Program for Individual Systems

This information is extracted from NFPA's Commissioning Fire Protection Systems and will assist the user in developing a commissioning plan to meet the minimum requirements of the following NFPA codes and standards:

- Chapter 1 Automatic Sprinklers (NFPA 13, 2010 edition)
- Chapter 2 Fire Alarm Systems (NFPA 72, 2010 edition)
- Chapter 3 Standpipes and Hose Systems (NFPA 14, 2010 edition)
- Chapter 4 Fire Pumps (NFPA 20, 2010 edition)

These chapters include extracts of the documentation, inspection, testing, and other commissioning requirements from the respective NFPA installation standards for all of the fire protection and fire safety systems listed earlier. The extracts focus specifically on the documentation, inspection, and acceptance testing for fire protection systems and equipment, including commentary on how and why these activities are conducted. For the reader's convenience, the extracted NFPA code or standard number is indicated in the margin and Annex material is indicated by an “A” icon.
NFPA statistics indicate that sprinkler systems function exceptionally well when properly maintained. The few instances of system failure are found to be directly related to shut water supply control valves and inadequate maintenance, which can be construed as a misunderstanding of the operational needs of the system. Commissioning, beginning in the planning stages of a construction project, is intended not only to address the operational requirements for sprinkler systems but to also provide for the documentation of the concepts employed in the system design and the installation and testing of the system. This documentation, when combined with appropriate training during project closeout, is intended to ensure peak system performance throughout the life cycle of the building and system.

This chapter provides excerpts from NFPA 13, *Standard for the Installation of Sprinkler Systems*, that directly relate to the commissioning of sprinkler systems. The chapter begins with a discussion of plans and calculations and concludes with testing requirements and project closeout documentation.

### OVERVIEW

**Automatic Sprinkler System Defined**

A sprinkler system can be described as a system employing automatic sprinklers attached to a piping system containing water and connected to a water supply so that water discharges immediately from sprinklers opened by heat from a fire (commonly referred to as a *wet-pipe system*). For unheated spaces, such a system employs automatic sprinklers attached to a piping system containing air or nitrogen under pressure.

The release of this air or nitrogen (as from the opening of a sprinkler) permits the water pressure to open a dry-pipe valve, and the water then flows into the piping system and out of the opened sprinklers (a *dry-pipe system*).

For high hazard areas, a deluge sprinkler system employs open sprinklers attached to a piping system connected to a water supply through a valve. The valve is opened by the operation of a detection system installed in the same areas as the sprinklers. When this valve opens, water flows into the piping system and discharges from all sprinklers attached thereto.

A preaction sprinkler system employs automatic sprinklers attached to a piping system containing air that may or may not be under pressure. A supplemental detection system is installed in the same areas as the sprinklers.

Each of these system types will have specific commissioning requirements, because each employs different types of valves and activation mechanisms.
Level of Protection

NFPA 13 requires protection of all areas of a building with only specific omissions allowed, such as noncombustible concealed spaces. The basis of design (BOD), project specifications, and preliminary plans should clearly document areas where sprinklers are omitted.

A building, where protected by an automatic sprinkler system installation, shall be provided with sprinklers in all areas except where specific sections of this standard permit the omission of sprinklers. [NFPA 13-10: 4.1]

When partial sprinkler systems are installed, the requirements of this standard shall be used insofar as they are applicable. [NFPA 13-10: 4.2.1]

The authority having jurisdiction shall be consulted in each case. [NFPA 13-10: 4.2.2]

Owner Requirements

The owner(s) of a building or structure where the fire sprinkler system is going to be installed or their authorized agent shall provide the sprinkler system installer with the following information prior to the layout and detailing of the fire sprinkler system [see NFPA 13-10: Figure A.22.1(b) [Exhibit 1.1]:

1. Intended use of the building including the materials within the building and the maximum height of any storage
2. A preliminary plan of the building or structure along with the design concepts necessary to perform the layout and detail for the fire sprinkler system
3. Any special knowledge of the water supply, including known environmental conditions that might be responsible for corrosion, including microbiologically influenced corrosion (MIC) [NFPA 13-10: 4.3]

For new construction, this information is sent to the registered design professional (RDP) for inclusion in the project plans and specifications. This information is used to develop the BOD documentation. Exhibit 1.1 can be included as a section of the BOD.

PLANS

Construction Documents Defined

Documents that consist of scaled design drawings and specifications for the purpose of construction of new facilities or modification to existing facilities. [NFPA 1-12: 3.3.69]

Preliminary Plans

Preliminary plans should be submitted for review to the authority having jurisdiction prior to the development of working plans [see NFPA 13-10: Figure A.22.1(a)][Exhibit 1.2]. The preliminary plans can be part of the construction documents submitted in order to obtain a building permit. However, working drawings in accordance with Section 22.1 should be submitted and approved prior to the installation of system equipment. Preliminary plans should include as much information as is required to provide a clear representation of the hazard to be protected, the system design concept, the proposed water supply configuration, and building construction information pertinent to system layout and detailing.

The owner’s information certificate [see NFPA 13-10: Figure A.22.1(b)][Exhibit 1.1]: should be used to obtain a declaration of the intended use of the occupancy to be protected. Drawings that accompany the certificate should include the following:
EXHIBIT 1.1 Owner’s Information Certificate  Source: Adapted from NFPA 13, 2010, Figure A.14.1(b).

OWNER’S INFORMATION CERTIFICATE

Name/address of property to be protected with sprinkler protection:

Name of owner:

Existing or planned construction is:

- Fire resistive or noncombustible
- Wood frame or ordinary (masonry walls with wood beams)
- Unknown

Describe the intended use of the building:

Note regarding speculative buildings: The design and installation of the fire sprinkler system is dependent on an accurate description of the likely use of the building. Without specific information, assumptions will need to be made that will limit the actual use of the building. Make sure that you communicate any and all use considerations to the fire sprinkler contractor in this form and that you abide by all limitations regarding the use of the building based on the limitations of the fire sprinkler system that is eventually designed and installed.

Is the system installation intended for one of the following special occupancies:

- Aircraft hangar
- Fixed guideway transit system
- Race track stable
- Marine terminal, pier, or wharf
- Airport terminal
- Aircraft engine test facility
- Power plant
- Water-cooling tower

If the answer to any of the above is “yes,” the appropriate NFPA standard should be referenced for sprinkler density/area criteria.

Indicate whether any of the following special materials are intended to be present:

- Flammable or combustible liquids
- Aerosol products
- Nitrate film
- Pyroxylin plastic
- Compressed or liquefied gas cylinders
- Liquid or solid oxidizers
- Organic peroxide formulations
- Idle pallets

If the answer to any of the above is “yes,” describe type, location, arrangement, and intended maximum quantities.
Indicate whether the protection is intended for one of the following specialized occupancies or areas:

- Spray area or mixing room
- Solvent extraction
- Laboratory using chemicals
- Oxygen-fuel gas system for welding or cutting
- Acetylene cylinder charging
- Production or use of compressed or liquefied gases
- Commercial cooking operation
- Class A hyperbaric chamber
- Cleanroom
- Incinerator or waste handling system
- Linen handling system
- Industrial furnace
- Water-cooling tower

If the answer to any of the above is “yes,” describe type, location, arrangement, and intended maximum quantities.

Will there be any storage of products over 12 ft (3.6 m) in height?  ❑ Yes  ❑ No
If the answer is “yes,” describe product, intended storage arrangement, and height.

Will there be any storage of plastic, rubber, or similar products over 5 ft (1.5 m) high except as described above?  ❑ Yes  ❑ No
If the answer is “yes,” describe product, intended storage arrangement, and height.

Is there any special information concerning the water supply?  ❑ Yes  ❑ No
If the answer is “yes,” provide the information, including known environmental conditions that might be responsible for corrosion, including microbiologically influenced corrosion (MIC).

I certify that I have knowledge of the intended use of the property and that the above information is correct.

Signature of owner’s representative or agent: ___________________________  Date: ___________________

Name of owner’s representative or agent completing certificate (print): ___________________________

Relationship and firm of agent (print): ___________________________
EXHIBIT 1.2  Typical Preliminary Plan  Source: NFPA 13, 2010, Figure A.14.1(a).

1. Name of owner and occupant.
2. Location, including street address.
3. Point of compass.
4. Construction and occupancy of each building.
5. Building height in feet.
6. Waterflow test information. If a waterflow test of the city main is available, the drawings should indicate the date and time of the test, the name of the party that conducted the test, the location of the hydrants where the flow was taken and where static and residual pressure readings were recorded (see A.23.2.1), the size and configuration of mains supplying the hydrants, the size and number of open hydrant butts flood, and results of the test.
7. Building features such as combustible concealed spaces, floor openings, areas subject to freezing, and areas from which it is intended to omit sprinkler protection.
8. Proposed location and approximate size, if a water supply employing pumps or tanks is contemplated.
9. Name and address of party submitting the preliminary plans.
10. Tentative location of major piping, including mains underground, risers, overhead mains, and fire department connections.
The preliminary plan discussed here is usually submitted by the RDP with the complete set of bid documents for the project. This set ordinarily includes the architectural, structural plans and all building systems, such as electrical; plumbing; heating, ventilation, and air conditioning (HVAC); fire protection; and so on. The preliminary plans should include sufficient information to permit an initial plan review for the issuance of a building permit.

**Working Plans**

Working plans are much more detailed than preliminary plans. As the name suggests, these are the plans normally used for installation and submission as the final as-built drawings during project closeout. They must, therefore, contain exact dimensions and instructions for the installer.

These plans can also be used for the fabrication of precut pipe and pipe supports. Ordinarily, sprinkler pipe is fabricated in a fabrication shop off-site and shipped to the project with pipe lengths cut based on the dimensions shown on the working drawing; pipe threads are fabricated onto the pipe and one fitting “made-on” or attached. The sprinkler system is assembled based on the order of installation indicated on the working plans with few, if any, deviations.

Underground mains should be designed so that the system can be extended with a minimum of expense. Possible future plant expansion should also be considered and the piping designed so that it will not be covered by buildings. [See NFPA 13-10: Figure A.22.1.1][Exhibit 1.3][NFPA 13-10: A.22.1.1]

**Working Plan Submittal**

Working plans must be submitted when applying for a permit to install the fire protection system.

Working plans shall be submitted for approval to the authority having jurisdiction before any equipment is installed or remodeled. [NFPA 13-10: 22.1.1]

**Deviation**

Deviation from approved plans shall require permission of the authority having jurisdiction. [NFPA 13-10: 22.1.2]

Deviation from the approved plans can take the form of change orders for the addition or deletion of work or correction of design or installation errors or spatial conflicts with the equipment of other trades.

**Content of Plans**

Working plans shall be drawn to an indicated scale, on sheets of uniform size, with a plan of each floor, and shall show those items from the following list that pertain to the design of the system:

1. Name of owner and occupant.
2. Location, including street address.
3. Point of compass.
4. Full height cross section, or schematic diagram, including structural member information if required for clarity and including ceiling construction and method of protection for nonmetallic piping.
5. Location of partitions.
6. Location of fire walls.
7. Occupancy class of each area or room.
8. Location and size of concealed spaces, closets, attics, and bathrooms.
(9) Any small enclosures in which no sprinklers are to be installed.
(10) Size of city main in street and whether dead end or circulating; if dead end, direction and distance to nearest circulating main; and city main test results and system elevation relative to test hydrant (see A.23.1.8).
(11) Other sources of water supply, with pressure or elevation.
(12) Make, type, model, and nominal K-factor of sprinklers including sprinkler identification number.
(13) Temperature rating and location of high-temperature sprinklers.
(14) Total area protected by each system on each floor.
(15) Number of sprinklers on each riser per floor.
(16) Total number of sprinklers on each dry pipe system, preaction system, combined dry pipe–preaction system, or deluge system.
(17) Approximate capacity in gallons of each dry-pipe system.
(18) Pipe type and schedule of wall thickness.
(19) Nominal pipe size and cutting lengths of pipe (or center-to-center dimensions). Where typical branch lines prevail, it shall be necessary to size only one typical line.
(20) Location and size of riser nipples.
(21) Type of fittings and joints and location of all welds and bends. The contractor shall specify on drawing any sections to be shop welded and the type of fittings or formations to be used.

(22) Type and locations of hangers, sleeves, braces, and methods of securing sprinklers when applicable.

(23) All control valves, check valves, drain pipes, and test connections.

(24) Make, type, model, and size of alarm or dry-pipe valve.

(25) Make, type, model, and size of preaction or deluge valve.

(26) Kind and location of alarm bells.

(27) Size and location of standpipe risers, hose outlets, hand hose, monitor nozzles, and related equipment.

(28) Private fire service main sizes, lengths, locations, weights, materials, point of connection to city main; the sizes, types and locations of valves, valve indicators, regulators, meters, and valve pits; and the depth that the top of the pipe is laid below grade.

(29) Piping provisions for flushing.

(30) Where the equipment is to be installed as an addition to an existing system, enough of the existing system indicated on the plans to make all conditions clear.

(31) For hydraulically designed systems, the information on the hydraulic data nameplate.

(32) A graphic representation of the scale used on all plans.

(33) Name and address of contractor.

(34) Hydraulic reference points shown on the plan that correspond with comparable reference points on the hydraulic calculation sheets.

(35) The minimum rate of water application (density or flow or discharge pressure), the design area of water application, in-rack sprinkler demand, and the water required for hose streams both inside and outside.

(36) The total quantity of water and the pressure required noted at a common reference point for each system.

(37) Relative elevations of sprinklers, junction points, and supply or reference points.

(38) If room design method is used, all unprotected wall openings throughout the floor protected.

(39) Calculation of loads for sizing and details of sway bracing.

(40) The setting for pressure-reducing valves.

(41) Information about backflow preventers (manufacturer, size, type).

(42) Information about antifreeze solution used (type and amount).

(43) Size and location of hydrants, showing size and number of outlets and if outlets are to be equipped with independent gate valves. Whether hose houses and equipment are to be provided, and by whom, shall be indicated. Static and residual hydrants that were used in flow tests shall be shown.

(44) Size, location, and piping arrangement of fire department connections.

(45) Ceiling/roof heights and slopes not shown in the full height cross section.

(46) Edition year of NFPA 13 that the sprinkler system is designed to. [NFPA 13-10: 22.1.3]

A signed copy of the owner’s certificate and the working plan submittal shall include the manufacturer’s installation instructions for any specially listed equipment, including descriptions, applications, and limitations for any sprinklers, devices, piping, or fittings. [NFPA 13-10: 22.1.4]
Owner’s certificate should be furnished for all new systems and where there is a change of occupancy and/or building use.

**Auxiliary Equipment Symbols**

Special symbols shall be used and explained for auxiliary piping, pumps, heat exchangers, valves, strainers, and the like, clearly distinguishing these devices and piping runs from those of the sprinkler system. [NFPA 13-10: 22.1.5.1]

Model number, type, and manufacturer’s name shall be identified for each piece of auxiliary equipment. [NFPA 13-10: 22.1.5.2]

**WATER SUPPLY**

Generally, existing water supply data, if available, can be used, provided the data were obtained within the last five years. If the data were obtained more than five years ago or if no water supply data are available, a waterflow test must be conducted.

**Testing of Water Supply.** To determine the value of public water as a supply for automatic sprinkler systems, it is generally necessary to make a flow test to determine how much water can be discharged at a residual pressure at a rate sufficient to give the required residual pressure under the roof (with the volume flow hydraulically translated to the base of the riser) — that is, a pressure head represented by the height of the building plus the required residual pressure.

The proper method of conducting this test is to use two hydrants in the vicinity of the property. The static pressure should be measured on the hydrant in front of or nearest to the property and the water allowed to flow from the hydrant next nearest the property, preferably the one farthest from the source of supply if the main is fed only one way. The residual pressure will be that indicated at the hydrant where water is not flowing.

Referring to Figure A.23.2.1 [Exhibit 1.4], the method of conducting the flow tests is as follows:

1. Attach the gauge to the hydrant (A) and obtain static pressure.
2. Either attach a second gauge to the hydrant (B) or use the pitot tube at the outlet. Have hydrant (B) opened wide and read pressure at both hydrants.
3. Use the pressure at (B) to compute the gallons flowing and read the gauge on (A) to determine the residual pressure or that which will be available on the top line of sprinklers in the property.

Water pressure in pounds per square inch for a given height in feet equals height multiplied by 0.433.

In making flow tests, whether from hydrants or from nozzles attached to hose, always measure the size of the orifice. While hydrant outlets are usually 2½ in. (64 mm), they are sometimes smaller and occasionally larger. Underwriters Laboratories play pipe is 1⅛ in. (29 mm) and 1⅝ in. (44 mm) with the tip removed, but occasionally nozzles will be 1 in. (25.4 mm) or 1¼ in. (33 mm), and with the tip removed the opening can be only 1½ in. (38 mm).

The pitot tube should be held approximately one-half the diameter of the hydrant or nozzle opening away from the opening. It should be held in the center of the stream, except that in using hydrant outlets the stream should be explored to ascertain the average pressure.

For further information on water supply testing, see NFPA 291, *Recommended Practice for Fire Flow Testing and Marking of Hydrants.* [NFPA 13-10: A.23.2.1]
**Capacity Data**

The following information shall be included:

1. Location and elevation of static and residual test gauge with relation to the riser reference point
2. Flow location
3. Static pressure, psi (bar)
4. Residual pressure, psi (bar)
5. Flow, gpm (L/min)
6. Date
7. Time
8. Name of person who conducted the test or supplied the information
9. Other sources of water supply, with pressure or elevation [NFPA 13-10: 22.2.1]

Where a water flow test is used for the purposes of system design, the test shall be conducted no more than 12 months prior to working plan submittal. [NFPA 13-10: 22.2.1.1]

**Treatment Data**

The following information shall be included when water supply treatment is provided in accordance with NFPA 13-10: 23.1.5:

1. Type of condition that requires treatment
2. Type of treatment needed to address the problem
3. Details of treatment plan [NFPA 13-10: 22.2.2]

**HYDRAULIC CALCULATION FORMS**

Hydraulic calculation forms provide written, mathematical verification of the system’s pipe diameters and demonstrate that the attached water supply meets or exceeds the required flow and pressure of the fire protection system. The hydraulic calculations must be submitted any time the plans are submitted, because the plans cannot be reviewed completely without a review of the hydraulic characteristics of the system.

Hydraulic calculations shall be prepared on form sheets that include a summary sheet, detailed worksheets, and a graph sheet. [See copies of typical forms in Figure A.22.3.2(a), Figure A.22.3.3, and Figure A.22.3.4.][Exhibits 1.5, 1.6, 1.7], [NFPA 13-10: 22.3.1]
Summary Sheet

The summary sheet shall contain the following information, where applicable:

1. Date
2. Location
3. Name of owner and occupant
4. Building number or other identification
5. Description of hazard (for storage applications, the commodity classification, storage height, and rack configuration shall be included)
6. Name and address of contractor or designer
7. Name of approving agency
8. System design requirements, as follows:
   (a) Design area of water application, ft² (m²)
   (b) Minimum rate of water application (density), gpm/ft² (mm/min). Where sprinklers are listed with minimum water application in gpm (L/min) or pressure in psi (bar), the minimum rate of water application shall be indicated in gpm (L/min) or pressure, psi (bar).
   (c) Area per sprinkler, ft² (m²)

EXHIBIT 1.5  Sample Filled-Out Summary Sheet

Hydraulic Calculations

for

ABC Company, employee garage

7499 Franklin Road
Charleston, SC

Contract No. 4001
Date 1 – 7 – 08

Design data:

Occupancy classification ORD GR 1
Density 0.15 gpm/ft²
Area of application 1500 ft²
Coverage per sprinkler 150 ft²
Special sprinklers

No. of sprinklers calculated 12

In-rack demand
Hose streams 250 gpm
Total water required 510.4 gpm including hose streams

Name of contractor

Name of designer

Address

Authority having jurisdiction

Source: NFPA 13, 2010, Figure A.14.3.2(a).
(9) Total water requirements as calculated, including allowance for inside hose, outside hydrants, and water curtain and exposure sprinklers

(10) Allowance for in-rack sprinklers, gpm (L/min)

(11) Limitations (dimension, flow, and pressure) on extended coverage or other listed special sprinklers [NFPA 13-10: 22.3.2]
### EXHIBIT 1.5  Continued

<table>
<thead>
<tr>
<th>Sheet No.</th>
<th>Nozzle Ident. and Location</th>
<th>Flow in gpm</th>
<th>Pipe Size</th>
<th>Pipe Fittings and Devices</th>
<th>Equivalent Pipe Length</th>
<th>Friction Loss psi</th>
<th>Pressure Summary</th>
<th>Normal Pressure</th>
<th>Notes</th>
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<tbody>
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<td>1</td>
<td>BL-1</td>
<td>q</td>
<td>1</td>
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<td>12.1</td>
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<td>F</td>
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<td></td>
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<td>1(\frac{1}{2})</td>
<td>L 13.0</td>
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<td>15.3</td>
<td></td>
<td></td>
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<tr>
<td>4</td>
<td>DN RN</td>
<td>q 23.1</td>
<td>1(\frac{1}{2})</td>
<td>L 20.5</td>
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<td>26.0</td>
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<tr>
<td>6</td>
<td>BL-2 CM TO BL-3</td>
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<td>7</td>
<td>CM TO FIB</td>
<td>q 259.6</td>
<td></td>
<td>L 119.0</td>
<td>AV15 F 21</td>
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<tr>
<td>8</td>
<td>THROUGH UNDERGROUND TO CITY MAIN</td>
<td>q 259.6</td>
<td>E5</td>
<td>L 50.0</td>
<td>GV1 T 140.0</td>
<td>0.081</td>
<td></td>
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</tbody>
</table>

### Worksheet

Detailed worksheets or computer printout sheets shall contain the following information:

1. Sheet number
2. Sprinkler description and discharge constant \((K)\)
3. Hydraulic reference points

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### Program for Individual Systems

13
Graph Sheet

A graphic representation of the complete hydraulic calculation shall be plotted on semi-exponential graph paper ($Q^{1.85}$) and shall include the following:

1. Water supply curve
2. Sprinkler system demand
3. Hose allowance (where applicable)
4. In-rack sprinkler demand (where applicable) [NFPA 13-10: 22.3.4]
### EXHIBIT 1.6 Sample Worksheet
*Source: NFPA 13, 2010, Figure A.14.3.3.*

<table>
<thead>
<tr>
<th>Contract no.</th>
<th>Name and location</th>
<th>Sheet no. of</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Reference</th>
<th>Nozzle type and location</th>
<th>Flow in gpm/L/min</th>
<th>Pipe size in.</th>
<th>Fitting and devices</th>
<th>Pipe equivalent length</th>
<th>Friction loss psi/ft (bar/m)</th>
<th>Required psi (bar)</th>
<th>Normal Pressure</th>
<th>Notes</th>
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</tr>
</tbody>
</table>

\[ P_t: \text{ total pressure. } P_f: \text{ friction loss pressure. } P_v: \text{ velocity pressure. } P_e: \text{ elevation pressure.} \]
In addition to acceptance testing, approval and acceptance involves a number of inspections or action items that must be documented on the contractor’s material and test certificate (Exhibit 1.8) or other project closeout documentation. These items are as follows:

- Installation of spare sprinklers
- Verification of pipe and fitting types
- Verification of test blank removal (if applicable)
- Welding certification (if applicable)
- Hydraulic data nameplate installation
- Field verification of as-built drawings
- Verification of approved equipment and components
- Verification of training of maintenance personnel
- Project closeout submittals, such as system component maintenance instructions, general system care, maintenance instructions, and copy of NFPA 25, Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems
- Valve identification (installation of valve signs)

Although these items can be verified and documented on the Contractor’s Material and Test Certificate, training of operations personnel and submission of as-built plans and operation and maintenance manuals should be completed as discussed in Chapter 1.

Source: NFPA 13, 2010, Figure A.14.3.4.
**Contractor’s Material and Test Certificate for Aboveground Piping**

**Source:** Adapted from NFPA 13, 2010, Figure 16.1.

**PROCEDURE**

Upon completion of work, inspection and tests shall be made by the contractor’s representative and witnessed by the property owner or their authorized agent. All defects shall be corrected and system left in service before contractor’s personnel finally leave the job.

A certificate shall be filled out and signed by both representatives. Copies shall be prepared for approving authorities, owners, and contractor. It is understood the owner’s representative’s signature in no way prejudices any claim against contractor for faulty material, poor workmanship, or failure to comply with approving authority’s requirements or local ordinances.

<table>
<thead>
<tr>
<th>Property name</th>
<th>Date</th>
</tr>
</thead>
</table>

**Plans**

<table>
<thead>
<tr>
<th>Accepted by approving authorities (names)</th>
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<tbody>
<tr>
<td>Address</td>
</tr>
<tr>
<td>Installation conforms to accepted plans</td>
</tr>
<tr>
<td>Yes ✅ No ❌</td>
</tr>
<tr>
<td>Equipment used is approved</td>
</tr>
<tr>
<td>Yes ✅ No ❌</td>
</tr>
<tr>
<td>If no, explain deviations</td>
</tr>
</tbody>
</table>

**Instructions**

<table>
<thead>
<tr>
<th>Has person in charge of fire equipment been instructed as to location of control valves and care and maintenance of this new equipment?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes ✅ No ❌</td>
</tr>
<tr>
<td>If no, explain</td>
</tr>
<tr>
<td>Have copies of the following been left on the premises?</td>
</tr>
<tr>
<td>Yes ✅ No ❌</td>
</tr>
</tbody>
</table>

- 1. System components instructions
- 2. Care and maintenance instructions
- 3. NFPA 25

**Location of system**

<table>
<thead>
<tr>
<th>Supplies buildings</th>
</tr>
</thead>
</table>

**Sprinklers**

<table>
<thead>
<tr>
<th>Make</th>
<th>Model</th>
<th>Year of manufacture</th>
<th>Orifice size</th>
<th>Quantity</th>
<th>Temperature rating</th>
</tr>
</thead>
</table>

**Pipe and fittings**

<table>
<thead>
<tr>
<th>Type of pipe</th>
<th>Type of fittings</th>
</tr>
</thead>
</table>

**Alarm valve or flow indicator**

<table>
<thead>
<tr>
<th>Alarm device</th>
<th>Maximum time to operate through test connection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make</td>
<td>Model</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dry valve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q. O. D.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dry pipe operating test</th>
<th>Time to trip through test connection&lt;sup&gt;a,b&lt;/sup&gt;</th>
<th>Water pressure</th>
<th>Air pressure</th>
<th>Trip point air pressure</th>
<th>Time water reached test outlet&lt;sup&gt;a,b&lt;/sup&gt;</th>
<th>Alarm operated properly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make</td>
<td>Model</td>
<td>Serial no.</td>
<td>Make</td>
<td>Model</td>
<td>Serial no.</td>
<td>Minutes</td>
</tr>
</tbody>
</table>

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<sup>a</sup> Measured from time inspector’s test connection is opened

<sup>b</sup> NFPA 13 only requires the 60-second limitation in specific sections
### EXHIBIT 1.8 Continued

#### Deluge and Preaction Valves

<table>
<thead>
<tr>
<th>Operation</th>
<th>Pneumatic</th>
<th>Electric</th>
<th>Hydraulics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piping supervised</td>
<td>Yes</td>
<td>No</td>
<td>Detecting media supervised</td>
</tr>
<tr>
<td>Does valve operate from the manual trip, remote, or both control stations?</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Is there an accessible facility in each circuit for testing?</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Make</th>
<th>Model</th>
<th>Does each circuit operate supervision loss alarm?</th>
<th>Does each circuit operate valve release?</th>
<th>Maximum time to operate release</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Minutes</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Minutes</td>
</tr>
</tbody>
</table>

#### Pressure-Reducing Valve Test

<table>
<thead>
<tr>
<th>Location and floor</th>
<th>Make and model</th>
<th>Setting</th>
<th>Static pressure</th>
<th>Residual pressure (flowing)</th>
<th>Flow rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inlet (psi)</td>
<td>Outlet (psi)</td>
<td>Inlet (psi)</td>
<td>Outlet (psi)</td>
<td>Flow (gpm)</td>
<td></td>
</tr>
<tr>
<td>Hydrostatic: Hydrostatic tests shall be made at not less than 200 psi (13.6 bar) for 2 hours or 50 psi (3.4 bar) above static pressure in excess of 150 psi (10.2 bar) for 2 hours. Differential dry pipe valve clappers shall be kept open during the test to prevent damage. All aboveground piping leakage shall be stopped.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pneumatic: Establish 40 psi (2.7 bar) air pressure and measure drop, which shall not exceed 1 ¹⁄₂ psi (0.1 bar) in 24 hours. Test pressure tanks at normal water level and air pressure and measure air pressure drop, which shall not exceed 1 ¹⁄₂ psi (0.1 bar) in 24 hours.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Test Description

<table>
<thead>
<tr>
<th>Tests</th>
<th>Drain test</th>
<th>Reading of gauge located near water supply test connection: ______ psi (- - bar) for _____ hours</th>
<th>Residual pressure with valve in test connection open wide: ______ psi (- - bar)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>No</td>
<td>Other</td>
<td>Explain</td>
</tr>
</tbody>
</table>

| Underwater mains and lead-in connections to system risers flushed before connection made to sprinkler piping |
| Verified by copy of the Contractor's Material and Test Certificate for Underground Piping, Flushed by installer of underground sprinkler piping |
| Yes | No |

If powder-driven fasteners are used in concrete, has representative sample testing been satisfactorily completed?

<table>
<thead>
<tr>
<th>Blank Testing Gaskets</th>
<th>Number used</th>
<th>Locations</th>
<th>Number removed</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Welding piping</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

Do you certify as the sprinkler contractor that welding procedures used complied with the minimum requirements of AWS B2.1, ASME Section IX Welding and Brazing Qualifications, or other applicable qualification standard as required by the AHJ?

Do you certify that all welding was performed by welders or welding operators qualified in accordance with the minimum requirements of AWS B2.1, ASME Section IX Welding and Brazing Qualifications, or other applicable qualification standard as required by the AHJ?

Do you certify that the welding was conducted in compliance with a documented quality control procedure to ensure that (1) all discs are retrieved; (2) that openings in piping are smooth, that slag and other welding residue are removed; (3) the internal diameters of piping are not penetrated; (4) completed welds are free from cracks, incomplete fusion, surface porosity greater than ¹⁄₂₄ in. diameter, undercut deeper than the lesser of 25% of the wall thickness or ¹⁄₂ in.; and (5) completed circumferential butt weld reinforcement does not exceed ¹⁄₃₂ in.?
<table>
<thead>
<tr>
<th>Cutouts (discs)</th>
<th>Do you certify that you have a control feature to ensure that all cutouts (discs) are retrieved?</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydraulic data nameplate</td>
<td>Nameplate provided If no, explain</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Sprinkler contractor removed all caps and straps?</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Remarks</td>
<td>Date left in service with all control valves open</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Signatures</td>
<td>Name of sprinkler contractor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tests witnessed by</td>
<td>The property owner or their authorized agent (signed) Title Date</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>For sprinkler contractor (signed) Title Date</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additional explanations and notes</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Acceptance Testing Activities

Acceptance testing involves a number of activities that must be performed, witnessed, and documented. These activities are as follows:

- Functional test of the system alarm device
- Trip and water transit time for dry-pipe systems
- Trip test for deluge/preaction systems
- Pressure-reducing valve test (if present)
- Hydrostatic test
- Main drain test

The completion of these tests can be documented on the contractor’s material and test certificate (Exhibit 1.8).

Approval Requirements

As defined by NFPA, approved means acceptable to the authority having jurisdiction (AHJ). During acceptance testing, it is customary to schedule the tests to allow the AHJ to witness the tests and sign the contractor’s material and test certificate. By witnessing the acceptance tests, the AHJ can verify that the system has been designed and installed in accordance with the plans, specifications, and all applicable codes and standards and functions to the satisfaction of the AHJ.

In addition to the preceding requirements, the project specifications may also require documentation in the form of a punch list for the following specialties:

- Installation of sprinkler and wall escutcheons
- Installation of sprinkler guards (where required)
- Pipe identification (where required)
- Installation of sleeves including appropriate packing material

The sprinkler checklist in Appendix D can be used for project closeout.

Contractor’s Responsibilities

By code, the contractor is responsible for scheduling the test and coordinating this schedule with all of the AHJs. The contractor will perform the test, complete the test reports, and have the AHJ sign the test report if satisfactory. If the system test fails, the contractor is usually responsible for any needed repairs or corrective action and subsequent retest.

The installing contractor shall do the following:

1. Notify the authority having jurisdiction and the property owner or the property owner’s authorized representative of the time and date testing will be performed
2. Perform all required acceptance tests [see NFPA 13-10: 24.2]
3. Complete and sign the appropriate contractor’s material and test certificate(s) [see NFPA 13-10: Figure 24.1] [Exhibit 1.8]
4. Remove all caps and straps prior to placing the sprinkler system in service [NFPA 13-10: 24.1]

Hydrostatic Tests

Testing Pressure

A hydrostatic test is a pressure test to reveal the presence of leaks in the piping system. For fire protection systems, the piping is pressurized to 200 psi (13.8 bar) for a period of 2 hours. During this time period, the system piping is inspected for leaks. Leaks in the piping system are revealed either by observation of water droplets or by a reduction in test
pressure. Any leaks or reduction in test pressure necessitates a repair of the pipe joint involved and a retest to verify that the leak has been repaired. In cases where high pressure exists, the standard requires that the test pressure be 50 psi (3.5 bar) in excess of the normal system pressure if the resultant test pressure will be greater than 200 psi (13.8 bar).

In the case of underground piping, a certain amount of leakage is allowed due to the type of valves and fittings permitted by the design standard. During the hydrostatic test of underground piping, a slight pressure loss should be anticipated. The system should be pressurized such that this slight pressure loss does not permit the test pressure to drop below the specified 200 psi (13.8 bar). Following the 2-hour test period, the pressure loss should be simulated by opening a small drain valve installed for the test and draining the water into a calibrated container. The water volume should be measured and compared to the values permitted by NFPA 13. If the amount of water drained from the system is less than permitted, the test can be considered to be acceptable.

Unless permitted by 24.2.1.2 through 24.2.1.8, all piping and attached appurtenances subjected to system working pressure shall be hydrostatically tested at 200 psi (13.8 bar) and shall maintain that pressure without loss for 2 hours. [NFPA 13-10: 24.2.1.1]

Portions of systems normally subjected to system working pressures in excess of 150 psi (10.4 bar) shall be tested as described in 24.2.1.1, at a pressure of 50 psi (3.5 bar) in excess of system working pressure. [NFPA 13-10: 24.2.1.2]

Where cold weather will not permit testing with water, an interim air test shall be permitted to be conducted as described in 24.2.2. This provision shall not remove or replace the requirement for conducting the hydrostatic test as described in 24.2.1.1. [NFPA 13-10: 24.2.1.3]

Modifications affecting 20 or fewer sprinklers shall not require testing in excess of system working pressure. [NFPA 13-10: 24.2.1.4]

Where addition or modification is made to an existing system affecting more than 20 sprinklers, the new portion shall be isolated and tested at not less than 200 psi (13.8 bar) for 2 hours. [NFPA 13-10: 24.2.1.5]

Modifications that cannot be isolated, such as relocated drops, shall not require testing in excess of system working pressure. [NFPA 13-10: 24.2.1.6]

While there are multiple methods for conducting the hydrostatic test, basic procedures for conducting these are as follows.

**Hydrostatic Test Procedure for Water-Based Fire Protection Systems**

**Description**
- General acceptance test of water-based fire protection systems
- Accomplished by visual inspection and hydrostatic pressure

**Objective**
- To ensure piping integrity and absence of leaks

**Conditions/Assumptions**
- Piping system, including all valves, drains, and accessories, are installed
- Underground supply has been installed, flushed, tested, and activated

**Specifications**
- Appropriate NFPA installation standard
- Underwriters Laboratories (UL) Fire Protection Equipment Directory
- Factory Mutual (FM) Approval Guide
- Local/state building codes (as applicable)
- Approved fire protection shop drawings
- Project specifications
Test Equipment
- Pressure pump
- Calibrated test gauges
- Fittings, hose, plugs, valves, and tools, as required

Test Parameters
- This procedure delineates the method for hydrostatic testing of a water-based fire protection system.
  - The system installation shall be complete and verified by visual inspection.
  - All openings shall be plugged, and valves shall be closed.
  - Test blanks shall be installed, as necessary, to isolate the system being tested.
  - Whenever a test blank is used, it shall be of the self-indicating type.
  - Test blanks shall have red painted lugs protruding beyond the flange in such a way as to clearly indicate their presence.
  - The installer shall have all test blanks numbered to assure their removal after the test is completed.
  - A written log should be used to monitor the use of test blanks.
- Water used for testing the system should be taken from the same source that will supply the system wherever possible.
- A test pump will be used to achieve the required test pressure.
  - A calibrated test gauge shall be used.
  - The calibration tolerance shall be +/-5%.
  - Test gauges supplied by the owner or commissioning agent may be used.
  - The dial of the test gauge shall be graduated over a range of at least 1.5 times the intended test pressure, but not more than 4 times that pressure.

Test Procedure
- Inspect the system to verify that openings are plugged and valves are closed.
- Connect the test pump to a convenient location in the system.
- Connect the water source to the test pump.
- Open the main control valve to fill the system. (If the water service is not installed or has not been flushed, fill the system through the test pump water source.)
- Fill the system slowly to avoid entrapment of air.
- Open a valve (such as the inspector’s test connection or a temporary valve) to vent any trapped air.
- Close the valve when water flows continuously through it.
- When the system pressure equals that of the water source, close the supply valve and inspect the entire system for leaks.
  - Leaks may result from flanges not bolted properly, plugs not properly installed, cracked or improperly tightened fittings, etc.
  - If leaks are found, open the 2-in. main drain connection or other low-point drain connection and allow the system to drain. Repair any leaks found and repeat this procedure.
  - If no leaks are detected, begin to increase pressure with the test pump up to 200 psi or 50 psi in excess of the static pressure when static pressure exceeds 150 psi.
  - Monitor the test gauge to determine that the system pressure is stable. If pressure drops, check for leaks in the system, for open valves, or for leaks in the test apparatus.
  - Once it is determined that the test pressure has stabilized, disconnect the power to the test pump and notify the commissioning agent or authority having jurisdiction that the 2-hour test period has begun.
• Record the time of day and test pressure at this time.
• Hold the test pressure for 2 hours.
• After the test, open the drain valve to drain the system, or, if the system is to be commissioned immediately, relieve the test pressure and leave the water in the system.
• Disconnect the test pump and plug the outlet or test port through which the system was tested.

**Measurements**
• Test pressure is to be maintained for 2 hours without any visible leaks.

**Pass/Fail Criteria**
• The system must hold the test pressure for 2 hours without loss of pressure.
• Absence of water leakage is verified by visual examination of the system.

**Hydrostatic Test Procedure for Underground Fire Service Mains**

**Description**
• General acceptance of underground fire service main
• System acceptance in sections or in entirety as authorized by authority having jurisdiction
• Ensure city main valves are closed and locked before opening fire pump valves

**Objective**
• To ensure piping integrity and absence of leaks

**Conditions/Assumptions**
• Adequate water supply is available
• Isolation valves are open or closed as appropriate
• Thrust blocks (as required) are properly installed
• Pipe or pipe segments are properly installed

**Specifications**
• Appropriate NFPA installation standard
• Underwriters Laboratories (UL) Fire Protection Equipment Directory
• Factory Mutual (FM) Approval Guide
• Local/state building codes (as applicable)
• Approved fire protection shop drawings
• Project specifications

**Test Equipment**
• Pressure pump
• Calibrated gauges
• Flanges, connectors, hose, and tools required to connect to system
• Calibrated liquid container

**Test Parameters**
• This procedure describes the method used to flush and test underground systems in accordance with the project specification.
  – The underground piping is flushed using the hydraulic method, consisting of flowing water through the underground piping in the same direction in which it would flow during a fire.
  – The purpose of flushing is to remove obstructive material from the pipe.
  – Successful flushing is dependent on establishing sufficient velocity of flow to remove the obstructing materials.
  – When the water supply cannot produce the stipulated flow rates, the maximum available must be used. Table 9.1.1 of NFPA 24 provides the required water flow for flushing piping.
- The owner’s representative shall be notified at least 24 hours prior to the start of flushing.
- The flushing may be accomplished by using the existing fire water supply system feeding the system being flushed.
- Water used for flushing shall be that contained in the existing fire water supply system feeding the system being flushed.
- After making the appropriate water supply connections, provisions are made for the disposal of the water issuing from the test outlets to avoid property damage.
- Water is allowed to flow 4 or 5 minutes or until water is clean.

• This procedure delineates the method for hydrostatic testing of the underground supply to fire protection systems.
• The test should be made before the joints are covered, if practical, so any leaks may be readily detected.
• Thrust blocks should be sufficiently hardened before testing is begun.
  - Inspect the system to ensure that openings are plugged and valves are closed.
  - Connect the test pump to a convenient location in the system.
  - Connect the water source to the test pump.
  - Open the main control valve to fill the system (if water service is not completed, fill the system through test water source).
  - Fill the system slowly.
  - Vent the air from the system through a temporary valved connection or other appropriate means.
  - Close the vent when water flows continuously through it.
  - Begin to increase pressure with the test pump up to 200 psi or 50 psi in excess of the maximum static pressure when static pressure exceeds 150 psi.
  - Monitor the test gauge to determine that the system pressure is not escaping.
  - If pressure drops, check for leaks in the system, for open valves, or for leaks on the test apparatus.
  - If the system holds the required test pressure, disconnect the power to the pump and notify the commissioning agent or authority having jurisdiction designated to witness the test that the 2-hour test period has begun.
  - Record the time of day and test pressure at this time.
• Measure the amount of leakage in the system at the specified test pressure by pumping from a calibrated container.
  - For new pipe, the amount of leakage at the joints should not exceed 2 quarts per hour per 100 gaskets or joints, irrespective of pipe diameter.
  - The amount of allowable leakage may be increased by 1 fluid ounce per inch valve diameter per hour for each metal-seated valve isolating the test section. If dry barrel hydrants are tested with the main valve open, so the hydrants are under pressure, an additional 5 ounces per minute leakage is permitted for each hydrant.
  - New pipe installed with rubber gasketed joints should, if the workmanship is satisfactory, have no leakage at the joints. Unsatisfactory amounts of leakage usually result from twisted, pinched, or cut gaskets. Some leakage might result from small amounts of grit or small imperfections in the surfaces of the pipe joints.
• After the test, open the drain valve to drain system.
• Once the system is drained, disconnect test pump and plug opening through which the system is tested.
Measurements

- System pressure
- Quantity of liquid required from calibrated container to maintain the test pressure

Pass/Fail Requirements

- Test pressure is maintained without significant decrease.
- Quantity of water required to maintain system does not exceed allowable.
- No visible leakage is observed.

Air Testing

It is important to note that an interim air test is permitted only where there is concern for freezing. When possible, a hydrostatic test using water must be completed.

Where cold weather will not permit testing with water, an interim air test shall be permitted to be conducted as described in NFPA 13-10: 24.2.2. This provision shall not remove or replace the requirement for conducting the hydrostatic test as described in NFPA 13-10: 24.2.1.1. [NFPA 13-10: 24.2.1.3]

A sample test procedure for an air test is as follows.

Pneumatic Test Procedure for Water-Based Fire Protection Systems

Description

- General acceptance test of water-based fire protection system.
- Accomplished by visual inspection and pneumatic pressure.
- This is an interim test during seasons when freezing may occur; hydrostatic testing is required when weather permits.

Objective

- To ensure piping integrity and absence of leaks

Conditions/Assumptions

- Piping system, including all valves, drains, and accessories, is installed.
- Underground supply has been installed, flushed, tested, and activated.
- Available air supply is adequate to test the system.

Specifications

- Appropriate NFPA installation standard
- Underwriters Laboratories (UL) Fire Protection Equipment Directory
- Factory Mutual (FM) Approval Guide
- Local/state building codes (as applicable)
- Approved fire protection shop drawings
- Project specifications
- ASTM specifications

Test Equipment

- Supply air in excess of 50 psi or air compressor
- Calibrated test gauges
- Fittings, hose, plugs, valves, and tools, as required

Test Parameters

- This procedure delineates the method for pneumatic testing of a water-based fire protection system.
  - The system installation shall be complete and verified by visual inspection.
  - All openings shall be plugged, and valves shall be closed.
  - Test blanks shall be installed, as necessary, to isolate the system being tested.
Whenever a test blank is used, it shall be of the self-indicating type.

Test blanks shall have red painted lugs protruding beyond the flange in such a way as to clearly indicate their presence.

The installer shall have all test blanks numbered to assure their removal after the test is completed.

A written log should be used to monitor the use of test blanks.

The clapper of a differential type dry-pipe valve shall be held off its seat during any test in excess of 50 psi to prevent damaging the valve.

A test pump will be used to achieve the required test pressure.

A calibrated test gauge shall be used.

- The calibration tolerance shall be +/-5%.
- Test gauges supplied by the owner or commissioning agent may be used.
- The dial of the test gauge shall be graduated over a range of at least 1.5 times the intended test pressure, but not more than 4 times that pressure.

Test Procedure

- Inspect the system to verify that openings are plugged and valves are closed.
- Connect the air supply to a convenient location in the system.
- Fill the system slowly.
- When the system reaches 40 psi, close the supply valve and inspect the entire system for leaks.

  - Leaks may result from flanges not bolted properly, plugs not properly installed, cracked or improperly tightened fittings, etc.
  - If leaks are found, bleed off air pressure. Repair any leaks found and repeat the test.
  - A soap solution or any acceptable indicating solution may be used on areas suspected to be leaking to determine the exact location of leaks.

- Monitor the test gauge to determine that the system pressure is stable. If pressure drops over 1.5 psi in 24 hours, check for leaks in the system, open valves, or leaks in the test apparatus.
- Once it has been determined that the test pressure has stabilized, shut off the air supply and notify the commissioning agent or authority having jurisdiction that the 24-hour test period has begun.
- Record the time of day and the pressure at this time.
- Hold the test pressure for 24 hours.
- After the test, open the drain valve to bleed air from the system.
- Once the air pressure is bled off, disconnect the air supply and plug the opening through which the system was tested.

Measurements

- Test pressure is to be maintained for 24 hours without any visible leaks in the system or loss of 1.5 psi during the 24-hour test period.

Pass/Fail Criteria

- The system must hold the test pressure for 24 hours without loss of more than 1.5 psi.
- Absence of leakage is verified by visual examination of the system.

Pressure Loss

Loss shall be determined by a drop in gauge pressure or visual leakage. [NFPA 13-10: 24.2.1.7]

The test pressure shall be read from a gauge located at the low elevation point of the system or portion being tested. The pressures in piping at higher elevations shall
be permitted to be less than 200 psi (13.8 bar) when accounting for elevation losses. Systems or portions of systems that can be isolated shall be permitted to be tested separately. [NFPA 13-10: 24.2.1.8]

**Additives or Chemicals**

Additives, corrosive chemicals such as sodium silicate, or derivatives of sodium silicate, brine, or similar acting chemicals shall not be used while hydrostatically testing systems or for stopping leaks. 24.2.1.9. [NFPA 13-10: 24.2.1.9]

**Piping Testing**

Piping between the exterior fire department connection and the check valve in the fire department inlet pipe shall be hydrostatically tested in the same manner as the balance of the system. After repair or replacement work affecting the fire department connection, the piping between the exterior and the check valve in the fire department inlet pipe shall be isolated and hydrostatically tested at 150 psi (10.3 bar). [NFPA 13-10: 24.2.1.10]

**Deluge Systems Testing**

When deluge systems are being hydrostatically tested, plugs shall be installed in fittings and replaced with open sprinklers after the test is completed, or the operating elements of automatic sprinklers shall be removed after the test is completed. [NFPA 13-10: 24.2.1.12]

In order to test the pipe shown in Exhibit 1.9, the trench should be backfilled in such a way as to reveal the pipe joints for inspection for leaks when hydrotesting is taking place. Upon completion of the hydrostatic test, backfill and compaction of earth can be completed.

Hydrostatic tests should be made before the joints are covered, so that any leaks can be readily detected. Thrust blocks should be sufficiently hardened before hydrostatic testing is begun. If the joints are covered with backfill prior to testing, the contractor remains responsible for locating and correcting any leakage in excess of that permitted. [NFPA 13-10: A.10.10.2.2.4]

**System Operational Tests**

Commonly referred to as an alarm test, the system operational test is completed by opening the inspector’s test connection. The inspector’s test connection is a length of pipe usually installed on the portion of the system most remote from the water supply connection. This pipe terminates in a smooth-bore, corrosion-resistant outlet that is sized to simulate the flow of a single sprinkler. The purpose of this test is to approximate the flow of a single sprinkler to verify that such a small flow of water will activate the water flow alarm.

The acceptance criterion, as stated earlier, is an alarm that must sound within 5 minutes. The 5-minute criterion is acceptable only when the alarm is composed of a local alarm bell or water motor alarm gong. It is important to note that if the sprinkler system is connected to a fire alarm system, then the water flow alarm must sound within 90 seconds. Sprinkler systems are frequently connected to fire alarm systems by means of a pressure switch or vane-type flow switch. Both devices are equipped with a retard setting, which is intended to compensate for momentary pressure surges, thus preventing false alarms. The delay setting, however, should be adjusted to sound an alarm within the 90 seconds required by NFPA 72®, National Fire Alarm Code®.
Waterflow detecting devices including the associated alarm circuits shall be flow tested through the inspector’s test connection and shall result in an audible alarm on the premises within 5 minutes after such flow begins and until such flow stops. [NFPA 13-10: 24.2.3.1]

Exhibit 1.10 illustrates a system test connection on a wet pipe system, and Exhibit 1.11 illustrates the operation of a floor control valve.

**Dry Pipe**

Dry-pipe systems are used to protect unheated spaces. The system is pressurized with air to hold the dry-pipe valve closed. It is not desirable to fill the system piping with water in cold weather, since the water in the pipe may freeze. This section of NFPA 13 permits a trip test without filling the system so that operation of the dry-pipe valve may be demonstrated. To accomplish this test, the water supply control valve is opened only partially (a few turns of the valve handle). The system is tripped by releasing the air pressure in the system. Immediately upon dry-pipe valve actuation, the water supply control valve is closed, thus preventing water from entering the system.

When the acceptance test is being performed during freezing conditions, a partial flow trip test should be conducted at that time and the full flow trip test specified should be conducted as soon as conditions permit. [NFPA 13-10: A.24.2.3.2]
A working test of the dry pipe valve alone and with a quick-opening device, if installed, shall be made by opening the inspector’s test connection. [NFPA 13-10: 24.2.3.2.1]

If a quick-opening device is installed, the trip test is conducted, and the test is repeated with and without the device operating.

The test shall measure the time to trip the valve and the time for water to be discharged from the inspector’s test connection. All times shall be measured from the time the inspector’s test connection is completely opened. [NFPA 13-10: 24.2.3.2.2]

Program for Individual Systems
Dry systems calculated for water delivery in accordance with 7.2.3.6 shall be exempt from any specific delivery time requirement. [NFPA 13-10: 24.2.3.2.2.1]

The results shall be recorded using the contractor’s material and test certificate for aboveground piping [see Figure 24.]. [Exhibit 1.8] [NFPA 13-10: 24.2.3.2.3]

Deluge Systems

The automatic operation of a deluge or preaction valve shall be tested in accordance with the manufacturer’s instructions. [NFPA 13-10: A.24.2.3.3.1]

The manual and remote control operation, where present, shall also be tested. [NFPA 13-10: 24.2.3.3.2]

Main Drain

The main drain test is intended to provide a record of static and residual pressures when flowing the 2" (50 mm) main drain connection. No measurement of flow is required for this test. The static and residual pressures are recorded on the contractor’s material and test certificate to provide a baseline pressure for future evaluation. The main drain test is required to be performed annually on existing systems. The inspector is required to compare future test results with that shown on the contractor’s material and test certificate to reveal any potential issues with the water supply, such as a closed or partially closed water supply control valve or any condition that would affect the water supply to the sprinkler system.

The main drain valve shall be opened and remain open until the system pressure stabilizes. [NFPA 13-10: 24.2.3.4.1]

The static and residual pressures shall be recorded on the contractor’s material and test certificate [see Figure 24.1] [Exhibit 1.8]. [NFPA 13-10: 24.2.3.4.2]

Main drains are installed on system risers for one principal reason: to drain water from the overhead piping after the system is shut off. This allows the contractor or plant maintenance department to perform work on the system or to replace nozzles after a fire or other incident involving system operation.

The test for standpipe systems should be done at the low-point drain for each standpipe or the main drain test connection where the supply main enters the building. These drains also are used to determine whether there is a major reduction in waterflow to the system, such as could be caused by a major obstruction, a dropped gate, a valve that is almost fully closed, or a check valve clapper stuck to the valve seat.

A large drop in the full flow pressure of the main drain (as compared to previous tests) normally is indicative of a dangerously reduced water supply caused by a valve in an almost fully closed position or other type of severe obstruction. After closing the drain, a slow return to normal static pressure is confirmation of the suspicion of a major obstruction in the waterway and should be considered sufficient reason to determine the cause of the variation.

A satisfactory drain test (i.e., one that reflects the results of previous tests) does not necessarily indicate an unobstructed passage, nor does it prove that all valves in the upstream flow of water are fully opened. The performance of drain tests is not a substitute for a valve check on 100 percent of the fire protection valving.

The main drain test is conducted in the following manner:

1. Record the pressure indicated by the supply water gauge.
2. Close the alarm control valve on alarm valves.
3. Fully open the main drain valve.
4. After the flow has stabilized, record the residual (flowing) pressure indicated by the water supply gauge.
(5) Close the main drain valve slowly.
(6) Record the time taken for the supply water pressure to return to the original static (nonflowing) pressure.
(7) Open the alarm control valve. [NFPA 25-11: A.13.2.5]

Operating Test

Hydrants and Control Valves

Each hydrant shall be fully opened and closed under system water pressure. [NFPA 24-10:10.10.2.4.1]

Dry barrel hydrants shall be checked for proper drainage. [NFPA 24-10:10.10.2.4.2]

All control valves shall be fully closed and opened under system water pressure to ensure proper operation. [NFPA 24-10:10.10.2.4.3]

Where fire pumps are available, the operating tests required by 10.10.2.4 shall be completed with the pumps running. [NFPA 24-10:10.10.2.4.4]

All control valves shall be fully closed and opened under system water pressure to ensure proper operation. [NFPA 13-10: 24.2.3.5]

Pressure-Reducing Valves

Pressure-reducing valves must be flow tested to verify the correct pressure setting. Failure to perform this test can result in system damage.

Each pressure-reducing valve shall be tested upon completion of installation to ensure proper operation under flow and no-flow conditions. [NFPA 13-10: 24.2.4.1]

Testing shall verify that the device properly regulates outlet pressure at both maximum and normal inlet pressure conditions. [NFPA 13-10: 24.2.4.2]

The results of the flow test of each pressure-reducing valve shall be recorded on the contractor’s material and test certificate [see Figure 24.1]. [Exhibit 1.8] [NFPA 13-10: 24.2.4.3]

The results shall include the static and residual inlet pressures, static and residual outlet pressures, and the flow rate. [NFPA 13-10: 24.2.4.4]

Backflow Prevention Devices

Backflow prevention devices are not fire protection devices and add nothing to the protection features of a sprinkler system. Under the requirements of NFPA 13, these valves must be subject to a flow test to verify that they are operating correctly and the friction loss associated with these devices has been taken into consideration in the hydraulic design. As part of the system commissioning, a backflow prevention test may be required by other regulations, such as environmental or health authority requirements.

The backflow prevention assembly shall be forward flow tested to ensure proper operation. [NFPA 13-10: 24.2.5.1]

The minimum flow rate shall be the system demand, including hose stream allowance where applicable. [NFPA 13-10: 24.2.5.2]

Exposure Systems

Operating tests shall be made of exposure protection systems upon completion of the installation, where such tests do not risk water damage to the building on which they are installed or to adjacent buildings. [NFPA 13-10: 24.2.6]
Circulating Closed Loop Systems

For sprinkler systems with non-fire protection connections, additional information shall be appended to the contractor’s material and test certificate for aboveground piping shown in Figure 24.1 as follows:

1. Certification that all auxiliary devices, such as heat pumps, circulating pumps, heat exchangers, radiators, and luminaires, if a part of the system, have a pressure rating of at least 175 psi or 300 psi (12.1 bar or 20.7 bar) if exposed to pressures greater than 175 psi (12.1 bar).
2. All components of sprinkler system and auxiliary system have been pressure tested as a composite system in accordance with 24.2.2.
3. Waterflow tests have been conducted and waterflow alarms have operated while auxiliary equipment is in each of the possible modes of operation.
4. With auxiliary equipment tested in each possible mode of operation and with no flow from sprinklers or test connection, waterflow alarm signals did not operate.
5. Excess temperature controls for shutting down the auxiliary system have been properly field tested. [NFPA 13-10: 24.3]

Required Signage

Hydraulic Nameplate

A permanent record of the hydraulic design parameters must be attached to the system riser for future reference and inspection (see Exhibit 1.12). This record normally contains the water supply information and design density, including occupancy and commodity classification.

The installing contractor shall identify a hydraulically designed sprinkler system with a permanently marked weatherproof metal or rigid plastic sign secured with corrosion-resistant wire, chain, or other approved means. Such signs shall be placed at the alarm valve, dry-pipe valve, preaction valve, or deluge valve supplying the corresponding hydraulically designed area. [NFPA 13-10: 24.5.1]

EXHIBIT 1.12 Hydraulic Nameplate

As-built drawings often become lost or misplaced over time. By keeping a permanent record of the design parameters attached to the system riser, as required by NFPA 13-10: 24.5.1, it is much easier and less costly to perform any future modifications or work on the system. The information contained on such a nameplate is also of vital importance in assessing the ability of the system to control fires as the building’s occupancy changes or the water supply’s strength deteriorates.

The sign shall include the following information:

1. Location of the design area or areas
2. Discharge densities over the design area or areas
3. Required flow and residual pressure demand at the base of the riser
4. Occupancy classification or commodity classification and maximum permitted storage height and configuration
5. Hose stream allowance included in addition to the sprinkler demand
6. The name of the installing contractor [NFPA 13-10: 24.5.2]

A sample nameplate is provided in Exhibit 1.13.

**SUMMARY**

The minimum requirements for commissioning a sprinkler system involve a number of tests, including a hydrostatic pressure test to verify piping integrity, a main drain test to establish baseline water supply pressures (static and residual), and a water flow test to

<table>
<thead>
<tr>
<th>EXHIBIT 1.13 Sample Nameplate</th>
</tr>
</thead>
<tbody>
<tr>
<td>This system as shown on ................. company print no ................. dated ................. for .......................................................... contract no ................. at ................. is designed to discharge at a rate of ................. gpm/ft² (L/min/m²) of floor area over a maximum area of ................. ft² (m²) when supplied with water at a rate of ................. gpm (L/min) at ................. psi (bar) at the base of the riser. Hose stream allowance of ................. gpm (L/min) is included in the above. Occupancy classification ................................................ Commodity classification ................................................ Maximum storage height ................................................</td>
</tr>
</tbody>
</table>

*Source: NFPA 13, 2010, Figure A.16.5.*
confirm operation of system alarms. These tests are usually documented on the contractor’s material and test certificate. This test certificate also requires verification of other checks of the system, such as as-built drawings and care and maintenance instructions.

In addition to the information required by the test certificate, NFPA 13 requires other components to be installed, such as pipe sleeves and valve signs. The installation and adequacy of these components or other equipment and components can be verified by a checklist. Also, the training and documentation recommendations in Part One of NFPA 3 should be followed to properly document the commissioning activities for the system.
The information contained in this chapter is intended to assist the registered design professional (RDP), commissioning agent, authority having jurisdiction (AHJ), and the installing contractor in the proper commissioning of a fire alarm system. Included here are preliminary design requirements in the basis of a design document, information on the submission of plans and calculations during the permitting process, and a description of the inspections and tests required to verify system performance. Information related to the needed documentation required for operation and maintenance manuals is also included. This information will assist the RDP, commissioning agent, and/or the AHJ in developing the systemspecific commissioning requirements, methods, and procedures for a project specification.

**APPROVAL AND ACCEPTANCE**

In most jurisdictions a building permit is required. In addition, a permit to install may be required for building systems, including fire alarm systems. Separate submittals should be made to the appropriate code official, RDP, and insurance company for approval. These submittals and approvals should be obtained prior to the installation of any system or component. The requirements of NFPA 72®, National Fire Alarm and Signaling Code, include provisions on the qualifications of persons designing, installing, and testing fire alarm systems.

Fire alarm system and emergency communications system plans and specifications shall be developed in accordance with this Code by persons who are experienced in the proper design, application, installation, and testing of the systems. [NFPA 72-10:10.4.1.1]

Evidence of qualifications shall be provided to the authority having jurisdiction upon request. [NFPA 72-10:10.4.3.2]

The authority having jurisdiction shall be notified prior to installation or alteration of equipment or wiring. [NFPA 72-10:10.18.1.1]

At the authority having jurisdiction’s request, complete information regarding the system or system alterations, including specifications, type of system or service, shop drawings, input/output matrix, battery calculations, and notification appliance circuit voltage drop calculations, shall be submitted for approval. [NFPA 72-10:10.18.1.2]

**Shop Drawings**

Ordinarily, prior to obtaining a permit to install, shop drawings are submitted to the AHJ for review and approval. Shop drawings may contain more detailed information than the preliminary concept drawings submitted by the RDP for the building permit.
Such approval is not intended to relieve the contractor or the RDP of the responsibility for compliance with codes, standards, and specifications. This review and permit application should be completed prior to installation.

Note that the standard scale for architectural drawings is \( \frac{1}{8} \) in. = 1 ft and should be indicated in the title block of the drawing. In some cases, \( \frac{1}{4} \) in. = 1 ft is used for smaller buildings, with larger scales such as \( \frac{3}{8} \) in. = 1 ft or \( \frac{1}{2} \) in. = 1 ft for elevation views or enlarged plan details.

Shop drawings provide the details of the system and its installation and form the basis of the record drawings that are needed to document the system design, installation, operation, and maintenance. The term “record drawings” is defined in the *Fire Alarm and Signaling Code* as drawings that document the location of all devices, appliances, wiring sequences, wiring methods, and connections of the components of the fire alarm system as installed.

Shop drawings for fire alarm systems should provide basic information and should provide the basis for the record drawings required elsewhere in this Code.

Shop drawings should include, to an extent commensurate with the extent of the work being performed, floor plan drawings, riser diagrams, control panel wiring diagrams, point-to-point wiring diagrams, conduit, conductor routing, typical wiring diagrams, and other information as described herein.

All shop drawings should be drawn on sheets of uniform size and should include the following information:

1. Name of protected premises, owner, and occupant (where applicable)
2. Name of installer or contractor
3. Location of protected premises
4. Device legend in accordance with NFPA® 170, *Standard for Fire Safety and Emergency Symbols*
5. Date of issue and any revisions

Floor plan drawings should be drawn to an indicated scale and should include the following information:

1. Floor identification
2. Point of compass (indication of north)
3. Graphic scale
4. All walls and doors
5. All partitions extending to within 10 percent of the ceiling height (where applicable)
6. Room descriptions
7. Fire alarm device/component locations
8. Locations of fire alarm primary power connection(s)
9. Locations of monitor/control interfaces to other systems
10. Riser locations
11. Type and number of fire alarm system components/devices on each circuit, on each floor or level
12. Type and quantity of conductors and conduit (if used) used for each circuit
13. Location of all supply and return air diffusers (where automatic detection is used)

Fire alarm system riser diagrams should include the following information:

1. General arrangement of the system in building cross-section
2. Number of risers
3. Type and number of circuits in each riser
(4) Type and number of fire alarm system components/devices on each circuit, on each floor or level
(5) Type and quantity of conductors and conduit (if used) for each circuit

Control unit wiring diagrams should be provided for all control equipment (i.e., equipment listed as either a control unit or control unit accessory), power supplies, battery chargers, and annunciators and should include the following information:

(1) Identification of the control equipment depicted
(2) Location(s)
(3) All field wiring terminals and terminal identifications
(4) All circuits connected to field wiring terminals and circuit identifications
(5) All indicators and manual controls, including the full text of all labels
(6) All field connections to supervising station signaling equipment, releasing equipment, and fire safety control interfaces

Typical wiring diagrams should be provided for all initiating devices, notification appliances, remote indicators, annunciators, remote test stations, and end-of-line and power supervisory devices. [NFPA 72-10: A.10.18.1.2]

**Final Approval**

The fire alarm system record of completion can be used for documenting the final approval.

Before requesting final approval of the installation and if required by the authority having jurisdiction, the installing contractor shall furnish a written statement stating that the system has been installed in accordance with approved plans and tested in accordance with the manufacturer’s published instructions and the appropriate NFPA requirements. [NFPA 72-10:10.18.1.3]

Regarding installation and testing prior to the final approval, it should be noted that the requirements of the *National Fire Alarm and Signaling Code* include provisions on the qualifications and experience of those supervising installation personnel.

State or local licensure regulations shall be followed to determine qualified personnel. Depending on state or local licensure regulations, qualified personnel shall include, but not be limited to, one or more of the following:

(1) Personnel who are registered, licensed, or certified by a state or local authority
(2) Personnel who are certified by a nationally recognized certification organization acceptable to the authority having jurisdiction
(3) Personnel who are factory trained and certified for fire alarm system design and emergency communications system design of the specific type and brand of system and who are acceptable to the authority having jurisdiction [NFPA 72-10: 10.4.1.2]

Service personnel shall be qualified and experienced in the inspection, testing, and maintenance of systems addressed within the scope of this Code. Qualified personnel shall include, but not be limited to, one or more of the following:

(1) Personnel who are factory trained and certified for the specific type and brand of system being serviced
(2) Personnel who are certified by a nationally recognized certification organization acceptable to the authority having jurisdiction
(3) Personnel who are factory trained and certified for fire alarm system design and emergency communications system design of the specific type and brand of sys-
COMPLETION DOCUMENTS

Record of Completion Defined

The record of completion is an essential part of fire alarm system documentation. Among other things, it documents the type of system, the names of the installers, and the locations of record drawings, owners’ manuals, and test reports. It also provides a confirming record of the acceptance tests and gives details of the components and wiring of the system. It is required for all fire alarm systems. The system installer is responsible for its completion.

Part 1 and Part 2 of the record of completion should verify the system description and installation requirements as detailed in the basis of design. Part 10 is verification by more than one party of tests and deviations from the initial design.

The record of completion should be included with other project closeout documentation, such as as-built drawings and operation and maintenance manuals (see Exhibit 2.1).

EXHIBIT 2.1 Checklist for Required System Testing Documentation

<table>
<thead>
<tr>
<th>Documentation Checklist:</th>
</tr>
</thead>
<tbody>
<tr>
<td>☐ Fire Alarm System Record of Completion</td>
</tr>
<tr>
<td>☐ Point-to-Point Wiring Diagrams</td>
</tr>
<tr>
<td>☐ Individual Device Interconnection Drawings</td>
</tr>
<tr>
<td>☐ As-Built (Record) Drawings</td>
</tr>
<tr>
<td>☐ Copy of Original Equipment Submittals</td>
</tr>
<tr>
<td>☐ Operational Manuals</td>
</tr>
<tr>
<td>☐ Manufacturer's Proper Testing and Maintenance Requirements</td>
</tr>
<tr>
<td>☐ Device Address List/Conventional Device Location List</td>
</tr>
</tbody>
</table>


Preparation of a Record of Completion

The preparation of a record of completion, Figure 10.18.2.1.1, shall be the responsibility of the qualified and experienced person described in 10.4.2. [NFPA 72-10: 10.18.2.1.1]

(A) Parts 1, 2, and 4 through 10 shall be completed after the system is installed and the installation wiring has been checked. Part 3 shall be completed after the operational acceptance tests have been completed.

(B) A preliminary copy of the record of completion shall be given to the system owner and, if requested, to other authorities having jurisdiction after completion of the installation wiring tests. [NFPA 72-10: 10.18.2.1.2.2]

A final copy shall be provided after completion of the operational acceptance tests. [NFPA 72-10: 10.18.2.1.2.3]

Part 3 of the record of completion includes a provision for the attachment of the inspection, testing, and maintenance form to document the completion of the inspection and testing required by Chapter 10 of the National Fire Alarm and Signaling Code.
## FIRE ALARM AND EMERGENCY COMMUNICATION SYSTEM RECORD OF COMPLETION

To be completed by the system installation contractor at the time of system acceptance and approval. It shall be permitted to modify this form as needed to provide a more complete and/or clear record. Insert N/A in all unused lines. Attach additional sheets, data, or calculations as necessary to provide a complete record.

### 1. PROPERTY INFORMATION

<table>
<thead>
<tr>
<th>Name of property:</th>
<th>Main Street Towers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address:</td>
<td>12345 Main Street, Pleasantville, NY 01111</td>
</tr>
<tr>
<td>Description of property:</td>
<td>40-story high-rise building with an adjacent 1-story parking structure</td>
</tr>
<tr>
<td>Occupancy type:</td>
<td>B</td>
</tr>
<tr>
<td>Name of property representative:</td>
<td>Mary Morris, Property Manager, Mary’s Management Company</td>
</tr>
<tr>
<td>Address:</td>
<td>12345 Main Street, Pleasantville, NY 01111</td>
</tr>
<tr>
<td>Phone:</td>
<td>222/222-2222</td>
</tr>
<tr>
<td>Fax:</td>
<td>333/333-3333</td>
</tr>
<tr>
<td>E-mail:</td>
<td><a href="mailto:mm@mmc.com">mm@mmc.com</a></td>
</tr>
<tr>
<td>Authority having jurisdiction over this property:</td>
<td>Inspector Jack Jones, Pleasantville Fire Department</td>
</tr>
<tr>
<td>Phone:</td>
<td>444/444-4444</td>
</tr>
<tr>
<td>Fax:</td>
<td>555/555-5555</td>
</tr>
<tr>
<td>E-mail:</td>
<td><a href="mailto:jackjones@pfd.org">jackjones@pfd.org</a></td>
</tr>
</tbody>
</table>

### 2. INSTALLATION, SERVICE, AND TESTING CONTRACTOR INFORMATION

| Installation contractor for this equipment: | Fred’s Fine Fire Alarm Systems |
| Address: | 789 Broad Street, Pleasantville, NY 01113 |
| License or certification number: | NY–1634 |
| Phone: | 666/666-6666 |
| Fax: | 999/999-9999 |
| E-mail: | fredfriendly@fffas.com |
| Service organization for this equipment: | Fred’s Fine Fire Alarm Systems |
| Address: | Same |
| License or certification number: | |
| Phone: | |
| Fax: | |
| E-mail: | |
| A contract for test and inspection in accordance with NFPA standards is in effect as of: | June 11, 2010 |
| Contracted testing company: | Fred’s Fine Fire Alarm Systems |
| Address: | Same |
| Phone: | |
| Fax: | |
| E-mail: | |
| Contract expires: | June 11, 2011 |
| Contract number: | 45678 |
| Frequency of routine inspections: | Quarterly |

### 3. DESCRIPTION OF SYSTEM OR SERVICE

- Fire alarm system (nonvoice)
- Fire alarm with in-building fire emergency voice alarm communication system (EVACS)
- Mass notification system (MNS)
- Combination system, with the following components:
  - Fire
  - EVACS
  - MNS
  - Two-way, in-building, emergency communication system
- Other (specify): N/A
### 3. DESCRIPTION OF SYSTEM OR SERVICE (continued)

**NFPA 72 edition:** 2010  
**Additional description of system(s):** N/A

<table>
<thead>
<tr>
<th>3.1 Control Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer: <strong>Megasystems</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3.2 Mass Notification System</th>
</tr>
</thead>
<tbody>
<tr>
<td>This system does not incorporate an MNS.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3.2.1 System Type:</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ In-building MNS — combination</td>
</tr>
<tr>
<td>□ In-building MNS — stand-alone</td>
</tr>
<tr>
<td>□ Wide-area MNS</td>
</tr>
<tr>
<td>□ Distributed recipient MNS</td>
</tr>
<tr>
<td>□ Other (specify): N/A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3.2.2 System Features:</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ Combination fire alarm/MNS</td>
</tr>
<tr>
<td>□ MNS autonomous control unit</td>
</tr>
<tr>
<td>□ Wide-area MNS to regional national alerting interface</td>
</tr>
<tr>
<td>□ Local operating console (LOC)</td>
</tr>
<tr>
<td>□ Distributed recipient MNS (DRMNS)</td>
</tr>
<tr>
<td>□ Wide-area MNS to DRMNS interface</td>
</tr>
<tr>
<td>□ Wide-area MNS to high-power speaker array (HPSA) interface</td>
</tr>
<tr>
<td>□ In-building MNS to wide-area MNS interface</td>
</tr>
<tr>
<td>□ Other (specify): N/A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3.3 System Documentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ An owner’s manual, a copy of the manufacturer’s instructions, a written sequence of operation, and a copy of the numbered record drawings are stored on site. Location: <strong>Building management office, Suite 2222</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3.4 System Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>This system does not have alterable site-specific software.</td>
</tr>
</tbody>
</table>

| Operating system (executive) software revision level: 4.567 |
| Site-specific software revision date: June 26, 2010 |
| Revision completed by: Fred Friendly |
| ✓ A copy of the site-specific software is stored on site. Location: **Building management office, Suite 2222** |

<table>
<thead>
<tr>
<th>3.5 Off-Premises Signal Transmission</th>
</tr>
</thead>
<tbody>
<tr>
<td>This system does not have off-premises transmission.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name of organization receiving alarm signals with phone numbers:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alarm: Manny’s Monitoring Phone: 777/777-7777</td>
</tr>
<tr>
<td>Supervisory: Manny’s Monitoring Phone: 777/777-7777</td>
</tr>
<tr>
<td>Trouble: Manny’s Monitoring Phone: 777/777-7777</td>
</tr>
<tr>
<td>Entity to which alarms are retransmitted: Pleasantville Fire Department Phone: 444/444-4444</td>
</tr>
<tr>
<td>Method of retransmission: Central station operator calls 444/444-4444 after receiving a signal</td>
</tr>
</tbody>
</table>

If Chapter 26, specify the means of transmission from the protected premises to the supervising station: **DACT**

If Chapter 27, specify the type of auxiliary alarm system: □ Local energy □ Shunt □ Wired □ Wireless
### 4. CIRCUITS AND PATHWAYS

#### 4.1 Signaling Line Pathways

**4.1.1 Pathways Class Designations and Survivability**

<table>
<thead>
<tr>
<th>Pathways class</th>
<th>Survivability level</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2</td>
<td>12</td>
</tr>
</tbody>
</table>

(See NFPA 72, Sections 12.3 and 12.4)

**4.1.2 Pathways Utilizing Two or More Media**

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>N/A</td>
</tr>
</tbody>
</table>

---

**4.1.3 Device Power Pathways**

- ✓ No separate power pathways from the signaling line pathway
- ❏ Power pathways are separate but of the same pathway classification as the signaling line pathway
- ❏ Power pathways are separate and different classification from the signaling line pathway

**4.1.4 Isolation Modules**

<table>
<thead>
<tr>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
</tr>
</tbody>
</table>

---

#### 4.2 Alarm Initiating Device Pathways

**4.2.1 Pathways Class Designations and Survivability**

<table>
<thead>
<tr>
<th>Pathways class</th>
<th>Survivability level</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td>N/A</td>
<td>0</td>
</tr>
</tbody>
</table>

(See NFPA 72, Sections 12.3 and 12.4)

**4.2.2 Pathways Utilizing Two or More Media**

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>N/A</td>
</tr>
</tbody>
</table>

---

**4.2.3 Device Power Pathways**

- ❏ No separate power pathways from the initiating device pathway
- ❏ Power pathways are separate but of the same pathway classification as the initiating device pathway
- ❏ Power pathways are separate and different classification from the initiating device pathway

#### 4.3 Non-Voice Audible System Pathways

**4.3.1 Pathways Class Designations and Survivability**

<table>
<thead>
<tr>
<th>Pathways class</th>
<th>Survivability level</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>N/A</td>
<td>24</td>
</tr>
</tbody>
</table>

(See NFPA 72, Sections 12.3 and 12.4)

**4.3.2 Pathways Utilizing Two or More Media**

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>N/A</td>
</tr>
</tbody>
</table>

---

**4.3.3 Appliance Power Pathways**

- ✓ No separate power pathways from the notification appliance pathway
- ❏ Power pathways are separate but of the same pathway classification as the notification appliance pathway
- ❏ Power pathways are separate and different classification from the notification appliance pathway
5. ALARM INITIATING DEVICES

5.1 Manual Initiating Devices

5.1.1 Manual Fire Alarm Boxes

This system does not have manual fire alarm boxes.

Type and number of devices: Addressable: 74 Conventional: 0 Coded: 0 Transmitter: 0

Other (specify): N/A

5.1.2 Other Alarm Boxes

This system does not have other alarm boxes.

Description: ____________________________

Type and number of devices: Addressable: 10 Conventional: 0 Coded: 0 Transmitter: 0

Other (specify): N/A

5.2 Automatic Initiating Devices

5.2.1 Smoke Detectors

This system does not have smoke detectors.

Type and number of devices: Addressable: 96 Conventional: 0

Other (specify): N/A

Type of coverage: ✔ Complete area ☑ Partial area ☑ Nonrequired partial area

Located in all electrical and equipment rooms, in elevator lobbies, and at fire doors

Type of smoke detector sensing technology: ☑ Ionization ☑ Photoelectric ☑ Multicriteria ☑ Aspirating ☑ Beam

Other (specify): N/A

5.2.2 Duct Smoke Detectors

This system does not have alarm-causing duct smoke detectors.

Type and number of devices: Addressable: 33 Conventional: 0

Other (specify): N/A

Type of coverage: Located at the supply and return of all air handling units

Type of smoke detector sensing technology: ☑ Ionization ☑ Photoelectric ☑ Aspirating ☑ Beam

5.2.3 Radiant Energy (Flame) Detectors

This system does not have radiant energy detectors.

Type and number of devices: Addressable: Conventional: 0

Other (specify): N/A

Type of coverage: N/A

5.2.4 Gas Detectors

This system does not have gas detectors.

Type of detector(s): N/A

Number of devices: Addressable: Conventional: 0

Type of coverage: N/A

5.2.5 Heat Detectors

This system does not have heat detectors.

Type and number of devices: Addressable: 12 Conventional: 0

Type of coverage: ☐ Complete area ☑ Partial area ☐ Nonrequired partial area ☑ Linear ☑ Spot

Type of heat detector sensing technology: ☑ Fixed temperature ☑ Rate-of-rise ☑ Rate compensated
## EXHIBIT 2.2  Continued

### 5. ALARM INITIATING DEVICES (continued)

#### 5.2.6 Addressable Monitoring Modules
- Number of devices: 67
  - This system does not have monitoring modules.

#### 5.2.7 Waterflow Alarm Devices
- Type and number of devices: Addressable: 42, Conventional: 0, Coded: 0, Transmitter: 0
  - This system does not have waterfall alarm devices.

#### 5.2.8 Alarm Verification
- Number of devices subject to alarm verification: N/A
  - Alarm verification set for N/A seconds

#### 5.2.9 Presignal
- Number of devices subject to presignal: N/A
  - Describe presignal functions: N/A

#### 5.2.10 Positive Alarm Sequence (PAS)
- Describe PAS: N/A
  - This system does not incorporate PAS.

#### 5.2.11 Other Initiating Devices
- Describe: N/A
  - This system does have other initiating devices.

### 6. SUPERVISORY SIGNAL–INITIATING DEVICES

#### 6.1 Sprinkler System Supervisory Devices
- Type and number of devices: Addressable: 49, Conventional: 0, Coded: 0, Transmitter: 0
  - Other (specify): N/A
  - This system does not have sprinkler supervisory devices.

#### 6.2 Fire Pump Description and Supervisory Devices
- Type fire pump: Electric, Engine
- Type and number of devices: Addressable: 3, Conventional: 0, Coded: 0, Transmitter: 0
  - Other (specify): N/A
  - This system does not have a fire pump.

#### 6.2.1 Fire Pump Functions Supervised
- Power, Running, Phase reversal, Selector switch not in auto, Engine or control panel trouble, Low fuel
  - Other (specify): N/A

#### 6.3 Duct Smoke Detectors (DSDs)
- Type and number of devices: Addressable: N/A, Conventional: N/A
  - Other (specify): N/A
  - Type of coverage: N/A
  - Type of smoke detector sensing technology: Ionization, Photoelectric, Aspirating, Beam
  - This system does not have DSDs causing supervisory signals.

#### 6.4 Other Supervisory Devices
- Describe: N/A
  - This system does not have other supervisory devices.
### 7. MONITORED SYSTEMS

#### 7.1 Engine-Driven Generator

- **This system does not have a generator.**

#### 7.1.1 Generator Functions Supervised

- [x] Engine or control panel trouble
- [x] Generator running
- [x] Selector switch not in auto
- [✓] Low fuel
- [✓] Other (specify): N/A

#### 7.2 Special Hazard Suppression Systems

- **This system does not monitor special hazard systems.**

Description of special hazard system(s):

- Sprinkler preaction system in 24th floor computer room

#### 7.3 Other Monitoring Systems

- **This system does not monitor other systems.**

Description of other system(s):

- N/A

### 8. ANNUNCIATORS

- **This system does not have annunciators.**

#### 8.1 Location and Description of Annunciators

<table>
<thead>
<tr>
<th>Location</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fire command center</td>
</tr>
<tr>
<td>2</td>
<td>Front lobby at east entrance doors</td>
</tr>
<tr>
<td>3</td>
<td>Engineering office on P1 level</td>
</tr>
</tbody>
</table>

### 9. ALARM NOTIFICATION APPLIANCES

#### 9.1 In-Building Fire Emergency Voice Alarm Communication System

- **This system does not have an EVACS.**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of single voice alarm channels</td>
<td>58</td>
</tr>
<tr>
<td>Number of speakers</td>
<td>490</td>
</tr>
<tr>
<td>Number of multiple voice alarm channels</td>
<td>0</td>
</tr>
<tr>
<td>Number of speaker circuits</td>
<td>58</td>
</tr>
<tr>
<td>Location of amplification and sound-processing equipment</td>
<td>Fire command center</td>
</tr>
<tr>
<td>Location of paging microphone stations:</td>
<td></td>
</tr>
<tr>
<td>Location 1:</td>
<td>Fire command center</td>
</tr>
<tr>
<td>Location 2:</td>
<td>N/A</td>
</tr>
<tr>
<td>Location 3:</td>
<td>N/A</td>
</tr>
</tbody>
</table>

#### 9.2 Nonvoice Notification Appliances

- **This system does not have nonvoice notification appliances.**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horns</td>
<td>0</td>
</tr>
<tr>
<td>Bells</td>
<td>0</td>
</tr>
<tr>
<td>Chimes</td>
<td>0</td>
</tr>
<tr>
<td>Visible only</td>
<td>566</td>
</tr>
<tr>
<td>Other (describe):</td>
<td>0</td>
</tr>
</tbody>
</table>

#### 9.3 Notification Appliance Power Extender Panels

- **This system does not have power extender panels.**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity</td>
<td>42</td>
</tr>
<tr>
<td>Locations:</td>
<td>2 in the fire command center and 1 in the electrical equipment room on each floor</td>
</tr>
</tbody>
</table>
### EXHIBIT 2.2 Continued

10. MASS NOTIFICATION CONTROLS, APPLIANCES, AND CIRCUITS

<table>
<thead>
<tr>
<th>Location</th>
<th>Fire command center</th>
<th>N/A</th>
<th>N/A</th>
</tr>
</thead>
</table>

10.1 MNS Local Operating Consoles

- Location 1: Fire command center
- Location 2: N/A
- Location 3: N/A

10.2 High-Power Speaker Arrays

- Location 1:
- Location 2:
- Location 3:

10.3 Mass Notification Devices

| Combination fire alarm/MNS visible appliances | 0 | MNS-only visible appliances | 216 |
| Textual signs | 0 | Other (describe) | N/A |
| Supervision class | B |

10.3.1 Special Hazard Notification

- This system does not have special suppression predischarge notification.
- MNS systems DO NOT override notification appliances required to provide special suppression predischarge notification.

11. TWO-WAY EMERGENCY COMMUNICATION SYSTEMS

11.1 Telephone System

- Number of telephone jacks installed: 13
- Number of warden stations installed: 0
- Number of telephone handsets stored on site: 8
- Type of telephone system installed: Electrically powered

11.2 Two-Way Radio Communications Enhancement System

- Percentage of area covered by two-way radio service: Critical areas: ___% General building areas: ___%
- Amplification component locations: N/A

<table>
<thead>
<tr>
<th>Inbound signal strength</th>
<th>216 dBm</th>
<th>Outbound signal strength</th>
<th>216 dBm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Donor antenna isolation</td>
<td>216 dBm</td>
<td>above the signal booster gain</td>
<td></td>
</tr>
<tr>
<td>Radio frequencies covered: N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radio system monitor panel location: N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
11. TWO-WAY EMERGENCY COMMUNICATION SYSTEMS (continued)

11.3 Area of Refuge (Area of Rescue Assistance) Emergency Communications Systems

☐ This system does not have an area of refuge (area of rescue assistance) emergency communications system.

Number of stations: 45

Location of central control point: Fire command center

Days and hours when central control point is attended: During incident

Location of alternate control point: Building management office

Days and hours when alternate control point is attended: 8 to 5 on weekdays

11.4 Elevator Emergency Communications Systems

☐ This system does not have an elevator emergency communications system.

Number of elevators with stations: 12

Location of central control point: Fire command center

Days and hours when central control point is attended: During incident

Location of alternate control point: Building management office

Days and hours when alternate control point is attended: 8 to 5 on weekdays

11.5 Other Two-Way Communication Systems

Describe: N/A

12. CONTROL FUNCTIONS

This system activates the following control functions:

☑ Hold-open door releasing devices ☑ Smoke management ☐ HVAC shutdown ☑ F/S dampers

☑ Door unlocking ☑ Elevator recall ☑ Fuel source shutdown ☐ Extinguishing agent release

☑ Elevator shunt trip ☑ Mass notification system override of fire alarm notification appliances

Other (specify): N/A

12.1 Addressable Control Modules

☐ This system does not have control modules.

Number of devices: 122

Other (specify): N/A

13. SYSTEM POWER

13.1 Control Unit

13.1.1 Primary Power

Input voltage of control panel: 120 VAC

Control panel amps: 6.2

Overcurrent protection: Type: Circuit breaker

Amps: 15

Location (of primary supply panel board): First floor electrical room

Disconnecting means location: First floor electrical room

13.1.2 Engine-Driven Generator

☐ This system does not have a generator.

Location of generator: Lower level generator room

Location of fuel storage: Sub basement fuel storage room

Type of fuel: Diesel

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NFPA 72 (p. 8 of 12)
### 13. SYSTEM POWER (continued)

#### 13.1.3 Uninterruptible Power System

- **This system does not have a UPS.**

  - Equipment powered by a UPS system: 
  - Location of UPS system: 
  - Calculated capacity of UPS batteries to drive the system components connected to it:
    - In standby mode (hours): 
    - In alarm mode (minutes): 

#### 13.1.4 Batteries

- **Location:** Fire command center  
  - **Type:** Gel cell  
  - **Nominal voltage:** 24 VDC  
  - **Amp/hour rating:** 30

  - Calculated capacity of batteries to drive the system:
    - In standby mode (hours): 58
    - In alarm mode (minutes): 11

  - Batteries are marked with date of manufacture  
  - Battery calculations are attached

#### 13.2 In-Building Fire Emergency Voice Alarm Communication System or Mass Notification System

- **This system does not have an EVACS or MNS system.**

#### 13.2.1 Primary Power

- **Input voltage of EVACS or MNS panel:** 120 VAC  
  - **EVACS or MNS panel amps:** 11.9

  - **Overcurrent protection:** Circuit breaker  
  - **Location (of primary supply panel board):** First floor electrical room

  - **Disconnecting means location:** First floor electrical room

#### 13.2.2 Engine-Driven Generator

- **This system does not have a generator.**

  - **Location of generator:** Lower level generator room

  - **Location of fuel storage:** Sub basement fuel storage room  
  - **Type of fuel:** Diesel

#### 13.2.3 Uninterruptible Power System

- **This system does not have a UPS.**

  - Equipment powered by a UPS system: 
  - Location of UPS system: 
  - Calculated capacity of UPS batteries to drive the system components connected to it:
    - In standby mode (hours): 
    - In alarm mode (minutes): 

#### 13.2.4 Batteries

- **Location:** Fire command center  
  - **Type:** Gel cell  
  - **Nominal voltage:** 24 VDC  
  - **Amp/hour rating:** 120

  - Calculated capacity of batteries to drive the system:
    - In standby mode (hours): 30
    - In alarm mode (minutes): 8

  - Batteries are marked with date of manufacture  
  - Battery calculations are attached
13. SYSTEM POWER (continued)

13.3 Notification Appliance Power Extender Panels

- This system does not have power extender panels.

13.3.1 Primary Power

Input voltage of power extender panel(s): 120 VAC  
Power extender panel amps: 2  
Overcurrent protection: Type: Circuit breaker  
Amps: 15  
Location (of primary supply panel board): E Power panels located every three floors in the electrical rooms  
Disconnecting means location: E Power panels

13.3.2 Engine-Driven Generator

- This system does not have a generator.

Location of generator: Lower level generator room  
Location of fuel storage: Sub basement fuel storage room  
Type of fuel: Diesel

13.3.3 Uninterruptible Power System

- This system does not have a UPS.

Equipment powered by a UPS system:  
Location of UPS system:  
Calculated capacity of UPS batteries to drive the system components connected to it:  
In standby mode (hours):  
In alarm mode (minutes):  

13.3.4 Batteries

Location: Inside each panel  
Type: Gel cell  
Nominal voltage: 24 VDC  
Amp/hour rating: 14  
Calculated capacity of batteries to drive the system:  
In standby mode (hours):  
In alarm mode (minutes):  

- Batteries are marked with date of manufacture  
- Battery calculations are attached

14. RECORD OF SYSTEM INSTALLATION

Fill out after all installation is complete and wiring has been checked for opens, shorts, ground faults, and improper branching, but before conducting operational acceptance tests.

This is a: ✓ New system  
- Modification to an existing system  
Permit number: 4567

The system has been installed in accordance with the following requirements: (Note any or all that apply.)

- NFPA 72, Edition: 2010  
- NFPA 70, National Electrical Code, Article 760, Edition: 2008  
- Manufacturer’s published instructions  
Other (specify): Pleasantville local codes, revised 2008

System deviations from referenced NFPA standards: None known

Signed: Fred Friendly  
Printed name: Fred Friendly  
Date: 8/21/2010  
Organization: Fred’s Fine Fire Alarm Syst.  
Title: President  
Phone: 444/444-4444

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15. RECORD OF SYSTEM OPERATIONAL ACCEPTANCE TEST

- **New system**
  All operational features and functions of this system were tested by, or in the presence of, the signer shown below, on the date shown below, and were found to be operating properly in accordance with the requirements for the following:

- Modifications to an existing system
  All newly modified operational features and functions of the system were tested by, or in the presence of, the signer shown below, on the date shown below, and were found to be operating properly in accordance with the requirements of the following:

- **NFPA 72, Edition:** 2010
- **NFPA 70, National Electrical Code, Article 760, Edition:** 2008
- Manufacturer's published instructions

  Other (specify): Pleasantville local codes, revised 2008

- Individual device testing documentation [Inspection and Testing Form (Figure 14.6.2.4) is attached]

<table>
<thead>
<tr>
<th>Signed:</th>
<th>Fred Friendly</th>
<th>Printed name: Fred Friendly</th>
<th>Date: 8/21/2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organization:</td>
<td>Fred’s Fine Fire Alarm Syst.</td>
<td>Title: President</td>
<td>Phone: 444/444-4444</td>
</tr>
</tbody>
</table>

16. CERTIFICATIONS AND APPROVALS

16.1 System Installation Contractor:
This system, as specified herein, has been installed and tested according to all NFPA standards cited herein.

<table>
<thead>
<tr>
<th>Signed:</th>
<th>Fred Friendly</th>
<th>Printed name: Fred Friendly</th>
<th>Date: 8/21/2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organization:</td>
<td>Fred’s Fine Fire Alarm Syst.</td>
<td>Title: President</td>
<td>Phone: 888/888-8888</td>
</tr>
</tbody>
</table>

16.2 System Service Contractor:
The undersigned has a service contract for this system in effect as of the date shown below.

<table>
<thead>
<tr>
<th>Signed:</th>
<th>Fred Friendly</th>
<th>Printed name: Fred Friendly</th>
<th>Date: 8/21/2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organization:</td>
<td>Fred’s Fine Fire Alarm Syst.</td>
<td>Title: President</td>
<td>Phone: 888/888-8888</td>
</tr>
</tbody>
</table>

16.3 Supervising Station:
This system, as specified herein, will be monitored according to all NFPA standards cited herein.

<table>
<thead>
<tr>
<th>Signed:</th>
<th>Manny Monitor</th>
<th>Printed name: Manny Monitor</th>
<th>Date: 8/30/2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organization:</td>
<td>Manny’s Monitoring</td>
<td>Title: President</td>
<td>Phone: 777/777-7777</td>
</tr>
</tbody>
</table>
16. CERTIFICATIONS AND APPROVALS (continued)

16.4 Property or Owner Representative:
I accept this system as having been installed and tested to its specifications and all NFPA standards cited herein.

Signed: Mary Morris  
Organization: Mary's Management  
Printed name: Mary Morris  
Title: Property Manager  
Date: 8/30/2010  
Phone: 222/222-2222

16.5 Authority Having Jurisdiction:
I have witnessed a satisfactory acceptance test of this system and find it to be installed and operating properly in accordance with its approved plans and specifications, with its approved sequence of operations, and with all NFPA standards cited herein.

Signed: Jack Jones  
Organization: Pleasantville Fire Dept.  
Printed name: Jack Jones  
Title: Inspector  
Date: 9/10/2010  
Phone: 444/444-4444
The preparation of a record of completion, Figure 10.18.2.1.1 shall be in accordance with 10.18.2.1.2.1 through 10.18.2.1.2.8. [NFPA 72-10: 10.18.2.1.2.1]

Parts 1 through 14 of the record of completion shall be completed after the system is installed and the installation wiring has been checked. [NFPA 72-10: 10.18.2.1.2.1]

Parts 15 and 16 of the record of completion shall be completed after the operational acceptance tests have been completed. [NFPA 72-10: 10.18.2.1.2.2]

A preliminary copy of the record of completion shall be given to the system owner and, if requested, to other authorities having jurisdiction after completion of the installation wiring tests. [NFPA 72-10: 10.18.2.1.2.3]

A final copy of the record of completion shall be provided after completion of the operational acceptance tests. [NFPA 72-10: 10.18.2.1.2.4]

One copy of the record of completion shall be stored at the fire alarm control unit or other approved location. [NFPA 72-10: 10.18.2.1.2.5]

This copy shall be updated to reflect all system additions or modifications and maintained in a current condition at all times. [NFPA 72-10: 10.18.2.1.2.6]

System Documentation

Every system shall include the following documentation, which shall be delivered to the owner or the owner’s representative upon final acceptance of the system:

1. An owner’s manual and manufacturer’s published instructions covering all system equipment
2. Record drawings
3. For software-based systems, record copy of the site-specific software
4. A written sequence of operation [NFPA 72-10: 10.18.2.3]

Compliance Verification

Where compliance verification is required, it should be completed by an independent third party. The inspections, tests, and documentation required by NFPA 72®, the National Fire Alarm Signaling Code, form the documentation package that supports compliance verification.

Where required, compliance of the completed installation with the requirements of this Code, as implemented via the referring code(s), specifications, and/or other criteria applicable to the specific installation, shall be certified by a qualified and impartial third-party organization acceptable to the authority having jurisdiction. [NFPA 72-10: 18.2.4]

This section is intended to provide a basis for the authority having jurisdiction to require third-party verification and certification that the authority having jurisdiction and the system owner can rely on to reasonably assure that the fire alarm system installation complies with the applicable requirements. [NFPA 72-10: A.10.18.2.4.4]

Verification shall ensure that the installed system includes all components and functions, that those components and functions are installed and operate as required, that the system has been 100 percent acceptance tested in accordance with Chapter 14, and that all required documentation has been provided to the system owner. [NFPA 72-10: 10.18.2.4.1]

Exception: Where the installation is an extension, modification, or reconfiguration of an existing system, the verification shall be required for the new work only, and reacceptance testing in accordance with Chapter 14 shall be acceptable. [NFPA 72-10:10.18.2.4.1]
SYSTEM TESTING

Initial Acceptance Testing

All new systems shall be inspected and tested in accordance with the requirements of Chapter 14 [of NFPA 72]. [NFPA 72-10: 14.4.1.1.1]

A visual inspection should always be conducted prior to any testing, including initial and reacceptance testing. Exhibit 2.3 identifies various fire alarm system components and subsystems and also provides the frequency required for periodic inspections. Visual inspections confirm that equipment is located and installed as intended by the system design and as documented on the record drawings and system documentation.

EXHIBIT 2.3 Visual Inspection Frequencies  

<table>
<thead>
<tr>
<th>Component</th>
<th>Initial/Reacceptance</th>
<th>Monthly</th>
<th>Quarterly</th>
<th>Semiannually</th>
<th>Annually</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Fuses</td>
<td>X</td>
<td>—</td>
<td>—</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>(b) Interfaced equipment</td>
<td>X</td>
<td>—</td>
<td>—</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>(c) Lamps and LEDs</td>
<td>X</td>
<td>—</td>
<td>—</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>(d) Primary (main) power supply</td>
<td>X</td>
<td>—</td>
<td>—</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>2. Control Equipment: Fire Alarm Systems Unmonitored for Alarm, Supervisory, and Trouble Signals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Fuses</td>
<td>X (weekly)</td>
<td>—</td>
<td>—</td>
<td></td>
<td>—</td>
</tr>
<tr>
<td>(b) Interfaced equipment</td>
<td>X (weekly)</td>
<td>—</td>
<td>—</td>
<td></td>
<td>—</td>
</tr>
<tr>
<td>(c) Lamps and LEDs</td>
<td>X (weekly)</td>
<td>—</td>
<td>—</td>
<td></td>
<td>—</td>
</tr>
<tr>
<td>(d) Primary (main) power supply</td>
<td>X (weekly)</td>
<td>—</td>
<td>—</td>
<td></td>
<td>—</td>
</tr>
<tr>
<td>3. Batteries</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Lead-acid</td>
<td>X</td>
<td>X</td>
<td>—</td>
<td></td>
<td>—</td>
</tr>
<tr>
<td>(b) Nickel-cadmium</td>
<td>X</td>
<td>—</td>
<td>—</td>
<td>X</td>
<td>—</td>
</tr>
<tr>
<td>(c) Primary (dry cell)</td>
<td>X</td>
<td>X</td>
<td>—</td>
<td></td>
<td>—</td>
</tr>
<tr>
<td>(d) Sealed lead-acid</td>
<td>X</td>
<td>—</td>
<td>—</td>
<td>X</td>
<td>—</td>
</tr>
<tr>
<td>4. Transient Suppressors</td>
<td>X</td>
<td>—</td>
<td>—</td>
<td>X</td>
<td>—</td>
</tr>
<tr>
<td>5. Control Unit Trouble Signals</td>
<td>X (weekly)</td>
<td>—</td>
<td>—</td>
<td>X</td>
<td>—</td>
</tr>
<tr>
<td>6. Fiber-Optic Cable Connections</td>
<td>X</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>X</td>
</tr>
<tr>
<td>7. Emergency Voice/Alarm Communications Equipment</td>
<td>X</td>
<td>—</td>
<td>—</td>
<td>X</td>
<td>—</td>
</tr>
<tr>
<td>8. Remote Annunciators</td>
<td>X</td>
<td>—</td>
<td>—</td>
<td>X</td>
<td>—</td>
</tr>
<tr>
<td>9. Initiating Devices</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Air sampling</td>
<td>X</td>
<td>—</td>
<td>—</td>
<td>X</td>
<td>—</td>
</tr>
<tr>
<td>(b) Duct detectors</td>
<td>X</td>
<td>—</td>
<td>—</td>
<td>X</td>
<td>—</td>
</tr>
<tr>
<td>(c) Electromechanical releasing devices</td>
<td>X</td>
<td>—</td>
<td>—</td>
<td>X</td>
<td>—</td>
</tr>
<tr>
<td>(d) Fire extinguishing system(s) or suppression system(s) switches</td>
<td>X</td>
<td>—</td>
<td>—</td>
<td>X</td>
<td>—</td>
</tr>
</tbody>
</table>
Chapter 2 • Fire Alarm Systems 55

Chapter 14 of the National Fire Alarm and Signaling Code includes requirements for testing of all fire alarm system components and subsystems. Initial acceptance testing of the entire system in accordance with the test methods prescribed in Chapter 14 is required before the system can be approved and put into service.

Reacceptance Testing

Whenever a fire alarm system is modified or parts are replaced for maintenance, reacceptance testing is required. Reacceptance testing of specific components or subsystems must also be in accordance with the test methods prescribed in Chapter 14 before the equipment and system can be approved and put back into service.

Initiating Device, Notification Appliance, Control Relay Changes

Initiating devices and notification appliances are defined as follows:

Initiating Device: A system component that originates transmission of a change-of-state condition, such as in a smoke detector, manual fire alarm box, or supervisory switch. [NFPA 72-10: 3.3.122]
**Notification Appliance.** A fire alarm system component such as a bell, horn, speaker, light, or text display that provides audible, tactile, or visible outputs, or any combination thereof. [NFPA 72-10: 3.3.160]

When an initiating device, notification appliance, or control relay is added, it shall be functionally tested. [NFPA 72-10: 14.4.1.2.1.1]

When an initiating device, notification appliance, or control relay is deleted, another device, appliance, or control relay on the circuit shall be operated. [NFPA 72-10: 14.4.1.2.1.2]

**Control Equipment Hardware Changes**

When modifications or repairs to control equipment hardware are made, the control equipment shall be tested in accordance with Table 14.4.2.2, items 1(a) and 1(d). [NFPA 72-10: 14.4.1.2.1.3]

**Site-Specific Software Changes**

**Programs, instruments, procedures, data, and the like that are executed by a central processing unit of a product and that influence the functional performance of that product. For the purpose of software is one of two types: executive software and site-specific software. (SIG-TMS) . [NFPA 72-10: 3.3.255]**

**Executive Software.** Control and supervisory execution of all other programs and directly or indirectly causes the required functions of the product to be performed. Executive software is sometimes referred to as firmware, BIOS, or executive program. (SIG-TMS) [NFPA 72-10: 3.3.255.1]

**Site-Specific Software.** Program that is separate from, but controlled by, the executive software which allows inputs, outputs, and system configuration to be selectively defined to meet the needs of a specific installation. Typically it defines the type and quantity of hardware, customized labels, and the specific operating features of a system. (SIG-TMS) [NFPA 72-10:3.3.255.2]

When changes are made to site-specific software, the following shall apply:

1. All functions known to be affected by the change, or identified by a means that indicates changes, shall be 100 percent tested.
2. In addition, 10 percent of initiating devices that are not directly affected by the change, up to a maximum of 50 devices, also shall be tested and correct system operation shall be verified.
3. A revised record of completion in accordance with 10.18.2.1 shall be prepared to reflect these changes. [NFPA 72-10: 14.4.1.2.1.4]

**Control Units Changes**

Changes to all control units connected or controlled by the system’s executive software shall require a 10 percent functional test of the system, including a test of at least one device on each input and output circuit to verify critical system functions such as notification appliances, control functions, and off-premises reporting. [NFPA 72-10:114.4.1.2.2]
Operating System Software Changes

The system’s executive software is the operating system software that is fundamental to the system’s operation and can only be altered by the equipment manufacturer or its authorized representative.

TEST METHODS

Specific test methods for each fire alarm system component and subsystem apply to initial acceptance testing, reacceptance testing, and to periodic testing. Testing completed in accordance with these methods assures that the system will perform as intended by the system design and as documented on the record drawings and system documentation. A record of all system inspection and testing is required. The inspection and testing form (Exhibit 2.4) contains additional information that must be provided; the form can be used to facilitate documentation of the system inspection and testing.

Fire alarm systems and other systems and equipment that are associated with fire alarm systems and accessory equipment shall be tested according to Table 14.4.2.2. [NFPA 72-10: 14.4.2.2]

RECORDS

Permanent Records

A permanent record is defined as one that has been determined by the AHJ to have sufficient value to warrant its permanent preservation and protection. In commissioning fire alarm systems, the permanent records should include, as a minimum, the as-built drawings, operation and maintenance manuals (O&M), inspection and test reports, and the basis of design document. These records can be maintained in paper or electronic format and should be stored appropriately as required by NFPA 232, Standard for the Protection of Records.

Permanent records are intended to be maintained on file for the life of the system. The information contained therein is critical to provide the system owner, the AHJ, and maintenance personnel with a complete understanding of the system operation and function of system components throughout the operational life of the system.

After successful completion of acceptance tests approved by the authority having jurisdiction, the requirements in 14.6.1.1 through 14.6.1.3 shall apply. [NFPA 72-10: 14.6.1]

A set of reproducible as-built installation drawings, operation and maintenance manuals, and a written sequence of operation shall be provided to the building owner or the owner’s designated representative. [NFPA 72-10: 14.6.1.1]

The system owner shall be responsible for maintaining these records for the life of the system for examination by any authority having jurisdiction. Paper or electronic media shall be permitted. [NFPA 72-10: 14.6.3]

SUMMARY

The commissioning of a fire alarm system involves the following process:

- Development of the system design and installation documents
- Submittal and approval of the system design and installation documents

Program for Individual Systems
**FIRE ALARM AND EMERGENCY COMMUNICATION SYSTEM INSPECTION AND TESTING FORM**

*To be completed by the system inspector or tester at the time of the inspection or test. It shall be permitted to modify this form as needed to provide a more complete and/or clear record. Insert N/A in all unused lines. Attach additional sheets, data, or calculations as necessary to provide a complete record.*

Date of this inspection or test: ______________________  Time of inspection or test: ______________________

1. **PROPERTY INFORMATION**

   Name of property: ________________________________
   Address: ________________________________________
   Description of property: ____________________________
   Occupancy type: _________________________________
   Name of property representative: ____________________
   Address: ________________________________________
   Phone: ___________________  Fax: ___________________  E-mail: ___________________
   Authority having jurisdiction over this property: ______________________
   Phone: ___________________  Fax: ___________________  E-mail: ___________________

2. **INSTALLATION, SERVICE, AND TESTING CONTRACTOR INFORMATION**

   Service and/or testing organization for this equipment: __________________
   Address: ________________________________________
   Phone: ___________________  Fax: ___________________  E-mail: ___________________
   Service technician or tester: __________________________
   Qualifications of technician or tester: __________________
   A contract for test and inspection in accordance with NFPA standards is in effect as of: ______
   The contract expires: __________  Contract number: __________  Frequency of tests and inspections: ______
   Monitoring organization for this equipment: ______________________
   Address: ________________________________________
   Phone: ___________________  Fax: ___________________  E-mail: ___________________
   Entity to which alarms are retransmitted: __________________
   Phone: ___________________

3. **TYPE OF SYSTEM OR SERVICE**

   - Fire alarm system (nonvoice)
   - Fire alarm with in-building fire emergency voice alarm communication system (EVACS)
   - Mass notification system (MNS)
   - Combination system, with the following components:
     - Fire alarm
     - EVACS
     - MNS
     - Two-way, in-building, emergency communication system
   - Other (specify): __________________

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**EXHIBIT 2.4** Sample Inspection and Testing Form  *Source: Adapted from NFPA 72®, 2010, Figure 10.6.2.3.*
### 3. TYPE OF SYSTEM OR SERVICE (continued)

<table>
<thead>
<tr>
<th>Additional description of system(s):</th>
</tr>
</thead>
</table>

#### 3.1 Control Unit

<table>
<thead>
<tr>
<th>Manufacturer:</th>
<th>Model number:</th>
</tr>
</thead>
</table>

#### 3.2 Mass Notification System

- **This system does not incorporate an MNS.**

##### 3.2.1 System Type:

- In-building MNS — combination
- In-building MNS — stand-alone
- Wide-area MNS
- Distributed recipient MNS
- Other (specify):

##### 3.2.2 System Features:

- Combination fire alarm/MNS
- MNS ACU only
- Wide-area MNS to regional national alerting interface
- Local operating console (LOC)
- Direct recipient MNS (DRMNS)
- Wide-area MNS to DRMNS interface
- Wide-area MNS to high-power speaker array (HPSA) interface
- In-building MNS to wide-area MNS interface
- Other (specify):

#### 3.3 System Documentation

- An owner's manual, a copy of the manufacturer's instructions, a written sequence of operation, and a copy of the record drawings are stored on site. Location:

#### 3.4 System Software

- This system does not have alterable site-specific software.

<table>
<thead>
<tr>
<th>Software revision number:</th>
<th>Software last updated on:</th>
</tr>
</thead>
<tbody>
<tr>
<td>A copy of the site-specific software is stored on site. Location:</td>
<td></td>
</tr>
</tbody>
</table>

#### 4. SYSTEM POWER

##### 4.1 Control Unit

##### 4.1.1 Primary Power

| Input voltage of control panel: | Control panel amps: |

##### 4.1.2 Engine-Driven Generator

- This system does not have a generator.

| Location of generator: |
| Location of fuel storage: | Type of fuel: |

##### 4.1.3 Uninterruptible Power System

- This system does not have a UPS.

| Equipment powered by a UPS system: |
| Location of UPS system: |

| Calculated capacity of UPS batteries to drive the system components connected to it: |
| In standby mode (hours): | In alarm mode (minutes): |
4. SYSTEM POWER  (continued)

4.1.4 Batteries
Location:  ________  Type:  ________  Nominal voltage:  ________  Amp/hour rating:  ________  
Calculated capacity of batteries to drive the system:
In standby mode (hours):  ________  In alarm mode (minutes):  ________
☒ Batteries are marked with date of manufacture.

4.2  In-Building Fire Emergency Voice Alarm Communication System or Mass Notification System
☒ This system does not have an EVACS or MNS.

4.2.1 Primary Power
Input voltage of EVACS or MNS panel:  ________  EVACS or MNS panel amps:  ________

4.2.2 Engine-Driven Generator
☒ This system does not have a generator.
Location of generator:  ________  
Location of fuel storage:  ________  Type of fuel:  ________

4.2.3 Uninterruptible Power System
☒ This system does not have a UPS.
Equipment powered by a UPS system:  ________
Location of UPS system:  ________
Calculated capacity of UPS batteries to drive the system components connected to it:
In standby mode (hours):  ________  In alarm mode (minutes):  ________

4.2.4 Batteries
Location:  ________  Type:  ________  Nominal voltage:  ________  Amp/hour rating:  ________  
Calculated capacity of batteries to drive the system:
In standby mode (hours):  ________  In alarm mode (minutes):  ________
☒ Batteries are marked with date of manufacture.

4.3 Notification Appliance Power Extender Panels
☒ This system does not have power extender panels.

4.3.1 Primary Power
Input voltage of power extender panel(s):  ________  Power extender panel amps:  ________

4.3.2 Engine-Driven Generator
☒ This system does not have a generator.
Location of generator:  ________  
Location of fuel storage:  ________  Type of fuel:  ________

4.3.3 Uninterruptible Power System
☒ This system does not have a UPS.
Equipment powered by a UPS system:  ________
Location of UPS system:  ________
Calculated capacity of UPS batteries to drive the system components connected to it:
In standby mode (hours):  ________  In alarm mode (minutes):  ________
4. SYSTEM POWER (continued)

4.3.4 Batteries
Location: ________________ Type: __________ Nominal voltage: ______ Amp/hour rating: ______
Calculated capacity of batteries to drive the system:
In standby mode (hours): ________________ In alarm mode (minutes): ________________
☐ Batteries are marked with date of manufacture.

5. ANNUNCIATORS

☐ This system does not have annunciators.

5.1 Location and Description of Annunciators
Annunciator 1: _________________________________________________________________
Annunciator 2: _________________________________________________________________
Annunciator 3: _________________________________________________________________

6. NOTIFICATIONS MADE PRIOR TO TESTING
Monitoring organization Contact: ___________________ Time: ________________
Building management Contact: ___________________ Time: ________________
Building occupants Contact: ___________________ Time: ________________
Authority having jurisdiction Contact: ___________________ Time: ________________
Other, if required Contact: ___________________ Time: ________________

7. TESTING RESULTS
7.1 Control Unit and Related Equipment

<table>
<thead>
<tr>
<th>Description</th>
<th>Visual Inspection</th>
<th>Functional Test</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control unit</td>
<td>❑</td>
<td>❑</td>
<td></td>
</tr>
<tr>
<td>Lamps/LEDs/LCDs</td>
<td>❑</td>
<td>❑</td>
<td></td>
</tr>
<tr>
<td>Fuses</td>
<td>❑</td>
<td>❑</td>
<td></td>
</tr>
<tr>
<td>Trouble signals</td>
<td>❑</td>
<td>❑</td>
<td></td>
</tr>
<tr>
<td>Disconnect switches</td>
<td>❑</td>
<td>❑</td>
<td></td>
</tr>
<tr>
<td>Ground-fault monitoring</td>
<td>❑</td>
<td>❑</td>
<td></td>
</tr>
<tr>
<td>Supervision</td>
<td>❑</td>
<td>❑</td>
<td></td>
</tr>
<tr>
<td>Local annunciator</td>
<td>❑</td>
<td>❑</td>
<td></td>
</tr>
<tr>
<td>Remote annunciators</td>
<td>❑</td>
<td>❑</td>
<td></td>
</tr>
<tr>
<td>Power extender panels</td>
<td>❑</td>
<td>❑</td>
<td></td>
</tr>
<tr>
<td>Isolation modules</td>
<td>❑</td>
<td>❑</td>
<td></td>
</tr>
<tr>
<td>Other (specify)</td>
<td>❑</td>
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<td></td>
</tr>
</tbody>
</table>
### 7. TESTING RESULTS (continued)

#### 7.2 Control Unit Power Supplies

<table>
<thead>
<tr>
<th>Description</th>
<th>Visual Inspection</th>
<th>Functional Test</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>120-volt power</td>
<td>☐</td>
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<tr>
<td>Generator or UPS</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Battery condition</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Load voltage</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Discharge test</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Charger test</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Other (specify)</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
</tbody>
</table>

#### 7.3 In-Building Fire Emergency Voice Alarm Communications Equipment

<table>
<thead>
<tr>
<th>Description</th>
<th>Visual Inspection</th>
<th>Functional Test</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control unit</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Lamps/LEDs/LCDs</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Fuses</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Primary power supply</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Secondary power supply</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Trouble signals</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Disconnect switches</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Ground-fault monitoring</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Panel supervision</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>System performance</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Sound pressure levels</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Occupied □ Yes □ No</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ambient _______ dBA</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Alarm _______ dBA</td>
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<td>☐</td>
<td></td>
</tr>
<tr>
<td>(attach report with locations, values, and weather conditions)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>System intelligibility</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>□ CSI □ STI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(attach report with locations, values, and weather conditions)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (specify)</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
</tbody>
</table>
### 7. TESTING RESULTS (continued)

#### 7.4 Notification Appliance Power Extender Panels

<table>
<thead>
<tr>
<th>Description</th>
<th>Visual Inspection</th>
<th>Functional Test</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lamps/LEDs/LCDs</td>
<td>✗</td>
<td>✗</td>
<td></td>
</tr>
<tr>
<td>Fuses</td>
<td>✗</td>
<td>✗</td>
<td></td>
</tr>
<tr>
<td>Primary power supply</td>
<td>✗</td>
<td>✗</td>
<td></td>
</tr>
<tr>
<td>Secondary power supply</td>
<td>✗</td>
<td>✗</td>
<td></td>
</tr>
<tr>
<td>Trouble signals</td>
<td>✗</td>
<td>✗</td>
<td></td>
</tr>
<tr>
<td>Ground-fault monitoring</td>
<td>✗</td>
<td>✗</td>
<td></td>
</tr>
<tr>
<td>Panel supervision</td>
<td>✗</td>
<td>✗</td>
<td></td>
</tr>
<tr>
<td>Other (specify)</td>
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</tr>
</tbody>
</table>

#### 7.5 Mass Notification Equipment

<table>
<thead>
<tr>
<th>Description</th>
<th>Visual Inspection</th>
<th>Functional Test</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
</tr>
<tr>
<td>Reset/power down test</td>
<td>✗</td>
<td>✗</td>
<td></td>
</tr>
<tr>
<td>Fuses</td>
<td>✗</td>
<td>✗</td>
<td></td>
</tr>
<tr>
<td>Primary power supply</td>
<td>✗</td>
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<tr>
<td>UPS power test</td>
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<td></td>
</tr>
<tr>
<td>Trouble signals</td>
<td>✗</td>
<td>✗</td>
<td></td>
</tr>
<tr>
<td>Disconnect switches</td>
<td>✗</td>
<td>✗</td>
<td></td>
</tr>
<tr>
<td>Ground-fault monitoring</td>
<td>✗</td>
<td>✗</td>
<td></td>
</tr>
<tr>
<td>CCU security mechanism</td>
<td>✗</td>
<td>✗</td>
<td></td>
</tr>
<tr>
<td>Prerecorded message content</td>
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<td>✗</td>
<td></td>
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<tr>
<td>Prerecorded message activation</td>
<td>✗</td>
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<tr>
<td>Software backup performed</td>
<td>✗</td>
<td>✗</td>
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<tr>
<td>Test backup software</td>
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</tr>
<tr>
<td>Fire alarm to MNS interface</td>
<td>✗</td>
<td>✗</td>
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<tr>
<td>MNS to fire alarm interface</td>
<td>✗</td>
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<td>In-building MNS to wide-area MNS</td>
<td>✗</td>
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</table>
### 7. TESTING RESULTS (continued)

#### 7.5 Mass Notification Equipment (continued)

<table>
<thead>
<tr>
<th>Description</th>
<th>Visual Inspection</th>
<th>Functional Test</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>MNS to direct recipient MNS</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Sound pressure levels</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Occupied</td>
<td>☐ Yes ☐ No</td>
<td></td>
<td></td>
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<tr>
<td>Ambient _____ dBA</td>
<td></td>
<td></td>
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<tr>
<td>Alarm _____ dBA</td>
<td></td>
<td></td>
<td>(attach report with locations, values, and weather conditions)</td>
</tr>
<tr>
<td>System intelligibility</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>☐ CSI ☐ STI</td>
<td></td>
<td></td>
<td>(attach report with locations, values, and weather conditions)</td>
</tr>
<tr>
<td>Other (specify)</td>
<td>☐</td>
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</table>

#### 7.6 Two-Way Communications Equipment

<table>
<thead>
<tr>
<th>Description</th>
<th>Visual Inspection</th>
<th>Functional Test</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phone handsets</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Phone jacks</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Off-hook indicator</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Call-in signal</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>System performance</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>System audibility</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>System intelligibility</td>
<td>☐</td>
<td>☐</td>
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</tr>
<tr>
<td>Radio communications enhancement system</td>
<td>☐</td>
<td>☐</td>
<td></td>
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<tr>
<td>Area of refuge communication system</td>
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<td>Elevator emergency communications system</td>
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<tr>
<td>Other (specify)</td>
<td>☐</td>
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</table>
7. TESTING RESULTS (continued)

7.7 Combination Systems

<table>
<thead>
<tr>
<th>Description</th>
<th>Visual Inspection</th>
<th>Functional Test</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire extinguishing monitoring devices/system</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Carbon monoxide detector/system</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Combination fire/security system</td>
<td>☐</td>
<td>☐</td>
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</tr>
<tr>
<td>Other (specify)</td>
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7.8 Special Hazard Systems

<table>
<thead>
<tr>
<th>Description (specify)</th>
<th>Visual Inspection</th>
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<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td></td>
<td>☐</td>
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<td></td>
</tr>
</tbody>
</table>

7.9 Emergency Communications System

- Visual
- Functional
- Simulated operation

Ensure predischarge notification appliances of special hazard systems are not overridden by the MNS. See NFPA 72, 24.4.1.7.1.

7.10 Monitored Systems

<table>
<thead>
<tr>
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<th>Visual Inspection</th>
<th>Functional Test</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine-driven generator</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Fire pump</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Special suppression systems</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Other (specify)</td>
<td>☐</td>
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</table>
7. TESTING RESULTS (continued)

7.11 Auxiliary Functions

<table>
<thead>
<tr>
<th>Description</th>
<th>Visual Inspection</th>
<th>Functional Test</th>
<th>Comments</th>
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</thead>
<tbody>
<tr>
<td>Door-releasing devices</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Fan shutdown</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Smoke management/Smoke control</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Smoke damper operation</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Smoke shutter release</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Door unlocking</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Elevator recall</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Elevator shunt trip</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>MNS override of FA signals</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
<tr>
<td>Other (specify)</td>
<td>☐</td>
<td>☐</td>
<td></td>
</tr>
</tbody>
</table>

7.12 Alarm Initiating Device

- Device test results sheet attached listing all devices tested and the results of the testing

7.13 Supervisory Alarm Initiating Device

- Device test results sheet attached listing all devices tested and the results of the testing

7.14 Alarm Notification Appliances

- Appliance test results sheet attached listing all appliances tested and the results of the testing

7.15 Supervisory Station Monitoring

<table>
<thead>
<tr>
<th>Description</th>
<th>Yes</th>
<th>No</th>
<th>Time</th>
<th>Comments</th>
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<tbody>
<tr>
<td>Alarm signal</td>
<td>☐</td>
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<tr>
<td>Alarm restoration</td>
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<tr>
<td>Trouble signal</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>Trouble restoration</td>
<td>☐</td>
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<tr>
<td>Supervisory signal</td>
<td>☐</td>
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<tr>
<td>Supervisory restoration</td>
<td>☐</td>
<td>☐</td>
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</tr>
</tbody>
</table>
8. NOTIFICATIONS THAT TESTING IS COMPLETE

<table>
<thead>
<tr>
<th></th>
<th>Contact</th>
<th>Time:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitoring organization</td>
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<td></td>
</tr>
<tr>
<td>Building management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Building occupants</td>
<td></td>
<td></td>
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<tr>
<td>Authority having jurisdiction</td>
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<td></td>
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<tr>
<td>Other, if required</td>
<td></td>
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</tr>
</tbody>
</table>

9. SYSTEM RESTORED TO NORMAL OPERATION

Date: ___________________________  Time: ___________________________

10. CERTIFICATION

10.1 Inspector Certification:

This system, as specified herein, has been inspected and tested according to all NFPA standards cited herein.

Signed: ___________________________  Printed name: ___________________________  Date: ___________________________

Organization: ___________________________  Title: ___________________________  Phone: ___________________________

10.2 Acceptance by Owner or Owner’s Representative:

The undersigned has a service contract for this system in effect as of the date shown below.

Signed: ___________________________  Printed name: ___________________________  Date: ___________________________

Organization: ___________________________  Title: ___________________________  Phone: ___________________________
### DEVICE TEST RESULTS

(Attach additional sheets if required)

<table>
<thead>
<tr>
<th>Device Type</th>
<th>Address</th>
<th>Location</th>
<th>Test Results</th>
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<tbody>
<tr>
<td></td>
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</tbody>
</table>
• Installation, inspection, and testing of the system in accordance with the system design and installation documents
• Documentation of the as-built installation as well as the inspection and testing
• Final approval of the system installation and testing

The fire alarm system record of completion is the focal point for the documentation of the system design, installation, testing, and approval. This document requires verification and documentation of items such as the types of system or service, record of system installation and operation, and information on signaling line circuits, alarm-initiating and supervisory devices and circuits, alarm notification appliances and circuits, and system power supplies. The record of completion also requires documentation of the inspection and testing of the fire alarm system through the attachment of the completed inspection and testing form.

In addition, the project specification may require other components to be installed, such as sleeving and packing of wall or floor penetrations, signage, and so on. Verification of the installation can be made and adequacy of these components or other equipment and components can be verified by an installation report or a supplement to the fire alarm system record of completion. The training and documentation recommendations in Part One of NFPA 3, Chapter 1 should be followed for proper documentation of the commissioning activities for the system.
This chapter, which opens with an overview of standpipe and hose systems, is intended to assist the registered design professional (RDP), commissioning agent, authority having jurisdiction (AHJ), and the installing contractor in the proper commissioning of these systems. Included here is information needed for the submission of plans and calculations during the permitting process and for inspections and tests required to verify system performance. Also provided is information the RDP, commissioning agent, and/or the AHJ can use to develop the system-specific commissioning requirements, methods, and procedures for a project specification.

OVERVIEW

Standpipe and Hose Systems Defined

A standpipe system is intended to eliminate the need for excessively long runs of hose for manual fire fighting. With a standpipe system installed in a building, the fire fighter can connect hose to a permanently installed valve on the standpipe system and, with not more than 100 to 200 ft (35.5 m to 61 m) of hose, can fight a fire anywhere on a given floor. Standpipe systems are divided into classes to identify their specific function. Those classifications are as follows:

- **Class I.** Intended for fire department use only. This type of system is equipped with a 2½ in. (65 mm) angle valve for hose attachment. The system is not provided with hose; the fire department will use their own hose (see Exhibit 3.1).
- **Class II.** Previously intended for building occupant use only. NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, now restricts this type of system for use by trained industrial fire brigades.
  
  The Class II system is usually equipped with 1½ in. (65 mm) hose in varying lengths of 50 to 150 ft (50 m to 45.7 m) and is designed to discharge water at a rate of 50 gpm (189 L/m) per hose rack at a pressure of 65 psi (4.5 bar).
- **Class III.** A combination of Class I and Class II. This type of system is usually equipped with a 2½ in. (65 mm) angle valve for fire department use and a 1½ in. (40 mm) hose rack assembly for industrial fire brigade use, although a 2½ in. (65 mm) hose valve with a 2½ in. × 1½ in. (40 mm) reducer and a 1½ in. (40 mm) cap and chain can, by definition in NFPA 14, be used to satisfy the Class III standpipe system requirement. It is important to note that many building codes will require the installation of a Class III standpipe system. Such a requirement can be met without the installation of a hose rack assembly (see Exhibit 3.2).
Owner Requirements

Although there are no specific owner requirements contained in NFPA 14, to be consistent with the concept of fire protection systems commissioning, the building owner should provide the RDP with the general information discussed in the basis of design (BOD). Similarly, since many modern standpipe system installations are “combined” systems, the same owner information required by NFPA 13, Standard for the Installation of Sprinkler Systems, applies to standpipe systems (see Exhibits 3.3 and 3.4).

Contractor Requirements

The contractor will be legally bound to comply with the provisions of the contract, which should include, as a minimum, compliance with plans and specifications and with NFPA 14.

PLANS AND CALCULATIONS

Plans

NFPA 14 does not consider the use of preliminary plans. Preliminary plans, discussed in Part I of this handbook, are usually submitted by the RDP when he or she applies for a building permit. The plan requirements contained in NFPA 14 are intended to be working plans and should be prepared in sufficient detail as described in NFPA 13, with the particulars necessary for standpipe systems included as described below.
EXHIBIT 3.2 Class III Standpipe System

EXHIBIT 3.3 Acceptable Piping Arrangement for Combined Sprinkler/Standpipe System

Source: NFPA 14, 2010, Figure A.7.10.1.3.1(a).

Program for Individual Systems
Plans accurately showing the details and arrangement of the standpipe system shall be furnished to the authority having jurisdiction prior to the installation of the system.

[NFPA 14-10: 8.1.1] Plans shall be clear, legible, and drawn to scale. [NFPA 14-10: 8.1.2] The drawings shall show the location, arrangement, water supply, equipment, and all other details necessary to establish compliance with this standard. [NFPA 14-10: 8.1.3]

The plans shall include specifications covering the character of materials used and shall describe all system components. [NFPA 14-10: 8.1.4] The plans shall include an elevation diagram, and the vertical elevation of each floor shall be indicated. [NFPA 14-10: 8.1.5]

**Hydraulic Calculations**

Standpipe system calculations should be prepared in a format similar to that of sprinkler systems. Standpipe calculations are intended to verify that the proper flow and pressure are available at the hose valve outlet. Calculations for all standpipes are mandated by NFPA 14.

The following information should be included on all hydraulic calculation submittals:

- Standpipe system piping should be sized by hydraulic calculations.
- A complete set of calculations should be submitted with the plans.
- Hydraulic calculations should be prepared on form sheets that include a summary sheet, detailed worksheets, and a graph sheet.
- The summary sheet should contain the following information, where applicable:
  1. Date
  2. Location
  3. Name of owner and occupant
  4. Building number or other identification
  5. Description of hazard
  6. Name and address of contractor or designer
  7. Name of approving agency

![Combined Sprinkler/Standpipe System](EXHIBIT 3.4)
8. System design requirements, including the number of standpipes flowing and the minimum rate of water application gpm/ft² (mm/min)
9. Total water requirements as calculated, including allowance for inside hose, outside hydrants, and sprinklers for buildings with partial sprinkler protection

- Detailed worksheets or computer printout sheets should contain the following information:
  1. Sheet number
  2. Hose connection description and discharge constant (K)
  3. Hydraulic reference points
  4. Flow in gpm (L/min)
  5. Pipe size
  6. Pipe lengths, center-to-center of fittings
  7. Equivalent pipe lengths for fittings and devices
  8. Friction loss in psi/ft (bar/m) of pipe
  9. Total friction loss between reference points
  10. Devices such as alarm valves, dry-pipe valves, deluge valves, strainers, pressure-regulating devices, backflow preventers
  11. Elevation head in psi (bar) between reference points
  12. Required pressure in psi (bar) at each reference point
  13. Velocity pressure and normal pressure if included in calculations
  14. Notes to indicate starting points or reference to other sheets or to clarify data shown

- A graphic representation of the complete hydraulic calculation should be plotted on semi-exponential graph paper (Q₁₀,₈₅) and should include the following:
  1. Water supply curve
  2. Standpipe system demand
  3. Hose demand (where applicable)
  4. Partial sprinkler demand (where applicable)

### APPROVAL AND ACCEPTANCE

**General**

Any concealed pipe should be pressure tested prior to concealment. Leaks discovered after concealment can be very costly to repair. NFPA 14 addresses this concern in Chapter 11 of the standard by recommending the pressure test before pipe is concealed.

Where standpipe connections are built into the walls or partitions, the hydrostatic tests should be made before they are covered or permanently sealed. [NFPA 14-10: A.11.1.1]

All new systems shall be tested prior to the occupancy of the building. [NFPA 14-10: 11.1.1]

Ordinarily, the AHJ will not issue an occupancy permit until all fire systems have been tested and accepted.

Existing standpipe systems that are to be utilized as standpipes for a combination system in the retrofit of a new sprinkler system shall be tested in accordance with NFPA 14-2010 Section 11.4. [NFPA 14-10: 11.1.2]

The installing contractor shall complete and sign the appropriate contractor’s material and test certificate(s) as shown in Figure 11.1.3(a) [Exhibit 3.5] and Figure 11.1.3(b) [Exhibit 3.6]. [NFPA 14-10: 11.1.1]
**CONTRACTOR’S MATERIAL AND TEST CERTIFICATE FOR ABOVEGROUND PIPING**

**Standpipe System NFPA 14**

**PROCEDURE**

Upon completion of work, inspection and tests shall be made by the contractor’s representative and witnessed by an owner’s representative. All defects shall be corrected and the system left in service before the contractor’s personnel finally leave the job.

A certificate shall be filled out and signed by both representatives. Copies shall be prepared for approving authorities, owners, and contractor. It is understood that the owner’s representative’s signature in no way prejudices any claim against the contractor for faulty material, poor workmanship, or failure to comply with the approving authority’s requirements or local ordinances.

<table>
<thead>
<tr>
<th>Property name</th>
<th>Date</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Plans</th>
<th>Accepted by approving authorities (names)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Address</td>
</tr>
<tr>
<td></td>
<td>Installation conforms to accepted plans?</td>
</tr>
<tr>
<td></td>
<td>Equipment used is approved or listed?</td>
</tr>
<tr>
<td></td>
<td>If no, explain deviations.</td>
</tr>
</tbody>
</table>

<table>
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<td></td>
<td>Automatic wet</td>
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<td></td>
<td>Semiautomatic dry</td>
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<td>Manual dry</td>
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<td>Manual wet</td>
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<tr>
<td></td>
<td>Combination standpipe/sprinkler</td>
<td>Yes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Water Supply Data Used for Design and As Shown on Plans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire pump data</td>
</tr>
<tr>
<td>Manufacturer</td>
</tr>
<tr>
<td>Type:</td>
</tr>
<tr>
<td>Rated, gpm</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Water Supply Source Capacity, Gallons</th>
<th>Static, psi</th>
<th>Residual, psi</th>
<th>Flow, gpm</th>
</tr>
</thead>
<tbody>
<tr>
<td>q Public waterworks system</td>
<td>q Storage tank</td>
<td>q Gravity tank</td>
<td>q Open reservoir</td>
</tr>
<tr>
<td>q Other (explain)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>If Public Waterworks System:</th>
</tr>
</thead>
<tbody>
<tr>
<td>System components instructions</td>
</tr>
<tr>
<td>Copy of accepted plans</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Supplies Building(s)</th>
<th>Main waterflow shutoff location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of standpipe risers</td>
<td>Do all standpipe risers have base of riser shutoff valves?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Valve Supervision</th>
<th>Locked open</th>
<th>Sealed and tagged</th>
<th>Tamperproof switch</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>If other, explain:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pipe and Fittings</th>
<th>Type of pipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of fittings</td>
<td></td>
</tr>
</tbody>
</table>

| Hose Threads | Hose threads have been verified for compliance with local fire department | Yes | No |

<table>
<thead>
<tr>
<th>Backflow Preventor</th>
<th>Double check assembly</th>
<th>Size</th>
<th>Make and model</th>
</tr>
</thead>
</table>

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NFPA 14 (p. 1 of 3)
### Exhibit 3.5 Continued

#### Control Valve Device

<table>
<thead>
<tr>
<th>Type</th>
<th>Size</th>
<th>Make</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time to trip through remote hose valve</th>
<th>Water pressure</th>
<th>Air pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min Sec</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time water reached remote hose valve outlet</th>
<th>Trip point air pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min Sec</td>
<td>psi</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Alarm operated properly?</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time water reached remote hose valve outlet</th>
<th>Hydraulic activation</th>
<th>Electric activation</th>
<th>Pneumatic activation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min Sec</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Make and model of activation device</th>
<th>Each activation device tested?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
</tr>
</tbody>
</table>

### Pressure-Regulating Device

<table>
<thead>
<tr>
<th>Location &amp; Floor</th>
<th>Model</th>
<th>Nonflowing (psi)</th>
<th>Flowing (psi)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Inlet</td>
<td>Outlet</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>All hose valves on system operated properly?</th>
<th>Yes</th>
<th>No</th>
<th>If no, explain.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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### Hydrostatic Tests

- Hydrostatic tests shall be made at not less than 200 psi (13.6 bar) for 2 hours or 50 psi (3.4 bar) above static pressure in excess of 150 psi (10.2 bar) for 2 hours. Differential dry pipe valve clappers shall be left open during test to prevent damage. All aboveground piping leakage shall be stopped.

### Pneumatic Tests

- Establish 40 psi (2.7 bar) air pressure and measure drop, which shall not exceed $1\frac{1}{2}$ psi (0.1 bar) in 24 hours.

- Test pressure tanks at normal water level and air pressure and measure air pressure drop, which shall not exceed $1\frac{1}{2}$ psi (0.1 bar) in 24 hours.

### Flow Tests

- Flow water from the hydraulically most remote standpipe outlet(s).

- Pitot pressure: _____ psi ( _____ bar) Total flow: _____ gpm ( _____ L/min)

- Note: The minimum flow should be 500 gpm (1893 L/min) at 100 psi (6.9 bar) residual pressure for Class I or Class III systems and 100 gpm (379 L/min) at 65 psi (4.5 bar) for Class II systems.
### CONTRACTOR’S MATERIAL AND TEST CERTIFICATE FOR UNDERGROUND PIPING

#### PROCEDURE

Upon completion of work, inspection and tests shall be made by the contractor’s representative and witnessed by an owner’s representative. All defects shall be corrected and the system left in service before the contractor’s personnel finally leave the job.

A certificate shall be filled out and signed by both representatives. Copies shall be prepared for approving authorities, owners, and contractor.

It is understood that the owner’s representative’s signature in no way prejudices any claim against the contractor for faulty material, poor workmanship, or failure to comply with the approving authority’s requirements or local ordinances.

<table>
<thead>
<tr>
<th>Property name</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plans</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Accepted by approving authorities (names)</td>
<td></td>
</tr>
<tr>
<td>Address</td>
<td></td>
</tr>
<tr>
<td>Installation conforms to accepted plans?</td>
<td>[ ] Yes [ ] No</td>
</tr>
<tr>
<td>Equipment used is approved?</td>
<td>[ ] Yes [ ] No</td>
</tr>
<tr>
<td>If no, state deviations.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Instructions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Has person in charge of fire equipment been instructed as to the location of control valves and care and maintenance of this new equipment?</td>
<td>[ ] Yes [ ] No</td>
</tr>
<tr>
<td>If no, explain.</td>
<td></td>
</tr>
<tr>
<td>Have copies of appropriate instructions and care and maintenance charts been left on premises?</td>
<td>[ ] Yes [ ] No</td>
</tr>
<tr>
<td>If no, explain.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Location</th>
<th>Supplies buildings</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Underground Pipes and Joints</th>
<th>Type joint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe conforms to _________ standard</td>
<td>[ ] Yes [ ] No</td>
</tr>
<tr>
<td>Fittings conform to _________ standard</td>
<td>[ ] Yes [ ] No</td>
</tr>
<tr>
<td>If no, explain.</td>
<td></td>
</tr>
</tbody>
</table>

| Joints needing anchorage clamped, strapped, or blocked in accordance with _________ standard | [ ] Yes [ ] No |
| If no, explain. |   |

<table>
<thead>
<tr>
<th>Test Description</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flushing:</strong> Flow the required rate until water is clear, as indicated by no collection of foreign material in burlap bags at outlets such as hydrants and blow-offs. Flush at flows not less than 390 gpm (1476 L/min) for 4 in. (100 mm) pipe, 880 gpm (3331 L/min) for 6 in. (150 mm) pipe, 1560 gpm (5905 L/min) for 8 in. (200 mm) pipe, 2440 gpm (9235 L/min) for 10 in. (250 mm) pipe, and 3520 gpm (13,323 L/min) for 12 in. (300 mm) pipe. When supply cannot produce stipulated flow rates, obtain maximum available.</td>
<td></td>
</tr>
<tr>
<td><strong>Hydrostatic:</strong> Hydrostatic tests shall be made at not less than 200 psi (13.8 bar) for 2 hours or 50 psi (3.4 bar) above static pressure in excess of 150 psi (10.3 bar) for 2 hours.</td>
<td></td>
</tr>
<tr>
<td><strong>Leakage:</strong> New pipe laid with rubber gasketed joints shall, if the workmanship is satisfactory, have little or no leakage at the joints. The amount of leakage at the joints shall not exceed 2 q/hr (1.89 L/hr) per 100 joints, irrespective of pipe diameter. The leakage shall be distributed over all joints. If such leakage occurs at a few joints, the installation shall be considered unsatisfactory and necessary repairs made. The amount of allowable leakage specified above can be increased by 1 fl oz per in. valve diameter per hr (30 mL/25 mm/hr) for each metal seated valve isolating the test section. If dry barrel hydrants are tested with the main valve open, so that the hydrants are under pressure, an additional 5 oz/min (150 mL/min) leakage is permitted for each hydrant.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flushing Tests</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>New underground piping system flushed according to _________ standard by (company)</td>
<td>[ ] Yes [ ] No</td>
</tr>
<tr>
<td>If no, explain.</td>
<td></td>
</tr>
<tr>
<td>How flushing flow was obtained</td>
<td></td>
</tr>
<tr>
<td>[ ] Public water [ ] Tank or reservoir [ ] Fire pump</td>
<td>Through what type of opening</td>
</tr>
<tr>
<td>[ ] Fire pump</td>
<td>Through what type of opening</td>
</tr>
<tr>
<td>How flushing tests were obtained</td>
<td></td>
</tr>
<tr>
<td>[ ] Y conn. to flange &amp; spigot [ ] Open pipe</td>
<td></td>
</tr>
</tbody>
</table>

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### EXHIBIT 3.6  Continued

<table>
<thead>
<tr>
<th>Test</th>
<th>Description</th>
<th>Joints covered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrostatic Test</td>
<td>All new underground piping hydrostatically tested at __________________ psi for _________ hours</td>
<td>❑ Yes ❑ No</td>
</tr>
<tr>
<td>Leakeae Test</td>
<td>Total amount of leakage measured ___________________________________________</td>
<td></td>
</tr>
<tr>
<td></td>
<td>__________ gal __________ hours</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Allowable leakage __________________________________________________________</td>
<td></td>
</tr>
<tr>
<td></td>
<td>__________ gal __________ hours</td>
<td></td>
</tr>
<tr>
<td>Hydrants</td>
<td>Number installed ___________________________________________________________</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type and make</td>
<td>All operate satisfactorily ❑ Yes ❑ No</td>
</tr>
<tr>
<td>Control Valves</td>
<td>Water control valves left wide open? If no, explain. ________________________</td>
<td>❑ Yes ❑ No</td>
</tr>
<tr>
<td></td>
<td>Hose threads of fire department connections and hydrants interchangeable with those of fire department answering alarm</td>
<td>❑ Yes ❑ No</td>
</tr>
<tr>
<td>Remarks</td>
<td>Date left in service ______________________________________________________</td>
<td></td>
</tr>
<tr>
<td>Name of installing contractor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tests Witnessed By</td>
<td>For property owner (signed) ________________ Title __________ Date __________</td>
<td></td>
</tr>
<tr>
<td></td>
<td>For installing contractor (signed) ________________ Title __________ Date __________</td>
<td></td>
</tr>
</tbody>
</table>

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Inspections and Action Items

In addition to acceptance testing, approval and acceptance involve a number of inspections or action items that must be documented on the contractor’s material and test certificate for standpipe systems or other project closeout documentation. These items are as follows:

- Documentation of fire pump data
- Documentation of other water supply source
- Location of control valves
- Number of standpipe risers and riser isolation valves
- Method of valve supervision
- Verification of pipe and fitting type
- Backflow preventer type and size
- Verification of test blank removal (if applicable)
- Welding certification (if applicable)
- Posting of hydraulic data nameplate
- Project closeout submittals, such as system component maintenance instructions, general system care and maintenance instructions, and a copy of NFPA 25, Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems
- Valve identification (installation of valve signs)
- Verification of flushing of underground supply piping

These items can be verified and documented on the contractor’s material and test certificate for standpipe systems, but training of operations personnel and submission of as-built plans and operation and maintenance manuals (O&M) should be completed in much more detail.

Acceptance Testing Activities

Acceptance testing involves a number of activities that must be performed, witnessed, and documented. These activities are as follows:

- Functional test of the system alarm device
- Trip test and water transit time for dry systems
- Trip test for semiautomatic systems
- Pressure regulating device test (if present)
- Hydrostatic test
- Main drain test

The completion of these tests can be documented on the contractor’s material and test certificate for standpipe systems.

Flushing of Piping

The underground main must be flushed to remove obstructive material such as dirt or rocks before aboveground piping is attached. A copy of the contractor’s material and test certificate for underground piping should be obtained prior to commencing work on aboveground piping. This test form verifies pressure, flushing, and flow tests and verifies that the underground piping system is complete.

Underground piping supplying the system shall be flushed in accordance with NFPA 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances. [NFPA 14-10: 11.2.1]

Piping between the fire department connection and the check valve in the inlet pipe shall be flushed with a sufficient volume of water in order to remove any construction debris and trash accumulated in the piping prior to the completion of the system and prior to the installation of the fire department connection. [NFPA 14-10: 11.2.2]
Hose Thread Testing

All hose connection and fire department connection threads shall be tested to verify their compatibility with threads used by the local fire department. [NFPA 14-10: 11.3.1]

The test shall consist of threading coupling samples, caps, or plugs onto the installed devices. [NFPA 14-10: 11.3.2]

Hydrostatic Tests

Testing Pressure

A hydrostatic test is a pressure test to reveal the presence of leaks in the piping system. For fire protection systems, the piping is pressurized to 200 psi (13.8 bar) for a period of 2 hours. During this time period, the system piping is inspected for leaks. Leaks in the piping system are revealed either by observation of water droplets or by a reduction in test pressure. Any leaks or reduction in test pressure necessitates a repair of the pipe joint involved and a retest to verify that the leak has been repaired. In cases where high pressure exists, the standard requires that the test pressure be 50 psi (3.5 bar) in excess of the normal system pressure if the resultant test pressure will be greater than 200 psi (13.8 bar).

In the case of underground piping, a certain amount of leakage is permitted due to the type of valves and fittings permitted. During the hydrostatic test of underground piping, a slight pressure loss should be anticipated. The system should be pressurized such that this slight pressure loss does not permit the test pressure to drop below the specified 200 psi (13.8 bar). Following the 2-hour test period, the pressure loss should be simulated by opening a small drain valve installed for the test and draining the water into a calibrated container. The water volume should be measured and compared to the values permitted by NFPA 13, Standard for the Installation of Sprinkler Systems. If the amount of water drained from the system is less than that permitted, the test can be considered to be acceptable.

All systems, including yard piping and fire department connections, shall be tested hydrostatically at not less than 200 psi (13.8 bar) of pressure for 2 hours, or at 50 psi (3.5 bar) in excess of the maximum pressure where the maximum pressure is in excess of 150 psi (10.3 bar). [NFPA 14-10: 11.4.1]

The hydrostatic test pressure shall be measured at the low elevation point of the individual system or zone being tested. [NFPA 14-10: 11.4.2]

An air pressure leakage test at 40 psi (2.8 bar) shall be conducted for 24 hours. [NFPA 14-10: 11.4.5.1]

Any leakage that results in a loss of pressure in excess of 1½ psi (0.1 bar) during a continuous 24-hour period shall be corrected. [NFPA 14-10: 11.4.5.2]

Air Testing

It is important to note here that this interim air test is permitted only where there is concern for freezing. When possible, a hydrostatic test using water must be completed. An air test can be difficult to pass, since the acceptance criterion is a pressure variation of not more than 1.5 psi in a 24-hour period. With an air test, temperature fluctuations can cause a pressure variation of more than 1.5 psi in many cases. As a result, careful consideration should be given to conducting an air test, which may require substantial time to complete.

Where cold weather prevents testing with water, an interim air test shall be permitted to be conducted prior to the standard hydrostatic test. [NFPA 14-10: 11.4.5]

Piping Testing

The standpipe system piping shall show no leakage other than as permitted by NFPA 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances. [NFPA 14-10: 11.4.3]
Underground pipe shall be tested in accordance with NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*. [NFPA 1410: 11.4.4]

Piping between the fire department connection and the check valve in the inlet pipe shall be tested hydrostatically in the same manner as the balance of the system. [NFPA 14-10: 11.4.6]

Where an existing standpipe system, including yard piping and fire department connection, is modified, the new piping shall be independently tested in accordance with 11.4.1. [NFPA 14-10: 11.4.7.1]

During testing, care shall be taken to ensure that no portion of the piping is subject to freezing during cold weather. [NFPA 14-10: 11.4.8]

During the hydrostatic test, the pressure gauge at the top of each standpipe shall be observed and the pressure recorded. [NFPA 14-10: 11.4.9]

### Additives or Chemicals

Additives, corrosive chemicals such as sodium silicate or derivatives of sodium silicate, brine, or other chemicals shall not be used while hydrostatically testing systems or for stopping leaks. [NFPA 14-10: 11.4.10]

### System Operational Test

#### Flow Test

The flow test is intended to verify the system design. The test is completed by flowing 500 gpm at 100 psi (1892 L/min at 6.9 bar) at the most hydraulically demanding riser plus an additional 250 gpm (946 L/min) for each additional riser simultaneously. The total flow needed is 1250 gpm (4731 L/min) for buildings that are not completely sprinklered or 1000 gpm (3785 L/min) for buildings that are protected throughout with an automatic sprinkler system.

The standpipe system shall be tested to verify system demand. [NFPA 14-10: 11.5.1]

This test shall be conducted by flowing water simultaneously from the outlet(s) indicated in the approved hydraulic calculations of each standpipe as required by Sections 7.8 and 7.10 of NFPA 14 2010. [NFPA 14-10: 11.5.1.1]

A manual system is connected to a water supply that is intended to keep the system full of only water. The needed flow and pressure for a manual system is provided by the fire department through the fire department connection. Therefore, a fire department pumper or portable pump is needed to achieve the required pressure for this test.

### Testing Devices

Pressure-regulating devices must be tested to verify that the pressure setting is correct and that each device is installed in the correct location. Pressures are measured for flowing and nonflowing conditions and are recorded on contractor’s material and test certificate. Pressure-regulating devices are available in a variety of configurations. Care must be taken to verify that they are installed correctly, because failure to do so can and has resulted in death or injury to operators. These devices are defined as follows:

**Pressure-Regulating Device:** A device designed for the purpose of reducing, regulating, controlling, or restricting water pressure. Examples include pressure-reducing valves, pressure control valves, and pressure-restricting devices.

**Pressure-Reducing Valve:** A valve designed for the purpose of reducing the downstream water pressure under both flowing (residual) and nonflowing (static) conditions.

**Pressure-Restricting Device:** A valve or device designed for the purpose of reducing the downstream water pressure under flowing (residual) conditions only.

---

*Program for Individual Systems*
Pressure-regulating devices may be field adjustable or factory set. In either case, the valve must be clearly marked for the appropriate set pressure and installed in the correct location. A valve set for lower pressures on higher floors will not function correctly if mistakenly installed on lower floors. It is recommended that set numbers or other identifying features be included on installation drawings and verified during commissioning.

Each alarm and supervisory device provided shall be tested in accordance with NFPA 72, National Fire Alarm Code. [NFPA 14-10: 11.7]

Main Drain Testing

The main drain test is intended to provide a record of static and residual pressures when flowing the 2 in. (50 mm) main drain connection. No measurement of flow is required for this test. The static and residual pressures are recorded on the contractor’s material and test certificate to provide a baseline pressure set for future evaluation. The main drain test must be performed annually on existing systems. The inspector is required to compare future test results with that shown on the contractor’s material and test certificate to reveal any potential issues with the water supply, such as a closed or partially closed water supply control valve or any condition that would affect the water supply to the standpipe system.

The main drain valve shall be opened and shall remain open until the system pressure stabilizes. [NFPA 14-10: 11.5.5.1] The static and residual pressure shall be recorded on the contractor’s test certificate. [NFPA 14-10: 11.5.5.2]

Dry System Testing

Similar to the test required for dry-pipe sprinkler systems, a dry standpipe system must be automatically activated and the water transit time must be recorded on the contractor’s material and test certificate. An automatic dry standpipe system uses a dry-pipe valve, which must be tested to verify that the valve is functioning correctly. A semiautomatic standpipe system uses a deluge valve and normally an electrically operated manual pull station for activation. The deluge valve and manual pull devices must be tested to verify proper function.

Automatic dry and semiautomatic systems shall be tested by initiating a flow of water from the hydraulically most remote hose connection. [NFPA 14-10: 11.5.6.1] The system shall deliver a minimum of 250 gpm (946 L/min) at the hose connection within 3 minutes of opening the hose valve if the system capacity exceeds 750 gal (2480 L). [NFPA 14-10: 11.5.6.2] Each remote control activation device for operating a semiautomatic system shall be tested in accordance with the manufacturer’s specifications and instructions. [NFPA 14-10: 11.5.6.3] In addition the standard hydrostatic test, an air pressure leakage test at 40 psi (2.8 bar) shall be conducted for 24 hours. Any leakage that results in a loss of pressure in excess of ½ psi (0.1 bar) for the 24 hours shall be corrected. [NFPA 13-10: 24.2.2] These tests shall be conducted in addition to all the tests required for automatic and manual systems. [NFPA 14-10: 11.5.6.5] Where pumps are part of the water supply for a standpipe system, testing shall be conducted while the pumps are operating. [NFPA 14-10: 11.5.7]

System Hydraulic Information Sign

The installing contractor shall provide a sign identifying the basis of the system design as either hydraulic calculations or pipe schedule. [NFPA 14-10: 6.8.1]
The sign shall be located at the water supply control valve for automatic or semiautomatic standpipe systems and at an approved location for manual systems. [NFPA 14-10: 6.8.2]

The sign shall indicate the following:

1. Location of the two hydraulically most remote hose connections
2. Design flow rate for the connections identified in 6.8.3(1)
3. Design residual inlet and outlet pressures for the connections identified in 6.8.3(1)
4. Design static pressure and the design system demand (i.e., flow and residual pressure) at the system control valve, or at the pump discharge flange where a pump is installed, and at each fire department connection [NFPA 14-10: 6.8.3]

Exhibit 3.7 provides a sample system hydraulic information sign.

**EXHIBIT 3.7** System Hydraulic Information Sign.

| Location of the two hydraulically most remote hose connections: __________________________ |
| Design flow rate for the connections identified above: ____________ |
| Design residual inlet and outlet pressures for the connections identified above: ______________ |
| Design static pressure and design system demand (i.e., flow and residual pressure) at the system control valve, or at the pump discharge flange where a pump is installed, and at each fire department connection: ______________ |

*Source: NFPA 14, 2010, Figure A.6.7.*

**SUMMARY**

Like all water-based fire protection systems, standpipe systems must undergo a pressure test, an alarm test, and a main drain test during commissioning. Standpipe systems must also be flow tested to verify the system design flow and pressures. In addition to these tests, the verification of pressure-regulating devices — that is, their location and static and residual pressures — is critical to the safety of the system user and system components. All of these tests must be conducted and documented accurately to ensure proper operation of the system.

In many cases, standpipe system commissioning can be conducted simultaneously with that of a sprinkler system because many combined systems are installed. The documentation and general test procedures are consistent with those of other water-based fire protection systems.
Commissioning of fire pumps is much more involved than commissioning of most other systems and must be completed correctly to verify operation of this critical equipment. This chapter provides information to assist the registered design professional (RDP), the commissioning agent, the authority having jurisdiction (AHJ), and the installing contractor in the proper commissioning of water supplies for water-based fire protection systems. It includes information needed for the submission of plans and calculations during the permitting process and for inspections and tests required to verify system performance. The RDP, commissioning agent, and/or AHJ can use this information to develop the system-specific commissioning requirements, methods, and procedures for a project specification.

FIRE PUMP OVERVIEW

Fire Pump Unit Defined

A fire pump is a device that provides the required water flow and pressure for a fire protection system. The fire pump unit itself consists of a pump, a drive, a driver coupling connecting the two, and a base plate. Fire pumps are normally purchased as a complete package that includes the following:

- **Pump accessories (electric drive):** Including automatic air release valve, pressure gauges (suction and discharge), circulation relief valve, and hose header complete with hose valves for outdoor use or flow meter
- **Fire pump controller with remote pump panel:** Including power transfer switch (where required)
- **Pump accessories (diesel drive):** Including automatic air release, pressure gauges (suction and discharge), fuel tank with support legs, fuel system connections, hose header complete with hose valves for outdoor use or flow meter, main relief valve, and waste cone (open or closed)
- **Pressure maintenance pump:** Including casing relief valve
- **Pressure maintenance pump controller**

Fire Pump Unit Responsibility

The fire pump unit, consisting of a pump, driver, and controller, shall perform in compliance with this standard as an entire unit when installed or when components have been replaced. [NFPA 20-10: 4.4.1]

A single entity should be designated as having unit responsibility for the pump, driver, controller, transfer switch equipment, and accessories. *Unit responsibility* means the accountability to answer and resolve any and all problems regarding
the proper installation, compatibility, performance, and acceptance of the equipment. Unit responsibility should not be construed to mean purchase of all components from a single supplier. [NFPA 20-10: A.4.4.1]

The registered design professional (RDP) or commissioning agent may play a significant role regarding unit responsibility. In addition to the minimum requirements of the standard, fire pumps should be subject to additional inspections in the manufacturer’s fabrication shop and particularly in the field.

The complete fire pump unit shall be field acceptance tested for proper performance in accordance with the provisions of this standard. [NFPA 20-10: 4.4.2]

A fire pump is a complex piece of equipment and often requires an entire day for acceptance testing. Pre-functional testing and inspections should be conducted to ensure that the individual components and the system as a complete installation function as intended.

APPROVAL AND ACCEPTANCE

Approval Requirements

A complete plan and detailed data describing pump, driver, controller, power supply, fittings, suction and discharge connections, and liquid supply conditions shall be prepared for approval. [NFPA 20-10: 4.2.3]

Each pump, driver, controlling equipment, power supply and arrangement, and liquid supply shall be approved by the authority having jurisdiction for the specific field conditions encountered. [NFPA 20-10: 4.2.4]

Certified shop test curves showing head capacity and brake horsepower of the pump shall be furnished by the manufacturer to the purchaser. [NFPA 20-10: 4.5.1]

The certified shop test is performed when the fire pump and driver are assembled at the manufacturing facility. On some projects, the commissioning agent may wish to witness the shop test. In such cases, the test should be coordinated with the purchaser and the commissioning agent. The certified shop test curve must be submitted for review prior to the field acceptance test.

The purchaser shall furnish the data required in 4.5.1 to the authority having jurisdiction. [NFPA 20-10: 4.5.2]

Upon completion of the entire fire pump installation, an acceptance test shall be conducted in accordance with the provisions of this standard. [NFPA 20-10: 4.32]

Most building codes will require plans and calculations to be submitted when applying for a building permit or a permit to install fire protection systems. On every project, plans should be submitted for review and approval before installation begins. Installing any system or equipment prior to approval can expose the installer to expensive field modifications if the plan review reveals the need for modifications to the proposed system.

Product data or equipment catalog cuts should be included as part of the submittal process. This submittal should include details of each piece of equipment associated with the proposed fire pump installation.

Flushing

Flushing the suction line is intended to remove any debris that may enter the pump and damage the pump impeller.
Suction piping shall be flushed at a flow rate not less than indicated in Table 14.1.1.1(a) [Exhibit 4.1] and Table 14.1.1.1(b) [Exhibit 4.2] of NFPA 14(2010) or at the hydraulically calculated water demand rate of the system, whichever is greater. [NFPA 20-10: 14.1.1.1]

Flushing shall occur prior to hydrostatic test. [NFPA 20-10: 14.1.1.2]

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**EXHIBIT 4.1** Flow Rates for Stationary Pumps

<table>
<thead>
<tr>
<th>Metric Units</th>
<th>U.S. Customary Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pipe Size (mm)</td>
<td>Flow Rate (L/min)</td>
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<tr>
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<tr>
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<td>20,023</td>
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</tbody>
</table>

*Source: NFPA 20, 2010, Table 14.1.1.1(a).*

**EXHIBIT 4.2** Flush Rates for Positive Displacement Pumps

<table>
<thead>
<tr>
<th>Metric Units</th>
<th>U.S. Customary Units</th>
</tr>
</thead>
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<tr>
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<td>1,703.25</td>
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<tr>
<td>150</td>
<td>1,892.5</td>
</tr>
</tbody>
</table>

*Source: NFPA 20, 2010, Table 14.1.1.1(b).*

**Hydrostatic Test**

The flushing and hydrostatic tests are identical to the tests required for all water-based fire protection systems.

**Testing Pressure**

All new systems are required to be tested hydrostatically at a minimum pressure of either 200 psi (13.8 bar), or 50 psi (3.4 bar) above the maximum discharge pressure, whichever is greater, at the fire pump discharge flange. Verification that the proper pressure rating for pipe and fittings is used in the installation is important. This value is set to ensure that all pipe joints and other equipment are installed properly to withstand that pressure without coming apart or leaking. Although the test is primarily a quality control test on
the installation and not a materials performance test, damaged materials (e.g., cracked fittings, leaky valves, bad joints, etc.) are routinely discovered during the hydrostatic test.

Suction and discharge piping shall be hydrostatically tested at not less than 200 psi (13.8 bar) pressure or at 50 psi (3.4 bar) in excess of the maximum pressure to be maintained in the system, whichever is greater. [NFPA 20-10: 14.1.2.1]

The pressure required in NFPA 20 (2010) 14.1.2.1 shall be maintained for 2 hours. [NFPA 20-10: 14.1.2.2]

Contractor’s Certificate

The installing contractor shall furnish a certificate for flushing and hydrostatic test prior to the start of the fire pump field acceptance test. [NFPA 20-10: 14.1.2.2]

The certificate referred to in 14.1.3 of NFPA 20 is the contractor’s material and test certificate in NFPA 13. Both flushing and hydrostatic tests must be documented and witnessed by the AHJ, the RDP, and/or the commissioning agent. The completed certificate should be included in the turnover package at the end of the project.

Field Acceptance Tests

Pumps and drivers on separately coupled-type pumps shall be aligned in accordance with the coupling and pump manufacturers’ specifications and the Hydraulic Institute Standards for Centrifugal, Rotary and Reciprocating. [NFPA 20-10: 6.5.2]

A pump and driver shipped from the factory with both machines mounted on a common base plate are accurately aligned before shipment. All base plates are flexible to some extent and, therefore, should not be relied upon to maintain the factory alignment. Realignment is necessary after the complete unit has been leveled on the foundation and again after the grout has set and foundation bolts have been tightened. The alignment should be checked after the unit is piped and rechecked periodically. To facilitate accurate field alignment, most manufacturers either do not dowel the pumps or drivers on the base plates before shipment or, at most, dowel the pump only.

After the pump and driver unit has been placed on the foundation, the coupling halves should be disconnected. The coupling should not be reconnected until the alignment operations have been completed.

The purpose of the flexible coupling is to compensate for temperature changes and to permit end movement of the shafts without interference with each other while transmitting power from the driver to the pump.

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

(1) Angular misalignment — shafts with axes concentric but not parallel
(2) Parallel misalignment — shafts with axes parallel but not concentric

The faces of the coupling halves should be spaced within the manufacturer’s recommendations and far enough apart so that they cannot strike each other when the driver rotor is moved hard over toward the pump. Due allowance should be made for wear of the thrust bearings. The necessary tools for an approximate check of the alignment of a flexible coupling are a straight edge and a taper gauge or a set of feeler gauges.

A check for angular alignment is made by inserting the taper gauge or feelers at four points between the coupling faces and comparing the distance between the faces at four points spaced at 90-degree intervals around the coupling. The unit will be in angular alignment when the measurements show that the coupling faces are the same distance apart at all points.
A check for parallel alignment is made by placing a straight edge across both coupling rims at the top, bottom, and both sides. The unit will be in parallel alignment when the straight edge rests evenly on the coupling rim at all positions.

Allowance might be necessary for temperature changes and for coupling halves that are not of the same outside diameter. Care should be taken to have the straight edge parallel to the axes of the shafts.

Angular and parallel misalignment are corrected by means of shims under the motor mounting feet. After each change, it is necessary to recheck the alignment of the coupling halves. Adjustment in one direction can disturb adjustments already made in another direction. It should not be necessary to adjust the shims under the pump.

The permissible amount of misalignment will vary with the type of pump, driver, and coupling manufacturer, model, and size.

The best method for putting the coupling halves in final accurate alignment is by the use of a dial indicator.

When the alignment is correct, the foundation bolts should be tightened evenly but not too firmly. The unit can then be grouted to the foundation. The base plate should be completely filled with grout, and it is desirable to grout the leveling pieces, shims, or wedges in place. Foundation bolts should not be fully tightened until the grout has hardened, usually about 48 hours after pouring.

After the grout has set and the foundation bolts have been properly tightened, the unit should be checked for parallel and angular alignment and, if necessary, corrective measures taken. After the piping of the unit has been connected, the alignment should be checked again.

The direction of driver rotation should be checked to make certain that it matches that of the pump. The corresponding direction of rotation of the pump is indicated by a direction arrow on the pump casing.

The coupling halves can then be reconnected. With the pump properly primed, the unit should be operated under normal operating conditions until temperatures have stabilized. It then should be shut down and immediately checked again for alignment of the coupling. All alignment checks should be made with the coupling halves disconnected and again after they are reconnected.

After the unit has been in operation for about 10 hours or 3 months, the coupling halves should be given a final check for misalignment caused by pipe or temperature strains. If the alignment is correct, both pump and driver should be dowelled to the base plate. Dowel location is very important, and the manufacturer’s instructions should be followed, especially if the unit is subject to temperature changes.

The unit should be checked periodically for alignment. If the unit does not stay in line after being properly installed, the following are possible causes:

1. Settling, seasoning, or springing of the foundation and pipe strains distorting or shifting the machine
2. Wearing of the bearings
3. Springing of the base plate by heat from an adjacent steam pipe or from a steam turbine
4. Shifting of the building structure due to variable loading or other causes
5. If the unit and foundation are new, need for the alignment to be slightly readjusted from time to time [NFPA 20-10: A.6.5]

Prior to operating the pump a number of inspections and mechanical adjustments should be made. Coupling alignment verification is a required commissioning activity and should be documented in the commissioning report. Also prior to operation of the pump, the pump shaft bearings (Exhibit 4.3) should be lubricated with the lubricant recommended by the pump manufacturer. Packing gland adjustment should also be completed at this
time (Exhibit 4.4); one drop of water per second is appropriate when the pump is not operating, and a steady trickle of water is needed when the pump is operating.

**Test Participants**

The manufacturer’s representative for each major component of the fire pump installation must be present to perform the field acceptance test. The AHJ, including the fire code official, RDP, and/or the commissioning agent must be present to witness the acceptance test and sign the test forms as a witness.
The pump manufacturer, the engine manufacturer (when supplied), the controller manufacturer, and the transfer switch manufacturer (when supplied) or their factory authorized representatives shall be present for the field acceptance test. [NFPA 20-10: 14.2.1]

All the authorities having jurisdiction shall be notified as to the time and place of the field acceptance test. [NFPA 20-10: 14.2.2]

Electrical Equipment Testing

The fire pump controller is an electrical device; its operation must be verified by a qualified electrical contractor prior to testing. The pre-acceptance testing can include starting and operating the pump and the pressure maintenance pump and performing other control-related activities, including operating time, alarms, and so on.

All electric wiring to the fire pump motor(s), including control (multiple pumps) interwiring, normal power supply, alternate power supply where provided, and jockey pump, shall be completed and checked by the electrical contractor prior to the initial startup and acceptance test. [NFPA 20-10: 14.2.3]

Performance Results

In addition to verifying proper operation of the pump and pump system components, the most important purpose of the fire pump acceptance test is to re-verify the manufacturer’s shop test curve. The field acceptance test should illustrate the same performance of the pump following installation as that observed during the shop test. Therefore, it is critical to have the shop test results available for the field acceptance test.

A properly plotted fire pump curve will illustrate at least three points:

1. **Churn**: The pump is operating with no flow.
2. **Rated capacity**: The pump is discharging water at the specified pressure.
3. **Overload**: The pump is discharging water at a rate of 150 percent of rated flow at a pressure of 65 percent of rated pressure.

A copy of the manufacturer’s certified pump test characteristic curve shall be available for comparison of the results of the field acceptance test. [NFPA 20-10: 14.2.4.1]

The fire pump as installed shall equal the performance as indicated on the manufacturer’s certified shop test characteristic curve within the accuracy limits of the test equipment. [NFPA 20-10: 14.2.4.2]

The fire pump shall perform at minimum, rated, and peak loads without objectionable overheating of any component. [NFPA 20-10: 14.2.5.2.1]

Test Procedures

Initial operation of a fire pump may involve adjustments of the equipment and accessories. The pump operation should be carefully observed for vibration, leaks, packing gland adjustment, and so on. Following the acceptance test, the equipment will normally be left in the operating position. Final adjustments must be made at this time.

Note that the pressure maintenance pump (or jockey pump) is a low-flow pump installed to maintain system pressure to avoid intermittent starting of the fire pump. The pressure maintenance pump should have sufficient flow to compensate for any leaks in the system piping but not enough flow to maintain system pressure in the event of the discharge of a single sprinkler. The churn pressure is the pressure produced at the outlet of the pump when the pump is running with no water flow occurring in the fire protection system.

The fire pump operation is as follows:

1. **Motor-Driven Pump.** To start a motor-driven pump, the following steps should be taken in the following order:
(a) See that pump is completely primed.
(b) Close isolating switch and then close circuit breaker.
(c) Automatic controller will start pump if system demand is not satisfied (e.g., pressure low, deluge tripped).
(d) For manual operation, activate switch, push-button, or manual start handle. Circuit breaker tripping mechanism should be set so that it will not operate when current in circuit is excessively large.

(2) **Steam-Driven Pump.** A steam turbine driving a fire pump should always be kept warmed up to permit instant operation at full-rated speed. The automatic starting of the turbine should not be dependent on any manual valve operation or period of low-speed operation. If the pop safety valve on the casing blows, steam should be shut off and the exhaust piping examined for a possible closed valve or an obstructed portion of piping. Steam turbines are provided with governors to maintain speed at a predetermined point, with some adjustment for higher or lower speeds. Desired speeds below this range can be obtained by throttling the main throttle valve.

(3) **Diesel Engine–Driven Pump.** To start a diesel engine–driven pump, the operator should be familiar beforehand with the operation of this type of equipment. The instruction books issued by the engine and control manufacturer should be studied to this end. The storage batteries should always be maintained in good order to ensure prompt, satisfactory operation of this equipment (i.e., check electrolyte level and specific gravity, inspect cable conditions, corrosion, etc.).

(4) **Fire Pump Settings.** The fire pump system, when started by pressure drop, should be arranged as follows:

(a) The jockey pump stop point should equal the pump churn pressure plus the minimum static supply pressure.
(b) The jockey pump start point should be at least 10 psi (0.68 bar) less than the jockey pump stop point.
(c) The fire pump start point should be 5 psi (0.34 bar) less than the jockey pump start point. Use 10 psi (0.68 bar) increments for each additional pump.
(d) Where minimum run times are provided, the pump will continue to operate after attaining these pressures. The final pressures should not exceed the pressure rating of the system.
(e) Where the operating differential of pressure switches does not permit these settings, the settings should be as close as equipment will permit. The settings should be established by pressures observed on test gauges.
(f) Examples of fire pump settings follow (for SI units, 1 psi = 0.0689 bar):
   
i. Pump: 1000 gpm, 100 psi pump with churn pressure of 115 psi
   1. Suction supply: 50 psi from city — minimum static; 60 psi from city — maximum static
   iii. Jockey pump stop = 115 psi + 50 psi = 165 psi
   iv. Jockey pump start = 165 psi − 10 psi = 155 psi
   v. Fire pump stop = 115 psi + 50 psi = 165 psi
   vi. Fire pump start = 155 psi − 5 psi = 150 psi
   vii. Fire pump maximum churn = 115 psi + 60 psi = 175 psi

(g) Where minimum-run timers are provided, the pumps will continue to operate at churn pressure beyond the stop setting. The final pressures should not exceed the pressure rating of the system components.

(5) **Automatic Recorder.** The performance of all fire pumps should be automatically indicated on a pressure recorder to provide a record of pump operation and assistance in fire loss investigation. [NFPA 20-10: A.14.2.5]
Test Equipment

The installing contractor usually performs the flow test portion of the acceptance test and provides the test equipment. It is important to verify that the test equipment is properly calibrated and that a spare set of equipment is available in the event of failure of any piece of test equipment. Doing so will avoid costly delays should any piece of equipment fail during the test.

Calibrated test equipment shall be provided to determine net pump pressures, rate of flow through the pump, volts and amperes for electric motor–driven pumps, and speed. [NFPA 20-10: 14.2.5.1.1]

The test equipment should be furnished by either the authority having jurisdiction or the installing contractor or the pump manufacturer, depending upon the prevailing arrangements made between the aforementioned parties. The equipment should include, but not necessarily be limited to, the following:

1. **Equipment for Use with Test Valve Header.** 50 ft (15 m) lengths of 2½ in. (65 mm) lined hose should be provided including Underwriters Laboratories’ play pipe nozzles as needed to flow required volume of water. Where a test meter is provided, however, these might not be needed.

2. **Instrumentation.** The following test instruments should be of high quality, accurate, and in good repair:
   - (a) Clamp-on volt/ammeter
   - (b) Test gauges
   - (c) Tachometer
   - (d) Pitot tube with gauge (for use with hose and nozzle)

3. **Instrumentation Calibration.** All test instrumentation should be calibrated by an approved testing and calibration facility within the 12 months prior to the test. Calibration documentation should be available for review by the authority having jurisdiction.

A majority of the test equipment used for acceptance and annual testing has never been calibrated. This equipment can have errors of 15 to 30 percent in readings. The use of uncalibrated test equipment can lead to inaccurately reported test results.

While it is desirable to achieve a true churn condition (no flow) during the test for comparison to the manufacturer’s certified pump test characteristic curve, it might not be possible in all circumstances. Pumps with circulation relief valves will discharge a small amount of water, even when no water is flowing into the fire protection system. The small discharge through the circulation relief valve should not be shut off during the test since it is necessary to keep the pump from overheating. For pumps with circulation relief valves, the minimum flow condition in the test is expected to be the situation where no water is flowing to the fire protection system but a small flow is present through the circulation relief valve. During a test on a pump with a pressure relief valve, the pressure relief valve should not open because these valves are installed purely as a safety precaution to prevent overpressurization during overspeed conditions.

Overspeed conditions should not be present during the test, so the pressure relief valve should not open. When pressure relief valves are installed on systems to relieve pressure under normal operating conditions, and if a true churn condition is desired during the acceptance test, the system discharge valve can be closed and the pressure relief valve can be adjusted to eliminate the flow. The pressure readings can be quickly noted and the pressure relief valve adjusted again to allow flow and relief of pressure. After this one-time test, a reference net pressure can be noted with the
relief valve open so that the relief valve can remain open during subsequent annual tests with the comparison back to the reference residual net pressure rather than the manufacturer’s curve. [NFPA 20-10: A.14.2.5.1]

Flow Tests
The field acceptance test is intended to verify that the pump is operating in accordance with the specified pump output. During the flow test, pump output pressure and flows are measured and then plotted on hydraulic graph paper. Field acceptance test results are compared to certified shop test curves.

Determining Loads
The minimum, rated, and peak loads refer to the amount of water flow that the pump will allow. The more water that is flowing, the more work the pump is performing; therefore, less pressure is available. The pump must produce not less than 65 percent of rated pressure when flowing water at a rate of 150 percent of rated flow.

The minimum, rated, and peak loads of the fire pump shall be determined by controlling the quantity of water discharged through approved test devices. [NFPA 20-10: 14.2.5.2.3]

Where a hose valve header is used, it should be located where a limited [approximately 100 ft (30 m)] amount of hose is used to discharge water safely. Where a flow test meter is used in a closed loop according to manufacturer’s instructions, additional outlets such as hydrants, hose valves, and so forth should be available to determine the accuracy of the metering device. [NFPA 20-10: A.14.2.5.2.3]

Measurement Procedure
While water is flowing and being measured, the pressure gauges on the pump are read and the suction and discharge pressures are recorded. This information is then used to plot the performance curve.

Water flow can be determined in a number of ways. One method uses a pitot tube to measure velocity pressure. Velocity pressure can then be used to calculate flow using the following formula:

\[ Q = 29.83cd^2\sqrt{P} \]

Where:
- \( Q \) = flow (gpm)
- \( C \) = coefficient of the flowing orifice
- \( d \) = diameter of flowing orifice squared
- \( P \) = velocity pressure measured by the pitot tube

A flow table derived from this formula can be used for convenience. Other devices that have a built-in pitot tube can be used for determining flow. Such devices may improve the accuracy of the readings taken and are much easier to use.

The quantity of water discharging from the fire pump assembly shall be determined and stabilized. [NFPA 20-10: 14.2.5.4.1]

Immediately thereafter, the operating conditions of the fire pump and driver shall be measured. [NFPA 20-10: 14.2.5.4.2]

Engine-Driven Units
Engine-driven units shall not show signs of overload or stress. [NFPA 20-10: 14.2.5.4.7.2]

The governor of such units shall be set at the time of the test to properly regulate the engine speed at rated pump speed. [NFPA 20-10: 14.2.5.4.7.3]
In fire pump systems, the governor is a device used to limit or control the speed of the diesel engine.

**Other Tests**

Acceptance testing involves more than a flow test of the pump unit. Acceptance must also include an evaluation of the pump installation as a whole under a variety of conditions.

**Loads Start Test**

The fire pump unit shall be started and brought up to rated speed without interruption under the conditions of a discharge equal to peak load. [NFPA 20-10: 14.2.5.5]

**Phase Reversal Test**

For electric motors, a test shall be performed to ensure that there is not a phase reversal condition in either the normal power supply configuration or from the alternate power supply (where provided). [NFPA 20-10: 14.2.5.6]

A simulated test of the phase reversal device is an acceptable test method. [NFPA 20-10: A.14.2.5.6]

**Controller Acceptance Test**

In addition to fire pump operation, the controller performs a number of alarm functions, which must also be verified during the acceptance test.

Fire pump controllers shall be tested in accordance with the manufacturer’s recommended test procedure. [NFPA 20-10: 14.2.6.1]

All controller starts required for tests described in 14.2.5 through 14.2.8 should accrue respectively to this number of tests. [NFPA 20-10: A.14.2.6.1]

As a minimum, no fewer than six automatic and six manual operations shall be performed during the acceptance test. [NFPA 20-10: 14.2.6.2]

An electric driven fire pump shall be operated for a period of at least 5 minutes at full speed during each of the operations required in 14.2.5. [NFPA 20-10: 14.2.6.3]

An engine driver shall not be required to run for 5 minutes at full speed between successive starts until the cumulative cranking time of successive starts reaches 45 seconds. [NFPA 20-10: 14.2.6.4]

The automatic operation sequence of the controller shall start the pump from all provided starting features. [NFPA 20-10: 14.2.6.5]

This sequence shall include pressure switches or remote starting signals. [NFPA 20-10: 14.2.6.6]

Tests of engine-driven controllers shall be divided between both sets of batteries. [NFPA 20-10: 14.2.6.7]

The selection, size, and setting of all overcurrent protective devices, including fire pump controller circuit breaker, shall be confirmed to be in accordance with this standard. [NFPA 20-10: 14.2.6.8]

The fire pump shall be started once from each power service and run for a minimum of 5 minutes.

CAUTION: Manual emergency operation shall be accomplished by manual actuation of the emergency handle to the fully latched position in a continuous motion. The handle shall be latched for the duration of this test run. [NFPA 20-10: 14.2.6.9]

**Alternate Power Supply**

If the alternate source is a generator, the acceptance test for the generator must be performed in accordance with NFPA 110.
On installations with an alternate source of power and an automatic transfer switch, loss of primary source shall be simulated and transfer shall occur while the pump is operating at peak load. [NFPA 20-10: 14.2.7.1]

Transfer from normal to alternate source and retransfer from alternate to normal source shall not cause opening of overcurrent protection devices in either line. [NFPA 20-10: 14.2.7.2]

At least half of the manual and automatic operations of 14.2.6.2 shall be performed with the fire pump connected to the alternate source. [NFPA 20-10: 14.2.7.3]

If the alternate power source is a generator set required by 9.3.2, installation acceptance shall be in accordance with NFPA 110, _Standard for Emergency and Standby Power Systems_. [NFPA 20-10: 14.2.7.4]

**SUMMARY**

Water supplies are a critical component of a fire protection system. As such, the water supply must be commissioned to verify that it will operate when needed. Fire pumps typically require several different tests, some electrical and some mechanical, to verify that the pump will perform as designed and that water delivered to the sprinkler and standpipe systems will be of sufficient flow and pressure.
Provided in this chapter is information intended to assist the registered design professional (RDP), the commissioning agent, the authority having jurisdiction (AHJ), and the installing contractor in the proper commissioning of smoke-control systems. It presents information needed for the development of the basis of design (BOD), for the submission of plans and calculations during the permitting process, and for inspections and tests required to verify system performance. The RDP, commissioning agent, and/or AHJ can use this information to develop the system-specific commissioning requirements, methods, and procedures for a project specification.

OVERVIEW

General*

Smoke will readily travel beyond the compartment of fire origin due to several factors, including:

- Stack effect — the vertical airflow within a building caused by pressure differences between the building interior and exterior
- Temperature effect of the fire — the energy (buoyancy) of the heated smoke, which causes it to move
- Weather conditions — wind direction and velocity as well as temperature conditions
- Mechanical air-handling systems

These factors create pressure differences across barriers (e.g., walls, doors, floors) that result in the spread of smoke. The primary means of controlling smoke movement is by developing pressure differences across these barriers that overcome the energy of the smoke and confine the smoke to the compartment of origin. The basic principle is to develop higher pressures in the areas of the building (zones) adjacent to the compartment of fire origin, thereby confining the smoke to the zone of fire origin. In Exhibit 5.1, smoke zones are indicated by a minus sign, and pressurized spaces are indicated by a plus sign. Each floor can be a smoke-control zone, as in (a) and (b), or a smoke zone can consist of more than one floor, as in (c) and (d). All of the non-smoke zones in a building could be pressurized, as in

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(a) and (c), or only nonsmoke zones adjacent to the smoke zone could be pressurized, as in (b) and (d). A smoke zone can also be limited to part of a floor, as in (e).

The tightness (completeness) of the construction is a significant issue in the effectiveness of a smoke-control system. Openings around penetrations or poor construction may permit excessive leakage so that adequate pressure differences cannot be established.

Airflow (air velocity) can also be used to confine smoke movement through an opening. This method can be used to control the movement of smoke through an open doorway. Because relatively large quantities of air are required to prevent smoke movement through an opening, this method is not the most practical.

Smoke-control systems are designed to limit the flow of smoke into the means of egress and to confine smoke to one area of the building. Limiting the size of the fire and therefore the amount of smoke production by the installation of automatic sprinklers is generally considered necessary for effective and economical smoke control. The activation of sprinklers cools the atmosphere and takes energy from the smoke, thereby reducing its ability to move. Other protection techniques may be appropriate in different, specific situations.

Where a smoke-control system is provided, it should be activated early in the fire development to limit smoke spread. Smoke-control systems are intended to control the migration of smoke, and it should not be assumed that such systems will get rid of all of the smoke in a compartment. The smoke-control system should be coordinated with the other fire safety systems in the building to provide a unified fire safety system for the building.

Smoke-Control System Defined

A smoke-control system can be defined as an engineered system that uses mechanical fans to produce pressure differences across smoke barriers to inhibit smoke movement. A smoke-control system is used to achieve one or more of the following design objectives:

- Inhibit smoke from entering stairwells, means of egress, areas of refuge, elevator shafts, or similar areas
- Maintain a tenable environment in areas of refuge and means of egress during the time required for evacuation
- Inhibit the migration of smoke from the smoke zone
- Provide conditions outside the fire zone that enable emergency response personnel to conduct search-and-rescue operations and to locate and control the fire
- Contribute to the protection of life and to the reduction of property loss

The document used for the design of smoke-control systems is NFPA 92, *Standard for Smoke-Control Systems*. It is important that the RDP and owner establish the desired performance characteristics for these systems in the basis of the design documentation described in Part I. This information must be clearly defined in the basis of design in order to allow meaningful acceptance tests to be performed.

Quality Assurance for Smoke-Control Systems Scope

Scope

The commissioning concepts discussed in this book can be used to meet the requirements for a quality assurance program for smoke-control systems. *NFPA 5000®, Building Construction and Safety Code®,* establishes minimum requirements for a quality assurance program and further requires performance testing of these systems. The test procedures outlined in NFPA 92 should be used to comply with these requirements.

A quality assurance program for the installation and operation of smoke control systems shall be prepared by the RDP responsible for design. [NFPA 5000-12: 40.6.1]

Special tests and inspection of smoke control systems shall include testing during erection and prior to concealment of ductwork for the purposes of identifying leakage and recording the actuating device location. [NFPA 5000-12: 40.6.1.1]

Prior to occupancy and after substantial completion, pressure difference testing, flow measurements, and detection and control verification shall be performed. [NFPA 5000-12: 40.6.1.2]

Qualifications

Testing and inspection agents for smoke control systems shall have expertise in fire protection engineering and mechanical engineering and shall be certified as air balancers. [NFPA 5000-12: 40.6.2]

DESIGN PARAMETERS

The design parameters should be outlined in the basis of a design document. In addition to the owner and RDP, the approving authority should be involved in the development of the basis of design for input related to system performance and acceptance testing.

Design Objectives

The methods for accomplishing smoke control shall include one or more of the following:

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(1) The containment of smoke to the zone of origin by establishment and maintenance of pressure differences across smoke zone boundaries
(2) The management of smoke within a large-volume space and any unseparated spaces that communicate with the large-volume space [NFPA 92-12: 4.1.1]

The specific objectives to be achieved over the design interval time shall include one or more of the following:

(1) Containing the smoke to the zone of fire origin
(2) Maintaining a tenable environment within exit stairwells for the time necessary to allow occupants to exit the building
(3) Maintaining a tenable environment within all exit access and smoke refuge area access paths for the time necessary to allow occupants to reach an exit or smoke refuge area
(4) Maintaining the smoke layer interface to a predetermined elevation in large volume spaces [NFPA 92-12: 4.1.1]

Design Basis

A smoke control system in a given building designed to contain smoke to a given zone or keep smoke from entering another zone. [NFPA 92-12: 4.2.1]

A smoke control system in a given building designed to contain smoke to a given zone or keep smoke from entering another zone. [NFPA 92-12: 4.2.1.1]

The performance objective of automatic sprinklers installed in accordance with NFPA 13, Standard for the Installation of Sprinkler Systems, is to provide fire control, which is defined as follows: limiting the size of a fire by distribution of water so as to decrease the heat release rate and pre-wet adjacent combustibles while controlling ceiling gas temperatures to avoid structural damage. A limited number of investigations have been undertaken involving full-scale fire tests in which the sprinkler system was challenged but provided the expected level of performance (Madrykowski and Vettori [29]; Lougheed, Mawhinney, and O’Neill [26]). These investigations indicate that, for a fire control situation, although the heat release rate is limited, smoke can continue to be produced. However, the temperature of the smoke is reduced, and the pressure differences provided in this document for smoke control systems in fully sprinklered buildings are conservative. In addition, with the reduced smoke temperatures, the temperature requirement for smoke control components in contact with exhaust gases can be limited. [NFPA 92-12: 4.2.3.1]

The temperature ratings for the equipment used for smoke control systems shall be based on the expected temperature experienced by the equipment while the equipment is intended to be operational. [NFPA 92-12: A.4.2.1]

Temperature ratings shall be based on the following:

(1) Proximity to the fire
(2) Effects of dilution of the smoke and hot gases by entrained air [NFPA 92-12: 4.2.3.2]

Design Approaches

The design approach for smoke containment systems shall be one of or a combination of the following:

(1) Stairwell pressurization
(2) Zoned pressurization
(3) Elevator pressurization
(4) Vestibule pressurization
(5) Smoke refuge area pressurization [NFPA 92-12: 4.3.1]
Tenability

Where the design of the smoke control system is based on the potential for occupants being exposed to smoke, the tenability conditions shall be assessed. [NFPA 92-12: 4.5.1.1]

Egress Analysis

Where the design of the smoke control system is based on occupants exiting a space before being exposed to smoke or before tenability thresholds are reached, there shall be sufficient time for the movement of the occupant as determined by a timed egress analysis. [NFPA 92-12: 4.5.1.2]

Design Considerations

Designs shall incorporate the effect of openings and leakage areas in smoke barriers on the performance of the smoke-control system. [NFPA 92-12: 4.4.4.3]

In the design of smoke-control systems, airflow paths must be identified and evaluated. Some leakage paths are obvious, such as gaps around closed doors, open doors, elevator doors, windows, and air transfer grilles. Construction cracks in building walls and floors are less obvious but no less important. The flow area of most large openings can be calculated easily. The flow area of construction cracks is dependent on workmanship — for example, how well a door is fitted or how well weather stripping is installed. Typical leakage areas of construction cracks in walls and floors of commercial buildings are listed in NFPA 92 (2012) Table A.4.4.4.3 [Exhibit 5.2]. Doors open for short periods of time result in a transition condition that is necessary in order to provide egress from or access to the smoke zone. [NFPA 92-12: A.4.6.1]

Designs shall incorporate the effect of outdoor temperature and wind on the performance of systems. [NFPA 92-12: 4.4.1]

The temperature differences between the exterior and the interior of the building cause stack effect and determine the stack effect’s direction and magnitude. The stack effect must be considered when selecting exhaust fans. The effect of temperature and wind velocity varies with building height, configuration, leakage, and openings in wall and floor construction. One source of weather data is the ASHRAE Handbook of Fundamentals, Chapter 26, Climatic Design Information. It is suggested that the 99.6 percent heating dry bulb (DB) temperature and the 0.4 percent cooling DB temperature be used as the winter and summer design conditions, respectively. It is also suggested that the 1 percent extreme wind velocity be used as the design condition. If available, more site-specific wind data should be consulted. [NFPA 92-12: A.4.4.1]

Except as specified by 4.4.2.1.2, the pressure differences in NFPA 92 (2012) Table 4.4.2.1.1 [Exhibit 5.3] shall be used for designs that are based on maintaining minimum pressure differences between specified spaces. [NFPA 92-12: 4.4.2.1.1]

Where the system designer has determined that a higher minimum pressure difference is necessary to achieve the smoke control system objectives, the higher minimum pressure difference shall be used. [NFPA 92-12: 4.4.2.1.2]

The minimum allowable pressure difference shall restrict smoke leakage during building evacuation to a level that maintains a tenable environment in areas outside the smoke zone. [NFPA 92-12: 4.4.2.1.3]

The minimum pressure difference for smoke control systems shall be established at a level that is high enough that it will not be overcome by the forces of wind, stack effect, or buoyancy of hot smoke. [NFPA 92-12: 4.4.2.14]

The calculations shall take into account the design number of doors to be opened simultaneously. [NFPA 92-12: 4.4.2.1.4]
### EXHIBIT 5.2
Typical Leakage Areas for Walls and Floors of Commercial Buildings.

<table>
<thead>
<tr>
<th>Construction Element</th>
<th>Tightness</th>
<th>Area Ratio $^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exterior building walls (includes construction cracks and cracks around windows and doors)</td>
<td>Tight $^b$</td>
<td>$0.50 \times 10^{-4}$</td>
</tr>
<tr>
<td></td>
<td>Average $^b$</td>
<td>$0.17 \times 10^{-3}$</td>
</tr>
<tr>
<td></td>
<td>Loose $^b$</td>
<td>$0.35 \times 10^{-3}$</td>
</tr>
<tr>
<td></td>
<td>Very loose $^b$</td>
<td>$0.12 \times 10^{-2}$</td>
</tr>
<tr>
<td>Stairwell walls (includes construction cracks, but not cracks around windows and doors)</td>
<td>Tight $^c$</td>
<td>$0.14 \times 10^{-4}$</td>
</tr>
<tr>
<td></td>
<td>Average $^c$</td>
<td>$0.11 \times 10^{-3}$</td>
</tr>
<tr>
<td></td>
<td>Loose $^c$</td>
<td>$0.35 \times 10^{-3}$</td>
</tr>
<tr>
<td>Elevator shaft walls (includes construction cracks, but not cracks and gaps around doors)</td>
<td>Tight $^c$</td>
<td>$0.18 \times 10^{-3}$</td>
</tr>
<tr>
<td></td>
<td>Average $^c$</td>
<td>$0.84 \times 10^{-3}$</td>
</tr>
<tr>
<td></td>
<td>Loose $^c$</td>
<td>$0.18 \times 10^{-2}$</td>
</tr>
<tr>
<td>Floors (includes construction cracks and gaps around penetrations)</td>
<td>Tight $^d$</td>
<td>$0.66 \times 10^{-4}$</td>
</tr>
<tr>
<td></td>
<td>Average $^e$</td>
<td>$0.52 \times 10^{-4}$</td>
</tr>
<tr>
<td></td>
<td>Loose $^d$</td>
<td>$0.17 \times 10^{-3}$</td>
</tr>
</tbody>
</table>

$^a$ For a wall, the area ratio is the area of the leakage through the wall divided by the total wall area. For a floor, the area ratio is the area of the leakage through the floor divided by the total area of the floor.

$^b$ Values based on measurements of Tamura and Shaw (1976), Tamura and Wilson (1966) and Shaw, Reardon, and Cheung (1993).

$^c$ Values based on measurements of Tamura and Wilson (1966), and Tamura and Shaw (1976).

$^d$ Values extrapolated from average floor tightness based on range of tightness of other construction elements.

$^e$ Values based on measurements of Tamura and Shaw (1978).

DOCUMENTATION

The testing documentation and owner’s manuals and instructions should be kept on file for the intended service life of the system.

Documentation Required

The following documents shall be generated by the designer during the design process:

1. Detailed design report
2. Operations and maintenance manual [NFPA 92-12: 7.1]

Detailed Design Report

The detailed design report shall provide documentation of the smoke control system as it is designed and intended to be installed. [NFPA 92-12: 7.2.1] The design report shall include the following elements, if applicable:

1. System purpose
2. System design objectives
3. Design approach
4. Design assumptions (building height, ambient conditions, reliance on other fire protection systems, leakage, etc.)
5. Location of smoke zone(s)
6. Design pressure differences
7. Building use limitations that arise out of the system design

EXHIBIT 5.3 Suggested Minimum Design Pressure Differences Across Smoke Barriers

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Ceiling Height (ft)</th>
<th>Design Pressure Difference* (in. w.g.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS</td>
<td>Any</td>
<td>0.05</td>
</tr>
<tr>
<td>NS</td>
<td>9</td>
<td>0.10</td>
</tr>
<tr>
<td>NS</td>
<td>15</td>
<td>0.14</td>
</tr>
<tr>
<td>NS</td>
<td>21</td>
<td>0.18</td>
</tr>
</tbody>
</table>

For SI units, 1 ft = 0.305 m; 0.1 in. w.g. = 25 Pa.
AS: Sprinklered. NS: Nonsprinklered.

Notes:
(1) The table presents minimum design pressure differences developed for a gas temperature of 1700°F (925°C) next to the smoke barrier.
(2) For design purposes, a smoke-control system shall maintain these minimum pressure differences under specified design conditions of stack effect or wind.
(3) For zoned smoke-control systems, the pressure difference shall be measured between the smoke zone and adjacent spaces while the affected areas are in the smoke-control mode.

Source: NFPA 92, 2012, Table 5.2.1.1.
(8) Design calculations  
(9) Fan and duct specifications  
(10) Damper specifications  
(11) Detailed inlet or exhaust inlets site information  
(12) Detailed method of activation  
(13) Smoke control system operation logic  
(14) System commissioning procedures [NFPA 92-12: 7.2.2]

**Operations and Maintenance Manual**

The operations and maintenance manual shall provide the requirements to ensure the proper operation of the system over the life of the building. [NFPA 92-12: 7.3]

The operations and maintenance manual shall include the following:

1. The procedures used in the initial commissioning of the system as well as the measured performance of the system at the time of commissioning  
2. The testing and inspection requirements for the system and system components and the required frequency of testing (see NFPA 92, Chapter 8)  
3. The critical design assumptions used in the design and limitations on the building and its use that arise out of the design assumptions and limitations  
4. The purpose of the smoke control system [NFPA 92-12: 7.3.1]

Copies of the operations and maintenance manual shall be provided to the owner and the authorities having jurisdiction. [NFPA 92-12:7.3.2]

The building owner shall be responsible for all system testing and shall maintain records of all periodic testing and maintenance in accordance with the operations and maintenance manual. [NFPA 92-12: 7.3.3]

The building owner shall be responsible for limiting the use of the space in a manner consistent with the limitations provided in the operations and maintenance manual. [NFPA 92-12: 7.3.4]

**TESTING PROCEDURES**

**General**

Some smoke control systems are designed to limit smoke migration at the boundaries of a smoke control area using pressure differences. A stairwell pressurization system is used to limit smoke movement from the floor area into the stairwell and thus provide a tenable environment during egress. For zoned smoke control, pressure differences are used to contain smoke within the smoke zone and limit the migration of smoke and fire gases to other parts of the building. Testing appropriate to the objective of the system consists of measuring the pressure difference between the smoke zone and the adjacent zones. The testing procedures provided in Section 8.4 are based on the measurement of pressure differences and door-opening forces under the design conditions agreed on with the authority having jurisdiction.

An understanding with the authority having jurisdiction on the expected performance of the system and the acceptance test procedures should be established early in the design. (Detailed engineering design information is contained in ASHRAE/SFPE Principles of Smoke Management [21] and the NFPA publication Smoke Movement and Control in High-Rise Buildings [49]).

Absence of a consensus agreement for a testing procedure and acceptance criteria historically has created numerous problems at the time of system acceptance, including delays in obtaining a certificate of occupancy.
It is recommended that the building owner, the designer, and the authority having jurisdiction meet during the planning stage of the project to share their thoughts and objectives concerning the smoke control system and agree on the design criteria and the pass/fail performance tests for the systems. Such an agreement helps to overcome the numerous problems that occur during final acceptance testing and facilitates obtaining the certificate of occupancy. [NFPA 92-12: A.8.1]

Preliminary Building Inspections

Prior to testing, the party responsible for testing shall verify completeness of building construction. [NFPA 92-12: 8.2.1]

The following architectural features, where applicable, shall be inspected:

1. Smoke barriers, including joints therein
2. Shaft integrity
3. Firestopping
4. Doors/closers
5. Glazing, including that enclosing a large-volume space
6. Partitions and ceilings [NFPA 92-12: 8.2.2]

The verification suggested in this section should be in the form of an inspection report or punch list for incomplete installations. The inspection should include each wall or floor penetration to verify that a fire stop, or a rated fire penetration sealing material, has been installed (see Exhibit 5.4). This verification should include a review of the specified materials, the approved product data submittals, and installation plans or sketches.

EXHIBIT 5.4  Pipe Penetration

Source: NFPA 221, 2000, Figure A.6.1.

OPERATIONAL AND ACCEPTANCE TESTING

Operational Testing

The project specifications and basis of design should clearly spell out the objectives of operational testing. Prior to performing any tests, an inspection of the completed system should be made and documented in an inspection report verifying the completeness of
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The inspection report can also include a punch list of incomplete items. The inspection is also an opportunity to revise installation plans to include any field changes, thus allowing the installation plans to be updated to as-built status.

The intent of component system testing is to establish that the final installation complies with the specified design, is functioning properly, and is ready for acceptance testing. Operational testing of system components should be completed during construction. These operational tests normally are performed by various trades before interconnection is made to integrate the overall smoke control system. It should be documented in writing that each individual system component’s installation is complete and the component is functional. Each component test, including items such as speed, volume, sensitivity calibration, voltage, and amperage, should be individually documented. [NFPA 92-12: A.8.3]

An operational test of each smoke control system component and subsystem shall be performed prior to the acceptance test. [NFPA 92-12: 8.3.1]

Operational tests shall be performed prior to interconnection of individual components and subsystems to the smoke control system. [NFPA 92-12: 8.3.2]

Smoke control system operational testing shall include all subsystems to the extent that they affect the operation of the smoke control system. [NFPA 92-12: 8.3.3]

Systems that could affect or be affected by the operation of the smoke control system include the following:

1. Fire alarm system (see NFPA 72®)
2. Energy management system
3. Building management system
4. Heating, ventilating, and air-conditioning (HVAC) equipment
5. Electrical equipment
6. Temperature control system
7. Power sources
8. Standby power
9. Automatic suppression systems
10. Automatic operating doors and closures
11. Other smoke control systems
12. Emergency elevator operation
13. Dampers
14. Fire fighters’ control station (FFCS) [NFPA 92-12: A.8.3.3]

Requirements and responsibilities for each component test shall be identified in the design documentation. [NFPA 92-12: 8.3.4]

All documentation from component system testing relative to the smoke control system shall be included in the final testing documentation. [NFPA 92-12: 8.3.5]

Acceptance Testing

Acceptance testing shall demonstrate that the final integrated system installation complies with the specific design and is functioning properly. [NFPA 92-12: 8.4.1]

Where appropriate to the design, all parameters shall be measured during acceptance testing. [NFPA 92-12: 8.4.2]

The locations for measurement of the parameters identified in 8.4.2 shall be in accordance with nationally recognized methods. [NFPA 92-12: 8.4.3]

The acceptance testing shall include the procedures described in 8.4.4.1 through 8.4.4.4. [NFPA 92-12: 8.4.4]

Prior to beginning acceptance testing, all building equipment shall be placed in the normal operating mode, including equipment that is not used to implement smoke control. [NFPA 92-12: 8.4.4.1]
If standby power has been provided for the operation of the smoke control system, the acceptance testing shall be conducted while on both normal and standby power. [NFPA 92-12: 8.4.4.2]

The acceptance testing shall include demonstrating that the correct outputs are produced for a given input for each control sequence specified. [NFPA 92-12: 8.4.4.3]

The complete smoke control sequence shall be demonstrated for the following:

1. Normal mode
2. Automatic smoke control mode for first alarm
3. Transfer to standby power if provided.
4. Return to normal [NFPA 92-12: 8.4.4.4]

SUMMARY

Commissioning of smoke-control systems must be based on the BOD and the performance of the system described therein. NFPA 92, Standard for Smoke-Control Systems, contains prescriptive measures for the testing of these systems. The procedures outlined in Part I should be followed to establish the BOD and the submission of plans, calculations, and project closeouts.