Fire Sprinkler System Plan Review
Based upon the 2019 Ed. of NFPA 13
Presented by the American Fire Sprinkler Association
www.firesprinkler.org

Instructor
Russell Leavitt, CFPS, SEI
Russ is Executive Chairman of Belgian Holdings, Inc., a graduate of the University of Nevada, Las Vegas, Russ holds a Level IV certification from NICET in Water-based Systems Layout and is a Certified Fire Protection Specialist. He is a licensed contractor with over 39 years of experience, including design, installation, and testing of the protection systems. Russ is member of the NFPA Board of Directors and currently serves as Chair. He is chair of the Technical Committee on Sprinkler System Discharge Criteria and sits on a number of other NFPA Technical Committees including NFPA 13 Installation Technical Committee, and NFPA 75. Russ is a long-time senior instructor for NFPA, and has authored a number of articles and training materials, including NFPA’s FM Inspector Development Program and the online hydraulic calculations series.

rleavitt@belgian.com | P 480-735-4444 | Belgian Holdings, Inc.

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Advisory Information

All NFPA 13 references are to the 2019 edition, including annex and tentative interim amendments (TIA) issued prior to this date.

All page numbers are for the soft-cover edition of NFPA 13.

Learning Objectives

- Interpret and determine compliance of fire sprinkler system plans and hydraulic calculations with applicable codes and standards for design and installation.

- Review coverage area maximums from NFPA 13, and identify sprinkler locations which do not conform, based on $S \times L/A_i$ method.

- Describe items found on plans and/or hydraulic calculations which are not in compliance with requirements, and explain the variances.

Be sure to sign your name on Sign-In Sheet and complete an evaluation form to receive credit for this class.
NFPA 13 Reorganized

1. Administration
2. Referenced Publications
3. Definitions
4. General Requirements
5. Water Supplies
6. Installation Underground Piping
7. Requirements for System Components and Hardware
8. System Types and Requirements
9. Sprinkler Location Requirements
10. Installation Requirements for Standard Pendent, Upright, and Sidewall Spray Sprinklers

NFPA 13 Reorganized

11. Installation Requirements for Extended Coverage Upright, Pendent, Sidewall Spray
12. Installation Requirements for Residential
13. Installation Requirements for CMSA
14. Installation Requirements for Early Suppression Fast-Response Sprinklers
15. Installation Requirements for Special Sprinklers
16. Installation of Piping, Valves, and Appurtenances
17. Installation Requirements for Hanging and Support of System Piping
18. Installation Requirements for Seismic Protection

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19. Design Approaches
20. General Requirements for Storage
21. Protection of High Piled Storage Using Control Mode Density Area (CMDA) Sprinklers
22. CMSA Requirements for Storage Applications
23. ESFR Requirements for Storage Applications
24. Alternative Sprinkler System Designs for Chapters 20 through 25
25. Protection of Rack Storage Using In-Rack Sprinklers
26. Special Occupancy Requirements
27. Plans and Calculations
NFPA 13 Reorganized

28. Systems Acceptance
29. Existing System Modifications
30. Marine Systems
31. System Inspection, Testing, and Maintenance
Annex A Explanatory Material
Annex B Miscellaneous Topics
Annex C Explanation of Test Data and Procedures for Rack Storage
Annex E Development of the Design Approach to Conform with ASCE/SEI 7 and Suggested Conversion Factor Adjustments for Locations Outside the United States

NFPA 13 Reorganized

Annex F Informational References

Confession!
What Are We Looking For?
- Compliance with applicable codes & standards
  - NFPA 13, Fire Sprinkler Systems
  - NFPA 13D, Single Family Residences
  - NFPA 13R, Multi-Family Residences
  - NFPA 14, Standpipes
  - NFPA 20, Fire Pumps
  - Building & Fire Codes (IBC, IFC, IRC, etc.)
  - NFPA 101, Life Safety Code (does it apply?)
  - Local amendments to the above?
- What edition is adopted in your jurisdiction?

What Are We Looking For?
- Information for field inspections
  - How well do you know your inspector?
- Information for stock listing & fabrication
  - Does the stock list see the hydraulics?
- Information detailing code compliance
  - What criteria was used for design and installations?

What Are We Looking For?
- Information for owner/occupant
  - Future tenant improvement, future owner?
- Information on the installing contractor
  - License number?
  - Phone number?
- Information on Authority Having Jurisdiction?
  - Is it really in your district?
NFPA 13 Requirements from Section 27.1.3 (working plans)

- Name of owner/occupant
- Building location & street address
- Point of compass
- Full-height cross section
  - Structural member information
    - Obstructed vs. unobstructed
    - Combustible vs. non-combustible
  - Ceiling construction
  - Roof/ceiling slope

NFPA 13 Requirements from Section 27.1.3 (working plans)

- Obstructed vs. Unobstructed:
  - Definitions in Chapter 3.3.41.2 & 3.3.41.2
    - Not just disruption of water, but trapping of heat to activate sprinklers in a timely manner
  - Sprinkler spacing, coverage & deflector positions...
    - Standard upright & pendant in Table 10.2.4.2.1(a)-(c) and 10.2.6.1, and 10.6.1.2
    - Extended coverage in Table 11.3.3.2.1
    - CMSA = Section 13 inclusive
    - FSFR = Section 14 inclusive

What Are We Looking For?

- Sprinkler location
- Coverage area
  - Storage - 100 ft$^2$ up to 130 ft$^2$, per sprinkler, based on required density of water
  - Maximum spacing 12'-0" or 15'-0", depending on density of water
What Are We Looking For?
- Deflector position
  - Relative to deck above
  - Relative to framing members above
    - Obstructed construction
    - Unobstructed construction

What Are We Looking For?
- Is the construction **combustible**?
  - NFPA 13, Section 3.3.129, and 4.10 Noncombustible:
  - When subjected to heat, the materials:
    - Will not burn
    - Will not ignite
    - Will not support combustion
    - Will not release flammable vapors
  - Reported as passing ASTM E136

What Are We Looking For?
- Is the construction **obstructed**?
- Obstructed vs. Unobstructed:
  - Definitions in chapter 3.3.42 & 3.3.42
  - Not just disruption of water, but trapping of heat to activate sprinklers in a timely manner
What Are We Looking For?

- Obstructed vs. Unobstructed:
  - Sprinkler spacing & deflector positions
  - SSU and SSP in Tables 10.2.4.21(a)-(c)
  - Sections 10.2.6 and 10.2.6.1.2
  - Extended coverage in Table 11.2.2.1.2
  - CMSA – Table 13.2.5.2.1 and 13.2.7.1
  - ESFR – Table 14.2.8.2.1

What Are We Looking For?

- **NFPA 13, Section 3.3.41.1, Obstructed**
  - Framing members impede heat flow
  - Framing members impede water distribution
  - Affects ability of sprinkler to
    - Control a fire
    - Suppress a fire

What Are We Looking For?

Exercise #1 – Construction Type

- **Panel construction - obstructed**
  - Ceiling panels formed by members
    - Trap heat to operate sprinklers
    - Maximum 300 ft² in area
  - Beams > 7”-6” apart may be panel if:
    - Maximum 300 ft² area
Exercise #1 – Construction Type

■ Panel construction - obstructed
  ■ Table 10.2.4.2.1(a)
    ■ Combustible obstructed
    ■ Members greater than 3'-0" on center
  ■ Maximum coverage per sprinkler 168 ft²
  ■ Maximum distance between sprinklers 15'-0"

■ Panel construction - obstructed
  ■ Deflector position, Section 10.2.6.1.2(1)
    ■ Within 1" to 6" below structural framing members
    ■ Maximum depth 22" down from deck
  ■ Section 9.5.4.1.3
    ■ If insulation installed at deck
    ■ Measure to bottom of insulation
Exercise #1 – Construction Type

- Panel construction - obstructed with insulation

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Exercise #1 – Construction Type

- A.3.3.41.1 (6) Wood Joist - obstructed
  - Solid wood members
    - Rectangular cross section
    - 2" to 4" nominal width*
    - Maximum 14" depth*
    - Minimum 3'-0" (36") on center*
    - Maximum span 40'-0"
    - May exceed 14" nominal depth
Exercise #1 - Construction Type

- Wood Joist Construction - obstructed
  - Table 10.2.4.2.1(a)
    - Combustible obstructed
    - Members less than 3'-0" on center
  - Maximum coverage per sprinkler 130 ft²
  - Maximum distance between sprinklers 15'-0"

Exercise #1 - Construction Type

- Wood Joist - obstructed

Exercise #1 - Construction Type

- Wood Joist - obstructed
Why do we care?

- Sprinkler spacing –
  - Table 10.3.3.2.1 – Sidewall
  - Table 11.2.2.1.2 – EC Pendant/Upright
  - Table 11.3.3.2.1 – EC Sidewall
  - Table 13.2.5.2.1 – CMSA
  - Table 14.2.8.2.1 – ESFR
- Note that for ESFR Combustible Obstructed is not permitted

NFPA 13 Requirements from Section 27.1.3 (working plans)

6. Location of partitions
   - Full height?
   - Unflet (down from ceiling)?
   - Pony wall? (30” high)?
   - Openings?

7. Location of firewalls
   - Method of penetration
   - Method sealing penetration
   - Listing number for sealant

NFPA 13 Requirements from Section 27.1.3 (working plans)

8. Occupancy class of each area or room
   - Light, ordinary or extra hazard?
   - Residential?
   - Storage?

9. Location and size of:
   - Concealed spaces
   - Closets
   - Attics
   - Bathrooms

10. Small enclosures where no sprinklers are provided
NFPA 13 Requirements from Section 27.1.3 (working plans)

- **Light Hazard:**
  - Quantity and combustibility are low
  - Low heat release rate, fire can be expected
  - Examples in A.4.3.2 (pg. 332)

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NFPA 13 Requirements from Section 27.1.3 (working plans)

- **Ordinary Hazard (Group 1):**
  - Quantity and combustibility are moderate
  - Moderate heat release rate, fire can be expected
  - Don’t exceed 12’-0” in height
  - Examples in A.4.3.3 (pg. 332-333)

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NFPA 13 Requirements from Section 27.1.3 (working plans)

- **Ordinary Hazard (Group 2):**
  - Quantity and combustibility are moderate to high
  - Moderate to high heat release rate, fire can be expected
  - Don’t exceed 12’-0” in height
  - Examples in A.4.3.4 (pg. 333)
NFPA 13 Requirements from Section 27.1.3 (working plans)

**Extra Hazard (Group 1):**
- Quantity and combustibility are high
- Dust, lint, etc., are present making rapid fire development probable
- High heat release rate fire can be expected
- Examples in A.4.3.5 (pg. 333)

NFPA 13 Requirements from Section 27.1.3 (working plans)

**Extra Hazard (Group 1):**
- Quantity and combustibility are **very** high
- Substantial flammable or combustible liquid
- Shielding of combustibles
- Examples in A.4.3.6 (pg. 333)

NFPA 13 Requirements from Section 27.1.3 (working plans)

11. Size of city main in street:
   - dead-end or circulating
   - direction/distance to nearest circulating main
   - city main test results
   - System elevation relative to test hydrant

12. Other sources of water supply
   - pressure?
   - elevation?
NFPA 13 Requirements from Section 27.1.3 (working plans)

13. Automatic sprinklers:
   - Make
   - Type
   - Model
   - K-factor
   - SIN for sprinklers to be installed

14. Temperature rating and location of:
   - High-temperature sprinklers

NFPA 13 Requirements from Section 27.1.3 (working plans)

15. Total area protected by each system on each floor
   - Maximum areas per 4.5.1:
     - Light, Ordinary Hazard = 52,000 ft²
     - Extra Hazard
       - 23,000 ft² if pipe schedule:
       - 40,000 ft² if hydraulically calculated
     - Storage = 40,000 ft²

16. Number of sprinklers on each riser per floor
   - Designates the number of classes required per 16.2.7.4

17. Total number of sprinklers on each dry pipe system, combined dry pipe-preaction system or deluge system

NFPA 13 Requirements from Section 27.1.3 (working plans)

18. Approximate capacity in gallons of each dry pipe system
   - 500 gallons?  750 gallons?

19. Pipe type and schedule of wall thickness
NFPA 13 Requirements from Section 27.1.3 (working plans)

19. Pipe type and schedule of wall thickness

<table>
<thead>
<tr>
<th>Nominal Size</th>
<th>Threadable</th>
<th>Light Wall</th>
<th>S40</th>
<th>ET</th>
<th>MLT</th>
<th>S10</th>
<th>EF</th>
<th>MFL</th>
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<td>1.083</td>
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</tr>
</tbody>
</table>

Examples of actual pipe ID's

NFPA 13 Requirements from Section 27.1.3 (working plans)

20. Nominal pipe size, cutting length, or center to center dimensions.

21. Location and size of riser nipples

22. Type of fittings and joints, location of welds, note any shop welding, and formations and fittings

NFPA 13 Requirements from Section 27.1.3 (working plans)

23. Type and location of hangers, sleeves, braces, and method of securing sprinklers (if applicable)
NFPA 13 Requirements from Section 27.1.3 (working Plans)

24. All control valves, check valves, drain and test connections

NFPA 13 Requirements from Section 27.1.3 (working plans)

26. Make, type, model and size of alarm or dry pipe valve
27. Make, type, model and size of preaction or deluge valve
28. Kind and location of alarm bells
29. Size and location of standpipe risers, hose outlets, hand hose, monitor nozzles, and related equipment

NFPA 13 Requirements from Section 27.1.3 (working plans)

30. Private fire service main sizes, lengths, locations, weights, materials, point of connection to the city main, sizes types and locations of valves, valve indicators, regulators, meters, and valve pits; the depth of the top of the paid below grade
31. Pipe provision for flushing
NFPA 13 Requirements from Section 27.1.3 (working plans)

32. 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.

33. Information on the hydraulic data nameplate.

34. A graphic representation of the scale used on plans.

NFPA 13 Requirements from Section 27.1.3 (working plans)

35. Name and address of contractor.

36. Hydraulic reference points on plan which correspond to those shown in hydraulic calculations.

37. Minimum rate of water application (density, flow, minimum pressure), design area of application, in-rack sprinkler demand, water required for hose streams (inside & outside).

38. Total quantity of water and the pressure required noted at a common point for each system.

NFPA 13 Requirements from Section 27.1.3 (working plans)

39. Relative location and size of fire protection water supply.

40. If room, identify the location of walls and openings.

41. Calculate size and location of floor and/or wall bracing.
NFPA 13 Requirements from Section 27.1.3 (working plans)

43. Settings for any pressure-reducing valves
44. Information on backflow preventers (if any)
45. 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.

NFPA 13 Requirements from Section 27.1.3 (working plans)

- Size, location and piping to FDCs
- Ceiling/roof height and slopes not shown in the full height cross section
- Edition of NFPA 13 used for design

Water Supply Capacity Information

Information Required by NFPA 13, 4.6.1:
1. Location and elevation of static and residual test gauge with relation to the riser reference point
2. Flow location
3. Static pressure, psi
4. Residual pressure, psi
5. Flow, gpm
6. Date
7. Time
8. Test conducted by or information supplied by
9. Other sources of water supply, with pressure or elevation
Detailed Worksheets
Information Required by NFPA 13 27.4.5.6:

Is the correct internal diameter for the pipe being installed shown in the calculations?

Graph Sheet
Information Required by NFPA 13, 27.4.5.3

Graph Sheet
Information Required by NFPA 13, 27.4.5.3
Pipe Diameters – Correct?

- Does the diameter used in the calculations match the diameter for the material to be installed?

Material data sheets from contractor may be used to verify dimensions of pipe not shown in Table A.16.3.2

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Reviewing Hydraulic Calculations

Hazen-Williams Formula

\[ \frac{P_F}{Q} = \frac{4.52 \times Q^{1.85}}{C^{1.85} \times d^{4.87}} \]

- \( P_F \) = Pressure loss per foot due to friction
- \( Q \) = Flow in gallons per minute
- \( C \) = Roughness factor for internal wall
- \( d \) = Internal diameter of pipe

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Do Minor Differences Matter?

Hazen-Williams Formula – Simplified for Electronic Hand Calculators

\[ 4.52 \times Q^{1.85} \div C^{1.85} \div d^{4.87} \]

Flow of 33 gpm through 20’ of 1” pipe

- **Schedule 40?**
  \[ 4.52 \times 33 \times (X^{1.85}) \div 120 \times (X^{1.85}) \div 1.049 \times (X^{4.87}) = 0.399 \text{ psi per foot} \times 20' = 6.98 \text{ psi} \]

- **Eddy-Thread?**
  \[ 4.52 \times 33 \times (X^{1.85}) \div 120 \times (X^{1.85}) \div 1.083 \times (X^{4.87}) = 0.281 \text{ psi per foot} \times 20' = 5.62 \text{ psi} \]

Almost 1 psi difference in one length of pipe!
S × L = A_s Coverage Area per Sprinkler

Choose the larger of either twice the distance to the wall or the distance to the next sprinkler. This dimension will be defined as L.

Choose the larger of either twice the distance to the wall or the distance to the next branch line. This dimension will be defined as L.

Reviewing Hydraulic Calculations
K-Factor Toolkit

P = \(Q \div K\)-factor\(^2\)

Q = K-factor \(\times \sqrt{P}\)

K-factor = \(Q \div \sqrt{P}\)

\[\sqrt{7.0} = \]
\[\sqrt{7.0} \times 4.2 = \]
\[\sqrt{7.0} 5.6 \times = \]
\[\sqrt{7.0} 8.0 \times = \]
Correct Flow per Sprinkler

\[
\text{Pressure} = (\text{Flow} \div K\text{-factor})^2
\]
If K=5.6, and flow is 12.0 at sprinkler #1, what is the pressure?
\[(12.0 \div 5.6)^2 = 4.59 \text{ psi}\]

Minimum pressure at any flowing sprinkler is 7.0 psi, per NFPA 13 27.2.4.11

I know what I have to look for... NOW what?

I - Verify Jurisdiction

Use street addresses, or Assessor’s parcel numbers to verify you have jurisdiction over the project.

Is this project **REALLY** in your area?
II - Read General Notes
Check off items they answer on your checklist

III - Carefully Read Through the Plans
- Mark off each item on your checklist
- Make notes on items either incomplete or in error

Common Errors:
Errors which require resubmittal to correct
- Information on the deflector position relative to the deck or framing is not in accordance with 10.2.6.1.1 & 10.2.6.1.2, or missing entirely!
- Storage occupancy designed in area where roof pitch is greater than 2:12 (20.6.1)
Common Errors:
Errors which require resubmittal to correct
- Remote area not sized correctly [27.2.4.2.1]
- Sprinklers designed outside listing
- Incorrect K-factor (orifice size) used for protection of storage occupancies [21.1.2 through 21.1.5]

IV – Go Back over the Checklist for Items Incomplete, Missing or in Error

V – Prepare Response Letter
Inform designer of what errors you found which must be corrected – be professional!