually check/inspect/repair tank exteriors.	Monthly	Table 8	Quarterly	9.2.4.1
	During freezing weather, verify tanks and enclosures with tanks/ piping are maintained above 40°F (4.5°C), and ice does not form on gravity tanks or structures beneath.	Daily or more frequently if warranted	Table 8	Weekly	9.2.3.3
	Inspect and maintain tank heating systems.	Varies	Table 8	Daily or More Frequently	9.2.2.2
	Inspect exterior coatings of steel and wood tanks for corrosion, rot and insulation.	Every 2 years	Table 8	Annually	9.2.4.5
	Inspect coating of the exposed surface of embankment-supported fabric tanks for weathering.	Every 2 years (or more frequently if required by the tank manufacturer)	Table 8	Quarterly	9.2.4.2 (4)
	Inspect the interior of the tank.	Every 5 years (or more frequently if warranted)	Table 8	5 years (3 for steel without protection)	9.2.5.1.2
Open-Water Sources	Visually check wet-pit intake screens and bar racks, and suction strainers for debris clogs and damage.	Weekly	Table 8	Weekly	8.2.2 (f)

APPENDIX D INSPECTION FORMS

FM Global

FIRE PROTECTION INSPECTION FORM

Account Number: Index Number:

Sample Only	No one form can be designed to fit all conditions. Use this sample as a basic guide in developing your own form. Items that do not apply can be omitted; other items can be expanded or added as desired. ***For assistance, consult the next FM Global engineer who visits your facility, as well as reference FM Global Data Sheet 2-81, "Fire Protection System Inspection, Testing and Maintenance and other Fire Loss Prevention Inspections."***
Instructions to Inspector:	*Fill out this form while inspecting fire protection. Send the completed form to your supervisor for necessary action. The report should be held for review by the next FM Global engineer who visits your facility.*

FACILITY: LOCATION: DATE:

VALVE INSPECTIONS
Visually inspect all locked valves weekly and physically try them monthly as required*.
Record both weekly and monthly inspections.

*Physically try gate valves, including non-indicating and indicator-post-gate valves. FM Approved post-indicator-valve assemblies (PIVAs), indicating-butterfly valves (IBVs) and standard outside-screw-and-yoke (OS&Y) valves do not have to be tried, but should be checked visually at close range.

All inside and outside valves controlling sprinklers or fire-protection water supplies are listed below. Check the condition of the valve. Do not report a valve open unless you have personally inspected it.

	VALVE LOCATION	AREA CONTROLLED	OPEN	SHUT	LOCKED	PHYSICALLY TURNED
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						

The FM Global ***Red Tag Permit System*** is used to guard against delayed reopening of valves. The *Red Tag Permit* should be used every time a sprinkler control valve is closed. When the valve is reopened, the 2-in. (51-mm) drain should be flowed wide-open to ensure there is no obstruction in the piping. The valve then should be relocked.

Were any valves closed since the last inspection?	☐ Yes	☐ No
Were FM Global *Red Tag Permits* used?	☐ Yes	☐ No
Was the valve(s) reopened fully and a 2-in. (51-mm) drain test conducted before the valve(s) was relocked?	☐ Yes	☐ No
COMMENTS:		

264 (Revised November 2007)

INSPECT THESE ITEMS AT LEAST WEEKLY

SPRINKLERS	Automatic Sprinklers	SPARE HEADS AVAILABLE? ☐ YES ☐ NO	OBSTRUCTED BY HIGH PILING (18 to 36-in. [46 to 91-cm] clearance)? ☐ YES ☐ NO
		HEAT ADEQUATE TO PREVENT FREEZING (40 F [4 C] min.)? (Note broken windows, etc.) MIN. TEMP.	WATER PRESSURE — PSI AT YARD LEVEL:
		ANY HEADS DISCONNECTED OR NEEDED:	COMMENTS:

DRY-PIPE VALVES	Valve Room Properly Heated?	No. 1 Min.: 42 F/6 C Measured: F/C	No. 2 Min.: 42 F/6 C Measured: F/C	No. 3 Min.: 42 F/6 C Measured: F/C	No. 4 Min.: 42 F/6 C Measured: F/C
	Air Pressure	No. 1 Min.: psi/bar Measured: psi/bar	No. 2 Min.: psi/bar Measured: psi/bar	No. 3 Min.: psi/bar Measured: psi/bar	No. 4 Min.: psi/bar Measured: psi/bar

WATER SUPPLIES	Fire Pump	FIRE PUMP PRESSURE: START STOP		PACKINGS COOL? ☐ YES ☐ NO
		JOCKEY PUMP PRESSURE: START STOP		FUEL TANK LEVEL (3/4 min.)
		PUMP ROOM PROPERLY HEATED? (F/C min.) TEMP. F/C	PROPERLY VENTILATED? ☐ YES ☐ NO	FIRE PUMP STARTED ON AUTOMATIC? ☐ YES ☐ NO
	Tank Or Reservoir	FULL? ☐ YES ☐ NO	TIME TO OVERFLOW TANK: Mins.	HEATING SYSTEM IN USE? ☐ YES ☐ NO
		TEMP. AT COLD WATER RETURN (should be 42 F [6 C] min.):		CIRCULATION GOOD? ☐ YES ☐ NO
	Inside Hose	IN GOOD CONDITION? ☐ YES ☐ NO		ACCESSIBLE? ☐ YES ☐ NO

Fire Doors	CONDITION:	CLOSE PROPERLY? ☐ YES ☐ NO	OBSTRUCTED? ☐ YES ☐ NO	BLOCKED OPEN? ☐ YES ☐ NO

OCCUPANCY	General Order Neatness	GOOD? ☐ YES ☐ NO	COMBUSTIBLE WASTE REMOVED ON SCHEDULE? ☐ YES ☐ NO	HOW OFTEN?	
		PRESENCE OF COMBUSTIBLE DUST, LINT OR OIL DEPOSITS ON CEILINGS, BEAMS, MACHINES? ☐ YES ☐ NO If yes, arrange for cleaning and investigate the source.		LIST AREAS NEEDING ATTENTION, INCLUDING YARD:	
	Electrical Equipment	DEFECTS NOTED? ☐ YES ☐ NO			
	Flammable Liquids	SAFETY CANS USED? ☐ YES ☐ NO	LOW LEVEL VENT FANS ON? ☐ YES ☐ NO	FLAMMABLE LIQUID CABINETS USED? ☐ YES ☐ NO	GROUNDING STRAPS, SELF-CLOSING FAUCETS AND SAFETY BUNS IN USE? ☐ YES ☐ NO
	Smoking Regulations	LOCATIONS WHERE VIOLATIONS NOTED:		CORRECTIVE ACTION TAKEN:	
	Hot Work	PERMITS ISSUED FOR ALL HOT WORK APPLICATIONS? ☐ YES ☐ NO		LISTED PRECAUTIONS TAKEN? ☐ YES ☐ NO	
	Storage	WELL-ARRANGED? ☐ YES ☐ NO	AISLES CLEAR? ☐ YES ☐ NO	CLEAR OF LAMPS, HEATERS (36 in. [91 cm] min.)? ☐ YES ☐ NO	

OTHER ITEMS:

INSPECT THESE ITEMS AT LEAST MONTHLY

MANUAL PROTECTION	Extinguishers	CHARGED? ☐ YES ☐ NO	ANY MISSING? ☐ YES ☐ NO	ACCESSIBLE? ☐ YES ☐ NO	LOCATION OF EXTINGUISHERS NEEDING ATTENTION:
	Yard Hydrants and Hose	CONDITION: NO. 1 NO. 2	NO. 3 NO. 4	NO. 5 NO. 6	NO. 7
		HYDRANTS DRAINED? ☐ YES ☐ NO	REMARKS:		

OTHER ITEMS:

INSPECT THESE ITEMS AT LEAST QUARTERLY

Sprinkler Alarms	TESTED? ☐ YES ☐ NO	TIME FOR ALARM	OPERATION SATISFACTORY? (If no, comment below.) ☐ YES ☐ NO

OTHER ITEMS:

INSPECTED BY:		DATE:
REVIEWED BY:	TITLE:	DATE:

264 (Revised November 2007)

Weekly Fire Pump Test Form

Test all fire pumps weekly. Enter correct settings in the shaded column. Make sure all test results are within normal limits. If you find that repairs are needed, make them immediately and follow manufacturer's instructions.

Driver type, make and model

Pump manufacturer | Year installed

Manufacturer's model no. | gpm/psi rating gpm☐ psi☐ RPM☐

FM Global office

	Phone no.		Pump on		psi/bar/kPa	Jockey pump on		psi/bar/kPa
	Fax no.		Pump off		psi/bar/kPa	Jockey pump off		psi/bar/kPa
	Date tested							
	Tested by							
	Pressure at pump startup Method of start							
	Motor running time (min.)							
	Suction pressure							
	Discharge pressure							
	Temperature and tightness of shaft seal packing							
	Level of water supplies (suction tank should be overflowed)							
	Water temperature in suction tank/reservoir							
	Pump room temperature							
For Diesel Only	Engine instrument readings RPM							
For Diesel Only	Oil pressure							
For Diesel Only	Temperature							
For Diesel Only	Crank case oil level							
For Diesel Only	Last oil change/Next oil change							
For Diesel Only	Amps							
For Diesel Only	Fuel tank level should be at least ¾ full							
For Diesel Only	Condition of battery charger							
For Diesel Only	Last time battery charged Battery electrolyte level normal							
For Diesel Only	Cooling system strainer condition							
For Diesel Only	Cooling system temperature							
For Diesel Only	Operation of room ventilation dampers and fans (if provided)							
For Diesel Only	Inspection of drive belts/hose; replace per manufacturer's recommended frequency							

Annual pump flow test results ☐ Satisfactory ☐ Unsatisfactory

Explain findings

- Provide a work order for immediate repair.
- Follow impairment procedures detailed in *Managing Fire Protection System Impairment* (P9006).
- Keep records on file for review by appropriate personnel.
- Sign off when pump is restored to automatic:

(sign here)

TRIPPING RECORD

DRY PIPE VALVES

Use next page for deluge or pre-action valves.
Caution: Do not use grease or pipe compounds on valve seats.
Dry-pipe valves should be tripped, cleaned and reset annually

Instructions: Use one card for each dry-pipe valve. Post securely in dry-pipe valve enclosure.
Record the data each time the valve trips or is tripped.

VALVE MANUFACTURER'S NAME		MODEL NUMBER		YEAR INSTALLED		VALVE NO./AREA CONTROLLED			
DATE TRIPPED	**CAUSE OF TRIPPING OR BY WHOM TRIPPED**	**STATIC WATER PRESSURE**	**SYSTEM AIR PRESSURE**	**TRIP POINT AIR PRESSURE**	**TRIP TIME MIN. – SEC.**	**DATE RESET**	**RESET BY**	**RED TAG PERMITS USED?**	
								YES	**NO**
								❒	❒
								❒	❒
								❒	❒
								❒	❒
								❒	❒
								❒	❒
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								❒	❒
								❒	❒
								❒	❒
								❒	❒

ADDITIONAL COPIES MAY BE PRINTED AS NEEDED

FORM 57, page 1

TRIPPING RECORD

DELUGE OR PRE-ACTION VALVES

Use previous page for dry pipe valves.
Caution: Do not use grease or pipe compounds on valve seats.
Valves should be tripped, cleaned and reset annually

Instructions: Use one card for each valve. Attach securely to valve. Record the data each time the valve trips or is tripped.

VALVE MANUFACTURER'S NAME		MODEL NUMBER		YEAR INSTALLED		VALVE NO./AREA CONTROLLED			
DATE TRIPPED	**CAUSE OF TRIPPING OR BY WHOM TRIPPED**	**STATIC WATER PRESSURE**	**SYSTEM AIR PRESSURE**	**TRIP POINT AIR PRESSURE**	**TRIP TIME MIN. – SEC.**	**DATE RESET**	**RESET BY**	**RED TAG PERMITS USED?**	
								YES	**NO**
								❐	❐
								❐	❐
								❐	❐
								❐	❐
								❐	❐
								❐	❐
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								❐	❐
								❐	❐
								❐	❐

ADDITIONAL COPIES MAY BE PRINTED AS NEEDED
USE PREVIOUS PAGE FOR DRY-PIPE VALVE TRIPPING RECORD.

FORM 57, page 2

ANNUAL PERFORMANCE TEST RECORD OF PRESSURE REDUCING VALVES (PRV)

Property Name	Index Number	Account Number
Property Address	Operations Center Location	

INSTRUCTIONS	1. Conduct a Full Flow Test on each PRV on site in accordance with FM Global O.S. 3.11. 2. Use a separate form for each different valve model number. 3. Forward a copy of test form to the FM Global address shown above. 4. Keep a copy of form on site for review of test record.

Valve Manufacturer's Name	**Model Number**	**Type of Valve** ❐ Pilot Operated ❐ Direct Acting	**Installation At:** ❐ Sprinkler System ❐ Hose Connection ❐ Fire Main ❐ Other
Year Installed			

Date & Initials	Location of Valve (e.g., Floor No. Standpipe No.)	Valve Setting Per Manufacturer Specs.	Static Pressure		Residual Pressure		Flow Rate (gpm)	Performance S = Satis. U = Unsatis.	Red Tag Permits Used		Comments/ Corrective Action Needed
			Inlet (psi)	Outlet (psi)	Inlet (psi)	Outlet (psi)			Yes	No	
									❐	❐	
									❐	❐	
									❐	❐	
									❐	❐	
									❐	❐	
									❐	❐	
									❐	❐	
									❐	❐	
									❐	❐	
									❐	❐	
									❐	❐	
									❐	❐	
									❐	❐	
									❐	❐	
									❐	❐	
									❐	❐	

The FM Global ***RED TAG PERMIT SYSTEM*** is used to guard against delayed reopening of valves. The FM Global ***RED TAG PERMIT SYSTEM*** should be used every time a sprinkler control valve is closed. When the valve is reopened, the drain should be flowed wide open to be sure there is no obstruction in the piping. The valve should then be relocked.

Were any valves closed since the last inspection? ❐ Yes ❐ No	
If Inspected by Contractor (Contractor's Name)	Signature:
Address	Date:
Reviewed By:	Date:

FORM 2707, page 1

ANNUAL PERFORMANCE TEST RECORD OF PRESSURE REDUCING VALVES (PRV)

Date & Initials	*Location of Valve (e.g., Floor No. Standpipe No.)*	*Valve Setting Per Manufacturer Specs.*	*Static Pressure*		*Residual Pressure*		*Flow Rate (gpm)*	*Performance S = Satis. U = Unsatis.*	*Red Tag Permits Used*		*Comments/ Corrective Action Needed*
			Inlet (psi)	Outlet (psi)	Inlet (psi)	Outlet (psi)			Yes	No	
									❒	❒	
									❒	❒	
									❒	❒	
									❒	❒	
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FORM 2707, page 2