Residential Fire Sprinklers for Code Officials

NFPA 13R/13D AND P2904
UNDERSTANDING DESIGN AND INSTALLATION

1

1

Presented by

MAINE DEPARTMENT OF PUBLIC SAFETY

BUREAU OF BUILDING CODES AND STANDARDS

2

2

Course Goal

Address code officials' knowledge of residential fire sprinkler design and installation requirements.

Learn to apply appropriate National Fire Protection Association standards for residential sprinkler design.

Show how simple residential sprinkler design is.

3

3

Discussion

What is your experience with residential sprinkler systems?

What questions about residential sprinklers did you bring?

4

4

Learning Objectives

You will be able to:

- Describe occupancy types where residential fire sprinkler designs may be installed.
- List the four primary fire sprinkler design and installation standards for residential sprinkler systems.
- Identify five different connection means between residential fire sprinkler systems and their water supplies.
- Identify design details required for residential fire sprinklers.
- Explain the required tests and inspections for residential sprinkler systems.

5

5

Tomorrow

Not all Fire Sprinkler Systems are Created Equal

0900-Noon – Competition Center



6

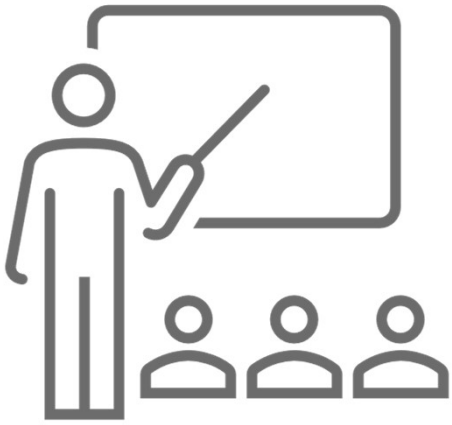
6

Course Layout

Module	Scope
1	Application and Standards
2	System Design Criteria
3	Water Supplies
4	Detailed Design
5	Inspections and Tests
6	Review and Post-Test

7

PRE-TEST



8

Activity

1. Which of the following is not a residential fire sprinkler design standard?
   a) NFPA 13D
   b) IRC P2904
   c) NFPA 13R
   d) NFPA 13
   e) None of the above

9

Activity

2. When designing a residential sprinkler system, what is the minimum total water flow needed in gallons per minute (gpm)?
   a) 1 gpm/sq.ft.
   b) 0.75 gpm/sq.ft.
   c) 0.5 gpm/sq.ft.
   d) 0.05 gpm/sq.ft.

10

Activity

3. Under current standards and listings, what is the approximate minimum total water supply allowed for a residential sprinkler system?
   a) 91 gallons
   b) 320 gallons
   c) 650 gallons
   d) 1000 gallons

11

Activity

4. In residential sprinkler systems, sprinklers may be omitted from bathrooms.

   True or False

5. In residential sprinkler systems, all sprinkler pipe must be hydrostatically tested to 200 psi for two hours.

   True or False

12

Activity

6. Domestic wells can be used to supply residential sprinkler systems.

   True or False

7. What is the minimum number of valves required by NFPA 13D in a sprinkler system?

   a) Zero
   b) One
   c) Two
   d) Three

13

Activity

8. Which of the following is the most hydraulically efficient method of fire sprinkler water delivery?

   a) Tree layout
   b) Loop layout
   c) Grid layout
   d) Orbital layout

14

Activity

9. What is the smallest diameter pipe or tube that is permitted in a residential sprinkler system?
   a) ½-inch
   b) ¾-inch
   c) 5/8-inch
   d) One-inch

15

Activity

10. All residential sprinkler systems must be provided with cross connection control to protect potable water supplies.

    True or False

16

Prerequisite Knowledge

- Familiarity with Maine Uniform Building and Energy Code
  - International Residential Code (2015)
  - Knowledge of Group R occupancy types
- Fire sprinkler performance

17

APPLICATION AND STANDARDS

MODULE NO. 1

18

Codes and Standards

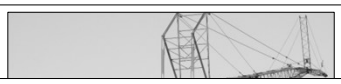
Play a significant role in life safety and fire protection

- Understanding their use and appropriate application is key

Image courtesy: gilbertlodge.com

19

Codes and Standards



- *Maine Uniform Building and Energy Code*
  - *International Building Code*
- *NFPA 1, Fire Code*
- *International Residential Code*

20

Codes and Standards

Where adopted and/or enforced,

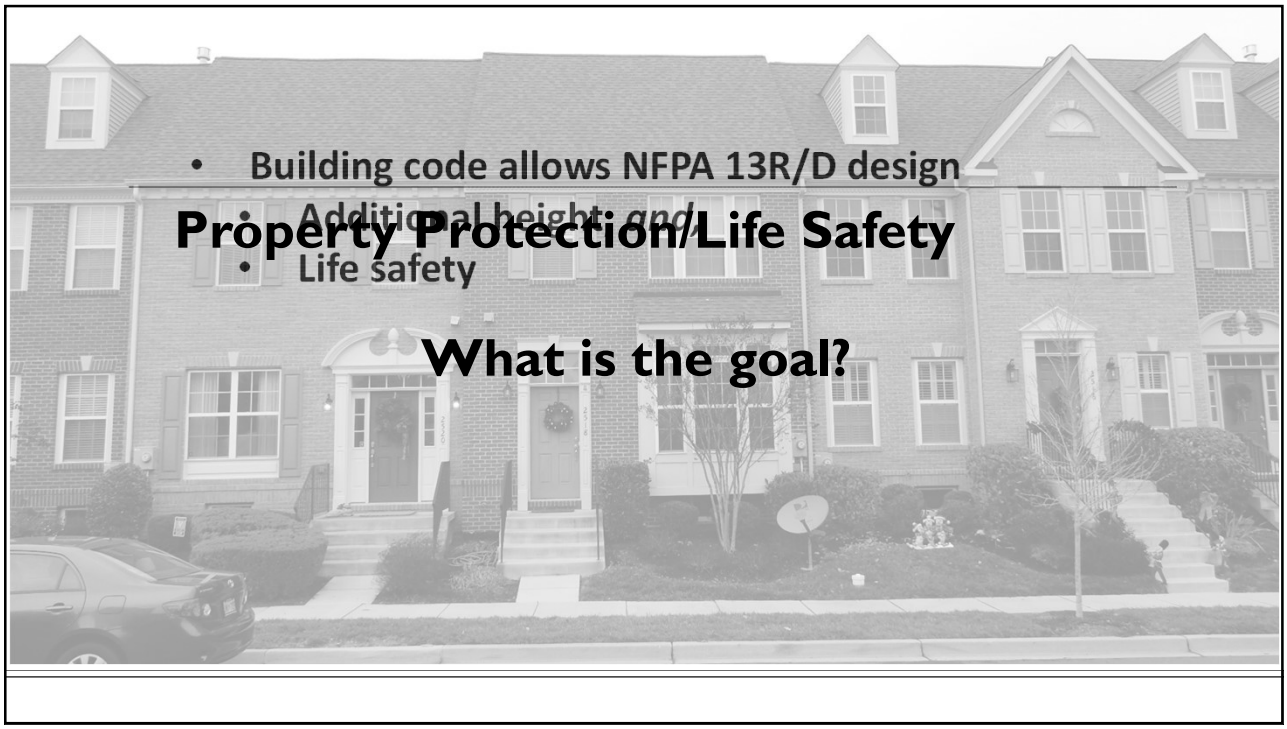
- building and fire codes set requirements for automatic fire sprinkler protection.
- NFPA sets design and installation standards.
  - *International Residential Code* has a prescriptive design for one- and two-family dwellings.

21

Codes and Sprinklers

- Required for
  - life safety (including fire fighters),
  - property protection,
  - special hazard control, and,
  - environmental protection.

22


• Building code allows NFPA 13R/D design
• Additional height; and
• Life safety
Property Protection/Life Safety
What is the goal?

23

24

24

Property Protection or Life Safety?

NFPA 13 - Property Protection

- Design intent: wet contents or extinguish*
- Accomplished by
  - Sprinkler coverage
  - Amount and pattern
  - Water supply
  - Control or suppression mode
  - Also effective for life safety
- UL 199/1767

* Special application ESFR: Early-Suppression Fast-Response

NFPA13R/NFPA 13D -Life Safety

- Design intent: prevent flashover
- Accomplished by
  - Sprinkler coverage
  - Amount and pattern
  - Water supply
  - Control mode
- UL 199

25

Property Protection/Life Safety

- Not an "either/or" proposition
  - Sprinklers designed for life safety can be effective for property protection.
  - Sprinklers designed for property protection are proved effective for life safety.

26

Sprinkler Design Standards

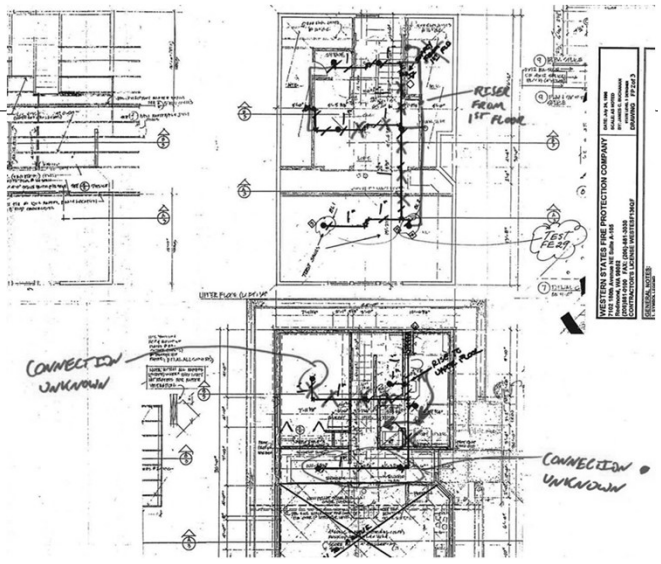
IBC	NFPA	Application
§903.3.1.1	13	All, except where 13R or 13D allowed
§903.3.1.2	13R	Multi-family residential not exceeding four stories or 60 feet in height
§903.3.1.3	13D	One- and two-family dwellings and townhouses
IRC R§313	P2904	

27

27

SYSTEM DESIGN CRITERIA

MODULE NO. 2



28

Property vs. Life: Design Differences

- Coverage
  - Sprinkler discharge configuration
- Water flow rates
- Water supply for
  - Sprinklers
  - Manual fire fighting

29

NFPA 13 Residential Omissions

- §9.2.4 Bathrooms
  - Except limited care facilities and nursing homes, or,
  - Bathrooms opening directly onto public corridors or means of egress
- Closets and pantries < 24 sq. ft.
- §12.1.1
  - Dwelling units and adjacent corridors may use residential sprinklers

30

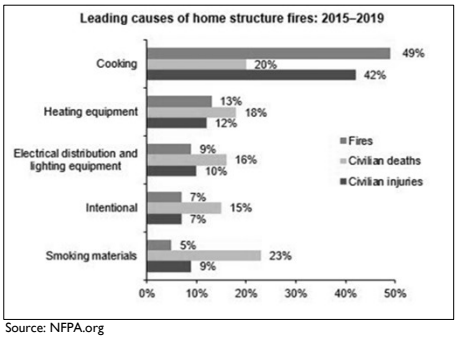
30

Discussion

- Why residential omissions?

31

Statistics and Markets



Source: NFPA.org

- Locations where most fatal fires start
  - Kitchen, heating spaces, bedrooms, living rooms
- Reduce costs
  - Less expensive pipe = less labor cost
  - Smaller pipe, fewer controls and fewer sprinklers = lower material costs
  - Less water demand = smaller water supplies

32

32

NFPA 13D/13R Residential Omissions

- Attics
- Garages and carports
- Chases and elevator shafts
- Open porches or balconies
- I-Codes require
  - Muti-family Group R balconies/decks
  - Open-ended corridors

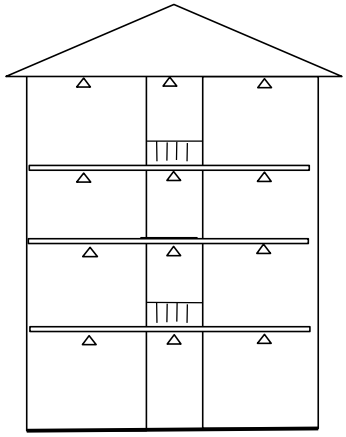
33

NFPA 13D/13R Residential Omissions

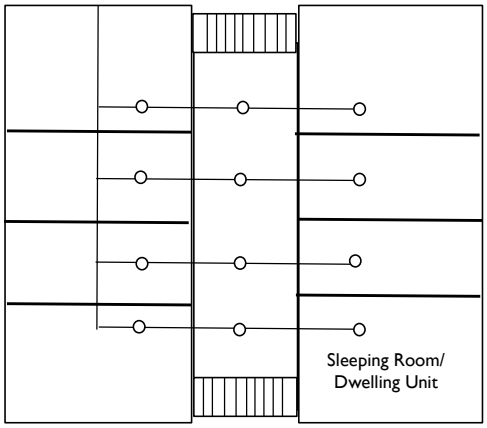
- Bathrooms less than 55 ft^2
- Closets/pantries less than 24 ft^2
  - Walls/ceilings
    - N/C or limited combustible materials
- Open attached porches
- Floor/ceiling assemblies

34

I-Code Open-ended Corridor



Elevation View



Plan View

35

WATER SUPPLIES

MODULE NO. 3

36

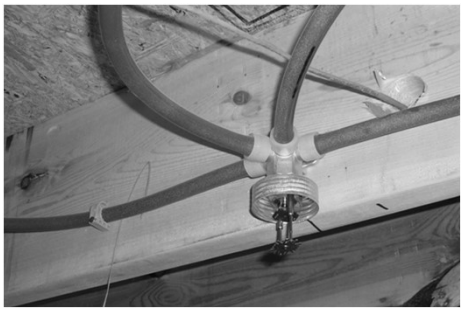
Water Supply Options

- Must be “automatic” and from a "reliable" source
- Municipal authority, private provider, or well of adequate capacity
  - Service size
  - Dedicated supply
  - Combined supply

37

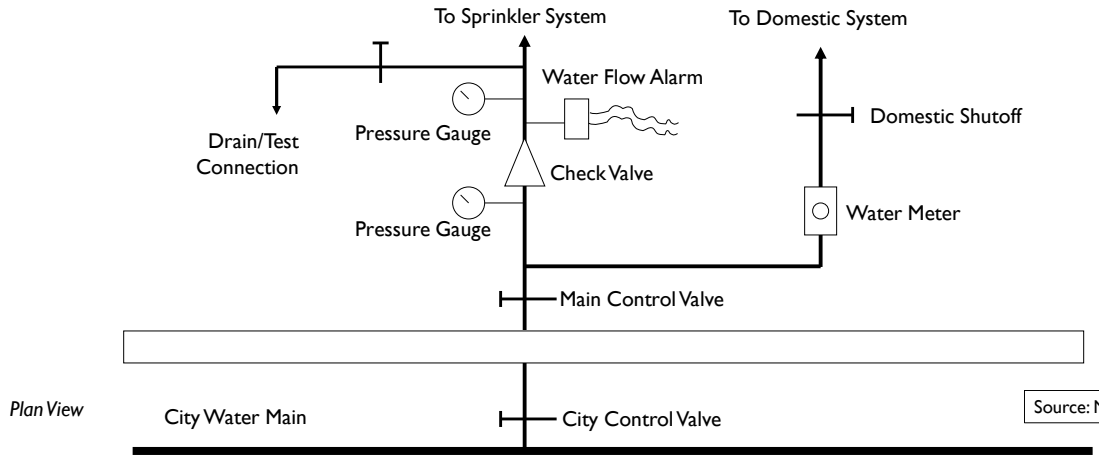
Water Supply Options

- Multipurpose system
- Nonpressurized tank with electric pump
- Pressure tank
  - Compressed air or inert gas



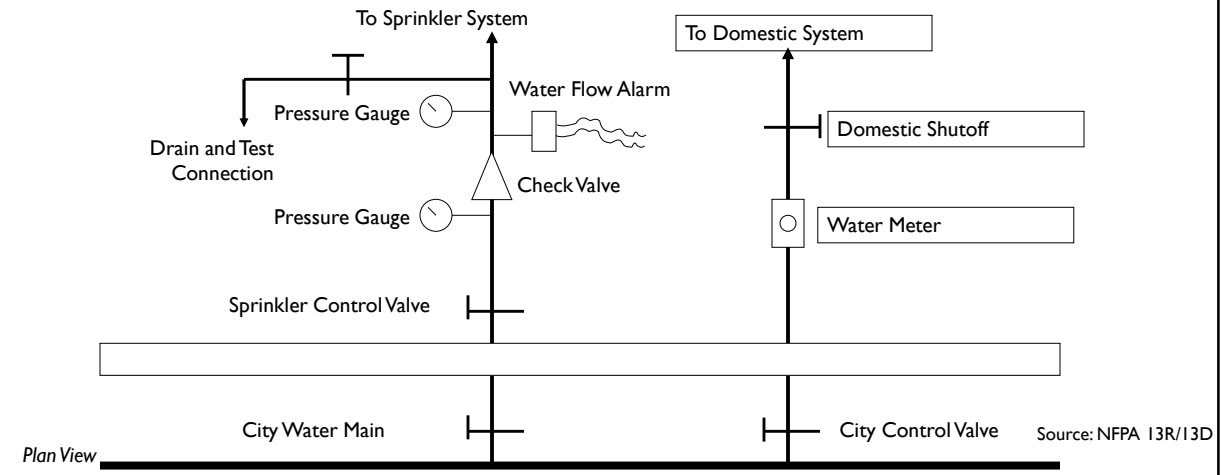
38

13D/13R Preferred Municipal Connection



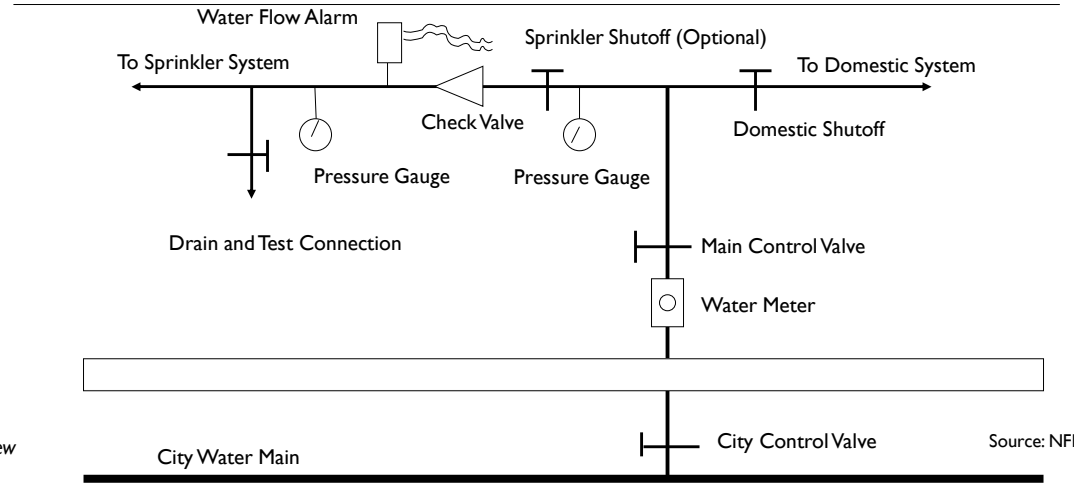
39

Alternative No. 1



40

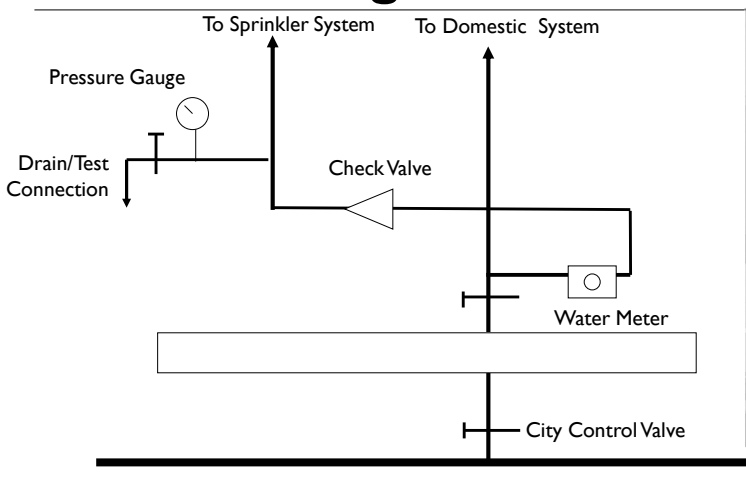
Alternate No. 2

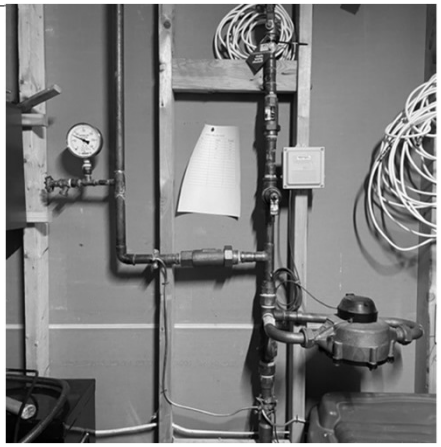


Source: NFPA 13R/13D

41

The Real Thing



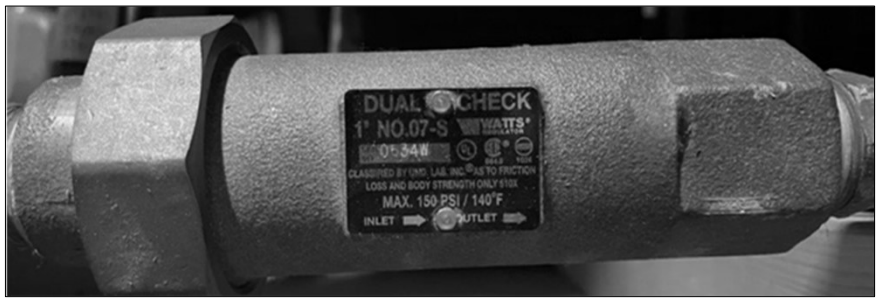


42

42

Cross-connection Control

- Not required by standards unless connected to potable system and antifreeze is used



43

Water Meters/Backflow

- Not required as part of sprinkler design standards
  - Check with local water purveyor
  - Can have serious negative affect on waterflow due to friction loss
    - As flow increases, so does friction loss
    - Refer to meter manufacturer for loss values

44

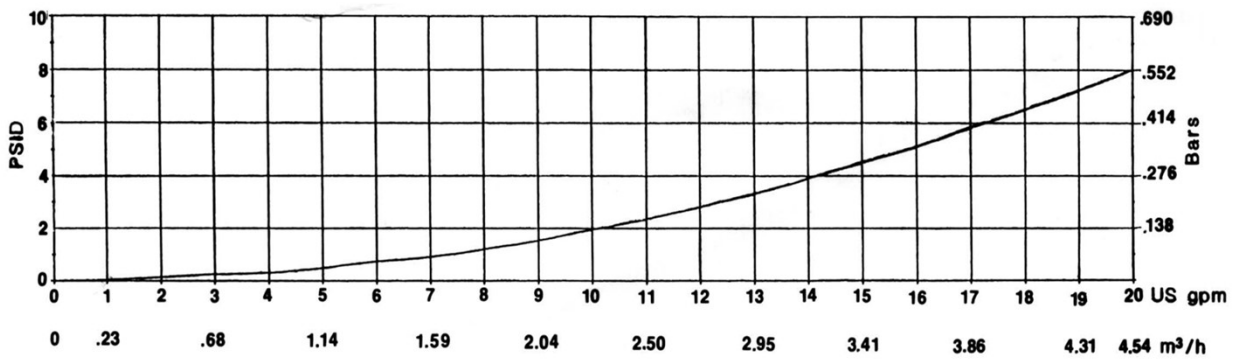
Meter Influence (Sample)

Pressure Loss (psi) in Various Meter Sizes						
Meter size (in.)	18 gpm	23 gpm	26 gpm	31 gpm	39 gpm	52 gpm
5/8	9	14	18	26	*	*
3/4	4	8	9	13	*	*
1	2	3	3	4	6	10
1	**	1	2	2	4	7
2	**	**	**	1	2	3

* Above maximum flow of commonly available meters.
** Less than one pound per square inch (psi).

45

Meter (Sample)



Neptune Model T-10 5/8-inch domestic meter loss

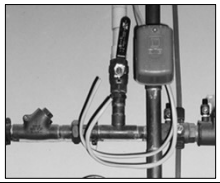
46

Non-pressurized Tank

- Plastic or metal container
  - Up to 350 gallons
  - Fit through standard door
  - Plumbed for refill
- Load considerations
  - 8.55 lb/gallon
  - 62.4 lb/cubic foot

47

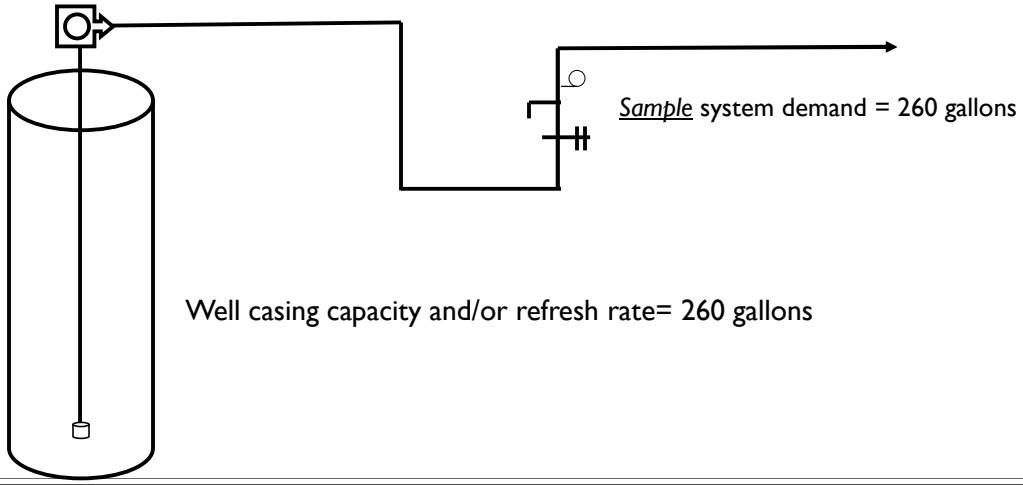
Non-pressurized Tank (cont'd)



- Electric pump
  - Sized to deliver required flow at needed pressure
  - Separate standby or emergency power not required
  - Fire protection listing not required
  - 240-volt normal circuit
  - Elevated above floor
- Oil furnace pressure switch

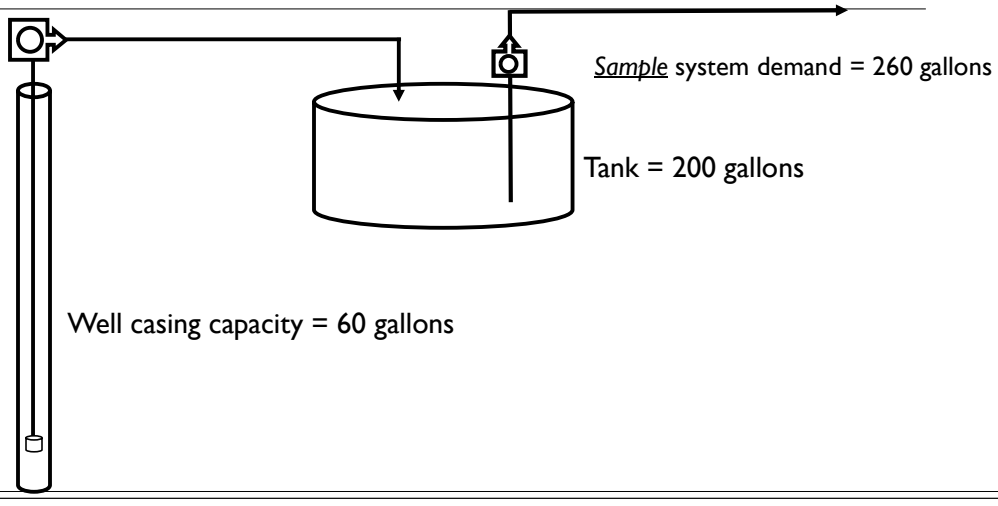
48

Private Well



49

Combined Well / Storage



50

Pressure Tank

Gettysburg National Military Park

51

51

Stored Water Supplies

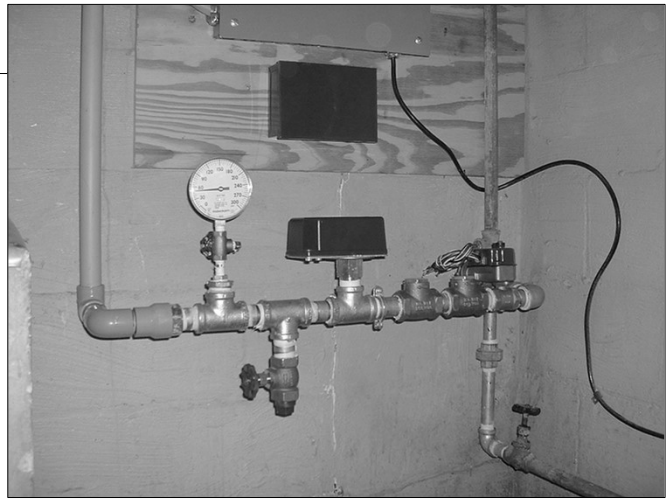
- Sprinkler design flow rates for minimum time
- NFPA 13D/IRC P2904
  - One-story dwelling less than 2,000 ft^2
    - Two sprinklers* x 7 minutes
  - Two- or more story dwelling or more than 2,000 ft^2
    - Two sprinklers* x 10 minutes
- NFPA 13R
  - Four sprinklers x 30 minutes

* See exception for single sprinkler in largest room

52

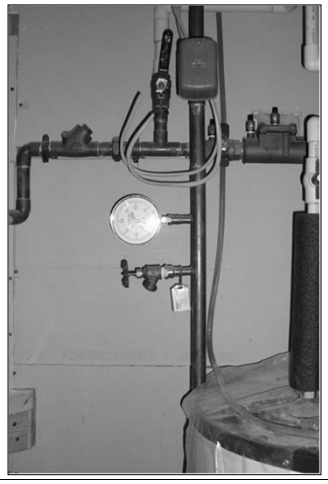
DETAILED DESIGN

MODULE NO. 4



53

System Types



Wet pipe
- Where temperature ≥ 40°F can be maintained

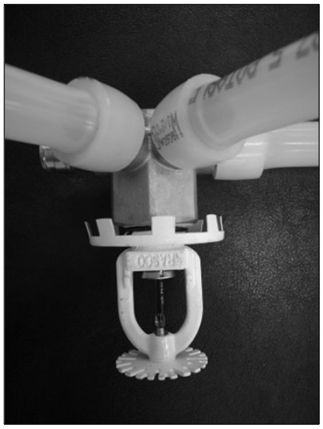
Dry pipe
- Must have sprinklers listed for dry-pipe systems

Pre-action
- Must have sprinklers listed for dry-pipe systems

Water/Antifreeze
- Food grade glycerine

54

System Types (cont'd)



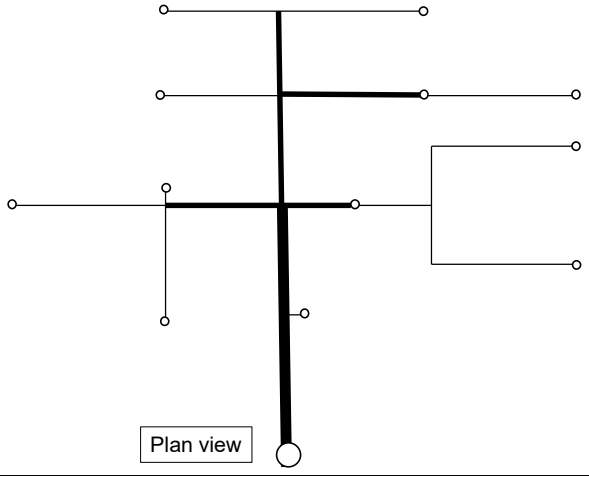
- Network
  - Each sprinkler served by three separate paths
    - Aquasafe®/Viega®
- Multi-purpose
  - Fire protection and domestic in excess of single fixture
- Passive purge
  - Fire protection and single toilet

55

55

System Layouts

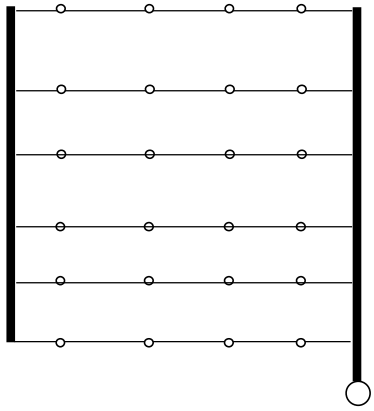
Tree



56

System Layouts

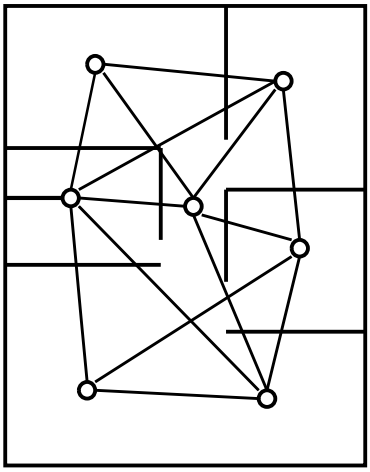
Grid



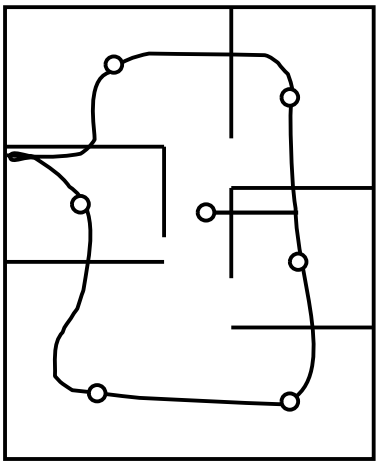
Plan view

57

Network or Multipurpose



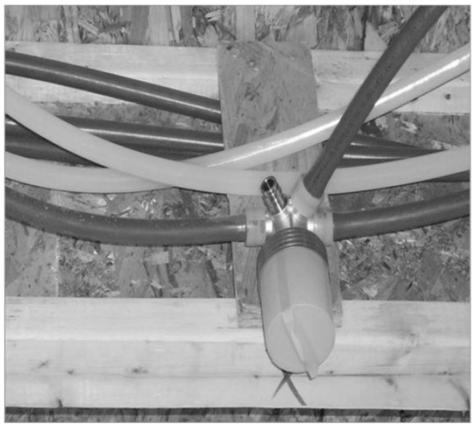
Plan View



58

Network/Multipurpose System

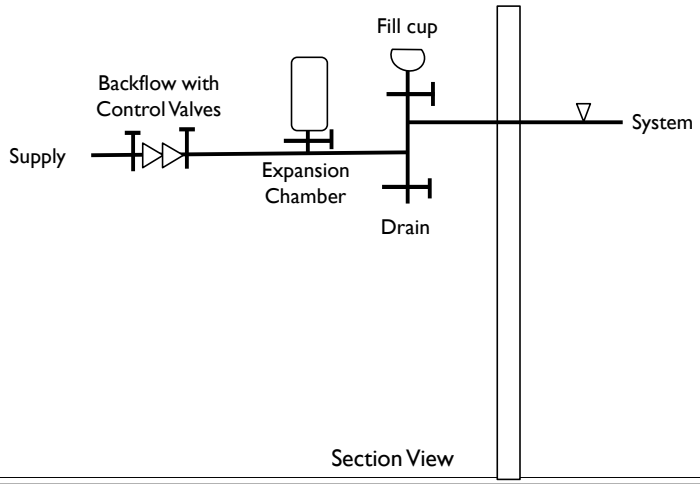
- Aquasafe® /Viega®
- Network
  - Proprietary design
  - ≥ 1/2-inch cross-linked polyethylene (PEX)
  - Limited number of domestic connections between sprinklers



59

Anti-Freeze Systems

- Anti-freeze solution
  - New systems: listed
  - Existing systems: USP Glycerine max 40% by volume
- Connection with backflow installed

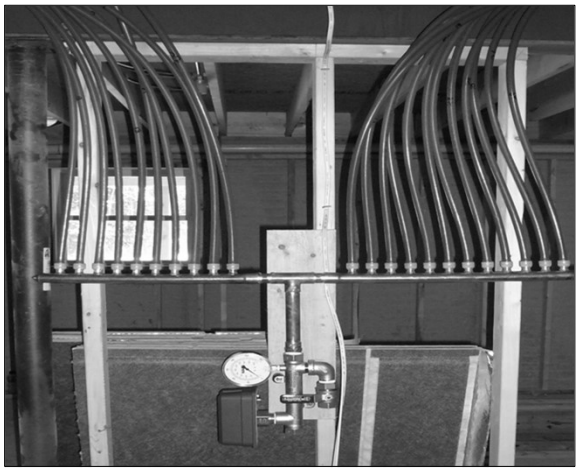


60

60

System Components

- Pipe
- Hangers
- Valves
- Alarm
- Sprinklers



61

Sprinkler Pipe

- May be one or a combination of:
  - Black iron or steel
  - Type K, L, or M copper
- Plastic
  - CPVC
  - PEX

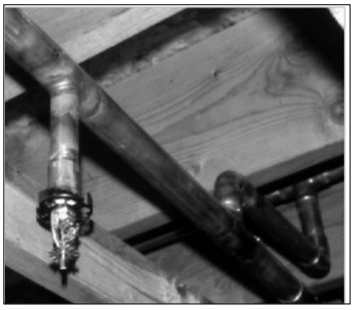
62

Black Iron Or Steel

- Schedule 40, 30, 10, 7, or 5
- NFPA 13D
  - Generally not larger than 1-in.
- NFPA 13R
  - Size dependent on number of sprinklers supplied

63

Copper



- Types K, L, M
  - IRC P2904 recognizes only Type M
  - NFPA 13D/IRC P2940
    - Generally not larger than 1-in. diameter
  - NFPA 13R
    - Size dependent on number of sprinklers supplied

64

Chlorinated Polyvinyl Chloride

- Generally sized 3/4- to $1^{1/2}$-inch
- Listed for fire protection service
- Concealed locations:
  - Must have a thermal barrier
    - 3/8-inch gypsum wallboard
    - 1/2-inch plywood veneer
    - Suspended membrane metal-grid ceiling with lay-in panels or tiles having a minimum weight of not less than 0.35 lb/ft^2

65

CPVC (cont'd)

- Chemical/product compatibility
  - Use only manufacturer-approved
    - Solvents
    - Cements
    - Sealants
- Avoid
  - Cutting and packing oils
  - Non-water-based paints
  - Pipe thread paste and dope
  - Adhesive tape

For latest:
www.systemcompatible.com

66

Exposed Installations

Beneath smooth, flat ceiling with approved one-step solvent.

Sprinkler Type	Max Sprinkler Temp (°F)	Max Clearance below ceiling (in.)	Max Clearance from sidewall (in.)	Max spacing between sprinklers (ft)	Special Conditions
Pendent	170	8			Pipe mounted direct to ceiling
Sidewall	200	12	6	14	Pipe mounted direct to sidewall
Upright	155	4		15	Max ceiling to pipe centerline $7^{1/2}$-in.

Refer to manufacturer's installation guide for other applications

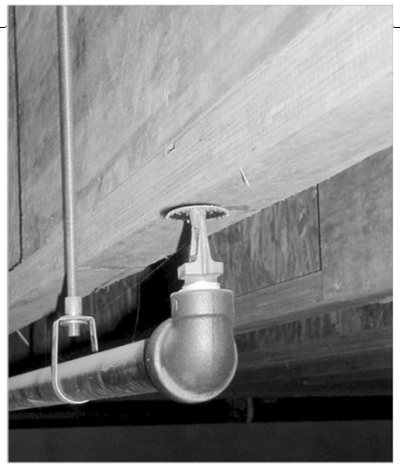
67

Cross-linked Polyethylene

- Listed for fire protection service in one- and two-family
- Intended for network/multipurpose combination systems
- Must meet National Sanitation Foundation (NSF) potability standards
- Thermal protection required

68

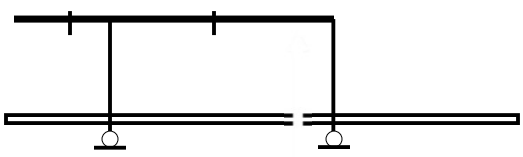
Pipe Hangers



69

Hanger Spacing

- Prevent routine pipe movement, or,
- Vertical displacement when sprinkler operates
  - Black iron/steel: One hanger per pipe section
  - Copper: Follow plumbing code
  - Nonmetallic: Follow manufacturer guidelines



70

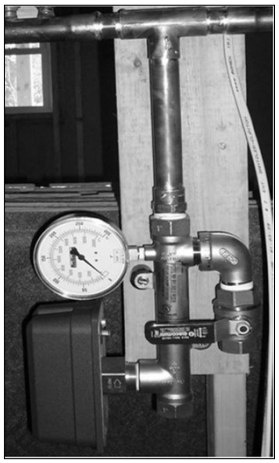
Control Valves

Indicating and non-indicating

- For combined domestic/fire
  - Control valve must shut off both
- Multipurpose sprinkler system may not have control valve unless
  - Electronically supervised, or
  - Locked in "open" position

71

Drain /Test Apparatus



All systems must have drain valve

- Should drain to safe location
  - Back into tank for stand-alone systems
- May be combined with flow test valve
  - If waterflow alarm is provided

72

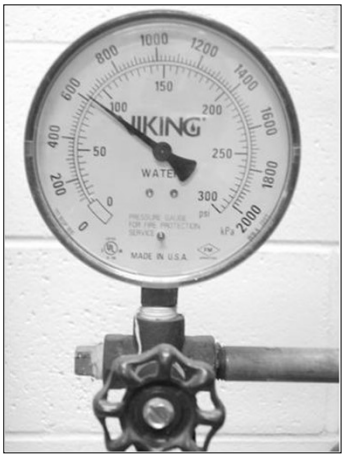
Pressure Gauges

NFPA 13D/P2904

- Not required on wet pipe
  - Air pressure gauge required on dry-pipe and/or pressure-tank systems

NFPA 13R

- On supply and system sides of main control valve



73

Supervisory/Waterflow

- NFPA 13D/IRC P2904
- Supervisory <u>not</u> required for combined domestic/fire service
  - Locked main control valve for standalone
- Waterflow not required if building provided with smoke detection

- NFPA 13R
  - Required
  - If building has fire alarm system, must be connected

74

Alarm

Alarm to notify occupants that water is flowing

- Bell, siren, or horn
- Required in one- and two-family only if no smoke alarms
  - Installed in accordance with NFPA® 72, *National Fire Alarm Code* and manufacturer's specifications

75

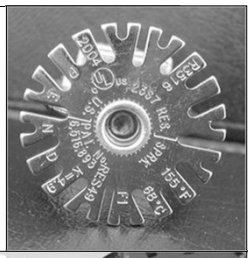
Fire Department Connection

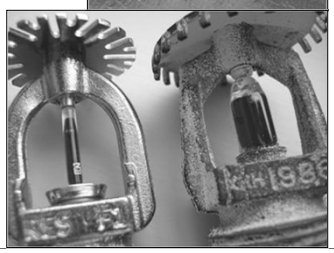
- NFPA 13D/IRC P2904
  - Not required
- NFPA 13R
  - When building is fire department accessible, and,
  - More than 2,000 ft^2, or,
  - More than one story.
- NFPA 13

76

Residential Sprinklers

- Must be listed by Underwriters Laboratories (UL) or other agency for residential use
  - Bear mark "Residential Sprinkler" or "RES SPKR"
  - Operational range 135 - 170 °F in most occupied spaces
  - May be exposed or concealed
- Response Time Index (RTI)
- Water distribution pattern





77

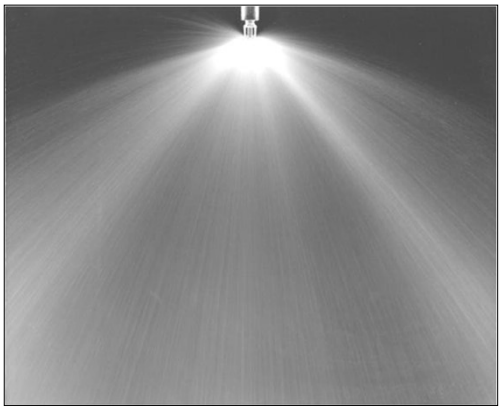
Response Time Index (RTI)

Category	RTI (meters/second)$^{1/2}$	RTI (feet/sec) $^{1/2}$
Fast response, QR and residential	50 or less	90 or less
Standard response	80 or more	145 or more

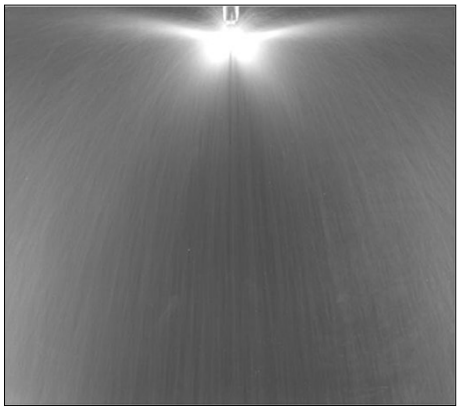
78

78

Water Distribution Pattern



Control/Suppression Mode: Property Protection



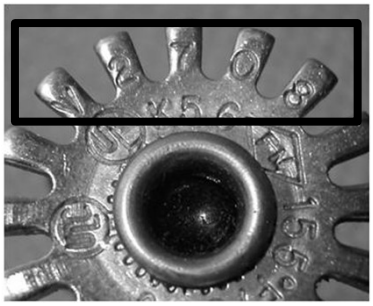
Control Mode: Residential

Courtesy: Tyco Fire Suppression & Building Products

79

Sprinkler Id Number (SIN)

- Sprinkler manufacturer's proprietary 5- or 6-character identification for:
  - Manufacturer
  - K-factor
  - Application (use)
  - Response characteristics
- Refer to manufacturer's technical literature for guidance



80

Placement Details

- Always follow listing details
  - For residential sprinklers without specific positioning criteria:
  - Pendent and upright
    - 1 to 4 inches from ceiling
    - In closets within 12 inches of ceiling
  - Sidewall
    - 4 to 6 inches from ceiling

81

Intermediate Temperature (175 To 225 °F)

Heat Source	Range (inches)
Fireplace, side of open or recessed	12 to 36
Fireplace, front of recessed	36 to 60
Coal or wood stove	12 to 42
Kitchen range top/Oven	9 to 18
Uninsulated heat duct/Vent/Chimney connector	9 to 18
Uninsulated hot water pipe	6 to 12
Side of ceiling or wall warm air register	12 to 24
Front of wall warm air register	18 to 36
Water heater, furnace or boiler	3 to 6
Luminaire up to 250 watts	3 to 6
Luminaire 250 to 499 watts	6 to 12

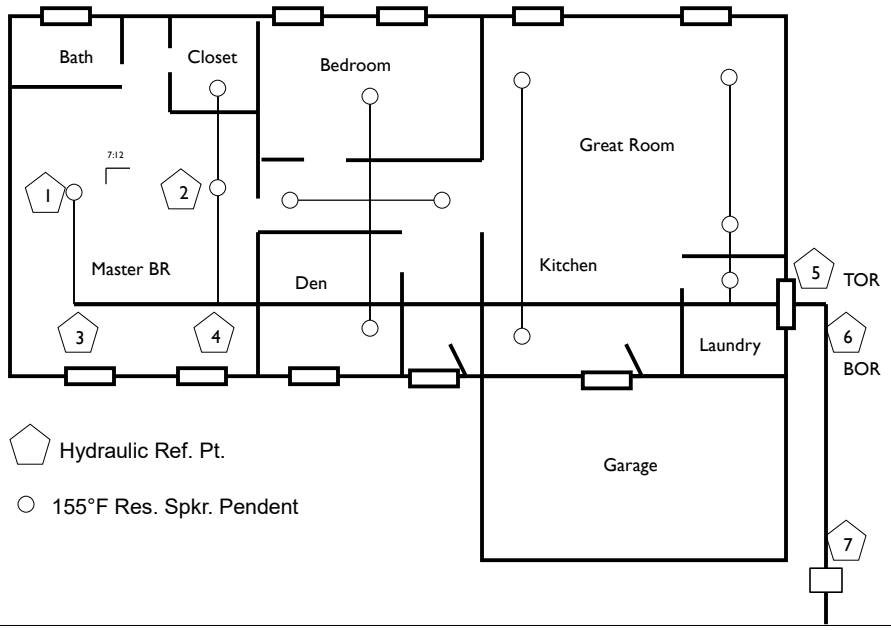
Slide 4-82

82

Hydraulic Design

- Mathematical calculations to verify the water supply's *pressure* and *volume* can:
  - Provide enough *volume* at correct *pressure* to each sprinkler to control a fire
  - Develop enough *volume* at correct *pressure* to all sprinklers likely to open in a fire

83



84

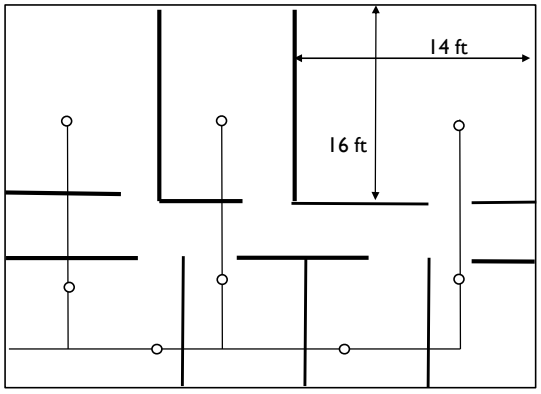
Design Criteria: Application

Flow Rates

Standard	Sprinklers/ Design Area	Flow Rate/Sprinkler	FDC	Water for Manual
NFPA13D/P2904	1	0.05 gpm/sq. ft (±13 gpm per sprinkler)	NR	No
	2		NR	No
NFPA 13R	4		R	No
NFPA 13	900-5,000 ft^2	0.05 to 0.4 gpm/ft^2	R	Yes

85

0.05 gpm/sq. ft



Plan View

Sprinkler Demand

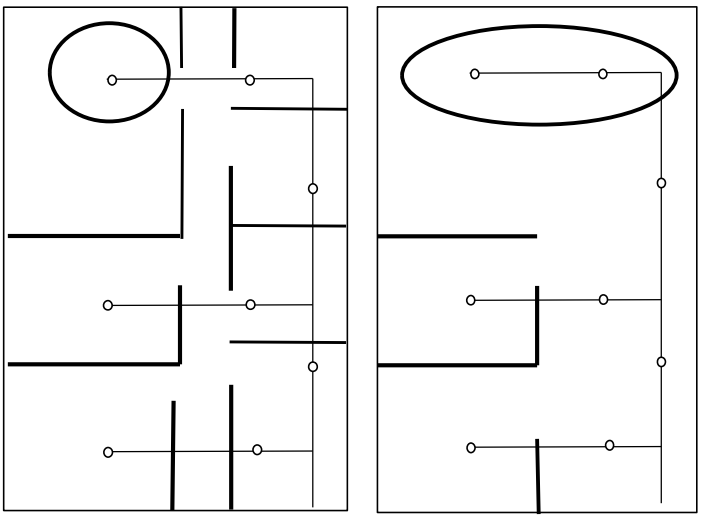
16 x 14 ft = 224 sq. ft.

224 sq. ft. x 0.05 gpm/sq. ft = 11.2 gpm

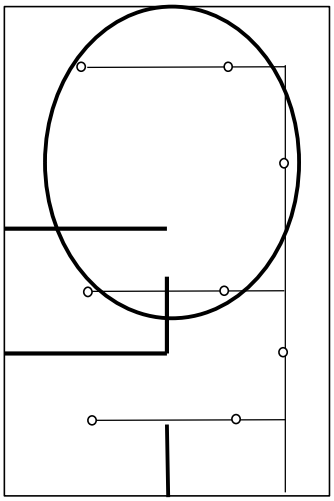
86

86

Design Criteria Simplified



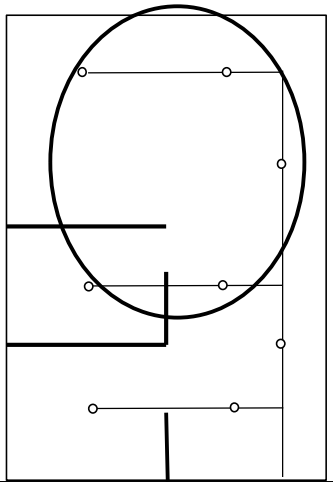
NFPA 13D/P2904 Plan View



NFPA 13R Plan View

87

Design Criteria Simplified



NFPA 13R Plan View

Hydraulic Design

EXAMPLE

- Four-sprinkler residential design
- 4 sprinklers, each delivers ±13 gpm
- 13 gpm x 4 = 42 gpm
- System demand ± 42 gpm

88

Design Criteria (Water Supply)

Standard	Water supply Duration (gpm/minutes)	Hose Stream Allowance (Manual)	Total Water Supply
NFPA13D/P2904*	7-10 min	Zero	--
Example	13 x 1 x 7	--	91 gal.
	13 x 2 x 10	--	260 gal.
NFPA 13R	30	Zero	--
Example	13 x 4 x 30	--	1,260 gal.
NFPA 13	30-90	100-250	System demand + hose stream
Example	60 x 252 gpm* = 15,210	60 x 250 gpm = 15,000	30,210 gal.

*Typical sprinkler demand for mercantile occupancy.

89

A Few Words About Water Mist

Courtesy: suppressionsystemssupport.co.uk

Courtesy: Fike.com

- High-, intermediate- and low-pressure water mist systems may be proposed as an alternative to sprinklers
  - Must meet NFPA 750 *Standard on Water Mist Fire Protection Systems*
  - Listed for Light and Ordinary Hazard occupancies

90

INSPECTIONS AND TESTS

MODULE NO. 5

91

Inspections/Tests

- Pre-conceal
  - Sprinklers installed in all required areas
  - Obstructions are addressed
    - Cabinets, fans, luminaires
  - Correct sprinklers and temperature rating
  - Pipe sizes and length are per plans or tables
  - Non-metallic pipe is listed for fire service
  - Pipe is supported per manufacturer's requirements

92

Inspections/Tests

- Final
  - Sprinklers not painted, damaged or hindered
  - Pump, if installed, starts and runs on system flow
    - Open test and drain assembly
  - Other impairments not installed
    - PRV, water softeners, water filters
  - Required signage in place for combination systems
  - Owner's manual provided

93

Warning Sign: Combination

WARNING

The water system for this home supplies fire sprinklers that require certain flows and pressures to fight a fire.

Devices that restrict the flow or decrease the pressure or automatically shut off water to the sprinkler system, such as water softeners, filtration systems and automatic shutoff valves, shall not be added to this system without a review of the fire sprinkler system by a fire protection specialist

Do not remove this sign.

94

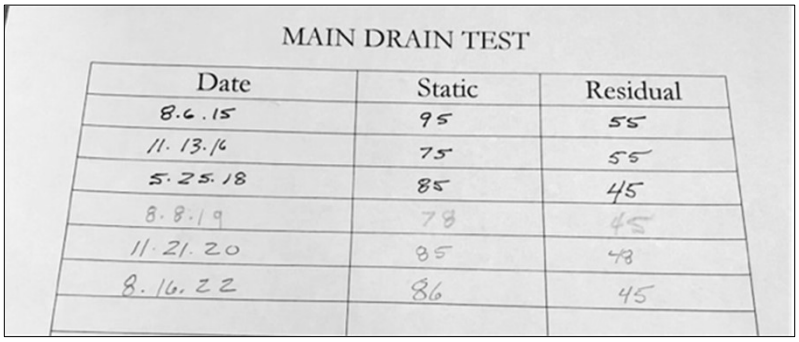
Inspections/Tests

- Tests
  - If no fire department connection
    - Normal system pressure for 15 minutes, or,
    - Air test at 50 psi for 15 minutes
  - If fire department connection installed
    - 200 psi for two hours taken at system low point
  - Standalone water supply
    - Pump starts automatically and runs for 10 minutes
  - "Bucket" test
    - Proprietary, not required by codes or standards

95

Maintenance

- No required by codes or standards
- Main drain test



MAIN DRAIN TEST

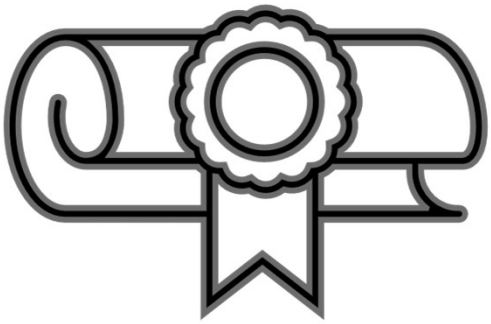
Date	Static	Residual
8.6.15	95	55
11.13.14	75	55
5.25.18	85	45
8.8.19	78	45
11.21.20	85	48
8.16.22	86	45

96

96

REVIEW AND POST-TEST

MODULE NO. 6



97

Review

You should be able to:

- Describe occupancy types where residential fire sprinkler designs may be installed.
- List the four primary fire sprinkler design and installation standards for residential sprinkler systems.
- Identify five different connection means between residential fire sprinkler systems and their water supplies.
- Identify design details required for residential fire sprinklers.
- Explain the required tests and inspections for residential sprinkler systems.

98

98

Activity

1. Which of the following is not a residential fire sprinkler design standard?
   a) NFPA 13D
   b) IRC P2904
   c) NFPA 13R
   d) NFPA 13
   e) None of the above

99

Activity

2. When designing a residential sprinkler system, what is the minimum total water flow needed in gallons per minute (gpm)?
   a) 1 gpm/sq.ft.
   b) 0.75 gpm/sq.ft.
   c) 0.5 gpm/sq.ft.
   d) 0.05 gpm/sq.ft.

100

Activity

3. Under current standards and listings, what is the approximate minimum total water supply allowed for a residential sprinkler system?
   a) 91 gallons
   b) 320 gallons
   c) 650 gallons
   d) 1000 gallons

101

Activity

4. In residential sprinkler systems, sprinklers may be omitted from bathrooms.

   True or False

5. In residential sprinkler systems, all sprinkler pipe must be hydrostatically tested to 200 psi for two hours.

   True or False

102

Activity

6. Domestic wells can be used to supply residential sprinkler systems.

   True or False

7. What is the minimum number of valves required by NFPA 13D in a sprinkler system?

   a) Zero
   b) One
   c) Two
   d) Three

103

Activity

8. Which of the following is the most hydraulically efficient method of fire sprinkler water delivery?

   a) Tree layout
   b) Loop layout
   c) Grid layout
   d) Orbital layout

104

Activity

9. What is the smallest diameter pipe or tube that is permitted in a residential sprinkler system?
   a) ½-inch
   b) ¾-inch
   c) 5/8-inch
   d) One-inch

105

Activity

10. All residential sprinkler systems must be provided with cross connection control to protect potable water supplies.

    True or False

106

Questions/Comments?

107

Additional Courses

This training program has been provided by the Maine Bureau of Building Codes and Standards.

For additional information and training requests, contact

Paul A. Demers
Phone: (207) 441-0996
Fax: (207) 287-6251
Email: Paul.a.demers@maine.gov
Office of the State Fire Marshal
52 State House Station
Augusta, ME 04333

108

108

This program was funded by a Federal Emergency Management Agency *Building Resilient Infrastructure and Communities* grant.

For more grant program information, contact FEMA Grants.

109

109