Commercial Fire Sprinkler System Plans Review

CFSSPR-Student Manual

1st Edition, 2nd Printing-May 2023

FEMA

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May 2023
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ACKNOWLEDGMENTS

The development of any National Fire Academy (NFA) course is a complex process aimed at providing students the best possible learning opportunity we can deliver.

There are many players in the course development, each of whom plays an equally important part in its success. We want to acknowledge their participation and contribution to this effort and extend our heartfelt thanks for making this quality product.

The following people participated in the creation of this course:

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COURSE DESCRIPTION

This five-day course will enable students to perform commercial fire sprinkler system plans reviews to allow structured decision-making in the students' real-life, job-related situations and responsibilities. These skills are essential to meet code officials' needs so they may conduct reviews and approve plans for sprinkler fire protection systems in their jurisdictions.

AUDIENCE, SCOPE AND COURSE PURPOSE

The target audience for this course includes fire service prevention and allied public officials who are responsible for the review of plans for sprinkler and standpipe systems in their jurisdictions. Applicants to this course should have familiarity with fire protection, codes/standards compliance, and fire protection systems and equipment.

The scope of this course spans instruction in the knowledge and skill necessary to evaluate the soundness and code compliance of engineering and architectural plans for commercial fire sprinkler systems proposed as part of facility and occupancy construction plans. The course will enable students to perform a plans review to evaluate the suitability of the fire sprinkler system calculations in accordance with nationally recognized standards for design and installation. Course content covers fire protection standards, plan reading, parts of a submittal package, classifying hazards, water supplies, sprinkler system components, remote areas and evaluating hydraulics calculations.

Students should be familiar with commercial fire sprinkler systems equipment and nomenclature, and have prior experience in fire prevention inspection programs and community goals and priorities. It is recommended that students meet the following minimum requirements:

- Incident Command System (ICS)-100-level and ICS-200-level training. Preferred courses are Q0462 and Q0463, available through NFA Online. Chief's signature attests that the applicant has completed this required training.

- Students in the fire service should not have less than three years' experience in either a code enforcement or fire safety inspection/plans review function.

- Allied professionals should possess an associate degree in engineering, architecture, building design or risk management from an accredited college.

- Required pre-application course work:
  - Q0218: Testing and Evaluation of Water Supplies for Fire Protection.

Priority enrollment will be given to applicants with one of the following:

- Completion of Fire Inspection Principles (FIP) I or FIP II.
- Completion of the "Plans Review for Fire and Life Safety" course.
- International Code Council (ICC) Fire Plans Examiner certification.
- ICC Commercial Plans Examiner certification.
- National Fire Protection Association (NFPA) Fire Plans Examiner certification.

The purpose of this course is to prepare qualified students to review and evaluate commercial fire sprinkler systems plans as part of the public code compliance and enforcement functions of the community fire prevention mission.

GRADING METHODOLOGY

The students' final grades will be computed using the final exam. The final exam will include 46 multiple-choice questions (46% of the total grade). The exam covers all the information in the Student Manual (SM), as well as the concepts presented during presentations and class discussions. In addition, eight activities in the course will be evaluated using points (54 pts. total, 54% of the total grade).

The required performance to successfully complete the course is attained by completing the class with at least a "C" or higher.

Assessment Tool	Point Score	Final Grade %
Precourse Assignment	10	54%
Activity 1.3	3	
Activity 2.3	5	
Activity 2.5	4	
Activity 3.4	6	
Activity 6.1	6	
Activity 6.2	5	
Activity 7.2	15	
Final Exam	46	46%
Totals	**100**	**100%**

Score Range	Letter Grade to be Assigned to Student
90-100	A
80-89	B
70-79	C
69 or less	F

GRADING RUBRICS

PRE-COURSE ACTIVITY GRADING RUBRIC

Assignment: In not more than 500 words, compare and contrast your jurisdiction's code enforcement process to the readings. Where is your system better or worse? Why do you think that? Where can you make or recommend improvements?

The table below details the point distribution for the pre-course activity. (Maximum points: 10.)

Element of performance	No submission 0 points	Deficient 1 to 2 points	Developing 3 to 4 points	Acceptable 5 to 6 points	Excellent 7 to 8 points	Exemplary 9 to 10 points
Pre-course activity write-up.	No write-up submitted.	Provides no connection to the reading nor to the student's jurisdiction's code enforcement process. Does not include an evaluation nor recommendation of the student's jurisdiction's code enforcement process.	Attempts to react to the reading but without making connections to the student's jurisdiction's code enforcement process. Does not include an evaluation nor recommendation of the student's jurisdiction's code enforcement process.	Provides comparison and contrast between the student's jurisdiction's code enforcement process and the reading. Provides a vague evaluation of the student's jurisdiction's code enforcement process, and lacks any recommendations for improvement.	Provides clear comparison and contrast between the student's jurisdiction's code enforcement process and the reading. Provides an evaluation of the student's jurisdiction's code enforcement process with at least one recommendation for improvement to the student's jurisdiction's process.	Provides clear comparison and contrast between the student's jurisdiction's code enforcement process and the reading. Provides an evaluation of the student's jurisdiction's code enforcement process with more than one recommendation for improvement with clear explanation on how to achieve the improved process.

ACTIVITY 1.3: FINDING GAPS IN SUBMITTAL PACKAGES GRADING RUBRIC

Assignment: Students will be provided with a sample submittal package, which they will review and find any existing gaps. Each student will write a letter outlining deficiencies (if any), or provide a letter explaining that the plans have been accepted for further review if there are no deficiencies identified.

The table below details the point distribution for Activity 1.3. (Maximum points: 3.)

Element of performance	No submission 0 points	Deficient 1 point	Acceptable 2 points	Exemplary 3 points
Letter to contractor.	No letter submitted.	Does not outline any deficiencies.	Outlines some deficiencies based on the evaluation of the submittal package.	Clearly outlines the deficiencies based on the evaluation of the submittal package.

ACTIVITY 2.3: DENSITY/AREA CURVES GRADING RUBRIC

Assignment: Use NFPA 13, *Standard for the Installation of Sprinkler Systems*, density/area curves to fill in the blanks of the five following examples, plus compute a rough estimate of water demand for the described conditions.

The table below details the point distribution for Activity 2.3. (Maximum points: 5.)

Element of performance	No submission 0 points	Deficient 1 point	Developing 2 points	Acceptable 3 points	Excellent 4 points	Exemplary 5 points
Water demand estimates (gallons per minute (gpm)).	No submission.	One of the estimates is within a margin of plus or minus 5% error.	Two of the estimates are within a margin of plus or minus 5% error.	Three of the estimates are within a margin of plus or minus 5% error.	Four of the estimates are within a margin of plus or minus 5% error.	All five of the estimates are within a margin of plus or minus 5% error.

ACTIVITY 2.5: DENSITY/AREA VERIFICATION GRADING RUBRIC

Assignment: Each small group will be assigned a scenario in which students will approve or reject the submittals and justify their decisions.

The table below details the point distribution for Activity 2.5. (Maximum points: 4.)

Element of performance	No submission 0 points	Deficient 1 point	Acceptable 2 points	Excellent 3 points	Exemplary 4 points
Approval or rejection decisions for five scenarios.	No approval or rejection decisions submitted.	No reasonable justifications are provided.	Decision for the assigned scenario is appropriate but justifications do not support the decision.	Decision and justifications for the assigned scenario are appropriate, but additional explanation is required.	Decision for the assigned scenario is appropriate and reasonable justifications are provided.

ACTIVITY 3.4: WATER SUPPLIES FOR SPRINKLER SYSTEMS GRADING RUBRIC

Assignment:

- Identify the duration (in minutes) of the required water supply.
- Calculate the total volume (in gallons) of the required water supply.

The table below details the point distribution for Activity 3.4. (Maximum points: 6.)

Element of performance	No submission 0 points	Deficient 1 point	Developing 2 to 3 points	Acceptable 4 points	Excellent 5 points	Exemplary 6 points
Determining the total water supply needed in five examples.	No submission.	Calculations were submitted, but none of the calculations are within a margin of plus or minus 5% error.	One or two of the calculations are within a margin of plus or minus 5% error.	Three of the calculations are within a margin of plus or minus 5% error.	Four of the calculations are within a margin of plus or minus 5% error.	All five of the calculations are within a margin of plus or minus 5% error.

ACTIVITY 6.1: VERIFYING ADJUSTED REMOTE AREAS GRADING RUBRIC

Assignment: Students will read five scenarios to verify the appropriateness of the adjusted remote areas and provide calculations for new remote area size.

The table below details the point distribution for Activity 6.1. (Maximum points: 6.)

Element of performance	No submission 0 points	Deficient 1 point	Developing 2 points	Acceptable 3 to 4 points	Excellent 5 points	Exemplary 6 points
Calculation of new remote area size.	No submission.	Calculations are attempted but no correct remote area sizes are provided.	One of the calculations is within a margin of plus or minus 5% error.	Two or three of the calculations are within a margin of plus or minus 5% error.	Four of the calculations are within a margin of plus or minus 5% error.	Five of the calculations are within a margin of plus or minus 5% error.

ACTIVITY 6.2: DETERMINING THE MINIMUM LENGTH OF REMOTE AREA AND THE MINIMUM NUMBER OF SPRINKLERS IN THE REMOTE AREA GRADING RUBRIC

Assignment: Given the remote areas (five) in a list, students will calculate the minimum length in feet and calculate the minimum number of sprinklers required in the remote area.

The table below details the point distribution for Activity 6.2. (Maximum points: 5.)

Element of performance	No submission 0 points	Deficient 1 point	Developing 2 points	Acceptable 3 points	Excellent 4 points	Exemplary 5 points
Minimum length and number of sprinklers required.	No submission.	Calculations are attempted but no correct data is provided.	Minimum length and number of sprinklers required are correctly calculated for one remote area size.	Minimum length and number of sprinklers required are correctly calculated for two remote area sizes.	Minimum length and number of sprinklers required are correctly calculated for three remote area sizes.	Minimum length and number of sprinklers required are correctly calculated for four or more remote area sizes.

ACTIVITY 7.2: HYDRAULIC CALCULATIONS GRADING RUBRIC

Assignment: Students will evaluate the provided calculations.

The table below details the point distribution for Activity 7.2. (Maximum points: 15.)

Element of performance	No submission 0 points	Deficient 1 to 3 points	Developing 4 to 6 points	Acceptable 7 to 9 points	Excellent 10 to 12 points	Exemplary 13 to 15 points
Hydraulic calculations.	No submission.	One to two incorrect calculation entries are appropriately identified.	Three to four incorrect calculation entries are appropriately identified.	Five to seven incorrect calculation entries are appropriately identified.	Eight to 10 incorrect calculation entries are appropriately identified.	Eleven or more incorrect calculation entries are appropriately identified.

SCHEDULE

TIME	DAY 1	DAY 2
8:00 - 9:00	Introduction, Welcome and Administrative	Unit 3: Water Supplies and Delivery Systems
9:00 - 9:10	*Break*	*Break*
9:10 - 10:40	Unit 1: Preparing for Plans Review Activity 1.1: Drawing/Grid Details	Activity 3.1: Available Stored Water Supply
10:40 - 10:50	*Break*	*Break*
10:50 - 11:55	Activity 1.2: National Fire Protection Association 13 Working Plan Details	Activity 3.2: Verifying National Fire Protection Association 24 Compliance Activity 3.3: Water Supply Effective Point
11:55 - 12:55	*Lunch*	*Lunch*
12:55 - 2:20	Activity 1.3: Finding Gaps in Submittal Packages Unit 2: Hazard Classification Activity 2.1: National Fire Protection Association 13, Sprinkler Hazard Classifications (Part 1)	Activity 3.4: Water Supplies for Sprinkler Systems Unit 4: System Components and Materials
2:20 - 2:35	*Break*	*Break*
2:35 - 5:00	Activity 2.2: National Fire Protection Association 13, Sprinkler Hazard Classifications (Part 2) Activity 2.3: Density/Area Curves Activity 2.4: "Real World" Impacts Activity 2.5: Density/Area Verification	Activity 4.1: Verification Between Plans and Equipment Submittal Activity 4.2: Determining Sprinkler Water Flows

Note: This schedule is subject to modification by the instructors and approved by the training specialist.

TIME	DAY 3	DAY 4
8:00 - 9:00	Unit 5: Fire Sprinkler System Layout	Unit 6: Hydraulic Remote Design Areas
9:00 - 9:10	*Break*	*Break*
9:10 - 10:40	Activity 5.1: Building Construction	Activity 6.1: Verifying Adjusted Remote Areas
10:40 - 10:50	*Break*	*Break*
10:50 - 11:55	Activity 5.2: Verify Sprinkler Spacing	Activity 6.2: Determining the Minimum Length of Remote Area and the Minimum Number of Sprinklers in the Remote Area
11:55 - 12:55	*Lunch*	*Lunch*
12:55 - 2:20	Activity 5.3: Obstructed Construction	Unit 6: Hydraulic Remote Design Areas (cont'd) Unit 7: Evaluating Sprinkler Hydraulic Calculations
2:20 - 2:35	*Break*	*Break*
2:35 - 4:00	Activity 5.4: Compartments and Small Rooms	Unit 7: Evaluating Sprinkler Hydraulic Calculations (cont'd)

TIME	DAY 5
8:00 - 9:00	Activity 7.1: Formula Exercise
9:00 - 9:10	*Break*
9:10 - 10:40	Activity 7.2: Hydraulic Calculations
10:40 - 10:50	*Break*
10:50 - 11:55	Activity 7.2: Hydraulic Calculations (cont’d) Activity 7.3: Reviewing Calculations for Plans
11:55 - 12:55	*Lunch*
12:55 - 2:20	Activity 7.3: Reviewing Calculations for Plans (cont’d)
2:20 - 2:35	*Break*
2:35 - 4:00	Course Review Final Exam Course evaluation Course graduation

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FIREFIGHTER CODE OF ETHICS

Background

The Fire Service is a noble calling, one which is founded on mutual respect and trust between firefighters and the citizens they serve. To ensure the continuing integrity of the Fire Service, the highest standards of ethical conduct must be maintained at all times.

Developed in response to the publication of the Fire Service Reputation Management White Paper, the purpose of this National Firefighter Code of Ethics is to establish criteria that encourages fire service personnel to promote a culture of ethical integrity and high standards of professionalism in our field. The broad scope of this recommended Code of Ethics is intended to mitigate and negate situations that may result in embarrassment and waning of public support for what has historically been a highly respected profession.

Ethics comes from the Greek word ethos, meaning character. Character is not necessarily defined by how a person behaves when conditions are optimal and life is good. It is easy to take the high road when the path is paved and obstacles are few or non-existent. Character is also defined by decisions made under pressure, when no one is looking, when the road contains land mines, and the way is obscured. As members of the Fire Service, we share a responsibility to project an ethical character of professionalism, integrity, compassion, loyalty and honesty in all that we do, all of the time.

We need to accept this ethics challenge and be truly willing to maintain a culture that is consistent with the expectations outlined in this document. By doing so, we can create a legacy that validates and sustains the distinguished Fire Service institution, and at the same time ensure that we leave the Fire Service in better condition than when we arrived.

FIREFIGHTER CODE OF ETHICS

I understand that I have the responsibility to conduct myself in a manner that reflects proper ethical behavior and integrity. In so doing, I will help foster a continuing positive public perception of the fire service. Therefore, I pledge the following…

- Always conduct myself, on and off duty, in a manner that reflects positively on myself, my department and the fire service in general.
- Accept responsibility for my actions and for the consequences of my actions.
- Support the concept of fairness and the value of diverse thoughts and opinions.
- Avoid situations that would adversely affect the credibility or public perception of the fire service profession.
- Be truthful and honest at all times and report instances of cheating or other dishonest acts that compromise the integrity of the fire service.
- Conduct my personal affairs in a manner that does not improperly influence the performance of my duties, or bring discredit to my organization.
- Be respectful and conscious of each member's safety and welfare.
- Recognize that I serve in a position of public trust that requires stewardship in the honest and efficient use of publicly owned resources, including uniforms, facilities, vehicles and equipment and that these are protected from misuse and theft.
- Exercise professionalism, competence, respect and loyalty in the performance of my duties and use information, confidential or otherwise, gained by virtue of my position, only to benefit those I am entrusted to serve.
- Avoid financial investments, outside employment, outside business interests or activities that conflict with or are enhanced by my official position or have the potential to create the perception of impropriety.
- Never propose or accept personal rewards, special privileges, benefits, advancement, honors or gifts that may create a conflict of interest, or the appearance thereof.
- Never engage in activities involving alcohol or other substance use or abuse that can impair my mental state or the performance of my duties and compromise safety.
- Never discriminate on the basis of race, religion, color, creed, age, marital status, national origin, ancestry, gender, sexual preference, medical condition or handicap.
- Never harass, intimidate or threaten fellow members of the service or the public and stop or report the actions of other firefighters who engage in such behaviors.
- Responsibly use social networking, electronic communications, or other media technology opportunities in a manner that does not discredit, dishonor or embarrass my organization, the fire service and the public. I also understand that failure to resolve or report inappropriate use of this media equates to condoning this behavior.

Developed by the National Society of Executive Fire Officers

A Student Guide to End-of-course Evaluations

Ten Things You Can Do to Improve the National Fire Academy

The National Fire Academy takes its course evaluations very seriously. Your comments and suggestions enable us to improve your learning experience.

Unfortunately, we often get end-of-course comments like these that are vague and, therefore, not actionable. We know you are trying to keep your answers short, but the more specific you can be, the better we can respond.

Actual quotes from student evaluations:	Examples of specific, actionable comments that would help us improve the course:
1 "Update the materials."	• The (ABC) fire video is out-of-date because of the dangerous tactics it demonstrates. The available (XYZ) video shows current practices. • The student manual references building codes that are 12 years old.
2 "We want an advanced class in (fill in the blank)."	• We would like a class that enables us to calculate energy transfer rates resulting from exposure fires. • We would like a class that provides one-on-one workplace harassment counseling practice exercises.
3 "More activities."	• An activity where students can physically measure the area of sprinkler coverage would improve understanding of the concept. • Not all students were able to fill all ICS positions in the exercises. Add more exercises so all students can participate.
4 "A longer course."	• The class should be increased by one hour per day to enable all students to participate in exercises. • The class should be increased by two days so that all group presentations can be peer evaluated and have written abstracts.
5 "Readable plans."	• The plans should be enlarged to 11 by 17 and provided with an accurate scale. • My plan set was blurry, which caused the dotted lines to be interpreted as solid lines.
6 "Better student guide organization," "manual did not coincide with slides."	• The slide sequence in Unit 4 did not align with the content in the student manual from slides 4-16 through 4-21. • The instructor added slides in Unit 4 that were not in my student manual.
7 "Dry in spots."	• The instructor/activity should have used student group activities rather than lecture to explain Maslow's Hierarchy. • Create a pre-course reading on symbiotic personal relationships rather than trying to lecture on them in class.
8 "More visual aids."	• The text description of V-patterns did not provide three-dimensional views. More photographs or drawings would help me imagine the pattern. • There was a video clip on NBC News (date) that summarized the topic very well.
9 "Re-evaluate pre-course assignments."	• The pre-course assignments were not discussed or referenced in class. Either connect them to the course content or delete them. • The pre-course assignments on ICS could be reduced to a one-page job aid rather than a 25-page reading.
10 "A better understanding of NIMS."	• The instructor did not explain the connection between NIMS and ICS. • The student manual needs an illustrated guide to NIMS.

UNIT 1: PREPARING FOR PLANS REVIEW

TERMINAL OBJECTIVE

The students will be able to:

1.1 Evaluate the materials for completeness and compliance with locally and nationally recognized design standards given a sample fire sprinkler plans submittal package.

ENABLING OBJECTIVES

The students will be able to:

1.1 Conclude if the appropriate National Fire Protection Association (NFPA) standards specific to sprinkler and standpipe systems are selected.

1.2 Explain plan symbols, notes and details found on the site drawings and the shop drawings.

1.3 Validate the basic submittal package for compliance with locally adopted rules and standards, or special rulings.

1.4 Identify special supplemental information that may be required.

1.5 Evaluate the basic submittal package completeness to approve or reject the submittal.

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FEMA

U.S. Fire Administration

UNIT 1: PREPARING FOR PLANS REVIEW

Slide 1-1

TERMINAL OBJECTIVE

Evaluate the materials for completeness and compliance with locally and nationally recognized design standards given a sample fire sprinkler plans submittal package.

Slide 1-2

ENABLING OBJECTIVES

- Conclude if the appropriate National Fire Protection Association (NFPA) standards specific to sprinkler and standpipe systems are selected.
- Explain plan symbols, notes and details found on the site drawings and the shop drawings.

Slide 1-3

ENABLING OBJECTIVES (cont'd)

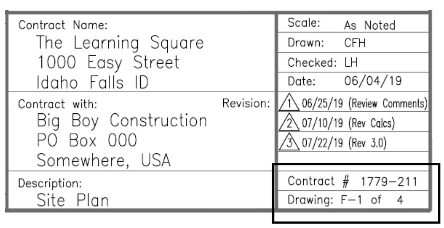
- Validate the basic submittal package for compliance with locally adopted rules and standards, or special rulings.
- Identify special supplemental information that may be required.
- Evaluate the basic submittal package completeness to approve or reject the submittal.

Slide 1-4

I. PROJECT ORIENTATION

PROJECT ORIENTATION

- Sheet numbers.
  - S.
  - C.
  - FP.
  - E.



SHEET F-1
GRID R-18

Slide 1-5

A. Sheet/Drawing numbers: General industry practice is to use the first letter to identify the sheet's primary content:

1. S = Site plan.

2. C = Civil drawings.

3. F or FP = Fire protection.

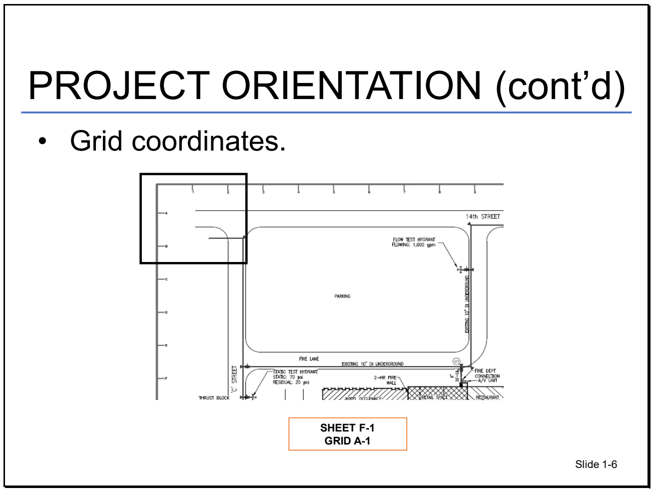
4. A = Architectural.

5. P = Plumbing.

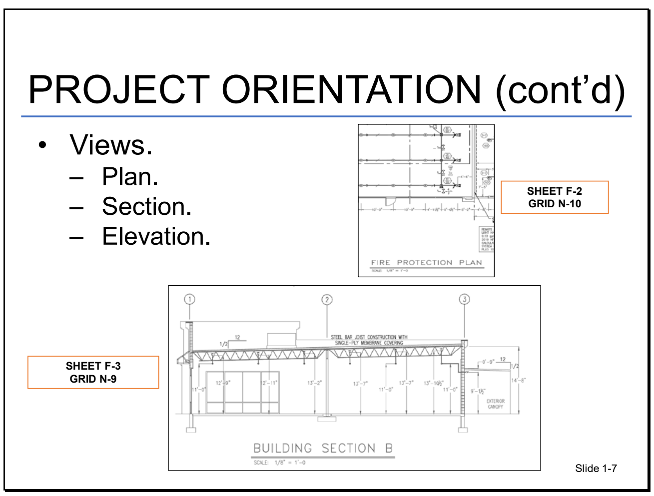
6. E = Electrical.

7. M = Mechanical.

8. L = Landscaping.



B. Plan grid coordinates are used to quickly find plan details.

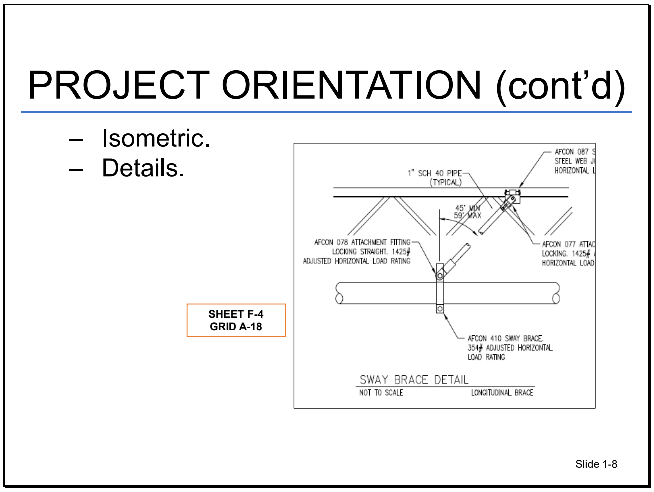


C. Common "views" are:

1. Plan view: as if looking down from above with the roof removed.

2. Section view: as if there is an imaginary "slice" through the building.

3. Elevation view: a building rendering of the outside walls. (There are none in this plans set.)



4. Isometric or orthographic view: sometimes called "three-dimensional" to add perspective. (There are none in this plans set.)

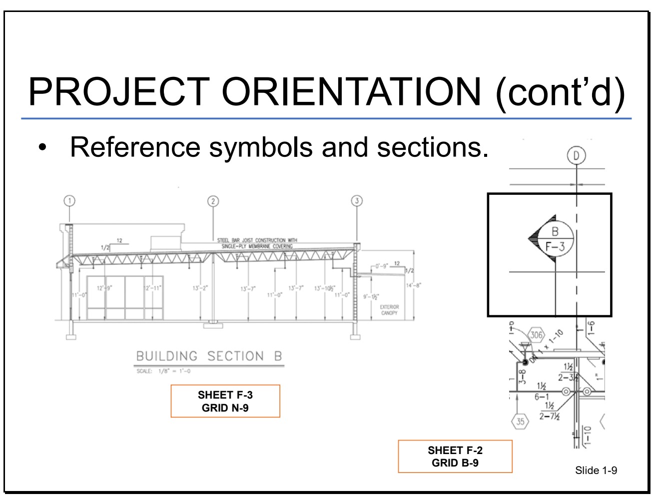
5. Details: enlargements of specific information to provide greater clarity.

   Examples found on (Sheet F-1, B/I-17/23): finished sprinkler heads.

6. Additional details can be found on:

   a. Examples found on (Sheet F-3, M/Q-2/6): "Rooster tail."

   b. Examples found on (Sheet F-4): hangers, bracing, pipe.



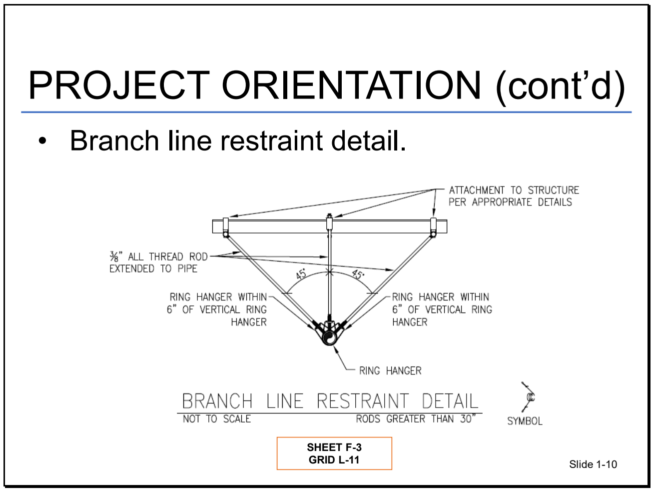
D. Reference symbols (Sheet F-2, B-9).

   1. These reference symbols are used to coordinate elements from various views to help the installer and reviewer understand the plans. (The following note pertains to the restaurant grid coordinate system added by the sprinkler designer.)

2. Reference symbols having the circle with the letter “B” in the circle above the “F-3” explain to the installer and reviewer that another view of this element can be found at Detail B on Sheet F-3.

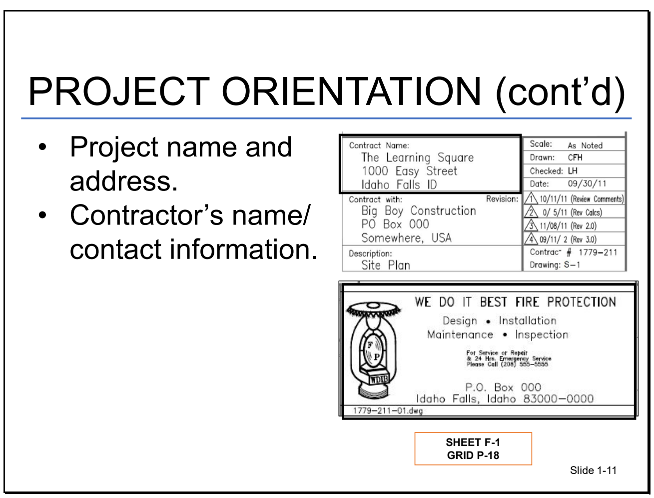
E. Sections (Sheet F-3, N-9).

Enable building or ceiling heights to be determined.



F. Branch line restraint detail (Sheet F-3, L-11).

Shows how branch lines will be supported by the structure.



G. Project name and address (Sheet F-1, P-18).

This information is repeated on sheets F-1 through F-4.

H. Installing contractor’s name and contact information (Sheet F-1, Q/R-18 to 23).

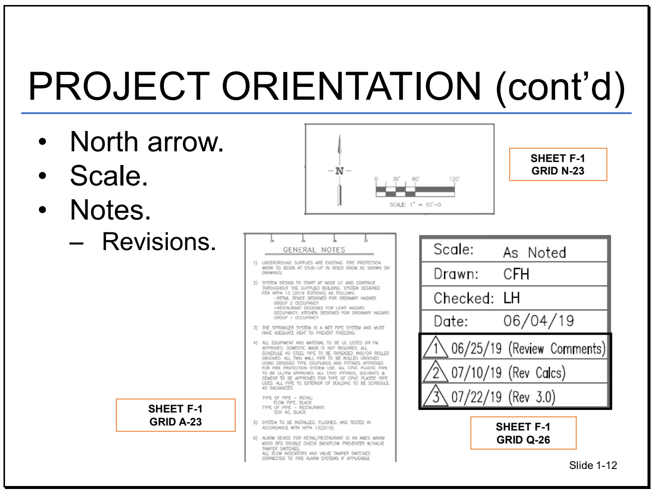
1. License number (if required).

2. Designer stamps and seals (if required).

    a. Contractor licensure and plans that are stamped or sealed by the designer are a state or local requirement. National Fire Protection Association (NFPA) 13, *Standard for the Installation of Sprinkler Systems*, does not require either one.

    b. Inspectors should confirm with their state or local licensing agencies whether these credentials are required.

    c. There is more discussion on this later in this unit.



I. North arrow and scale.

1. A north arrow should be included to help reviewers become oriented to the project's location and arrangement.

2. Scale is used to measure distances and lengths.

    a. Site plans generally are done with "engineering" scales because of the longer distances represented (Sheet F-1, N-23).

    b. Building drawings generally are done with "architectural" scales for more precision. Examples found on (Sheets F-2 and F-3, M/O-24/27).

3. Dimensions provided on plans always take precedence over scaled dimensions.

J. General notes (Sheet F-1, A-23).

1. General notes often accompany plans to provide overall project description and information that may not appear graphically on the drawings.

2. General notes routinely are copied from one set of plans to another, so careful attention to detail is important to confirm that the notes pertain to the project that is being reviewed.

3. It is common to find general notes transferred from another project that reference out-of-date code and standard editions, codes and standards from other jurisdictions, and requirements that reference other codes and standards such as NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*; NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*; and NFPA 22, *Standard for Water Tanks for Private Fire Protection*.

4. General notes are as much of the project as the plans and should be enforced.

   a. It is common to find notes such as "All hangers in accordance with NFPA 13" or "Valve supervision in accordance with NFPA 13 and NFPA 72" and not include the details on the plans.

   b. Students are encouraged to reject these vague notes because the responsibility for compliance falls on the installer and inspector. It is the designer's responsibility to include this information on the plans.

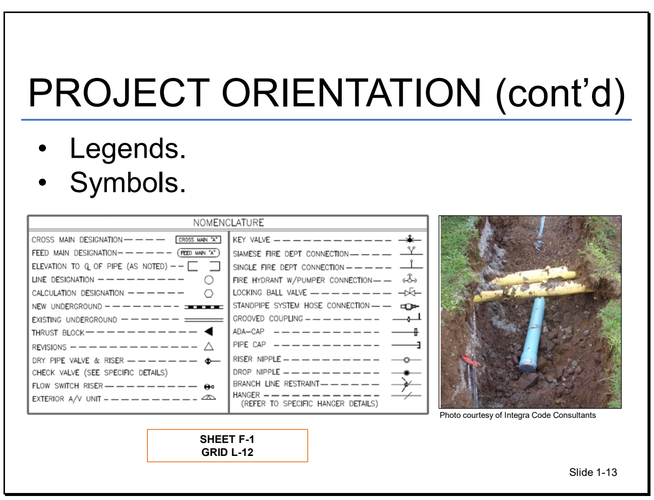
K. Revisions (Sheets F-1 through F-4, P/R-26/28).

1. Included to describe changes to the original drawing.

2. There is no standard revision labeling the method employed; designers are free to choose their own method.

   On this set, they are numbered, dated and marked on plans with a triangle.

3. Often demarcated on the drawing with a cloud.



L. Legends (Sheet F-1, L-12).

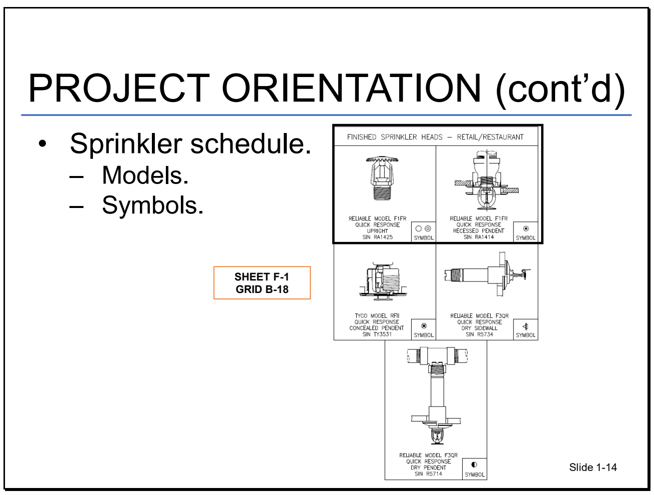
1. Provide tabular format to explain additional information.

2. On this submittal, the “Equipment and Device Legend” provides a list of fire protection system components that will be provided. Often, information on equipment and devices will be provided only as manufacturer’s product literature in the project submittal.

M. Symbols (Sheet F-1, L-12).

1. Labeled on this plan as “Nomenclature.”

2. Symbols are visual representations of the various components that will appear in the final installation. Note that while NFPA 170, *Standard for Fire Safety and Emergency Symbols*, is a referenced document within NFPA 13, industry practices do not always comply with it, and designers often use their own symbol sets.



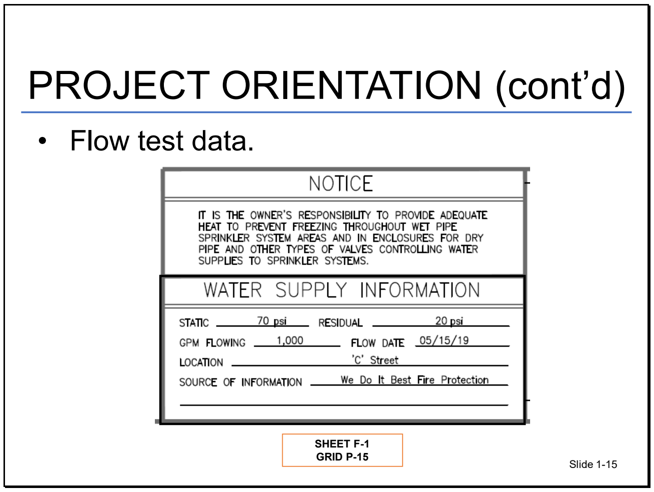
N. Sprinkler schedule (Sheet F-1, B-18).

1. Make/Model/Orientation.

2. Plan symbol.

3. Sprinkler Identification Number (SIN).

SIN will be explained in more detail in Unit 6: Hydraulic Remote Design Areas and Unit 7: Evaluating Sprinkler Hydraulic Calculations.



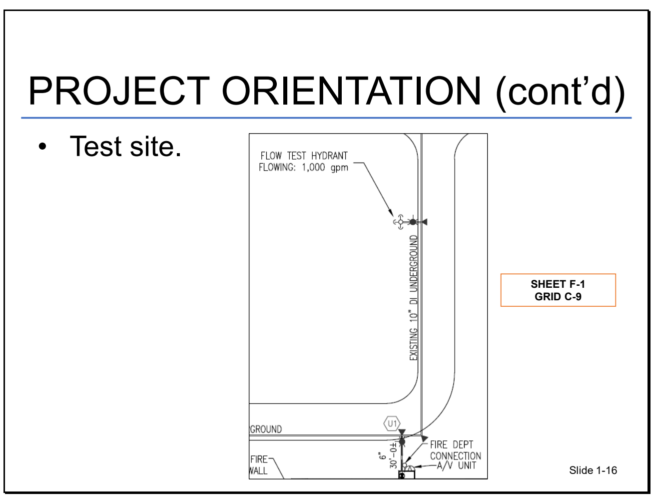
O. Water flow test data (Sheet F-1, P-15).

1. Pressure and flow.

2. Test date.

3. Test location.

4. Testing entity.



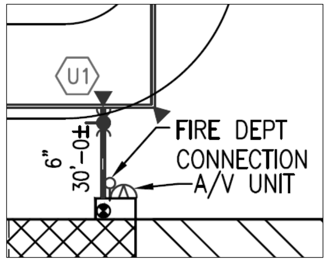
P. Test site (Sheet F-1, C-9).

1. Verify proximity to the project site.

2. Confirm that it is taken from the same water distribution system.

PROJECT ORIENTATION (cont'd)

- Sprinkler tap.
  - "Lead in."
- Fire department connection (FDC).



SHEET F-1
GRID F-9

Slide 1-17

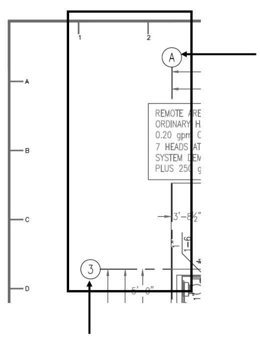
Q. Fire department connection (FDC) and sprinkler tap or "lead in" (Sheet 1, F-9).

The point where the underground supply line connects to the supply and enters the building.

PROJECT ORIENTATION (cont'd)

- Coordinate transition.
  - Designer's option.

SHEET F-2
GRID A-2



Slide 1-18

PROJECT ORIENTATION (cont'd)

- Sprinkler distribution.

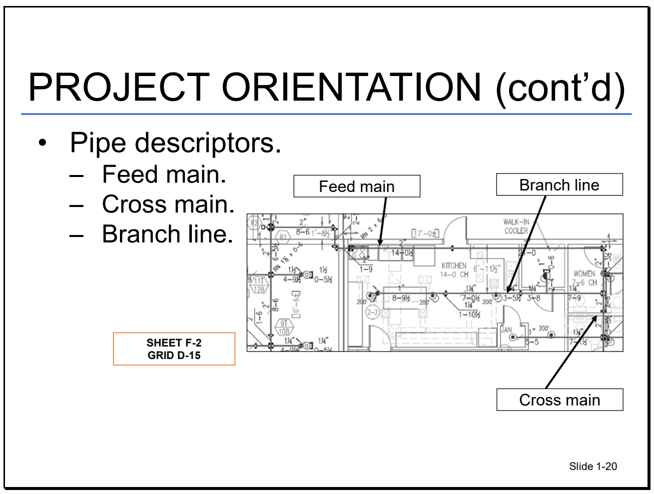
HEAD COUNT							
Sprinkler	Type	Fin.	K–Fac.	Can	Temp.	Symb.	Qty.
Retail Space							
Reliable F1FR56	Pendent	White	5.6	White	155°	◉	12
Tyco RFII	Pendent	White	5.6	White	155°	⊗	3
Reliable F1FR56	Upright	Brass	5.6	---	200°	◎	55
Reliable F1FR56	Upright	Brass	5.6	---	200°	○	1
Reliable F3QR	Sidewall	Brass	5.6	Brass	200°	◁	9
Total – Retail Space							80
Restaurant							
Reliable F1FR56	Pendent	Brass	5.6	White	155°	◉	31
Reliable F1FR56	Pendent	Brass	5.6	White	200°	◉ 200°	6
Reliable F3QR	Pendent	Brass	5.6	White	155°	◐	1
Reliable F1FR56	Upright	Brass	5.6	---	200°	○	31
Total – Restaurant							69

SHEET F-2
GRID P-14

Slide 1-19

R. Sprinkler distribution (Sheet F-2, P-14).

1. Make, model.
2. Orientation (type).
3. K-factor.
4. Cover plate color.
5. Temperature rating.
6. Plan symbol.
7. Number of sprinklers per plan sheet.

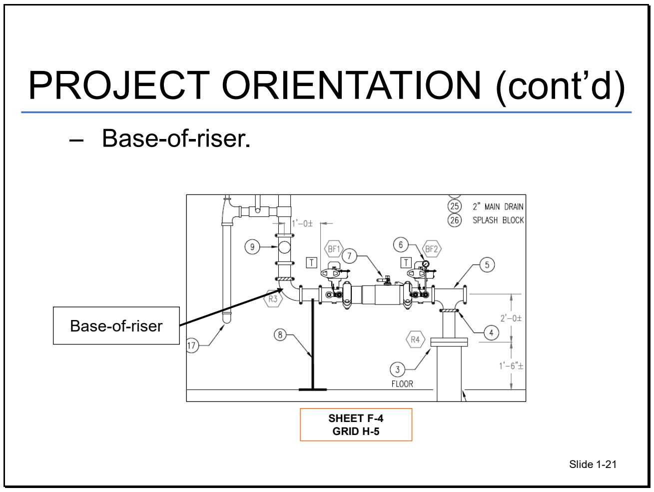


S. Pipe descriptors (Sheet F-2, D-15).

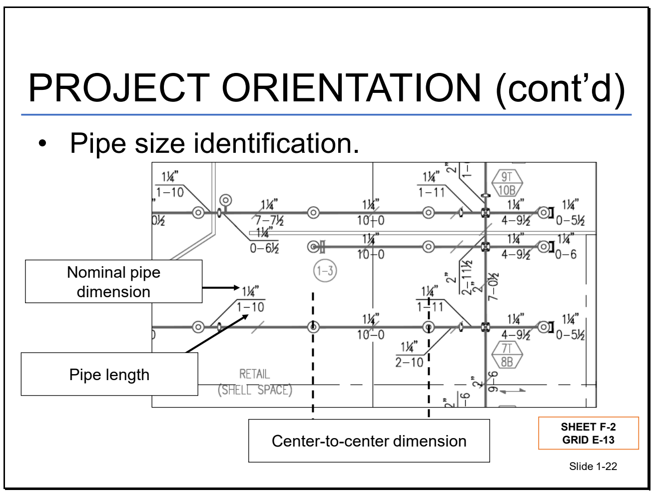
1. Feed mains.
    a. Pipes supplying cross mains.
    b. Also called bulk mains or express mains.
2. Cross mains.

    Pipes supplying the branch lines.
3. Branch lines.

    Pipes supplying sprinklers.



4. Base-of-riser (Sheet F-4, H-5).



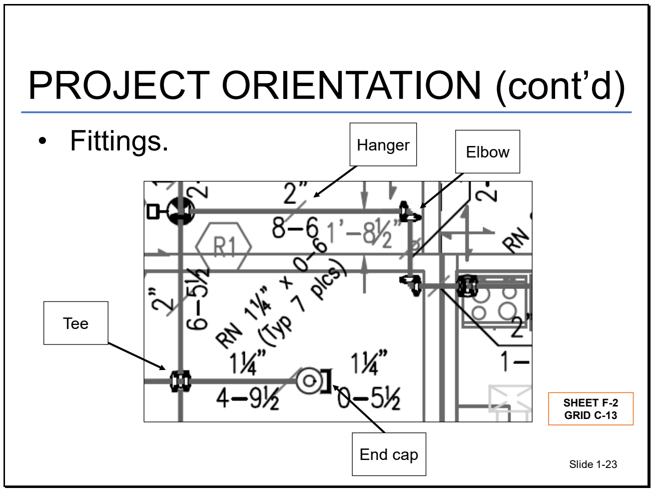
T. Pipe size identification (Sheet F-2, E-13).

1. Call-out describes two values:

a. Upper value is pipe nominal dimension (1 1/4 inches).

b. Lower value is length in feet and inches (1 foot, 10 inches).

2. Dotted lines represent center-to-center measurements between sprinklers (10 feet).



U. Fittings (Sheet F-2, C-13).

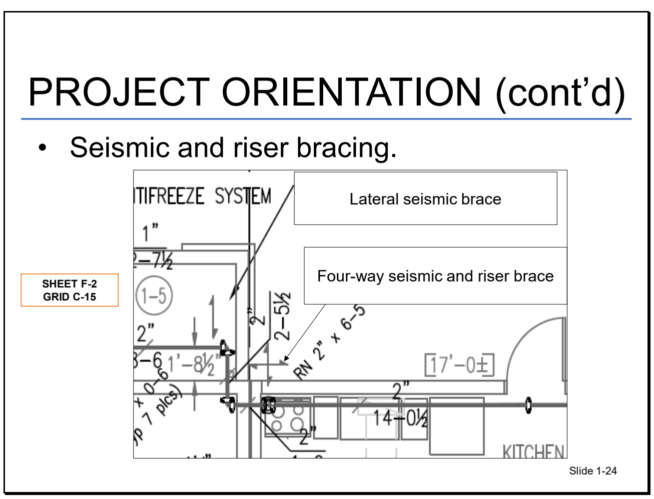
1. Pipe hanger (diagonal line across branch line).

2. Tee.

3. Elbow.

4. End cap (for internal pipe inspection).

5. Verifying that the fittings shown on the plans correspond with the "as-built" conditions is important because of their potential impact on the hydraulic calculations.



V. Seismic and riser bracing (Sheet F-2, C-15).

1. Seismic bracing to prevent sprinkler pipe movement is common in the western United States where earthquakes are common, but it is rare east of the Mississippi River.

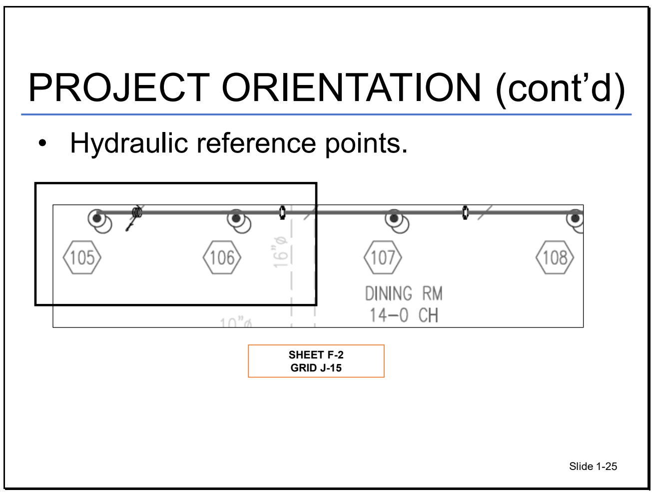
2. While the sprinkler design standards describe how to install seismic bracing, students should refer to their local building codes to learn where and when it is required.

3. Four-way seismic or riser brace.

   A four-way brace is required at the top of all risers, regardless if the rest of the system requires seismic bracing.

4. Lateral seismic brace.

5. Longitudinal seismic braces are represented by double-arrow lines parallel to the sprinkler pipe (not shown on this detail).



W. Hydraulic reference points (nodes) (Sheet F-2, J-15).

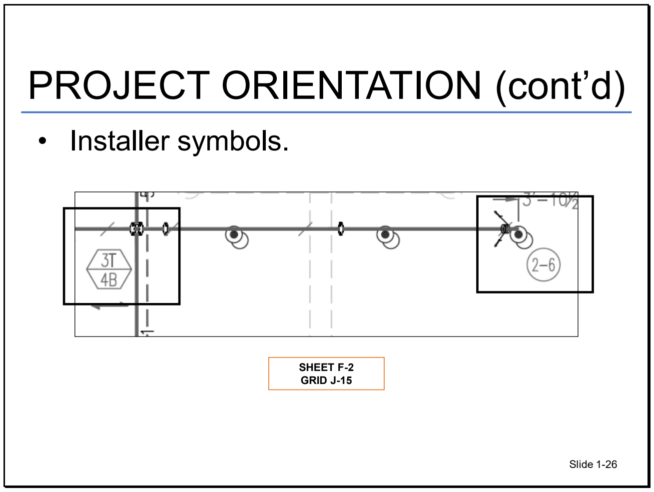
Identify the point in the water flow where something affects pressure and volume.

1. Sprinkler discharge.

2. Elbows.

3. Tees.

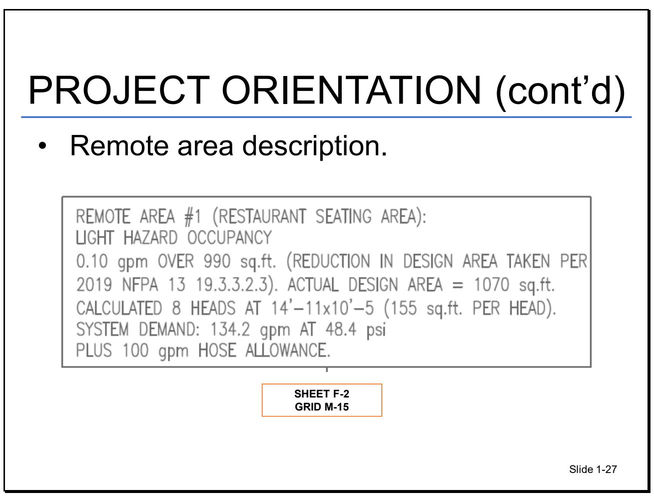
4. Fittings.



X. Installer symbols and notes (Sheet F-2, J-15).

1. These are often notes or comments from the designer to the installer to ensure that the correct pipe is installed in the correct location.

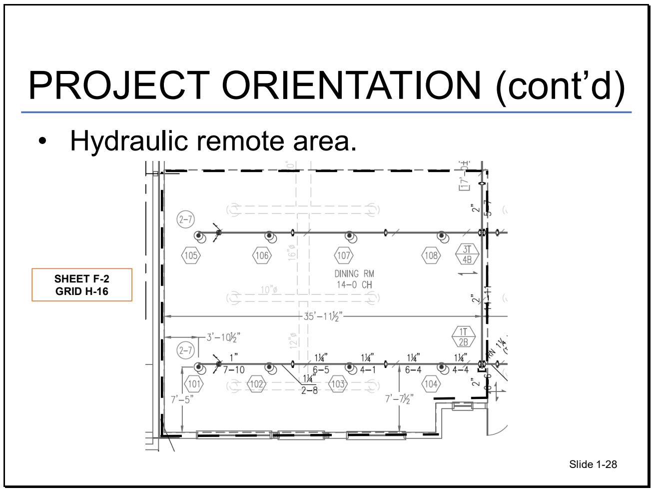
2. Pre-cut pipe from a production facility may be marked for identification with numbers, colors or another identifier.



Y. Remote area description.

Note: Remote area describes the portion of the sprinkler system where it is hydraulically most difficult to deliver water at adequate volume and pressure.

1. Includes details on how the hydraulic remote area was determined.



2. Dining room hydraulic remote area (Sheet F-2, H-16).

3. Generally demarcated with dashed lines.

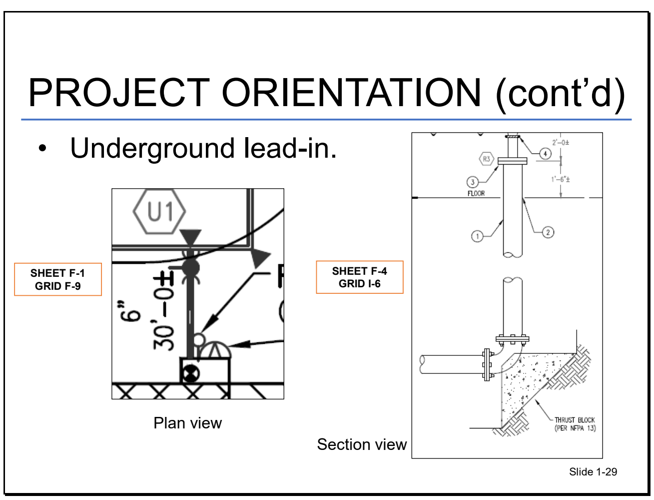
   This drawing set has four hydraulic remote areas.

   a. The restaurant dining area.

   b. Retail A-2 at the west end of the building.

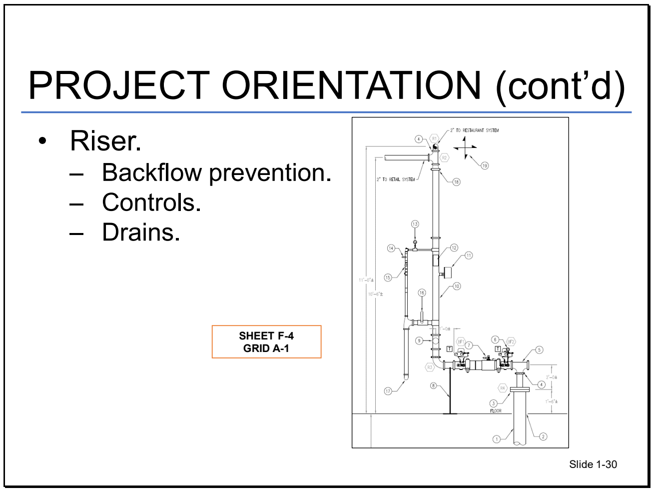
   c. South half of the retail area (shell space).

   d. Exterior covered storage.



Z. Equipment details (Sheet F-1, F-9 and Sheet F-4, I-6).

1. Supply water main (lead-in) in plan and section views.



2. Riser (Sheet F-4, A-1).

   a. Primary control point for sprinkler system.

   b. May include:

      - Backflow prevention device.

      - Sprinkler main controls.

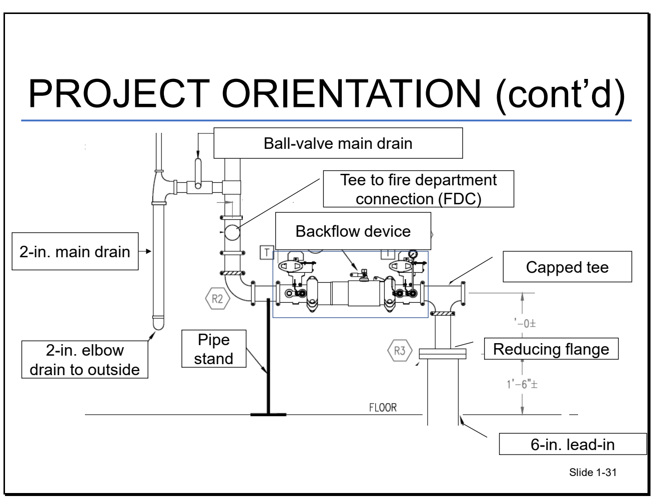
      - Main drain/test drain.

      - Gauges.

      - Signs.

         -- Hydraulic nameplate.

         -- General design data sign.



3. Lower riser components.

   a. Six-inch underground supply (lead-in).

   b. Six-inch by 3-inch reducing flange.

   c. Six-inch tee with cap for flushing underground main.

   d. Backflow prevention device with supervised indicating valves at both ends.

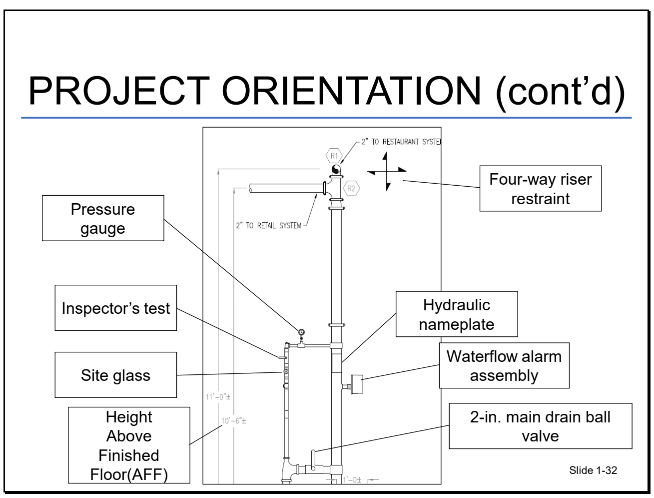
   e. Tee outlet to FDC.

   f. Pipe stand to support backflow preventer and base-of-riser.

   g. Two-inch main drain line with quarter-turn ball valve control.

   h. Two-inch main drain line.

   i. Two-inch elbow to allow main drain to discharge outdoors.



4. Upper riser information and components.

   a. Height measurements Above Finished Floor (AFF).

      - Be aware that "AFF" is a common abbreviation you will see on fire protection system plans.

   b. Site glass for viewing main drain discharge.

   c. Inspector's test assembly.

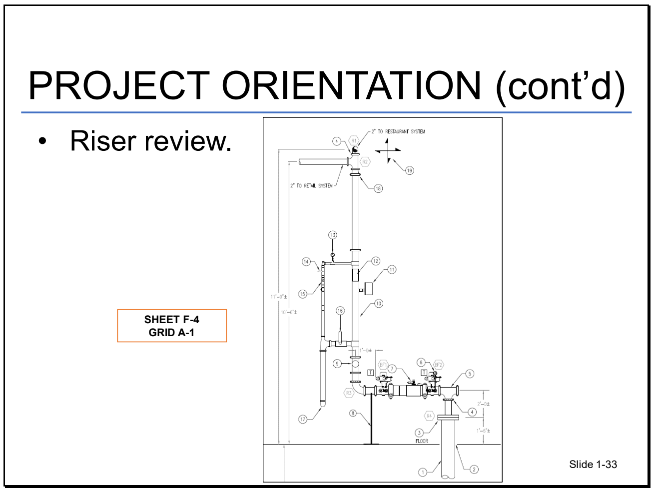
d. Water pressure gauge.

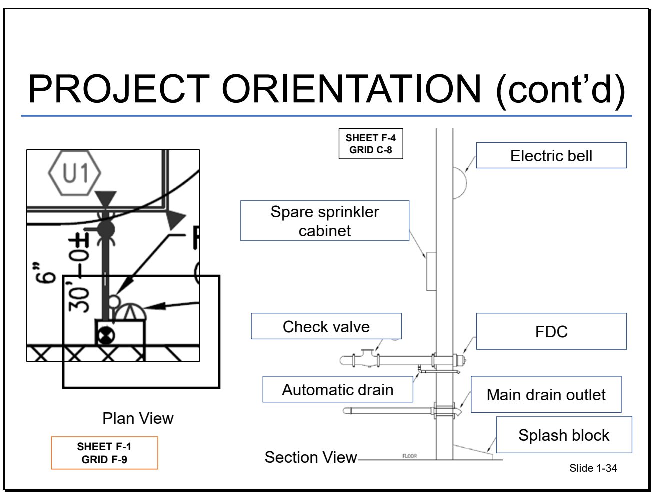
e. Four-way riser restraint to prevent riser movement and provide seismic bracing.

f. Hydraulic nameplate.

g. Electronic waterflow assembly (flow switch).

h. Two-inch main drain ball valve.





AA. FDC elevation (Sheet F-1, F-9 and Sheet F-4, C-8).

1. Electric waterflow alarm bell mounted outdoors.

2. Spare sprinkler cabinet.

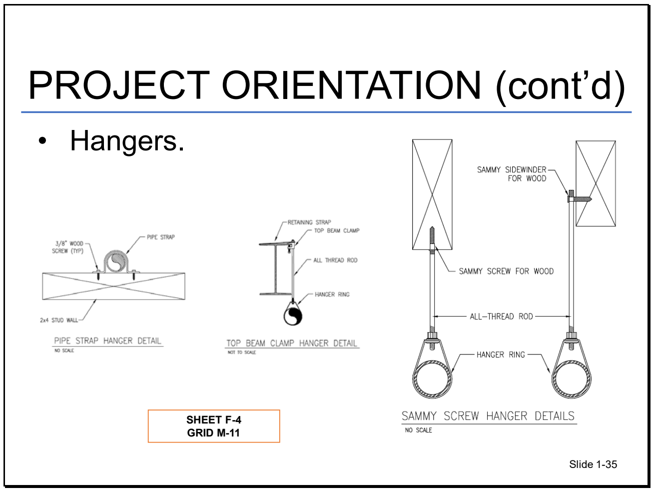
3. Check valve in FDC line.

4. Automatic drain valve assembly for FDC line.

5. Splash block to prevent damage during main drain tests.

6. Main drain outlet.

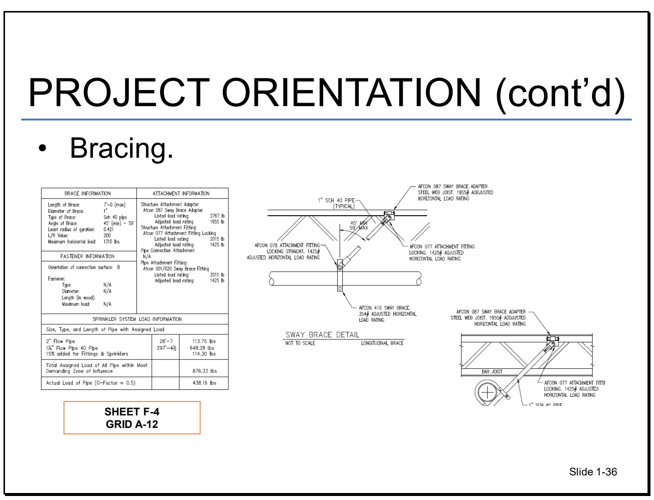
7. FDC.



BB. Hanger details (Sheet F-4, M-11).

1. Hangers connect sprinkler pipe to structural supports.

2. Generally, one hanger for each piece of pipe.



CC. Sway or seismic bracing details (Sheet F-4, A-12).

1. Where required by seismic analysis or building code, allow sprinkler pipe to move synchronously with building during earthquakes.

2. Attached to feed and cross mains.

3. Bracing is installed:

    a. Four-way: at riser tops.

    b. Laterally: perpendicular to sprinkler pipe.

    c. Longitudinally: parallel to sprinkler pipe.

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ACTIVITY 1.1

Drawing/Grid Details

Purpose

Orient students with grid and drawing designations.

Directions

Using The Learning Square plans, work in your group to answer the following questions. Be prepared to explain your group's answers to the class.

1. On Sheet F-1, what appears near the grid coordinates of C-9?

___

___

___

2. On Sheet F-1, along the 10-inch DI underground main along grid line A, what does the symbol at intersecting point 12 most nearly represent?

___

___

___

3. On Sheet F-3, the kitchen ceiling elevation can be found nearest which grid coordinates?

___

___

___

4. On Sheet F-2, what is the nearest grid coordinate for the sprinkler system FDC for retail (shell space)?

___

___

___

5. On Sheet F-1, near the grid coordinates E/F-8/9, what does the hexagonal symbol represent?

____

____

____

6. On Sheet F-2, what is the value of the number inside the calculation designation symbol at grid coordinates J/K-19?

____

____

____

7. What piece of equipment can be found between grid lines D and E and intersecting points 18 and 19 on Sheet F-2?

____

____

____

8. Sheet F-1 includes a "line designation symbol." Using those symbols, what note can be found at the grid coordinates of E/F-22 of Sheet F-2?

____

____

____

9. On Sheet F-1, near the grid coordinates of I-9, what does the solid triangle represent?

____

____

____

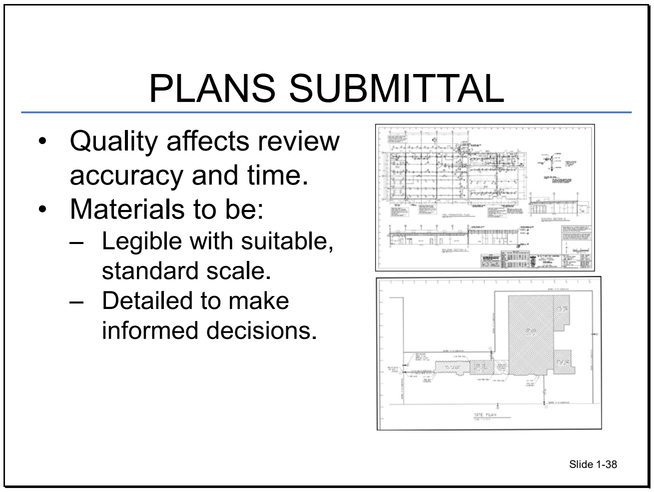
10. On Sheet F-2, what piece of equipment can be found nearest the grid coordinates 13-C?

____

____

____

II. PROPERLY SUBMITTED PLANS

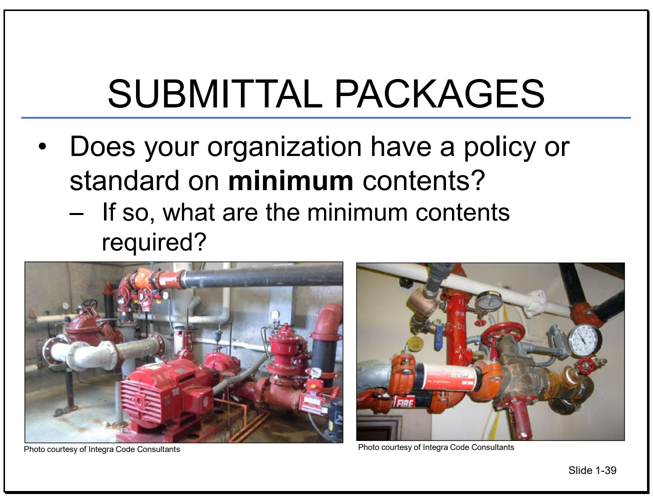


A. Plans submittal.

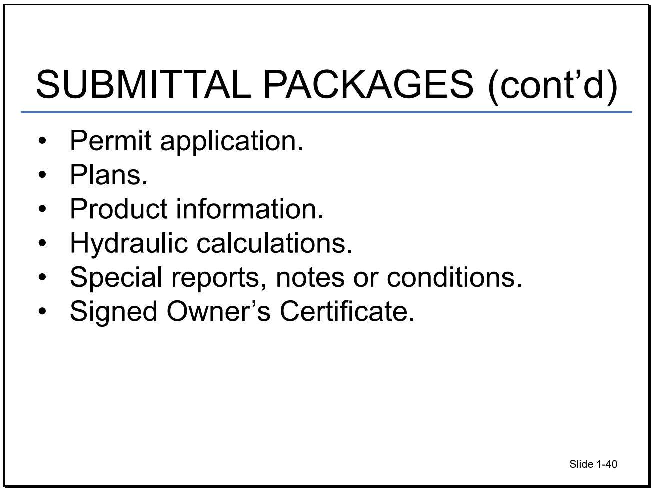
1. The quality of the submitted plans affects the quality of the plans review and ability to shorten turnaround time.

2. Plans must be legible with a suitable and standard scale.

3. Plans must be detailed so the reviewer can make informed decisions.



B. Submittal packages.



1. Permit application.

2. Plans.

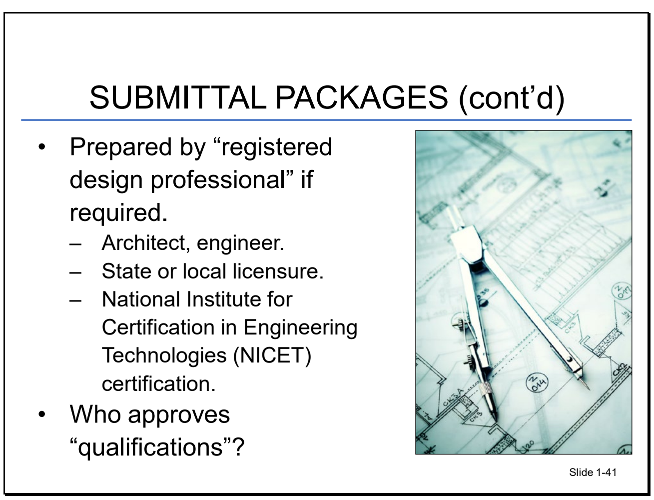
3. Product information.

   Manufacturers' published product information is an important part of the submittal. This will allow the code official to find more information about the uses and limits of materials and equipment that are shown on the plans.

4. Hydraulic calculations.

5. Special reports, notes or conditions.

6. Signed Owner's Certificate.



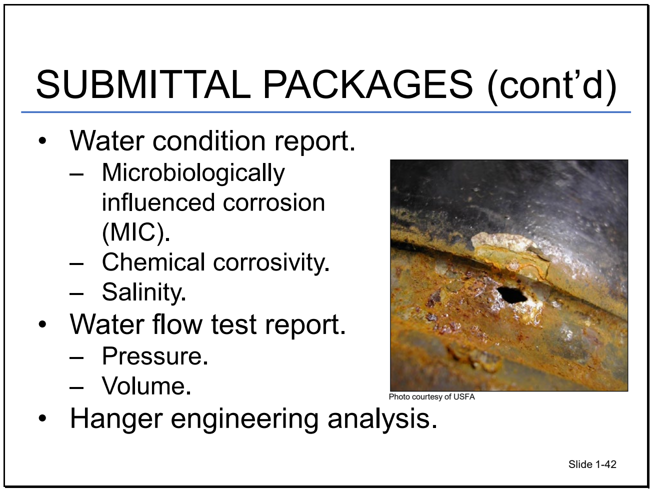
7. Plans may have to be prepared by a "registered design professional" if required by local and state laws. Verify state or local licensure if necessary.

Examples:

a. Professional architect or engineer.

b. State or locally licensed fire protection specialist.

c. National Institute for Certification in Engineering Technologies (NICET) designer.



8. Where special conditions exist, the code official may require additional documents to be prepared by the design professionals.

a. Water condition report of conditions that might affect pipe and equipment performance.

- Microbiologically influenced corrosion (MIC).

- Chemical corrosivity.

- Salinity.

b. Water flow test report.

- Pressure.

- Volume.

c. Hanger engineering analysis to verify:

- Structural ability to handle loads.

- Hanger placement on trusses and other supports.

SUBMITTAL PACKAGES (cont'd)

- Special rulings.
  - Insurance carrier.
  - Owner.
  - Code official.
- Seismic analysis.
- Inerting system requirements.
- Required or optional system.

Photo courtesy of Integra Code Consultants

Slide 1-43

d. Special rulings from other sources.

- Insurance carrier may require additional protection features based on the risk they are underwriting.

- Owner may have special design criteria or spacing requirements for the systems.

- Code official may require additional fire protection.

  -- Water supplies.

  -- Hose stations.

e. Seismic analysis.

- Seismic bracing may be required depending upon the building's underlying soil conditions.

f. Inerting system requirements.

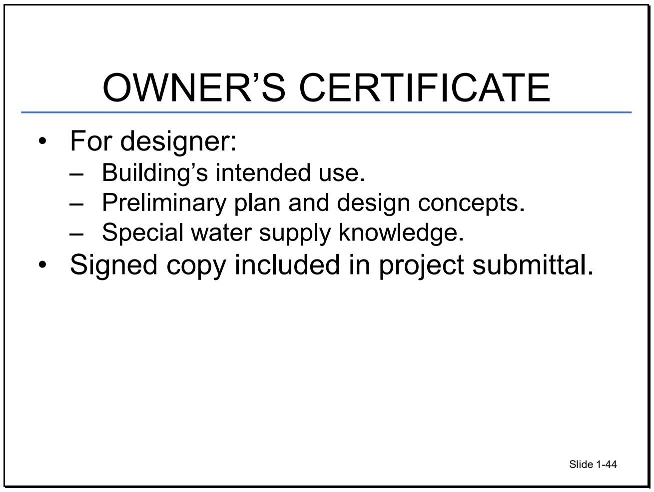
- Where MIC analysis results in recommendations that an inerting system be added, the details should be included.

g. Verification or statement that the system is required by code or is optional.

- Systems that are installed for code compliance, exceptions to code compliancy or alternate methods for code compliance are required systems.

- Nonrequired systems may be installed, but must meet fire and building code requirements.

III. GENERAL INFORMATION PROVIDED



A. Owner's Certificate — for designer:

1. Building's intended use.

   a. Storage heights.

   b. Hazardous materials or operations.

2. Preliminary plan and design concepts.

   a. Building layout.

   b. Construction type.

   c. Areas needing special attention.

3. Special water supply knowledge.

   a. MIC.

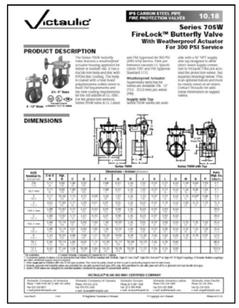
   b. Quality.

   c. Duration.

4. NFPA 13 requires a signed copy of the Owner's Certificate to be included in the plans submittal package.

PRODUCT LITERATURE

- Manufacturer's literature.
  - Cut sheets.
- Installation and listing details:
  - Sprinklers.
  - Valves.
  - Pipe.
  - Fittings.
  - Attachments.



Slide 1-45

B. Product literature.

1. Manufacturer's literature.

   Cut sheets/technical bulletins.

2. Installation and listing details.

   a. Sprinklers.

   b. Valves.

   c. Pipe.

   d. Fittings.

   e. Attachments.

LISTINGS

- Underwriters Laboratories (UL)/Underwriters Laboratories of Canada (ULC).
- Factory Mutual (FM) Global.
- Nationally Recognized Testing Laboratories (NRTLs).
- City and state agencies.

Slide 1-46

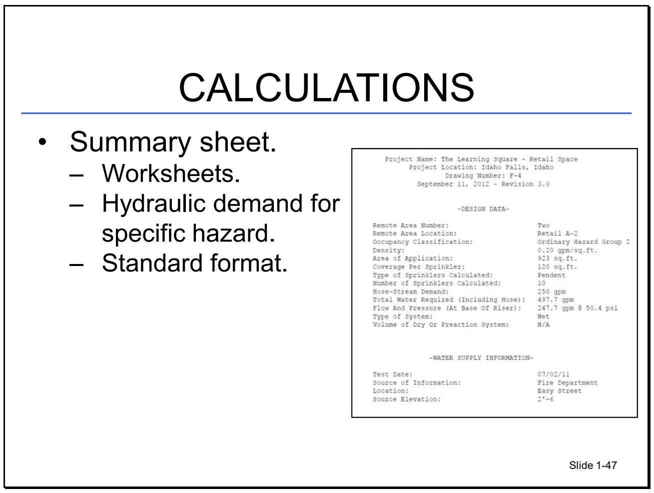
3. Listings.

   a. Underwriters Laboratories (UL)/Underwriters Laboratories of Canada (ULC).

   b. Factory Mutual (FM) Global.

   c. Nationally Recognized Testing Laboratories (NRTLs).

   d. City and state agencies.



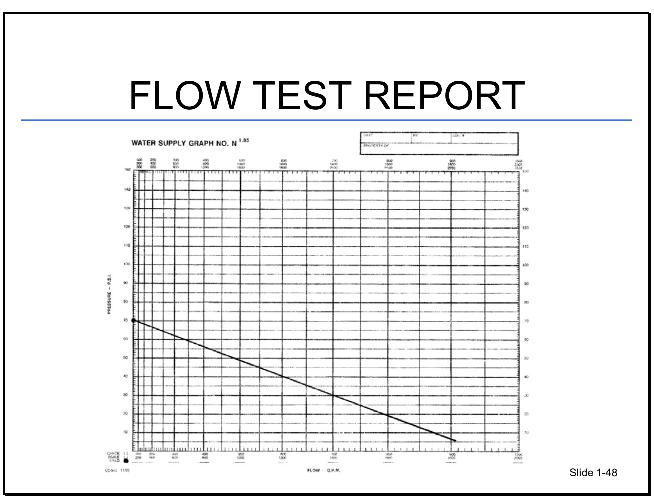
4. Calculations — summary sheet should include:

   a. Standard format.

   b. Cover sheet.

   c. Water supply analysis.

   d. Explanation/Legend of abbreviations.



5. Flow test report.

   a. Contractor is responsible for performing.

   b. No specific time before working plans are submitted.

      - Code official may require the test to be conducted within a specific period of time to ensure that the data reflect current conditions.

   c. Location: same water distribution network that supplies the system.

      - Occasionally, water from different distribution networks or service zones may be installed near the same project. It is essential that the test report be conducted on the distribution system that will supply the sprinklers.

ACTIVITY 1.2

National Fire Protection Association 13 Working Plan Details

Purpose

Identify working plans information and details required by NFPA 13.

Directions

1. Annex A of NFPA 13 includes a list of items that pertain to the system design and must appear on a set of fire sprinkler plans. The entire list has been divided into four small group lists.

2. Using the checklist provided, work in your group and identify those items that appear on The Learning Square plans and supporting documents assigned to your group.

3. Place a check mark in the box next to the described item. Be prepared to explain your group's answers to the class.

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ACTIVITY 1.2 (cont'd)

National Fire Protection Association 13 Working Plan Details Worksheet

Group 1

- ☐ Name and address of contractor.
- ☐ Other water sources.
- ☐ 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.
- ☐ 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.
- ☐ Any small enclosures in which no sprinklers are to be installed.
- ☐ Ceiling/Roof heights and slopes not shown in the full-height cross section.
- ☐ Full-height cross section.
- ☐ Relative elevations of sprinklers, junction points, and supply or reference points.
- ☐ Location and size of riser nipples.
- ☐ Partition locations.
- ☐ Calculation of loads for sizing and details of sway bracing.
- ☐ Kind and location of alarm bells.
- ☐ Total number of sprinklers on each system.

Group 2

- ☐ Hydraulic reference points shown on the plan.
- ☐ A graphic representation of the scale used on all plans.
- ☐ Size and location of standpipe risers, hose outlets, hand hose, monitor nozzles and related equipment.
- ☐ Size, location and piping arrangement of FDCs.
- ☐ Sprinkler make, type, model and nominal K-factor.
- ☐ Total quantity of water and the pressure required noted at a common reference point for each system.
- ☐ If room design method is used, all unprotected wall openings throughout the floor protected.
- ☐ Point of compass.
- ☐ Total area protected by each system on each floor.
- ☐ Make, type, model and size of preaction or deluge valve.
- ☐ Ceiling and roof heights.
- ☐ Location, with street address.
- ☐ City main size and dead-end or circulating.

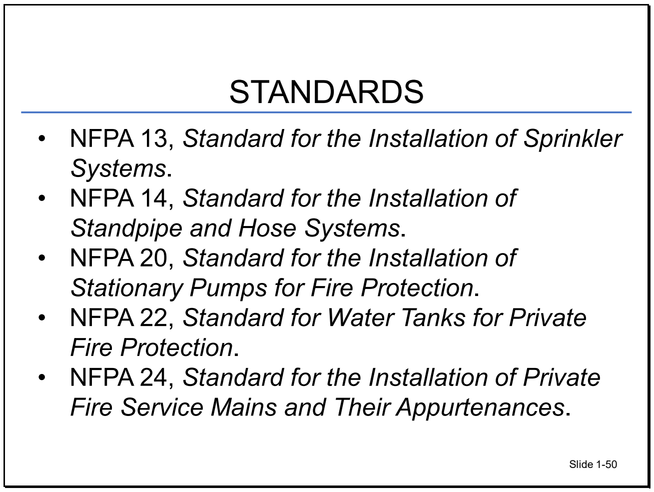
Group 3

- ☐ Occupancy class of each room.
- ☐ For hydraulically designed systems, the information on the hydraulic data nameplate.
- ☐ Approximate capacity in gallons of each dry pipe system.
- ☐ Pipe type and schedule of wall thickness.
- ☐ Type and locations of hangers, sleeves, braces and methods of securing sprinklers when applicable.
- ☐ Make, type, model and size of alarm or dry pipe valve.
- ☐ Sprinkler temperature rating.
- ☐ All control valves, check valves, drain pipes and test connections.
- ☐ The setting for pressure-reducing valves.
- ☐ Size and location of hydrants showing size and number of outlets and if outlets are to be equipped with independent gate valves.
- ☐ Information about listed antifreeze solution used (type and amount).

Group 4

- ☐ Fire wall locations.
- ☐ Enough of the existing system indicated on the plans to make all conditions clear.
- ☐ Location and size of concealed spaces, closets, attics and bathrooms.
- ☐ Piping provisions for flushing.
- ☐ Number of sprinklers on each riser per floor.
- ☐ Nominal pipe size and cutting lengths of pipe (or center-to-center dimensions).
- ☐ Type of fittings and joints and location of all welds and bends.
- ☐ A signed copy of the Owner's Certificate and the working plans 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.
- ☐ Information about backflow preventers (manufacturer, size, type).
- ☐ Edition year of NFPA 13 to which the sprinkler system is designed.

IV. STANDARDS



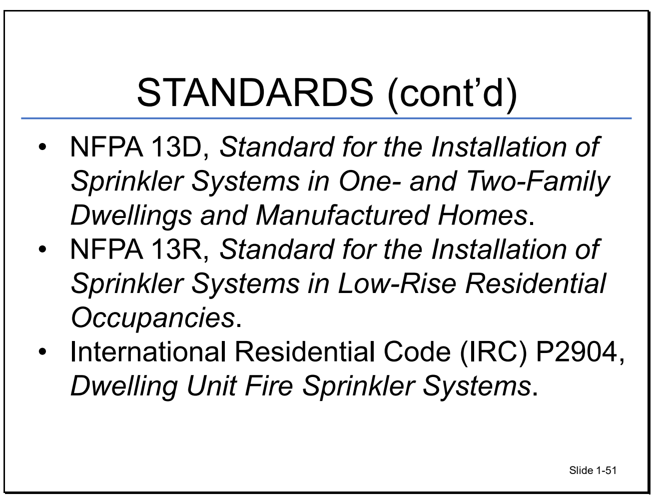
A. NFPA 13.

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

C. NFPA 20.

D. NFPA 22.

E. NFPA 24.



F. NFPA 13 series and International Residential Code (IRC) standards.

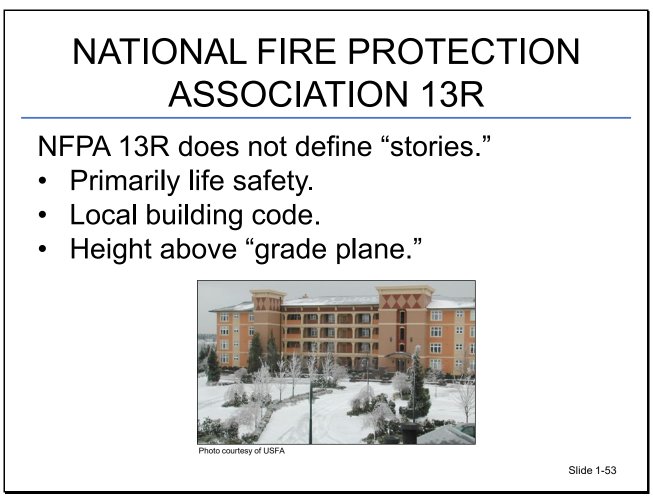
1. These are different design and installation **standards,** not different fire protection **systems.**

2. The building code complexities of where different sprinkler designs are acceptable (e.g., area or height increases, other hazards, etc.) make it imperative that there is agreement among the code officials that the suitable design option is applied.

a. NFPA 13.

- Oldest U.S. sprinkler system standard.

- Intended primarily for property protection.



b. NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies* (formerly "Up to Four Stories in Height").

- Intended primarily for life safety.

- NFPA 13R does not define "stories."

-- Local building code establishes definitions and limitations on stories.

-- To be eligible for NFPA 13R design, buildings are not to exceed 60 feet above "grade plane" as defined in building code.

G. Mixed-use designs.

1. NFPA 13/13R: The project includes elements of NFPA 13 for commercial spaces and NFPA 13R for low-rise residential spaces.

2. In the left photo on the slide, the parking garage should be protected by an NFPA 13 design while the dwelling units above can be protected by a 13R design.

3. NFPA 13 "Residential": employs NFPA 13 entirely and addresses living space protection (sleeping room or dwelling units and adjacent corridors) in accordance with NFPA 13 mid- and high-rise residential design guidance.

   a. In the right photo on the slide, because it is a high-rise, the entire building must be protected with an NFPA 13 design.

   b. NFPA 13 allows some sprinkler omissions in the residential areas, e.g., small bathrooms and small closets.

4. The plans reviewer must coordinate with the building code official to understand **why** the sprinkler system is installed to satisfy the building code, **especially in mixed construction noncombustible and combustible, low-rise buildings such as the one illustrated.**

   a. Life safety: If the sprinkler system is solely for life safety, an NFPA 13R design is suitable.

   b. Area: The sprinkler system may be required to satisfy building code limits on floor area based on the type of construction (combustible or noncombustible).

      - The area calculations will determine if the system design can be NFPA 13R or must be NFPA 13.

   c. Height: The system may be required to satisfy building code limits on height above grade plane or a number of stories based on the type of construction (combustible or noncombustible).

      - The height will establish if the system design can be NFPA 13R or must be NFPA 13.

H. NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*/IRC P2904, *Dwelling Unit Fire Sprinkler Systems*.

1. Sprinkler system designs using NFPA 13D or IRC P2904 are intended for one- and two-family dwellings, manufactured and modular homes, and townhouses.

2. These two standards are outside the scope of this course. If you wish to learn more, consider enrolling in the National Fire Academy (NFA) course on residential sprinkler plans review.

I. NFPA 14.

1. Independent or interconnected to the fire sprinkler system.

2. Influences water pressure and volume demand if connected to the fire sprinkler system.

NATIONAL FIRE PROTECTION ASSOCIATION 20

Stationary pumps for fire protection.

- Fire pumps.
- Booster pumps.

Slide 1-58

J. NFPA 20.

1. Fire pumps.

   Draw water from approved static sources: lakes, ponds, reservoirs, underground, low-elevation tanks, etc.

2. Booster pumps.

   Supplement pressure from incoming water lines that already are pressurized by gravity or utility purveyor pump systems.

NATIONAL FIRE PROTECTION ASSOCIATION 22

Water tanks for private fire protection.

- Elevated.
- Suction.
- Underground.

Photo courtesy of Integra Code Consultants

Slide 1-59

K. NFPA 22.

1. Elevated.

2. Suction.

3. Underground.

NATIONAL FIRE PROTECTION ASSOCIATION 24

Private fire service mains and their appurtenances.

- Water mains.
- Hydrants.
- Hose houses.
- Thrust restraints.

Photo courtesy of Integra Code Consultants

Slide 1-60

L. NFPA 24.

1. Water mains.

2. Hydrants.

3. Hose houses.

4. Thrust restraints (thrust blocks).

LOCAL POLICIES/STANDARDS

- Model codes/standards provide generic requirements.
- Locally adopted code grants policy-writing authority.
  - Adopted and enforced by legally recognized process.
  - May be annulled at state level.

Slide 1-61

M. Local policies/standards.

1. Model codes/standards provide generic requirements based on a consensus national, or even international, process. They cannot anticipate all conditions that might arise.

2. Locally adopted codes may grant policy-writing authority. The code official can write policies to address specific local conditions such as topography, climate, and fire services capacity and capability.

3. These policies can address what the fire code official will "approve" under various conditions and clarify minimum standards for that particular jurisdiction.

   a. Adopted and enforced by legally recognized process as part of the authority granted by the administrative sections of the fire code.

   b. Policy-making authorities granted in the model codes may be annulled at the state level. Some states remove the administrative sections of the fire code and replace it with their own state process. Code officials should verify which option exists in their jurisdiction.

LOCAL POLICIES/STANDARDS (cont'd)

- Policy clarifies minimum standards for that particular jurisdiction.

Photo courtesy of Bellingham, Washington, Fire Department

Slide 1-62

4. Policy clarifies minimum standards for that particular jurisdiction.

LOCAL POLICIES/STANDARDS (cont'd)

- Policies are usually developed to clarify application and enforcement.
- Outside review experts.
  - Third-party plans review service.
  - Technical assistance.
    - Technical assistance report.
  - Approved suitability of expert.

Slide 1-63

5. Policies are usually developed to clarify application and enforcement.

6. May defer plans review to outside review experts.

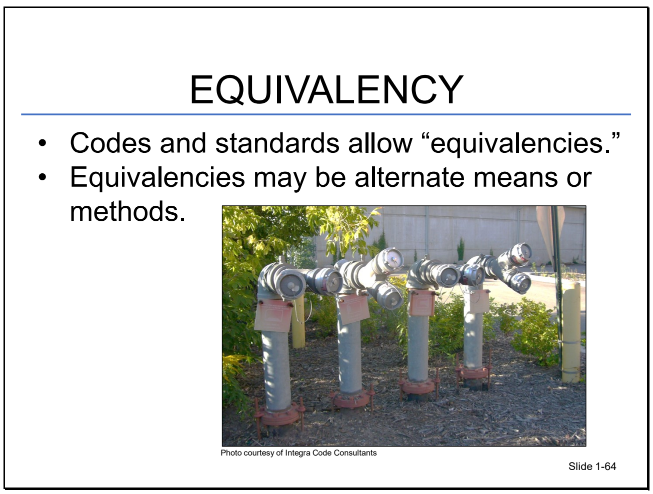
a. Third-party plans review service. Generally, these are private contractors who have special experience in fire protection systems and codes.

b. Technical assistance and third-party plan reviewers can be obtained at no charge to the jurisdiction.

- A technical assistance report can identify special hazards or conditions that need to be addressed in the design and installation of the fire protection equipment.

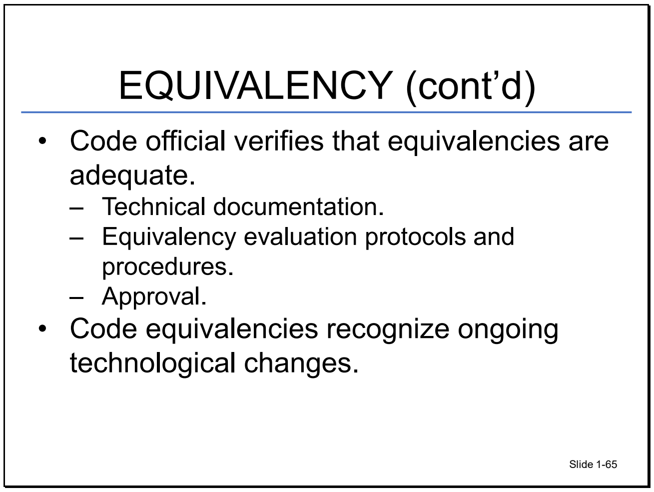
c. Approved suitability of the expert. The code official is authorized to establish and approve the experts' qualifications.

V. EQUIVALENCY



A. Codes and standards allow "equivalencies."

B. Equivalencies may be alternate means or methods to achieve code and standards compliance.



C. The code official verifies that equivalencies are adequate.

1. Technical documentation: The code official can request documentation from qualified experts or test labs to evaluate equivalencies.

2. Equivalency evaluation protocols and procedures: The code official should have a process in place to evaluate equivalencies based on sound scientific and engineering principles.

   a. Why is the equivalency being proposed?

   b. How does the proponent justify it as "equivalent"?

   c. Does the equivalency meet the life safety and fire protection intent of the standard? How?

   d. Has the equivalency been proposed and/or accepted elsewhere? What were the results?

   e. Are there any engineering, regulatory or scientific sources (e.g., laboratory reports, tests, peer-reviewed journals or books, etc.) that support the proposed equivalency?

3. Approval: The code official is authorized to approve equivalencies once they have been evaluated.

D. Code equivalencies recognize ongoing technological changes. The code development cycle — typically three years — is unable to keep up with changes in technology, so the equivalency or alternate methods approaches allow the code official to approve new products and designs.

PERFORMANCE-BASED DESIGN

- Desired outcome stated.
- Design to meet outcome.

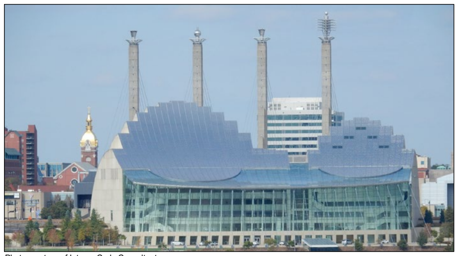


Photo courtesy of Integra Code Consultants

Slide 1-66

E. Performance-based design.

1. Current fire protection standards are "prescriptive": They prescribe how systems will be designed and installed based on consensus standards.

2. Performance-based designs may be employed as an alternative or equivalent.

   a. Desired outcome stated. In performance-based design, the desired outcome is described in engineering documents, e.g., "contain a fire in solid-pile Group A plastics without opening more than five sprinklers."

   b. Design to meet the outcome. Given this desired outcome, the sprinkler designer strives to achieve that objective.

VI. DOCUMENTATION

DOCUMENTATION

- Review:
  - Plans.
  - Calculations.
  - Manufacturer's product literature.
  - Special reports.
  - Owner's Certificate.

Liberty Mountain Resort
78 Country Club Trail
Carroll Valley Borough
Adams County, Pennsylvania 17320
Fire Sprinkler System Plan Review
Report No.: CV-15001
January 26, 2019

1.0 PROJECT DESCRIPTION

The applicant proposes the installation of a wet pipe automatic sprinkler system in new construction at Liberty Mountain Resort, 78 Country Club Trail in Carroll Valley Borough, Adams County, Pennsylvania.

The building is classified as an unseparated, mixed use occupancy, and is sprinklered for compliance with the *International Building Code,* Section 903.2.7 for a building housing a Group A2 and R fire areas. The construction type is III-B in accordance with the 2009 Edition of the *International Building Code.*

2.0 APPLICANT	**BUILDING CODE OFFICIAL**
The permit applicant is:	The Building Code Official having jurisdiction is:
Jim Tambini	Dave Baker
Rowe Sprinkler Systems, Inc.	Codes/Zoning Officer
7993 Route 522	Carroll Valley Borough
Middleburg, Pennsylvania 17842	5685 Fairfield Road
Telephone: 570.837.7647	Fairfield, PA 17320
Fax: 570.837.6335	Telephone: 717.642.8269

3.0 LIMITATIONS AND EXCLUSIONS

3.1 Requirements specified in this report are written in the permissive "should" solely to guide the authority having jurisdiction in the application and interpretation of the codes and standards listed. This does not imply that these items are discretionary and may be waived by the authority having jurisdiction.

3.2 The owner should maintain a minimum temperature of 40°F in all areas protected by the wet pipe sprinkler system.

Photo courtesy of Integra Code Consultants

Slide 1-67

Good documentation and recordkeeping are essential to assure clear communication, provide excellent customer service, maintain a permanent historical record of the project and protect the jurisdiction from tort lawsuits.

A. The plans examiner should review:

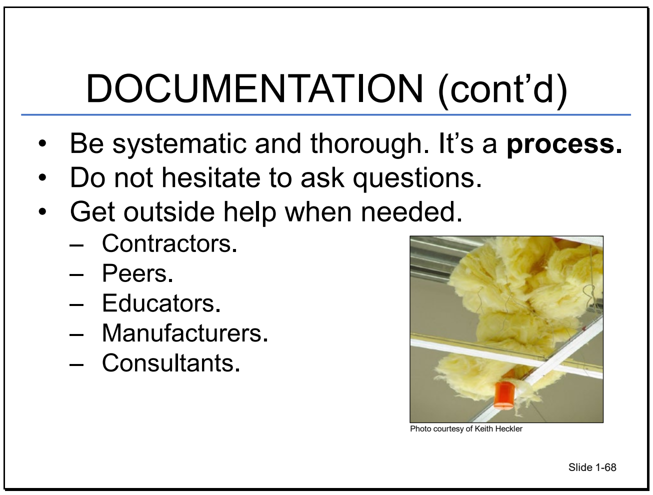
1. Plans.

2. Calculations.

3. Manufacturer's product literature.

4. Special rulings, reports or outside comments.

5. Owner's Certificate.



B. Keys to successful plans review.

1. Be systematic and thorough.

2. Do not hesitate to ask questions of the:

a. Project owner.

b. Architect or designer.

c. General contractor.

d. Sprinkler contractor.

3. Get outside help when needed.

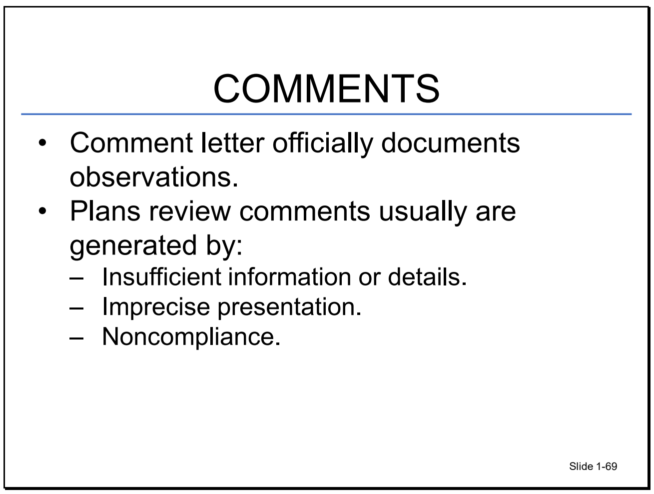
a. Contractors: General and fire protection contractors often are willing to share their experience and expertise.

b. Peers: Contact peers in other building or fire departments who may have had similar projects in their jurisdictions.

c. Educators: Community college, university and industry trainers can share information.

d. Manufacturers: Product manufacturers, distributors and installers are sources for details and technical data on materials and their installation.

e. Consultants: Fire protection engineers and code consultants can provide information or third-party plans review services.



C. Comments.

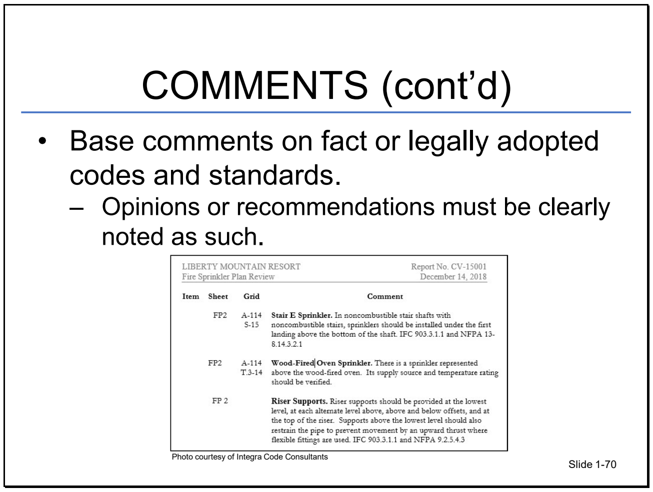
1. A comment letter officially documents what has been observed on the plans.

2. Plans review comments usually are generated by:

a. Insufficient information or details for the plans reviewer to make educated and informed comments.

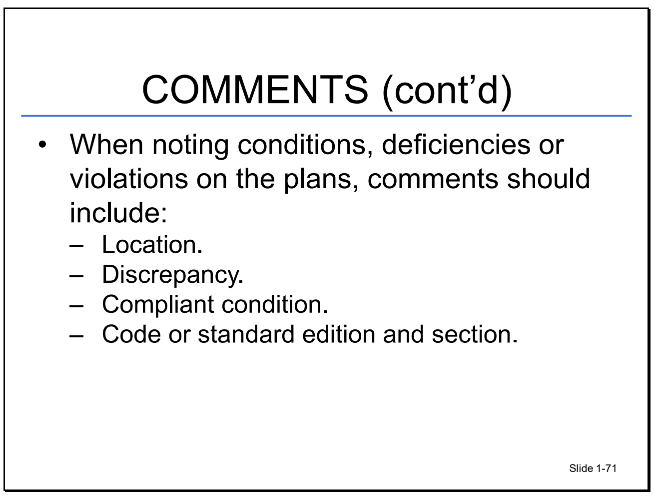
b. Imprecise presentation that may lead to confusion or misunderstanding.

c. Noncompliance with codes or standards.



3. Base comments on fact or the legally adopted codes and standards in effect.

   Opinions or recommendations should be avoided, but if included, must be clearly noted as such.



4. When noting conditions, deficiencies or violations on the plans, your comments should include:

   a. The location of the condition identified.

      - Sheet/Drawing number and grid coordinates enable the submitter to find the condition quickly and efficiently.

   b. The item that has been observed that needs clarification or correction.

   c. The correct condition required.

- What is needed to satisfy the code or standard?

  -- Plans examiners must be careful not to suggest or provide designs, technical solutions, or alternate methods and materials; that is the designer's responsibility. The code official's role is to verify that the solution complies with or provides equivalent protection to what the codes and standards require.

d. The reference to the code or standard edition and section.

- Often the code or standard edition is listed in the comment letter introduction. This provides a historical reference.

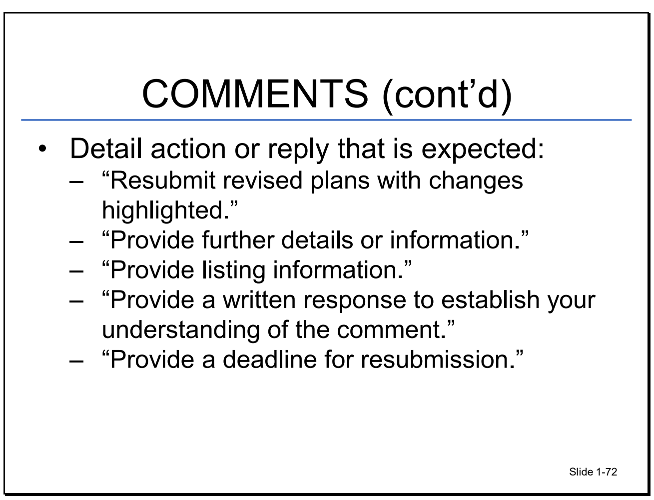
  -- Example: "The plans were reviewed in accordance with NFPA 13, 2019 edition."

- If plans were reviewed under a different code or standard edition from the one legally in effect at the time of the permit submittal, that should be noted.

  -- Example: "NFPA 13 (2012 edition) is the legally adopted version in effect, but by mutual consent, the plans were reviewed in accordance with NFPA 13, 2019 edition."

- Section numbers included to validate the comment as well as provide reference to find it quickly.

  -- Example: NFPA 13-8.4.7.7.



5. The plans review report or letter should indicate the type of action or reply that is expected, such as:

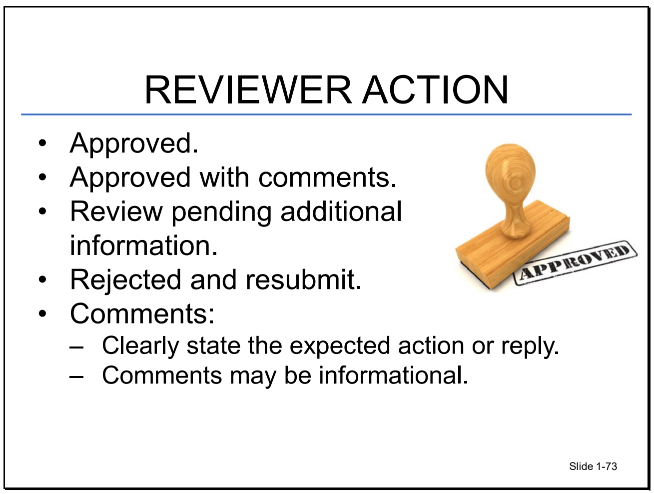
   a. "Resubmit revised plans with changes highlighted."

   b. "Provide further details or information."

   c. "Provide listing information."

   d. "Provide a written response to establish your understanding of the comment."

   e. "Provide a deadline for resubmission."



D. Reviewer action: Correspondence should close with a clear statement of the reviewer's conclusions:

1. Approved.

2. Approved with comments.

   a. This generally implies the contractor can start work while the comments are resolved.

   b. The code official should clarify if work can start before the permit is issued or plans have been approved.

3. Review pending additional information.

   Try to provide specific guidance on what additional information is needed.

4. Rejected and resubmit.

   Must provide a specific explanation on why the plans were rejected.

5. Comments.

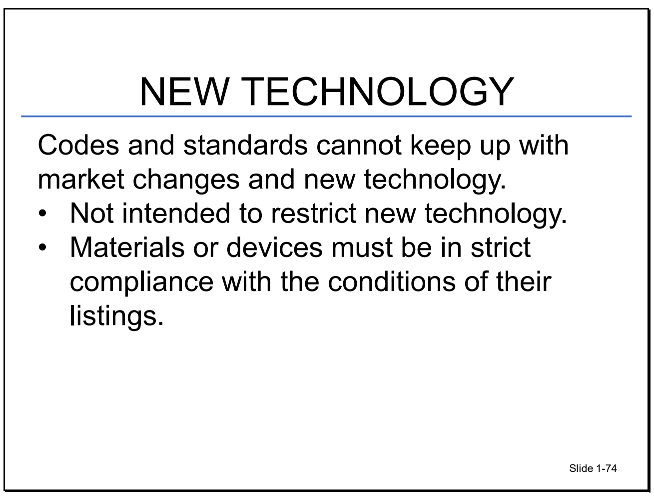
   a. Clearly indicate the type of action or reply that is expected.

   b. Comments may be informational.

      - Example: “The Department of Public Works reports the underground water mains to the site will not be completed until [date].”

      - Example: “For information on current water supply tests, call the Water Department at 555-1212.”

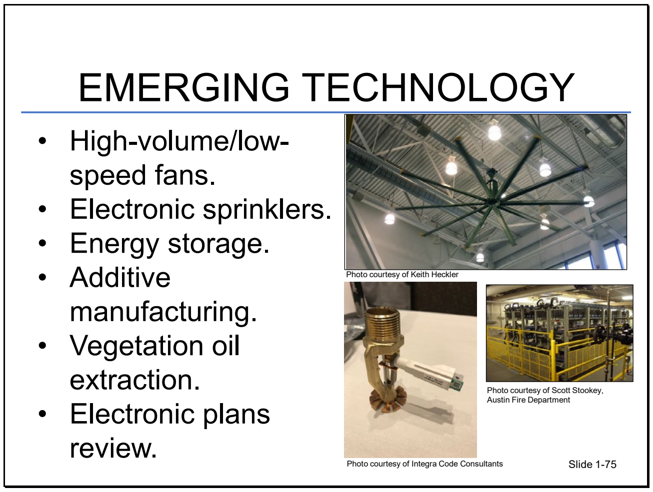
VII. TECHNOLOGY TRENDS



A. Codes and standards cannot keep up with market changes and new technology.

   1. Not intended to restrict new technology so long as minimum safety levels are maintained.

   2. Materials or devices not specifically designated must be used in strict accordance with the conditions of their listings and manufacturer’s installation instructions.



B. Emerging technology.

Items on this list represent emerging challenges to fire sprinkler technology, fire sprinkler design, and professional skills and training.

1. High-volume/low-speed fans.

    a. Affect heated air movement in large spaces.

    b. Blades interfere with sprinkler discharge.

2. Electronic sprinklers.

    Connected to individual smoke alarms that trigger water flow in a specific discharge pattern.

3. Energy storage.

    Flammable gases (hydrogen) and combustible metals (lithium) may affect fire behavior or the system's ability to control a fire.

4. Additive manufacturing (3D printing).

    Combustible plastics and dusts.

5. Vegetation oil extraction (cannabis oil).

    Highly flammable liquids and gases used in extraction processing.

6. Electronic plans review.

    a. Plans submitted in PDF or DWG format (or drawing format).

b. Comments appended to files.

c. Potential turnaround time improvements.

d. Digital storage benefits.

e. Plan portability to job site using tablet devices.

f. Electronic plans review tables.

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ACTIVITY 1.3

Finding Gaps in Submittal Packages

Purpose

Evaluate the thoroughness of a commercial fire sprinkler plans submittal package so you can verify that its contents provide adequate information to perform a model standard-compliant plans review.

Directions

1. You will use NFPA 13, Annex A and a sample fire sprinkler submittal (fire station project in Collegeville, Pennsylvania) to identify and report any gaps in the information provided.

2. To expose you to electronic plans review, the submittal package will be provided in Adobe PDF format. The activity must be done on a personal computer, tablet or other device that can adequately display the files.

   Note: This is not a detailed plans review and analysis. It is an exercise only to evaluate the submittal package's completeness. For the purpose of the exercise, you may assume all data is current.

3. In addition to the first list in Annex A of NFPA 13 that was used in Activity 1.2, there are additional requirements in the Annex for water supply test data and the hydraulic calculation cover sheet. You must address all three lists.

4. You will review the package as a small group, but each student must write a letter outlining the deficiencies (if any). If no deficiencies are identified, you must provide a letter explaining that the plans have been accepted for further review. You may have additional requirements based on your local standards and policies that can be added to the letter. The letter should be addressed to the contractor. (The letter may be submitted electronically to the instructor.)

5. The letter is due to the instructor by the last day of class.

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ACTIVITY 1.3 (cont'd)

Finding Gaps in Submittal Packages Worksheet

	Item	Location
1	Owner/Occupant name	
2	Location/Address	
3	Compass point	
4	Full-height cross section	
5	Partition location	
6	Fire wall location	
7	Room/Space occupancy description	
8	Concealed spaces, closets, bathrooms	
9	Small enclosures with no sprinklers	
10	City main size and whether dead-end or circulating	
11	Other water supply sources	
12	Sprinkler make, model, type and K-factor	
13	Sprinkler temperature rating and high-temp sprinkler location	
14	Total area protected by each system per floor	

	Item	Location
15	Number of sprinklers per riser per floor	
16	Total sprinklers on dry, deluge or preaction	
17	Dry pipe system capacity (gallons)	
18	Pipe type and wall thickness schedule	
19	Nominal pipe size and cutting lengths	
20	Location and size of riser nipples	
21	Fitting/Joint types and welds	
22	Hanger, sleeve, bracing types and locations	
23	All control, check, drain and test valves	
24	Make/Model/Type of alarm or dry valve	
25	Make/Model/Type of preaction or deluge valve	
26	Alarm bell type and location	
27	Standpipe size, riser location, hose outlets	
28	Private fire service mains, size, lengths, locations	
29	Piping provisions for flushing	

	Item	Location
30	Additions to existing system	
31	Hydraulic nameplate data	
32	Graphic representation of scale	
33	Contractor name and address	
34	Hydraulic reference points on plans	
35	Minimum water application rate	
36	Total water required at common reference points	
37	Relative sprinkler, junction and reference point elevations	
38	All unprotected openings if room design method used	
39	Load calculations for sizing/details of sway bracing	
40	Pressure-reducing valve settings	
41	Backflow preventer information	
42	Antifreeze solution used	
43	Hydrant location, size and outlets	
44	FDC size and location	

	Item	Location
45	Ceiling roof heights not shown in full height cross section	
46	NFPA 13 edition	

Water Flow Test

	Item	Location
1	Water test location/elevation in relation to riser reference point	
2	Flow location	
3	Static pressure (pounds per square inch (psi))	
4	Residual pressure (psi)	
5	Flow (gallons per minute (gpm))	
6	Test date	
7	Test time	
8	Person’s name who supplied data or performed test	
9	Other water sources and details	

Hydraulic Calculation Cover Sheet

	Item	**Location**
1	Date	
2	Location	
3	Owner/Occupant name	
4	Building number or identification	
5	Hazard description	
6	Contractor name/address	
7	Approving agency name	
8	System design:	
	a) Design area	
	b) Application rate (density)	
	c) Area per sprinkler	
9	Total water requirements	
10	Allowance for in-racks	
11	Limitations on extended coverage or other special listed sprinklers	

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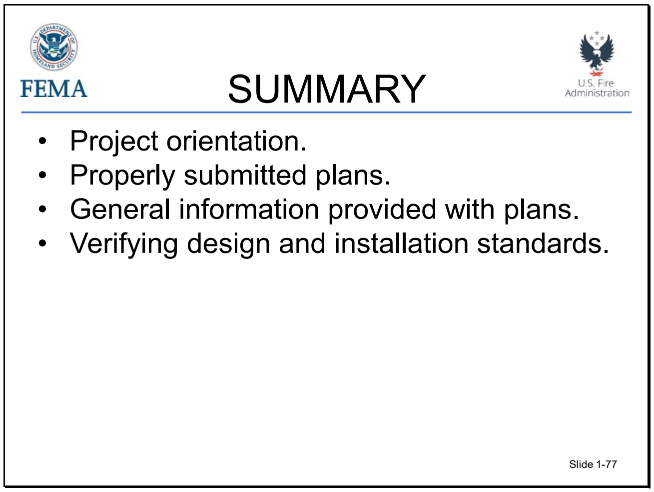
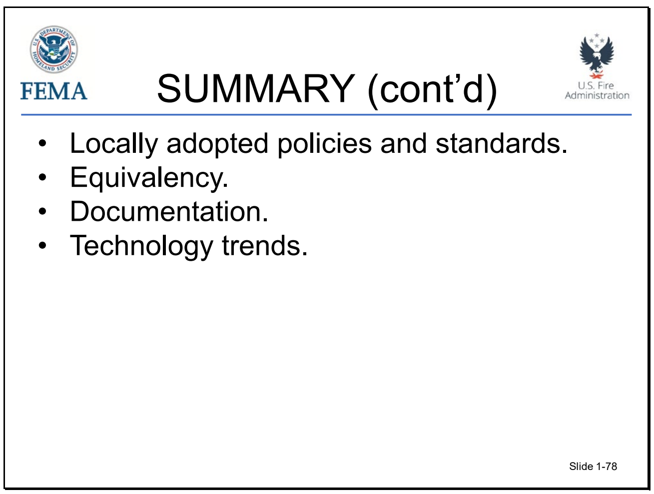
VIII. SUMMARY





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APPENDIX

SUPPLEMENTAL MATERIALS

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Using Engineer and Architect Scales

NOTE: When PRINTING this document, be sure the pull down menu next to "Print Scaling" in the Print Dialog window is set to "None". This will ensure the sample drawings will measure accurately.

Introduction

Using and interpreting information from engineer (civil) and architect scales is an important fire protection engineering skill. Construction and fire protection equipment drawings must be interpreted with a high degree of accuracy.

Student Performance Objective

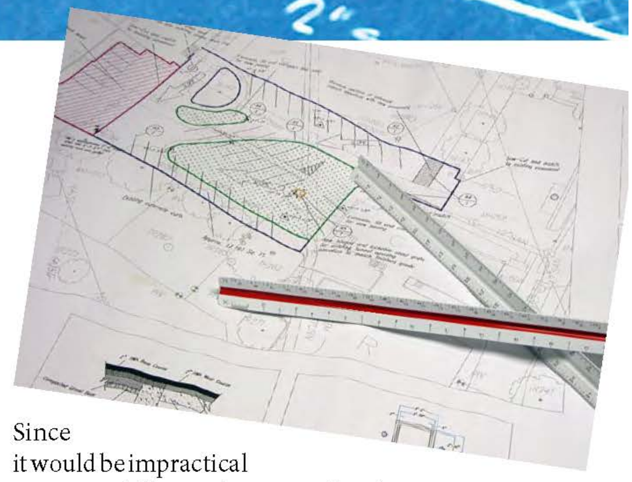
Given an architect or engineer scale and a set of scaled drawings, you will be able to select the correct scale (tool) and interpret dimensions with 100 percent accuracy.

Enabling Objectives

1) *You will be able to identify the difference between engineer (civil) and architect scales.*
2) *Using a scale, you will be able to measure objects shown on civil engineering plans and architectural renditions of buildings and structures.*
3) *You will be able to interpret the results of the measurements.*

Scales

Before they are built or assembled, roads, water mains, structures, and fire protection systems are designed in accordance with nationally recognized standards. The design concept is transferred to a set of plans (drawings) that provide a two- or three-dimensional representation of the project.



Since it would be impractical to create full-size drawings for these objects, they are reduced to a manageable size (scale) so they can be studied. A set of plans may include a variety of different scales, depending upon what objects are being rendered. The selected scale normally is found in the title block in the lower right hand corner of the drawings, but may be found anywhere on the plans. You may find more than one scale on a single sheet when there are "details," parts of the objects that are enlarged for clearer explanation.

In order to interpret the size of what the renderings represent, the plan reviewer must use a tool called a "scale." The word "scale" is used synonymously to represent the tool and the size reduction in the drawing. The scale tool provides a quick method for measuring the object and interpreting its eventual size when finished.

Selecting the Correct Tool

Traditional scales are prism-shaped tools that look similar to the rulers you may have used in elementary school. There are two types of drafting scales used in design and construction:

1. *Engineer, or civil, scales*, such as 1″ = 10′ or 1″ = 50′, are used for measuring roads, water mains, and topographical features. The distance relationships also may be shown as 1:10 or 1:50.

2. *Architect scales*, such as 1/4″ = 1′-0″ (1/48 size) or 1/8″ = 1′-0″ (1/96 size), are used for structures and buildings. They are used to measure interior and exterior dimensions such as rooms, walls, doors, windows, and fire protection system details.

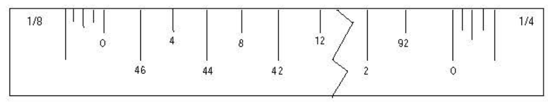
Other scale tools include flat scales and rolling scales. Rolling scales have the advantage of being able to measure travel distances easily, an important feature when evaluating means of egress.

1. Look closely at the dimensions shown on the faces of the tools.
   - Architect scales have numbers that run incrementally both from *left to right* and from *right to left*. A whole number or fraction to the left or right of the number line indicates the scale those numbers represent.
   - Engineer scales have numbers that run incrementally from *left to right*. The whole number to the left of the number line indicates the scale those numbers represent.

2. *Architect scales* use fractions and have the following dimensional relationships:

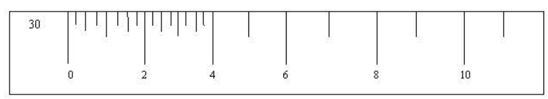
3/32 = 1 foot	1/4 = 1 foot	3/4 = 1 foot
3/16 = 1 foot	3/8 = 1 foot	1 inch = 1 foot
1/8 = 1 foot	1/2 = 1 foot	1½ inches = 1 foot

- The scale marked "16" is a standard ruler.
- You must learn to read both from left to right, and right to left. Note in the example below, the numbers on the 1/8-inch scale increase from *left to right*. The numbers on the 1/4-inch scale increase from *right to left*.
- Note that the "0" point on an architect scale is not at the extreme end of the measuring line. The numbers "below" the "0" represent fractions of one foot.



3. *Engineer scales* have the following dimensional relationships:

1 inch = 10 feet	1 inch = 40 feet
1 inch = 20 feet	1 inch = 50 feet
1 inch = 30 feet	1 inch = 60 feet



- When using the engineer scale, you must multiply the value you identify by 10.
- The small lines between the whole numbers represent individual feet, so a point that falls two marks to the right of the whole number 4 is interpreted as 42 feet.

Using the Tool and Interpreting the Results

You should never use your scale to draw lines. It should be used *only* for measuring.

1. Identify the scale shown on the plans by the architect, engineer or fire protection contractor (*i.e.,* 1/8 = 1 foot; 1:40).
2. Select the object you wish to measure, and select the appropriate *architect* or *engineer* scale (tool).
3. Align your scale tool with the selected scale to verify they match. During blueprint reproduction, the image size may be adjusted to fit the paper so it may not represent precisely the scale the designer intended to use.
4. Correctly align the "0" with one end of the object as a starting point, and identify the object's end point. The corresponding number on the scale tool represents the object's length when built.

   Example No. 1:

   The drawings state that the scale is 1/8 inch equals 1 foot. Using your *architect* scale, select the face of the tool with the 1/8 mark in the upper left-hand corner. Lay the "0" point at the extreme left end of this line, and read the corresponding value at the right end of the line.

   You should see the value "32" on your scale. Given a 1/8-inch scale, this line represents a 32-foot long object.

   Example No. 2:

   Using the same line, measure the distance using a 1/4-inch to 1-foot scale. In this example, you will lay the "0" end of the tool on the right end of the line.

   The left end of the line should correspond to the "16" on your scale. This line represents a 16-foot long object even though the line on the paper is the same length as the one above: that is the influence of "scale."

   If the object's end point does not align exactly with a corresponding foot mark, slide the scale right or left until the fractional mark aligns, then take your reading. Translate the fraction into inches (e.g., the 1/2 mark equals 6 inches, the 3/4 mark equals 9 inches).

   Example No. 3:

   Using the same line, measure the distance using a 3/8-inch to 1-foot scale. Lay the "0" at the left end of the scale on the left end of the line.

   You will see that the right end of the line falls between 10 and 11 feet. Slide the scale to the right until the 10 foot mark aligns with the right end of the line.

   Now, look at the marks on the left end of the line, left of the "0." The left end of the line corresponds to the ninth mark left of the "0," which in this case represents 9 inches. Thus, in a scale of 3/8 inch to 1 foot, this line represents an object 10 feet, 9 inches long.

   Example No. 4:

   Use the same line, but this time you are measuring a "water main" and the plans show a scale of 1 inch equals 20 feet. Use the *engineer* scale to measure this water line.

   Lay the engineer scale marked "20" on the left end of the line. The right end of the line should align with the number "8". Remember to multiply that value by 10 to get an answer of "80 feet."

Try the activities on the next pages to test your new skills. The answers are found on the last page.

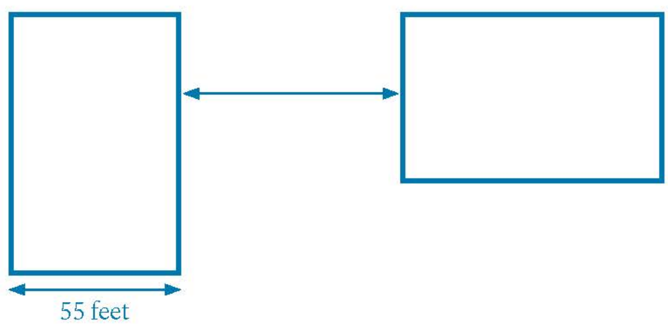
1. Measure the height and width of this rectangle. The scale is 1/4 inch equals 1 foot.

Height:______feet Width:_______feet

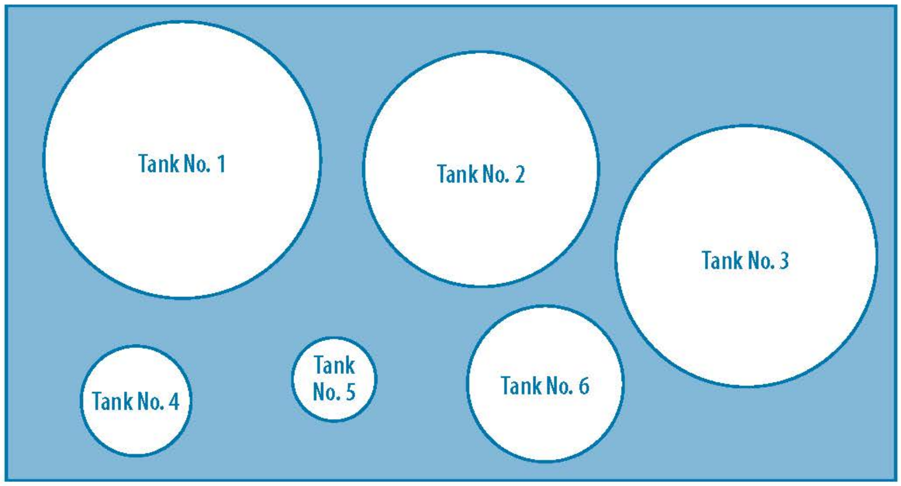
2. Measure the exterior dimensions of this rectangle. The scale is 1/8 inch equals one foot.

Height:______feet Width:_______feet

3. In scale, how far apart are these two rectangles?



4. This drawing represents the plan view of a bulk tank facility. The scale is 1:60. What are the tank diameters in feet?



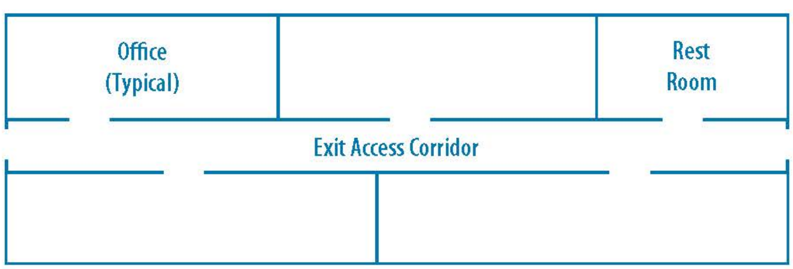
Tank No. 1 =__________feet   Tank No. 4 =__________feet

Tank No. 2 =__________feet   Tank No. 5 =__________feet

Tank No. 3 =__________feet   Tank No. 6 =__________feet

5. Given the above information, how far apart at their nearest edges are Tanks 1 and 6, measured in a straight line?

6. This drawing represents the floor plan of a small office. Given a scale of 3/32 = 1 foot, how long in feet is the exit access corridor?



Scale versus Dimensions

While using a scale tool is an important skill, there are times when the fire inspector must rely on other information.

When drawings are prepared with dimensions written on the plans, the *written dimensions always take precedence over scaled measurements.*

During blueprint reproduction, the image size may be adjusted to fit the paper, so it may not represent precisely the scale the designer intended to use. If the image was adjusted just a small amount, its accuracy would be in doubt. Therefore, the dimensions written on the plans should be used.

Example

A fire sprinkler contractor submits drawings with the branch lines marked as follows:

You apply your scale to verify the dimensions, and discover the sprinklers are 10 feet apart based on your scale. How do you reconcile the difference?

The correct answer is 8 feet, 6 inches, because the *written dimensions always take precedence over scaled measurements.* In this example, you likely would obtain inaccurate scaled dimensions anywhere on the drawings when using your scale tool.

Activity answers

(Note: Your answers may be slightly different from these due to margins of error among scale tools.)

1. Height = 5 feet, width = 21 feet, 6 inches

2. Height = 12 feet, width = 33 feet, 4 inches

3. Using the engineer scale tool, you must first establish which scale was selected. By rotating the scale tool until you align it with a known dimension (55 feet), you will see that the selected scale is 1 inch = 50 feet. Applying the scale tool to the outer edges of the rectangles reveals they are spaced 70 feet apart.

4. Tank No. 1 = 105 feet   Tank No. 4 = 44 feet
   Tank No. 2 = 90 feet   Tank No. 5 = 32 feet
   Tank No. 3 = 99 feet   Tank No. 6 = 62 feet

5. 86 feet

6. 53 feet

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Do You Need Seismic Protection?

By Victoria B. Valentine, P.E.

Discussions about earthquakes and the damages caused to the built world from earthquakes are trending in the last decade. However, many people still view seismic activity as just a California problem. Yet, the largest earthquake recorded on the Richter Scale for the United States was a 9.2 that occurred in Prince William Sound, Alaska on March 27, 1964. There has also been recent ground motion activity in the northeastern United States as well as the New Madrid fault, which runs through Missouri, Tennessee, and Kentucky.

Although there is more awareness of earthquake activity in the United States than years ago, many people still struggle to determine if seismic protection is needed for the fire sprinkler system within a building. NFPA 13, 2013 Edition, Section 9.3.1.1 states, "Where water-based fire protection systems are required to be protected against damage from earthquakes, the requirements of Section 9.3 shall apply…" This means that the requirement to provide earthquake protection for the sprinkler system is determined outside of NFPA 13. The key piece of information that is needed for this determination is the Seismic Design Category (SDC).

Where do I find the SDC?

The layout and detail technicians need to know what the Seismic Design Category (SDC) is for the building. The SDC is determined by the engineer of record prior to design of the structural components of the building. By the time the details of the fire sprinkler system are planned the SDC should be well known on the project. Jurisdictional requirements should always be confirmed. There are specifications for buildings that could invoke the earthquake protection requirement. For example, an insurance carrier for the property may require seismic protection for the fire sprinkler system. Another example is a building following military specifications that require earthquake protection for most, if not all, buildings.

The International Building Code refers to ASCE 7 for the protection of buildings and nonstructural components from earthquake forces. Section 13.1.2 in ASCE 7-10 states "For the purposes of this chapter, nonstructural components shall be assigned to the same seismic design category as the structure that they occupy or to which they are attached." This means that the SDC that has been assigned to the building will apply to all of the components within that building. The classification will range from A through F. Section 11.7 exempts SDC A from seismic design requirements. Section 13.1.4 (4) exempts mechanical systems, which fire sprinkler systems are, in SDC B. Therefore, seismic protection is required for sprinkler systems that are in SDC C through F.

Some states and jurisdictions have modified their submittal process so that the SDC is called out on the cover page of the project since it is used by all involved with the building. Where this practice is followed, the SDC can be followed and seismic protection used where applicable. If this is not the case, the SDC will have to be determined.

How is the SDC determined?

Should the case be one where the SDC has not been communicated to those responsible for the fire sprinkler system, it can be determined with a few pieces of information. First, the risk category for the building needs to be determined. This is tied to the occupancy or use of the building. It is broken into 4 groups, where a risk category I is the lowest level of risk and IV is the highest including buildings used as emergency shelters and other essential facilities.

Second, the values for the expected ground acceleration from the design earthquake are needed. This begins with finding the site class for the soil where the building is/will be located. This is another characteristic that is used by the structural engineer as well as others designing other components that will be within the structure. Thus it could be taken from information provided within the specifications of the building. Where this is not the case, a geotechnical specialist will be needed to analyze the soil and classify it

>> CONTINUED ON PAGE 16

NFSA's Director of Engineering

Victoria B. Valentine, P.E.

TABLE 1: DETERMINING SEISMIC DESIGN CATEGORY

S_{DS} Value	Risk Category I, II, or III	Risk Category IV
$S_{DS} \leq 0.167$	A	A
$0.167 \leq S_{DS} < 0.33$	B	C
$0.33 \leq S_{DS} < 0.50$	C	D
$0.50 \leq S_{DS}$	D	D
S_{D1} Value		
$S_{D1} < 0.067$	A	A
$0.067 \leq S_{D1} < 0.133$	B	C
$0.133 \leq S_{D1} < 0.20$	C	D
$0.20 \leq S_{D1}$	D	D

>>CONTINUED FROM PAGE 15

or generic information can be obtained through the website for the United States Geological Survey (USGS). Whenever site specific information is available it should be used.

Once classified, the site class will be noted A through F. Although the same letters are used, this is not the same designation as the SDC. Site class A represents hard rock, which would shift very little due to ground motions. Site class F represents liquefiable soils or those that have little strength to resist ground motions.

The third piece of information needed to determine the SDC for a building is the spectral response acceleration parameters. There are two values that are looked at when determining the SDC. S_S is the spectral response acceleration parameter for short periods (0.2s) and S_1 is the spectral response acceleration parameter for a 1-second period. These are values that have been mapped for the United States. These maps are updated over time to represent the best information available when the standard was revised. The maps can be found in ASCE 7-10 *(as well as other editions)*. A version is also available on the USGS website. It will allow the user to enter an address or the latitude and longitude for a site and return the S_S and S_1 data amongst other values.

The values in the maps are for the Maximum Considered Earthquake (MCE). Adjustments are used to arrive at the design values that determine the SDC. The first adjustment is for the type of soil. This is done as the mapped values are based on Site Class B, but not all buildings are built on this type of soil. Then two-thirds of that value is used as the design spectral acceleration parameter. The process is the same for S_S and S_1, but each parameter has its own table for soil coefficients, F_a and F_v respectively. The design value is noted with a "D" in the subscript as follows: S_{DS} and S_{D1}.

After the above pieces of information are gathered, two tables *(Tables 11.6-1 and 11.6-2 in ASCE 7-10)* are used to determine the SDC. Similar information can be found in Table 1. The higher SDC designation after comparing S_{DS} and S_{D1} to the risk categories is used. There is also a caveat when S_1 is equal to or greater than 0.75. Where this is the case and the risk category is I, II or III, SDC E is used. Where this is the case and the risk category is IV, SDC F is used.

Summary

The Seismic Design Category (SDC) for a building is one value applied to the structure and its components. Information on the use of the building, the soil under the building, and the acceleration parameters is needed if the SDC is not communicated from the structural engineer(s) for the project. Once the SDC is determined, buildings in A or B will not require seismic protection. Buildings with an SDC C through F will need earthquake protection for the fire sprinkler system. NFPA 13 provides the guidelines for the seismic protection when it is deemed necessary.

REFERENCES

1. ASCE/SEI 7-10 Minimum Design Loads for Buildings and Other Structures. American Society of Civil Engineers, Reston, VA. 2010.

2. NFPA 13, Standard for the Installation of Sprinkler Systems, 2013 Edition. National Fire Protection Association, Quincy, MA. 2012.

3. "Historic Earthquakes." USGS Earthquake Hazards Program. U.S. Department of the Interior. 1993. Web. August 12, 2014.

<table>
<tr><td colspan="2">Local Department of Public Safety
Community Risk Reduction Division</td></tr>
<tr><td>TITLE/SUBJECT: Fire Department Connections for Water-based Fire Protection Systems</td><td>POLICY NUMBER:
CRR-14.16</td></tr>
<tr><td colspan="2">TO: Fire Protection System Designers and Installers, General and Specialty Contractor, Project Architects and Design Professionals, Building Inspectors and Fire Inspectors.</td></tr>
<tr><td colspan="2">AUTHORITY:
International Fire Code (2018 Edition) §102.8
International Fire Code (2018 Edition §912</td></tr>
<tr><td colspan="2">EFFECTIVE DATE:
March 1, 2018</td></tr>
<tr><td>APPROVED BY:

Fire Marshal</td><td>DATE:
January 1, 2018</td></tr>
</table>

I. Purpose

The purpose of this policy is to establish standard methods for the design and installation of fire department connections that supplement water-based fire protection systems.

II. Policy

It is the policy of the Local Department of Public Safety that all new and renovated fire water-based fire protection systems shall be provided with fire department connections in accordance with this policy.

The Local Department of Public Safety recognizes that not all future conditions can be anticipated in written policy, and therefore reserves the authority to review installations on an individual basis.

III. Definitions

Water-based Fire Protection System shall include automatic fire sprinklers, manual and automatic fire standpipe systems, low- and medium-pressure water mist systems, stationary fire pump systems, water-spray systems, hose stations and monitor nozzles and their appurtenances.

Fire department connection means a permanently attached apparatus or equipment connected to a water-based fire protection system that allows the fire service to supplement the systems' water pressure and volume.

Fire protection system riser means the primary vertical pipe where the main controls for the water-based system are installed.

IV. Standards

1. All water-based fire protection systems shall be designed and installed in accordance with the latest editions of the nationally recognized standards adopted by reference in the 2018 Edition of the *International Fire Code®*, published by the International Code Council.

2. All water-based fire protection systems connected in an fashion to the City of Local municipal water supply shall be provided with suitable cross-contamination controls.

   For information on cross-contamination controls, contact:

   City of Local Department of Water and Sewer
   1234 5th Street
   Local, State
   Telephone 555.1212

V. Details

1. **Location.** All fire department connections shall be located adjacent to the curb cut of the main entrance for the building or project it serves.

   Exception: Where the exterior wall of the building or project is immediately adjacent to the public sidewalk nearest the main entrance, the fire department connection may be installed on that wall.

2. **Size.** The size of the fire department connection piping for supply shall be equal in size to the fire protection system riser to a maximum six (6) inches in diameter.

   Exception: Where the water-based fire protection system riser is three (3) inches or less in diameter, the fire department connection may consist of a single two-and-one-half-inch supply inlet with National Standard Threads.

3. **Check Valve Vault.** Where fire department connections are located adjacent to the curb cut of the main entrance for the building or project it serves, the required check valve and automatic drain assembly shall be installed at the first 90-degree elbow into

the system. The vault shall be large enough to allow removal of the check valve cover to facilitate backward flushing.

4. **Height**. All fire department connections shall be installed so the lowest point of the connection is between eighteen (18) and thirty (30) inches above finished grade at that location.
5. **Locking Caps**. All fire department connections shall be provided with locking caps. For details on the manufacturer and model of the locking cap assemblies, contact the Local Department of Public Safety Community Risk Reduction Division.
6. **Signs**. All fire department connections shall be provided with permanent signs describing the building or portion of the building the fire protection system services. Signs shall have letters not less than one-half (1/2) -inch high on a contrasting background and shall be approved by the Local Department of Public Safety Community Risk Reduction Division prior to installation.

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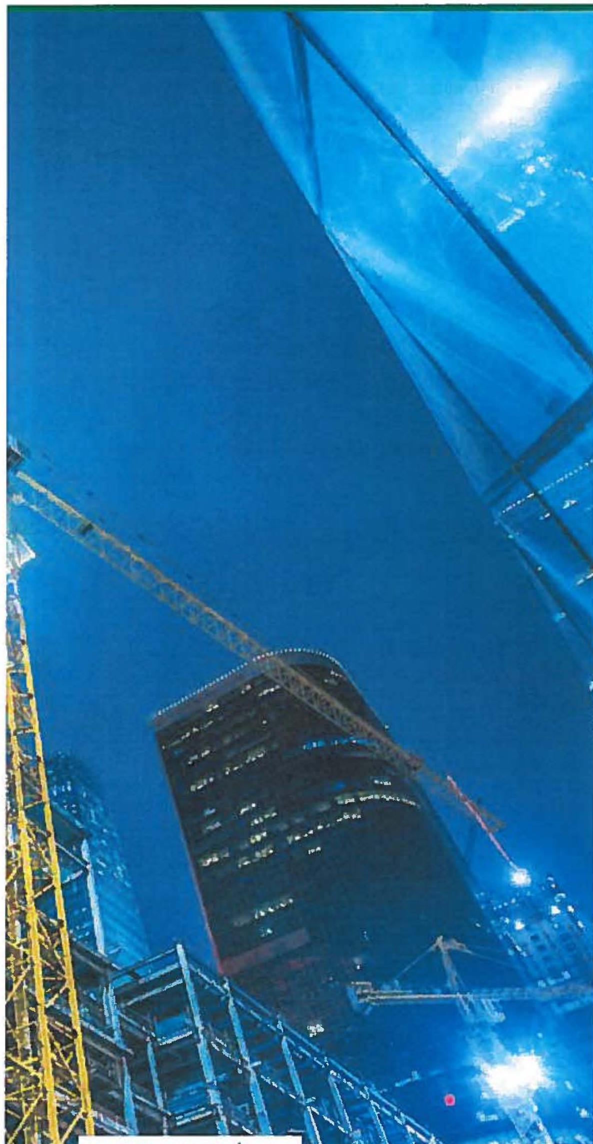


Technical And Research Reports: A Guide

Editor's note: The June edition of Building Safety Journal Online included an article on alternate design approaches and technical reports.

As modern construction projects become more complex, owners, architects and engineers may address their unique design challenges by seeking alternatives to prescriptive code requirements.

The code official is responsible for reviewing and approving those proposals. To assure life safety, fire protection and structural demands are met, the code official must have full confidence the designs are somehow equivalent or better than the requirements outlined in the codes. One way to achieve that confidence is to obtain, review and approve a technical or research report as authorized in the model codes.

The technical report must be prepared by an individual or organization acceptable to the code official. The code official must approve its contents and conclusions; the code official is not obligated accept the report. The *International Building Code*® (IBC) authorizes the code official to ask for research and test reports from approved agencies. The *International Fire Code*® (IBC) allows the code official to rely on technical reports from a fire protection engineer, testing laboratory or research organization to support alternative design and material proposals.

Effective in the 2015 *I-Codes*, if the code official does not approve the alternative material, design or method of construction, he or she must respond to the applicant in writing and explain why. This assures an extra element of due process in code enforcement.

TECHNICAL AND RESEARCH REPORTS

The technical report submitted to the code official must be sufficiently detailed and documented to validate any conclusions or recommendations. The following checklist provides the code official a framework to establish the minimum requirements for technical reports for alternative methods and materials, modifications or any circumstance when the code official believes more information is needed to make an informed decision:

By Rob Neale, Vice President, National Fire Service Activities, International Code Counci

Administrative Requirements

- The report and opinion should be written at a 12th grade reading comprehension level, in English or the predominant language of the jurisdiction. Where highly complex technical terms or units of measurement are used, they should be explained.

- Three printed copies of the report in Word or PDF format should be submitted to the code official. Additional copies should be available through online sources such as FTP (file transfer protocol) sites. The free commercial website Dropbox is a good source of file sharing.
- Drawings and illustrations should be in .DXF, .DWG or PDF format.

Executive Summary

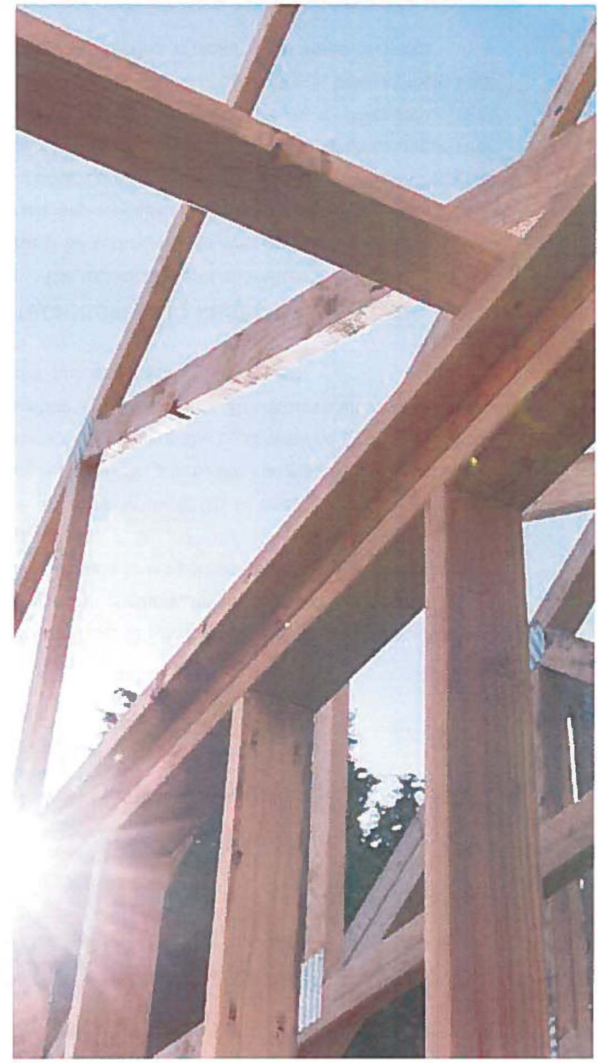
- An executive summary of the report's findings, conclusions and recommendations should be included *at the beginning.* The summary should describe the project and explain why an alternative method or material is requested. The summary generally does not need to include references to specific code sections; it should be more conversational in style.

Credentials and Experience Summary

- The author(s)' experience, education, and expertise in the field should be cited to establish credibility. This may include references to research reports or articles the author or organization has prepared.
- The report should reference similar projects or jurisdictions where the proposal has been accepted, if any. If the proposal has been approved elsewhere, the contact information for the approving code official should be provided.

Project Scope

- A detailed description of the applicant's proposal should be included. This section should reference specific code sections for which the report is prepared.
- Company name and principal's name, address, telephone, and email address, including the project leaders or primary points of contact.
- List of permits sought.
- Site location/zoning designations.
- Additional permits required (e.g., environmental, transportation, utility or other infrastructure).
- Name of the agency and contact person requesting the report.
- Summary of conclusions (executive summary).



Occupancy Information

Describe:

- Site plan, setbacks, adjacent property, slopes topographical or geographical considerations
- Floor plan and occupancy description
- Construction details for the Building Code Official to establish occupancy and construction (e.g., construction type, area, height, setbacks, fire walls, fire barriers or fire partitions and their rating [in hours]) hazardous materials control areas.
- Fire apparatus access roads, fences, barriers and gates.
- Utility infrastructure (e.g., water mains, hydrant and shutoff valve locations).
- Location and contents of outside storage areas
- Location of outside above- and below-ground storage tanks, including their proposed contents, size and containment features.
- Location and type of mechanical and plumbing systems (e.g., air handling units, exhaust ducts, floor drains).
- Hazardous materials engineering control features (e.g. cabinets, hoods, scrubbers, exhaust systems).
- Tank and piping systems, controls (remote and automatic).
- Fire protection systems (e.g. automatic sprinklers, fire alarm and detection, standpipes, explosion suppression, dry chemical or clean agent systems).
- Security features and systems used to prevent unauthorized access to the site or operations.

Fire Safety Plan during Construction

- Contractor name and principal's name, address, telephone, email address, including the project leaders or primary points of contact.
- Description of fire safety procedures to be maintained during construction.

Operations Summary

- Describe in detail any processes, operations or equipment that may use hazardous materials, and explain how they comply with code, include code sections.
- Summary of manufacturing, storage and/or operational processes.
- Inventory of hazardous materials storage or use. Inventory in accordance with fire code criteria.
- Include a hazardous materials management plan.
- (Provide) Material Safety Data Sheets (MSDS) for all materials.
- For high-piled storage, display storage arrangement and provide commodity classification for materials in storage. Provide test results documentation to verify commodity classification.
- Describe warning systems to be employed to protect the site and adjacent properties.

Alternative Methods and Materials

- Document any proposed alternative methods and materials, and describe how they are equivalent to the existing code.
- Provide test procedures or analysis to substantiate alternative methods and materials.
- Cite national standards referenced for equivalencies (e.g., ICC-Evaluation Service, National Fire Protection Association, Underwriter Laboratories, Compressed Gas Association, American Society of Testing and Materials).

Recommendations/Conclusions

- Provide a summary analysis of the operational hazards and methods or materials intended to protect them.
- Describe in detail any special construction, setbacks, fire protection systems or storage arrangements intended to minimize hazards.
- Provide recommendations for isolation, separation, containment or protection of hazardous materials or operations.
- To the extent possible, describe the change in behavior of hazardous materials or operations if there is fire, earthquake, flood or other calamity. BSJO

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Coffee Break Training - Fire Protection Series

Automatic Sprinklers: Hydraulic Nameplates

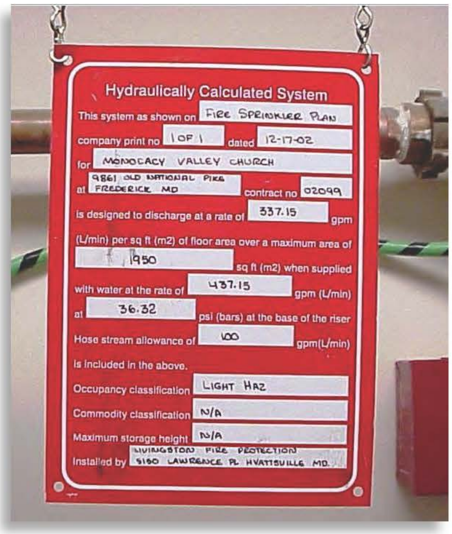
No. FP-2012-16 April 17, 2012

Learning Objective: *The student shall be able to identify the information required to be printed on a fire sprinkler system hydraulic nameplate.*

Most automatic sprinkler systems designed today have been hydraulically calculated: an engineered approach that matches the fire hazard potential to the available water supply pressure and volume.

The sprinkler plans examiner will verify the hydraulic calculations to ensure that all of the design considerations have been met.

In order to help keep track of the design criteria, National Fire Protection Association (NFPA) 13, *Standard for the Installation of Sprinkler Systems*, requires that the installing contractor identify hydraulically designed sprinkler systems with a permanently marked weatherproof metal or rigid plastic sign secured with corrosion-resistant wire, chain, or other approved means. The sign must be placed at the alarm valve, dry-pipe valve, preaction valve, or deluge valve supplying the corresponding hydraulically designed area. (This sign is in addition to the general information sign described in Coffee Break Training 2012-13).



This nameplate is typical of the style that should be found on a hydraulically calculated sprinkler system.

According to NFPA 13, the sign must have the following minimum information:

- The location of the design area(s). These are also known as the "hydraulic remote areas" and constitute the portion of the building and contents that are most challenging for the sprinkler system to protect. It is important to remember that the hydraulic remote area **may not** be the area physically most remote from the sprinkler risers.
- The discharge densities over the design area or areas. This is the amount of water that the design criteria specify are needed to control a fire in the hydraulic remote area. This value may come from NFPA 13 or the authority having jurisdiction (AHJ).
- The required flow and residual pressure demand at the base of the riser.
- Occupancy classification or commodity classification and maximum permitted storage height and configuration.
- Hose stream allowance included in addition to the sprinkler demand.
- The name of the installing contractor.

For additional information, refer to NFPA 13, Chapters 8 and 24.

Eligible for Continuing Education Units (CEUs)
at www.usfa.fema.gov/nfaonline

For archived downloads, go to:
www.usfa.fema.gov/nfa/coffee-break/

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Coffee Break Training - Fire Protection Series

Automatic Sprinklers: General Information Signs

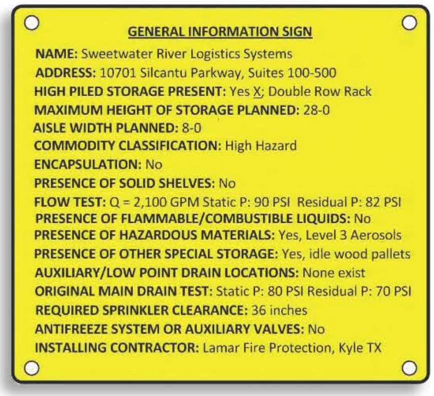
No. FP-2012-13 March 27, 2012

Learning Objective: *The student shall be able to describe the requirement for general information signs on new automatic sprinkler systems.*

One of the leading causes of sprinkler system ineffectiveness occurs when storage contents or configurations change and the sprinkler system is not altered to match the new hazard. A sprinkler system that is designed and installed to protect one level of hazard may not adequately protect another.

For example, a sprinkler system designed to protect an office supply retail sales building may be installed to protect predominantly an ordinary hazard occupancy. If that tenant were to leave or change products to something highly flammable or combustible, the original fire protection system might not have the sprinkler spacing, pipe size, or water delivery capacity to control a fire in the new materials.

To help inspectors identify the original design criteria and be on the lookout for changes that could affect sprinkler performance, the National Fire Protection Association (NFPA) 13, *Standard for the Installation of Sprinkler Systems* now requires the installation of a permanently marked and securely mounted general information sign on each riser, antifreeze loop, or auxiliary system control valve.



This sample general information sign is required by the National Fire Protection Association (NFPA) 13, *Standard for the Installation of Sprinkler Systems* on new sprinkler systems. *Illustration courtesy of Scott Stookey, Austin, TX.*

The sign must include the following information:

- name and location of the facility protected;
- occupancy classification;
- commodity classification;
- presence of high-piled and/or rack storage;
- maximum height of storage planned;
- aisle width planned;
- encapsulation of pallet loads;
- presence of solid shelving;
- flow test data;
- presence of flammable/combustible liquids;
- presence of hazardous materials;
- presence of other special storage;
- location of auxiliary drains and low-point drains on preaction and dry-pipe systems;
- original results of main drain flow test;
- name of installing contractor or designer; and
- indication of presence and location of antifreeze or other auxiliary systems.

While the information on this sign is useful during an inspection, it should not be considered a complete hazard assessment of the facility or fire protection systems.

For additional information, refer to NFPA 13, Chapter 24.

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UNIT 2: HAZARD CLASSIFICATION

TERMINAL OBJECTIVE

The students will be able to:

2.1 *Evaluate if the proposed sprinkler design is suitable for the hazard classification given a nationally recognized design standard and description of building use and contents.*

ENABLING OBJECTIVES

The students will be able to:

2.1 *Describe elements that establish hazard classification for design.*

2.2 *Evaluate use and storage conditions identified in National Fire Protection Association (NFPA) 13,* Standard for the Installation of Sprinkler Systems.

2.3 *Describe special hazards in NFPA 13 that would require additional protection levels.*

2.4 *Interpret design density curves from NFPA 13.*

2.5 *Determine if the submittal provides the appropriate level of protection for the hazard.*

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FEMA

U.S. Fire Administration

UNIT 2:
HAZARD CLASSIFICATION

Slide 2-1

TERMINAL OBJECTIVE

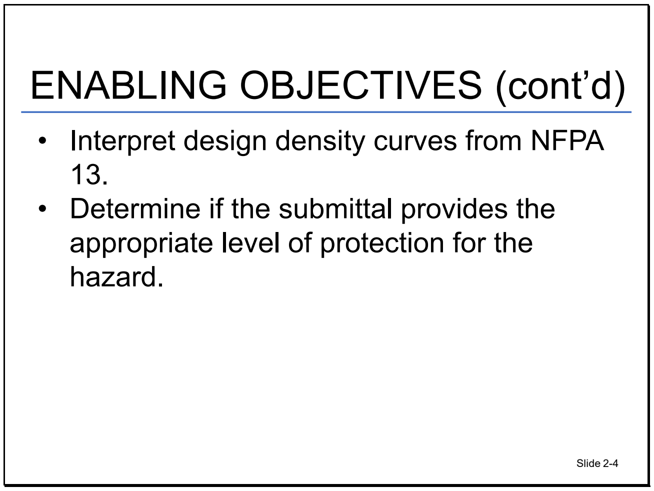
Evaluate if the proposed sprinkler design is suitable for the hazard classification given a nationally recognized design standard and description of building use and contents.

Slide 2-2

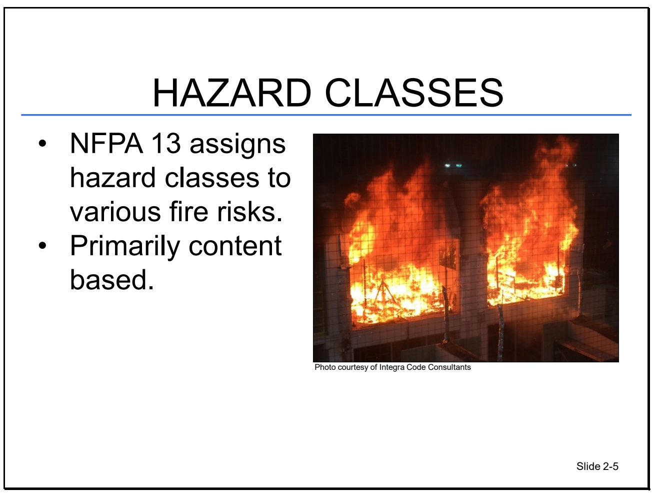
ENABLING OBJECTIVES

- Describe elements that establish hazard classification for design.
- Evaluate use and storage conditions identified in National Fire Protection Association (NFPA) 13, *Standard for the Installation of Sprinkler Systems*.
- Describe special hazards in NFPA 13 that would require additional protection levels.

Slide 2-3



I. HAZARD CLASSIFICATION



A. Hazard classes.

1. National Fire Protection Association (NFPA) 13, *Standard for the Installation of Sprinkler Systems*, assigns hazard classes to various fire risks.

2. Primarily content based.

   There is no correlation between building or fire code occupancy classifications and features (such as control areas) and the NFPA 13 hazard classes. The NFPA 13 categories have been derived by its technical committee members over time, independently from building or fire code changes.

HAZARD CLASSES (cont'd)

- Primary factors.
  - Latent heat potential: total fuel available.
  - Potential fire severity: heat release rate (HRR).
  - Spatial configurations.
    - -- Storage.
    - -- Operational.

Photo courtesy of Integra Code Consultants

Slide 2-6

3. Primary factors affecting classification.

   a. Latent heat potential: total fuel available.

   b. Potential fire severity (heat release rate (HRR)).

   c. Spatial configurations, whether the primary use is:

      - Storage.

        -- "Ordinary" up to 12 feet.

        -- "High-piled" above 12 feet.

      - Operational.

        -- Factory, industrial, assembly, school, health care.

HAZARD CLASSES (cont'd)

- Selected by the project design team and/or sprinkler designer.
- Code official approves.

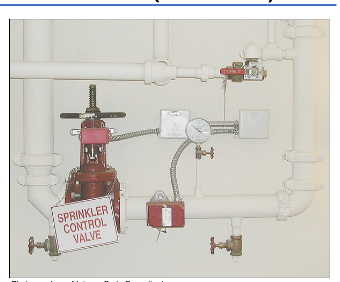


Photo courtesy of Integra Code Consultants

Slide 2-7

4. Selected by the project design team and/or sprinkler designer.

   Based on information provided in Owner's Certificate.

5. Code official approves.

   Code official should have experience in fire protection principles, fire protection systems, water supplies and hazard analysis.

COMBUSTIBILITY

Energy of combustion.

- Amount of heat released during full combustion.

Photo courtesy of Integra Code Consultants

Fuel	BTU/lb
Methane	23,900
Propane	21,700
Polyethylene	20,050
Paraffin wax	19,900
Kerosene	19,862
Diesel	19,300
Coal (WV bituminous)	15,178
Coal (anthracite)	14,000
Polyurethane	10,180
Coal (lignite)	6,500
Wood	8,700 – 9,142
Polyvinyl chloride	7,720

Data courtesy of NIST Chemistry Webbook

Slide 2-8

6. Combustibility.

   An item's combustibility is related to its latent heat of combustion: energy released if totally consumed.

FIRE LOAD

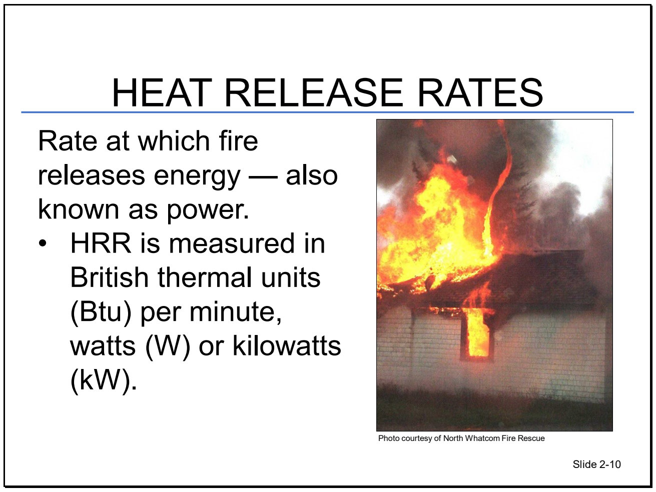
Use	Average (lbs/ft²)
Printing warehouse	174.4
Printing plant	34.0
Office	18.4
School	15.7
Furniture factory	15.3
Residence	8.8
Clothing factory	10.7
Hospital	2.8

Data courtesy of Measurements of Fire Loads and Calculations of Fire Severity, D. Gross, National Bureau of Standards, 2007.

Slide 2-9

7. Fire load.

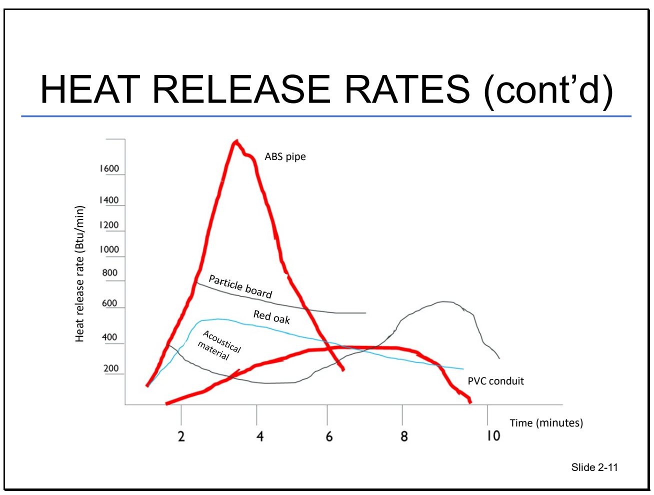
   Estimated measurement of total fuel per square foot based on occupancy.



8. HRR.

a. Rate at which fire releases energy, also known as power.

b. HRR is measured in units of British thermal units (Btu) per minute, watts (W) or kilowatts (kW).

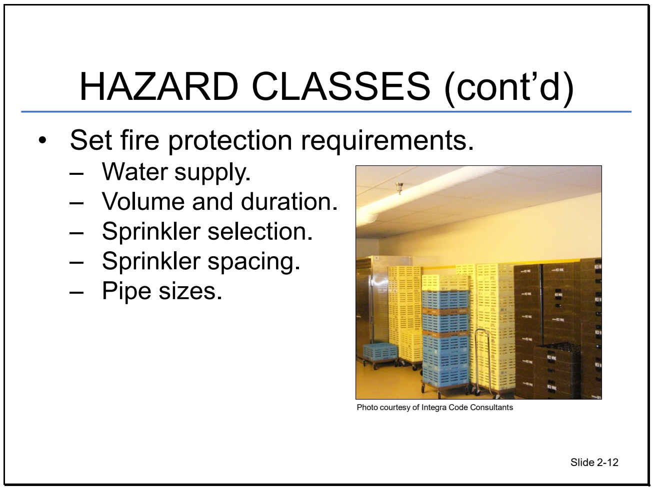


c. The graph on the slide represents the comparative HRR of five products under controlled conditions:

- Red oak.
- Cellulosic acoustical ceiling tiles (ACTs).
- Particle board (common wood product).
- Polyvinyl chloride (PVC) pipe.
- Acrylonitrile butadiene styrene (ABS) pipe.

d. Although plastic materials often are considered to be high-hazard materials because of their petroleum base, the HRR depends on their ultimate chemical makeup.

e. While the ABS pipe sample spikes to an early and high HRR, PVC exceeds red oak high heat release only after 6 1/2 minutes of burning. This graph shows that some plastics burn with overall less energy output than other nonplastic materials.



9. Hazard classes establish the fire protection requirements. As the hazard class increases, the following items are affected:

a. Water supply: More water is required for fire control.

b. Volume and duration: The volume and time it has to continue flowing is increased.

c. Sprinkler selection: Different sprinklers, often with higher operating temperature ratings or larger orifices, are required.

d. Sprinkler spacing: Sprinklers are required to be spaced closer together in higher hazard classes.

e. Pipe sizes: The increased water supply requirements often mean larger pipe sizes are required to deliver the minimum flow.

HAZARD CLASSES (cont'd)

- Not correlated to building code occupancy classes.
  - Portions of a building may be different hazard classes for sprinkler design.

Photo courtesy of Integra Code Consultants

Slide 2-13

10. Hazard classes are **not** correlated directly to building code occupancy classes.

    Portions of a building may be different hazard classes for sprinkler design.

    a. Office or waiting area in a motor vehicle repair garage.

    b. Day care use at an industrial facility.

    c. Residential portion of mixed use.

HAZARD CLASSES (cont'd)

- Increasing hazard sliding scale.
- NFPA 13, Annex A list of consensus occupancy descriptors.
  - Representative, not absolute.
  - Use experienced judgment.

Slide 2-14

11. Increasing hazard classes represent a sliding scale from low to extreme fire hazards.

12. NFPA 13, Annex A includes a list of consensus-based occupancy descriptors that are intended to provide typical examples of each hazard class.

a. The examples are representative and not absolutely reflective of what might be found in each. The code official should rely on their knowledge of the project.

- Many outdated examples are included in the NFPA 13 list:

-- "Dairy products manufacturing" may not address the packaging transition from glass to waxed paper or high-hazard plastic containers.

-- "Museums" do not address the nature of materials or exhibits that may be on display.

-- "Electronic plants" may not address hazardous materials found in occupancies like semiconductor fabrication facilities.

b. Use experienced judgment. The designer is responsible for using experienced judgment to design the system, but may not have all the information needed to address all hazards.

B. Light Hazard.

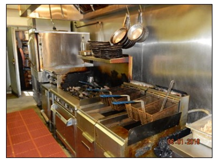
1. Low quantity combustibles.

2. Low HRR.

Churches, schools, office buildings, assembly (restaurant seating areas) and health care.

ORDINARY HAZARD

- Group 1.
  - Low to moderate amount of combustibles.
  - Moderate HRRs.
  - Storage less than 8 feet.

Photos courtesy of Integra Code Consultants

Slide 2-16

C. Ordinary Hazard.

1. Ordinary Hazard, Group 1.

a. Low to moderate amount of combustibles.

b. Moderate HRRs.

c. Storage less than 8 feet.

- Automobile parking and showrooms, beverage manufacturing, laundries, and restaurant service areas.

ORDINARY HAZARD (cont'd)

- Group 2.
  - Moderate combustible load.
  - Moderate HRRs.
  - Storage less than 12 feet.

Photos courtesy of Integra Code Consultants

Slide 2-17

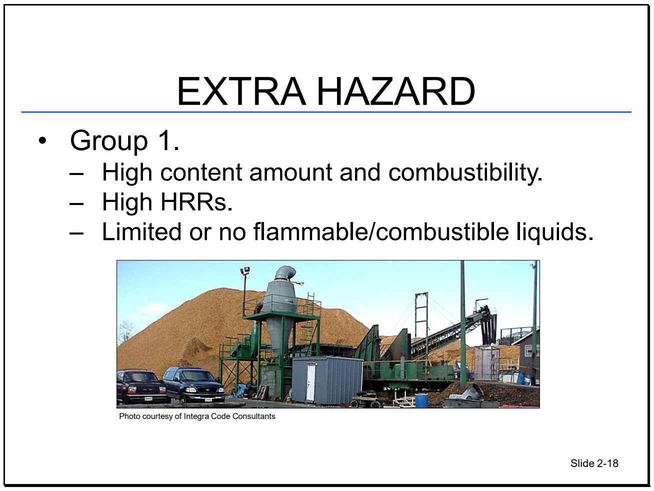
2. Ordinary Hazard, Group 2.

a. Moderate combustible load.

b. Moderate HRRs.

c. Storage less than 12 feet.

- Dry cleaners, mercantile, printing and publishing, wood products, and machining and assembly.



D. Extra Hazard.

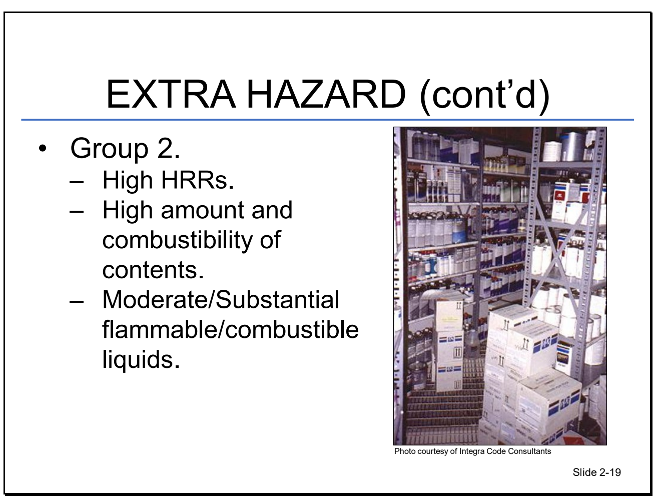
1. Extra Hazard, Group 1.

a. High content amount and combustibility.

b. High HRRs.

c. Limited/No flammable/combustible liquids.

- Aircraft hangars, plywood and particle board manufacturing, textile preparation.



2. Extra Hazard, Group 2.

   a. High HRRs.

   b. High amount and combustibility of contents.

   c. Moderate/Substantial flammable/combustible liquids.

      - Flammable liquid spraying, flow coating, plastics processing, open dipping operations and combustible shielding.

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ACTIVITY 2.1

National Fire Protection Association 13, Sprinkler Hazard Classifications (Part 1)

Purpose

Orient students to the fire sprinkler hazard classifications listed in NFPA 13.

Directions

1. Use the hazard classification lists in NFPA 13, Annex A to classify the following occupancies that are illustrated in the slides.

    a. Museum.

    ____

    b. Wood product assembly.

    ____

    c. Flammable liquid spraying.

    ____

    d. Glass product manufacturing.

    ____

    e. Mercantile.

    ____

2. At the end of the activity, the instructor will call on various students to provide their responses. Be prepared to discuss them in class.

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ACTIVITY 2.2

National Fire Protection Association 13, Sprinkler Hazard Classifications (Part 2)

Purpose

Evaluate hazard class samples where NFPA 13 may not provide clear guidance.

Directions

1. Using the hazard classification primary factors (potential fire severity, latent heat and operational configurations), classify the following occupancies that are illustrated in the slides. Briefly explain your decisions.

    a. Welding shop.

    ____

    ____

    ____

    b. Museum.

    ____

    ____

    ____

    c. Fiberglass operations.

    ____

    ____

    ____

    d. Auditorium.

    ____

    ____

    ____

e. Winery.

f. Coal-fired power station.

g. Self-storage.

h. Boat yard.

i. Wood shop bag house.

j. Tennis club.

2. At the end of the activity, the instructor will call on various students to provide their responses. Be prepared to discuss them in class.

3. Make sure to record your answers as you will refer to them in Activity 2.4: “Real World” Impacts.

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II. STORAGE OCCUPANCIES

A. Ordinary combustibles (items that burn essentially similar to wood, paper and cardboard) can be protected up to 12 feet Above Finished Floor (AFF) by Ordinary Hazard class systems.

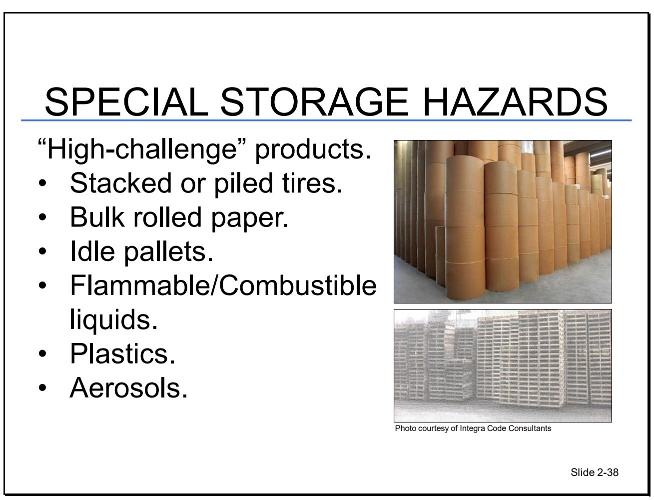
B. The 8- and 12-foot height limits are derived from historical full-scale fire tests.

1. Ordinary Hazard, Group 1 to 8 feet.

2. Ordinary Hazard, Group 2 to 12 feet.

C. High challenge threats are covered in NFPA 13 but require special consideration.

III. SPECIAL STORAGE HAZARDS



A. "High-challenge" products.

1. Stacked or piled tires: Hard to ignite, but once burning, hard to suppress because of latent heat of combustion, exposed surface area and numerous pockets where water accumulates rather than reaching the burning materials. Fires tend to be smoky and hot, making manual suppression challenging.

2. Bulk rolled paper.

   a. Rolled papers are classified as heavy, medium or tissue weight for fire protection designs.

   b. Rolled paper burns from the outside in and peels or exfoliates in a spiral fashion, so the fire is always moving, often opening more sprinklers than needed.

3. Idle pallets: Wood pallets tend to dry out, and their edges splinter, making them easy to ignite. The amount of available combustible surface area and ambient oxygen enable them to burn ferociously.

4. Flammable/Combustible liquids: These products have high rates of heat release and latent energy. Leaks and explosions allow products to flow and imperil other storage.

5. Plastics: Depending upon the plastic class and configuration (expanded or unexpanded), these provide extremely high fire threats due to their HRR and latent energy.

6. Aerosols.

   a. Aerosol products are classified into three categories depending on the mixture of product and propellant.

      - Level 1: generally low hazard employing water-based product and mildly or nonflammable propellant.

      - Level 2: moderate hazard with flammable (usually alcohol-based) product and flammable propellant.

      - Level 3: high hazard with petroleum-based product and propellant.

   b. Level 2 and 3 aerosols have high latent energy and HRR.

      - Once ignited, pressure containers can burst and “rocket” through the storage area, spreading flammable trails.

B. Heights: As height increases, so does hazard.

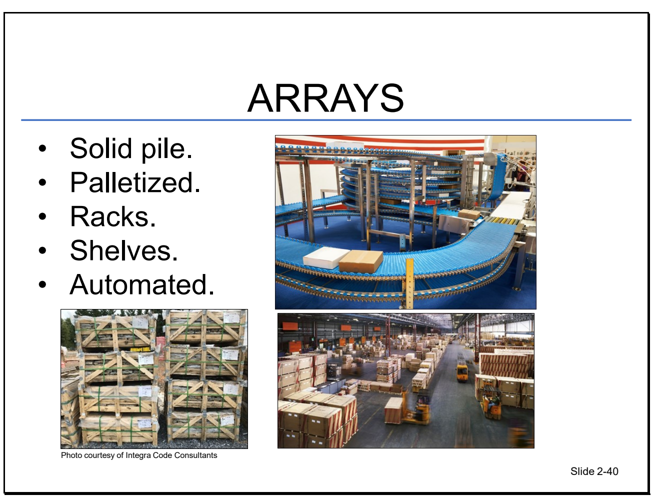
1. More fuel per floor area. As illustrated, fuels may include a mix of ordinary combustibles and plastics.

2. Fire suppression access can be difficult, if not impossible.

a. Automatic sprinkler discharge may be blocked by obstructions in the racks, preventing cooling water from protecting the product and the racks themselves.

b. Manual suppression efforts can be compromised by sprinkler discharge cooling products of combustion and lessening visibility for effective fire attack.

3. Collapse threat: Racks can become unstable due to the added water weight or heat stress and fail, spreading fire and threatening firefighters' safety.



C. Arrays: In storage occupancies, the storage method affects the fire protection system design; not all sprinkler systems are suited to protect what are called different storage arrays. The products and arrays must be evaluated by competent personnel.

1. Solid pile: self-supporting material in solid piles with narrow aisles for product movement and slowing fire spread.

2. Palletized: products stored on wood, metal, plastic or other pallets.

3. Racks: typically 4-foot by 8-foot storage surfaces supported by a metal structure (e.g., “big box” home improvement retail stores).

   a. Racks can be single row, double row, multiple row, flow through, moveable, portable, open shelf, closed shelf and more.

   b. The complexity of rack storage array fire protection should be evaluated by qualified personnel.

4. Shelves differ from racks in that they are less than 30 inches deep and not more than 36 inches apart vertically.

5. Automated storage includes carousels, computer-controlled robotics, vertical lift modules and unit load stackers. The fire challenge is that unless properly controlled, the moving storage array can take burning products great distances at great speeds throughout the storage area.

6. In high-piled storage arrays, early suppression fast response (ESFR) sprinkler protection may be encountered.

   a. This protection method is intended to suppress fires in their early stages rather than simply control them until manual fire fighting can extinguish the fire.

   b. ESFR systems are highly sophisticated and should be reviewed and approved only by qualified persons.

COMMODITY CLASSIFICATIONS

Class	Examples
I	• Alcoholic beverages not exceeding 20% alcohol. • Bagged cement. • Glass bottles in single-thickness cardboard boxes.
II	• Foods in combustible containers. • Light bulbs in cartons. • Thinly coated wire on reels or in cartons.
III	• Bagged feed. • Wood doors, frames and cabinets. • Baled waste paper.
IV	• Synthetic clothing. • Plastic upholstered furniture. • Oil-based paints in combustible containers.
High- or special hazard	• Level 3 aerosols. • Lubricating or hydraulic fluids in plastic containers. • Rubber tires.

Slide 2-41

D. Commodity classifications: Like occupancy hazard classes, storage arrays employ a method of classifying the products — a packaging and storage method called "commodity classification."

1. Commodities are classified based on their latent heat of combustion and HRR.

2. The table on the slide illustrates examples of various commodities and their classifications. Class I commodities are the least hazardous with increasing hazards to Class IV. The International Fire Code (IFC) employs a "high-hazard" category.

3. NFPA 13 describes these high-hazard commodities as "special hazard occupancies" and offers separate chapters and design criteria for each.

PLASTIC GROUPS

Group A Highest combustibility	Group B	Group C Least combustibility
Acrylonitrile butadiene styrene (ABS) copolymer	Cellulosics Cellulose acetate, ethyl cellulose	Melamine
Fiberglass reinforced polyester	Chloroprene rubber	Phenolic
Polyethylene	Nonexpanded natural rubber	Polyvinyl chloride (PVC)
Polystyrene	Silicone rubber	Urea
Polypropylene	Fluoroplastics	Fluoroplastics
Polyurethane		Polyvinyl fluoride (PVF)
Styrene acrylonitrile		

Note: This is not the entire list of referenced plastics. See NFPA 13.

Slide 2-42

E. Plastic groups: The presence of plastics in commodities can have a significant impact on the fire protection system design.

1. Plastics are classified into three groups based on their combustibility.

   a. Group A is the highest hazard class.

   b. Group B is the moderate hazard class.

   c. Group C plastics burn at about the same rate as ordinary combustibles (wood, paper, natural fiber cloth, etc.).

2. Evaluating the type, amount and impact of plastics in stored commodities is a skill best left to qualified persons.

F. Special occupancies: NFPA 13 has a chapter for sprinkler design for at least 36 special occupancies that may have one or more unique hazards that are not adequately addressed in the general sprinkler design standards.

1. These are also outside the scope of this course. If a plans reviewer encounters a project that could fall under one or more of these standards, they should consult an experienced code official or third party for support.

SPECIAL OCCUPANCIES (cont'd)

- Flammable and combustible liquids.
- Aerosols.
- Hypobaric chambers.
- Animal housing.
- Cooling towers.
- Laboratories with chemicals.
- Wharves/Piers.
- Aircraft hangars.
- Light water reactors.
- Culturally significant properties.
- Coal mines.

Photo courtesy of National Park Service

Slide 2-44

2. Partial list of special occupancies. Check NFPA 13 for the complete and current list under "Special Occupancies."

   a. Flammable and combustible liquids.

   b. Aerosols.

   c. Hypobaric chambers.

   d. Animal housing.

   e. Cooling towers.

   f. Laboratories with chemicals.

   g. Wharves/Piers.

   h. Aircraft hangars.

   i. Light water reactors.

   j. Culturally significant properties.

   k. Coal mines.

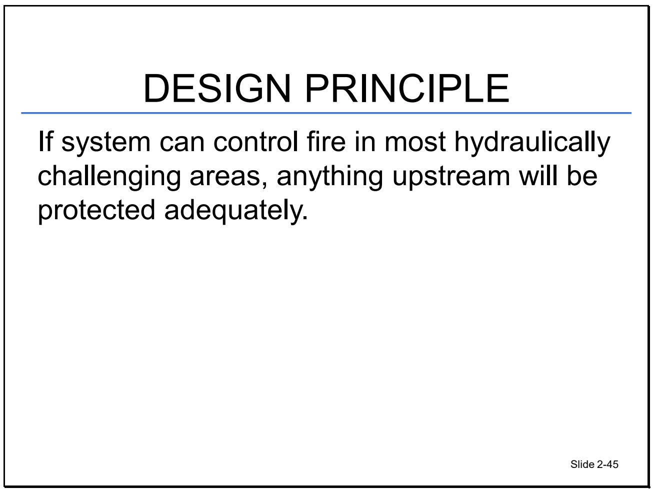
IV. SPRINKLER DEMAND: DENSITY/AREA CURVES

A. Once the hazard classification(s) has been established, the designer must determine how the system will be designed to ensure that it is capable of controlling or suppressing a fire.

1. With most modern sprinkler systems, this is done through a “hydraulic design” approach where the design specifies a water application rate over a specific area. This is known as the density/area approach.

2. The plans reviewer must be able to interpret density/area curves for successful plans review.

3. The key to successful fire outcomes is simple: apply enough water at the right rate over the burning materials to control a fire until the fire department arrives to suppress it.



B. Design principle.

1. If a sprinkler system can control fire in the most hydraulically challenging areas, anything upstream of the remote area is adequately protected.

2. The hydraulic remote area may not be the physically most remote from where the riser enters the building. The designer will analyze the most efficient way to deliver water through pipe configurations and sizes.

3. The remote area is analyzed by the hydraulic worksheets described in Unit 1: Preparing for Plans Review and which will be explained in detail in Unit 6: Hydraulic Remote Design Areas and Unit 7: Evaluating Sprinkler Hydraulic Calculations.

DESIGN OBJECTIVE

- Deliver water at required volume/pressure to control fire.
- Density/Area curve most widely used method.
  - Density: flow in gallons per minute (gpm).
  - Area: floor area in specific location (square feet).

Slide 2-46

C. Design objective.

1. Deliver water at required volume and pressure to control fire by overcoming the HRR and latent heat of combustion.

2. Density/Area curve from NFPA 13 is the most widely used method.

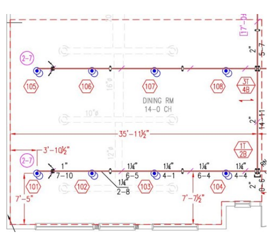
   a. Density: flow in gallons per minute (gpm).

   b. Area: floor area in specific location (square feet).

REMOTE AREA

Water flow covers explicit area.

- Hydraulic remote area.
- Remote area.
- Design area.
- Area of application.
- Demand area.



Plan View

Slide 2-47

D. Remote area.

1. Water flow covers an explicit area. Depending upon local practices and traditions, this also may be called the:

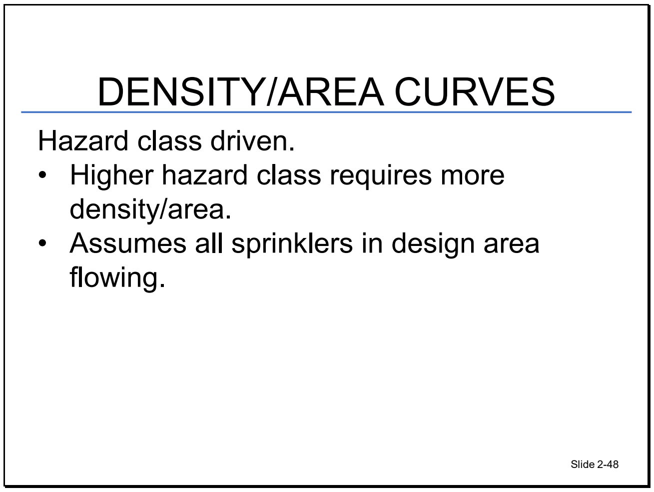
   a. Hydraulic remote area.

b. Remote area.

c. Design area.

d. Area of application.

e. Demand area.



2. Hazard class driven. The amount of water and the size of the remote area are described in the density/area curve graph in NFPA 13.

   a. Higher hazard classes require more density/area.

   b. Assumes all sprinklers in the design area are flowing.

      - This is an important concept: The total water flow and pressure in the remote area are based on the assumption that every sprinkler in the remote area is discharging water simultaneously.

      - Given that, statistically, 97% of fires with operating sprinklers are controlled by five or fewer sprinklers (Ahrens, 2017), the fact that the design anticipates all sprinklers operating provides an inherent safety margin in the design.

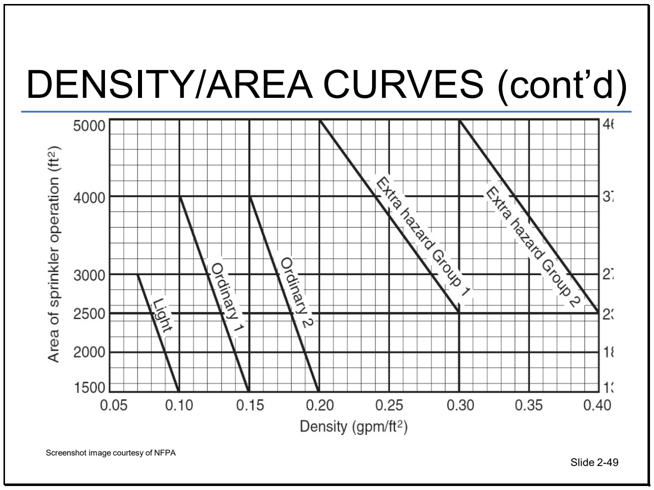
3. A single building may have more than one hydraulic remote area depending upon the type of occupancy, uses and sprinkler design.

   For example, a manufacturing facility with offices and storage areas may have at least three remote areas:

   a. Office: Light Hazard.

b. Manufacturing: Ordinary or Extra Hazard.

c. Storage: Ordinary or Special Storage Hazard.



4. Density/Area curves from NFPA 13.

a. The left-to-right ("X") axis of this graph represents the minimum flow in gpm per square foot that is necessary to control a fire. This is the density.

b. The bottom-to-top ("Y") axis represents the minimum area of application in square feet required by the standard. This is the area of application, remote area, hydraulic area, etc.

c. The five sloping lines represent the five hazard classifications addressed in NFPA 13:

- Light Hazard.
- Ordinary Hazard, Group 1.
- Ordinary Hazard, Group 2.
- Extra Hazard, Group 1.
- Extra Hazard, Group 2.

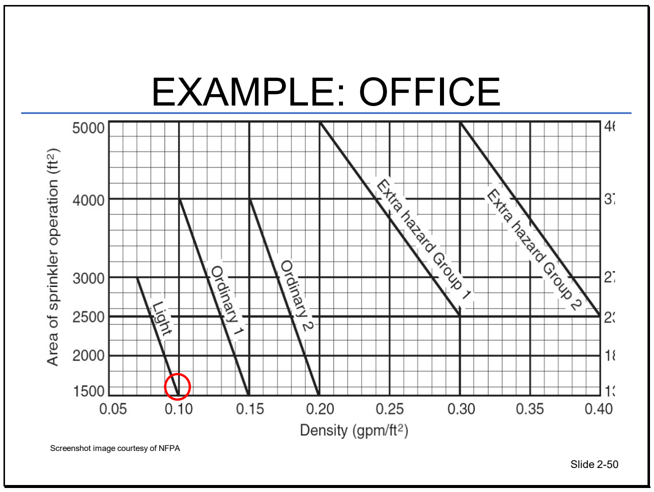
d. Although the lines are straight, historically they are called "curves."

e. The sprinkler designer must show that the design density curve intersects the area of application at a point on or to the right of the curve specified for the hazard class.

- The intersection of the density and area of application on the designated line is the **minimum** that meets NFPA 13.

- Any point that occurs to the right of this intersection is above the minimum requirements. Special rulings from code officials or property insurance underwriters may require these higher densities or areas of application.

f. The designer will satisfy the minimum requirements if the intersecting point occurs anywhere along the hazard classification curve. The designer may choose a lesser density and larger area of application, or a smaller area of application and greater density. These decisions usually are based on the available pressure and flow from the water source.



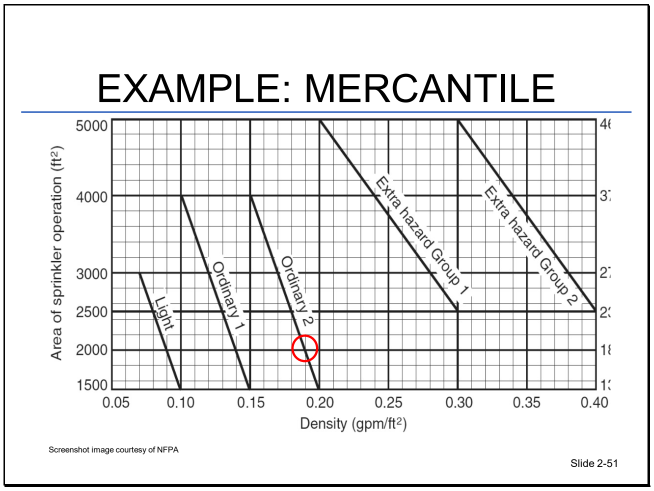
5. Example: office.

a. Light Hazard occupancy.

b. Designer selects 0.10 gpm per square foot over a 1,500-square-foot area of application.

- Common industry shorthand: 0.10/1,500.

c. Assuming the office is a Light Hazard occupancy, this density/ area selection complies with NFPA 13.

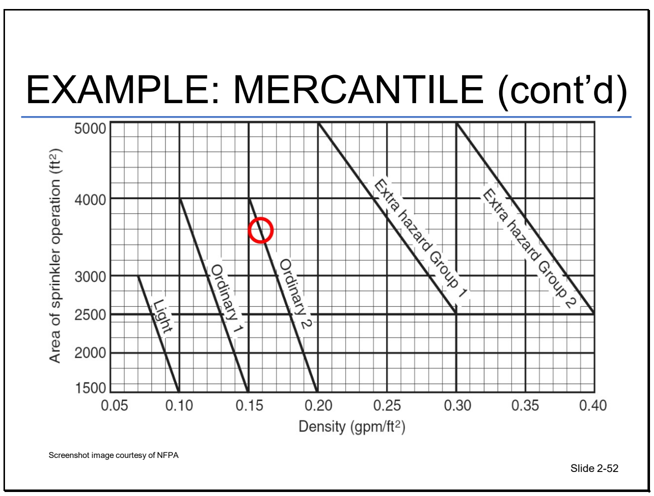


6. Mercantile example 1.

    a. Ordinary Hazard, Group 2 occupancy.

    b. Designer selects 0.19 gpm over 2,000 square feet.

    c. Assuming the mercantile is an Ordinary Hazard, Group 2 occupancy, this density/area selection complies with NFPA 13.

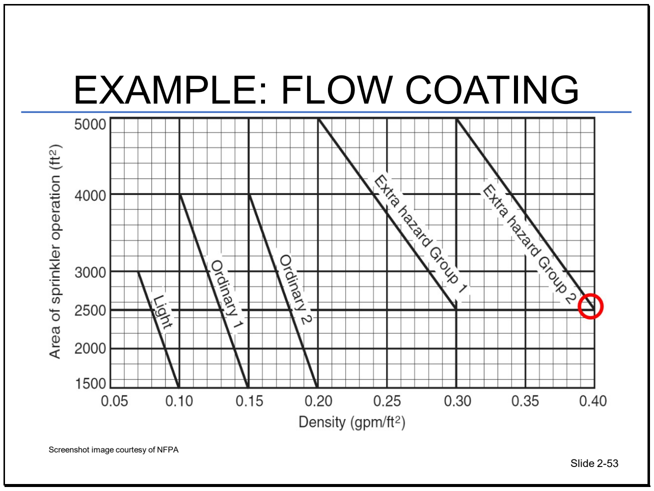


7. Mercantile example 2.

    a. Ordinary Hazard, Group 2 occupancy.

    b. Designer selects 0.16 gpm over 3,600 square feet.

    c. Assuming the mercantile is a Ordinary Hazard, Group 2 occupancy, this density/area selection complies with NFPA 13.



8. Example: flow coating.

   a. Extra Hazard, Group 2 occupancy.

   b. Designer selects 0.40 gpm over 2,500 square feet.

   c. Assuming the flow coating operation is an Extra Hazard, Group 2 occupancy, this density/area selection complies with NFPA 13.

DEMAND COMPARISON

Density x area = rough hydraulic estimate.

Example	Hazard class	Selected density	Area (square feet)	Demand (gpm)
Office	Light	0.10 gpm	1,500	150
Mercantile	Ordinary Hazard 2	0.19 gpm	2,000	380
Mercantile	Ordinary Hazard 2	0.16 gpm	3,700	592
Flow coating	Extra Hazard 2	0.40 gpm	2,500	1,000

Slide 2-54

E. Demand comparison among four examples.

1. By multiplying the density (gpm per square foot) by the area of application, the designer can obtain a very rough estimate of the amount of water that will be needed to control a fire in the hydraulic remote area.

2. Rough estimate water demand:

   a. Office: 150 gpm.

b. Mercantile example 1: 380 gpm.

c. Mercantile example 2: 592 gpm.

d. Flow coating: 1,000 gpm.

SOURCE PRESSURE VERSUS FLOW

- Upper example.
  - High pressure, low volume.
- Lower example.
  - Low pressure, high volume.

Example	Hazard class	Selected density	Area (square feet)	Demand (gpm)
Mercantile	Ordinary Hazard 2	0.19 gpm	2,000	380
Mercantile	Ordinary Hazard 2	0.16 gpm	3,700	592

Slide 2-55

F. Source pressure versus flow.

Designer may pick any point on the curve to adjust for water source considerations.

1. In the first mercantile example, the water source may have high pressure but low volume, so the designer selects a greater density but smaller area of application. The rough water demand is 380 gpm.

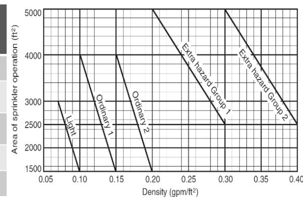
2. In the second mercantile example, the water source may have high volume but low pressure, so the designer selects a greater area of application but lesser density. The rough water demand is 592 gpm.

3. As long as the proposed design intersects the curve at some point, or falls to the right of the curve, it satisfies the minimum NFPA 13 requirements.

AREA LIMITS

- For smaller application areas, use curve minimum.
- No need to exceed larger area.

Hazard class	Area less than (square feet)	Selected density (gpm/square feet.)
Light	1500	0.10
Ordinary Hazard 1	1500	0.15
Ordinary Hazard 2	1500	0.20
Extra Hazard 1	2500	0.30
Extra Hazard 2	2500	0.40



Screenshot image courtesy of NFPA

Slide 2-56

G. Remote area limits.

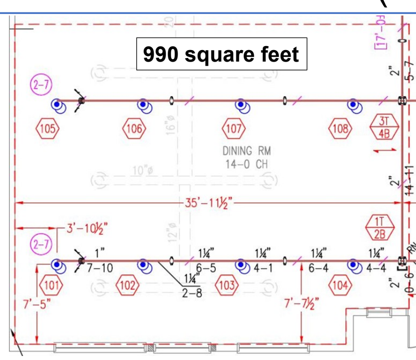
1. For smaller application areas, use the minimum density from the curve.

   a. Light/Ordinary Hazard: Remote area smaller than 1,500 square feet, use the 1,500-square-foot density value.

   b. Extra Hazard: Remote area smaller than 2,500 square feet, use the 2,500-square-foot density value.

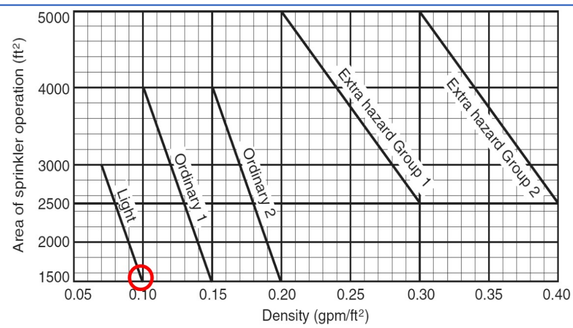
2. There is no requirement to increase the size of any remote area beyond what the curves provide.

DEMAND COMPARISON (cont'd)



Slide 2-57

DINING ROOM: 0.10/990 SQUARE FEET



Screenshot image courtesy of NFPA

Slide 2-58

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ACTIVITY 2.3

Density/Area Curves

Purpose

Interpolate NFPA 13 density/area curves.

Directions

1. Using the NFPA 13 density/area curves, fill in the blanks of the following examples. Once you have done that, compute a rough estimate of water demand for the described conditions.

2. Your answers should be within plus or minus 5% of the correct values.

	Occupancy class	Density (gpm/square foot)	Area (square feet)	Estimated total flow (gpm)
1	Light Hazard	0.07		
2	Ordinary Hazard, Group 1	0.11		
3	Ordinary Hazard, Group 2		2,500	
4	Extra Hazard, Group 2		4,000	
5	Extra Hazard, Group 2	0.375		

Optional (not graded): If you require additional practice, fill in the blanks of the following examples:

	Occupancy class	Density (gpm/square foot)	Area (square feet)	Estimated total flow (gpm)
6	Extra Hazard, Group 2	0.315		
7	Ordinary Hazard, Group 1		3,350	
8	Extra Hazard, Group 1		3,750	
9	Light Hazard		2,650	
10	Ordinary Hazard, Group 2		2,600	

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ACTIVITY 2.4

"Real World" Impacts

Purpose

Understand how hazard class values affect sprinkler system water supply requirements.

Directions

1. Using the slides and your responses from Activity 2.2, you will compare how the hazard class values you chose affect sprinkler system water supply requirements.

2. Area/Density values on the slides have been selected randomly, solely for the purpose of the activity. You may have to interpolate points on the curve due to the curves' error margin.

3. Using the points on the curves for the hazard class you applied in Activity 2.2, determine the estimated flow in gpm for the remote area.

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ACTIVITY 2.4 (cont'd)

"Real World" Impacts Worksheet

Occupancy	Remote area (square feet)	Density					Remote area total flow (gpm)				
		Light Hazard	Ordinary Hazard, Group 1	Ordinary Hazard, Group 2	Extra Hazard, Group 1	Extra Hazard, Group 2	Light Hazard	Ordinary Hazard, Group 1	Ordinary Hazard, Group 2	Extra Hazard, Group 1	Extra Hazard, Group 2
Welding shop	**1,800**										
Museum	**2,675**										
Fiberglass	**1,850**										
Auditorium	**1,950**										
Winery	**1,500**										
Power plant	**3,225**										
Self-storage	**2,350**										
Boat yard	**4,250**										
Bag house	**250**										
Tennis club	**1,000**										

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ACTIVITY 2.5

Density/Area Verification

Purpose

Evaluate NFPA 13 density/area proposals using scenarios and justify the decisions.

Directions

1. The instructor will walk you through the solution to the first scenario.

2. Your group will be assigned a scenario in which density/area proposals will be provided for review and approval. Using NFPA 13, your group should evaluate if the proposals are suitable.

3. You will have to make a consensus decision to approve or reject the submittal and write a short justification for your decision.

4. Each group will present their findings to the larger class the following day.

Scenarios

1. The instructor will review the hydraulic design cover sheet for the restaurant dining room in The Learning Square project. It includes information on the design/area designations.

   Based on the information provided, do you approve or reject the submittal, and why?

   ____

   ____

   ____

   ____

   ____

2. Maxim's Nouvelle Cuisine will be a newly constructed Group A-2 occupancy with a seating capacity of 362 persons. The building will be a one-story, Type VB construction measuring 10,820 square feet. The building will include formal dining seating, a commercial kitchen, a sous kitchen, dry storage, an 800-square-foot walk-in cooler, a 1,000-square-foot boulangerie (bread bakery), and a mahogany-paneled cocktail lounge.

   The sprinkler design calls for a complete wet pipe system with an overall design density of 0.09 gpm over 2,000 square feet.

   Do you approve or reject the submittal, and why?

   ____

   ____

   ____

   ____

   ____

3. Hammerin' Hank's Bargain World wants to occupy a former supermarket that was a Type IIIB building, Group M occupancy measuring 48,000 square feet with a 2,000-square-foot office mezzanine. Hammerin' Hank is a local legend for buying and reselling dry stock from failed businesses. At any time, his store might include furniture and bedding (including mattresses), camping gear, bicycles and toys, books and music collections (CDs and DVDs), clothing, fishing tackle and hunting supplies (guns and ammunition), pesticides, herbicides, fertilizers, and paints of all kinds. Products are stored on the floor or shelves six feet high.

   Fifteen years ago, Hammerin' Hank's original store burned to the ground, so he is very cautious about fire safety and always complies with all codes and standards. He is willing to make changes to the sprinkler system to satisfy current standards.

   An analysis by the fire sprinkler company shows that the design for the supermarket sprinkler was 0.09 over the entire area of the mezzanine, and 0.17 over 3,000 square feet throughout the retail area. The sprinkler company says no changes are needed.

   Do you approve or reject the submittal, and why?

   ____

   ____

   ____

   ____

   ____

4. Blazac® Corporation wants to build a new tractor and semitruck painting facility. The company promises to employ 150 or more new highly skilled painters and shop operators and pay them union wages with benefits.

The proposed building will be a Group F-1, Type IIB construction measuring 120,000 square feet. It will be 28 feet tall in the production area. The building will be fully sprinklered and complies with the building code for allowable height and area. At the northeast corner of the building, between the production area and parking, there will be a 10,000-square-foot administrative building that is connected to the plant by a noncombustible, enclosed pedestrian walkway that has tempered glass walls.

To accommodate the large objects being painted, the plant will have six drive-through paint spray rooms. The spray rooms are classified as Group H-2 occupancies and are constructed with four-hour fire barriers to separate them from the production floor. There also is a Group H-3 flammable liquid storage room where liquids are piped under low pressure (less than 15 pounds per square inch (psi)) to the paint rooms.

Although there is no open-flame welding, there is "final stage" grinding before painting, where tractors and truck cabs get a final check to verify that there are not exposed, shaped metal edges or burs.

The fire sprinkler plans include the following legend explaining the proposed design densities:

Location	**Hazard class**	**Density (gpm)**	**Application area (square feet)**
Office	Light Hazard	0.10	1,500
Production floor	Ordinary Hazard, Group 1	0.17	3,600
Spray rooms	Extra Hazard, Group 2	0.35	3,800
Flammable liquid storage	Ordinary Hazard, Group 2	0.25	3,750

Do you approve or reject the submittal, and why?

____

____

____

____

____

5. Marge Bauer plans to open “The Hair Cuttery” in the end unit of an old outdoor shopping mall. When the shopping mall was built, there was no water supply in the area, so it was permitted to be constructed without sprinklers. Under current code — and because of the remodel — the floor area between fire barriers now requires the unit to be sprinklered.

   The sprinkler contractor submits a design proposal at 0.10 gpm over 1,800 square feet. Recent flow tests in the area show the dead-end water system capable of flowing only 312 gpm.

   Do you approve or reject the submittal, and why?

   ____

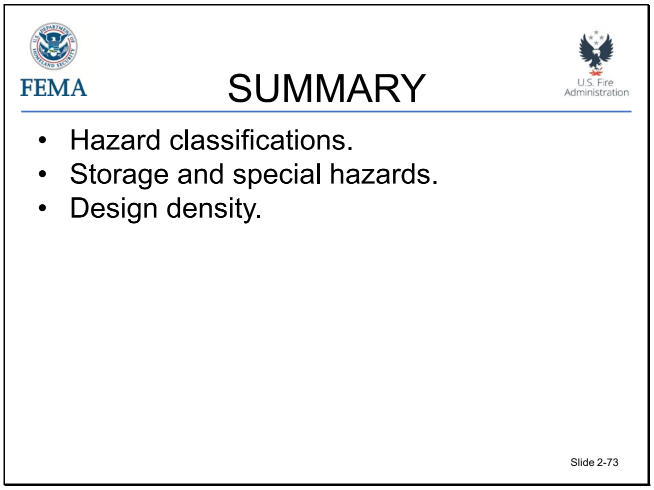
   ____

   ____

   ____

   ____

V. SUMMARY


FEMA
SUMMARY
U.S. Fire Administration
• Hazard classifications.
• Storage and special hazards.
• Design density.
Slide 2-73

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REFERENCE

Ahrens, M. (2017). *U.S. experience with sprinklers* (NFPA No. USS14). Retrieved from https://www.nfpa.org/-/media/Files/News-and-Research/Fire-statistics-and-reports/Suppression/ossprinklers.pdf

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APPENDIX

SUPPLEMENTAL MATERIALS

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Accessing Online Codes and Standards

Both the National Fire Protection Association (NFPA) and International Code Council (ICC) allow users to review their codes and standards online at no cost. These “read only” versions may not be edited, highlighted, downloaded or otherwise modified, but they provide a resource to codes and standards users.

To obtain access to these documents, follow the steps outlined below.

National Fire Protection Association Codes and Standards

1. Point your web browser to the NFPA home page: www.nfpa.org.
2. Select “Codes & Standards.”
3. Select “Free access.”
4. Select “View the list of NFPA’s codes and standards.”
5. Select the code or standard you wish to view.
6. Select “Free Access.”
7. Using the drop-down menu under “Select the Free Access Edition,” select the code or standard edition you wish to view.
8. Select “View.”
9. You must consent to the NFPA user agreement to proceed. Select “I Agree.”
10. Once it appears, you may scroll through the document. In PDF files, Crtl+F allows the user to search on key words.

International Code Council Codes and Standards

1. Point your web browser to the ICC home page: www.iccsafe.org.
2. Select “Online Building Codes.”
3. In the search box next to “Find Codes” enter key words, e.g., “2015 IFC.”
4. Select the Search icon (magnifying glass).
5. When the code and edition appear, select “Free View.”
6. You will be delivered to that code edition’s Table of Contents. Scroll to the code section you wish to view.

UNIT 3: WATER SUPPLIES AND DELIVERY SYSTEMS

TERMINAL OBJECTIVE

The students will be able to:

3.1 Evaluate the water supply system's ability to supply a fire protection system given the performance capabilities of a water supply system and a set of plans.

ENABLING OBJECTIVES

The students will be able to:

3.1 Compare the volume, reliability, functionality and features of the water sources available to supply sprinklers.

3.2 Conclude if the specific sample water supply system components comply with National Fire Protection Association (NFPA) 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.

3.3 Determine if the underground piping configuration meets nationally recognized standards.

3.4 Evaluate the water supply test point data using a site plan.

3.5 Evaluate the calculations for the water storage capacity of a cylindrical suction tank and a water storage reservoir.

3.6 Verify the minimum required water supply for a sprinkler system.

3.7 Verify the minimum required water supply for a combined sprinkler system.

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FEMA

U.S. Fire Administration

UNIT 3: WATER SUPPLIES AND DELIVERY SYSTEMS

Slide 3-1

TERMINAL OBJECTIVE

Evaluate the water supply system's ability to supply a fire protection system given the performance capabilities of a water supply system and a set of plans.

Slide 3-2

ENABLING OBJECTIVES

- Compare the volume, reliability, functionality and features of the water sources available to supply sprinklers.
- Conclude if the specific sample water supply system components comply with National Fire Protection Association (NFPA) 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances.*

Slide 3-3

ENABLING OBJECTIVES (cont'd)

- Determine if the underground piping configuration meets nationally recognized standards.
- Evaluate the water supply test point data using a site plan.
- Evaluate the calculations for the water storage capacity of a cylindrical suction tank and a water storage reservoir.

Slide 3-4

ENABLING OBJECTIVES (cont'd)

- Verify the minimum required water supply for a sprinkler system.
- Verify the minimum required water supply for a combined sprinkler system.

Slide 3-5

I. WATER SOURCES

A. Not every jurisdiction has the luxury of being able to connect fire sprinkler or standpipe systems to "municipal-type" water service that includes large storage tanks, distribution and service mains, or even fire hydrants. In some instances, fire sprinkler systems may have to be connected directly to their own supply sources such as tanks or ponds.

B. This section addresses the water sources included in National Fire Protection Association (NFPA) 13, *Standard for the Installation of Sprinkler Systems*, and NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*.

WATER SOURCES

- NFPA recognizes four "automatic" types.
  - Public and private.
  - Fire pump assemblies.
  - Pressure tanks.
  - Gravity or suction tanks.

Photo courtesy of Integra Code Consultants

Slide 3-6

WATER SOURCES (cont'd)

Photo courtesy of Integra Code Consultants

- Public.
  - Domestic, industrial, fire.
  - Separate domestic and fire.
- Private.
  - Owner designed/ maintained.

Slide 3-7

C. All sprinkler systems must be connected to an automatic water source. NFPA recognizes four automatic sources.

1. Public and private.

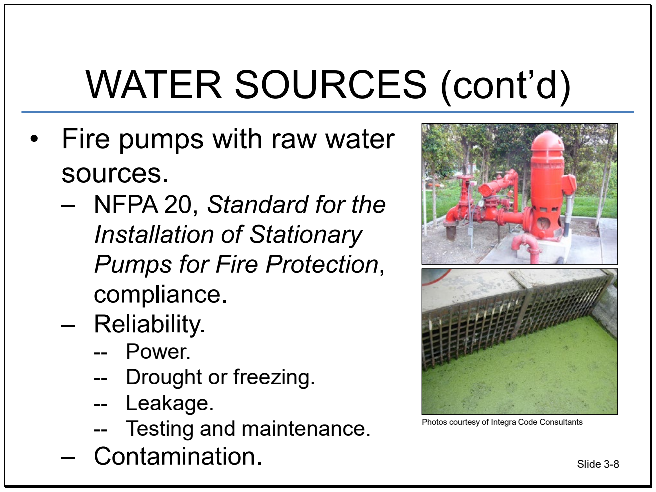
a. Public (municipal, water districts and similar entities). These providers may supply water for:

- Combined domestic, industrial and fire protection uses.

- Separate domestic and fire supplies.

b. Private (water companies, on-site supplies).

- Owner designed/maintained.



2. Fire pump assemblies with raw water sources (tanks, lakes, ponds, reservoirs, salt water).

   a. Pump installations must comply with NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*.

   b. Reliability: Pump assemblies must be dependable.

      - Power supplies must be maintained.

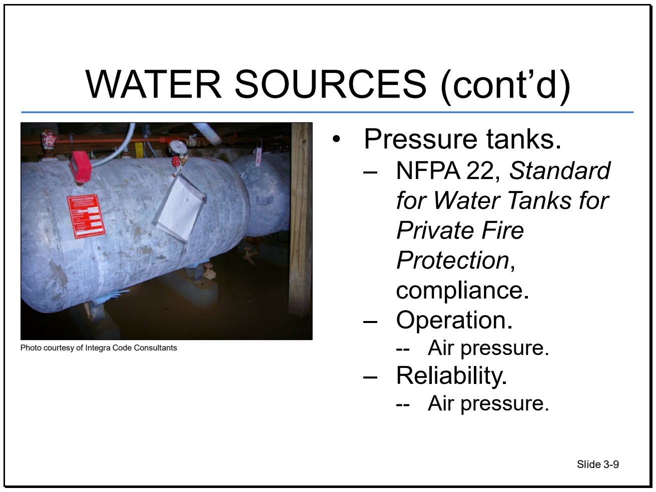
        -- Electric or diesel.

      - Drought or freezing issues must be considered in the design.

      - Leakage from the water supply should be monitored to prevent volumes falling below requirements.

      - Testing and maintenance requirements should be implemented to enhance reliability.

   c. Contamination: Water sources should be free from contaminants (vegetation, dirt/rocks, chemicals, etc.) that might affect pump performance.



3. Pressure tanks: used most often in remote areas where other sources are unavailable.

   a. NFPA 22, *Standard for Water Tanks for Private Fire Protection*, compliance is required.

      - Capacity is approved by the code official based on the protected hazard.

      - Vessels must meet "ASME Boiler and Pressure Vessel Code" strength standards for unfired pressure vessels.

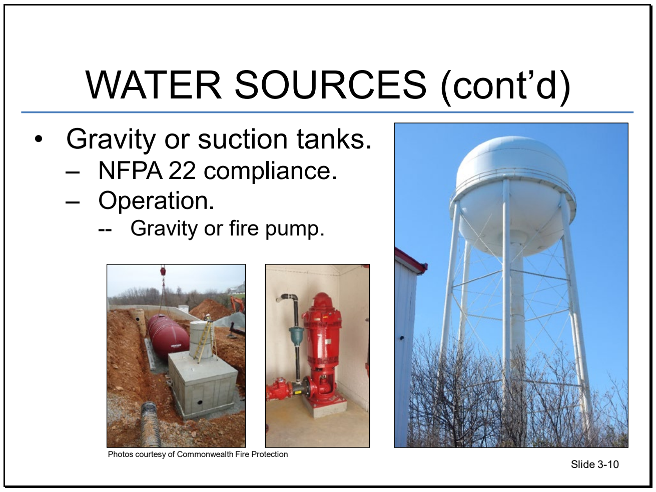
   b. Operation.

      - Air pressure: Pressure tanks operate by compressed air pushing water through the pipes and out sprinklers when a sprinkler opens.

      - Air quantity must be adequate to push all the water out of the tank.

   c. Reliability.

      - Air pressure must be maintained with a compressor sized in accordance with tank volume.

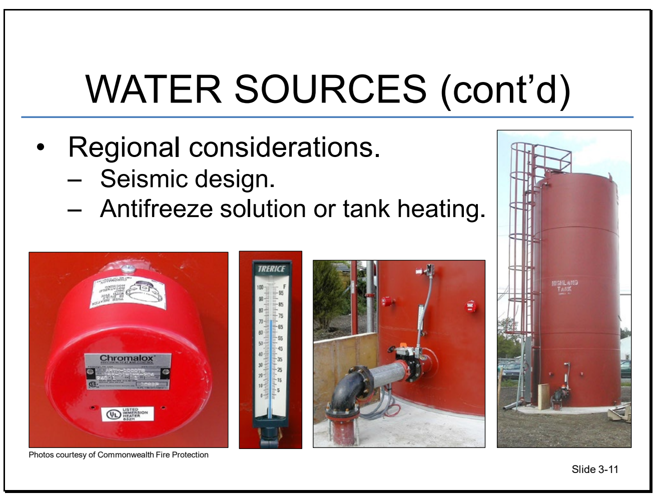


4. Gravity or suction tanks.

   a. NFPA 22 compliance required.

   b. Operation.

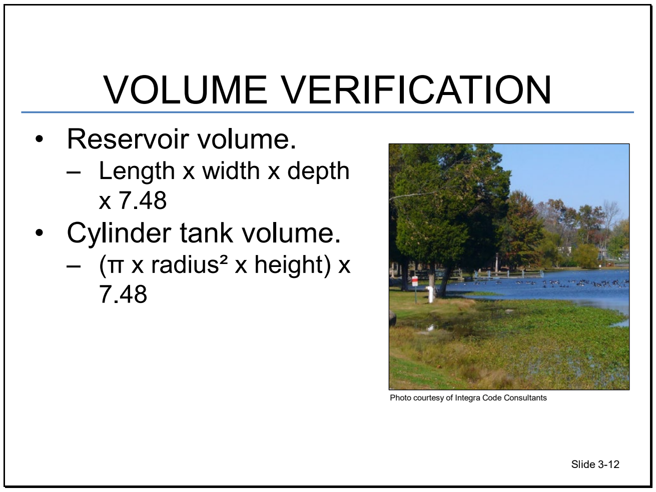
      - Gravity or fire pump water delivery.



D. Regional considerations.

   1. Seismic design based on earthquake potential.

   2. Antifreeze solution or tank heating for cold environments.



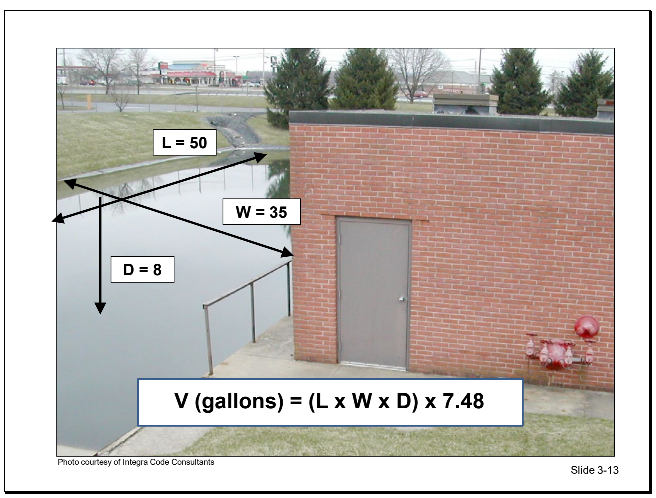
E. Volume verification: The code official may be asked to verify the volume of various water sources. This is easily accomplished with simple arithmetic.

1. Reservoir volume can be computed by the formula:

   Length x width x depth x 7.48 (cubic feet per gallon)

2. Cylindrical tank volumes can be computed by the formula:

   (π x radius^2 x height) x 7.48



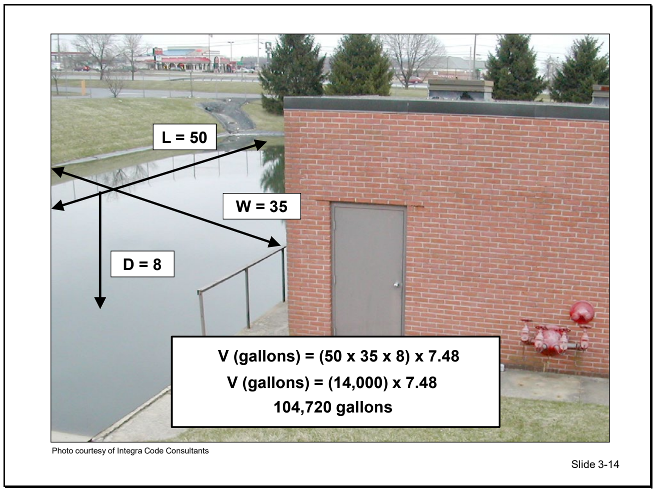
3. Reservoir example.

   a. Dimensions:

      - Length = 50 feet.

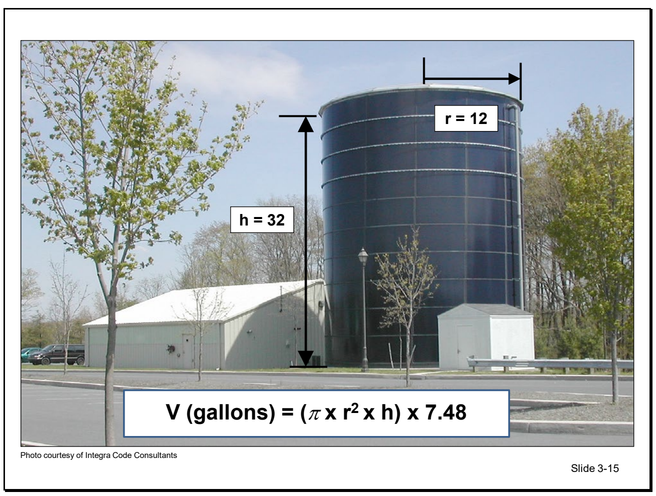
      - Width = 35 feet.

- Depth of the vertical turbine fire pump bowl = 8 feet.



b. Solution.

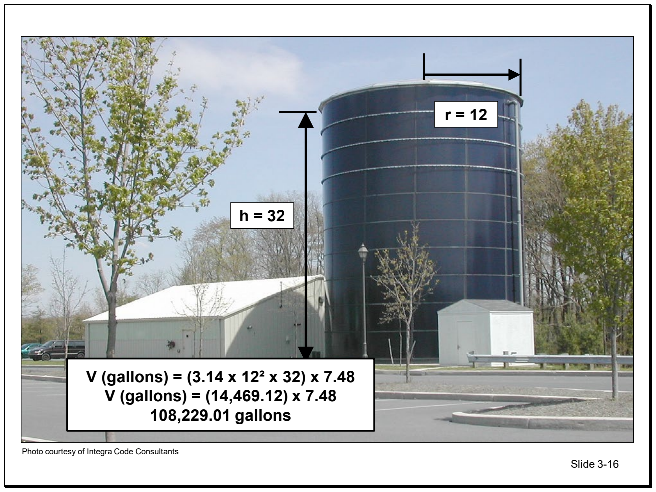
- Volume = (14,000 cubic feet) x 7.48.
- Total available supply = 104,720 gallons.



4. Aboveground cylindrical tank (example 1).

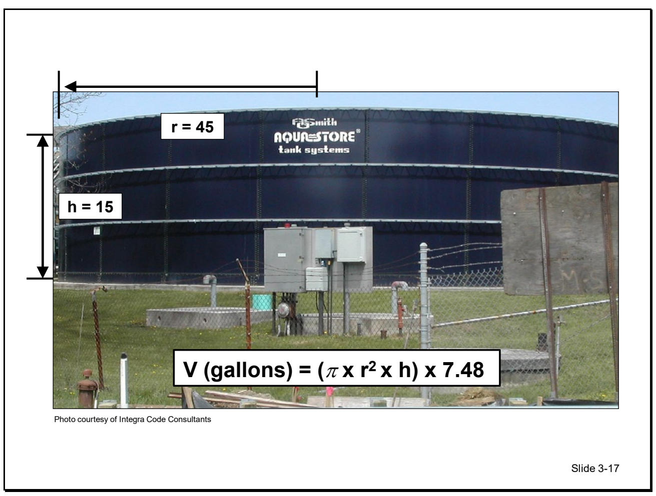
a. Dimensions:

- Height = 32 feet.
- Radius = 12 feet.



b. Solution.

- Volume = (14,469.12 cubic feet) x 7.48.
- Total available supply = 108,229.01 gallons.



5. Aboveground cylindrical tank (example 2).

a. Dimensions:

- Height = 15 feet.
- Radius (r) = 45 feet.

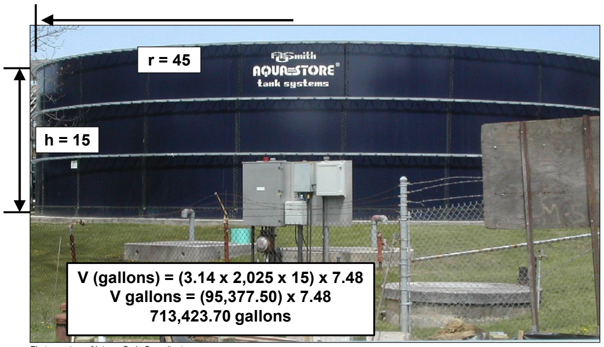


Photo courtesy of Integra Code Consultants

Slide 3-18

b. Solution.

- Volume = (95,377.50 cubic feet) x 7.48.

- Total available supply = 713,423.70 gallons.

ACTIVITY 3.1

Available Stored Water Supply

Purpose

Calculate the amount of stored water available, given a depiction of a scene with mixed water capability and the dimensions of the stored water sources.

Directions

1. In small groups, you will calculate the total available stored water from the example.

2. Each group will be asked to provide the answer to the problem. The instructor will then review the correct answer and discuss any discrepancies. Remember that a radius equals half of a diameter (or diameter = radius x 2).

Scenario

The owner of Acme Metal and Plastic fabrication has been in business 17 years and now wants to expand operations by adding three 800,000-square-foot buildings.

One building will be used for raw material storage, one for production, and the third will be for storing finished products on racks.

The property insurance underwriter wants to know the available on-site water volume for fire protection systems and manual suppression.

The owner claims that there is a combined total of 2.3 million gallons between the elevated tank and reservoir and wants you to write a letter to their insurance company verifying the volume.

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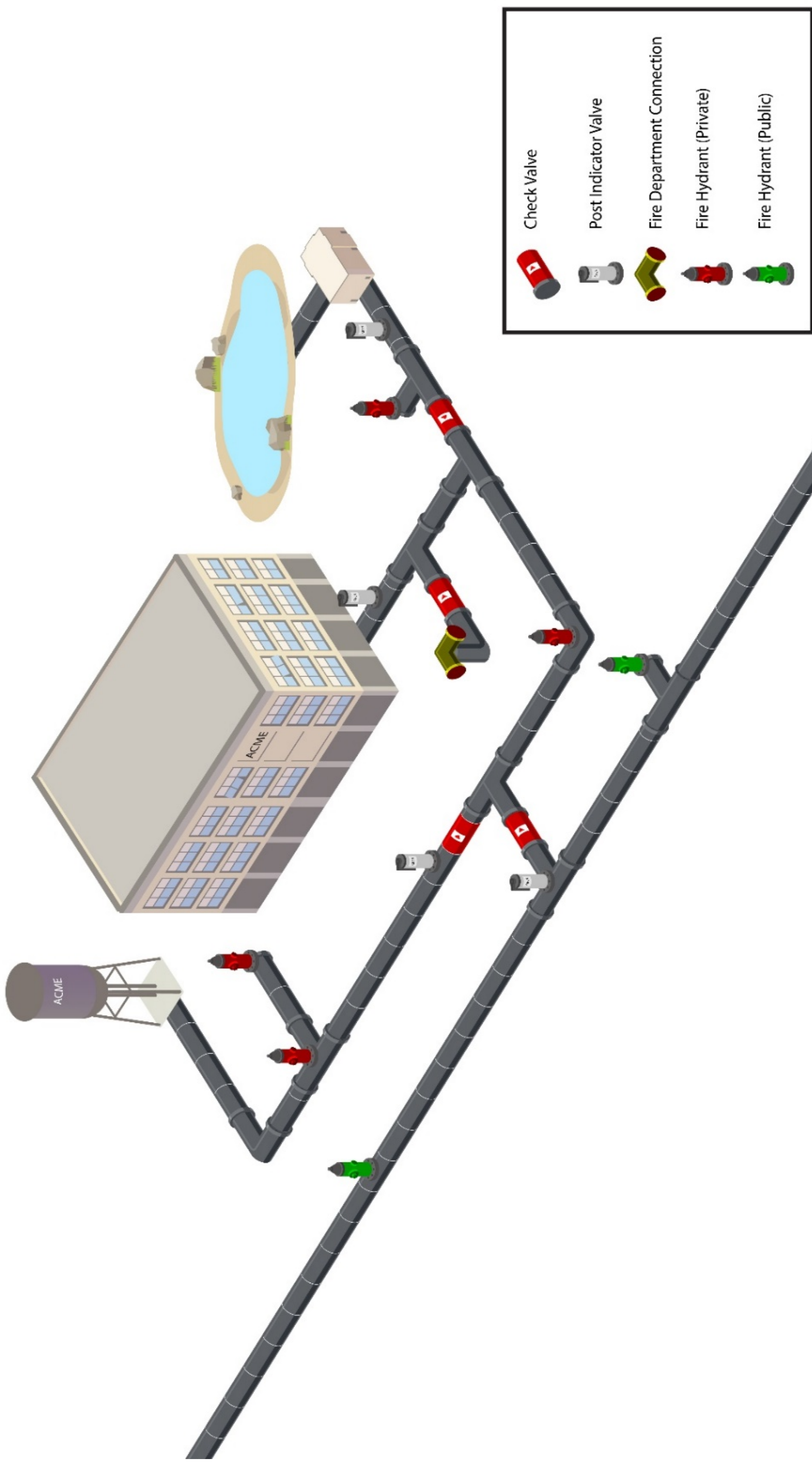
ACTIVITY 3.1 (cont'd)



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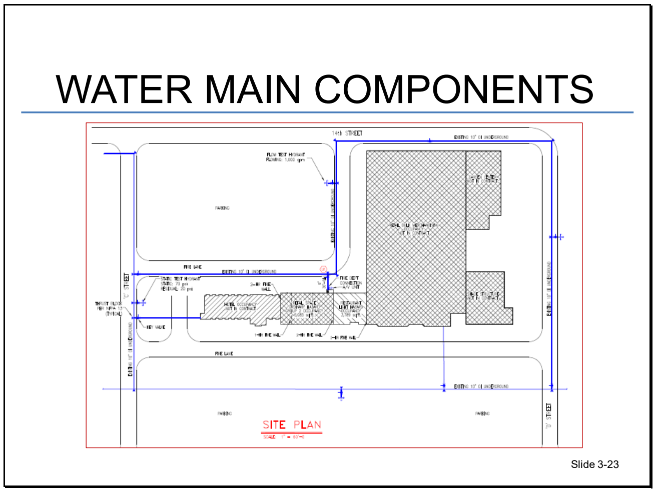
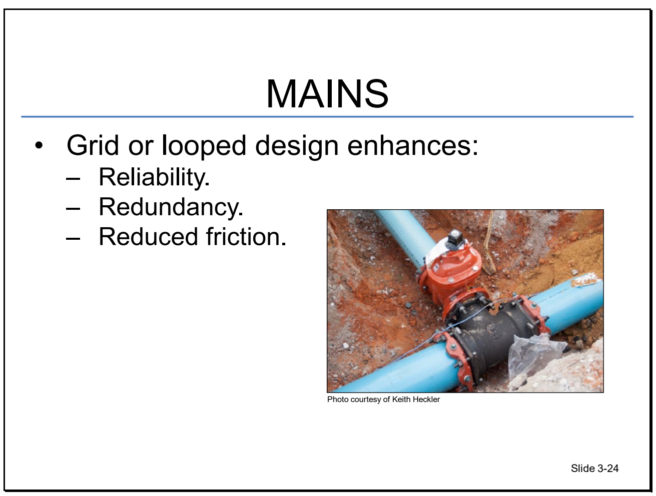
II. WATER MAIN COMPONENTS

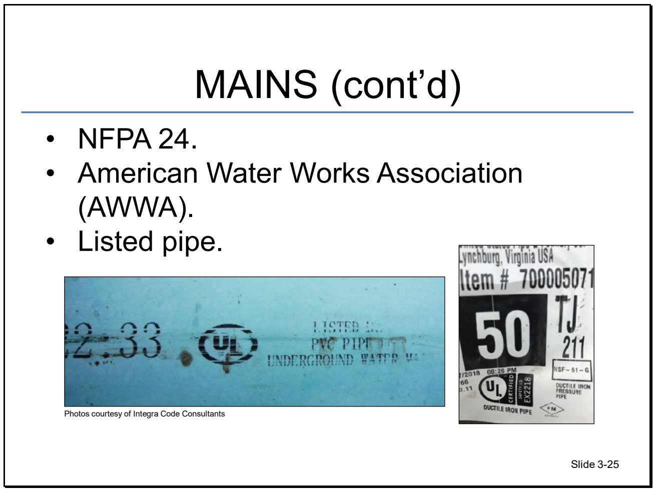
A. This section will address the infrastructure components that are needed to deliver water from its source to the building. These components must be reliable, designed for efficiency and comply with national standards for public or private water service.





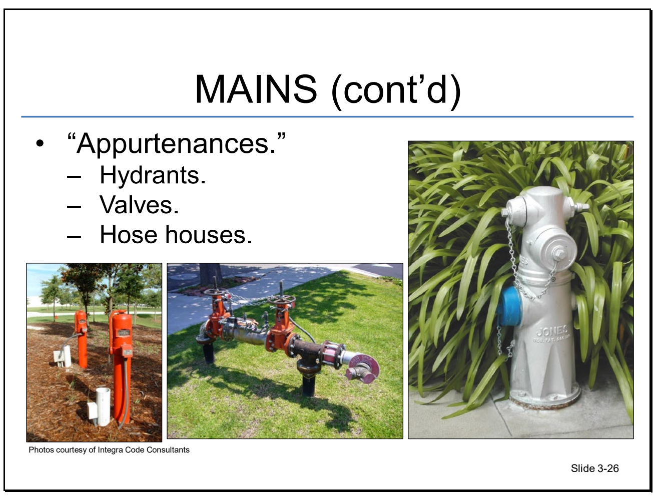
B. Mains.

1. Gridded or looped underground main network designs are preferred to enhance system reliability and redundancy and to reduce friction losses in water services.



2. NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, is the primary standard for the design and installation of water services on private property.

The American Water Works Association (AWWA) provides design guides and standards for public infrastructure.



3. "Appurtenances" are features connected to or controlling private fire service mains:

a. Fire hydrants.

b. Control valves.

c. Backflow prevention devices.

d. Hose houses.

- Do you know where “public” infrastructure ends and “private” infrastructure begins on projects in your jurisdictions?
- Who is responsible for the design, installation, inspection, testing, approval and maintenance of private infrastructure on projects in your jurisdictions?

Slide 3-27

MAINS (cont’d)

- Pipe must be listed/comply with these standards.

Material	Standard(s)	Diameters (inches)
Ductile iron	AWWA C104, C105, C110, C115	3-48
Steel	AWWA C200, C203, C205, C206	6-144
Concrete	AWWA C300, C301, C302, C303	
Asbestos concrete	AWWA C400, C401	4-16
Plastic	AWWA C900, C906	4-63
Copper	ASTM B75, B88, B251	

Slide 3-28

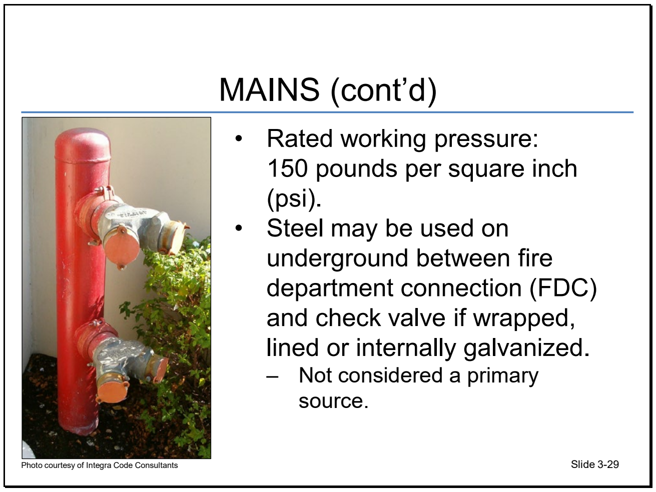
4. Water mains can be made from a variety of materials but must be listed with one of the standards shown in the table on the slide.

5. The table provides the:

   a. Materials.

   b. Listing standards.

   c. Sizes that are regulated by the listing.



6. Water mains must be capable of sustaining a working pressure of 150 pounds per square inch (psi).

   a. According to NFPA 13, working pressure is "the maximum anticipated static (nonflowing) or flowing pressure applied to sprinkler system components exclusive of surge pressures and exclusive of pressure from the fire department connection (FDC)" (NFPA, 2019, section 3.3.216).

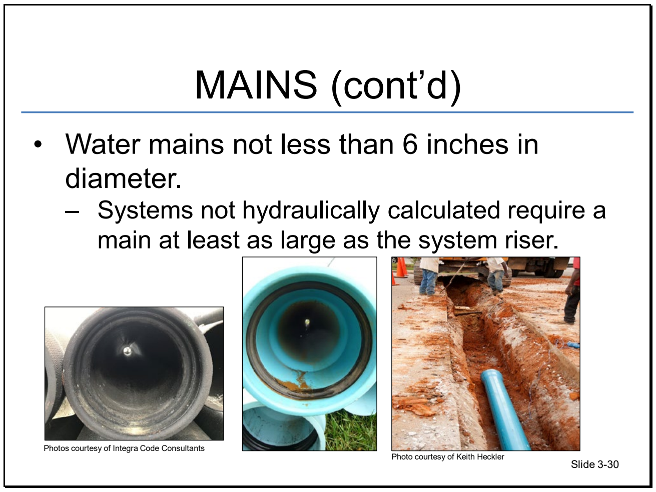
   b. Working pressure (150 psi) is different from the post-installation hydrostatic test pressure of 200 psi.

   c. Steel pipe wrapped and lined per applicable standards may be used between hose couplings and check valves on FDC.

   d. Steel pipe has a poor history of performance underground due to leaks and other failures. Steel is not permitted to supply a primary water source.

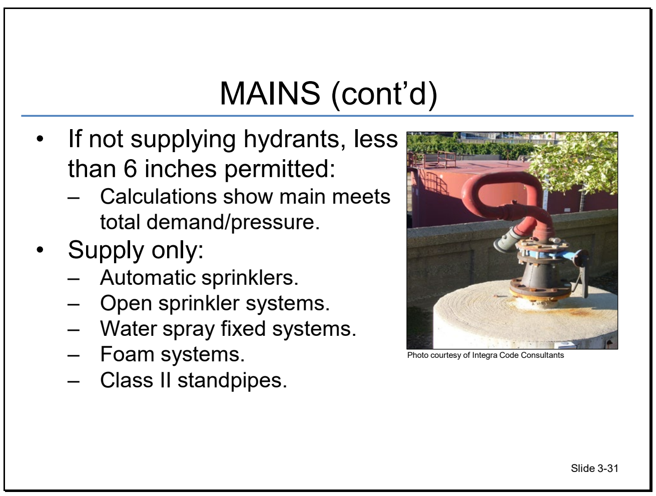
      - Remote FDCs may have a portion of their lines underground. If the pipe is steel, it must be wrapped and lined or internally galvanized.

      - FDC line is not considered a primary water source, so steel pipe may be installed.



7. Water mains should not be less than 6 inches in diameter.

   Systems that are not hydraulically calculated require a service main at least as large as the system riser.



8. Water mains less than 6 inches in diameter may be used if they are not supplying fire hydrants, and calculations show the main meets total demand/pressure.

9. Water mains may be smaller than 6 inches if they supply only:

   a. Automatic sprinklers.

   b. Open sprinkler systems.

   c. Water spray fixed systems.

   d. Foam systems.

e. Class II standpipes because they require only 100 gallons per minute (gpm).

MAINS (cont'd)

- Cover depth.
  - Measure from top of pipe to finished grade.
  - Consider future final grade and soil nature.

Conditions	Minimum cover depth (inches)
All	30
Driveways	36
Railroad tracks	48
Frost line	12 below
Building foundations	12 below

Slide 3-32

10. Cover depth: Pipe must be protected from physical and environmental factors. It should be covered based on where the pipe is installed:

    a. Measure from top of the pipe to the finished grade.

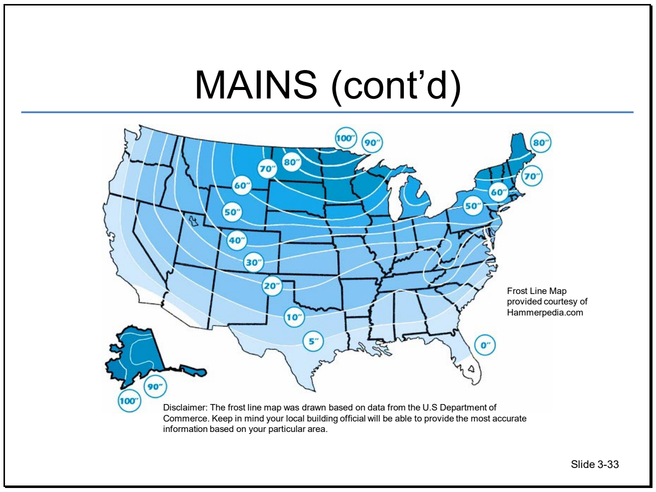
    b. Consider future final grade and soil nature.

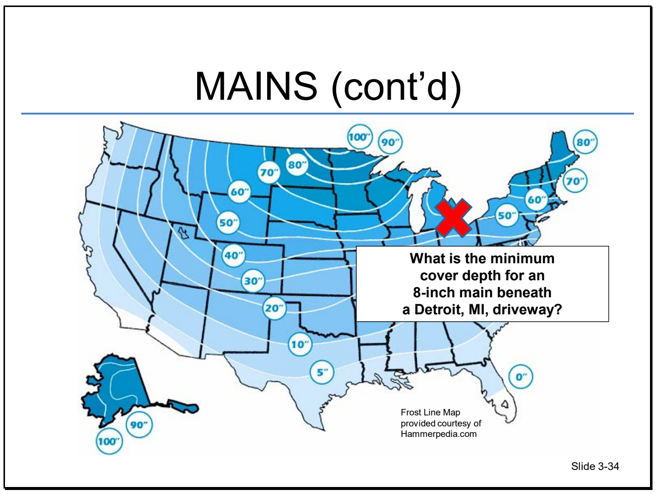
        - All pipe should be at least 30 inches underground.

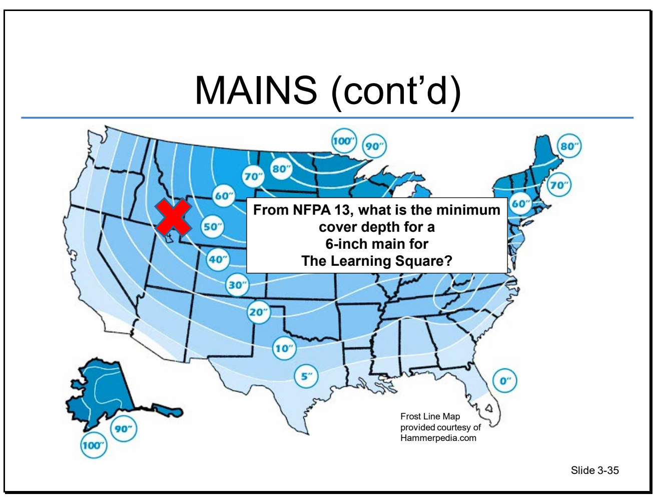
        - Where pipe runs under driveways or roads, it should be at least 36 inches deep.

        - Where pipe is under unusually heavy loads such as railroad tracks, burial depth should be at least 48 inches.

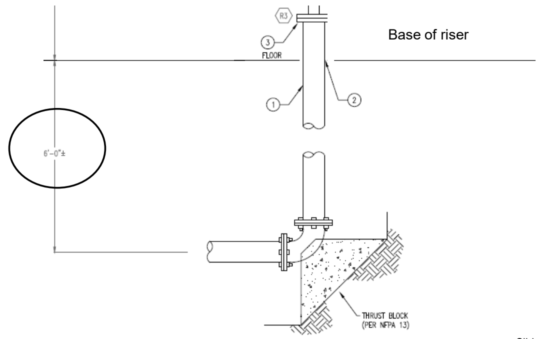
        - To prevent water lines from freezing, they should be buried at least 12 inches beneath the local frost line.


MAINS (cont'd)
Frost Line Map provided courtesy of Hammerpedia.com
Disclaimer: The frost line map was drawn based on data from the U.S Department of Commerce. Keep in mind your local building official will be able to provide the most accurate information based on your particular area.
Slide 3-33


MAINS (cont'd)
What is the minimum cover depth for an 8-inch main beneath a Detroit, MI, driveway?
Frost Line Map provided courtesy of Hammerpedia.com
Slide 3-34


MAINS (cont'd)
From NFPA 13, what is the minimum cover depth for a 6-inch main for The Learning Square?
Frost Line Map provided courtesy of Hammerpedia.com
Slide 3-35

MAINS (cont'd)



Slide 3-36

MAINS (cont'd)

- Pipe installation beneath structures.
  - Special situations and precautions.
    - -- Arching foundation walls over pipe.
    - -- Running pipe in covered trenches.
    - -- Providing valves to isolate sections of pipe under buildings.

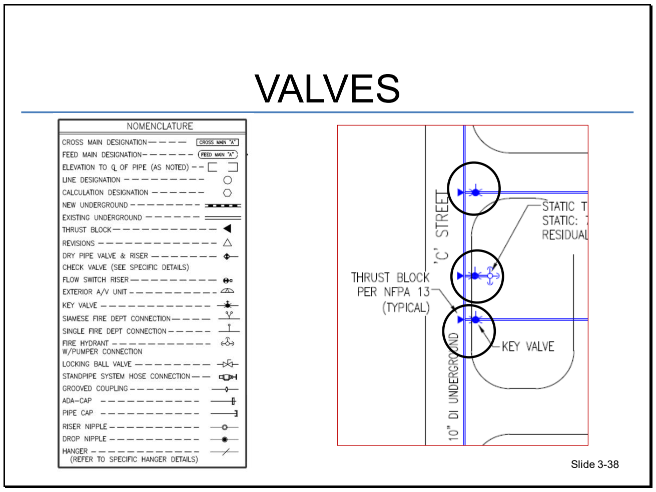
Slide 3-37

11. Pipe installation beneath structures should be avoided. If it must be done, NFPA 22 provides the following special situations and precautions:

    a. Arching foundation walls over pipe.

    b. Running pipe in covered trenches.

    c. Providing valves to isolate sections of pipe under buildings (NFPA, 2018).



C. Valves.

1. The underground valve symbols are highlighted on the slide to ease in their identification. This can be seen on Sheet S-1 (Site Plan). From top to bottom of the slide, the valves are for:

   a. The tee intersection of the existing 10-inch water mains on "C" Street and the fire lane.

   b. A fire hydrant south of the fire lane.

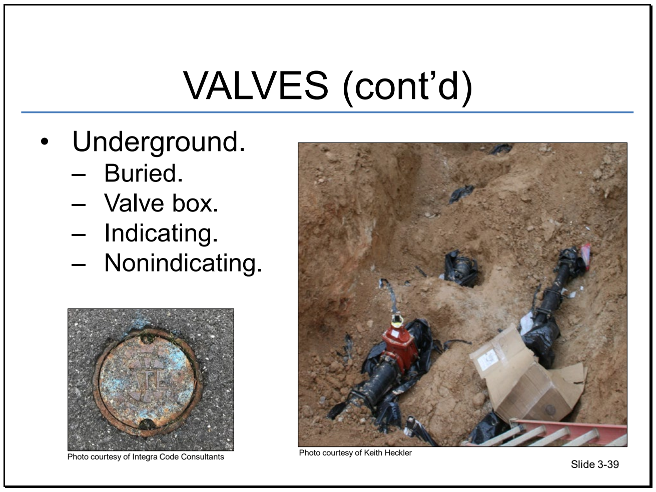
   c. The underground lead-in to the sprinkler systems for the hotel occupancy.

2. Valves are employed in water systems to:

   a. Control water flow.

   b. Isolate pipe segments for maintenance and repair.

3. NFPA 24 requires control at every water supply connection.



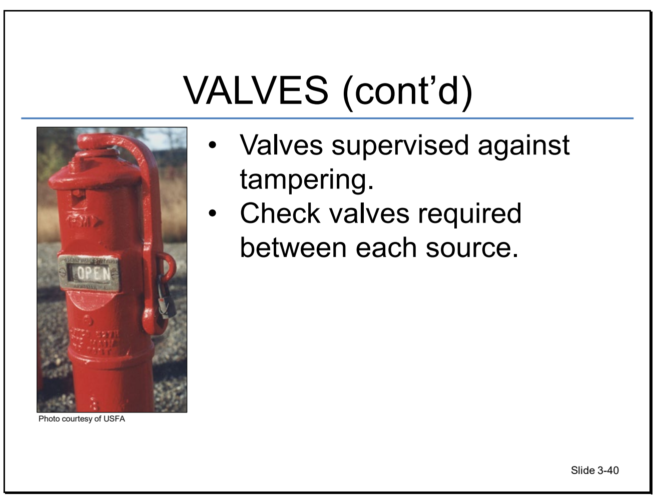
4. Underground valves: Valves installed where they are going to be buried can be:

   a. Buried if there is a valve box providing access to the operating nut.

   b. In a metal, plastic or concrete box with a lid that provides access to the entire valve assembly.

   c. Indicating (with an attached post indicator valve (PIV)).

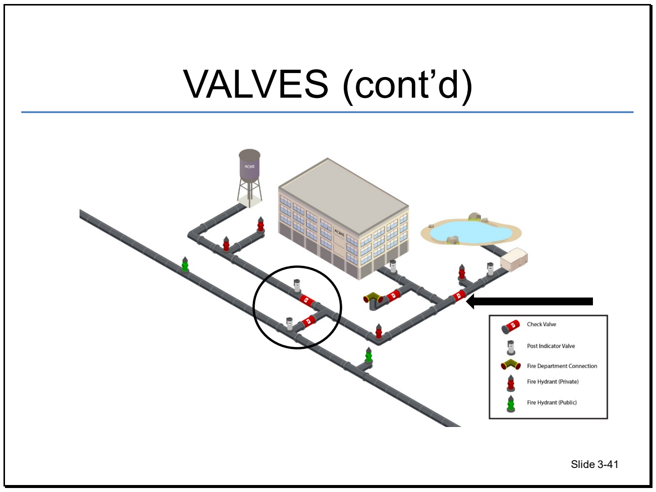
   d. Nonindicating.



5. Other than the one underground control valve, any valves controlling water supplies into the fire protection system must be supervised against tampering.

   NFPA 13 allows a variety of supervisory methods, but the model fire codes typically require electronic supervision.

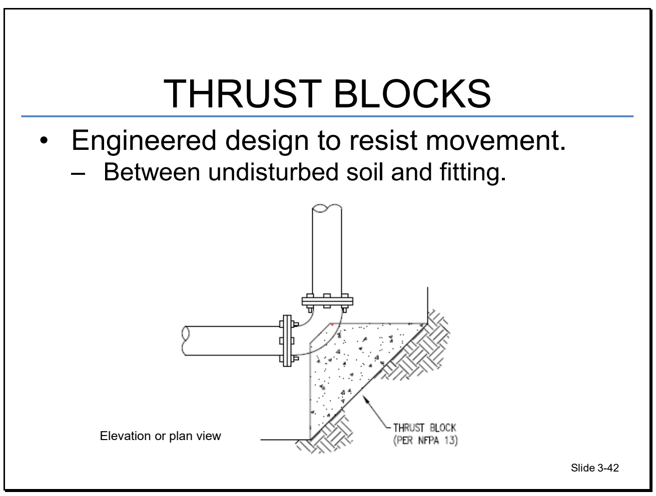
6. Check valves are required between each source so that if one drains the other is not affected.



7. Identify location if:

   a. Supervised PIVs.

   b. Check valves isolating each source.



D. Thrust blocks.

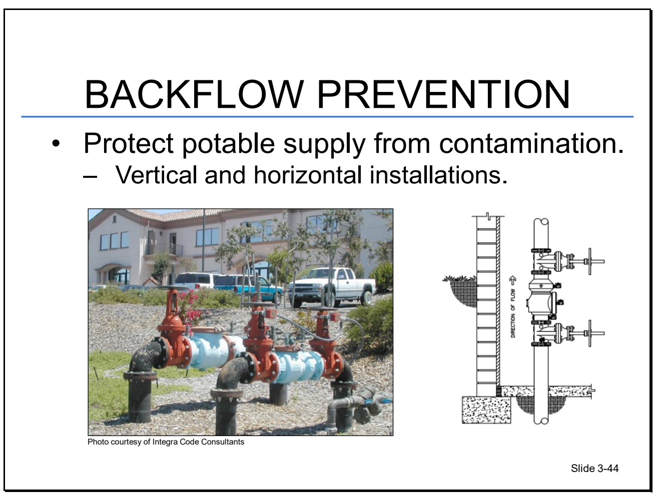
1. Engineered design to resist pipe movement at elbows and tees where water direction changes.

2. Installed between undisturbed soil and fitting.

E. Restrained joints.

1. Locking mechanical or push-on joints may be used as an alternative to thrust blocks.

2. Manufacturer's installation instructions must be followed.



F. Backflow prevention devices.

1. Protect potable supply from contamination.

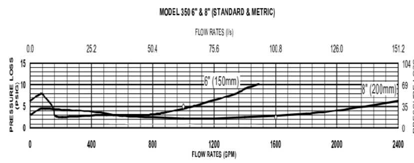
a. May be installed vertically or horizontally in accordance with their listings.

b. The code official should verify with the water purveyor if it allows either the vertical or horizontal orientation.

BACKFLOW PREVENTION (cont'd)

Photo courtesy of USFA

- Public water system requirements.
- Fixed pressure loss device.
  - Manufacturer's specifications.



Graph courtesy of Zurn Wilkins

Slide 3-45

2. Public water system requirements establish where backflow prevention devices are required.

   a. Backflow prevention devices are not required by NFPA 13 or NFPA 24.

   b. If a fire protection system is connected to a raw water source that has no chance of contaminating the potable supply (e.g., fire pump in pond or static tank), no backflow device should be installed.

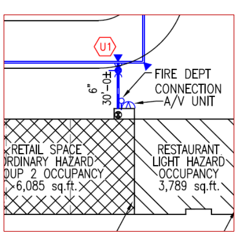
3. Backflow prevention equipment is described as a "fixed pressure loss device" because of its impact on fire protection system design.

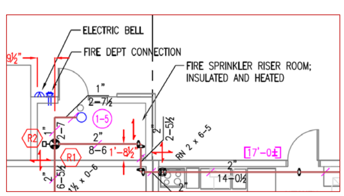
   a. Manufacturer's specifications will include graphs or charts showing the flowing pressure lost through the device at various flows.

   b. This information must be provided to accurately review the hydraulic calculations.

WATER METERS

- Evaluate meter influence on connection(s).
- Separate fire and domestic tap?



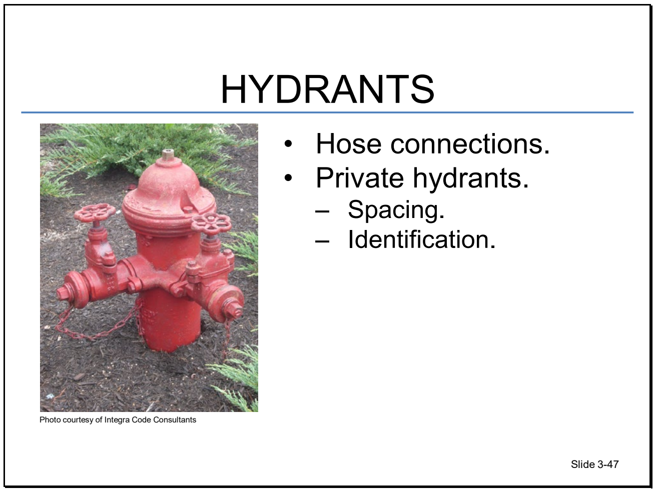


Slide 3-46

G. Water meters may be part of the backflow prevention device or separate.

1. If the fire protection service line has a meter installed on it, the meter's impact on flowing pressure losses must be addressed in the hydraulic calculations.

2. The plans examiner should verify if the fire protection system and potable (domestic use) water are served by the same line or if they are separate taps.



H. Hydrants may be connected to the private water main.

1. The plans examiner should verify that the size, number, arrangement, and thread or quick-connect feature of the hose outlets meet local fire department standards.

2. Private hydrants should be spaced in accordance with local standards and practices.

3. Private hydrants may have to be identified separately from those on the public side of the service. This can be accomplished with colors, signs or other markings.

ACTIVITY 3.2

Verifying National Fire Protection Association 24 Compliance

Purpose

Evaluate design documents for compliance with NFPA 24.

Directions

1. In small groups, you will be given five questions pertaining to the design and installation of The Learning Square underground water main and supply network.

2. You are to evaluate the data provided and verify if the information complies with NFPA 24 and design documents.

3. At the end of the exercise, be prepared to share your findings with the rest of the class.

Questions

1. The Learning Square fire protection contractor tells you that the backflow prevention device near the base of the riser will, at 250 gpm, reduce the flowing pressure by not more than 2 psi. Is this correct? (Hint: Refer to "The Learning Square Manufacturers' Product Literature" datasheet package.)

   ____

   ____

   ____

2. While reviewing The Learning Square fire hydrant details, the contractor discovers that the specifications and NFPA 24 call for the hydrant outlets to have National Hose Standard threads in accordance with NFPA 1963, *Standard for Fire Hose Connections*. The fire department converted a decade ago to large-diameter supply hose with quarter-turn quick connect couplings. Does NFPA 24 allow alternate hose threads? Why or why not?

   ____

   ____

   ____

3. Are the hydrants shown on The Learning Square site plan spaced far enough from the building(s) in accordance with NFPA 24? Why or why not?

___

___

___

4. Sheet F-2 near grid coordinates C/D-13/14 shows the interior distance between the sprinkler riser and exterior wall. Is this distance within the allowable limits of NFPA 24? Why or why not?

___

___

___

5. The plans describe the underground lead-in between the existing water mains as ductile iron pipe manufactured in accordance with the product standard AWWA C900, *Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 In. - 60 In. (100 mm - 1,500 mm)*. Does this type of pipe comply with NFPA 24 for this use? Why or why not?

___

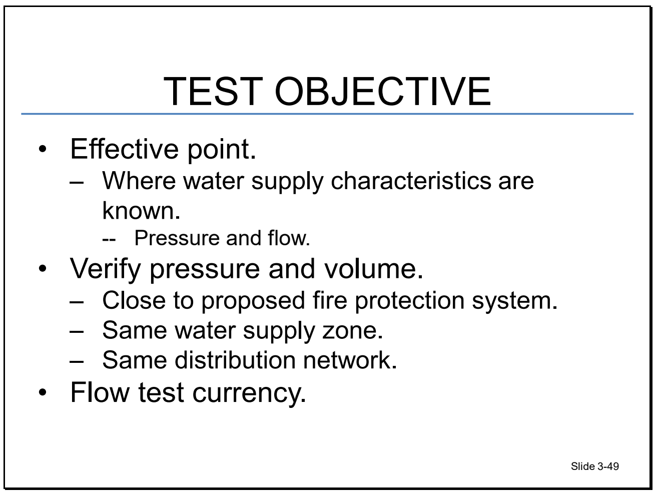
___

___

III. WATER SUPPLY EFFECTIVE POINT

A. When preparing hydraulic calculations — in addition to the pipe and fittings inside the building — the designer must document the impact on the water supply of friction loss and elevation between the base-of-riser and the point where the hydrant flow test(s) was conducted.

B. This test point must be identified on the plans, and in this course is defined as the "water supply effective point."



C. Test objective: Flow tests are performed to obtain input data for the hydraulic calculations and to validate the water conditions.

1. Effective point: location where water supply characteristics are known through testing for pressure and volume.

2. Verify pressure and volume.

   a. Test hydrants should be as close as possible to the proposed fire protection system.

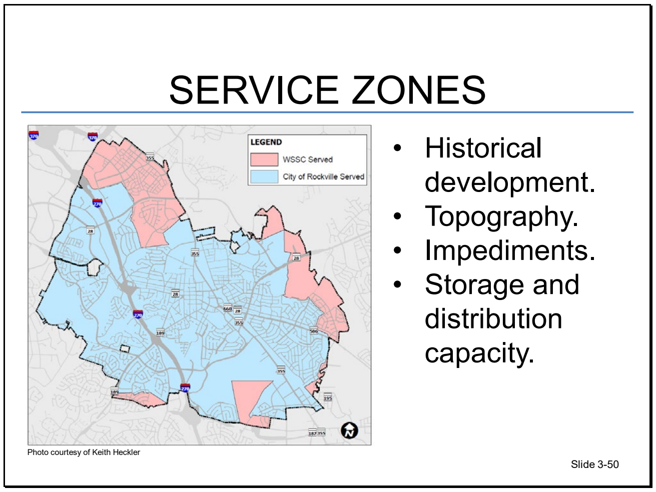
   b. Hydrants should be on the same water supply service zone.

   c. Hydrants should be on the same distribution network as the proposed project.

3. Flow test currency.

   a. Test results should be as current as possible.

   b. The code official is authorized to approve if the tests are current.



D. Service zones: In addition to different distribution networks, jurisdictions might have diverse service zones. Different service zones in the same jurisdiction may develop from:

1. Historical development and growth where jurisdictional boundaries took over separate water purveyors.

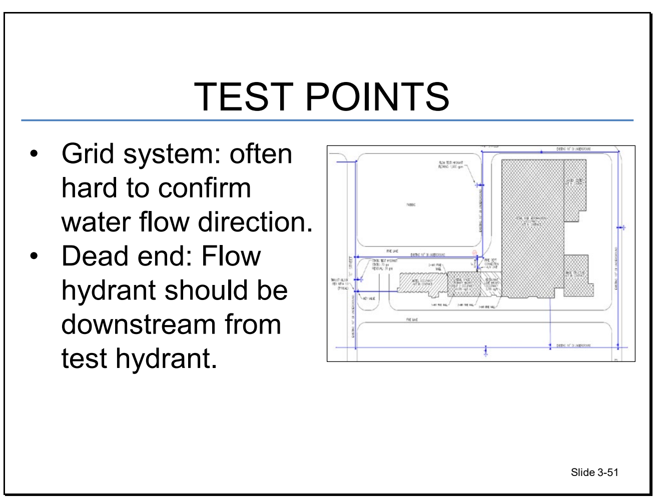
2. Topography where different elevations require different services.

    a. Higher elevations may require water to be pumped continuously from a lower elevation.

    b. Lower elevations may be fed by gravity.

3. Development impediments (e.g., rail and highway corridors, power and gas line easements) may prohibit service zones crossing boundaries.

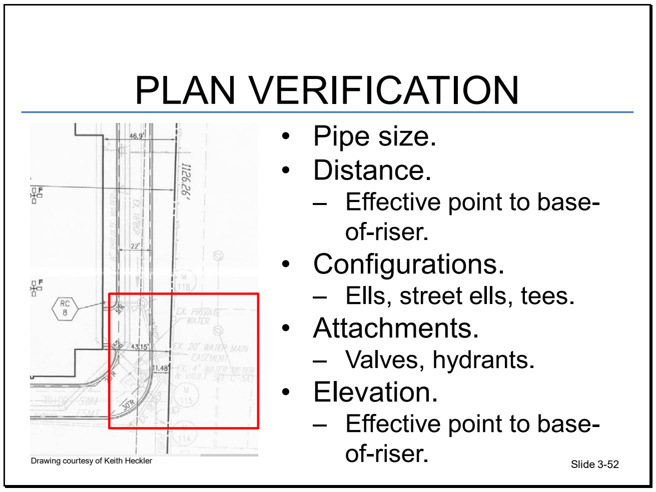
4. Existing and proposed storage and distribution capacity may affect how zones are demarcated.



E. Test points: Flow tests should be taken where they most accurately reflect the conditions that influence the fire protection system.

1. Grid system: often hard to confirm water flow direction, but provides the highest degree of reliability.

2. Dead end: Flow hydrant should be downstream from test hydrant.



F. Plan verification: The plans examiner must be able to verify the details on the plans for the underground lead-in will match the data input for the hydraulic calculations. Items to verify include:

1. The pipe size (diameter) in inches.

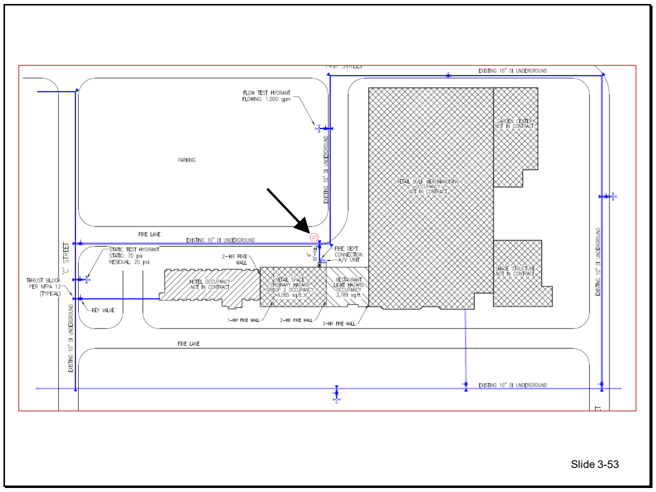
2. The combined distance of all pipe between the water supply effective point shown on the plans and the base of the sprinkler riser.

3. If not a straight run from the source to the base-of-riser, any elbows (90 degrees), “street” elbows (22.5 degrees to 90 degrees) or tee fitting that might affect flow.

4. Roadway box valves, PIVs, wall indicator valves or other valves that cause turbulence and restrict flow.

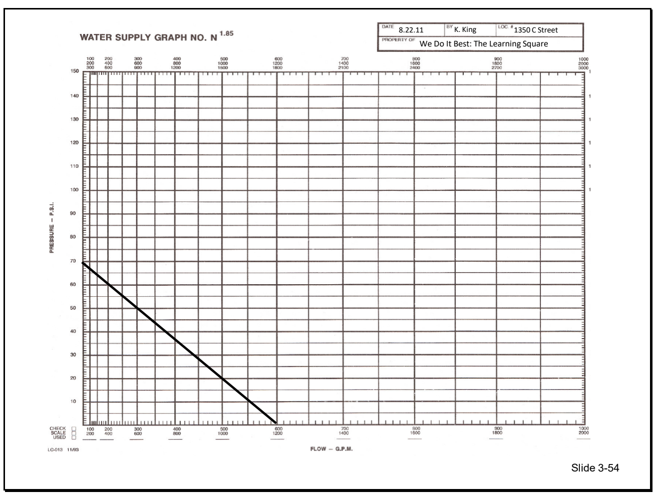
5. Placement of hydrant connections in relation to the lead-in.

6. The elevation difference between the water supply effective point and base-of-riser.



G. Water supply effective point.

H. Flow test report.



ACTIVITY 3.3

Water Supply Effective Point

Purpose

Identify information needed to verify that the underground lead-in between the base-of-riser and the water supply effective point is represented correctly on the plans.

Directions

1. This is a large group activity.

2. You will be shown five site plan details pertaining to water supply lead-ins between a building and the water supply effective point. The water supply effective point is represented by the alphanumeric U1 inside a hexagon.

3. You are to identify:

   a. The size (diameter) of the underground lead-in.

   b. If there is not a straight line between the water supply effective point, the pipe configuration and attachments.

   c. Gaps (if any) in the drawing(s) that prevent an accurate assessment of the water supply lead-ins between a building and the water supply effective point.

4. You should be prepared to discuss your observations in class.

   Example 1.

   ____

   ____

   ____

   Example 2.

   ____

   ____

   ____

Example 3.

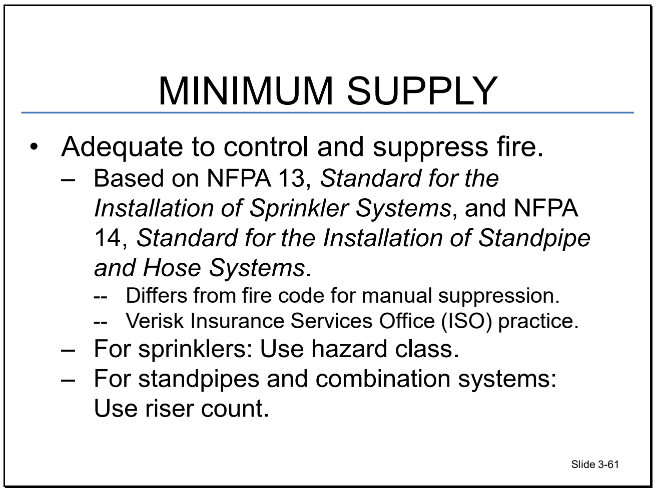
Example 4.

Example 5.

IV. WATER SUPPLIES

A. This section will address the importance of accurate water supply data (volume and pressure) while describing the minimum requirements from NFPA 13 and NFPA 14 for fire sprinkler systems.

B. It will explain how to compute the required water supplies based on NFPA 13 or NFPA 14, especially in those areas where a static water source exists (e.g., tanks, ponds, reservoirs).



C. Minimum supply.

1. Adequate to control and suppress fire.

a. Based on NFPA 13 and NFPA 14.

- Differs from model fire codes for manual suppression.

- Flow values in model codes allow reductions based on sprinkler protection.

- Verisk Insurance Services Office (ISO) practice.

-- Property protected by NFPA 13-compliant design does not need additional fire flow for manual suppression.

-- Manual flow values included in NFPA 13-compliant design (hose stream allowances).

b. For sprinklers: Use hazard class to determine the required flow.

MINIMUM SUPPLY (cont'd)

- Total volume based on combined system and hose stream demand. Code official can require more.

Slide 3-62

2. Volume and duration based on combined system and hose stream demand. Code official can require more based on sound engineering principles.

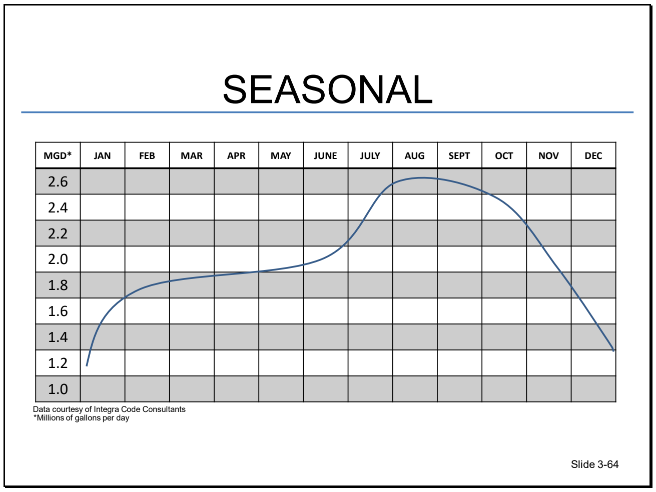
DEMAND INFLUENCES

- Seasonal.
- Diurnal.
- Projected expansion and use.

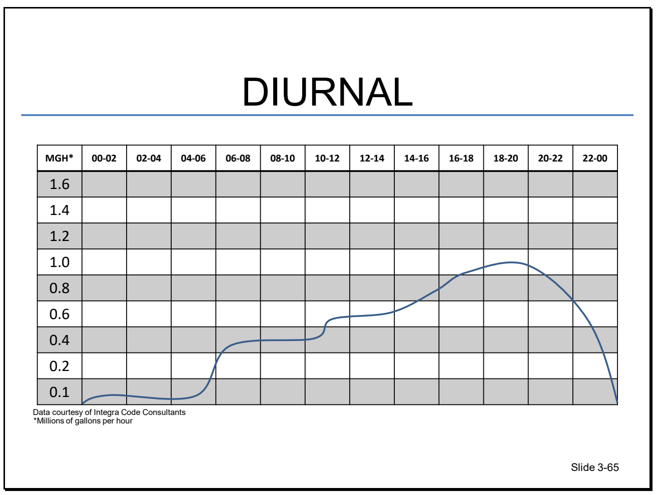
Slide 3-63

D. Demand influences: In systems that provide combined domestic, commercial and industrial service, "demand" describes the total uses that can affect the supply's volume and pressure. The code official must understand that water supplies are dynamic; they may vary with the seasons, daily (diurnal) use and changes in the water system's configuration. The code official must work closely with the water purveyor to understand the impact of these influences on water supplies.

1. Seasonal: changes that occur resulting from drought or high temperatures that cause more water usage.



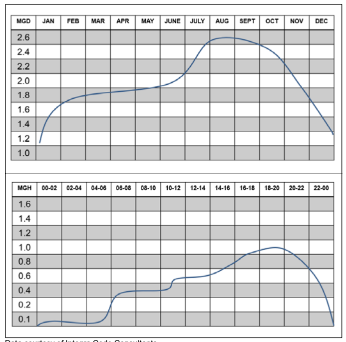
2. Diurnal: changes that occur in various times of the day because of commercial, industrial or domestic use.



3. Projected expansion and use: changes that will occur over time as systems grow.

E. Impact on supply (worst-case scenario).

Despite different scales, what do these graphs tell you about when a worst-case scenario might occur?



Data courtesy of Integra Code Consultants

Slide 3-66

PROJECTED EXPANSION

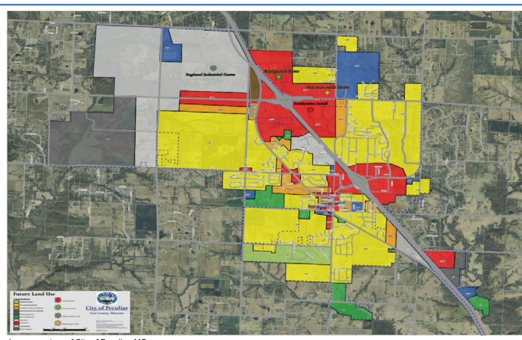


Image courtesy of City of Peculiar, MO

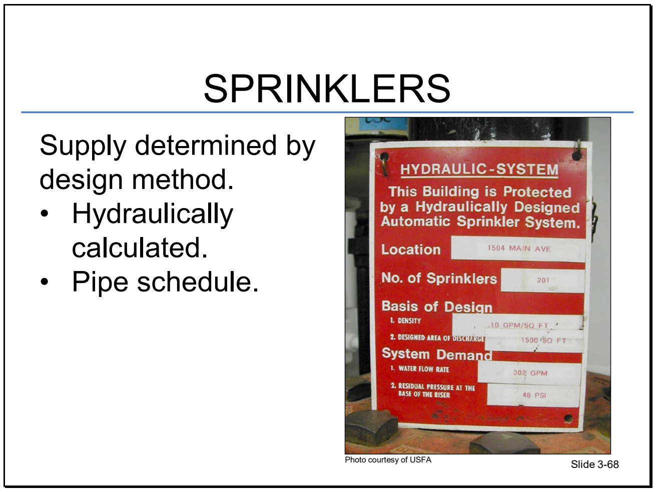
Slide 3-67

F. Projected expansion and use: Future growth and impact on water demand should be considered.

1. High-demand areas not yet developed should be anticipated in the water service assessment.

2. Without suitable infrastructure development, may create additional demands on existing system.

3. Fire code officials should work with utility purveyors to discuss long-term plans, potential developments, impact on municipal fire insurance grading, impact on fire flow and fire protection systems, and near-term project or impairments.



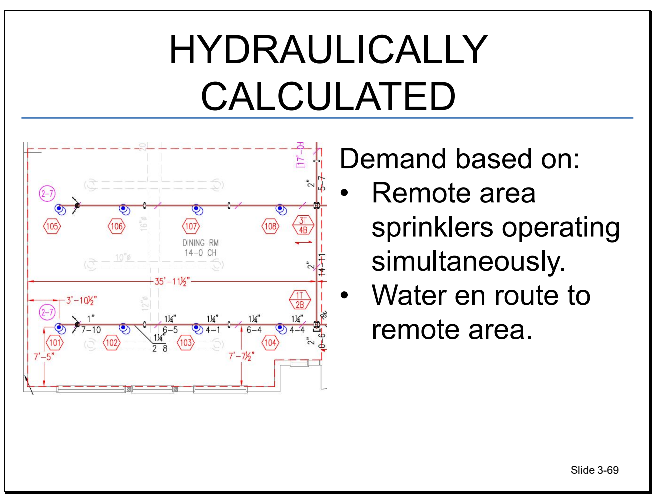
G. Sprinklers.

Required water supply determined by design method.

1. Hydraulically calculated.

2. Pipe schedule.

   Although rarely used, pipe schedule design remains a viable option for some projects.



H. Hydraulically calculated.

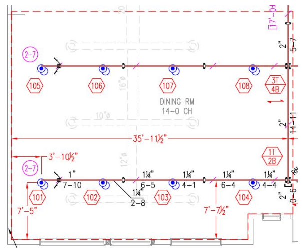
Demand based on:

1. Design assumption that all remote area sprinklers operate simultaneously.

2. Additional water en route to remote area.

DEMAND

- Example:
  - Dining room: Light Hazard.
  - Design 0.1 gallons per minute (gpm)/990 square feet.
  - Remote area demand ≈ 99 gpm.
- Plus water-filled pipe back to riser.



Slide 3-70

I. Demand.

1. Example:

   a. Dining room: Light Hazard.

   b. Design 0.1 gpm over 990 square feet.

   c. Remote area demand ≈ 99 gpm.

2. Plus water-filled pipe back to riser.

HOSE STREAM DEMAND

- NFPA 13 requires water for sprinkler system and manual fire fighting (hose streams).
- Amount (demand) based on:
  - Sprinkler system hazard class.
  - Expected duration of manual operations.
- Flow duration can be reduced if sprinkler system reports flow off-premises.

Slide 3-71

J. Hose stream demand.

1. NFPA 13 requires the water supply to include “system” demand, plus water for manual fire suppression operations — called “hose stream allowance.”

   a. Amount (gpm) is based on:

- Occupancy hazard classification.

- Expected duration of manual operations.

b. "Duration" (minutes) is based on the presence of water flow alarm supervision and off-premises reporting to summon the fire services.

HOSE STREAM DEMAND (cont'd)

- Inside hose: occupant-use 1 1/2-inch hose stations.
- Combined hose: total inside and fire department use.

Occupancy	Inside hose (gpm)	Combined hose (gpm)	Duration (minutes)
Light	0, 50, 100	100	30
Ordinary – supervised	0, 50, 100	250	60
Ordinary – unsupervised	0, 50, 100	250	90
Extra – supervised	0, 50, 100	500	90
Extra – unsupervised	0, 50, 100	500	120

Slide 3-72

2. Hose stream allowance table.

a. The left column is occupancy classification.

- Ordinary and Extra rows include "supervised" and "unsupervised" categories. Supervision influences supply duration.

b. The second column is "inside hose."

- Some sprinkler systems have "small hose" attachments for up to 1 1/2-inch hose lines. The hose stream demand is added to the sprinkler system demand.

- The flow demand for each hose station is rated at 50 gpm.

-- No hose stations: Add zero gpm.

-- One hose station: Add 50 gpm.

-- Two or more hose stations: Add 100 gpm.

c. The third column is "combined hose." The sum of the inside hose demand and "outside" hose demand that is the flow required for fire service manual fire suppression.

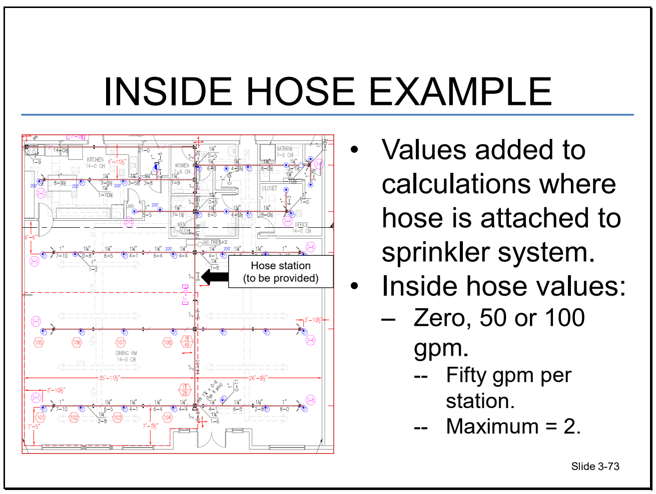
- Example: Ordinary Hazard, Group 2 supervised sprinkler system requires 225.6 gpm. The building has one inside hose station (50 gpm).

  -- Total is 275.6 gpm.

- The difference between combined (250 gpm) and one inside hose value (50 gpm) is 200 gpm. Two hundred gpm is added for manual suppression.

  -- Total system and hose demand is 475.6 gpm.

d. The fourth column is "duration." The amount of time in minutes that the water supply must last. Multiply the total system demand (475.6 gpm) by the duration (60 minutes) to contain total water supply required (28,536 gallons).



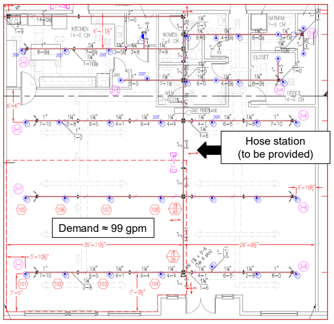
3. Inside hose example.

a. Inside hose demand values (gpm) added to the sprinkler system flow value where the hose station is to be installed.

- Inside hose values are 0, 50 and 100 gpm.

- Fifty gpm per hose station to a maximum demand of 100 gpm.

INSIDE HOSE EXAMPLE (cont'd)



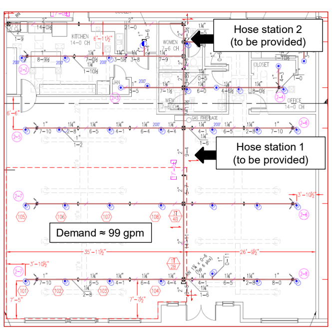
Area	Demand (gpm)
Dining room	≈ 99
Hose station	+ 50
Total system demand (at that point)	≈149

Slide 3-74

b. The illustration shows that the fire sprinkler demand for the hydraulic remote area is about 99 gpm. A single hose station is to be installed on the 2-inch cross main immediately outside the remote area.

c. The 50 gpm demand for that hose station is added to the remote area flow demand (99 gpm) to increase the total demand at that point in the hydraulic calculations to 149 gpm.

INSIDE HOSE EXAMPLE (cont'd)



Area	Demand (gpm)
Dining room	≈ 99
Hose station 1	+ 50
Hose station 2	+ 50
Total system demand (at that point)	≈199

Slide 3-75

d. If a second hose stream was installed, another 50 gpm would be added at that point. Now, the total sprinkler system demand there is about 199 gpm.

e. This additive approach ensures that there is enough water supply to operate all of the sprinklers in the remote area and supply the hose streams where they are connected to the system.

K. Tank sizing demand.

This design example illustrates how the sprinkler system demand affects the total water supply requirements.

1. Given: rural resort, no utilities.

2. NFPA 13 design, supervised for water flow.

   a. Light Hazard.

      - Dining/Sleeping/Office.

      - From calculations, system demand is 187.6 gpm.

   b. Ordinary Hazard, Group 1.

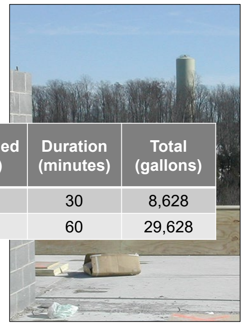
      - Parking, laundry/service.

      - From calculations, system demand is 243.6 gpm.

   c. No inside hose.

3. Storage tank size?

REQUIRED MINIMUM TANK



Hazard class	System demand (gpm)	Hose demand (gpm)	Combined (gpm)	Duration (minutes)	Total (gallons)
Light	187.6	100	287.6	30	8,628
Ordinary	243.6	250	493.6	60	29,628

Slide 3-77

4. Required minimum tank.

   a. Light Hazard.

      187.6 gpm + 100 (hose) = 287.6 gpm x 30 min. = 8,628 gal.

   b. Ordinary Hazard, Group 1.

      243.6 gpm + 250 (hose) = 493.6 gpm x 60 min. = 29,628 gal.

   c. Use larger value; do not sum.

PIPE SCHEDULE DESIGN

- Add or modify existing schedule system.
- New systems < 5,000 square feet.
- New systems where flows available at 50 psi residual at highest sprinkler.
  - Lower **flow** if noncombustible or compartmentalized.
  - Lower **duration** if flow is supervised off premises.

Occupancy	Min. pressure (psi)	Base-of-riser flow (gpm)	Duration (minutes)
Light	15	500-750	30-60
Ordinary	20	850-1500	60-90

Slide 3-78

L. Pipe schedule design: Although no longer common, pipe schedule design remains a viable option in some circumstances:

1. Adding to or modifying an existing schedule system.

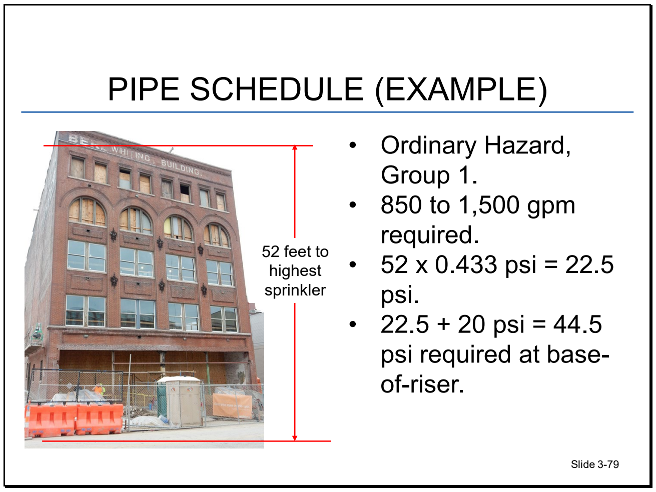
2. New systems less than 5,000 square feet.

3. New systems where flows are available at 50 psi residual at the highest sprinkler.

4. The table describes the minimum water pressure and flow at the base of the riser based on occupancy class as well as the water demand duration.

    a. Lower flow if noncombustible or compartmentalized.

    b. Lower duration if flow is supervised off premises.



5. Pipe schedule example.

    a. This building has an existing pipe schedule system that is proposed for modification during the remodeling. NFPA 13 allows this modification if the available volume and pressure are adequate.

    b. The highest sprinkler is located 52 feet above the base-of-riser. (The 52-foot height is an estimate.)

    c. The required flow for an Ordinary Hazard, Group 1 occupancy ranges from 850 to 1,500 gpm from 60 to 90 minutes based on off-premise water flow supervision. The flow must be available with a 20 psi minimum residual pressure at the base of the riser.

    d. To determine the pressure required to supply the sprinkler system:

        - Multiply the elevation of the highest sprinkler by 0.433 psi (pressure loss per foot).

        - Elevation (52 feet) times 0.433 equals 22.5 psi.

        - Twenty-two and one-half psi plus the 20 psi required minimum means that the required flow must be available at least 44.5 psi.

ACTIVITY 3.4

Water Supplies for Sprinkler Systems

Purpose

Identify the minimum required water supply for a hydraulically calculated sprinkler system given a copy of NFPA 13.

Directions

1. You will be given five examples of occupancy hazard class, sprinkler system demand and small hose stations.

2. Using NFPA 13, you are to determine the total water supply needed to supply the fire protection system.

3. For the purpose of the exercise, all sprinkler systems are assumed to be electronically supervised off premises, so a water flow alarm will summon the fire services.

4. Working individually, you are to:

    a. Identify the combined hose demand and duration (in minutes) of the required water supply.

    b. Calculate the total volume (in gallons) of the required water supply, showing your work.

5. Your results should be within a margin of error of plus or minus 5%.

6. The class will discuss the results of the activity the following day.

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ACTIVITY 3.4 (cont'd)

Results should be within a margin of error of plus or minus 5%.

Occupancy hazard class	Sprinkler demand	Combined hose demand	Minimum duration (minutes)	Formula	Total water supply needed (gallons)
Light Hazard	123.67				
Ordinary Hazard, Group 1	153.60				
Ordinary Hazard, Group 2	163.44				
Extra Hazard, Group 1	194.37				
Extra Hazard, Group 2	262.54				

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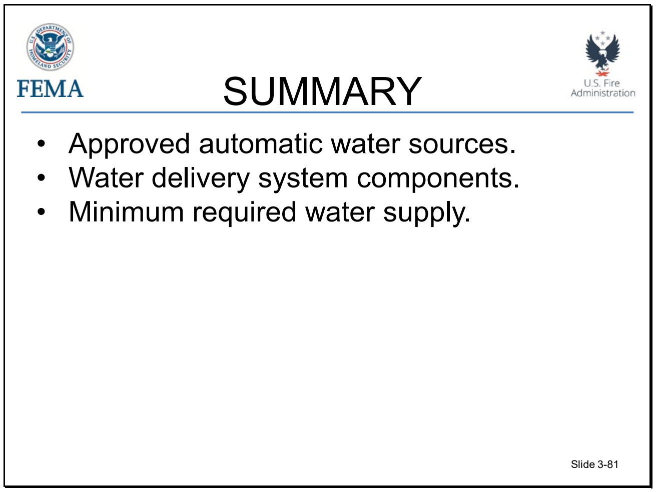
V. SUMMARY


FEMA
SUMMARY
U.S. Fire Administration
• Approved automatic water sources.
• Water delivery system components.
• Minimum required water supply.
Slide 3-81

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REFERENCES

National Fire Protection Association. (2018). *Standard for water tanks for private fire protection*. (Standard no. 22). Retrieved from https://www.nfpa.org

National Fire Protection Association. (2019). *Standard for the installation of sprinkler systems*. (Standard no. 13). Retrieved from https://www.nfpa.org

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APPENDIX

SUPPLEMENTAL MATERIALS

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Selecting a Fire Pump

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Consulting-Specifying Engineer
https://www.csemag.com/articles/selecting-a-fire-pump/
April 27, 2017

By Robert Kranz, PE
Page Southerland Page, Inc.

The need for a fire pump should be decided early—ideally as a project scope is being developed. This article outlines a process to determine if a fire pump is needed and explains how to select a fire pump that meets the required pressure and flow.

A fire pump is needed to supply the flow and pressure demands to fire suppression systems when there is an inadequate water supply. The need for a fire pump should be decided early—ideally as a project scope is being developed. This article will outline a process to determine if a fire pump is needed and explains how to select a fire pump that meets the required pressure and flow.

To determine if a fire pump is needed, the fire suppression system demands must be compared with the available water supply. If the supply cannot meet the demand, a fire pump is required. Conversely, if the water supply can meet the pressure and flow requirements, a fire pump is not needed.

Water can be supplied from a variety of different sources including public water mains, dedicated fire protection fire mains, elevated tanks, etc. Each scenario requires a slightly different approach, but first, it is important to determine if the water supply can accommodate the flow demands. For simplicity, this article assumes that the water supply contains an adequate volume to meet flow and duration needs.

When connecting to a fire main, hydrant-flow tests can be used to analyze the supply. Static and residual pressures as well as flow rate data help to conclude if the supply system can flow the amount of water needed and determine what residual pressure is available. It is most helpful to get this test data as close to the fire suppression system riser as possible to decrease errors resulting from hydraulic-calculation estimates.

When determining the worst-case flow, consider the flow demands from all of the fire suppression systems. For this example, the worst-case flow demand is an automatic sprinkler system in an office building. It is assumed that standpipe demand would be supplied via a firefighting apparatus.

Sprinkler demands are calculated per NFPA 13 based on factors such as design area, density, hose steam, overages, roof slope, and dry/pre-action system.

- Example: a light-hazard 5-story office building

- Sprinkler: 0.1 gpm/ft^2 x 1500 ft^2 = 150 gpm
- Sprinkler + 30% overage: 150 x 1.3 = 195 gpm
- Hose: 100 gpm
- Total: 295 gpm

The calculation shows a flow demand of 295 gpm. If the connected fire main cannot supply this flow, then a water tank and pump will need to be provided to flow the required amount to the sprinkler system. With the flow requirements known, the next step is to calculate the pressure required to operate the sprinkler system.

The pressure required to meet the system demand is calculated by first considering the pressure required at the most remote sprinkler and then adding all of the various pressure losses back to the supply. The minimum pressure required at a sprinkler head is defined per NFPA 13 and is typically 7 psi. Use a greater value to be conservative. Working back toward the supply, the sprinkler system pressure can be estimated to be ~20 psi. This is a decent guideline when supplying simple sprinkler systems. As sprinkler piping becomes more complicated due to strange floor layouts, obstructions, and uneven ceiling heights, increase the estimate accordingly.

Friction losses through the pipe from the sprinkler riser to the water supply can be estimated using the Hazen-Williams formula defined in NFPA 13. Pipe sizes; pipe lengths; fittings and their equivalent length of pipe; and C-factors can all be estimated to calculate a conservative pressure loss from friction. Hazen-Williams calculates a friction loss per foot, that value can then be multiplied by the total length of pipe to determine the pressure lost. Elevation is an important factor to pressure losses because overcoming gravity requires a significant amount of pressure: 0.433 psi is lost per foot of elevation needed to overcome. Major appurtenances, such as backflow preventers and strainers, should also be considered since pressure is lost as water flows through these devices. Product datasheets can be used to estimate the pressure lost through these pipe appurtenances.

Below is an example of the calculation showing the supply pressure required:

- Remote sprinkler: 10 psi
- Sprinkler system pressure loss: 20 psi
- Friction losses from supply to sprinkler system riser: 10 psi
- Elevation: 21 psi
- Backflow preventer: 7 psi
- Safety factor: 10 psi
- Total pressure required: 78 psi

At this point, the flow requirement and required pressure has been calculated and must be compared with the flow capacity and pressure available.

In this example, it is assumed the sprinkler system is connected to a city water main, and the hydrant-flow test data shows 65-psi static and 40-psi residual while flowing 500 gpm. This data shows that the water supply can adequately meet the flow requirements, but the available pressure does not meet the required pressure. Therefore, a fire pump is required to boost the pressure by 38 psi while meeting the required flow rate.

Fire pumps need to be selected based on their rated flow and pressure capacity. In our example, the required flow is 295 gpm. Fire pumps are required to operate at 150% of their rated flow. Therefore, it is not required to select a pump rated at the flow demand; this would result in an oversized pump. For instance, if the flow demand is 295 gpm, a 200-gpm-rated fire pump can technically supply that flow. The design point is just under 150% of its rated curve. Typically, using a design point between 115% and 135% of rated flow is preferred. In this example, a 250-gpm pump should be selected. Designing too close to the 150% curve may be problematic, with unseen issues or alterations over the life of the system. Specific pump curves should be analyzed for peak efficiency.

Knowing that the pump needs to provide a 38-psi pressure boost, it is time to research available pump curves with at least a 38-psi-rated total head. The total rated head is the pressure boost supplied at the rated flow.

Many fire pump manufacturers provide selection tools on their websites where the required flow and pressure can be input, and their results show the pumps offered that can meet those requirements. NFPA provides limits on the performance of pumps. This ensures that pump curves are not too steep, which would allow the pressure boost to drop quickly. At 150% of a pump's rated capacity, it can provide no less than 65% of its rated total head.

As pumps flow at rates beyond their rated flow, the pressure they can provide decreases. Some pumps have flatter curves where the pressure drops slowly as the flow increase, and others lose pressure more quickly. It is important to consider where on the pump curve the flow requirement is located. At the water-flow demand point, the pressure boost provided by the pump needs to be greater than the pressure required.

For a final check, place the design point (required flow and pressure) on the manufacturer's pump curve. This point needs to be below the pump curve to ensure that the pump will meet the needs of the suppression system.

There are likely many pumps offered that meet the performance requirements, but having the pressure and flow requirements will allow the design to progress and help scope the general size, cost, and space needed for the installation. Many other options, styles, and arrangements of fire pumps exist and will work, but the fact remains that each must meet the performance required by the suppression systems.

How to determine if a fire pump is needed:

1. Gather fire water-supply information
2. Calculate required flow
3. Calculate required pressure
4. If supply cannot meet flow, provide fire water tank and fire pump
5. If pressure cannot be met, provide fire pump
6. If supply can meet required pressure and flow, no fire water tank or fire pump is needed

How to select a fire pump:

1. Gather fire water-supply information
2. Calculate required flow
3. Calculate required pressure
4. Calculate pressure boost required
5. Select pump where flow demand is between 100% and 150% of rated flow. Preferably between 115% and 135%.
6. Select pump with performance curve where pressure boost is sufficient at flow demand.

***Robert Kranz**, a fire protection engineer with Page, has fire protection experience in corporate loss control as both a government-contractor owner-user and as a design consultant. With nearly a decade of experience, Kranz has been responsible for performing life safety analyses, maintaining and modifying existing fire protection systems, creating fire protection design documents, and using fire-modeling software to evaluate unique property and life safety risks. Page is a CFE Media content partner.*

CLASS I AND III STANDPIPE IMPACTS ON SPRINKLER WATER DEMANDS

In those circumstances where a water system supplies a combined sprinkler and Class I or III standpipe system, the total water demand is based on requirements in NFPA 14, *Standpipe and Hose Systems*. These requirements are greater than NFPA 13 and therefore take precedence.

Fire code officials should be careful when specifying minimum fire flow requirements to assure the total combined sprinkler demand and Class I or III are met.

Class I and III standpipe systems are intended for large diameter hose streams (2 ½-in.). The building and fire codes typically require one standpipe riser in each interior exit stair enclosure. While in most cases this means only two risers are required, in some larger buildings that have more interior exit stair enclosures, more standpipe risers are required.

For design purposes, NFPA 14 requires Class I and III standpipe systems to deliver 500 gallons per minute (gpm) for the first building riser, plus 250 gpm for each additional riser up to four. Table 1 summarizes the flow requirements for buildings with multiple risers.

Table 1

Class I or III Standpipe Volume Demands

Column 1	Column 2	Column 3
Standpipe Risers	**Building Sprinklered Throughout* Total Standpipe Demand (gpm)**	**Building Partially Sprinklered Total Standpipe Demand (gpm)**
1	500	500
2	750	750
3	1,000	1,000
4	1,000	1,250

*In accordance with NFPA 13 or NFPA 13R.

When the sprinkler and standpipe systems are supplied by the same piping network, the combined flow values must be considered:

1) If the building is sprinklered throughout per NFPA 13 or 13R, no additional flow above the Table 1, Column 2 value is required.

2) If the building is only partially sprinklered, the designer has two choices:
   a. Compute the total sprinkler demand *plus* the value from Table 1, Column 3, or,
   b. add 150 gpm for Light Hazard occupancies or 500 gpm for Ordinary Hazard to the values in Table 1, Column 3.

Scenario 1: Fully sprinklered office building with three (3) Class I standpipe risers.

1) NFPA 13 building occupancy classification: Light Hazard.
2) Fire sprinkler system demand: 216.7 gpm*
3) Three Class I risers demand: 500 + 250 + 250 = 1,000 gpm

Question: What is the total waterflow demand?

Answer: 1,000 gpm for 30 minutes. In this example, because the building is fully sprinklered, the total Class I standpipe demand is considered adequate to supply sprinklers and standpipes.

*This value is arbitrary for the scenario.

Scenario 2: Partially sprinklered office building with three (3) Class I standpipe risers.

1) NFPA 13 building occupancy classification: Light Hazard.
2) Fire sprinkler system demand: 216.7 gpm*
3) Three Class I risers demand: 500 + 250 + 250 = 1,000 gpm

*This value is arbitrary for the scenario.

Question: What is the total waterflow demand?

Answer:

Option 1: 1,216.7 gpm for 30 minutes. In this example, because the building is partially sprinklered, the sprinkler demand must be added to the Class I standpipe demand, or,

Option 2: At the designer’s choice, add 150 gpm to the standpipe demand of 1,000 gpm for a total of 1,150 gpm for 30 minutes.

The important point to remember is when the Class I or III standpipe systems share a piping network with the sprinklers, the combined demand must be considered based on NFPA 14.

Engineering Assumptions for Thrust Block Sizing

The plan reviewer is not expected to perform the math in the thrust block sizing formula, only to verify the data for the variables are correct.

There are several variables that go into the following formula to verify minimum thrust block sizes. The variables and an explanation of each are found in Table 1.

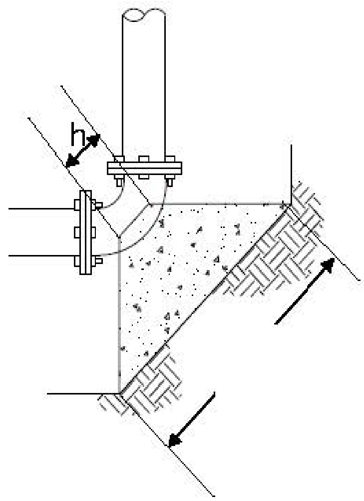
$$b = \frac{2\,S_f\,PA\,\sin(\theta/2)}{h\,S_b}$$

Table 1

Thrust Block Sizing Formula Variables

Variable	Description	Explanation
S_f	Safety factor (usually 1.5)	Most engineering practices include a safety factor to account for unanticipated events or variables. In this example, the safety factor increases the safety margin 1.5 times.
P	Maximum pressure	Maximum bearing stress (in psi) of the water in the mains.
A	Pipe cross section (3.14 x $[1/2ID]^2$)	Area of the pipe size. ("ID" is internal diameter.)
θ	Pipe turn angle in degrees	Θ [Theta] is the angle of the pipe turn in degrees (°).
h	Thrust block height	Height of the concrete face in contact with the pipe.
S_b	Soil bearing strength	Value based on the type of soil (sand, loam, etc.) provided from a table in NFPA 24.
b	Thrust block width	Face size in contact with the undisturbed soil.

In this example, we are solving for the minimum face size that will be in place against the undisturbed soil where the pipe diameter (A) is 6-inch ductile iron. The known operating pressure is 225 psi.



Formula Variables for this Example

Variable	Value
S_f	1.5
P	225 psi
A	6-inch
θ	90
h	2.5 feet
S_b	Silt: 1,500 lbs./ft2
b	To be determined

$$b = \frac{2(1.5)(225\,lb/sq.\ in.)(3.14)(3.08)^2)\ \sin\frac{90°}{2}}{(2.5\,ft.)(1{,}500\ lb/sq.\ ft.)}$$

$$b = \frac{(20{,}116\,lb)\ \sin 45°}{3{,}750\,lb/ft.}$$

Solution: The long side of the thrust block must be at least 3.8 feet.

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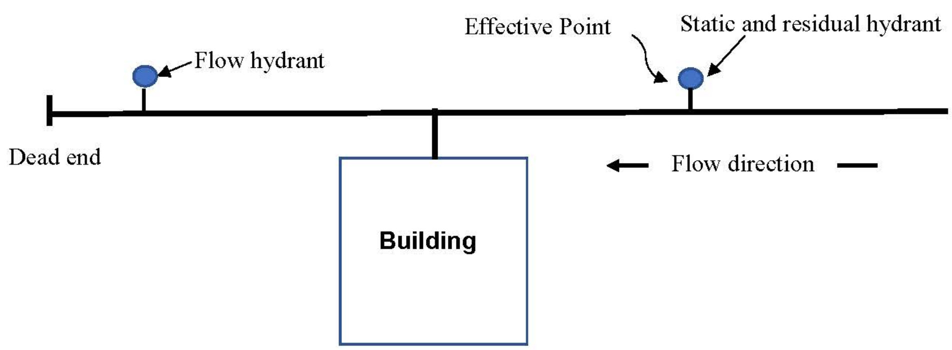
Water Supply Effective Point

Effective fire control with a hydraulically calculated system is accomplished by verifying the water supply meets or exceeds the fire protection demand. Hydraulic calculations are provided to match the impact of friction and elevation losses to the water discharge needed in the hydraulic remote area(s).

The calculations are identified by reference points or nodes from the most demanding sprinkler to the "water supply effective point." This "effective point" describes where the water supply characteristics of volume and pressure are known.

The following illustrations will help define the "water supply effective point."

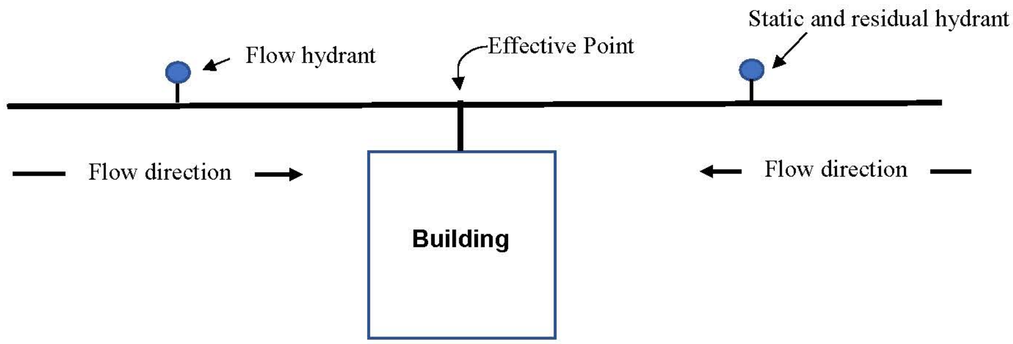
Example 1: Single directional flow toward a dead end.



In this example – with the single-directional feed – the residual pressure has meaning only at the point it was taken. The residual pressure at the junction of the sprinkler underground lead-in would be *less*, reflecting the friction loss between the junction and the point at which the residual pressure is taken.

Continued on next page

Example 2: Bi-directional flow.



In this example, the flow in the supply main is coming from two directions and the residual reading would be approximately the same at the junction of the sprinkler underground (lead-in) into the building.

Extracted from: Wass, H.S. Jr. (1983). *Sprinkler Hydraulics*. White Plains, NY: IRM Insurance.

UNIT 4: SYSTEM COMPONENTS AND MATERIALS

TERMINAL OBJECTIVE

The students will be able to:

4.1 Evaluate the adequacy of sprinkler system components for the intended use and compliance with recognized listings, standards and manufacturer's specifications given a set of manufacturer's datasheets.

ENABLING OBJECTIVES

The students will be able to:

4.1 Identify the corresponding components and equipment on system design drawings using provided data sheets.

4.2 Conclude if a specified pipe meets all requirements and listings for its intended use and installation in accordance with recognized codes and standards.

4.3 Determine the characteristics and limitations of various types of pipe in accordance with the listings and approvals.

4.4 Determine hanger and riser bracing requirements.

4.5 Interpret the information on a product data sheet in relation to listings intended for use as a part of a sprinkler system design.

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FEMA

U.S. Fire Administration

UNIT 4: SYSTEM COMPONENTS AND MATERIALS

Slide 4-1

TERMINAL OBJECTIVE

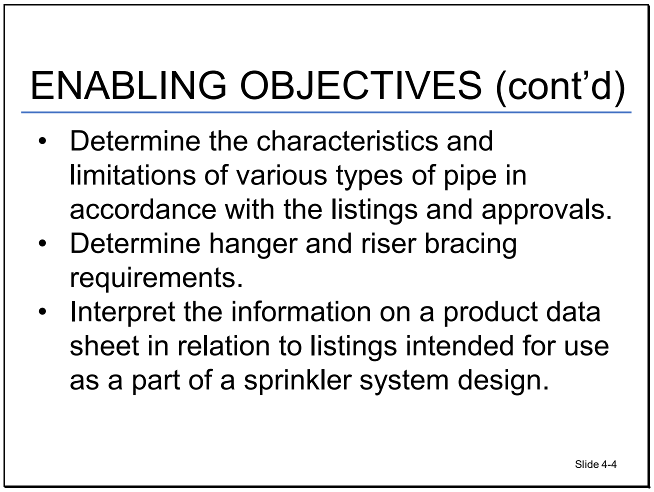
Evaluate the adequacy of sprinkler system components for the intended use and compliance with recognized listings, standards and manufacturer's specifications given a set of manufacturer's datasheets.

Slide 4-2

ENABLING OBJECTIVES

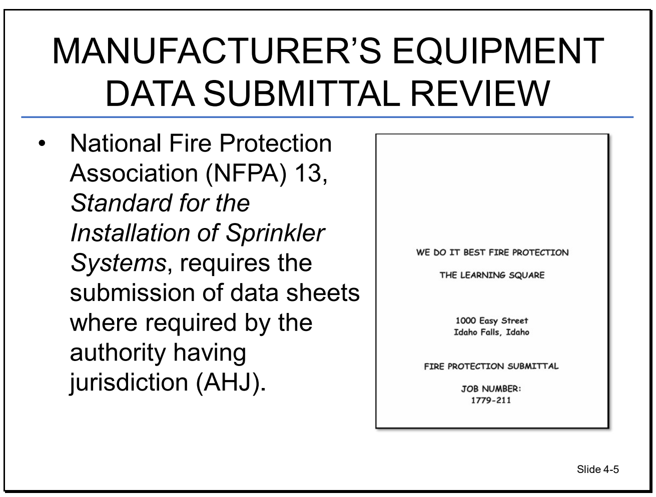
- Identify the corresponding components and equipment on system design drawings using provided data sheets.
- Conclude if a specified pipe meets all requirements and listings for its intended use and installation in accordance with recognized codes and standards.

Slide 4-3



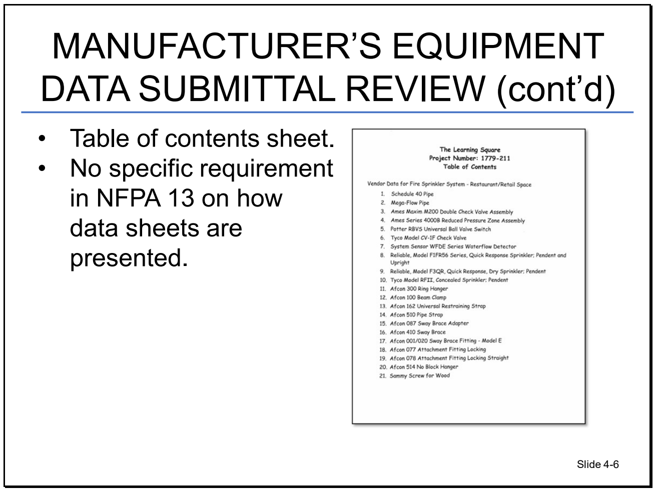
I. EQUIPMENT SUBMITTAL

A. The equipment submittal, sometimes called the manufacturer's data sheets or cut sheets, accompany the sprinkler shop drawings. They provide detail that is not marked on the shop drawings. The sheets are the location where the fine detail of the equipment is found. They are just as important as the plans themselves.



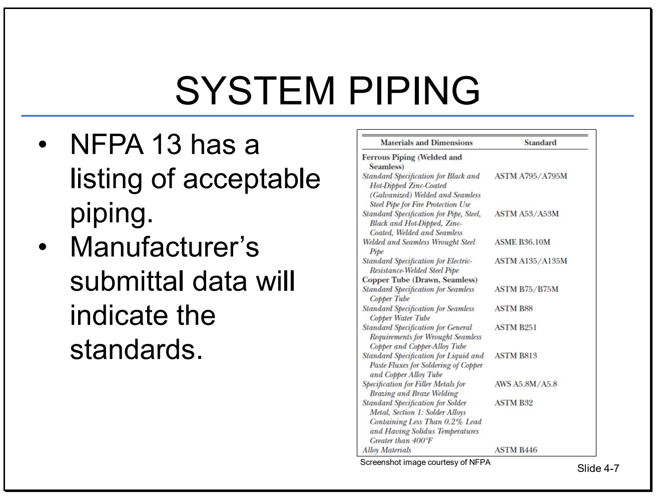
B. Manufacturer's equipment data submittal review.

1. National Fire Protection Association (NFPA) 13, *Standard for the Installation of Sprinkler Systems*, requires the submission of data sheets where required by the authority having jurisdiction (AHJ).



2. Sometimes, a table of contents sheet is provided.

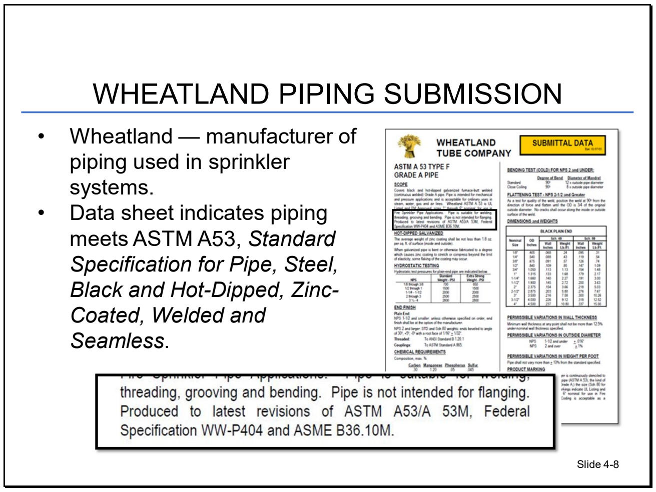
3. There is no specific requirement in NFPA 13 stating how the data sheets are to be presented.



C. System piping.

1. NFPA 13 has a listing of acceptable piping.

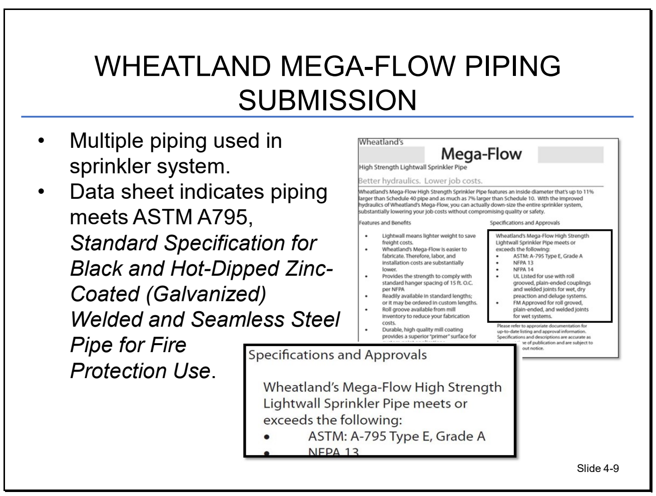
2. Manufacturer's submittal data will indicate the standards.



D. Wheatland piping submission.

1. Wheatland is a manufacturer of piping used in sprinkler systems.

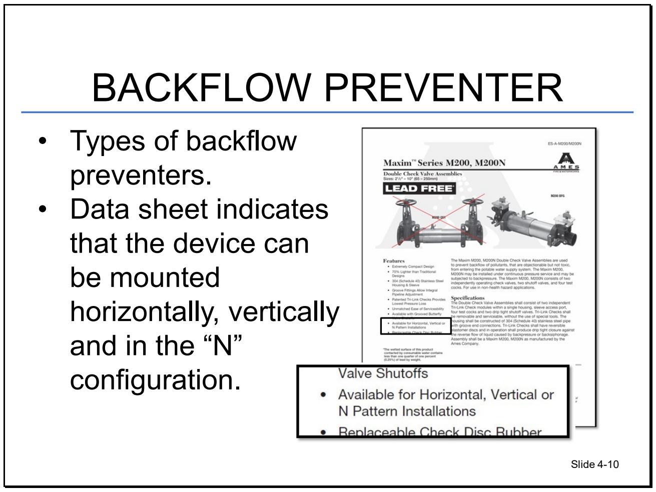
2. Data sheet indicates piping meets ASTM A53, *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless*.



3. Wheatland Mega-Flow® piping submission.

a. Wheatland has multiple piping used in sprinkler systems.

b. Data sheet indicates piping meets ASTM A795, *Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use*.

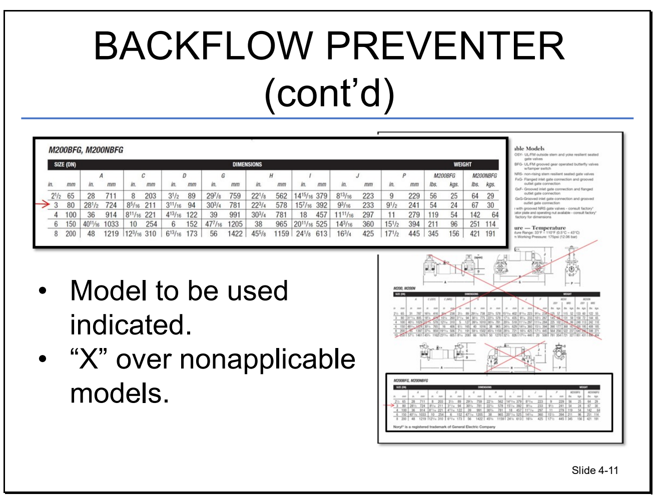


E. Backflow preventer.

1. There are different types of backflow preventers.

2. The data sheet indicates that the device can be mounted horizontally, vertically and in the "N" configuration.

3. The backflow preventer data is instrumental to the application that the preventer is to be used and installed for. There are some situations where a special type of backflow preventer such as a reduced pressure backflow preventer may be required.

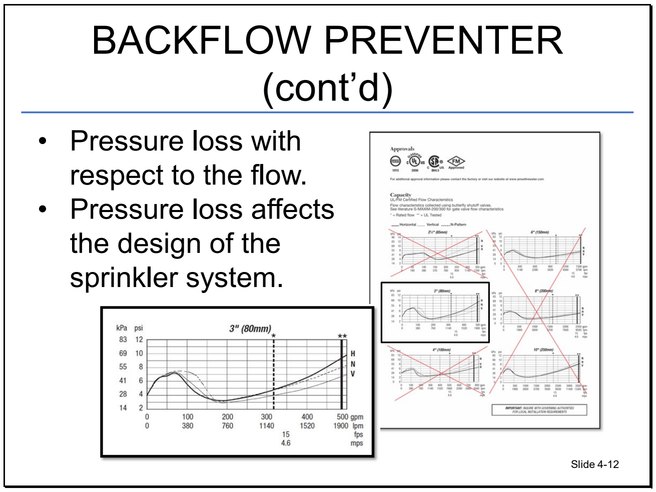


4. The contractor will indicate which model will be used.

5. Contractors typically place an "X" with nonapplicable models.

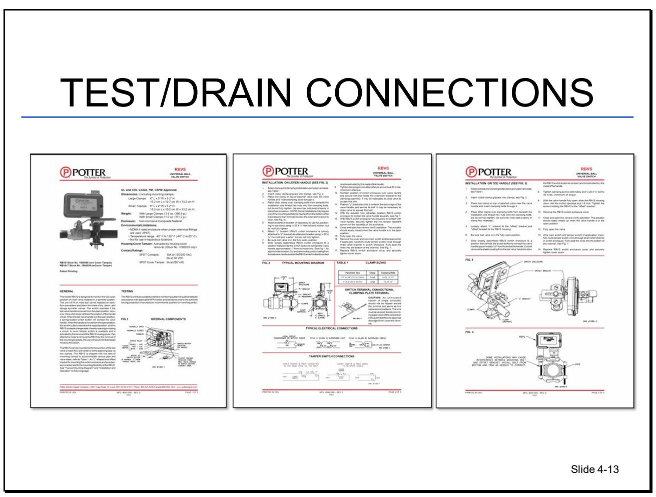
a. It is very important that the correct model is specified to be installed.

b. In this case, the diameter of the backflow preventer is specified.



6. Every backflow preventer has defined pressure loss with respect to the flow through the device.

7. Typically, the plumber is responsible for the backflow preventer, but the pressure loss affects the design of the sprinkler system.



F. Test/Drain connections.

1. With the test/drain connections data sheets, it is important to verify the correct diameter for the intended use.

TEST/DRAIN CONNECTIONS (cont'd)

- Inspector's test: verify presence and location on plans.
  - Wet system: downstream from the water flow detection.
  - Dry system: highest; most remote.

Slide 4-14

2. Inspector's test: verify presence and location on plans.

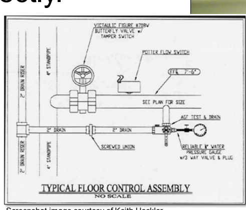
   a. Wet system: downstream from the water flow detection.

   b. Dry system: highest; most remote.

TEST/DRAIN CONNECTIONS (cont'd)

- Location needs to be on plans to be installed correctly.

Photo courtesy of Keith Heckler



Screenshot image courtesy of Keith Heckler

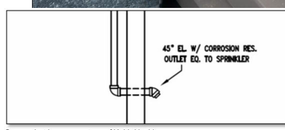
Slide 4-15

3. Location needs to be on plans to be installed correctly.

TEST/DRAIN CONNECTIONS (cont'd)

- Simulate the opening of one sprinkler.
- Have a reducing orifice equal to the smallest sprinkler on the system being tested.

Photo courtesy of Keith Heckler



Screenshot image courtesy of Keith Heckler

Slide 4-16

4. The inspector's test must simulate the opening of one sprinkler and should have a reducing orifice equal to the smallest sprinkler on the system being tested.

TEST/DRAIN CONNECTIONS (cont'd)

- Prefabricated units.
- Two settings with the ball valve.
  – One inch for draining.
  – Half inch for inspectors test.

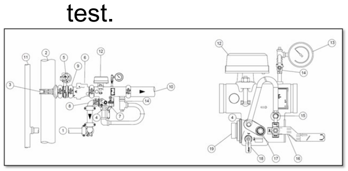


Photo courtesy of Keith Heckler

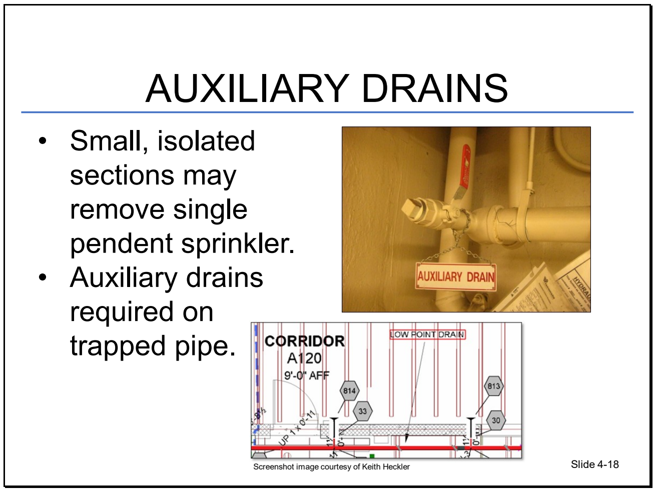
Slide 4-17

5. Prefabricated units.

6. Two settings with the ball valve.

   a. One inch for draining.

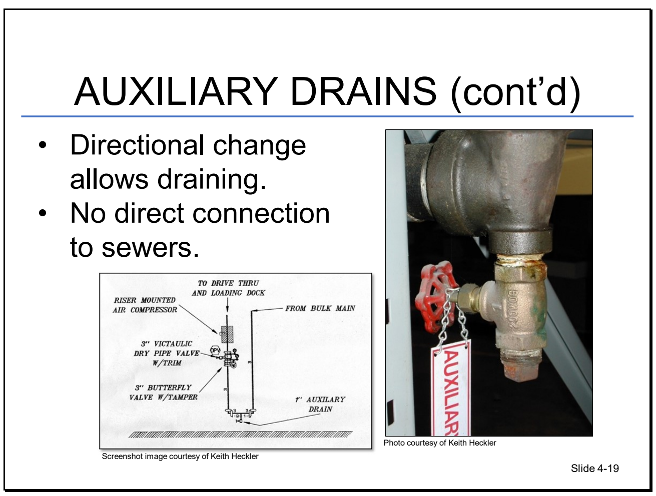
   b. Half inch for inspector's test.



G. Auxiliary drains.

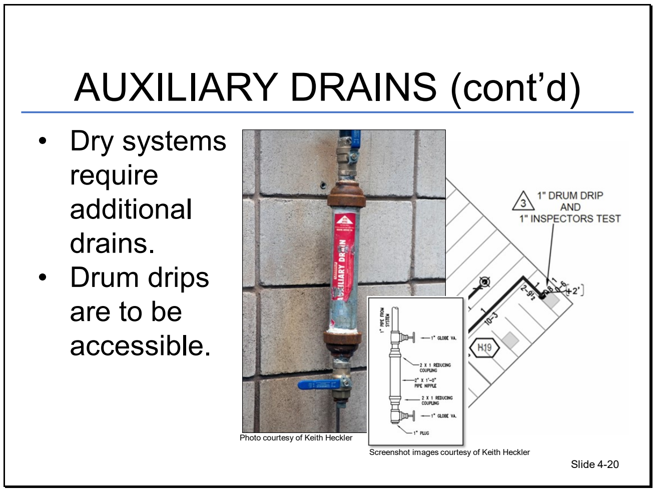
1. Small, isolated sections may remove single pendent sprinkler.

2. Auxiliary drains required on trapped pipe.



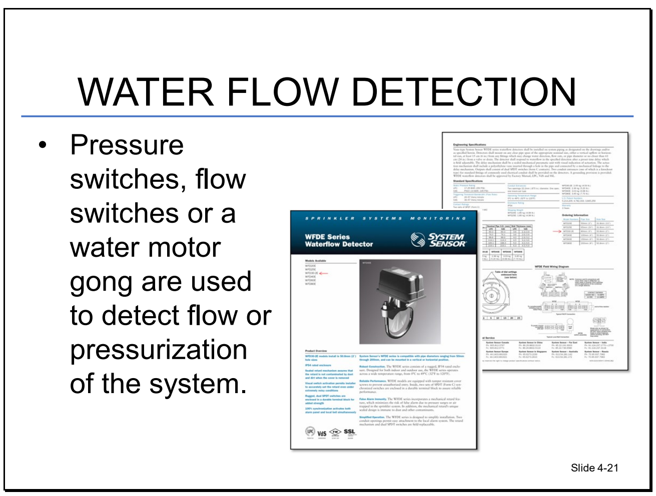
3. Directional change allows draining.

4. No direct connection to sewers.



5. Dry systems require additional drains.

6. Drum drips are to be accessible.



H. Water flow detection.

Pressure switches, flow switches or a water motor gong are used to detect flow or pressurization of the system.

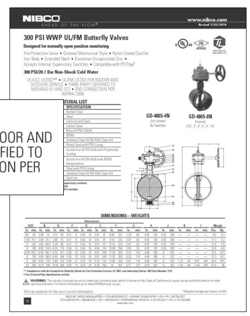
WATER FLOW DETECTION (cont'd)

- Pressure switch — used with retard chambers and dry pipe systems.
- Water flow switch — wet systems.
- Water motor gong — wet and dry pipe systems.

Photo courtesy of Keith Heckler

Slide 4-22

CONTROL VALVE



300 PSI/20.7 Bar Non-Shock Cold Water

UL/ULC LISTED** • UL/FM LISTED FOR INDOOR AND OUTDOOR SERVICE • THIRD PARTY CERTIFIED TO NSF/ANSI 61 AND 372 • END CONNECTION PER AWWA C606

Screenshot images courtesy of NIBCO

Slide 4-23

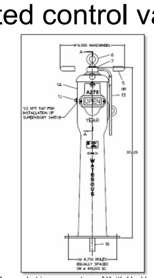
I. Control valve.

1. The data sheets for the control valves are submitted to show evidence that the valve is tested for fire protection use.

CONTROL VALVE (cont'd)

- Outside connections **should** be under control of a listed control valve.

Photo courtesy of Keith Heckler

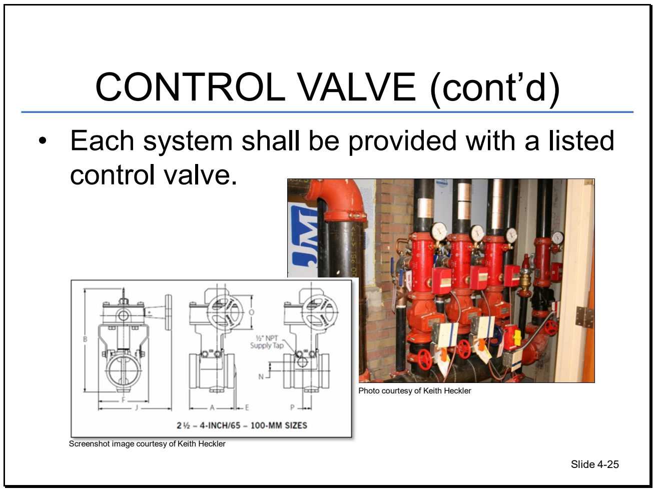


Screenshot image courtesy of Keith Heckler

Slide 4-24

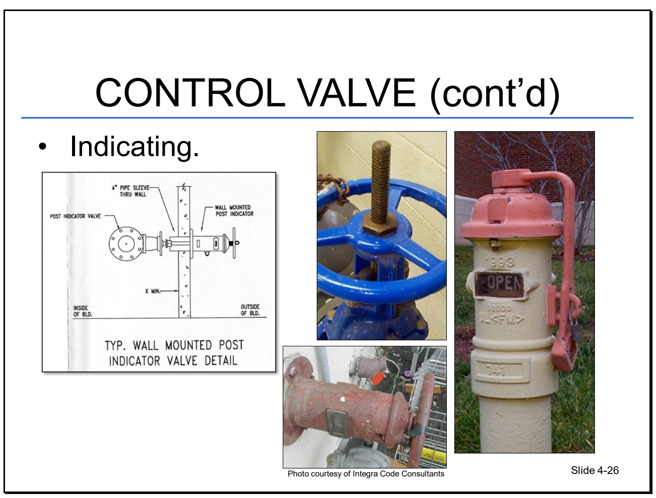
2. Outside connections **should** be under control of an outside listed control valve.

   Exterior control valves are not required to be listed with fire protection. Hence, underground valves can be used.



3. Each system shall be provided with a listed control valve.

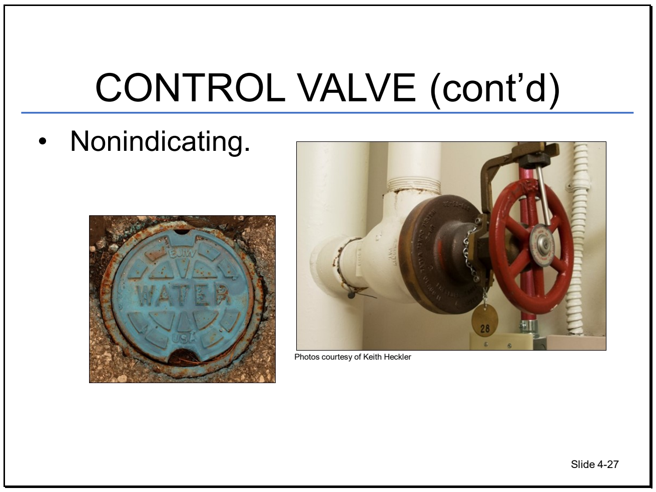
   Interior valves are required to be tested and listed. This is a butterfly valve.



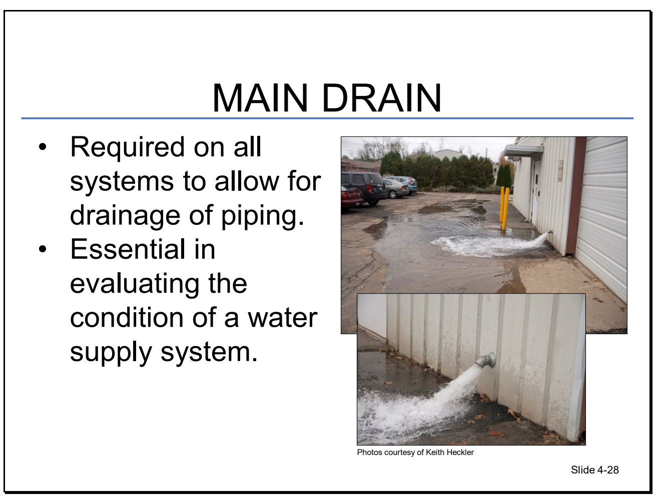
4. Indicating.

   a. Indicating valves are specifically arranged so an individual will immediately be able to observe the position of the valve.

b. A minimum of one control valve shall be located on the exterior of the building. The valve can be indicating or nonindicating. The intent of having an exterior valve is so if the fire has progressed past the capabilities of the sprinkler system, the system can be turned off so the water discharging in the building will be redirected for fire department operations.



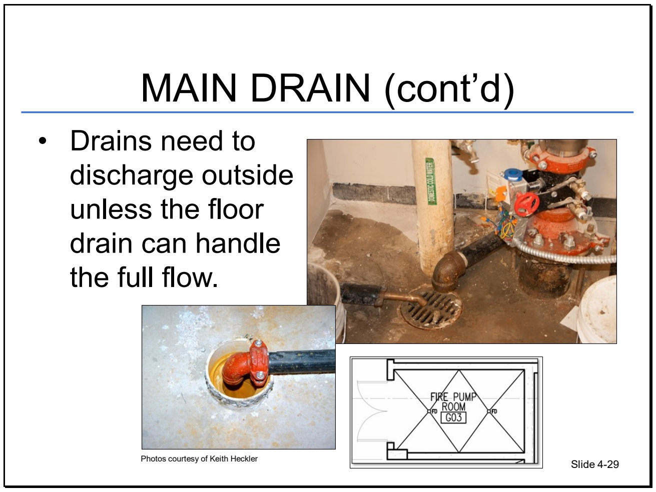
5. Nonindicating valves require exploration of the position of the valve.



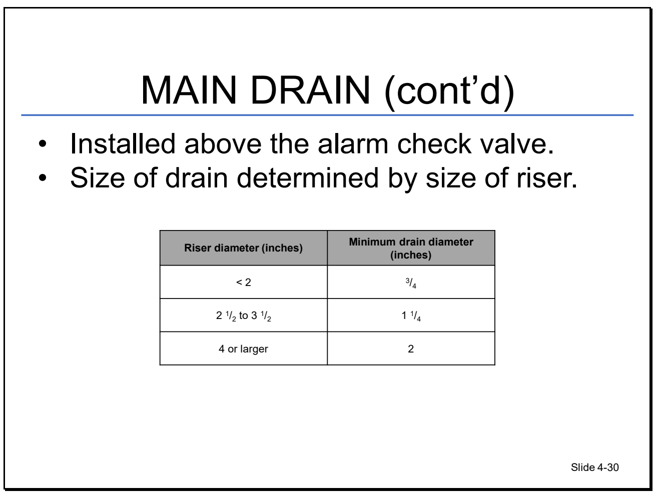
J. Main drain.

1. Required on all systems to allow for drainage of piping.

2. Main drains are essential in evaluating the condition of a water supply system.

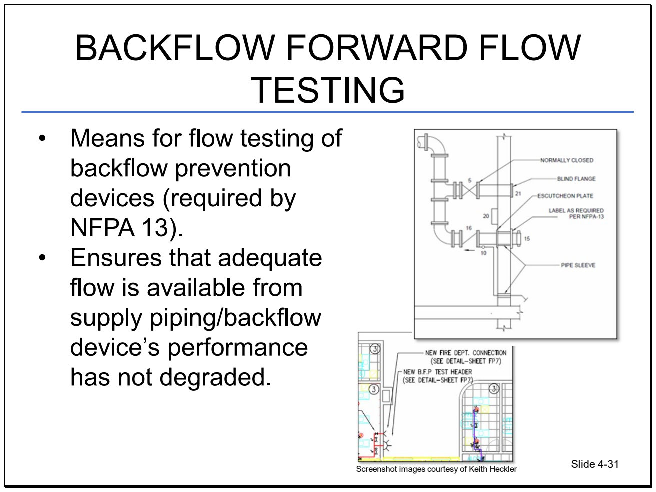


3. Drains need to discharge outside unless the floor drain can handle the full flow.



4. Installed above the alarm check valve.

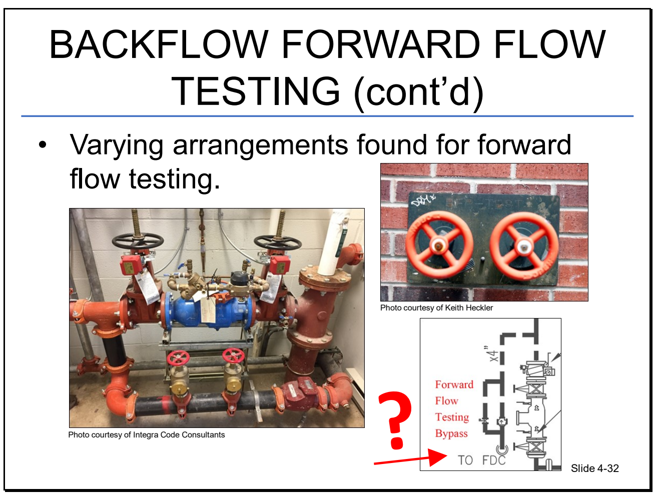
5. Size of drain determined by size of riser.



K. Backflow forward flow testing.

1. Provides a means for flow testing of backflow prevention devices, as required by NFPA 13.

2. Ensures that adequate flow is available from supply piping and that backflow device's performance has not degraded over time.



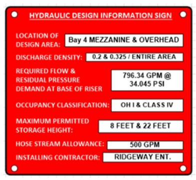
3. If the main drain outlet cannot handle the flow demand for testing the backflow prevention device, various alternatives may be found.

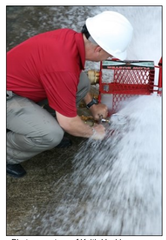
a. One or more 2 1/2-inch hose outlets on a bypass downstream of the backflow device.

b. Plumbing the backflow device through the fire pump test header hose outlets.

BACKFLOW FORWARD FLOW TESTING (cont'd)

- The flow shall not be less than the system demand, including hose streams.





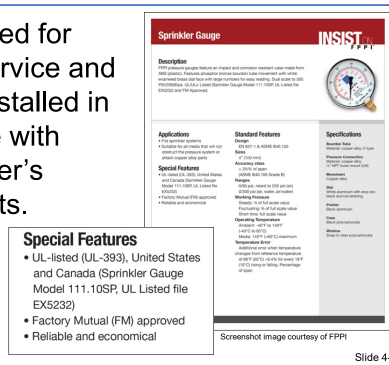
Photos courtesy of Keith Heckler

Slide 4-33

4. The flow shall not be less than the system demand, including hose streams.

GAUGES

- Must be listed for sprinkler service and are to be installed in accordance with manufacturer's requirements.



Screenshot image courtesy of FPPI

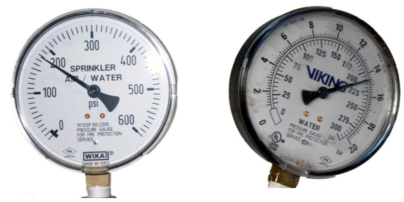
Slide 4-34

L. Gauges.

1. Must be listed for sprinkler service and are to be installed in accordance with the manufacturer's requirements.

GAUGES (cont'd)

- Need to have pressure range at least twice the anticipated system working pressure.
- Refer to calculations to verify pressures that will be exerted.



Photos courtesy of Keith Heckler

Slide 4-35

2. Need to have a pressure range at least twice the anticipated system working pressure.

3. Refer to calculations to verify pressures that will be exerted.

GAUGES (cont'd)

- Need to be installed on valves to permit removal for servicing.
- Need to be protected from physical damage and freezing.

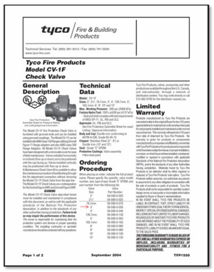
Slide 4-36

4. Need to be installed on valves to permit removal for servicing.

5. Need to be protected from physical damage and freezing.

CHECK VALVES

- Allow water flow in one direction only.



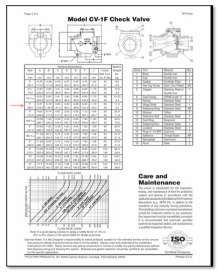


Photo courtesy of Keith Heckler

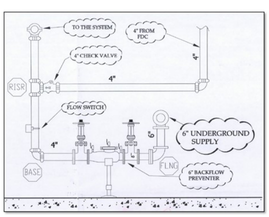
Slide 4-37

M. Check valves.

1. Allow water flow in one direction only.

CHECK VALVES (cont'd)

- Backflow prevention assembly can be substituted as a check valve.



Screenshot image courtesy of Keith Heckler

Photo courtesy of Keith Heckler

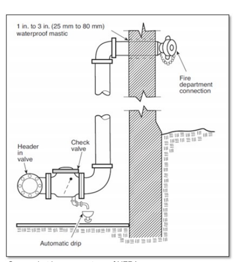
Slide 4-38

2. A backflow prevention assembly can be substituted as a check valve.

CHECK VALVES (cont'd)

- Required in fire department connections (FDCs).
  - Connection line must have automatic drain.

Photo courtesy of Keith Heckler



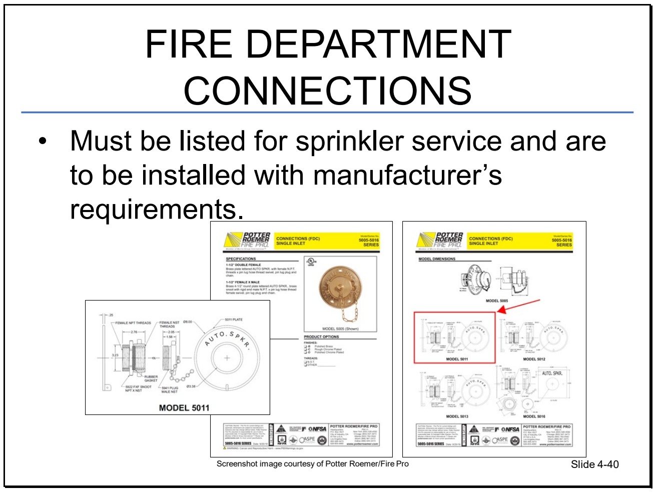
Screenshot image courtesy of NFPA

Slide 4-39

3. Required in fire department connections (FDCs).

   a. Connection line must have automatic drain.

   b. The manufacturer's recommended orientation (vertical, horizontal or both) for the automatic ball drip should be verified.



N. FDCs.

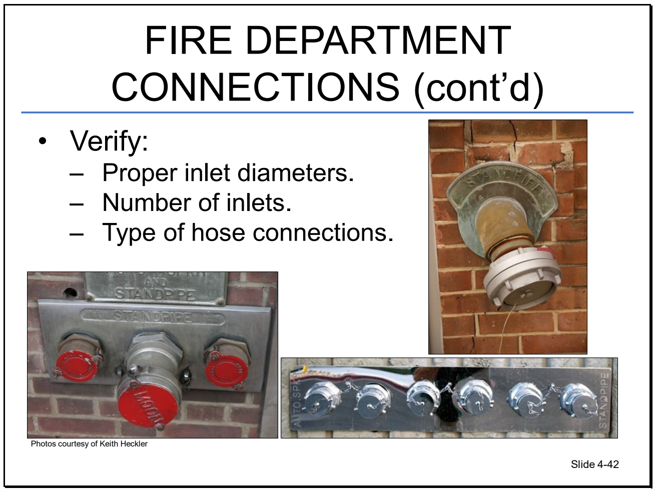
1. Must be listed for sprinkler service and are to be installed with the manufacturer's requirements.

   a. The manufacturer's data sheet is a single inlet as indicated on the shop drawings.

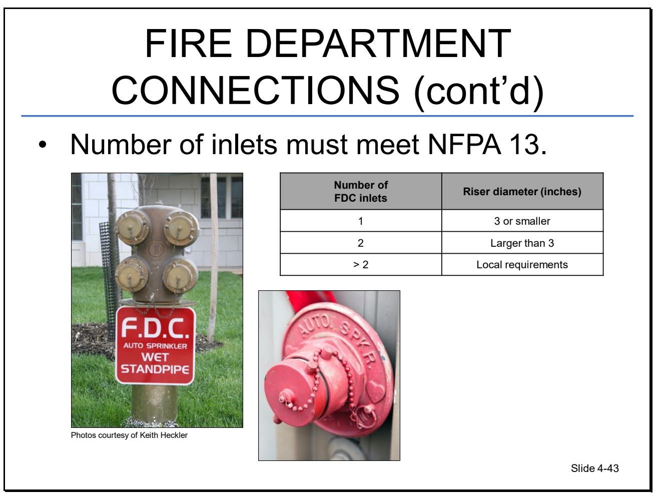
   b. It is imperative that the reviewer verifies the correct diameter for the FDC so the fire department will be able to adequately connect to the device.

2. Must be conveniently located.

3. Must be street side.



4. Verify proper inlet diameters, number of inlets and type of hose connections.



5. Number of inlets must meet NFPA 13.

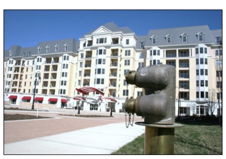
FIRE DEPARTMENT CONNECTIONS (cont'd)

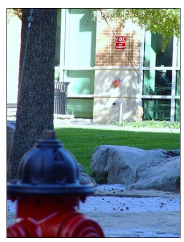
Photo courtesy of Keith Heckler

Slide 4-44

FIRE DEPARTMENT CONNECTIONS (cont'd)

- Examples of special requirements that may be in local code or policy:
  - Maximum distance from hydrant to connection.
  - Only free standing connections.





Photos courtesy of Keith Heckler

Slide 4-45

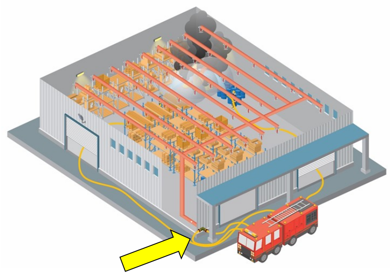
6. Special requirements such as a maximum distance from hydrant to connection or only free-standing connections may be in local code or policy.

   a. Some municipalities require the FDC to be within a certain distance of the closest fire hydrant.

   b. Others require a free-standing FDC outside of the potential collapse zone.

FIRE DEPARTMENT CONNECTIONS (cont'd)

- Allows fire department to supplement pressure and volume.



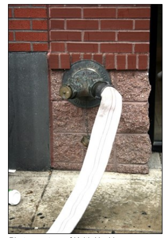


Photo courtesy of Keith Heckler

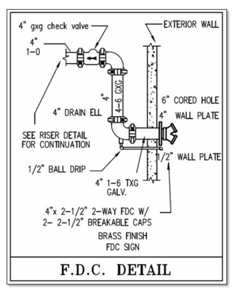
Slide 4-46

7. Allows fire department to supplement pressure and volume.

FIRE DEPARTMENT CONNECTIONS (cont'd)

- Feed piping diameter.

FDC piping diameter (inches)	Purpose
Minimum 4	Fire engine connections
Minimum 6	Fire boat connections
< 4	Hydraulically calculated systems but not less than riser size



Screenshot image courtesy of Keith Heckler

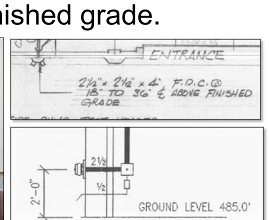
Slide 4-47

8. Feed piping diameter.

FIRE DEPARTMENT CONNECTIONS (cont'd)

- FDC height is required to be between 18 and 48 inches above finished grade.

Photos courtesy of Keith Heckler

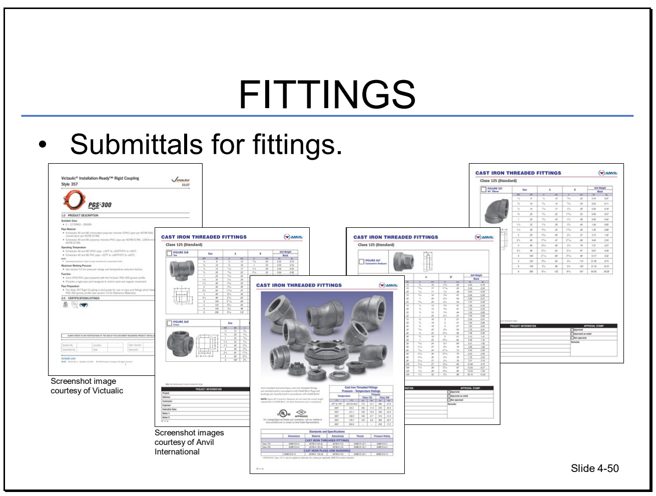


Screenshot images courtesy of Keith Heckler

Slide 4-48

9. FDC height is required to be between 18 and 48 inches above finished grade.

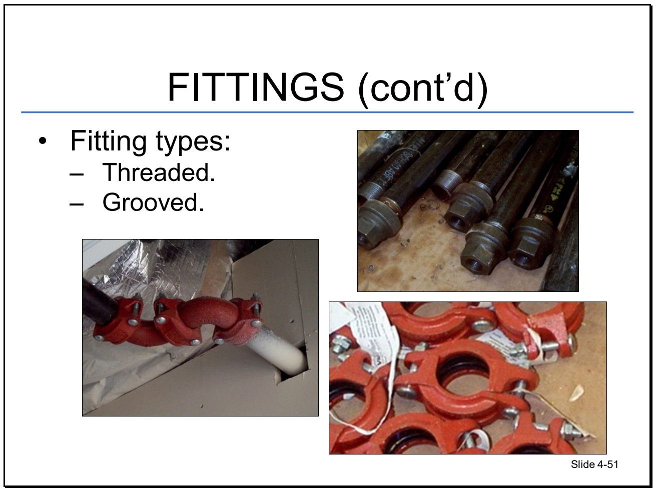
10. The design professional may have a special vision for the FDC.



O. Fittings.

1. Submittals for fittings.

The most important point for the fittings is the pressure rating. Additionally, the type of fitting is limited and/or not permitted.

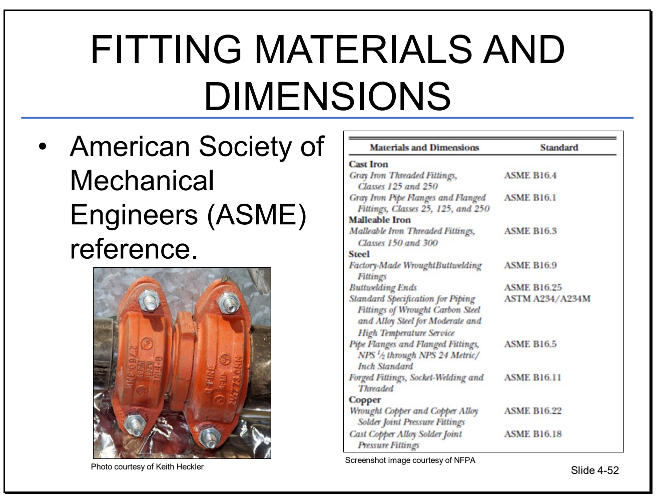


2. Fitting types.

   a. Threaded.

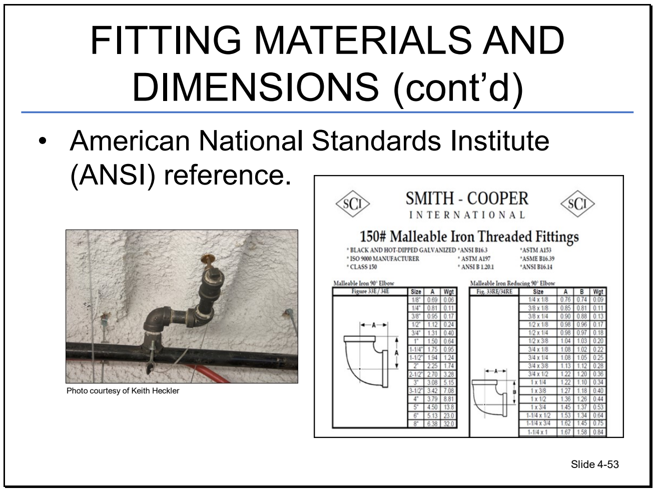
   b. Grooved.

      - Not all pipe and tube are suitable for rolled/grooved fittings. The plans examiner should refer to the pipe manufacturer's technical data sheet for verification.

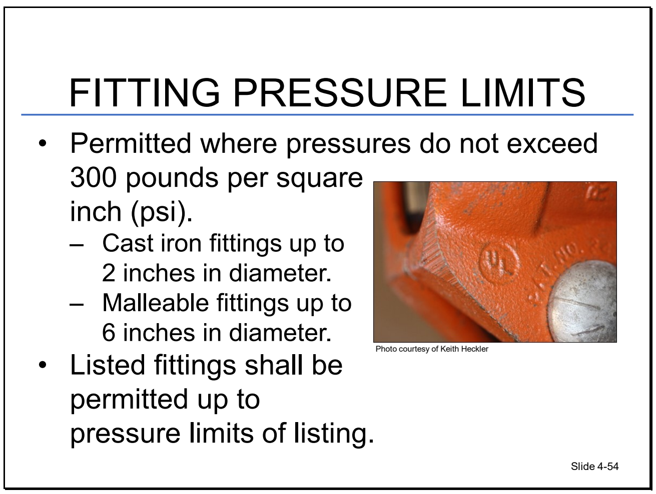


Materials and Dimensions	Standard
Cast Iron	
Gray Iron Threaded Fittings, Classes 125 and 250	ASME B16.4
Gray Iron Pipe Flanges and Flanged Fittings, Classes 25, 125, and 250	ASME B16.1
Malleable Iron	
Malleable Iron Threaded Fittings, Classes 150 and 300	ASME B16.3
Steel	
Factory-Made WroughtButtwelding Fittings	ASME B16.9
Buttwelding Ends	ASME B16.25
Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service	ASTM A234/A234M
Pipe Flanges and Flanged Fittings, NPS ½ through NPS 24 Metric/Inch Standard	ASME B16.5
Forged Fittings, Socket-Welding and Threaded	ASME B16.11
Copper	
Wrought Copper and Copper Alloy Solder Joint Pressure Fittings	ASME B16.22
Cast Copper Alloy Solder Joint Pressure Fittings	ASME B16.18

3. American Society of Mechanical Engineers (ASME) reference.



4. Manufacturer American National Standards Institute (ANSI) reference.

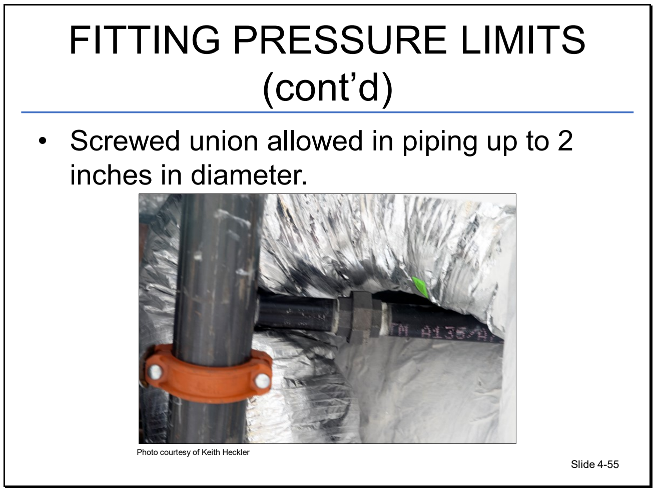


5. Permitted where pressures do not exceed 300 pounds per square inch (psi).

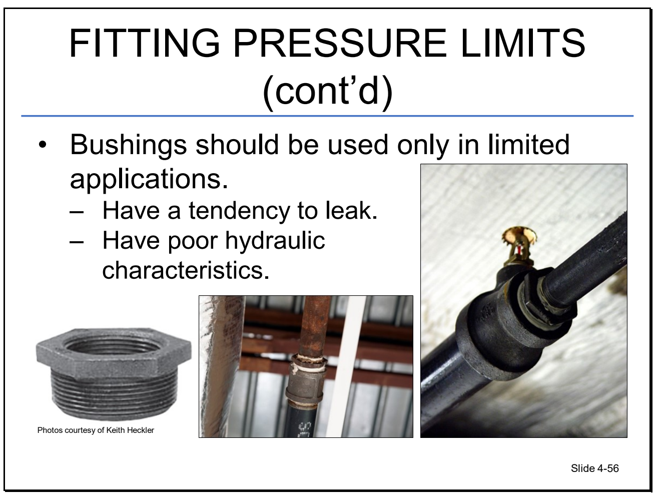
   a. Cast iron fittings up to 2 inches in diameter.

   b. Malleable fittings up to 6 inches in diameter.

6. Listed fittings shall be permitted up to the pressure limits of the listing.



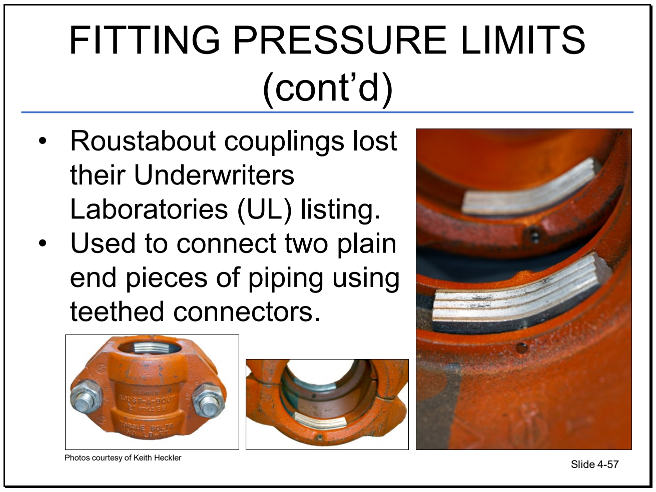
7. Screwed union allowed in piping up to 2 inches in diameter.



8. Bushings should be used only in limited applications.

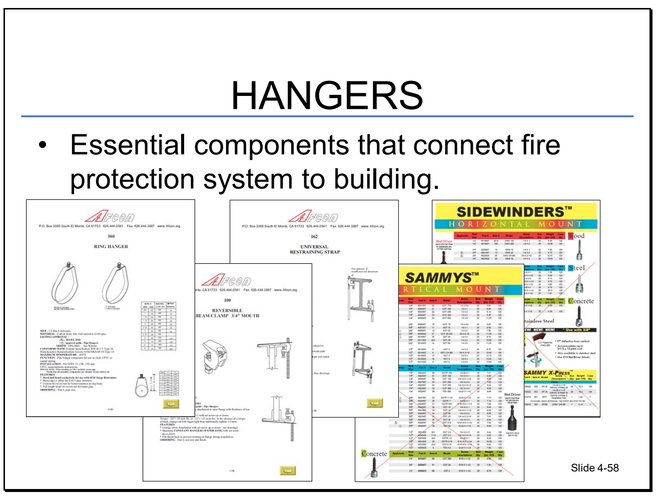
   a. Have a tendency to leak.

   b. Have poor hydraulic characteristics.



9. Roustabout couplings lost their Underwriters Laboratories (UL) listing.

10. Used to connect two plain end pieces of piping using teethed connectors.



P. Hangers.

1. Essential components that connect the fire protection system to the building.

HANGERS (cont'd)

- Support weight of water-filled pipe.
  - Must support five times the weight of pipe plus 250 pounds.
  - Building must be designed to support load points.
  - Except for mild steel rods, all hangers must be listed.

Photo courtesy of Keith Heckler

Slide 4-59

2. Support weight of water-filled pipe.

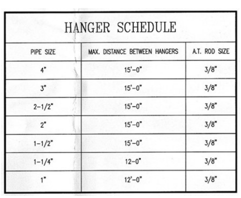
   a. Must support five times the weight of the pipe plus 250 pounds.

   b. Building must be designed to support load points.

   c. Except for mild steel rods, all hangers must be listed.

   d. Hangers sheets are provided to verify that components are tested for fire protection and that the items are proper for supporting five times the weight of the water-filled pipe plus 250 pounds.

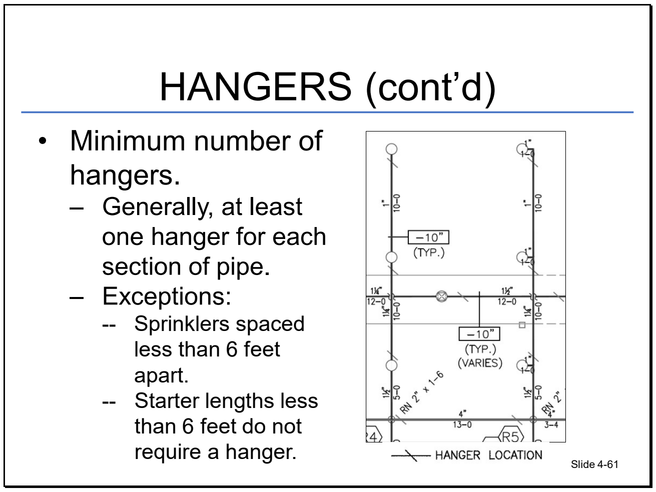
HANGERS (cont'd)


HANGER SCHEDULE

PIPE SIZE	MAX. DISTANCE BETWEEN HANGERS	A.T. ROD SIZE
4"	15'-0"	3/8"
3"	15'-0"	3/8"
2-1/2"	15'-0"	3/8"
2"	15'-0"	3/8"
1-1/2"	15'-0"	3/8"
1-1/4"	12-0"	3/8"
1"	12'-0"	3/8"

Photos courtesy of Keith Heckler

Slide 4-60



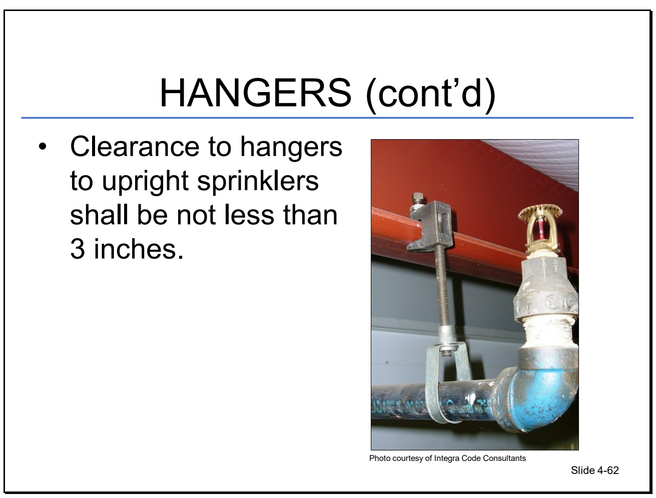
3. Minimum number of hangers.

   a. Generally, at least one hanger for each section of pipe.

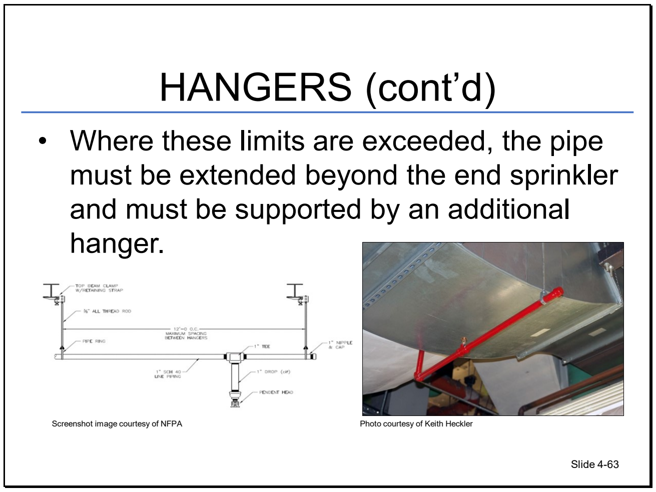
   b. Exceptions:

      - Sprinklers spaced less than 6 feet apart.

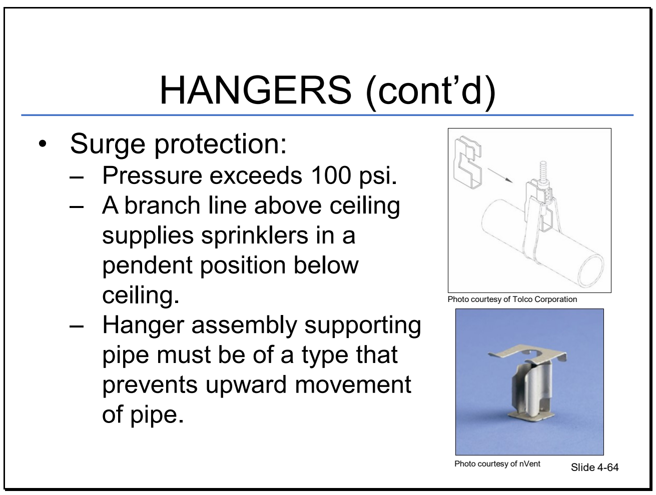
      - Starter lengths less than 6 feet do not require a hanger.



4. Clearance to hangers: The distance between a hanger and the centerline of an upright sprinkler must not be less than 3 inches to prevent the hanger from creating a "shadow" in the water spray pattern.



5. Where these limits are exceeded, the pipe must be extended beyond the end sprinkler and must be supported by an additional hanger.

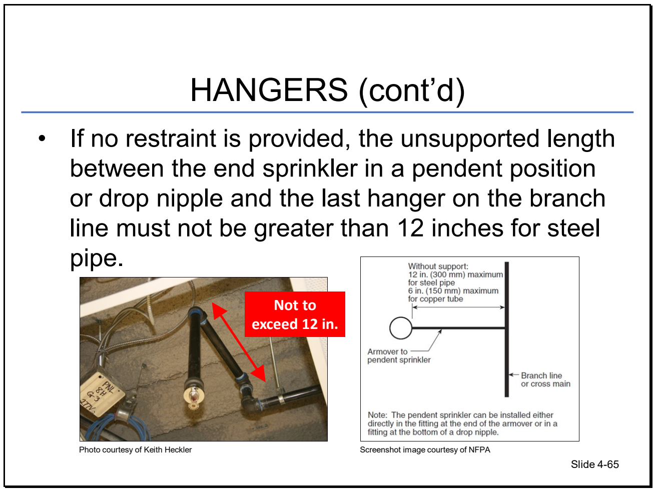


6. Surge protection.

   a. Maximum static or flowing pressure exceeds 100 psi.

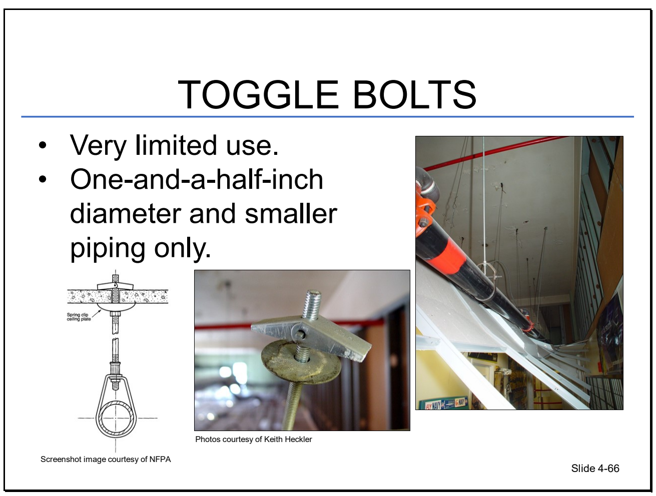
   b. A branch line above the ceiling supplies sprinklers in a pendent position below the ceiling.

   c. The hanger assembly supporting the pipe must be of a type that prevents upward movement of the pipe.



7. The unsupported length between the end sprinkler in a pendent position or drop nipple and the last hanger on the branch line must not be greater than 12 inches for steel pipe.

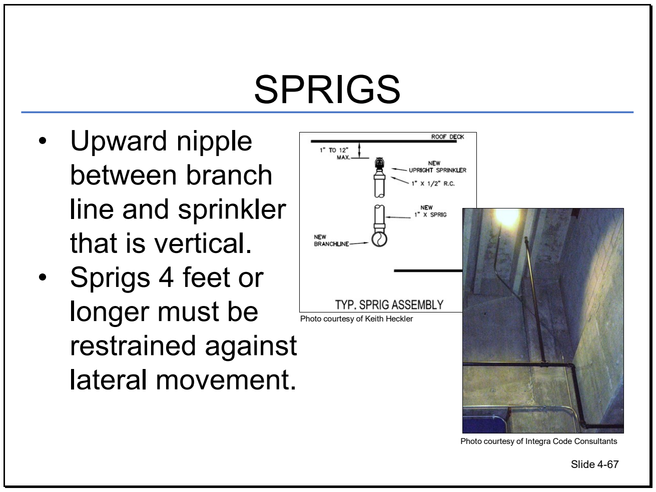
   The measurement must be 12 inches or less so no uplift surge restraint is installed.



Q. Toggle bolts.

1. Very limited use.

2. One-and-a-half-inch diameter and smaller piping only.

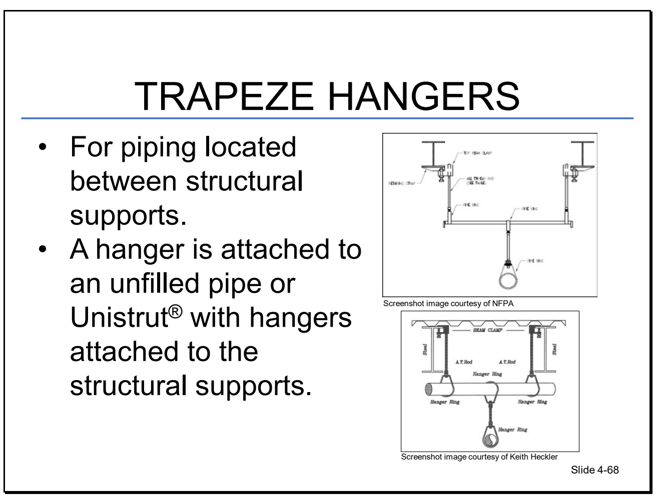


R. Sprigs.

1. Nipple between branch line and sprinkler that is vertical.

2. Sprigs 4 feet or longer must be restrained against lateral movement.

3. Note the length of the sprig on the slide. It is longer than 4 feet and is unrestrained.

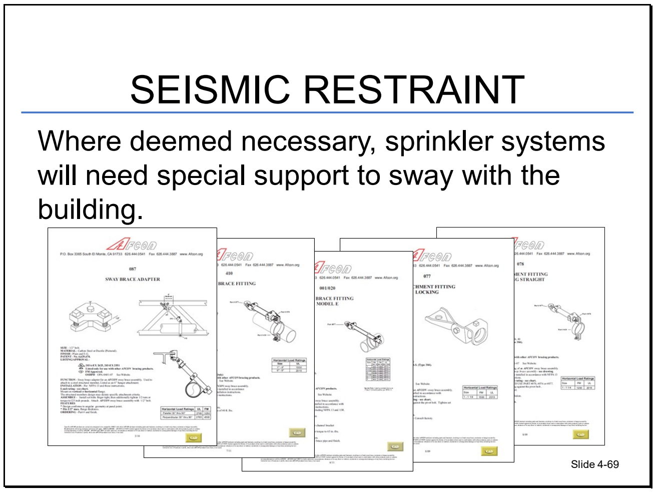


S. Trapeze hangers.

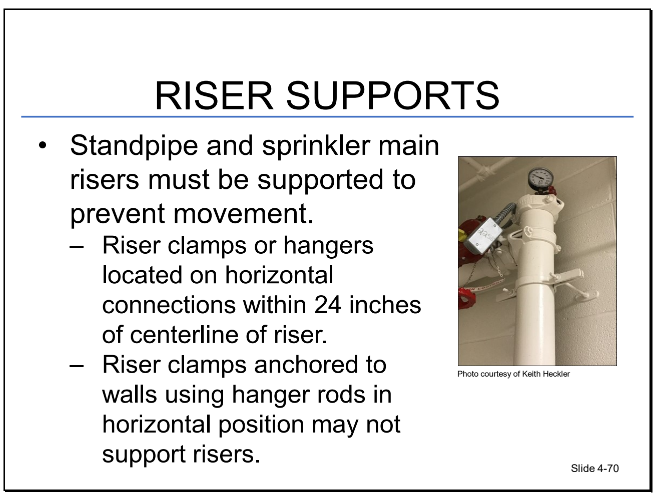
1. For piping located between structural supports.

2. A hanger is attached to an unfilled pipe or Unistrut® with hangers attached to the structural supports.

3. When exposed to trapeze hangers, one must review NFPA 13 to verify if the support piping is large enough to support the sprinkler piping. If not, the support will fail.



T. Seismic restraint: Where deemed necessary, sprinkler systems will need special support to sway with the building.



U. Riser supports.

1. Standpipe and sprinkler main risers must be supported to prevent movement.

a. Riser clamps or hangers located on horizontal connections within 24 inches of the centerline of the riser.

b. Riser clamps anchored to walls using hanger rods in horizontal position may not support risers.

RISER SUPPORTS (cont'd)

- Multistory buildings.
  - Riser supports must be provided at lowest level, at each alternate level above, above and below offsets, and at the top of riser.
  - Supports above lowest level must restrain pipe to prevent movement.
  - Distance between supports for risers is not to exceed 25 feet.

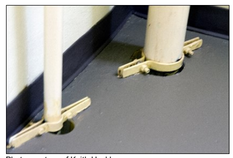


Photo courtesy of Keith Heckler

Slide 4-71

2. Multistory buildings.

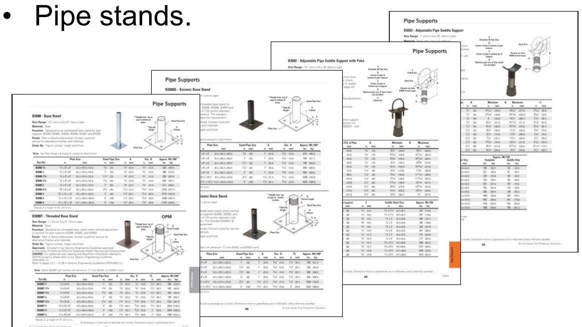
   a. Riser supports must be provided at the lowest level, at each alternate level above, above and below offsets, and at the top of the riser.

   b. Supports above the lowest level must restrain pipe to prevent movement.

   c. Distance between supports for risers is not to exceed 25 feet.

RISER SUPPORTS (cont'd)

- Pipe stands.

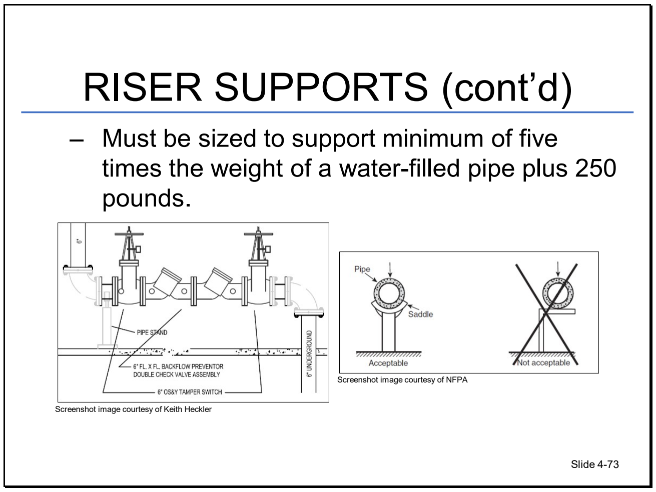


Screenshot image courtesy of Eaton

Slide 4-72

3. Pipe stands.

   a. Introduced in NFPA 13 in 2007. The requirements have evolved with each edition of NFPA 13.



b. Must be sized to support a minimum of five times the weight of a water-filled pipe plus 250 pounds.

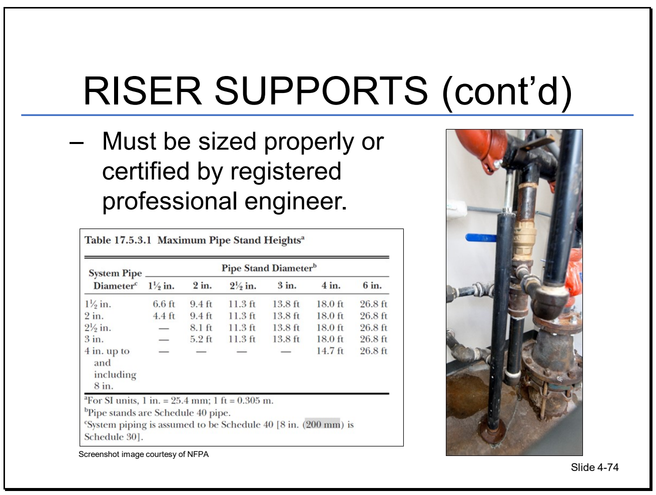


Table 17.5.3.1 Maximum Pipe Stand Heights[a]

System Pipe Diameter[c]	Pipe Stand Diameter[b]					
	1½ in.	2 in.	2½ in.	3 in.	4 in.	6 in.
1½ in.	6.6 ft	9.4 ft	11.3 ft	13.8 ft	18.0 ft	26.8 ft
2 in.	4.4 ft	9.4 ft	11.3 ft	13.8 ft	18.0 ft	26.8 ft
2½ in.	—	8.1 ft	11.3 ft	13.8 ft	18.0 ft	26.8 ft
3 in.	—	5.2 ft	11.3 ft	13.8 ft	18.0 ft	26.8 ft
4 in. up to and including 8 in.	—	—	—	—	14.7 ft	26.8 ft

[a]For SI units, 1 in. = 25.4 mm; 1 ft = 0.305 m.
[b]Pipe stands are Schedule 40 pipe.
[c]System piping is assumed to be Schedule 40 [8 in. (200 mm) is Schedule 30].

c. Must be sized properly or certified by a registered professional engineer.

d. NFPA 13 has an abundance of requirements for pipe stands.

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ACTIVITY 4.1

Verification Between Plans and Equipment Submittal

Purpose

Compare the vendor data catalogue with the plans to verify that the information matches.

Directions

1. Use the large-print The Learning Square plans to verify if the information submitted is located on the sprinkler shop drawings.

2. Locate the precise location of the information on the sprinkler shop drawings using the order in which the equipment submittal sheets are ordered, and verify that the shop drawings are correct with the reference.

3. If found, provide the sheet number and the location of the information by using the plan coordinates.

    a. Wheatland piping.

    ____

    ____

    ____

    b. Wheatland Mega-Flow piping.

    ____

    ____

    ____

    c. Backflow preventer.

    ____

    ____

    ____

d. Test/Drain connection.

e. Water flow detection.

f. Control valves.

g. Gauges.

h. Check valves.

i. FDC location.

j. Fittings.

____

____

____

k. Hangers.

____

____

____

l. Seismic restraints.

____

____

____

m. Pipe stand.

____

____

____

4. The instructor will review the correct answers with the class at the end of the activity.

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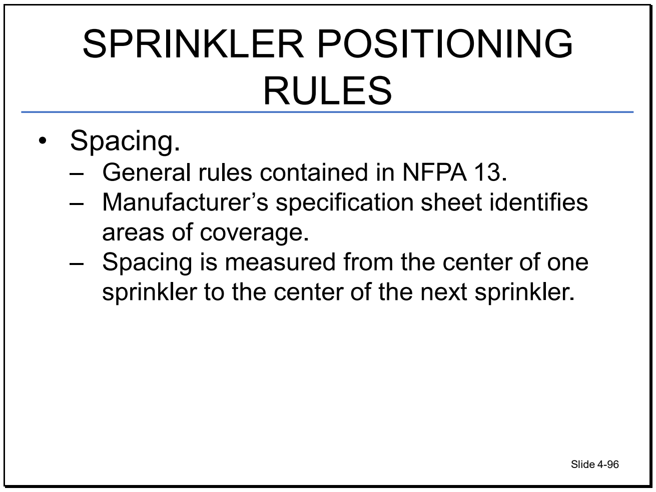
II. SPRINKLER POSITIONING RULES

A. The sprinkler has separate manufacturer's information that is very important to follow. A sprinkler is not an interchangeable item without verifying specific qualities it may possess.

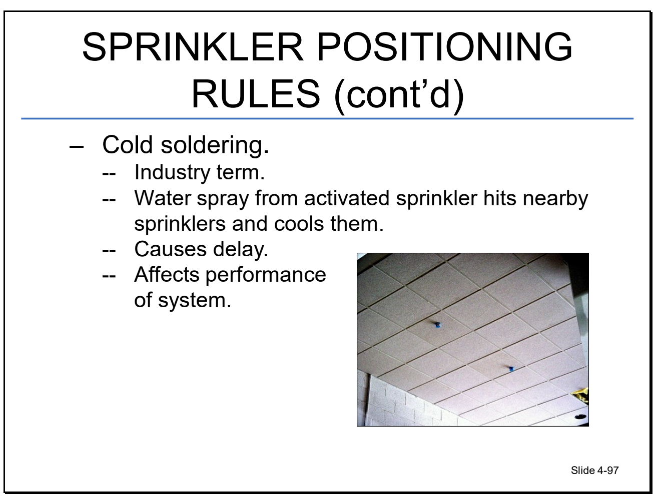


B. Spacing.

1. General rules contained in NFPA 13.

2. Manufacturer's specification sheet identifies areas of coverage.

3. Spacing is measured from the center of one sprinkler to the center of the next sprinkler.



4. Cold soldering.

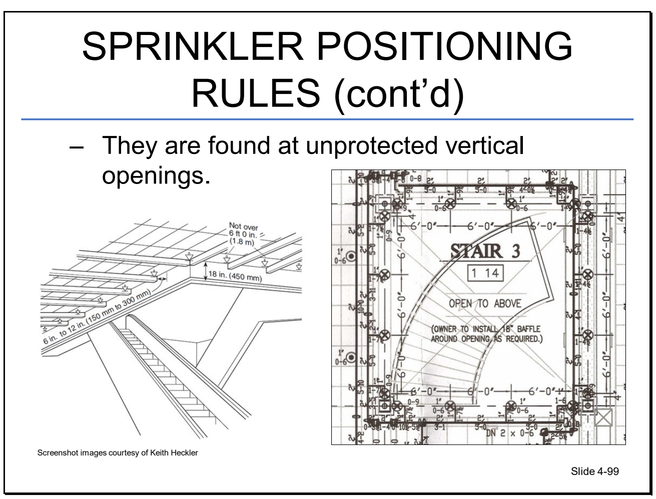
a. Industry term used for the effect one sprinkler may have on the next sprinkler when minimum distance is not maintained.

b. Water spray from activated sprinkler hits nearby sprinklers and cools them.

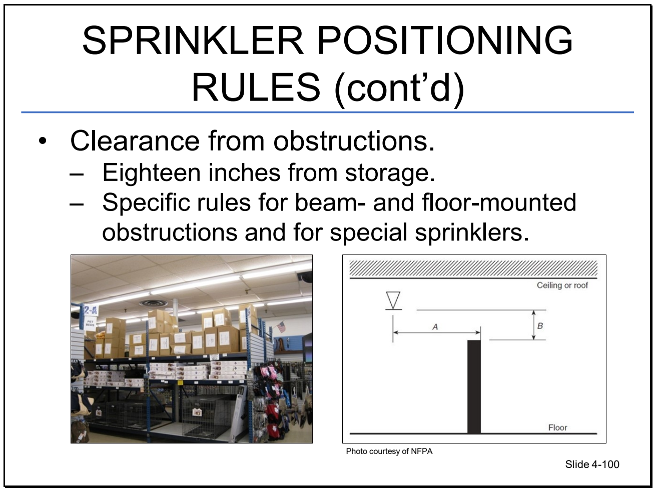
c. Causes delay.

d. Affects performance of system.

5. Water curtains have special applications and rules.



6. They are found at unprotected vertical openings.



C. Clearance from obstructions.

1. Generic rule is 18 inches from storage.

2. Specific rules for beam- and floor-mounted obstructions and for special sprinklers.

3. When performing plans review, the reviewer will need to visualize the side profile of the space with any potential effect of clearances with obstructions. With storage, a specific 18-inch rule applies. With floor-mounted obstructions, such as a cubicle wall or a fixed-height partition wall, the vertical separation is dependent upon the horizontal distance.

4. Beam obstructions will be discussed in detail in Unit 5: Fire Sprinkler System Layout.

D. Sprinkler Identification Number (SIN).

1. Effective 2001, sprinkler manufacturers use proprietary five- to six-character identification for:

    a. Manufacturer.

    b. K-factor (orifice size).

    c. Application (use).

    d. Response characteristics.

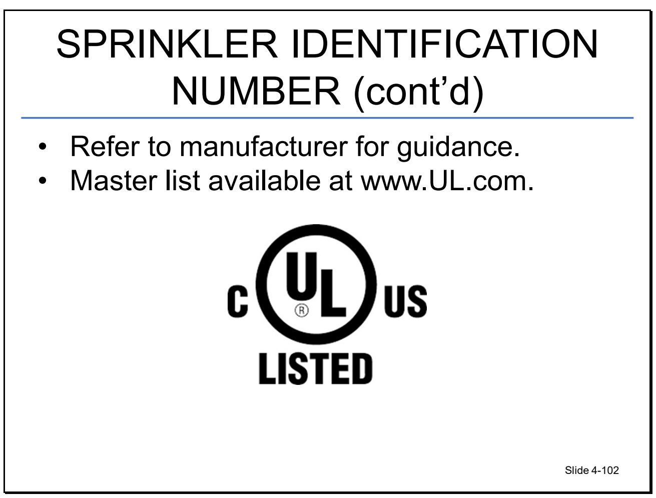
    e. All sprinklers are required to have a SIN.

        - The SIN is comprised of one or two letters followed by three or four numbers.

        - The requirement for this SIN is found in NFPA 13, as well as UL and Factory Mutual (FM) Global sprinkler product standards.

        - This requirement was implemented as of Jan. 1, 2001.

        - Therefore, sprinklers manufactured prior to 2001 may not have this mark on them.



2. Refer to manufacturer for guidance.

3. Master list is available at http://www.UL.com.

SPRINKLER IDENTIFICATION NUMBER (cont'd)

Mfg. abbrev.	Tech bulletin numbers	Deflector style		Assigned numbers/ K-factors				
R	57	1	Pendent	1	1.10	2.82	3.00	5.40
		2	Upright	2	1.98	2.72	3.90	5.50
		3	Horizontal	3	1.81	3.70	4.24	14.50
		4	EC pendent	4	2.57	4.10	5.60	
		5	EC upright	5	3.45	4.20	5.62	
		6	EC horizontal	6	4.9	5.70	7.96	11.21
		7	Conventional	7	2.75	4.15	6.40	8.20
		8	Vertical	8	5.53	7.00		
		9	Others	9	Reserved			

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SPRINKLER IDENTIFICATION NUMBER (cont'd)

Installation Data:

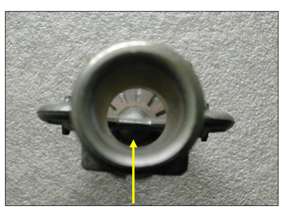
Nominal Orifice	Thread Size	Nominal K Factor		Sprinkler Height	Approval Organization	Sprinkler Identification Numbers (SIN)	
		US	Metric			Upright	Pendent
Standard-Upright (SSU) and pendent Deflectors Marked to Indicate Position							
½" (15mm)	½" NPT (R1/2)	5.6	80	2.2" (56mm)	1,2,3,4,5,6,7	R1725[4]	R1715
17/32" (20mm)	¾" NPT (R3/4)[1]	8.0	115	2.3" (58mm)	1,2,3,4,7,8	R1722[4]	R1712
½" (15mm)[3]	½" NPT (R1/2)	5.6	80	2.2" (56mm)	7		
17/32" (20mm)[3]	¾" NPT (R3/4)	8.0	115	2.3" (58mm)	7		
7/16" (11mm)	½" NPT (R1/2)	4.2	60	2.2" (56mm)	1,2,8	R1723[4]	R1713
3/8" (10mm)	½" NPT (R1/2)[2]	2.8	40	2.54" (65mm)	1,2,8	R1721[4]	R1711
10mm XLH	R3/8	4.2	60	56.1mm	4,6,7	R1724	R1714
Conventional-Install in Upright or Pendent Position							
10mm XLH	R3/8	4.2	60	56.1mm	-------	R1774	
15mm	½" NPT (R1/2)	5.6	80	56.1mm	4,6,7	R1775	
20mm	¾" NPT (R3/4)	8.0	115	58.1mm	4,7	R1772	

Reliable	Bulletin 17	Conventional	8.0 K-factor
R	17	7	2

Slide 4-104

ORIFICE SIZE: K-FACTOR

- Constant coefficient of orifice area.
- Higher K-factor means greater flow at lower pressure.
- Lower K-factor means lesser flow at greater pressure.



K = 2.8

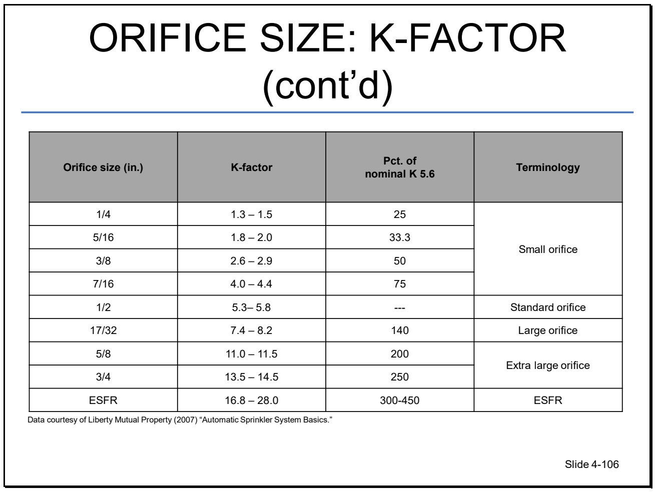
Slide 4-105

E. Orifice size: K-factor.

1. Constant coefficient of orifice area.

2. Higher K-factor means greater flow at a lower pressure.

3. Lower K-factor means lesser flow at a greater pressure.

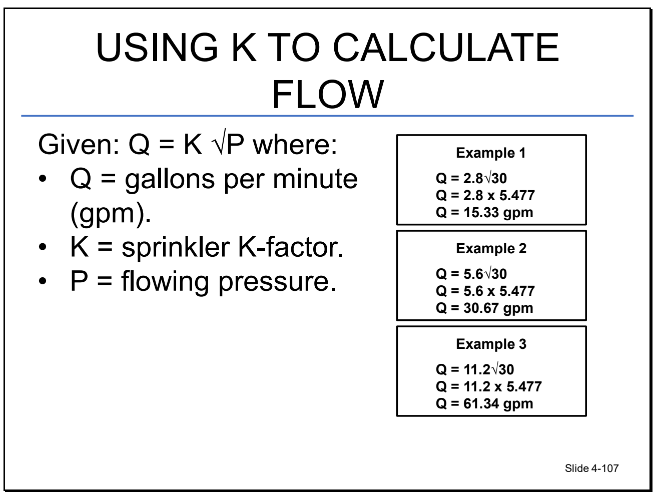

ORIFICE SIZE: K-FACTOR (cont'd)

Orifice size (in.)	K-factor	Pct. of nominal K 5.6	Terminology
1/4	1.3 – 1.5	25	Small orifice
5/16	1.8 – 2.0	33.3	
3/8	2.6 – 2.9	50	
7/16	4.0 – 4.4	75	
1/2	5.3– 5.8	---	Standard orifice
17/32	7.4 – 8.2	140	Large orifice
5/8	11.0 – 11.5	200	Extra large orifice
3/4	13.5 – 14.5	250	
ESFR	16.8 – 28.0	300-450	ESFR

Data courtesy of Liberty Mutual Property (2007) "Automatic Sprinkler System Basics."

Slide 4-106

4. The chart on the slide presents the wide variety of orifice sizes available on the market with the different K-factors associated with them.



F. Using K to calculate flow.

1. Given: $Q = K\sqrt{P}$ where:

a. Q = gallons per minute (gpm).

b. K = sprinkler K-factor.

c. P = flowing pressure.

2. Example 1.

$Q = 2.8\sqrt{30}$

Q = 2.8 x 5.477

Q = 15.33 gpm

3. Example 2.

Q = 5.6√30

Q = 5.6 x 5.477

Q = 30.67 gpm

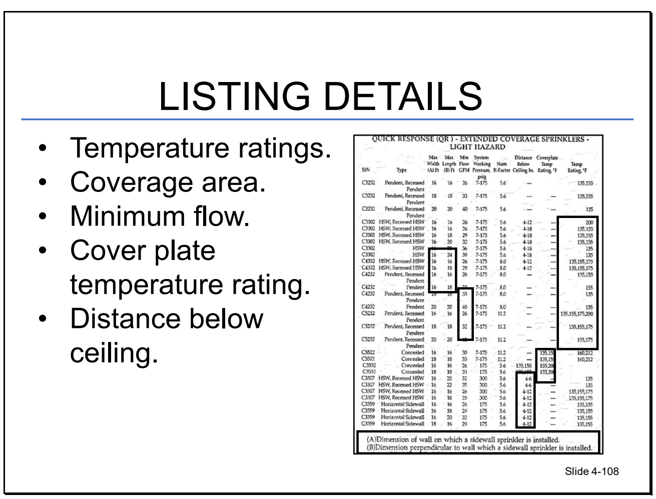
4. Example 3.

Q = 11.2√30

Q = 11.2 x 5.477

Q = 61.34 gpm

5. The flow characteristics can change at a sprinkler by inserting a different orifice size. A smaller orifice sprinkler at the same available pressure will cut the flow in half of a standard sprinkler. If an extra-large sprinkler orifice is installed, the flow is doubled. More water may discharge from the sprinkler creating an unbalanced discharge of water and allow the fire to grow and overtax the capabilities of the system.



G. Listing details.

1. Temperature ratings.

2. Coverage area.

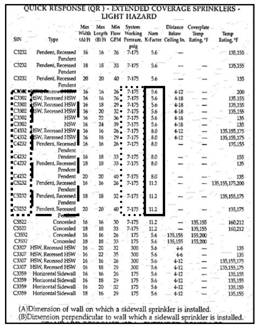
3. Minimum flow.

4. Cover plate temperature rating.

5. Distance below ceiling.

LISTING DETAILS (cont'd)

- Model (Sprinkler Identification Number (SIN)).
- Type.
- Working pressure.
- Orifice size (K).



QUICK RESPONSE (QR) - EXTENDED COVERAGE SPRINKLERS - LIGHT HAZARD

SIN	Type	Max Width (A) Ft	Max Length (B) Ft	Min Flow GPM	System Working Pressure, psig	Nom K-Factor	Distance Below Ceiling In.	Coverplate Temp Rating, °F	Temp Rating, °F
C3232	Pendent, Recessed Pendent	16	16	26	7-175	5.6	—		135,155
C3232	Pendent, Recessed Pendent	18	18	33	7-175	5.6	—	—	135,155
C3232	Pendent, Recessed Pendent	20	20	40	7-175	5.6	—	—	135
C3302	HSW, Recessed HSW	16	16	26	7-175	5.6	4-12	—	200
C3302	HSW, Recessed HSW	16	16	26	7-175	5.6	4-18	—	135,155
C3302	HSW, Recessed HSW	16	18	29	7-175	5.6	4-18	—	135,155
C3302	HSW, Recessed HSW	16	20	32	7-175	5.6	4-18	—	135,155
C3302	HSW	16	22	36	7-175	5.6	4-18	—	135
C3302	HSW	16	24	39	7-175	5.6	4-18	—	135
C4332	HSW, Recessed HSW	16	16	26	7-175	8.0	4-12	—	135,155,175
C4332	HSW, Recessed HSW	16	18	29	7-175	8.0	4-12	—	135,155,175
C4232	Pendent, Recessed Pendent	16	16	26	7-175	8.0	—	—	135,155
C4232	Pendent	16	18	33	7-175	8.0	—	—	155
C4232	Pendent, Recessed Pendent	18	18	33	7-175	8.0	—	—	135
C4232	Pendent	20	20	40	7-175	8.0	—	—	135
C5232	Pendent, Recessed Pendent	16	16	26	7-175	11.2	—	—	135,155,175,200
C5232	Pendent, Recessed Pendent	18	18	32	7-175	11.2	—	—	135,155,175
C5232	Pendent, Recessed Pendent	20	20	40	7-175	11.2	—	—	135,175
C5522	Concealed	16	16	30	7-175	11.2	—	135,155	160,212
C5522	Concealed	18	18	33	7-175	11.2	—	135,155	160,212
C3532	Concealed	16	16	26	175	5.6	135,155	155,200	
C3532	Concealed	18	18	33	175	5.6	135,155	155,200	
C3307	HSW, Recessed HSW	16	20	32	300	5.6	4-6	—	135
C3307	HSW, Recessed HSW	16	22	35	300	5.6	4-6	—	135
C3307	HSW, Recessed HSW	16	16	26	300	5.6	4-12	—	135,155,175
C3307	HSW, Recessed HSW	16	18	29	300	5.6	4-12	—	135,155,175
C3359	Horizontal Sidewall	16	16	26	175	5.6	4-12	—	135,155
C3359	Horizontal Sidewall	16	18	29	175	5.6	4-12	—	135,155
C3359	Horizontal Sidewall	16	20	32	175	5.6	4-12	—	135,155
C3359	Horizontal Sidewall	18	16	29	175	5.6	4-12	—	135,155

(A)Dimension of wall on which a sidewall sprinkler is installed.
(B)Dimension perpendicular to wall which a sidewall sprinkler is installed.

Slide 4-109

6. Model (SIN).

7. Type.

8. Working pressure.

9. Orifice size (K).

III. UNDERWRITERS LABORATORIES STANDARDS FOR SPRINKLER PERFORMANCE TESTING AND LISTINGS

PLAN VERIFICATION OF SPRINKLERS

- In plans review, one must have the correct sprinkler for the proper application.
- The definitions of "sprinkler" are in NFPA 13.
- Sprinklers are specific to design hazard classifications.

Photo courtesy of Keith Heckler

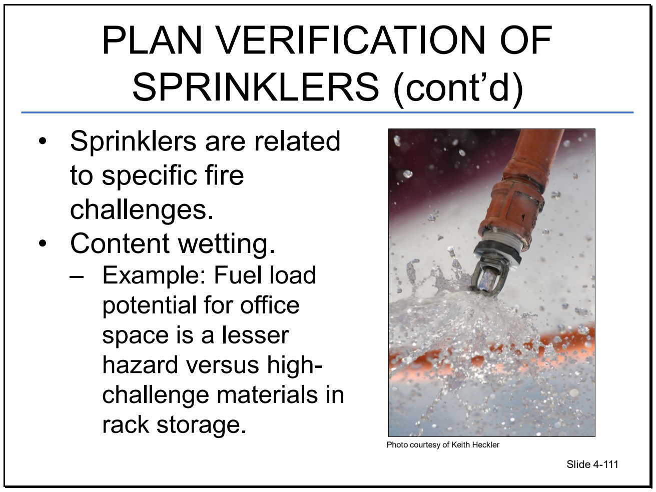
Slide 4-110

A. Plan verification of sprinklers.

1. In plans review, one must have the correct sprinkler for the proper application.

2. The definitions of "sprinkler" are in NFPA 13.

3. Sprinklers are specific to design hazard classifications.



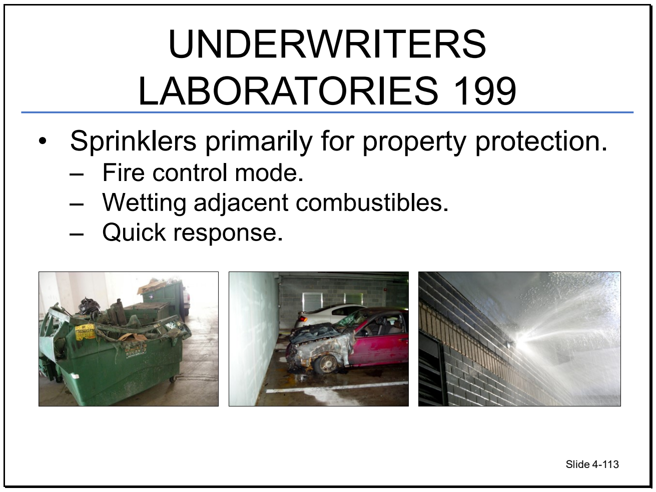
4. Sprinklers are related to specific fire challenges.

5. Content wetting.

Example: Fuel load potential for office space is a lesser hazard versus high-challenge materials in rack storage.

B. UL standards.

1. UL 199, *Standard for Automatic Sprinklers for Fire-Protection Service*.

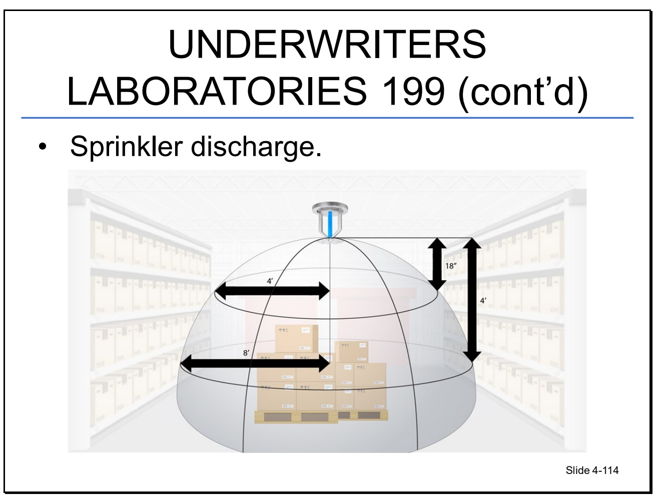


a. Property protection.

- Fire control mode.

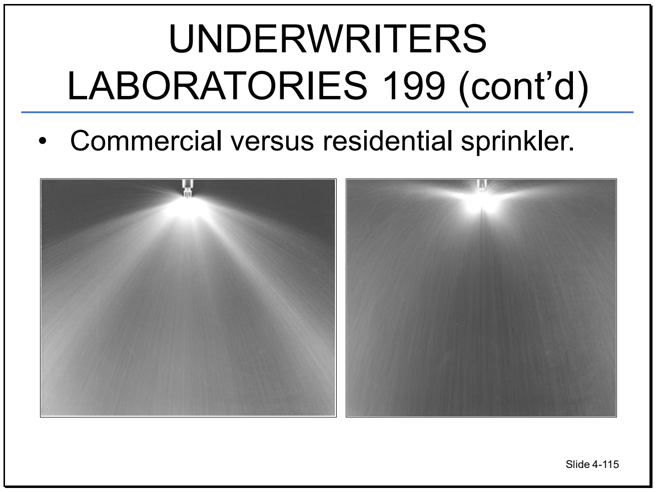
- Wetting adjacent combustibles.

- Quick response.

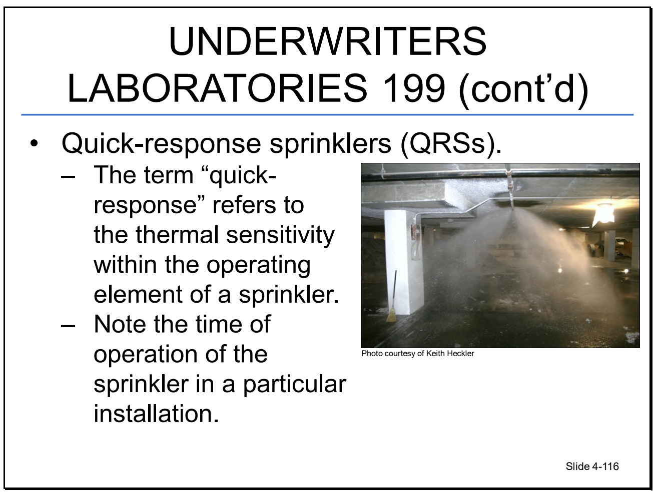


b. Sprinkler discharge.

- The UL 199 testing performance criteria is the genesis for the 18-inch clearance rule found in NFPA 13 for storage. As seen here and noted in NFPA 13, the 18-inch rule is really for commodities within a 4-foot radius of the sprinkler, hence storage could be higher when outside that parameter.



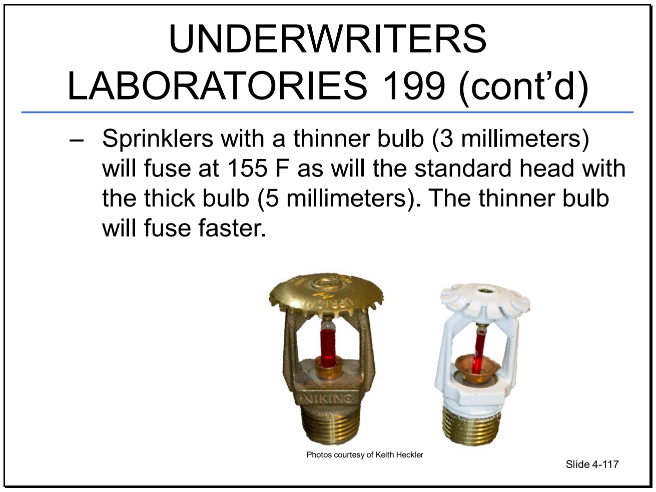
c. Commercial versus residential sprinkler.



d. Quick-response sprinklers (QRSs).

- The term "quick-response" refers to the thermal sensitivity within the operating element of a sprinkler.

- Note the time of operation of the sprinkler in a particular installation.



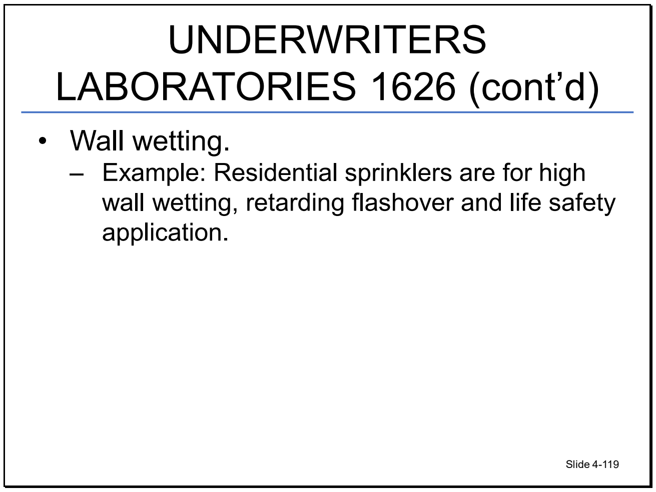
- Sprinklers with a thinner bulb (3 millimeters) will fuse at 155 F as will the standard head with the thick bulb (5 millimeters). The thinner bulb will fuse faster.

2. UL 1626, *Standard for Residential Sprinklers for Fire-Protection Service*.

   a. Primarily for life safety.

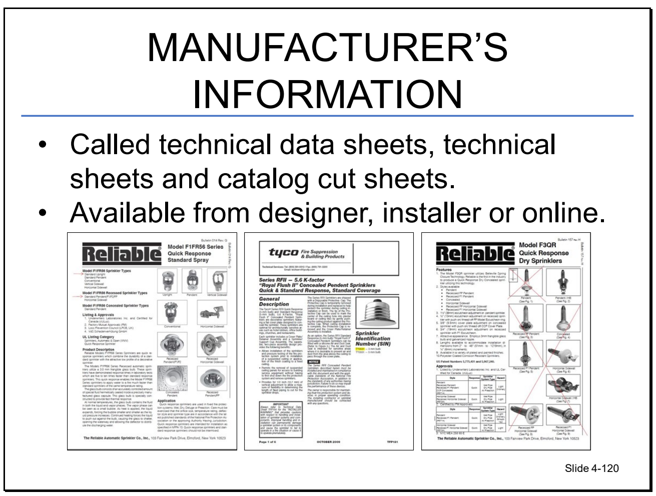
      - Prevent flashover in room of ignition.
      - Wet ceiling and walls.
      - Keep carbon monoxide levels low.
      - Maintain tenable environment for escape.

   b. Must be labeled "Residential Sprinkler" or "Res. Sprk."



c. Wall wetting.

- Example: Residential sprinklers are for high wall wetting, retarding flashover and life safety application.

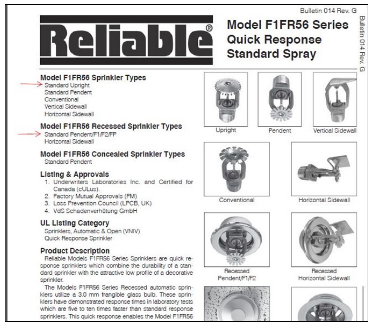


C. Manufacturer's information.

1. Called technical data sheets, technical sheets and catalog cut sheets.

2. Available from designer, installer or online.

MANUFACTURER'S INFORMATION (cont'd)



Bulletin 014 Rev. G

Reliable®

Model F1FR56 Series Quick Response Standard Spray

Model F1FR56 Sprinkler Types
- Standard Upright
- Standard Pendent
- Conventional
- Vertical Sidewall
- Horizontal Sidewall

Model F1FR56 Recessed Sprinkler Types
- Standard Pendent/F1/F2/FP
- Horizontal Sidewall

Model F1FR56 Concealed Sprinkler Types
- Standard Pendent

Listing & Approvals
1. Underwriters Laboratories Inc. and Certified for Canada (cULus).
2. Factory Mutual Approvals (FM)
3. Loss Prevention Council (LPCB, UK)
4. VdS Schadenverhütung GmbH

UL Listing Category
Sprinklers, Automatic & Open (VNIV)
Quick Response Sprinkler

Product Description
Reliable Models F1FR56 Series Sprinklers are quick response sprinklers which combine the durability of a standard sprinkler with the attractive low profile of a decorative sprinkler.

The Models F1FR56 Series Recessed automatic sprinklers utilize a 3.0 mm frangible glass bulb. These sprinklers have demonstrated response times in laboratory tests which are five to ten times faster than standard response sprinklers. This quick response enables the Model F1FR56

Upright — Pendent — Vertical Sidewall — Conventional — Horizontal Sidewall — Recessed Pendent/F1/F2 — Recessed Horizontal Sidewall

Bulletin 014 Rev. G

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MANUFACTURER'S INFORMATION (cont'd)

Model F1FR56 Quick Response Upright, Pendent & Conventional Sprinklers
Installation Wrench: Model D Sprinkler Wrench
Installation Data:

Nominal Orifice	Thread Size	Nominal K Factor		Sprinkler Height	Approval Organization	Sprinkler Identification Number (SIN)	
		US	Metric			Upright	Pendent
Standard-Upright (SSU) and pendent Deflectors Marked to Indicate Position							
½" (15mm)	½" NPT(R½)	5.6	80	2.25" (57mm)	1, 2, 3, 4	RA1425[1]	RA1414[1][2]
Conventional-Install in Upright or Pendent Position							
15mm[1]	½" NPT(R½)	5.6	80	57mm	3,4	RA1475	

[1] cULus listed corrosion resistant (Polyester coated) sprinkler.
[2] Polyester coated FM approved sprinkler.

Model F1FR56 Quick Response Recessed Pendent Sprinkler
Installation Wrench: Model GFR2 Sprinkler Wrench
Installation Data:

Nominal Orifice	Thread Size	K Factor		Sprinkler Height	Sprinkler Identification Number (SIN)
		US	Metric		
½" (15mm)	½" NPT(R½)	5.6	80	2.25" (57mm)	RA1414

[1] Refer to escutcheon data table for approvals and dimensions.

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MANUFACTURER'S INFORMATION (cont'd)

Bulletin 157 Rev. H

Reliable®

Model F3QR Quick Response Dry Sprinklers

Features
1. The Model F3QR sprinkler utilizes Belleville Spring Closure Technology. Reliable is the first in the industry to produce a Quick Response Dry Concealed sprinkler utilizing this technology.
2. Styles available
   - Pendent
   - Recessed FP Pendent
   - Recessed F1 Pendent
   - Concealed
   - Horizontal Sidewall
   - Recessed FP Horizontal Sidewall
   - Recessed F1 Horizontal Sidewall
3. 1½" (38mm) escutcheon adjustment on pendent sprinkler.
4. ½" (13mm) escutcheon adjustment on recessed sprinkler with push-on/ thread-off FP Model Escutcheon ring.
5. 3/8" (9.5mm) cover plate adjustment on concealed sprinkler with push-on/ thread-off CCP Cover Plate.
6. 3/4" (19mm) escutcheon adjustment on recessed sprinkler with F1 Escutcheon.
7. Attractive appearance. Employs 3mm frangible glass bulb and galvanized nipple.
8. Lengths available to accommodate installation dimensions from 2" - to - 48" (51mm - to - 1219mm), in ¼" (6mm) increments.
9. Available in a variety of plated and painted finishes.
10. Polyester Coated Corrosion Resistant Sprinklers.

US Patent Numbers 5,775,431 and 5,967,240.

Approvals
1. Listed by Underwriters Laboratories Inc. and UL Certified for Canada (cULus)

Style	Response	Sprinkler System Type	Hazard
Pendent, Recessed Pendent, Recessed F1 Pendent, CCP Concealed (R5714)	Quick	Wet Pipe, Dry Pipe, All Preaction	Light, Ordinary
Horizontal Sidewall, Recessed Horizontal Sidewall (R5734)	Quick	Wet Pipe, Dry Pipe, All Preaction	Light

2. Certified by FM Approvals

Style	Response	Sprinkler System Type	Hazard
Pendent, Recessed F1 Pendent (R5714)	Quick	Wet Pipe, Dry Pipe, All Preaction	Light, Ordinary, Groups 1&2
Horizontal Sidewall, Recessed F1 Horizontal Sidewall (R5734)	Quick	Wet Pipe, Dry Pipe, All Preaction	Light

3. NYC MEA 258-93-E

Pendent (See Fig. 1) — Pendent / HB (See Fig. 2) — Recessed FP Pendent (See Fig. 3) — Concealed (See Fig. 4) — Recessed F1 Pendent (See Fig. 5) — Horizontal Sidewall (See Fig. 6) — Horizontal Sidewall / HB (See Fig. 7) — Recessed FP Horizontal Sidewall (See Fig. 8) — Recessed F1 Horizontal Sidewall (See Fig. 9)

Bulletin 157 Rev. H

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MANUFACTURER'S INFORMATION (cont'd)

Model F3QR Dry Pendent Sprinkler

"A" Dim.	2" to 48" (51mm to 1219mm) in ¼" (6mm) increments

Finishes[1]

Sprinkler	Escutcheon
Bronze	Brass [3]
Chrome Plated	Chrome Plated
White Polyester [2]	White

[1] Other finishes and colors are available on special order. Consult factory for details.
[2] cULus Listed as a Corrosion Resistant sprinkler in standard Black or White.
[3] Not available for HB escutcheons.

Standard Temperature Ratings

Classification	Sprinkler Temperature Rating	Max. Ambient Temp.	Bulb Color
Ordinary	135°F (57°C)	100°F (38°C)	Orange
Ordinary	155°F (68°C)	100°F (38°C)	Red
Intermediate [1]	175°F (79°C)	150°F (66°C)	Yellow
Intermediate	200°F (93°C)	150°F (66°C)	Green
High [1]	286°F (141°C)	225°F (107°C)	Blue

Sprinkler can and escutcheon fabricated of brass for better weather resistance in exterior applications.

[1] **Listed and Certified only by cULus.**

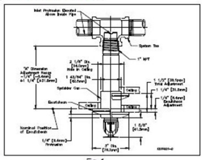

Fig. 1

Note: The sprinkler can protrudes ¼" when escutcheon is in nominal position. Escutcheon adjustment provides -¼" (-6mm) to +1¼" (+32mm) "A" dimension adjustment range.

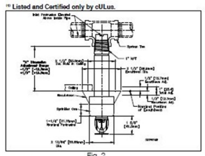

Fig. 2

Note: The sprinkler can protrudes 1¼" when escutcheon is in nominal position. Escutcheon adjustment provides -½" (-12.7mm) to +½" (+12.7mm) "A" dimension adjustment range.

Sprinkler Guard: Model C-2
Sprinkler Installation Wrench: Model G3 Sprinkler Wrench
Sprinkler Identification Number (SIN): R5714

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MANUFACTURER'S INFORMATION (cont'd)

Model F3QR Dry Horizontal Sidewall Sprinkler

"A" Dim.	2" to 48" (51mm to 1219mm) in ¼" (6mm) increments

Finishes[1]

Sprinkler	Escutcheon
Bronze	Brass [3]
Chrome Plated	Chrome Plated
White Polyester [2]	White

[1] Other finishes and colors are available on special order. Consult factory for details.
[2] cULus Listed as a Corrosion Resistant sprinkler in standard Black or White.
[3] Not available for HB escutcheons.

Standard Temperature Ratings

Classification	Sprinkler Temperature Rating	Max. Ambient Temp.	Bulb Color
Ordinary	135°F (57°C)	100°F (38°C)	Orange
Ordinary	155°F (68°C)	100°F (38°C)	Red
Intermediate [1]	175°F (79°C)	150°F (66°C)	Yellow
Intermediate	200°F (93°C)	150°F (66°C)	Green
High	286°F (141°C)	225°F (107°C)	Blue

Sprinkler can and escutcheon fabricated of brass for better weather resistance in exterior applications.

[1] **Listed and Certified only by cULus.**

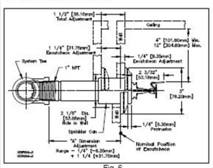

Fig. 6

Note: The sprinkler can protrudes ¼" when escutcheon is in nominal position. Escutcheon adjustment provides -¼" (-6mm) to +1¼" (+32mm) "A" dimension adjustment range.

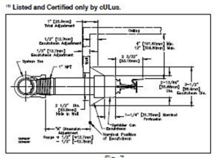

Fig. 7

Note: The sprinkler can protrudes 1¼" when escutcheon is in nominal position. Escutcheon adjustment provides -½" (-12.7mm) to +½" (+12.7mm) "A" dimension adjustment range.

Sprinkler Installation Wrench: Model G3 Sprinkler Wrench
Sprinkler Identification Number (SIN): R5734

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MANUFACTURER'S INFORMATION (cont'd)

tyco *Fire Suppression & Building Products*

Technical Services: Tel: (800) 381-9312 / Fax: (800) 791-5500
Email: techserv@tycofp.com

Series RFII — 5.6 K-factor "Royal Flush II" Concealed Pendent Sprinklers Quick & Standard Response, Standard Coverage

General Description

The Tyco® Series RFII Quick Response (3-mm bulb) and Standard Response (5-mm bulb), 5.6 K-Factor, "Royal Flush II" Concealed Pendent Sprinklers are decorative sprinklers featuring a flat cover plate designed to conceal the sprinkler. These sprinklers are optimal for architecturally sensitive areas such as hotel lobbies, office buildings, churches, and restaurants.

Each sprinkler includes a Cover Plate/Retainer Assembly and a Sprinkler/Support Cup Assembly. The separable, two-piece assembly design provides the following benefits:

- Allows installation of the sprinklers and pressure testing of the fire protection system prior to installation

The Series RFII Sprinklers are shipped with a Disposable Protective Cap. The Protective Cap is temporarily removed during installation and replaced to help protect the sprinkler during ceiling installation or finish. The tip of the Protective Cap can be used to mark the center of the ceiling hole into plaster board or ceiling tiles by gently pushing the ceiling product against the Protective Cap. When ceiling installation is complete, the Protective Cap is removed and the Cover Plate/Retainer Assembly is installed.

As an option, the Series RFII Standard Response (5-mm bulb) "Royal Flush II" Concealed Pendent Sprinklers can be fitted with a silicone Air and Dust Seal. (Refer to Figure 5.) The Air and Dust Seal is intended for sensitive areas where it is desirable to prevent air and dust from the area above the ceiling to pass through the cover plate

Sprinkler Identification Number (SIN)

TY3531 — 3 mm bulb
TY3551 — 5 mm bulb

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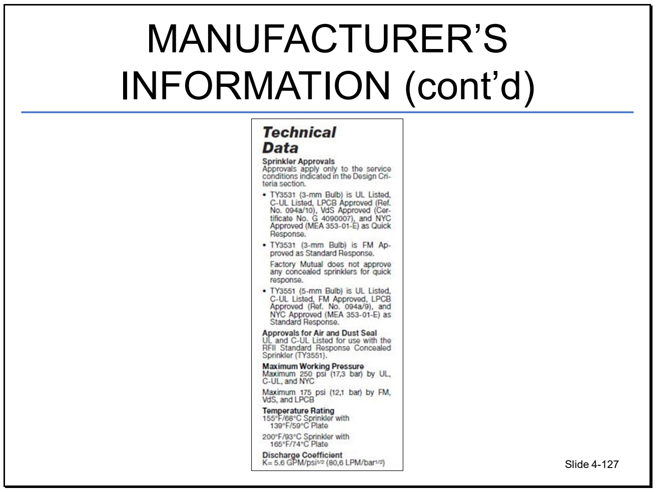

Technical Data

Sprinkler Approvals
Approvals apply only to the service conditions indicated in the Design Criteria section.

- TY3531 (3-mm Bulb) is UL Listed, C-UL Listed, LPCB Approved (Ref. No. 094a/10), VdS Approved (Certificate No. G 4090007), and NYC Approved (MEA 353-01-E) as Quick Response.
- TY3531 (3-mm Bulb) is FM Approved as Standard Response.

  Factory Mutual does not approve any concealed sprinklers for quick response.
- TY3551 (5-mm Bulb) is UL Listed, C-UL Listed, FM Approved, LPCB Approved (Ref. No. 094a/9), and NYC Approved (MEA 353-01-E) as Standard Response.

Approvals for Air and Dust Seal
UL and C-UL Listed for use with the RFII Standard Response Concealed Sprinkler (TY3551).

Maximum Working Pressure
Maximum 250 psi (17,3 bar) by UL, C-UL, and NYC

Maximum 175 psi (12,1 bar) by FM, VdS, and LPCB

Temperature Rating
155°F/68°C Sprinkler with 139°F/59°C Plate

200°F/93°C Sprinkler with 165°F/74°C Plate

Discharge Coefficient
K= 5.6 GPM/psi$^{1/2}$ (80,6 LPM/bar$^{1/2}$)

ACTIVITY 4.2

Determining Sprinkler Water Flows

Purpose

Determine the water flow from sprinklers installed in The Learning Square.

Directions

1. Use the large-print The Learning Square plans and "The Learning Square Manufacturers' Product Literature" data sheet package for this activity.

2. Given the SIN and flowing pressures, calculate the flow from each sprinkler.

3. Responses should be rounded to two decimal points.

4. At the end of the activity, the instructor will call on various students to provide their responses.

	SIN	"P" Operating pressure (psi)	Flow (gpm)
1.	R5714	15.76	
2.	TY3531		24.60
3.	RA1414	28.05	
4.	R5714		22.67
5.	RA1425	30.11	
6.	RA1414		17.41
7.	TY3531	18.30	
8.	TY3531		19.07
9.	RA1425	15.44	
10.	RA1414		25.67

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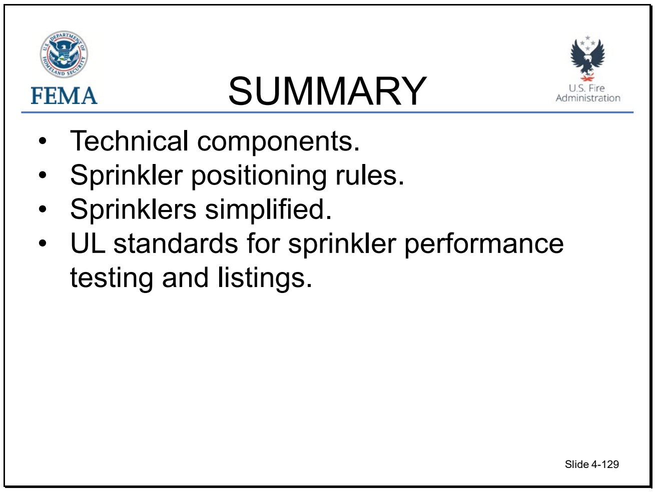
IV. SUMMARY


FEMA
SUMMARY
U.S. Fire Administration
• Technical components.
• Sprinkler positioning rules.
• Sprinklers simplified.
• UL standards for sprinkler performance testing and listings.
Slide 4-129

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APPENDIX

SUPPLEMENTAL MATERIALS

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XL CATLIN

GAPS Guidelines

GAP.14.5.0.2

A Publication of Global Asset Protection Services LLC

BACKFLOW PREVENTION FOR FIRE SERVICE MAINS

INTRODUCTION

The public expects the water supplied by public utilities to be safe to drink. Yet, there are many ways water distribution systems can become contaminated. To prevent contamination, most states and municipalities regulate the connection of private water systems to public systems.

Fire protection systems can contaminate public water supplies under some conditions. This GAPS Guideline discusses some of the potential sources of contamination presented by fire protection systems, the means available to prevent contamination of potable water systems, and the appropriate levels of backflow prevention for the hazards involved. The need to periodically inspect, test and maintain the fire protection system to ensure it is adequate and reliable is also discussed.

POSITION

Fire protection equipment should be installed and operated in a manner that will minimize the potential to contaminate potable water systems. Not all private fire protection systems require backflow prevention. Global Asset Protection Services (GAPS) recommends the level of backflow prevention installed be appropriate for the hazard presented. The following practices should be followed:

- Separate fire protection water supplies and distribution systems from potable and service water systems. Separation allows greater isolation and control of the fire protection system and eliminates most of the potential for contamination produced by hazardous cross-connections.
- Take extreme care that drains do not become potentially hazardous cross-connections. Drains should discharge directly to atmosphere (above grade) whenever possible. When drains discharge to sewers, sumps, or sanitary drainage systems, arrange the drains to prevent contamination through backsiphonage or backpressure.
- Do not introduce antifreeze or other chemicals into fire protection piping or equipment fed by potable water systems unless a suitable level of backflow prevention is provided. This includes hydrant additives used to lubricate parts or prevent freezing. Repair hydrants that do not drain or operate properly.
- Use listed backflow prevention assemblies. Since neither Underwriters Laboratories nor FM Global Research tests the ability of these devices to prevent backflow, water authorities may also require that the assemblies be approved by the Foundation for Cross-Connection Control and Hydraulic Research of the University of Southern California or the American Society of Sanitary Engineering (ASSE).
- Follow all applicable state and local regulations. In addition, provide the level of protection prescribed in AWWA M14 for both new and existing systems as modified herein.

100 Constitution Plaza, Hartford, Connecticut 06103

Installation Considerations

State or local regulations may dictate when and where backflow prevention devices are installed in the fire protection system. Normally they are located at the service connection.

When installing a backflow preventer:

- Analyze all existing water based extinguishing systems to determine if the additional friction loss created by the backflow preventer installation reduces the water flow and pressure available below that required to properly operate the fire protection system. In some systems, a minimal reduction in the available water pressure may be enough to render sprinklers ineffective. If hydrants are fed from the same system, be sure to include an adequate flow for hose streams.
- Place the backflow preventer on the discharge side of a booster pump and size the pump to make up for the friction loss of the device. NFPA 20 does not recommend installing restricting devices in the suction line of a fire pump. However, placing the device on the discharge side of the pump may require an additional backflow preventer for the jockey pump if it takes suction from the same source and discharges downstream of the fire pump backflow preventer.
- Do not locate reduced pressure zone (RPZ) devices in pits or other areas below grade. RPZ devices routinely discharge water. Providing reliable drainage below grade is difficult and if the drain from the device is submerged, a cross-connection will be created.
- Provide sufficient heat to prevent freezing and adequate drainage for semi-submerged pits or aboveground enclosures containing RPZ devices.
- Install backflow preventers only in the horizontal position unless the preventers are specifically approved for use in the vertical position. Most backflow preventers may only be installed in the horizontal position.
- Install backflow preventers so that they are accessible. Provide sufficient clearance around them for maintenance and testing.
- Do not modify backflow preventers. Substituting shutoff valves, test cocks or other components of backflow preventers may void their approval, even if the replacement components are listed.
- Consider other ways to prevent backflow. When installing a backflow preventer on systems using antifreeze, it may be possible to install dry pendent sprinklers or convert the antifreeze system to a dry system and eliminate the backflow preventer. If this is not feasible, place the backflow preventer at the point where an antifreeze (or foam) system connects to the remainder of the sprinkler or fire protection system. These methods minimize the effects a backflow preventer would have on the fire protection system.

Maintenance and Testing

Backflow preventers require routine testing and maintenance if they are to perform properly. Test personnel are required to be certified in most jurisdictions, therefore, detailed testing procedures will not be discussed here, but can be found in AWWA M14. Testing normally involves the following:

- An operational test of the pressure differential relief valve (RPZ only).
- A test of the second check valve for tightness under conditions of reverse flow.
- A test of the first check valve for tightness under conditions of reverse flow.

The above tests do not evaluate the performance of the backflow preventer under actual fire conditions. A backflow preventer could pass the above tests with the check valves stuck in the closed position. Therefore, GAPS recommends performing the following additional tests and maintenance procedures:

- Conduct a flow test representative of the anticipated fire demands, annually. Record the friction loss across the backflow preventer. Increases in the normal friction loss should be investigated and the cause corrected.

- Maintain backflow preventers according to the manufacturers' instructions. Many devices have screens or strainers that must be cleaned regularly.
- Perform an internal examination of all backflow preventers at least every five years. One of the most common causes of excessive friction loss is foreign material buildup above the check valves and around the springs. This buildup can prevent the devices from opening fully.

AWWA M14

AWWA M14 classifies industrial fire protection systems into six groups (Figure 1) based on the water sources available and the arrangement of the supplies. The following classifications and protection recommendations have been reprinted from Chapter 6 of Recommended Practice for Backflow Prevention and Cross-Connection Control, AWWA M14, by permission. Copyright 1990, American Waterworks Association.

Class 1 Direct connections from public water mains only; no pumps, tanks, or reservoirs; no antifreeze or additives of any kind; all sprinkler drains discharge to atmosphere, dry wells, or other safe outlets.

Class 2 Same as Class 1 except that booster pumps are installed in the connections from the street mains (booster pumps do not affect the potability of the system). To avoid drawing too much water from the main, it is necessary that pressure in the water main is not reduced below 10 psi (0.7 bar).

Class 3 Direct connections from public water supply mains, plus one or more of the following: elevated storage tanks; fire pumps taking suction from aboveground covered reservoirs, or tanks; and pressure tanks. (All storage facilities are filled or connected to public water only, the water in the tanks are to be maintained in a potable condition. Otherwise, Class 3 systems are the same as Class 1.)

Class 4 Directly supplied from public mains, similar to Class 1 and Class 2, with an auxiliary water supply dedicated to fire department use and available to the premises, such as an auxiliary supply located within 1700 ft (518 m) of the pumper connection.

Class 5 Directly supplied from public mains and interconnected with auxiliary supplies, such as pumps taking suction from reservoirs exposed to contamination, or rivers and ponds; driven wells; mills or other industrial water systems; or where antifreeze or other additives are used.

Class 6 Combined industrial and fire protection systems supplied from the public mains only, with or without gravity storage or pumps suction tanks."

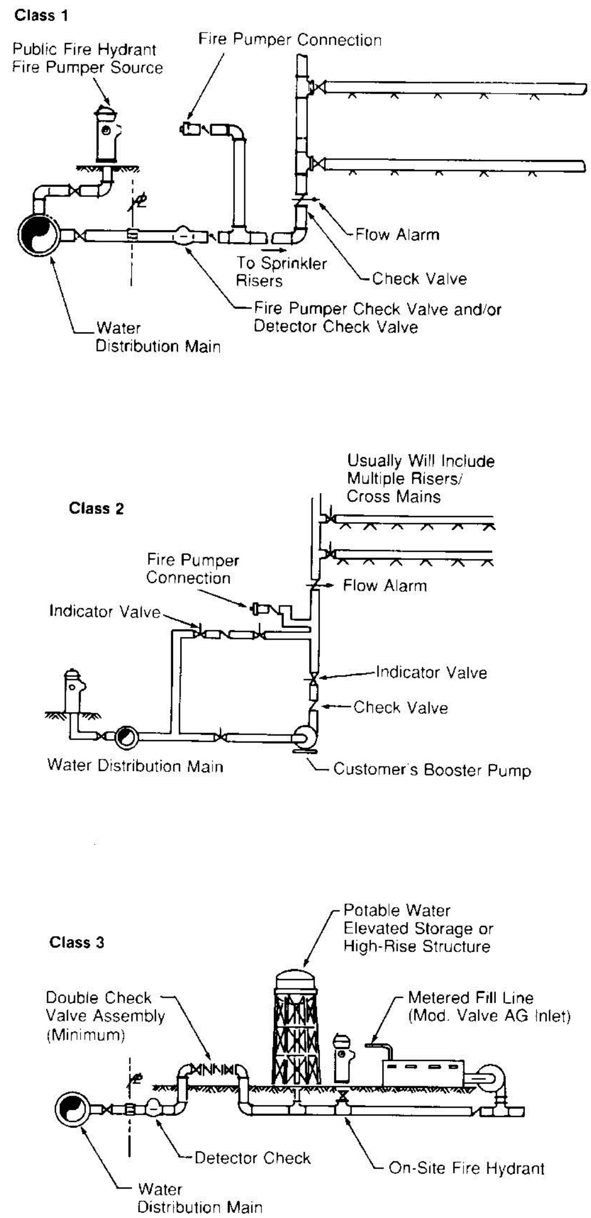
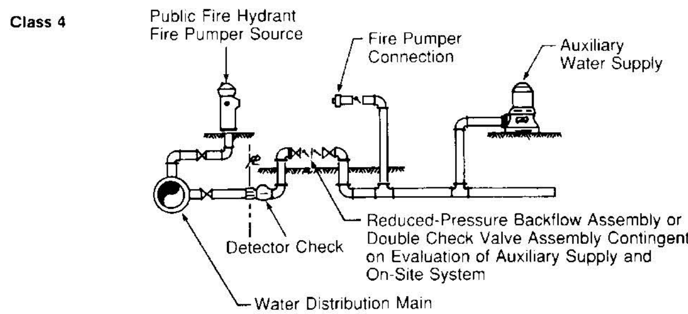
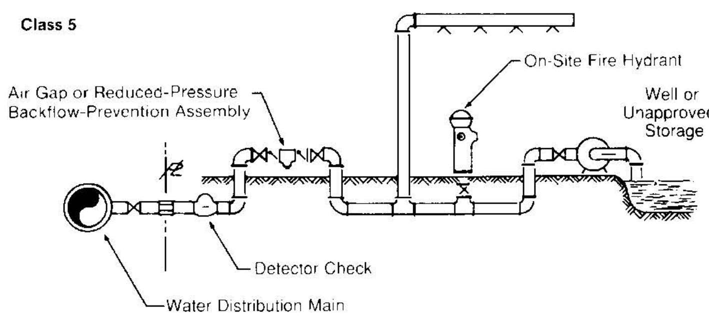


Figure 1. AWWA Classification Of Fire Protection Systems.

NOTE: Figures 1-4 do not show the use of indication control valves and all of the accessories that are typically found in fire protection systems. (See References[2])





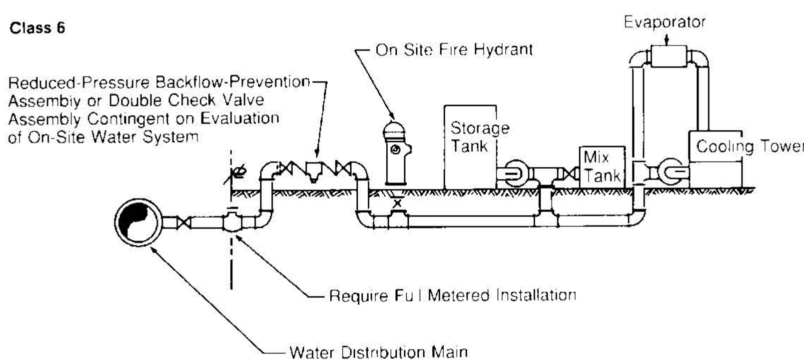


Figure 1. (Cont'd.) AWWA Classification Of Fire Protection Systems.

According to M14, Class 1 and Class 2 systems generally do not require a backflow prevention assembly. The existence of a fire department connection is not cause for concern unless there is a readily available source of nonpotable water that could be introduced into the system through the connection. AWWA M14 does recognize that there are special circumstances that may require protection for Class 1 or 2 systems. These include:

- "underground fire sprinkler pipelines parallel to and within 10 ft (3 m) horizontally of sewer pipelines or other pipelines carrying significantly toxic materials;
- "when water is supplied to a site or an area from two or more services of a water utility or two different water utilities, flow problems should be evaluated;
- "occupancies (or changes in occupancies) that involve the use, storage or handling of types and quantities of materials in a manner that could present a significant health hazard to the domestic supply;
- "premises with unusually complex piping systems (usually these premises will have an approved backflow-prevention assembly on their domestic service piping); and
- "systems with pumper connections in which corrosion inhibitors or other chemicals are added to tanks of fire trucks, or where the water purveyor cannot be assured of the potability of the input to the pumper connection.

"Class 3 systems will generally require minimum protection (approved double check valve assembly) to prevent stagnant waters from backflowing into the public potable water system.

"Class 4 systems will normally require backflow prevention at the service connection. The type (air gap, reduced-pressure backflow-prevention assembly, or double check valve assembly) will generally depend on the quality of the auxiliary supply.

"Class 4 and 5 systems normally would need maximum protection (air gap or reduced-pressure backflow-prevention assembly) to protect the public potable water system.

"Class 6 system protection would depend on the requirements of both industry and fire protection and can only be determined by a survey of the premises.

"A meter (compound or detector check) should not normally be permitted as part of a backflow-prevention assembly. However, an exception can be made if the meter and backflow prevention assembly are specifically designed for that purpose.

"At any time where the fire sprinkler system piping is not an acceptable potable water system material, there shall be a backflow-prevention assembly isolating the fire sprinkler system from the potable water system. There are also chemicals, such as liquid foam concentrates used for fighting certain types of fires, that are toxic and, therefore, require maximum protection.

"Note: Where backflow protection is required on an industrial-domestic service that is located on the same premises, backflow protection should be provided on the fire service connection. The industrial-domestic system and fire system in Classes 3, 4, 5, and 6 should have adequate protection for the highest degree of hazard affecting either system."

Application of the AWWA M14 Guidelines

GAPS recommends that reason and logic be used when applying the above guidelines. For example, a pond, open reservoir, or other "auxiliary source" located within 1700 ft (518 m) of a fire department connection may not need backflow prevention if the source is not accessible to the fire department, is not large enough to be of value, or would not be used even under emergency conditions.

Some jurisdictions no longer consider the black steel pipe used in many sprinkler systems as suitable for potable water service. Therefore, the water in a sprinkler system may be classified as nonpotable. The water may have increased turbidity (suspended matter), and a high concentration of dissolved metals, but these conditions are not usually considered a major health hazard. GAPS disagrees with the AWWA M14 recommendation to install a backflow preventer simply because of the hazard posed by black steel pipe, unless the preventer is required by the local jurisdiction.

When a booster pump is installed (Class 2 system) AWWA M14 cautions against reducing the suction pressure below 10 psi (0.7 bar). GAPS agrees with the caution, but recommends that the water supply be capable of providing 200% of the pump rated capacity at 20 psi (1.4 bar), not 10 psi (0.7 bar).

Finally, when the fire protection system is separated from all potable and industrial water systems as recommended by GAPS, the level of backflow prevention should be consistent with the hazards posed by the fire protection system as classified by AWWA M14. GAPS does not believe the level of protection for the fire protection system must be the same as that required by the industrial service water system, unless state or local authorities so stipulate.

DISCUSSION

Potential Sources Of Contamination

Under normal circumstances, the water in a sprinkler system does not pose a significant health threat. The National Fire Sprinkler Association (NFSA) in its publication, "Backflow Prevention for Fire Sprinkler Systems" discloses eight independent studies of fire systems. None of these reported a health threat. Contamination of the water in a fire protection system normally occurs by connecting to nonpotable auxiliary sources or introducing toxic chemicals to the system.

Antifreeze systems installed in accordance with NFPA 13 use antifreeze solutions that do not pose a health threat. However, most authorities will require backflow prevention for these systems, because toxic antifreeze solutions are available and may be used to maintain the systems.

Foam or other chemical additives are sometimes used for fire fighting. Foam is commonly used to protect areas handling flammable or combustible liquids. Since fire fighting foams represent a health hazard, they require backflow prevention when the fire protection system is connected to a potable water source.

Chemicals can also be added to fire protection systems when maintenance is performed. Corrosion inhibitors may be added to tanks or fire department pumpers. Maintenance and fire department personnel must be aware of the potential effects these practices have on system potability.

Lubricants and antifreeze solutions have been added to hydrant barrels to make them easier to operate or to prevent hydrants that do not drain properly from freezing. Such practices should not be condoned. Hydrants without drains should be marked and pumped out after each use. Hydrants with plugged drains should be repaired, or marked as having no drains and pumped out after each use. Hydrants that do not operate properly should be repaired.

Fire Department Connections

As previously noted, AWWA M14 does not recommend backflow prevention solely because there is a fire department connection. There has been considerable debate regarding need for backflow prevention when a fire department connection exists.

Some jurisdictions may require backflow protection if a pond or other nonpotable source exists, even though the source is not "dedicated for fire department use." Jurisdictions assume the fire department will use the water if they need it.

Protection may also be required if the fire department routinely or occasionally uses chemicals in its pumper trucks. Contamination is not likely during a fire, because the water will flow away from the connection toward the fire.

Backpressure and Backsiphonage

There are two ways water systems typically become contaminated other than direct contamination from chemical introduction. Backpressure and backsiphonage can reverse the flow in a water system (backflow).

Backpressure occurs when the system operates at a higher pressure than the potable supply. This could be caused by a pump, elevated tank or other source of pressure acting on the system. The higher pressure forces the water in the direction of the lower pressure potable water system.

Backsiphonage is caused by a negative or reduced pressure in a potable supply line. It can occur any time the pressure in the supply line drops below that in the fire protection system, as would occur with a high rate of water usage in the public water system.

Types of Backflow Prevention Devices

Fire protection systems are typically separated from a potable water supply by at least a single check valve. Often double check valves or detector check valves are used. These valves allow a higher pressure to be maintained in the fire protection system.

A single check valve has never been considered to be a backflow prevention device. Even when check valves with resilient faces are used, the valves can leak and allow nonpotable water to enter and contaminate a potable water system.

Backflow prevention for fire systems is usually provided at the public water connection. Sometimes, it is located at the source of contamination, such as the connection of an antifreeze or foam system.

Three types of devices are normally used for backflow prevention: the air gap (AG), the double check valve assembly (DCV), and the reduced pressure zone or reduced pressure principle backflow-prevention assembly (RPZ or RPBA).

Air Gap: An air gap (Figure 2) provides an open space between the supply pipe and the system to physically separate the systems and prevent contamination. The vertical separation must be twice the diameter of the supply pipe and at least 1 in. (25.4 mm) long.

Air gaps are not common on fire protection water supply systems. They may be provided on fill lines for pump suction tanks or on break tanks that supply fire pumps in jurisdictions where booster pumps are not allowed. Air gaps are also provided on 2½ in. (65 mm) main drain lines in some jurisdictions.

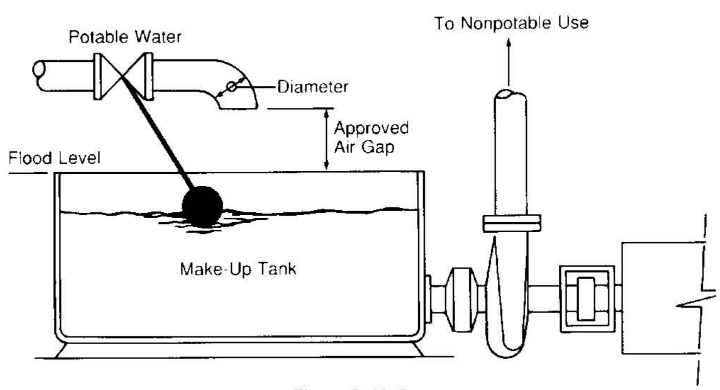


Figure 2. Air Gap.

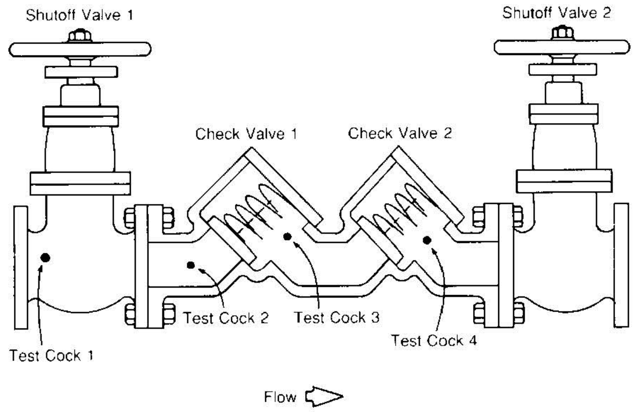


Figure 3. Double Check Valve Assembly.

Double Check Valve Assemblies: Double check valve assemblies (Figure 3) consist of two spring loaded-check valves. The assembly will also have a shutoff valve on either end and petcocks for leak testing. All of the seats will have a covering of rubber or other resilient material to ensure tightness. Note that two single check valves installed in series do not constitute a double check valve assembly. Double check valve assemblies are used only to protect against minimal exposures where contamination is objectionable (odors, color) but no health hazard exists.

Double check valve assemblies are the most desirable backflow prevention devices from a fire protection standpoint. The friction loss of a DCVA is normally 4 psi – 6 psi (0.3 bar – 0.4 bar), much less than an RPZ device.

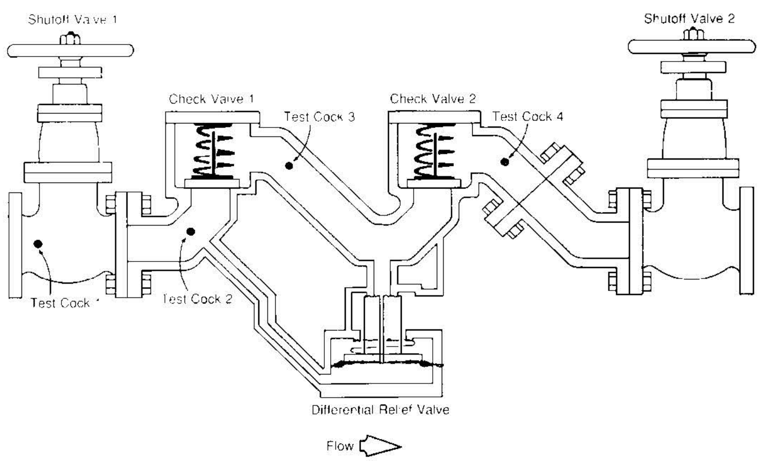


Figure 4. Reduced Pressure Zone Backflow Preventer.

Reduced Pressure Zone Backflow Preventer: The RPZ device (Figure 4) is similar to the double check valve assembly, except a pressure differential relief valve maintains a lower pressure in the chamber between the two check valves, than the pressure that exists on the supply side of the device.

A pressure differential of 2 psi – 5 psi (0.14 bar – 0.35 bar) is normally maintained between the intermediate chamber and the supply. When this differential is not maintained, the relief valve opens up and discharges as much water as necessary from the chamber to maintain the differential. If either check valve fails open, large quantities of water can be discharged through the relief valve. There is typically an additional 2 psi – 5 psi (0.14 bar – 0.35 bar) loss across the second check valve.

The RPZ device is the least desirable from a fire protection standpoint. Friction loss is high, typically 10 psi (0.7 bar) or greater at rated flow, and the water discharged from these devices results in installation problems. However, an RPZ device does offer excellent backflow protection when properly maintained.

POTTER®

Memorandum

Date: 11/24/03

Subject: Friction Loss Waterflow Switches

The May 2002 edition of NFPA 13, 14.4.4.5 (1) requires that the friction loss across vane type waterflow switches 2 inches and smaller be included in the fire sprinkler hydraulic calculations. As each community, County, State or local AHJ adopts this standard we can expect to receive telephone calls related to this topic. Our products are manufactured and tested to UL Standard 346.

UL 346

33. Hydraulic Friction Loss Test

"33.1 The head loss due to hydraulic friction in a waterflow indicator of a pipe size of 4 inches or less shall not exceed 3 psig (20.7 kPa) at a flow rate that will result in a velocity of 15 feet per second (4.6m/s) in the full-size pipe connection to a valve. For a size exceeding 4 inches, the head loss shall not exceed 1 psig (6.9 kPa) at the given flow rate."

In summary, when Potter is asked about friction loss across a vane type waterflow switch our answer is 3 psig for waterflow switches 4" through 1" and 1 psig for waterflow switches 5" through 10". This response is consistent with the requirements of NFPA 13, 14.4.3.1.1 "Table 14.4.3.1.1 shall be used to determine the equivalent length of pipe for fittings and devices unless manufacturers test data indicate that other factors are appropriate."

This memorandum is not confidential and may be distributed as needed.

Thanks,

Mike Cabral

Mike Cabral
Product Manager - Sprinkler
Potter Electric Signal Company
2081 Craig Road
St Louis, MO 63146
Phone 800-325-3936

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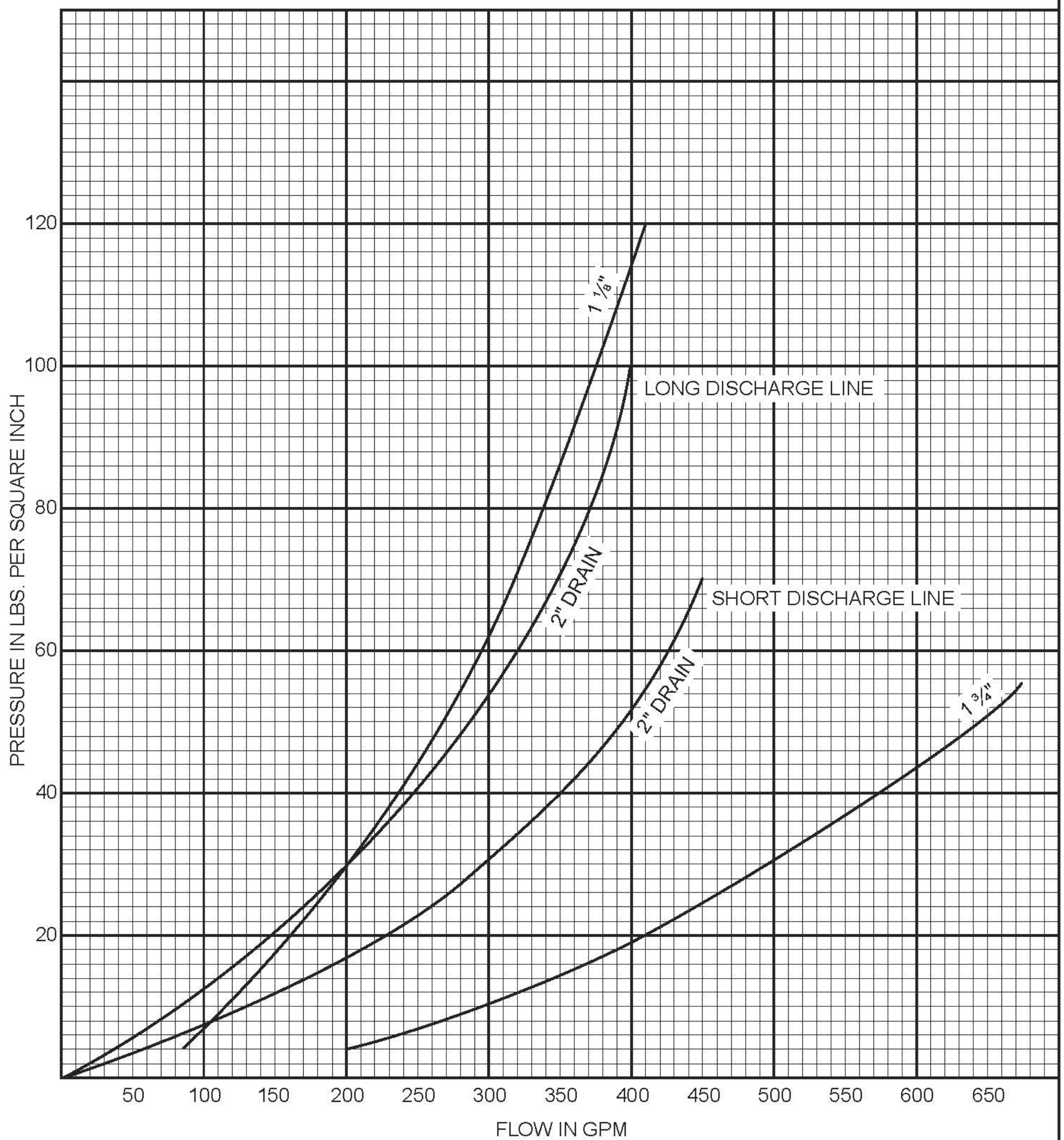
DISCHARGE CURVES FOR SMALL ORIFICES AND TWO INCH DRAINS



USE RESIDUAL PRESSURE FOR TWO INCH DRAINS–USE PITOT PRESSURE FOR NOZZLES

NOTE: Curves for the two inch drains have already taken into account the usual number of elbows or fittings in a two inch drain line. Long discharge line curve is to be used for two inch drain lines over 20 feet long. Length to be measured from the discharge side of the two inch drain valve. Do not extrapolate or extend curves.

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Sprinkler Identification Numbers

All sprinklers are required to have a Sprinkler Identification Number (SIN). The SIN is comprised of one or two letters followed by three or four numbers. The requirement for this SIN is found in NFPA 13, Installation of Automatic Sprinklers, as well as UL and FM sprinkler product standards. This requirement was implemented as of January 1, 2001. Therefore, sprinklers manufactured prior to 2001 may not have this mark on them.

The goal behind the use of the SIN is to ensure proper use of the sprinklers in the field. Specifiers, design engineers, and layout technicians can check the proposed use of a sprinkler against its capabilities. In addition, the SIN can be used after a system has been installed to assist inspectors in determining if a system is adequate. On a long term basis the SIN can help with proper replacement sprinklers when they are necessary. Previously, sprinkler markings were not especially helpful to anyone trying to identify the type of sprinkler with which they were dealing.

The original concept of the SIN was to create a unified model numbering system to assist the end user and authorities with easy identification in the field. However, this was soon realized to be impractical. The vast number of variations and the fact that the same product could have different classifications from different laboratories prohibited this concept from proceeding.

Every change in orifice size, response classification, distribution characteristic, and maximum working pressure must be identified by a separate model number. This system has not been established to create uniformity of model numbers among the manufacturers. For example, Model AB120 could be one manufacturer's standard response K-5.6 (K-80 metric) upright spray sprinkler, while Model BC120 could be another manufacturer's K-14 (K-200 metric) pendent ESFR.

The letters in the SIN represent the manufacturer of the sprinkler. Their one or two letter code must be registered with the International Fire Sprinkler Association at www.sprinklerworld.org. Each manufacturer is permitted a maximum of two different letter designations. However, there are also limitations on the possible letter combinations. First, the letters are limited to the English alphabet. Also, there is a list of letter(s) (shown in the table below) that are prohibited due to conflicts with established acronyms relative to the fire sprinkler industry (such as laboratories, K-factors, sprinkler orientations or hazards).

The three or four numbers are the model numbers and are set by the manufacturer themselves. Some manufacturers use each digit to represent a characteristic of the sprinkler, while others use it strictly as a cataloging number.

References:

NFPA 13, Installation of Automatic Sprinklers, 2007 Edition. National Fire Protection Association, Quincy, MA.

UL 199, Automatic Sprinklers for Fire-Protection Service, 11th Edition. Underwriters Laboratories, Northbrook, IL.

FM Class 2000 Approval Standard, March 2006. FM Approvals LLC, Norwood, MA.
Fleming, Russell P. "Identifying Sprinklers" NFPA Journal, Jan/Feb 2001, National Fire Protection Association, Quincy, MA.

Omitted Character	Reasons
CE	European Community product approval marking
D	
EC	ISO acronym for Extended Coverage sprinklers
EH	Could be confused with Extra Hazard occupancy classification
FM	Acronym for Factory Mutual
FR	ISO acronym for Fast Response
HS	Could be confused with Horizontal Sidewall sprinkler
I	Could be confused with the number "1"
IF	
II	Could be confused with numbers
IR	ISO acronym for Special (Intermediate) Response sprinklers
K	"K" followed by numbers could be confused with the sprinkler K-factor
LH	Could be confused with Light Hazard occupancy classification
O	Could be confused with the number "0"
OH	Could be confused with Ordinary Hazard occupancy classification
OO	ISO Acronym for on/off sprinklers or could be confused with numbers
P	Could be confused with Pendent orientation
QR	Acronym for Quick Response
SK	
SP	ISO acronym for Spray Pendent sprinkler
SR	Acronym for Standard Response
SU	ISO acronym for Spray Upright sprinkler
SW	Could be confused with the Sidewall orientation
U	Could be confused with the Upright orientation
UL	Acronym for Underwriters Laboratories
W	ISO acronym for Sidewall sprinkler
WH	ISO acronym for Sidewall Horizontal sprinkler
WP	ISO acronym for Sidewall Pendent sprinkler
WU	ISO acronym for Sidewall Upright sprinkler
2^{nd} Character "I" or "O"	As the number of digits in a SIN can range from 4 to 6 the second digit could be either a letter or a number. In order to later determine, with ease, if the second digit is a "1" versus an "I" or a "0" versus an "O", character designations will no longer be issued with the second character of "I" or "O" (effective August 2007).

UNIT 5:
FIRE SPRINKLER SYSTEM LAYOUT

TERMINAL OBJECTIVE

The students will be able to:

5.1 Verify that sprinkler spacing and installation are in compliance with nationally recognized standards given fire protection system plans.

ENABLING OBJECTIVES

The students will be able to:

5.1 Conclude if the design of the sprinkler system provides compliant coverage for all areas as required.

5.2 Determine if the spacing of the sprinklers is compliant.

5.3 Evaluate proposed sprinklers for application suitability.

5.4 Evaluate sprinkler positioning with respect to construction configuration.

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FEMA

U.S. Fire Administration

UNIT 5: FIRE SPRINKLER SYSTEM LAYOUT

Slide 5-1

TERMINAL OBJECTIVE

Verify that sprinkler spacing and installation are in compliance with nationally recognized standards given fire protection system plans.

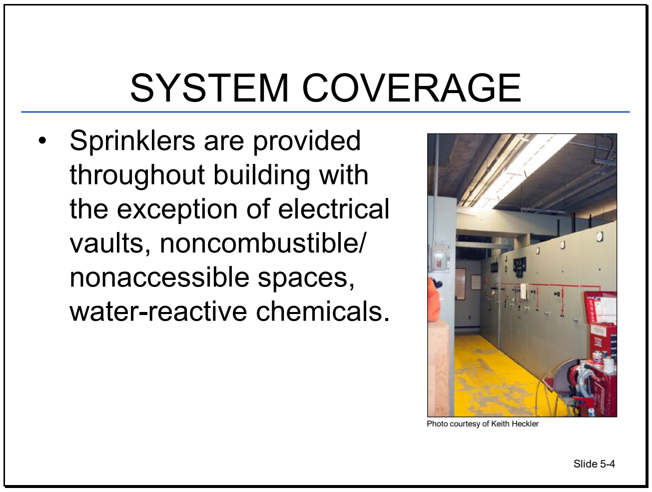
Slide 5-2

ENABLING OBJECTIVES

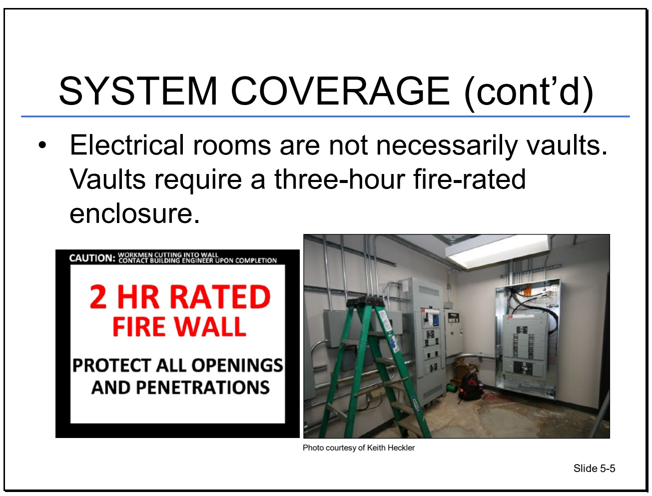
- Conclude if the design of the sprinkler system provides compliant coverage for all areas as required.
- Determine if the spacing of the sprinklers is compliant.
- Evaluate proposed sprinklers for application suitability.
- Evaluate sprinkler positioning with respect to construction configuration.

Slide 5-3

I. SYSTEM COVERAGE



A. Sprinklers are provided throughout the building, except for electrical vaults, noncombustible/nonaccessible spaces and water-reactive chemicals.



B. Electrical rooms are not necessarily vaults. Vaults require a three-hour fire-rated enclosure.

C. According to the *National Electrical Code*® (National Fire Protection Association (NFPA) 70), an electrical room for equipment exceeding 1,000 volts and surrounded by three-hour fire-rated construction is considered a "vault" and will qualify to eliminate sprinklers from the room (NFPA, 2017).

SYSTEM COVERAGE (cont'd)

- Areas above acoustical ceiling tiles (ACTs) with noncombustible surfaces can have sprinklers eliminated.

Photo courtesy of Keith Heckler

Slide 5-6

D. Sprinklers may be omitted from noncombustible spaces above acoustical ceiling tiles (ACTs) with noncombustible surfaces.

II. CONSTRUCTION INFLUENCES

CONSTRUCTION TYPES

- Combustible.
- Noncombustible.
- Limited combustible.
- Obstructed.
- Unobstructed.

Photos courtesy of Integra Code Consultants

Slide 5-7

A. Construction types.

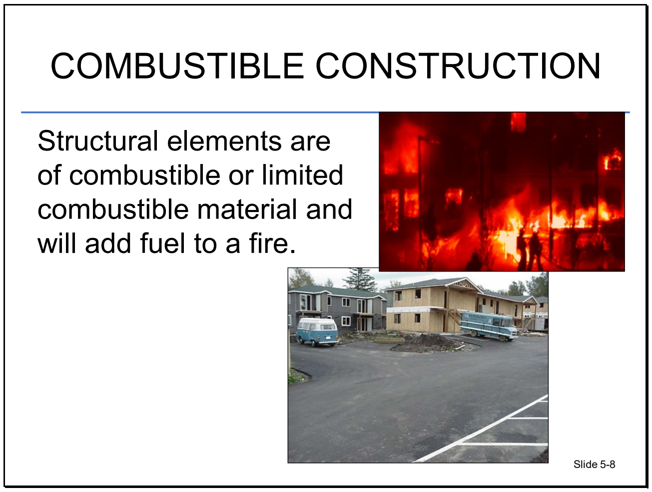
1. Combustible.

2. Noncombustible.

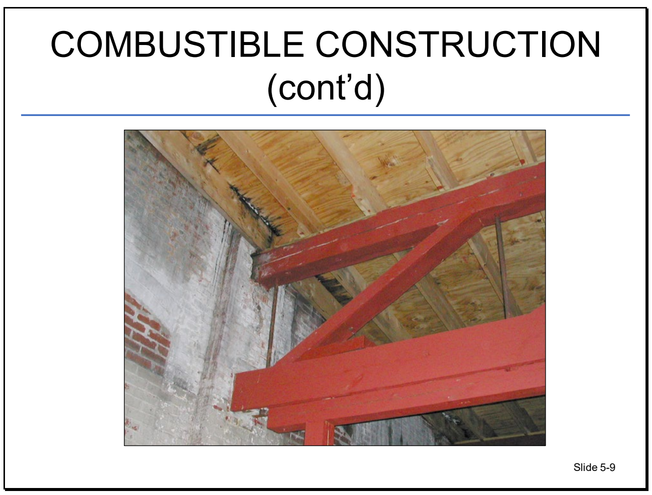
3. Limited combustible.

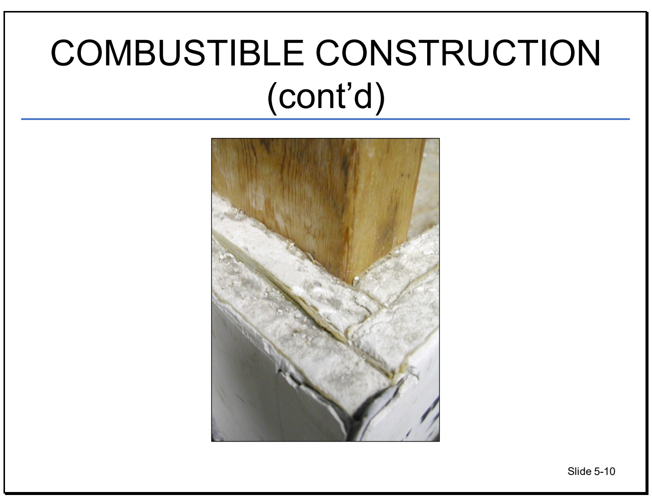
4. Obstructed.

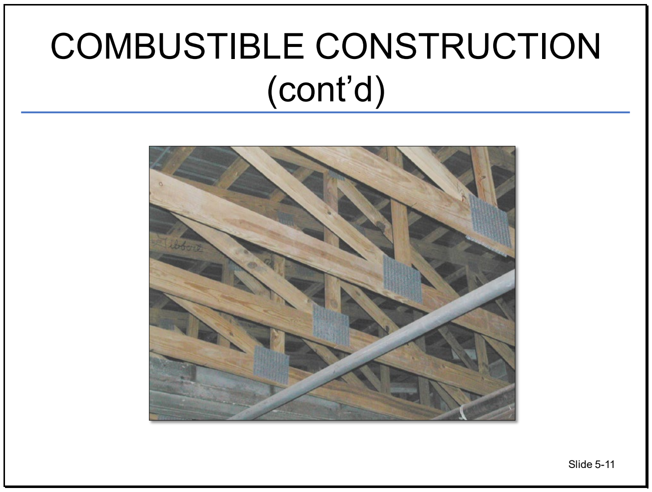
5. Unobstructed.

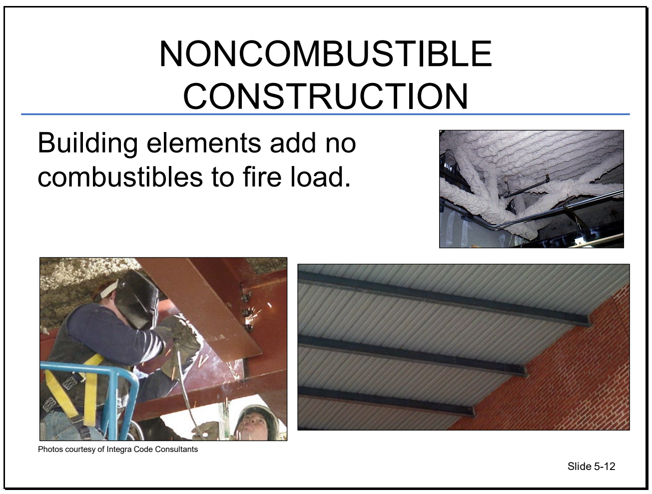


B. Combustible construction: Structural elements are of combustible or limited combustible material and will add fuel to a fire.



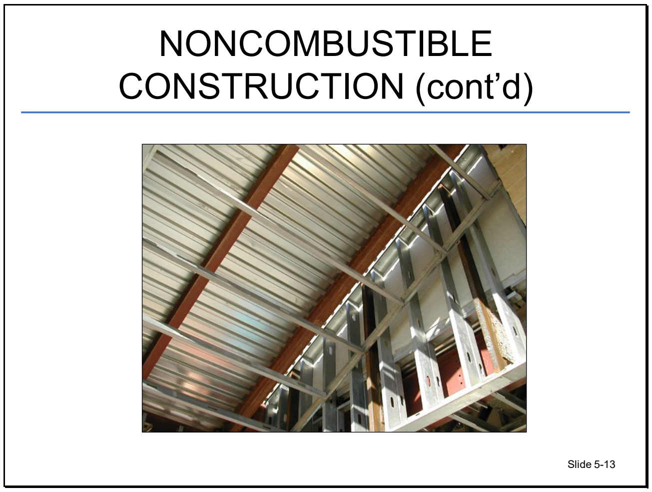






C. Noncombustible construction.

1. Structural components are defined by meeting the requirements of ASTM E136, *Standard Test Method for Assessing Combustibility of Materials Using a Vertical Tube Furnace at 750°C*. Noncombustible members are not subject to burning. Therefore, the structural members do not add to the fuel loading that occupies the structure.



2. Steel I-beams and open web joists are common noncombustible components.

ACTIVITY 5.1

Building Construction

Purpose

Determine if the building is considered combustible or noncombustible construction.

Direction

In your table group, view a series of images of construction and determine if each image indicates combustible or noncombustible construction.

Suggested responses:

- Image 1: ____________________
- Image 2: ____________________
- Image 3: ____________________
- Image 4: ____________________
- Image 5: ____________________
- Image 6: ____________________
- Image 7: ____________________

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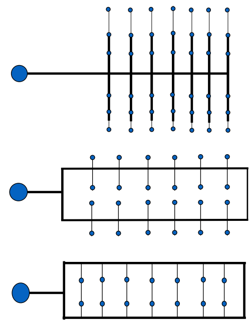
III. PIPING ARRANGEMENTS

A. The piping network is paramount to feeding the water from the source to the sprinklers. Different arrangements can be provided to disperse the water through different channels.

COMMON SYSTEM LAYOUTS

- Tree.
- Loop.
- Grid.



Slide 5-23

B. Common system layouts.

1. Tree (wet, dry, preaction, deluge).
2. Loop (wet, dry, preaction, deluge).
3. Grid (wet, preaction, deluge).

C. Designers have the option to choose which arrangement is the most economical yet adequate to provide adequate pressure and flow to sprinklers.

AREA LIMITATION FOR SPRINKLER SYSTEMS

Area limitation for sprinkler systems	
Hazard classification	Maximum area per riser (ft^2)
Light Hazard	52,000
Ordinary Hazard	52,000
Extra Hazard	
Pipe schedule	25,000
Hydraulic	40,000
Storage	40,000

Slide 5-24

D. Area limitation for sprinkler systems (maximum area per riser).

1. Light Hazard: 52,000 square feet.

2. Ordinary Hazard: 52,000 square feet.

3. Extra Hazard.

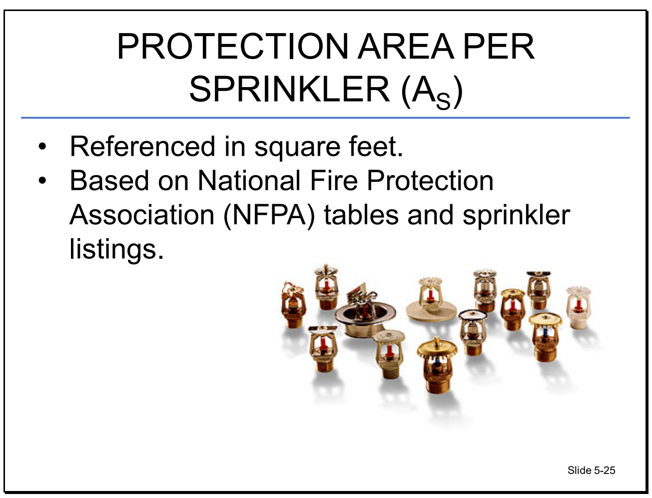
   a. Pipe schedule: 25,000 square feet.

   b. Hydraulic: 40,000 square feet.

4. Storage: 40,000 square feet.

IV. SPRINKLER SPACING RULES

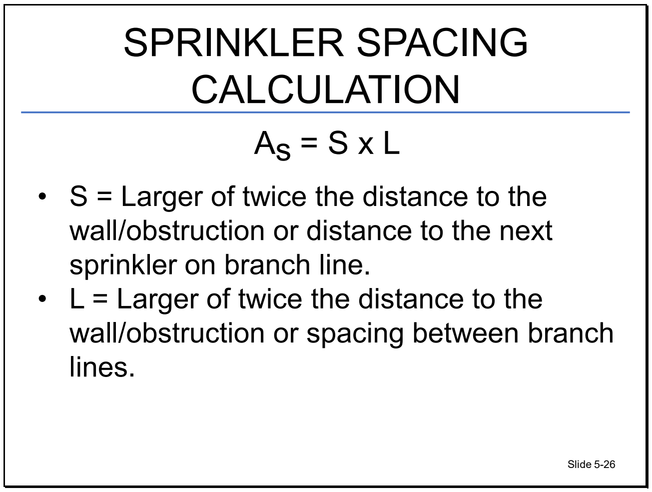
A. Sprinklers have limits for their installation based upon the hazard and construction. Also, there are special sprinklers with deflector arrangements that provide extended coverages.



B. Protection area per sprinkler (A_s).

1. Referenced in square feet.

2. Based on NFPA tables and sprinkler listings.

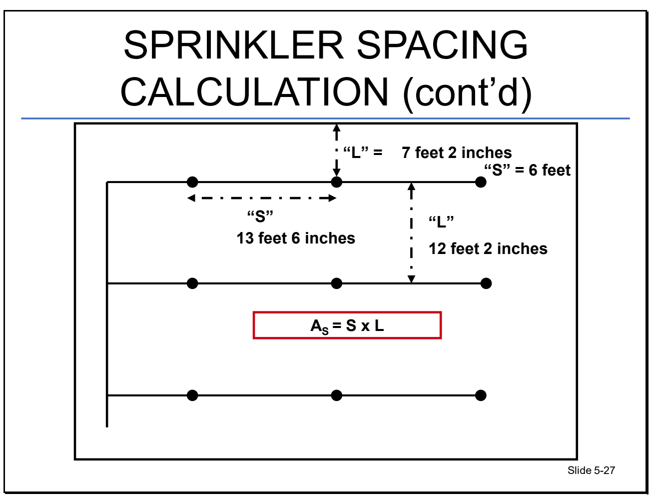


C. Sprinkler spacing calculation.

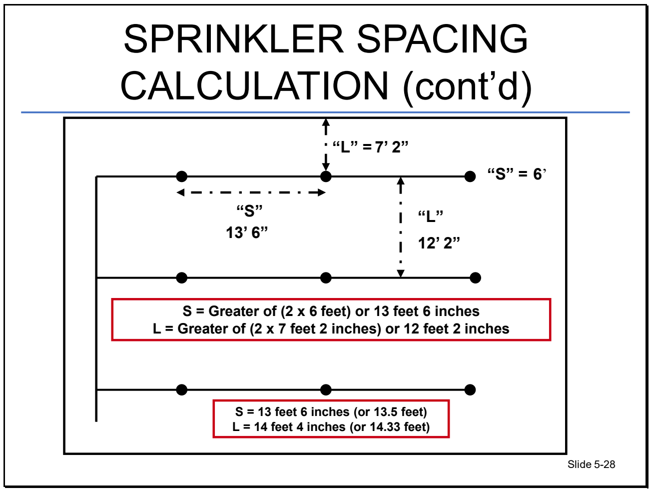
1. Determine $A_s = S \times L$.

   a. S = Larger of twice the distance to the wall/obstruction or distance to the next sprinkler on the branch line.

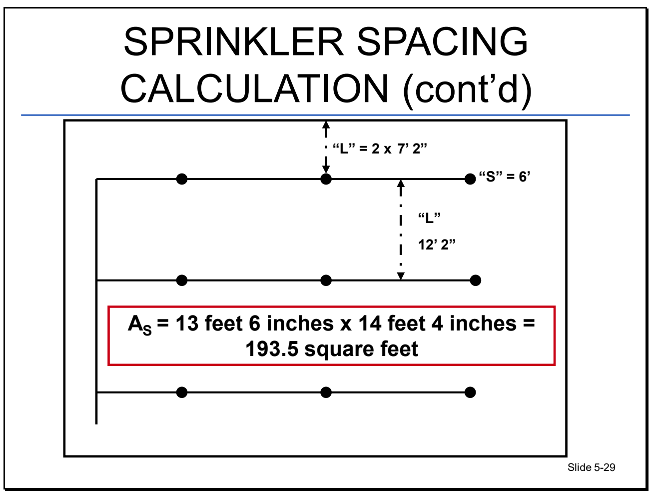
   b. L = Larger of twice the distance to the wall/obstruction or spacing between branch lines.



2. This layout is intended to express how the spacing is calculated for sprinklers. The measurements between the sprinklers and to the wall are shown.



3. This layout indicates how to perform the calculations and determine the larger of the spacing.



4. The final calculation for spacing is shown on this layout.

ACTIVITY 5.2

Verify Sprinkler Spacing

Purpose

Practice measuring sprinkler spacing between sprinklers and to adjacent walls.

Direction

Use your large-print The Learning Square plans to measure the sprinklers in the remote areas for the largest area.

1. Using your scale (1/8 inch equals 1 foot), determine the spacing of sprinklers in the restaurant. What was the maximum area calculated per sprinkler?

   ____

   ____

2. Using your scale (1/8 inch equals 1 foot), determine the spacing of sprinklers in the retail space. What was the maximum area calculated per sprinkler?

   ____

   ____

3. Using your scale (1/8 inch equals 1 foot), determine the spacing of sprinklers in Retail A-2. What was the maximum area calculated per sprinkler?

   ____

   ____

4. Using your scale (1/8 inch equals 1 foot), determine the spacing of sprinklers in the exterior covered storage. What was the maximum area calculated per sprinkler?

   ____

   ____

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V. SPRINKLER DISCHARGE OBSTRUCTIONS

A. There are physical arrangements that prevent the water from a sprinkler reaching the seat of the fire.

B. This section will address the situations that will be encountered during plans review. It is important to know these requirements because the result may warrant more sprinklers, specific arrangement of sprinklers or that it is acceptable as designed.

EVALUATION CONSIDERATIONS

Pay particular attention to:

- Sprinkler type.
- Occupancy classification.

Slide 5-31

C. Evaluation considerations.

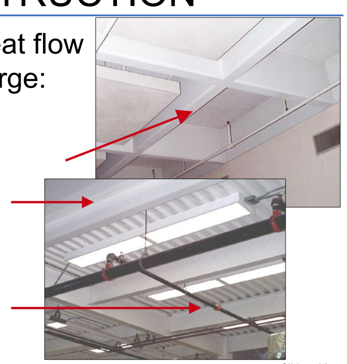
Pay particular attention to:

1. Sprinkler type.

2. Occupancy classification.

OBSTRUCTION CONSTRUCTION

- Design affects heat flow and water discharge:
  - Panel.
  - Beams.
  - Trusses.
  - Girders.
  - Wood joist/TJI®.



Slide 5-32

D. Obstruction construction.

1. Design affects heat flow and water discharge:

   a. Panel.

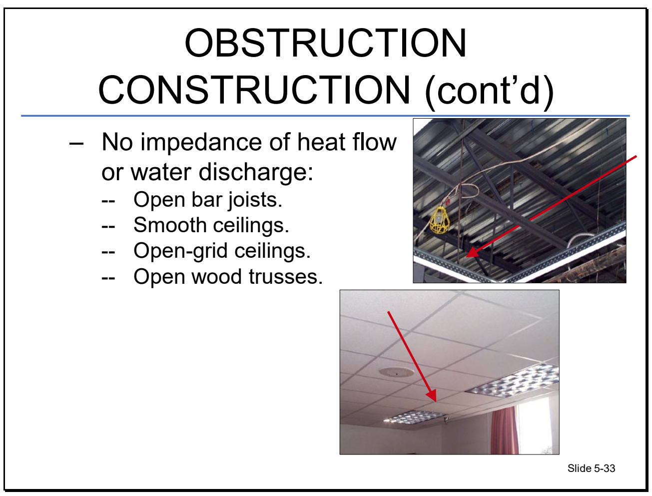
   b. Beams.

   c. Trusses.

   d. Girders.

   e. Wood joist.

   f. Engineered wood I-joist/TJI® joist.



2. No heat flow or water discharge impedance:

   a. Open bar joists.

   b. Smooth ceilings.

   c. Open-grid ceilings.

   d. Open wood trusses.

3. Openings in these components allow the heat to expand and spread, plus any water discharge spray pattern will not be disrupted.

MAXIMUM DEFLECTOR DIFFERENCE FROM CEILING/ROOF DECK

Construction type	Maximum deflector difference from ceiling/roof deck
Unobstructed	12 inches.
Obstructed	1 to 6 inches below structural members, maximum 22 inches to deck.
	12 inches below ceiling/roof deck when installed in bays.
	Variable above bottom of structural members to maximum 22 inches below ceiling as long as sprinklers meet obstruction criteria.

Slide 5-34

E. Maximum distance from ceiling/roof deck.

1. Unobstructed: 12 inches.

2. Obstructed.

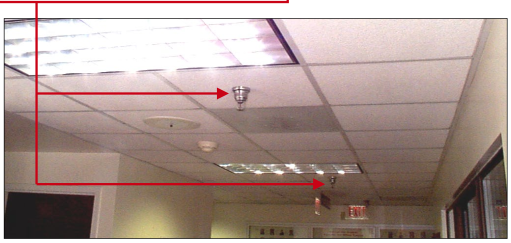
   a. One to 6 inches below structural members, maximum 22 inches to deck.

   b. Twelve inches below ceiling/roof deck when installed in bays.

   c. Variable above bottom of structural members to maximum 22 inches below ceiling as long as sprinklers meet obstruction criteria.

MAXIMUM DEFLECTOR DIFFERENCE FROM CEILING/ROOF DECK (cont'd)

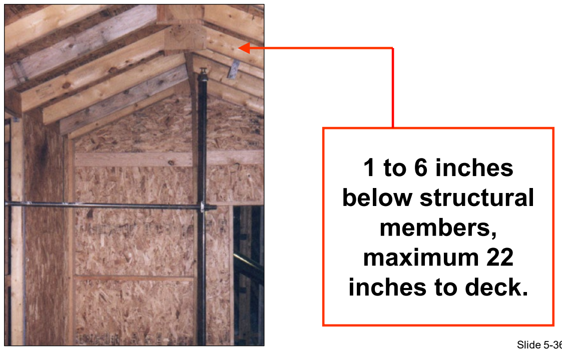
Maximum 12 inches below ceiling or roof deck.



Slide 5-35

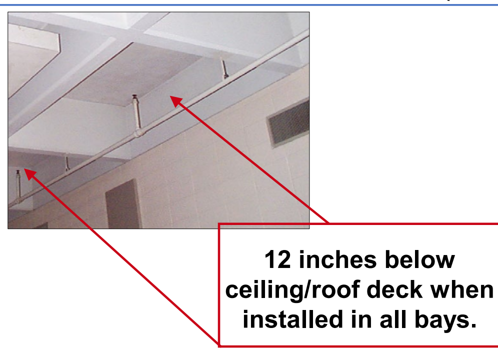
3. Smooth flat ceilings can have sprinklers positioned within 12 inches of the ceiling.

MAXIMUM DEFLECTOR DIFFERENCE FROM CEILING/ROOF DECK (cont'd)



4. The spacing of the sprinkler beneath the structural members is important because of the spray pattern that will develop. The total distance down is limited but shows that a delayed activation is not so important as discharging the water.

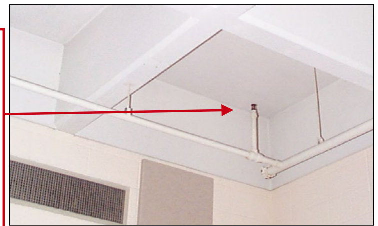
MAXIMUM DEFLECTOR DIFFERENCE FROM CEILING/ROOF DECK (cont'd)



5. The example on the slide shows how a sprinkler is installed in every bay, which means the spray pattern will only be associated with that bay.

MAXIMUM DEFLECTOR DIFFERENCE FROM CEILING/ROOF DECK (cont'd)

Above bottom of structural members to maximum 22 inches below ceiling as long as sprinklers meet obstruction criteria.



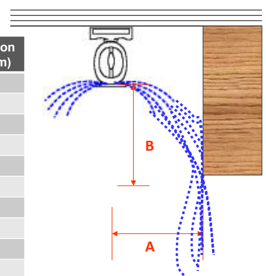
Slide 5-38

6. Sprinklers can be spaced lower to provide a spray pattern over a larger area.

CONTINUOUS OBSTRUCTION

- Beams, curtains, ducts.

CL sprinkler to obstruction (A)	Deflector to obstruction bottom (B) (maximum)
< 1 ft. 0 in.	0 in.
1 ft. 0 in. to < 1 ft. 6 in.	2 ½ in.
1 ft. 6 in. to < 2 ft. 0 in.	3 ½ in.
2 ft. 0 in. to <2 ft. 6 in.	5 ½ in.
2 ft. 6 in. to < 3 ft. 0 in.	7 ½ in.
3 ft. 0 in. to < 3 ft. 6 in.	9 ½ in.
3 ft. 6 in. to < 4 ft. 0 in.	12 in.
4 ft. 0 in. to < 4 ft. 6 in.	14 in.
4 ft. 6 in. to < 5 ft. 0 in.	16 ½ in.
5 ft. 0 in. to < 5 ft. 6 in.	18 in.
5 ft. 6 in. to < 6 ft. 0 in.	20 in.
6 ft. 0 in. to < 6 ft. 6 in.	24 in.
6 ft. 6 in. to < 7 ft. 0 in.	30 in.
7 ft. 0 in. to < 7 ft. 6 in.	35 in.



Elevation view

Slide 5-39

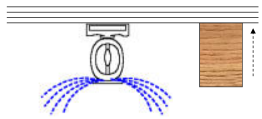
F. Continuous obstruction.

1. Beams, curtains, ducts.

When a continuous obstruction is installed, there are distance requirements from the obstruction which are dependent upon the depth of the obstruction. If too close, then water will not pass the obstruction.

CONTINUOUS OBSTRUCTION (cont'd)

CL sprinkler to obstruction (A)	Deflector to obstruction bottom (B) (maximum)
< 1 ft. 0 in.	0 in.
1 ft. 0 in. to < 1 ft. 6 in.	2 ½ in.
1 ft. 6 in. to < 2 ft. 0 in.	3 ½ in.
2 ft. 0 in. to <2 ft. 6 in.	5 ½ in.
2 ft. 6 in. to < 3 ft. 0 in.	7 ½ in.
3 ft. 0 in. to < 3 ft. 6 in.	9 ½ in.
3 ft. 6 in. to < 4 ft. 0 in.	12 in.
4 ft. 0 in. to < 4 ft. 6 in.	14 in.
4 ft. 6 in. to < 5 ft. 0 in.	16 ½ in.
5 ft. 0 in. to < 5 ft. 6 in.	18 in.
5 ft. 6 in. to < 6 ft. 0 in.	20 in.
6 ft. 0 in. to < 6 ft. 6 in.	24 in.
6 ft. 6 in. to < 7 ft. 0 in.	30 in.
7 ft. 0 in. to < 7 ft. 6 in.	35 in.

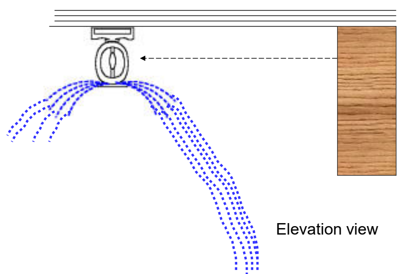


Elevation view

Slide 5-40

CONTINUOUS OBSTRUCTION (cont'd)

CL sprinkler to obstruction (A)	Deflector to obstruction bottom (B) (maximum)
< 1 ft. 0 in.	0 in.
1 ft. 0 in. to < 1 ft. 6 in.	2 ½ in.
1 ft. 6 in. to < 2 ft. 0 in.	3 ½ in.
2 ft. 0 in. to <2 ft. 6 in.	5 ½ in.
2 ft. 6 in. to < 3 ft. 0 in.	7 ½ in.
3 ft. 0 in. to < 3 ft. 6 in.	9 ½ in.
3 ft. 6 in. to < 4 ft. 0 in.	12 in.
4 ft. 0 in. to < 4 ft. 6 in.	14 in.
4 ft. 6 in. to < 5 ft. 0 in.	16 ½ in.
5 ft. 0 in. to < 5 ft. 6 in.	18 in.
5 ft. 6 in. to < 6 ft. 0 in.	20 in.
6 ft. 0 in. to < 6 ft. 6 in.	24 in.
6 ft. 6 in. to < 7 ft. 0 in.	30 in.
7 ft. 0 in. to < 7 ft. 6 in.	35 in.

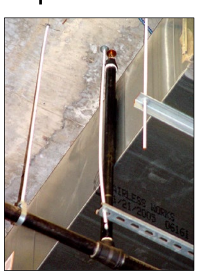


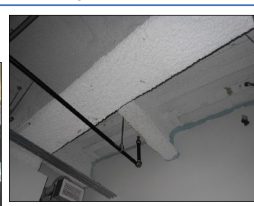
Elevation view

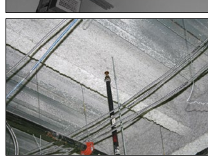
Slide 5-41

CONTINUOUS OBSTRUCTION (cont'd)

- Examples.

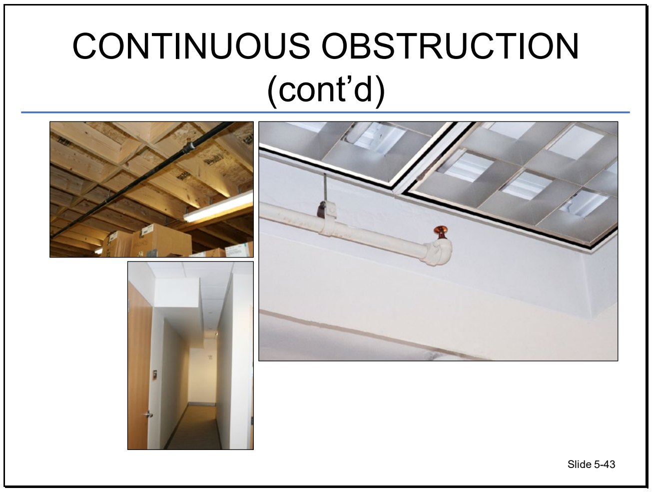




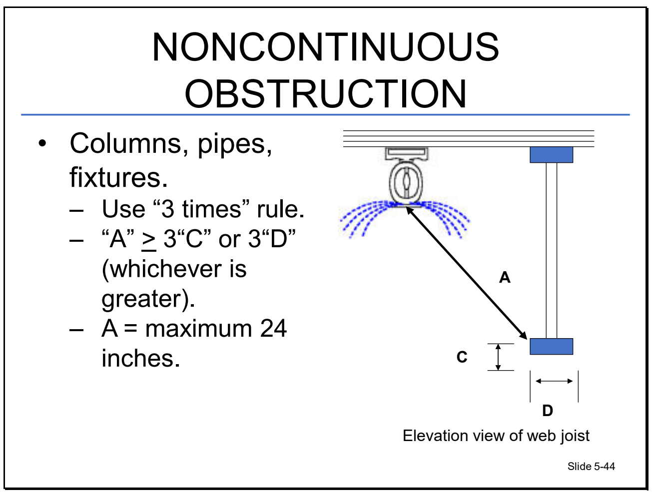


Slide 5-42

2. Examples: ductwork, wooden beams and a beam that would be an obstruction.



3. Examples of acceptable installation.



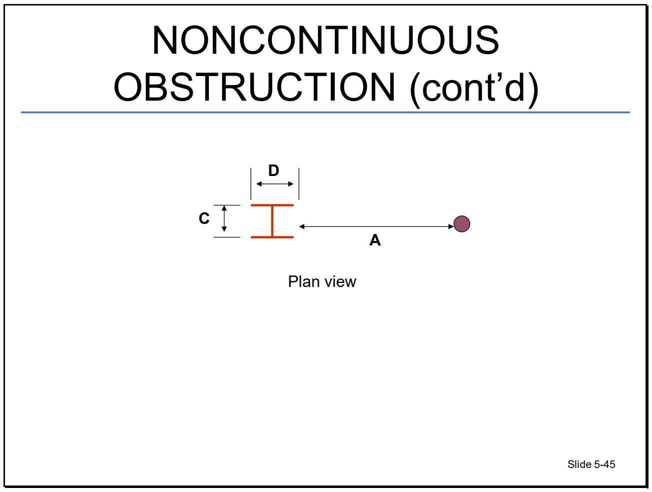
G. Noncontinuous obstruction.

1. Columns, pipes, fixtures.

a. Use "three times" rule.

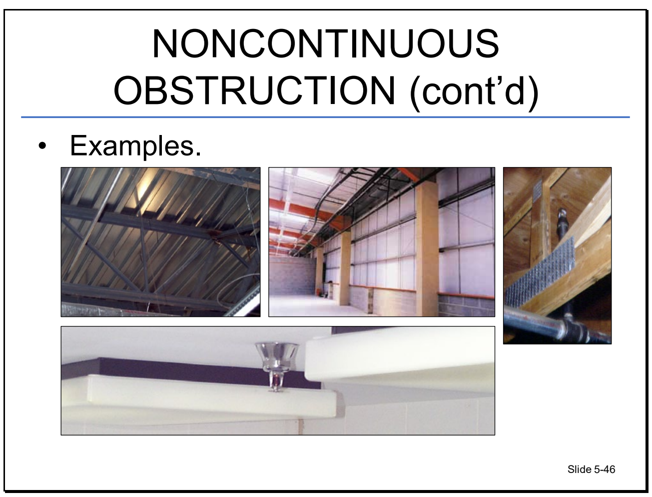
b. "A" is greater than or equal to 3"C" or 3"D" (whichever is greater).

c. A equals maximum 24 inches.

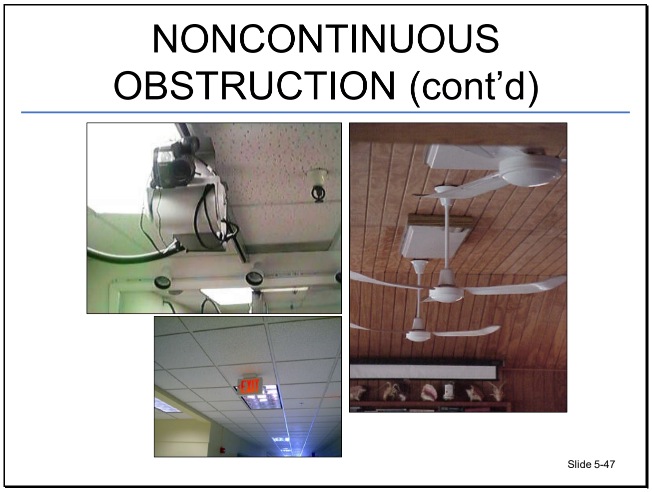


- The figure illustrates the distance required for adequate water distribution when an open web joist has a solid base member. The concern is not the water discharging through the openness of the vertical portion of the structural member, but the size of the shadow created by the base member.

- The measurements are the same if the obstruction is in the horizontal or the vertical arrangement.



2. Example: columns, a truss member, ceiling light fixtures and the flange for an open bar joist.



3. Examples of nonstructural components.

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ACTIVITY 5.3

Obstructed Construction

Purpose

Practice determining distances differentiating between obstructed and nonobstructed construction based on provided distances.

Direction

In your table group, view a series of images of construction and determine if each image indicates obstructed or unobstructed construction.

1. Example 1: What is the required minimum clearance (A) from this column obstruction? Solve for A.

   ____

   ____

   ____

2. Example 2: What is the maximum deflector distance (B) above the bottom of the beam? Solve for B.

   ____

   ____

   ____

3. Example 3: Is the sprinkler obstructed? If so, how can the sprinkler location be modified to provide adequate coverage?

   ____

   ____

   ____

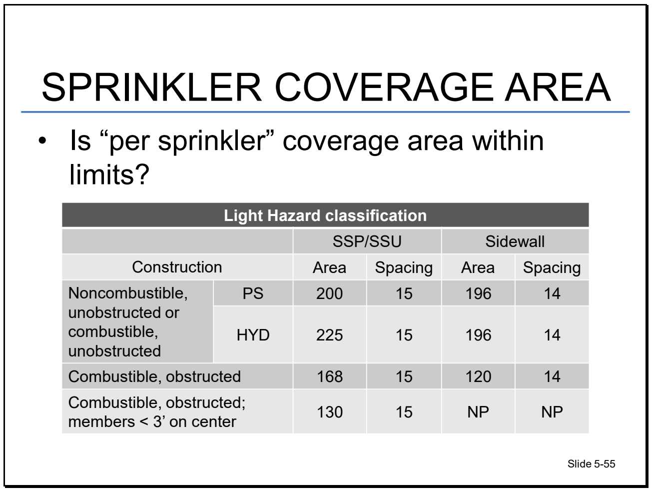
4. Example 4: Is the sprinkler obstructed? If so, how can the sprinkler location be modified to provide adequate coverage?

____

____

____

V. SPRINKLER DISCHARGE OBSTRUCTIONS (cont'd)



SPRINKLER COVERAGE AREA

- Is "per sprinkler" coverage area within limits?

Light Hazard classification					
		SSP/SSU		Sidewall	
Construction		Area	Spacing	Area	Spacing
Noncombustible, unobstructed or combustible, unobstructed	PS	200	15	196	14
	HYD	225	15	196	14
Combustible, obstructed		168	15	120	14
Combustible, obstructed; members < 3' on center		130	15	NP	NP

Slide 5-55

H. Sprinkler coverage area.

1. Is "per sprinkler" coverage area within limits?

2. This chart is composed from the spacing requirements in NFPA 13, *Standard for the Installation of Sprinkler Systems*, for sprinklers covering a Light Hazard occupancy.

3. Most design professionals automatically state that as a Light Hazard occupancy, they can design up to 225 square feet per sprinkler. As seen, that depends on many factors.

   a. SSP = standard spray pendent.

   b. SSU = standard spray upright.

   c. PS = pipe schedule.

   d. HYD = hydraulically calculated.

   e. NP = not permitted.

SPRINKLER COVERAGE AREA (cont'd)

Ordinary Hazard classification				
	SSP/SSU		Sidewall	
Construction	Area	Spacing	Area	Spacing
All	130	15		
Noncombustible, unobstructed				
Noncombustible, obstructed				
Combustible, obstructed				
Combustible finish			80	10
Noncombustible finish			100	10

Slide 5-56

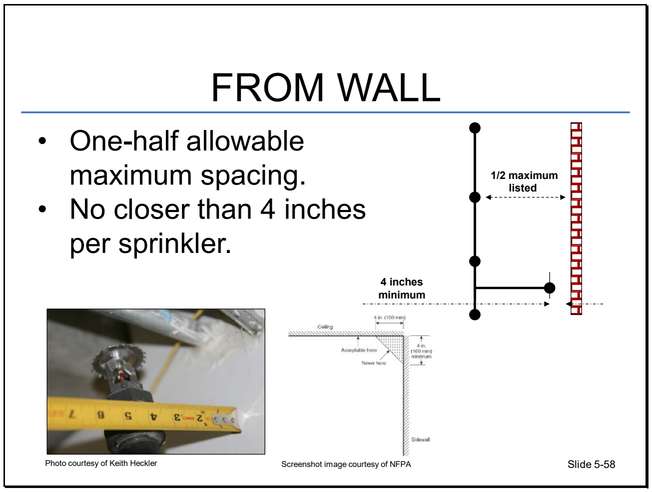
SPRINKLER COVERAGE AREA (cont'd)

Extra Hazard classification		
	SSP/SSU	
Construction	Area	Spacing
All, pipe schedule	90	12
All, hydraulically calculated with density ≥ 0.25 gpm/ft^2	100	12
All, hydraulically calculated with density < 0.25 gpm/ft^2	130	15

Slide 5-57

4. With the spacing calculated from the example, the system layout will not meet the requirements for Ordinary Hazard. We learned already that Ordinary Hazard will have one and a half to two times the amount of water discharge as compared to Light Hazard.

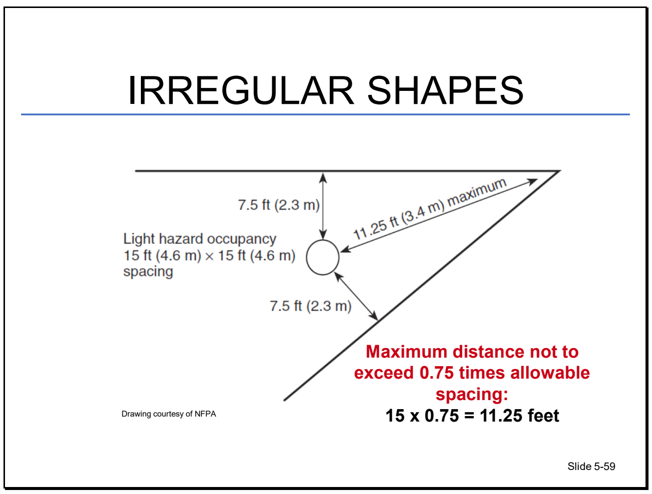
5. The amount of water discharge is substantially more than Light Hazard and double that of Ordinary Hazard. Copious amounts of water will discharge, and the spacing is reduced so there will be lower pressures at the sprinkler while operating.



I. Minimum distance to wall.

1. One-half allowable maximum spacing.

2. No closer than 4 inches per sprinkler (from the wall to the center of the sprinkler).



J. Irregular shapes.

1. Anything less than a 90-degree angle is considered an “irregular shape.”

2. Not every room is perfectly square. When an irregular shape is experienced, a special calculation is performed.

SIDEWALL SPRINKLERS LIMITATIONS

- Construction: flat, smooth, unobstructed.
- If used in trusses:
  - Web members less than 1 inch wide.
  - Trusses 7 1/2 feet on center.
- Ceilings: smooth, flat ceiling 4:12 pitch or less.
- Noncombustible construction in some cases.

Slide 5-60

K. Sidewall sprinklers limitations.

1. Construction: flat, smooth, unobstructed.

2. If used in trusses:

   a. Web members less than 1 inch wide.

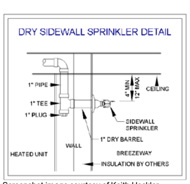
   b. Trusses 7 1/2 feet on center.

3. Ceilings: smooth, flat ceiling 4:12 pitch or less.

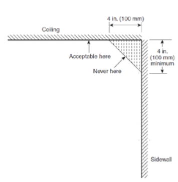
4. Noncombustible construction in some cases.

SIDEWALL SPRINKLERS SPACING FROM CEILING

- No closer than 4 inches.
- Distance from ceiling is dependent with listing.



Screenshot image courtesy of Keith Heckler



Screenshot image courtesy of NFPA

Photo courtesy of Keith Heckler

Slide 5-61

L. Sidewall sprinklers spacing from the ceiling.

1. No closer than 4 inches.

2. Distance from the ceiling is dependent with listing.

SMALL ROOM SPACING

- Maximum spacing of 9 feet from only a single wall.
- All other wall spacing must comply with spacing requirements of NFPA 13, *Standard for the Installation of Sprinkler Systems*.

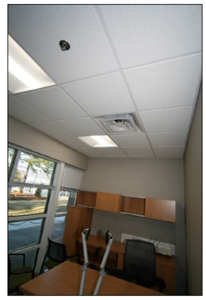


Photo courtesy of Keith Heckler

Slide 5-62

M. Small room spacing: The rules change in small room calculations.

1. Maximum spacing of 9 feet from only one wall.

2. All other wall spacing must comply with spacing requirements of NFPA 13.

SMALL ROOM SPACING (cont'd)

- Room must be considered Light Hazard.
- Room must be 800 square feet or less.
- Ceiling must be of unobstructed construction.

Slide 5-63

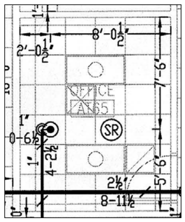
3. The room must be considered Light Hazard.

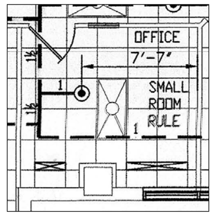
4. The room must be 800 square feet or less.

5. The ceiling must be of unobstructed construction.

SMALL ROOM SPACING (cont'd)

- Room must be surrounded with walls.
- Openings in walls must have a header depth of 8 inches or more to trap heat.





Screenshot images courtesy of Keith Heckler

Slide 5-64

6. The room must be surrounded with walls and a ceiling.

7. Openings in walls must have a header depth of 8 inches or more to trap heat.

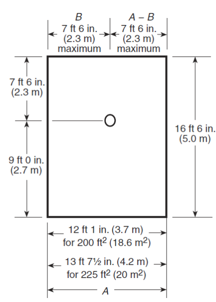
8. The small room rule allows designers to move sprinklers away from lights or heat vents and still provide coverage.

SMALL ROOM SPACING (cont'd)

- Special small room rule spacing calculation for sprinkler coverage.
  - Two hundred and twenty-five square feet maximum sprinkler coverage.

A_S = 13 ft 7 1/2 in x 15 ft

A_S = 204.53 ft^2



Drawing courtesy of NFPA

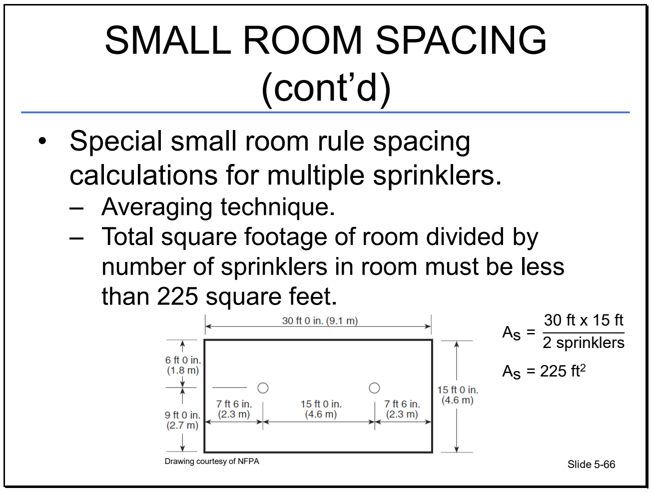
Slide 5-65

9. Special small room rule spacing calculation for sprinkler coverage.

   Two hundred and twenty-five square feet maximum sprinkler coverage.

   A_s = 13 ft 7 1/2 in x 15 ft

   A_s = 204.53 ft^2



10. Special small room rule spacing calculations for multiple sprinklers.

   a. Averaging technique.

   b. Total square footage of room divided by the number of sprinklers in a room must be less than 225 square feet.

$$A_s = \frac{30 \text{ ft x } 15 \text{ ft}}{2 \text{ sprinklers}}$$

$$A_s = 225 \text{ ft}^2$$

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ACTIVITY 5.4

Compartments and Small Rooms

Purpose

Recognize the conditions that classify an area as a compartment and the conditions that qualify an area for the small room rule.

Directions

1. You will be presented a series of plans and will determine if the arrangements qualify to have the small room rule applied.

2. Office 132 is part of a new office building that is being erected. The office will contain a desk/computer workstation, rolling chair, credenza and two upholstered armchairs. The building is combustible construction.

   a. Does this room meet the NFPA 13 definition of a compartment?

   ____

   ____

   ____

   b. Does this room qualify as a small room in accordance with the definitions in NFPA 13?

   ____

   ____

   ____

3. The local auto parts store offers parts, lube oil and antifreeze recycling service. Customers may bring in small quantities (not to exceed 5 quarts for lube oil or 5 gallons of other nonflammable fluids) in metal or plastic containers. The store's staff members will take the products and transfer them to larger containers (55-gallon drums for the lube oil and 100-gallon portable tanks for the nonflammable fluids). The building is noncombustible construction.

a. Is the recycling processing room a different compartment from the adjacent space?

____

____

____

b. Does this room qualify as a small room in accordance with the definitions in NFPA 13? Why or why not?

____

____

____

4. A furniture store has a small room for miscellaneous storage of repair parts, catalogs and brochures, packing materials, and fabric cleaning and treatment products. The building is combustible construction.

a. Is Space A part of the same compartment as Space B? Why or why not?

____

____

____

b. Is Space B part of the same compartment as Space C? Why or why not?

____

____

____

c. Does this room qualify as a small room in accordance with the definitions in NFPA 13? Why or why not?

____

____

____

5. This is a guest room at a local motel. In addition to the bathroom fixtures (all noncombustible), furniture in the room includes a bed, desk, wall-mounted television, two nightstands and a bureau for clothing. There is a clothes closet with solid, bifold closet doors.

   a. Is the closet part of the same compartment as the remainder of the room? Why or why not?

   ____

   ____

   ____

   b. Is the guest room part of the same compartment as the adjacent corridor? Why or why not?

   ____

   ____

   ____

   c. Does the bathroom qualify as a small room in accordance with the definitions in NFPA 13? Why or why not?

   ____

   ____

   ____

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VI. SPECIAL SITUATIONS

A. Although sprinklers are required in all areas, there are special situations where sprinklers are not required or additional sprinklers need to be added.

B. Fixed obstructions.

1. Fixed obstructions greater than 4 feet wide.

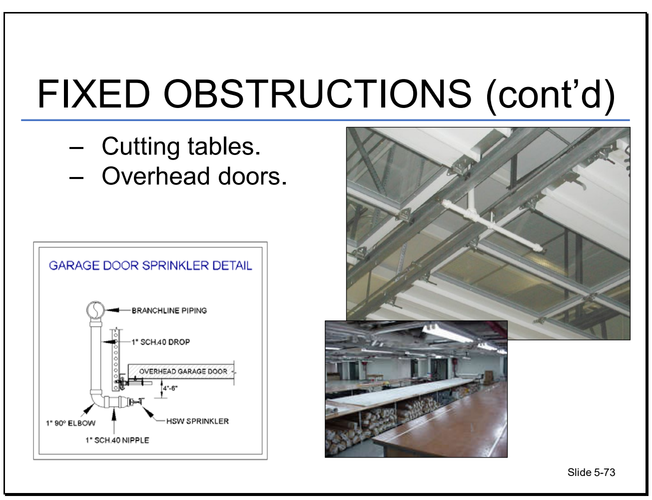
a. Ducts.

b. Decks.

c. Open-grate flooring.

d. Intermediate rack.

e. Shielded.



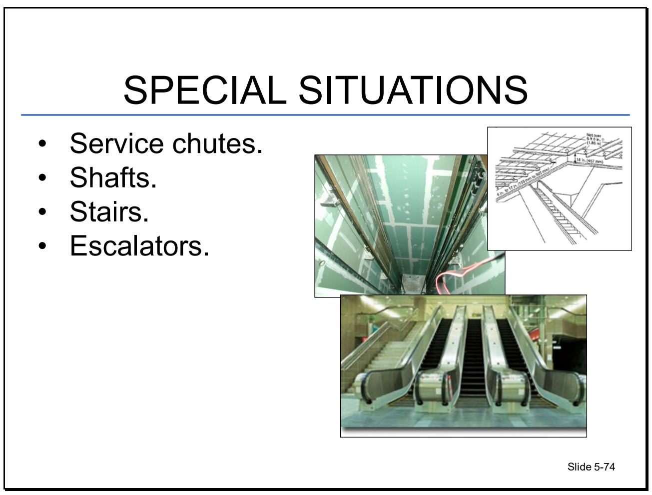
f. Cutting tables.

g. Overhead doors.

2. When obstructions are less than 4 feet wide, the shadow that is created is not considered prohibiting.

3. A recent technology found in parking garages of apartments/condominiums is car lifts. This allows occupants to park two or more cars in one parking space. The lift becomes an obstruction, and therefore sprinkler coverage must be provided underneath. A sidewall sprinkler positioned under the car lift in its highest position is normal.

4. Other situations, such as tables, are not required to have sprinklers underneath. With garage doors, a minimum of one sprinkler is needed under the garage door in the fully open position.



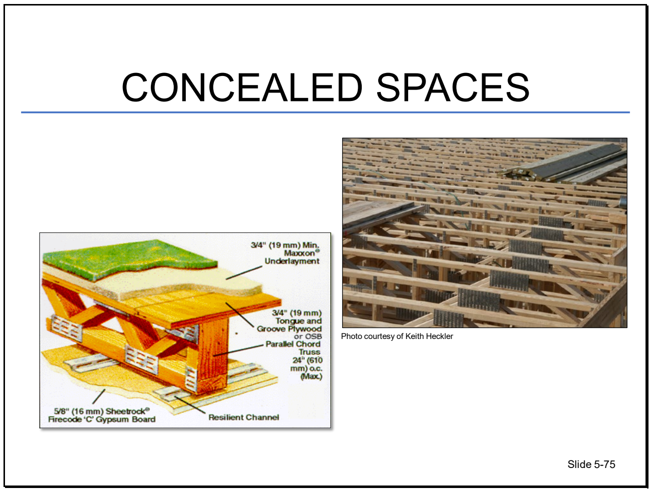
C. There are times where sprinklers are to be installed in certain arrangements.

1. Service chutes.

2. Shafts.

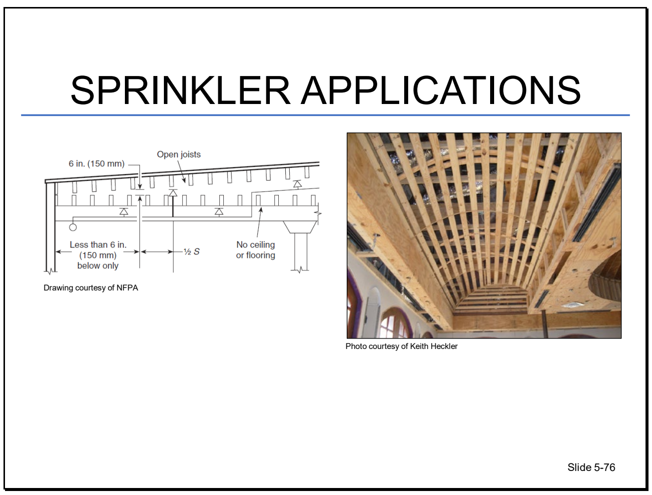
3. Stairs.

4. Escalators.



D. Concealed spaces.

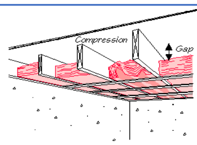
When combustible floor spaces are used, sprinklers may be required.



E. Sprinkler applications.

1. Architectural features made of combustible components will create combustible concealed space voids.

SPRINKLER APPLICATIONS (cont'd)



Photos courtesy of Keith Heckler

Slide 5-77

2. As designs become more complex, special attention will need to be paid.

SPRINKLER APPLICATIONS (cont'd)

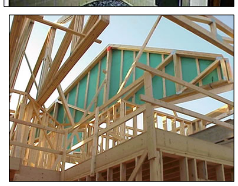


Photo courtesy of Keith Heckler

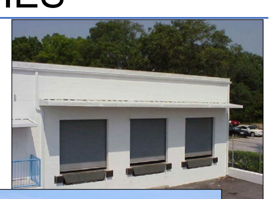
Slide 5-78

3. Cloud ceilings and other scenarios may require sprinklers.

CANOPIES

Canopies 4 feet wide, unless:

- Noncombustible or limited combustible construction.
- Noncombustible exterior exit corridors 50% open.



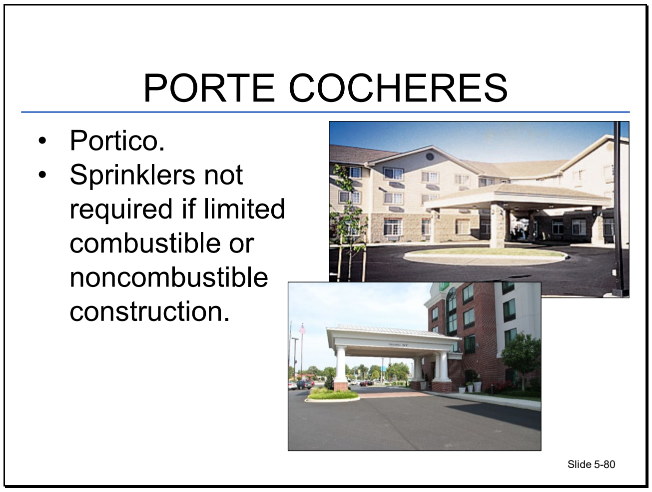
Slide 5-79

F. Canopies 4 feet wide, unless:

1. Noncombustible or limited combustible construction.

2. Noncombustible exterior exit corridors 50% open.

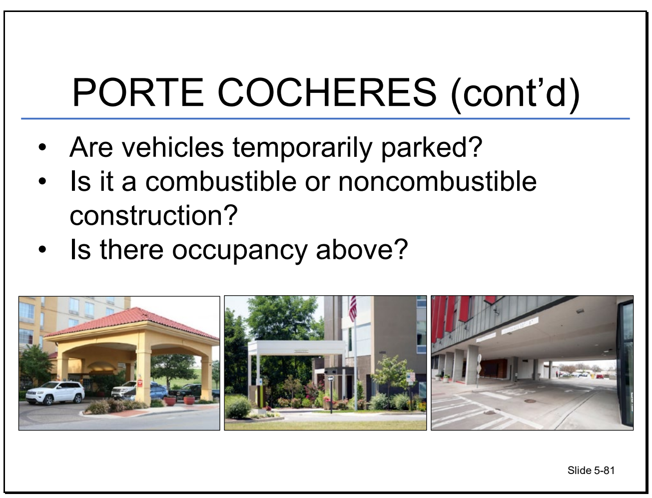
3. Sprinklers may be required under canopies depending upon the circumstances.



G. Porte cocheres.

1. Portico.

2. Sprinklers not required if limited combustible or noncombustible construction.



3. Are vehicles temporarily parked?

4. Is it a combustible or noncombustible construction?

5. Is there occupancy above?

OPEN-GRID AND DROP-OUT CEILINGS

- Open-grid ceilings.
  - Only permitted in Light and Ordinary Hazard occupancies.
  - Seventy percent open.
  - Minimum 1/4-inch openings.

Photos courtesy of Keith Heckler

Slide 5-82

H. Open-grid and drop-out ceilings.

1. Open-grid ceilings.

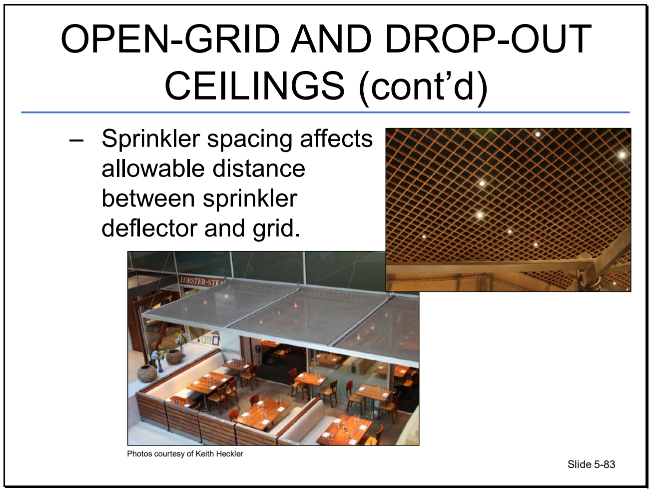
a. Only permitted in Light Hazard and Ordinary Hazard occupancies.

b. Seventy percent open.

c. Minimum 1/4-inch openings.

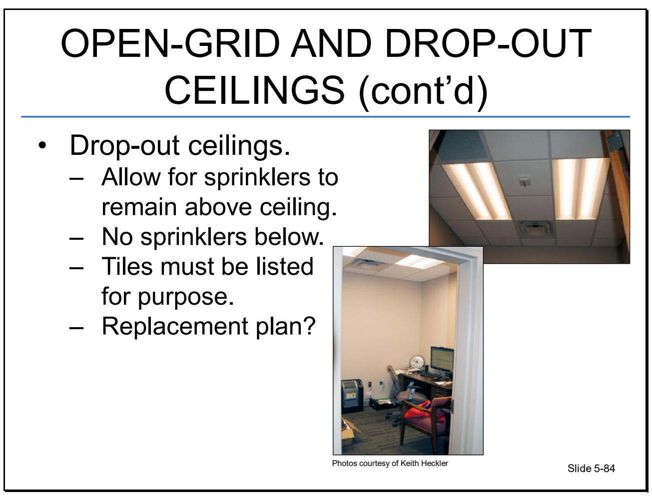
- The size of the openings will dictate if sprinklers will be required above and below the grid, and there are specific spacing limitations above the grid associated with the hazard classification as well.

- Openings of 1/4 inch mixed with the hazard classification will dictate if sprinklers are required below the grid.



d. Sprinkler spacing affects the allowable distance between the sprinkler deflector and the grid.

- Drop-out ceilings are intended to melt and then allow the smoke to the sprinklers about the ceiling. The only concern with this arrangement is the replacement by unsuspecting builders of a cheaper ceiling grid.



2. Drop-out ceilings.

a. Allow for sprinklers to remain above the ceiling.

b. No sprinklers below.

c. Tiles must be listed for this purpose.

d. Replacement plan?

VII. SUMMARY

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SUMMARY

U.S. Fire Administration

- Design of the sprinkler system provides compliant coverage for all areas as required.
- Benefits and limitations of three sprinkler piping arrangements: tree, grid and loop systems.
- Spacing of the sprinklers is compliant.

Slide 5-85

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SUMMARY (cont'd)

U.S. Fire Administration

- Sprinklers for application suitability.
- Sprinkler positioning with respect to construction configuration.

Slide 5-86

REFERENCES

National Fire Protection Association. (2016). *Standard for the installation of sprinkler systems*. (Standard no. 13). Retrieved from https://www.nfpa.org

National Fire Protection Association. (2017). *National electric code*. (Standard no. 70). Retrieved from https://www.nfpa.org

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UNIT 6: HYDRAULIC REMOTE DESIGN AREAS

TERMINAL OBJECTIVE

The students will be able to:

6.1 Evaluate the arrangement of the hydraulically remote area given a set of design drawings.

ENABLING OBJECTIVES

The students will be able to:

6.1 Identify the appropriate design method for the intended use area (room/area/storage).

6.2 Determine the most hydraulically demanding area based upon the use, occupancy and location of the space.

6.3 Determine the size and orientation of the most hydraulically remote area.

6.4 Identify sprinkler design area modification as prescribed in National Fire Protection Association (NFPA) 13, Standard for the Installation of Sprinkler Systems*.*

6.5 Calculate the minimum length required for the remote area.

6.6 Determine the spacing of sprinklers within the remote area.

6.7 Determine the minimum number of sprinklers required to be in the remote area.

6.8 Determine the minimum number of sprinklers on a branch line.

6.9 Determine the appropriate water flow rate to satisfy required levels of protection based on design density or area application as per recognized standards.

6.10 Conclude whether the remote area provides compliant protection for the intended hazard classification.

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UNIT 6: HYDRAULIC REMOTE DESIGN AREAS

Slide 6-1

TERMINAL OBJECTIVE

Evaluate the arrangement of the hydraulically remote area given a set of design drawings.

Slide 6-2

ENABLING OBJECTIVES

- Identify the appropriate design method for the intended use area (room/area/storage).
- Determine the most hydraulically demanding area based upon the use, occupancy and location of the space.
- Determine the size and orientation of the most hydraulically remote area.

Slide 6-3

ENABLING OBJECTIVES (cont'd)

- Identify sprinkler design area modification as prescribed in National Fire Protection Association (NFPA) 13, *Standard for the Installation of Sprinkler Systems*.
- Calculate the minimum length required for the remote area.
- Determine the spacing of sprinklers within the remote area.

Slide 6-4

ENABLING OBJECTIVES (cont'd)

- Determine the minimum number of sprinklers required to be in the remote area.
- Determine the minimum number of sprinklers on a branch line.
- Determine the appropriate water flow rate to satisfy required levels of protection based on design density or area application as per recognized standards.

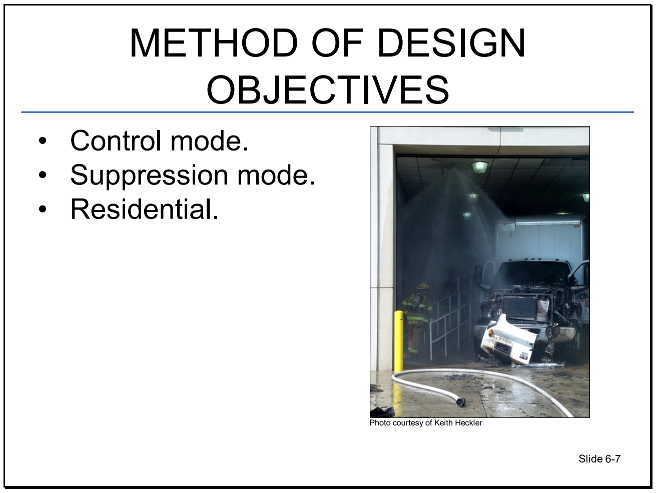
Slide 6-5

ENABLING OBJECTIVES (cont'd)

- Conclude whether the remote area provides compliant protection for the intended hazard classification.

Slide 6-6

I. METHODS OF DESIGN OBJECTIVES



A. Control mode provides fire control of specific fire hazards.

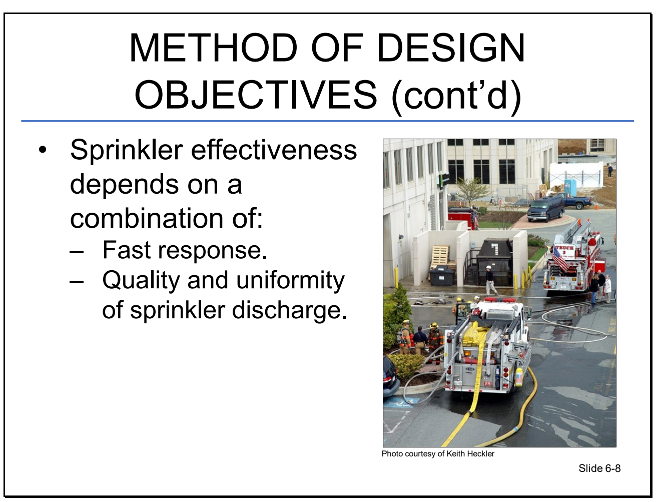
B. Suppression mode provides fire suppression of specific high-challenge fire hazards.

C. Residential.

1. National Fire Protection Association (NFPA) 13, *Standard for the Installation of Sprinkler Systems*, specific four-sprinkler discharge (no minimum area for remote area).

2. NFPA 13 property conservation requirements also applicable.

3. NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*, and 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*, are life safety design only.

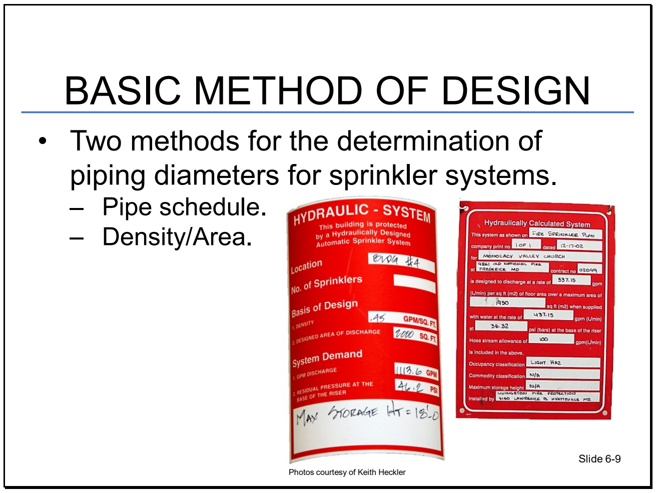


D. Sprinkler effectiveness depends on a combination of:

1. Fast response.

2. Quality and uniformity of sprinkler discharge.

II. BASIC METHOD OF DESIGN

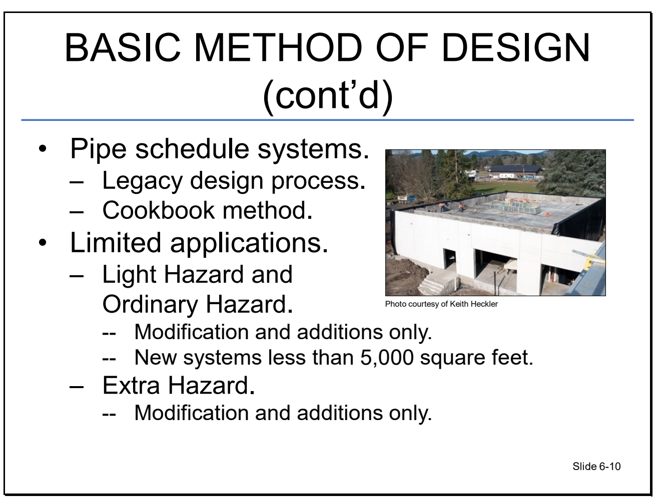


A. Basic methods.

1. Two methods for the determination of piping diameters for sprinkler systems.

a. Pipe schedule.

b. Density/Area.



2. Pipe schedule systems.

   a. Legacy design process.

   b. Cookbook method.

3. Limited applications.

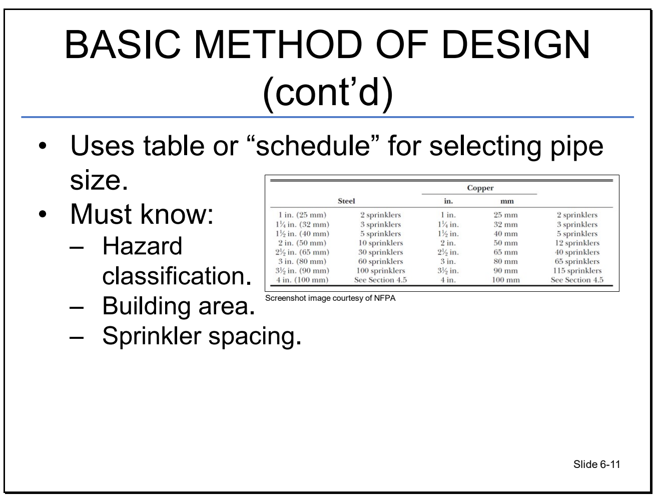
   a. Light Hazard and Ordinary Hazard.

      - Modification and additions only.

      - New systems less than 5,000 square feet.

   b. Extra Hazard.

      - Modifications only.



Steel		Copper in.	Copper mm	
1 in. (25 mm)	2 sprinklers	1 in.	25 mm	2 sprinklers
1¼ in. (32 mm)	3 sprinklers	1¼ in.	32 mm	3 sprinklers
1½ in. (40 mm)	5 sprinklers	1½ in.	40 mm	5 sprinklers
2 in. (50 mm)	10 sprinklers	2 in.	50 mm	12 sprinklers
2½ in. (65 mm)	30 sprinklers	2½ in.	65 mm	40 sprinklers
3 in. (80 mm)	60 sprinklers	3 in.	80 mm	65 sprinklers
3½ in. (90 mm)	100 sprinklers	3½ in.	90 mm	115 sprinklers
4 in. (100 mm)	See Section 4.5	4 in.	100 mm	See Section 4.5

4. Uses table or "schedule" for selecting pipe size.

5. Must know:

   a. Hazard classification.

   b. Building area.

   c. Sprinkler spacing.

BASIC METHOD OF DESIGN (cont'd)

- Given:
  - Ordinary Hazard, Group 1.
  - Building area: 12,000 square feet.
  - Spacing: 120 square feet per sprinkler.

$$\text{Number of sprinklers} = \frac{\text{Square footage of building}}{\text{Area per sprinkler}}$$

$$\text{Number of sprinklers} = \frac{12{,}000 \text{ ft}^2}{120 \text{ ft}^2 \text{ per sprinkler}}$$

Number of sprinklers = 100 sprinklers

Slide 6-12

6. Given:

   a. Ordinary Hazard, Group 1.

   b. Building area: 12,000 square feet if new system cannot be more than 5,000 square feet.

   c. Spacing: 120 square feet per sprinkler.

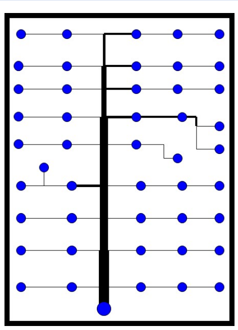
   Number of sprinklers = square footage of building/area per sprinkler

   Number of sprinklers = 12,000 ft^2/120 ft^2 per sprinkler

   Number of sprinklers = 100 sprinklers

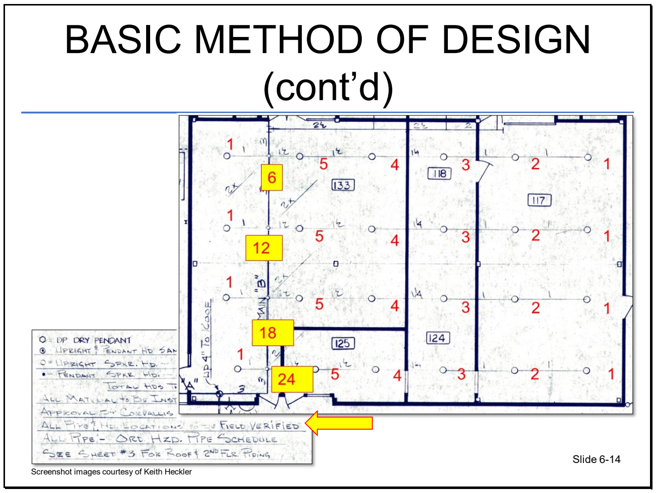
BASIC METHOD OF DESIGN (cont'd)

Number of sprinklers per pipe size		
Diameter (inches)	Light Hazard	Ordinary Hazard
1	2	2
1-1/4	3	3
1-1/2	5	5
2	10	10
2 1/2	30	20
3	60	40
3 -1/2	100	65
4		100



Slide 6-13

7. Comparison of piping diameters.



8. True life pipe schedule system: Sprinkler shop drawings for pipe schedule systems are drawn in the same manner as hydraulically calculated systems. The notes on the plans will specify that the design is in accordance with a pipe schedule system. No remote area will be indicated. The plan is marked with numbers counting the sprinklers. The numbers in boxes are the sum of sprinklers from the branch lines working back toward the riser. Note the large diameter cross main does not adjust to a lower number of sprinklers because this diagram is only a portion of a larger project.

BASIC METHOD OF DESIGN (cont'd)

- Residual pressure (pounds per square inch (psi)) at highest elevation (h x 0.433).
- Lower flow if noncombustible or compartmentalized.
- Lower duration if water flow supervised off premises.

Hazard classification	Minimum residual pressure (psi)	Base-of-riser flow (gallons per minute (gpm))	Duration (minutes)
Light	15	500-750	30-60
Ordinary	20	850-1,500	60-90

Slide 6-15

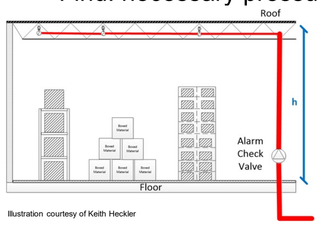
9. Residual pressure (pounds per square inch (psi)) at highest elevation (h x 0.433).

10. Lower flow if noncombustible or compartmentalized.

11. Lower duration if water flow is supervised off premises.

BASIC METHOD OF DESIGN (cont'd)

- Example: calculating necessary pressure.
  - Given: storage occupancy, height between floor to sprinklers is 20 feet.
  - Find: necessary pressure at base-of-riser.



Required pressure

= Sprinkler pressure + (h x 0.433)

= 20 psi + (20 ft. x 0.433)

= 28.66 psi

Illustration courtesy of Keith Heckler

Slide 6-16

12. Example: calculating necessary pressure.

    a. Given:

       - Storage occupancy.
       - Height between floor to sprinklers is 20 feet.

    b. Find: necessary pressure at base-of-riser.

       - Required pressure

         = Sprinkler pressure + (h x 0.433)

         = 20 psi + (20 feet x 0.433)

         = 28.66 psi

BASIC METHOD OF DESIGN (cont'd)

- Density/Area method is the currently accepted design process since 1966.
  - Cost and mathematically effective.
  - Hydraulically calculated systems permitted for all hazards.

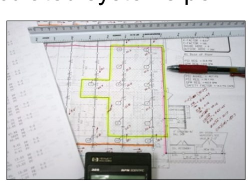


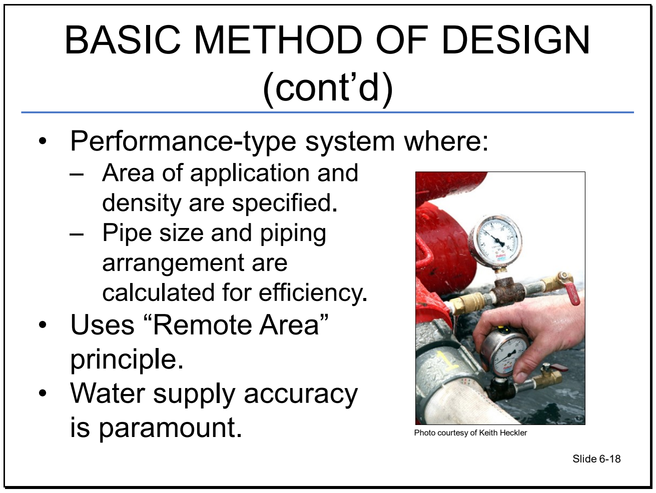
Photo courtesy of Keith Heckler

Slide 6-17

13. Density/Area method is the currently accepted design process since 1966.

    a. Cost and mathematically effective.

    b. Hydraulically calculated systems are permitted for all hazards.



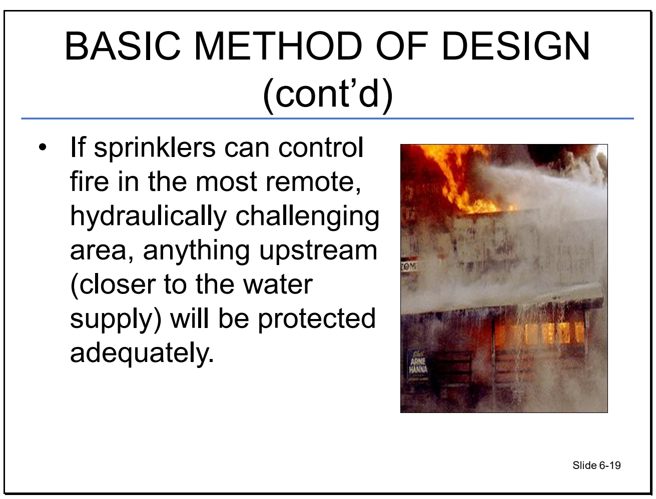
14. Performance-type system where:

    a. Area of application and density are specified.

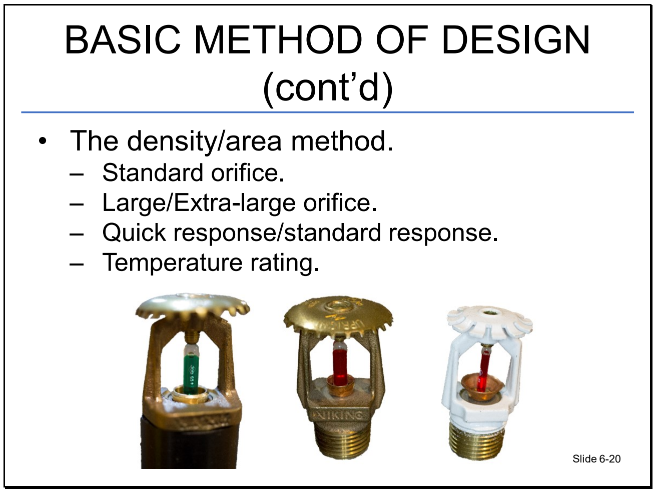
    b. Pipe size and piping arrangement are calculated for efficiency.

15. Uses "Remote Area" principle.

16. Water supply accuracy is paramount.



17. If sprinklers can control fire in the most remote, hydraulically challenging area, anything upstream (closer to the water supply) will be protected adequately.



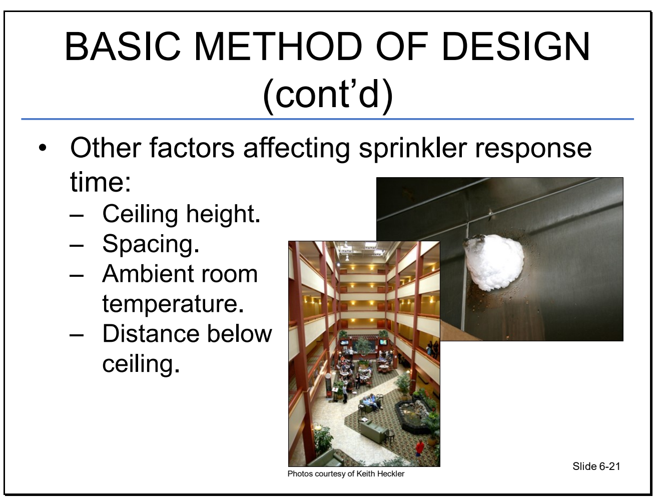
18. The density/area method.

a. Standard orifice.

b. Large/Extra-large orifice.

c. Quick response/standard response.

d. Temperature rating.



19. Other factors affecting sprinkler response time:

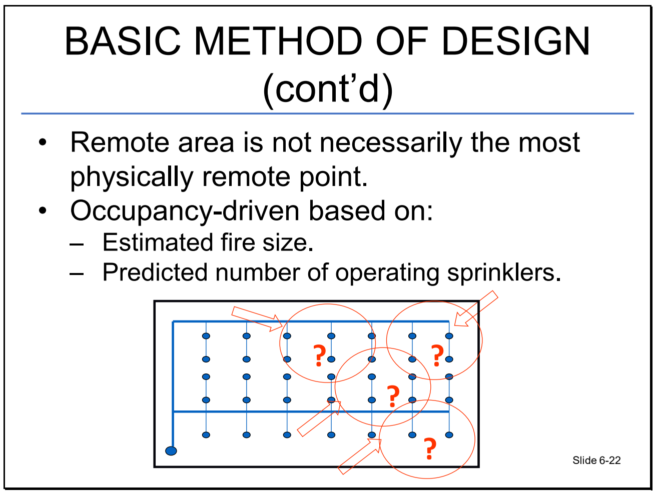
a. Ceiling height.

b. Spacing.

c. Ambient room temperature.

d. Distance below ceiling.

- In most fire scenarios, sprinkler activation times will be shortest where the thermal elements are located 1 inch (25.4 millimeters) to 3 inches (76.2 millimeters) below the ceiling.

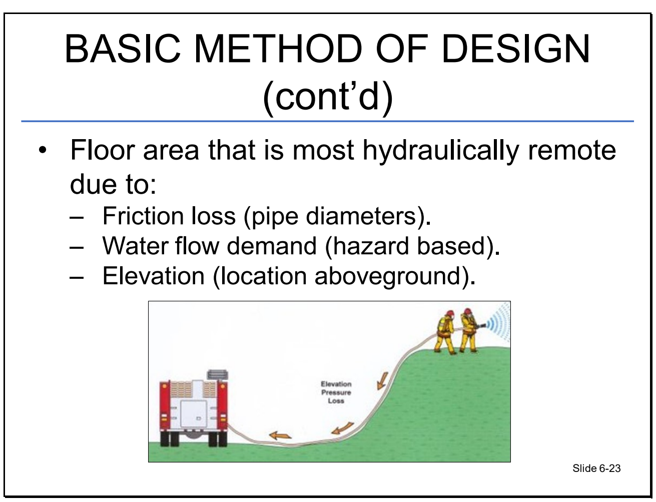


20. Remote area is not necessarily the most physically remote point.

21. Occupancy-driven based on:

a. Estimated fire size.

b. Predicted number of operating sprinklers.

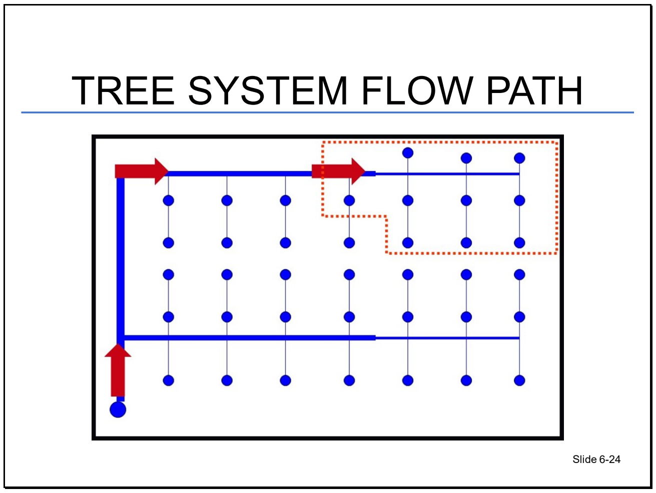


22. Floor area that is most hydraulically remote due to:

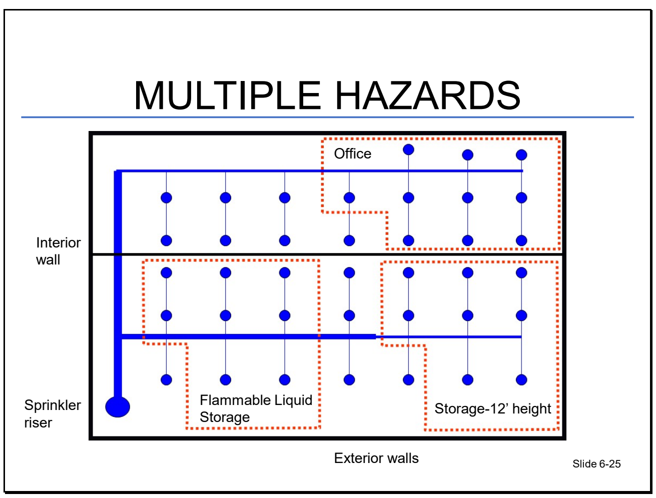
    a. Friction loss (pipe diameters).

    b. Water flow demand (hazard based).

    c. Elevation (location aboveground).

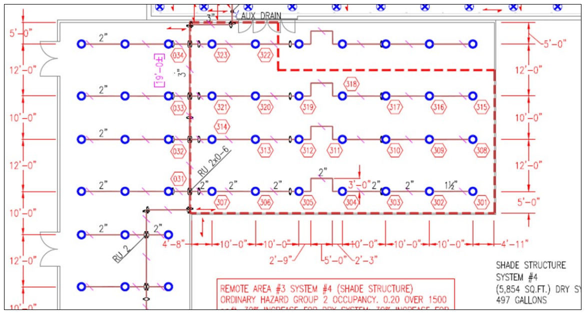


B. Tree system flow path.



C. Multiple remote areas: Depending upon pipe diameters, the most physically remote area may not be the most demanding.

TREE SYSTEM EXAMPLE



Slide 6-26

D. Tree system example.

III. IDENTIFY THE DESIGN HAZARD CLASSIFICATION

IDENTIFY THE DESIGN HAZARD CLASSIFICATION

Task	Tool
Identify the design hazard classification.	NFPA 13 and Unit 2: Hazard Classification.
Identify the remote area and modifications.	Density area chart.
Measure sprinkler spacing.	Maximum sprinkler spacing chart.
Verify number of sprinklers in remote area.	Formula: Demand area of coverage divided by sprinkler coverage.
Verify the size of the rectangular demand area.	Formula: 1.2 times the square root of the demand area.
Determine number of sprinklers on branch line.	Formula: Length of rectangle divided by sprinkler spacing.
Verify adequate density is being discharged.	Formula: Sprinkler flow divided by area per sprinkler.
Verify flow from remote sprinkler.	Formula: K-factor multiplied by square root of sprinkler pressure.
What is minimum flow demand for system?	Formula: Density times remote area.

Slide 6-27

Identify the design hazard classification using NFPA 13 and Unit 2: Hazard Classification.

A. Choices include:

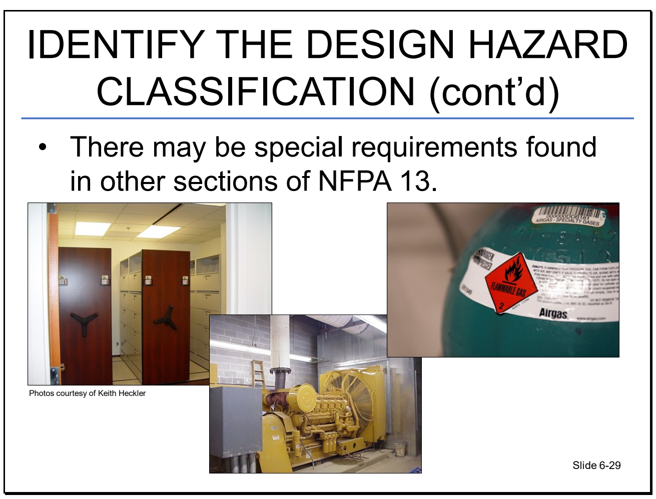
1. Light Hazard.

2. Ordinary Hazard, Group 1.

3. Ordinary Hazard, Group 2.

4. Extra Hazard, Group 1.

5. Extra Hazard, Group 2.



B. There may be special requirements found in other sections of NFPA 13.

Separate standards have distinctive sprinkler performance requirements. NFPA 13 has a chapter for special designs that is intended to expand upon these requirements.

IV. IDENTIFY REMOTE AREA AND MODIFICATIONS

IDENTIFY REMOTE AREA AND MODIFICATIONS

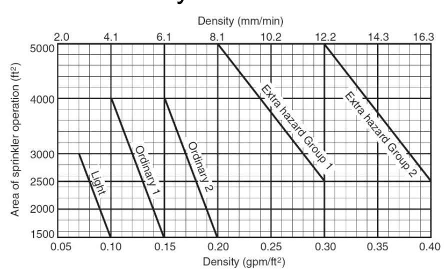
Task	Tool
Identify the design hazard classification.	NFPA 13 and Unit 2.
Identify the remote area and modifications.	Density area chart.
Measure sprinkler spacing.	Maximum sprinkler spacing chart.
Verify number of sprinklers in remote area.	Formula: Demand area of coverage divided by sprinkler coverage.
Verify the size of the rectangular demand area.	Formula: 1.2 times the square root of the demand area.
Determine number of sprinklers on branch line.	Formula: Length of rectangle divided by sprinkler spacing.
Verify adequate density is being discharged.	Formula: Sprinkler flow divided by area per sprinkler.
Verify flow from remote sprinkler.	Formula: K-factor multiplied by square root of sprinkler pressure.
What is minimum flow demand for system?	Formula: Density times remote area.

Slide 6-30

A. Determine the most demanding area and remote area modification using the density chart.

IDENTIFY REMOTE AREA AND MODIFICATIONS (cont'd)

- Density/Area curve method dictates the water necessary.

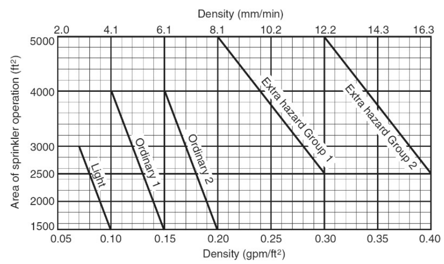


Slide 6-31

1. Density/Area curve method dictates the water necessary.

IDENTIFY REMOTE AREA AND MODIFICATIONS (cont'd)

- With the hazard classification, find the bold line with its classification.

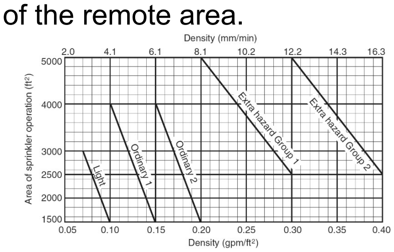


Slide 6-32

2. With the hazard classification, find the bold line with its classification.

IDENTIFY REMOTE AREA AND MODIFICATIONS (cont'd)

- To read the point chosen on the line, upward/downward indicates the amount of water required to be discharged per square foot of the remote area.

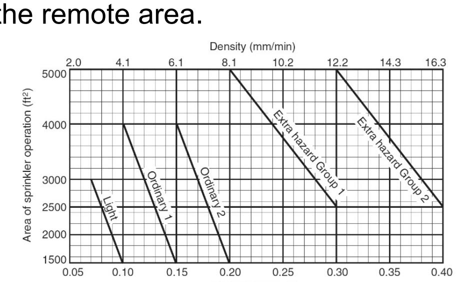


Slide 6-33

3. To read the point chosen on the line, upward/downward indicates the amount of water required to be discharged per square foot of remote area.

IDENTIFY REMOTE AREA AND MODIFICATIONS (cont'd)

- To the sides indicates the minimum size of the remote area.

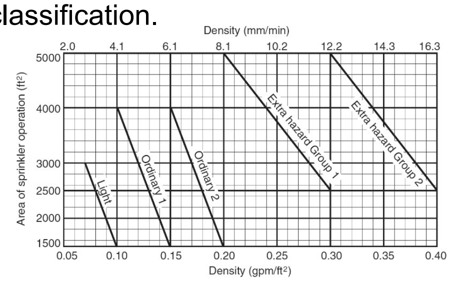


Slide 6-34

4. To the sides indicates the minimum size of the remote area.

IDENTIFY REMOTE AREA AND MODIFICATIONS (cont'd)

- Any point on the curve on the chart can be used with the appropriate hazard classification.

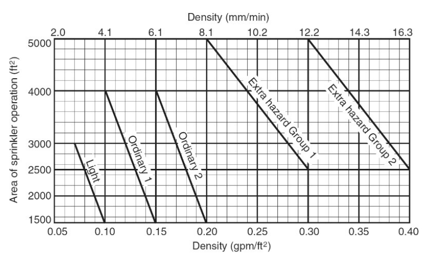


Slide 6-35

5. Any point on the curve on the chart can be used with the appropriate hazard classification.

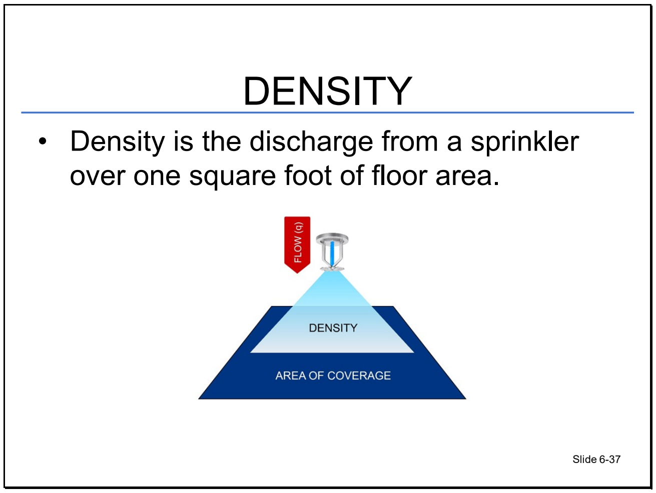
IDENTIFY REMOTE AREA AND MODIFICATIONS (cont'd)

- Using the greatest density and the smallest area of coverage is usually found to be the most economical.



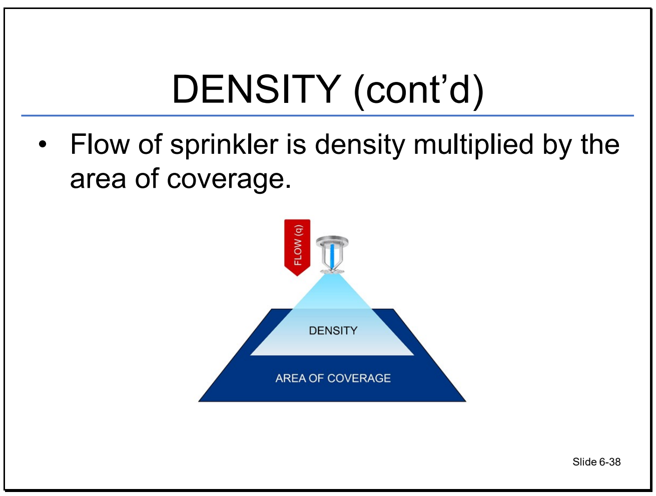
Slide 6-36

6. Using the greatest density and the smallest area of coverage is usually found to be the most economical.

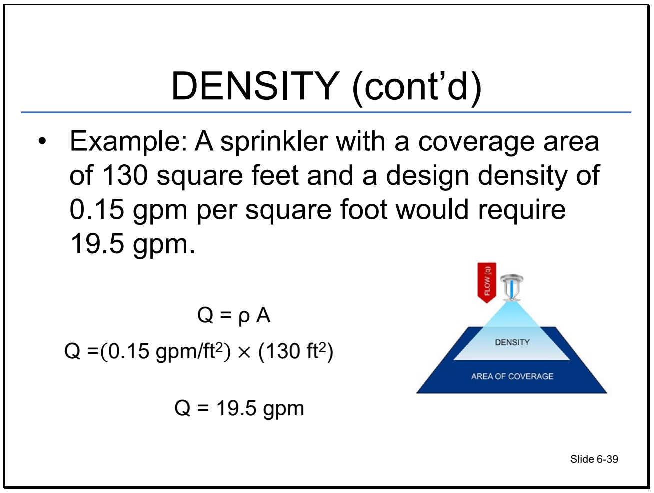


7. Density.

   a. Density is the discharge from a sprinkler over one square foot of floor area.



   b. Flow of sprinkler is density multiplied by the area of coverage.

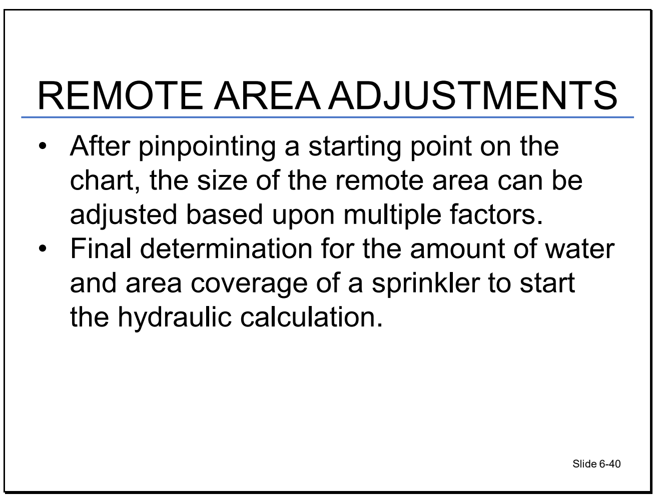


c. Example: A sprinkler with a coverage area of 130 square feet and a design density of 0.15 gallons per minute (gpm) per square foot would require 19.5 gpm.

$Q = \rho A$

$Q = (0.15\ \text{gpm/ft}^2) \times (130\ \text{ft}^2)$

$Q = 19.5$ gpm



8. Remote area adjustments.

a. After pinpointing a starting point on the chart, the size of the remote area can be adjusted based upon multiple factors.

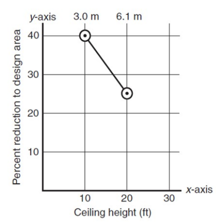
b. Final determination for the amount of water and area coverage of a sprinkler to start the hydraulic calculation.

c. Examples of universally accepted nomenclature:

- 0.1/1,500 (0.1 gpm/ft^2 over 1,500 ft^2).
- 0.15/1,500 (0.15 gpm/ft^2 over 1,500 ft^2).
- 0.3/2,500 (0.3 gpm/ft^2 over 2,500 ft^2).

REMOTE AREA ADJUSTMENTS (cont'd)

- Design area may be reduced:
  - Quick-response sprinkler (QRS).
  - Wet pipe system.
  - Light Hazard or Ordinary Hazard.
  - 20-foot ceiling height.
  - No unprotected ceiling pockets greater than 32 square feet.



Slide 6-41

d. Design area may be reduced by a specified percentage when all of the following conditions exist:

- Quick-response sprinklers (QRSs).
- Only wet pipe system.
- Only Light Hazard or Ordinary Hazard occupancies.
- Maximum 20-foot ceiling height.
- No unprotected ceiling pockets greater than 32 square feet.
  - According to NFPA 13, a ceiling pocket is "an architectural ceiling feature that consists of a bounded area of ceiling located at a higher elevation than the attached lower ceiling" (NFPA, 2019, section 3.3.25).

REMOTE AREA ADJUSTMENTS (cont'd)

- Use formula for exact dimensions.

$$y = \frac{-3x}{2} + 55 \text{ (US)}$$

$$y = -4.8x + 54.6 \text{ (SI)}$$

Slide 6-42

e. Use formula for exact dimensions.

- (y = ceiling height; x = reduction)
- $y = (-3x)/2 + 55$ (US)
- $y = -4.8x + 54.6$ (SI)

REMOTE AREA ADJUSTMENTS (cont'd)

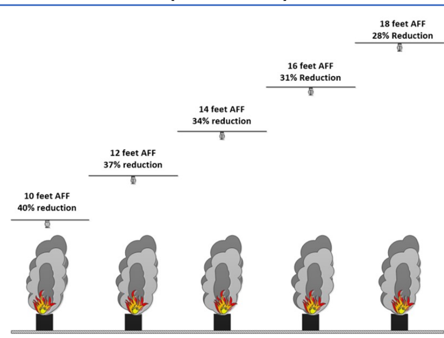


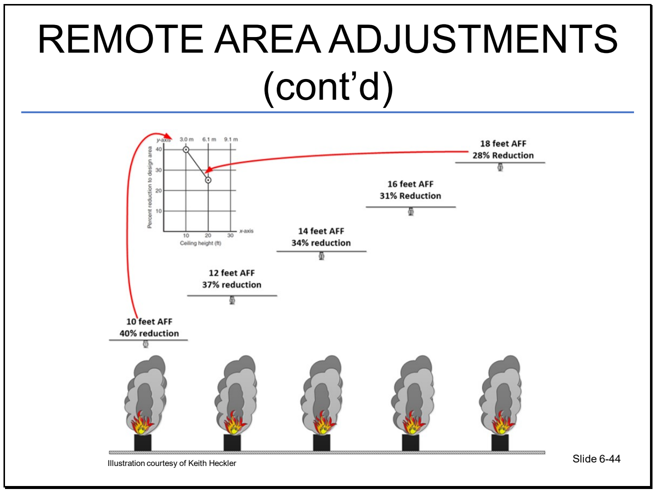
Illustration courtesy of Keith Heckler

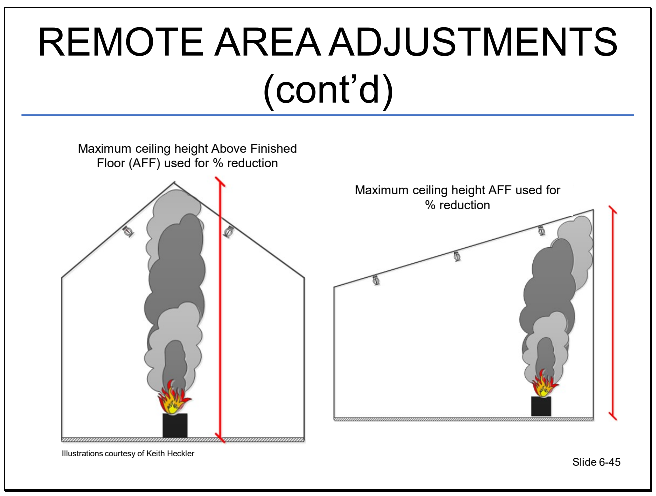
Slide 6-43

f. Different ceiling heights associated with the proximity to the fire.

- With the closer distance, the QRSs will be exposed to elevated temperatures of the fire plume at an earlier stage of the fire.
- A comparative study of standard response with QRSs found that fewer QRSs activated for the same fire.

- With the fire in an incipient stage, a lesser number of sprinklers will activate, thus allowing a smaller remote area to be designed.



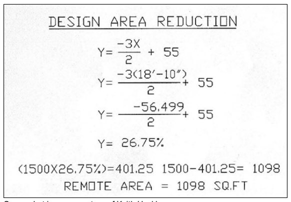


g. The reduction for sloped ceilings is based upon the maximum ceiling height located within the space.

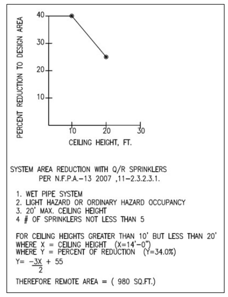
The high point will collect the heated gases and bank its way downward. The height of the sprinklers is not of concern; only the maximum height of the ceiling peak is.

REMOTE AREA ADJUSTMENTS (cont'd)

- Calculation is not required to be shown, but is useful.



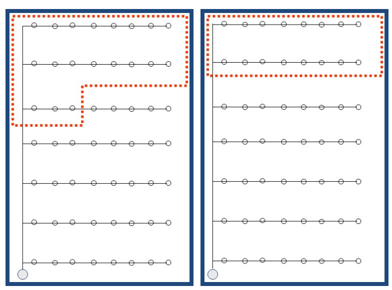
Screenshot images courtesy of Keith Heckler



Slide 6-46

h. Calculation is not required to be shown, but is useful.

Why would a designer want smaller area?



Slide 6-47

QUICK RESPONSE REDUCTION EXAMPLE

- Given:
  - Furniture store.
  - Wet pipe system.
  - Ordinary Hazard, Group 2 (0.2 gpm over 1,500 square feet).
  - Flat, horizontal acoustical ceiling tile (ACT) height of 12 feet, 0 inches.
- Can the remote area be adjusted, and if so, what is the new size?

Slide 6-48

9. Quick response reduction example.

a. Given:

- Furniture store.
- Wet pipe system.
- Ordinary Hazard, Group 2 (0.2 gpm over 1,500 square feet).
- Flat, horizontal acoustical ceiling tile (ACT) height of 12 feet, 0 inches.

b. Can the remote area be adjusted, and if so, what is the new size?

QUICK RESPONSE REDUCTION EXAMPLE (cont'd)

Ask yourself…	Yes	No
Is the sprinkler system a wet pipe system?	✓	
Is the hazard Light or Ordinary?	✓	
Is the ceiling 20 feet in height or less?	✓	
Are there no unprotected pockets greater than 32 square feet?	✓	

Slide 6-49

c. Ask yourself:

- Is the sprinkler system a wet pipe system?
- Is the hazard Light or Ordinary?
- Is the ceiling 20 feet in height or less?
- Are there no unprotected pockets greater than 32 square feet?

QUICK RESPONSE REDUCTION EXAMPLE (cont'd)

$$y = \frac{-3x}{2} + 55$$

(x = height of the ceiling)

$$y = \frac{-3\ (12\ \text{ft})}{2} + 55$$

$$y = \frac{-36}{2} + 55$$

$$y = -18 + 55$$

Slide 6-50

$y = (–3x)/2 + 55$

(x = height of the ceiling)

$y = (–3\ (12\ \text{ft}))/2 + 55$

$y = (–36)/2 + 55$

QUICK RESPONSE REDUCTION EXAMPLE (cont'd)

$$y = -18 + 55$$

(y = 37% reduction)

$$1{,}500\ \text{ft}^2 \times \frac{37}{100} = 555\ \text{ft}^2\ \text{reduction}$$

$$1{,}500\ \text{ft}^2 - 555\ \text{ft}^2 = 945\ \text{ft}^2$$

Adjusted remote area = 945 ft^2

Slide 6-51

$y = –18 + 55$

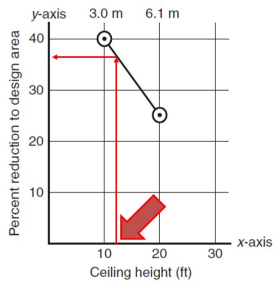
(y = 37% reduction)

1,500 ft^2 x 37/100 = 555 ft^2 reduction

1,500 ft^2 – 555 ft^2 = 945 ft^2

Adjusted remote area = 945 ft^2

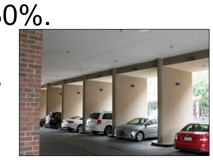
QUICK RESPONSE REDUCTION EXAMPLE (cont'd)

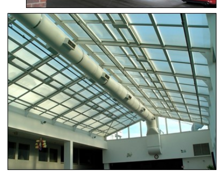


Slide 6-52

REMOTE AREA MODIFICATIONS

- Increase remote area by 30%.
  - Dry pipe and double interlock sprinkler systems.
  - Non-storage occupancies with ceilings sloped more than 1:6 (2 inches in 12 inches) when using spray, extended coverage, quick response or large drop sprinklers.





Photos courtesy of Keith Heckler

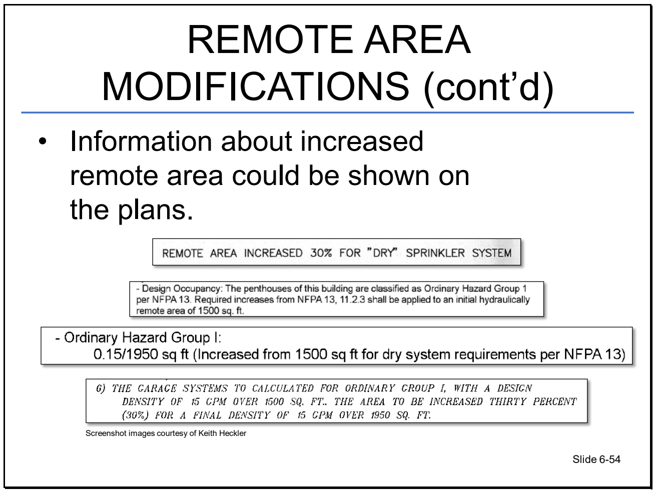
Slide 6-53

B. Remote area modifications.

1. Increase remote area by 30%.

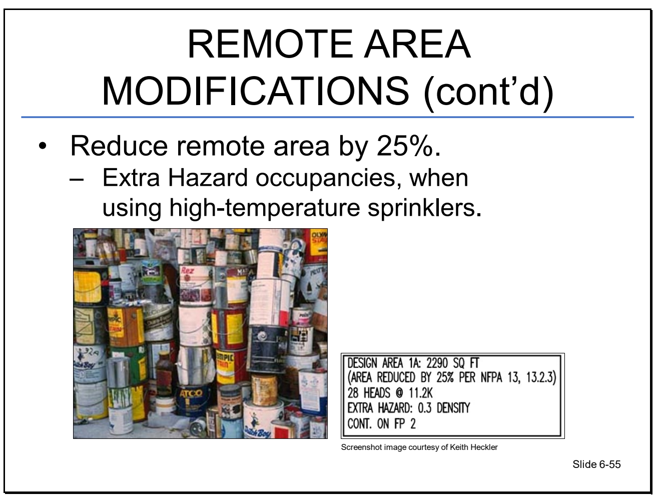
   a. Dry pipe and double interlock sprinkler systems.

   b. Non-storage occupancies with ceilings sloped more than 1:6 (2 inches in 12 inches) when using spray, extended coverage, quick response or large drop sprinklers.



2. Information about an increased remote area could be shown on the plans.

A designer may provide information as to why the remote area was increased. NFPA 13 does not require the designer to provide this information, but it may be introduced in many different forms on the plans.



3. Reduce remote area by 25%.

Extra Hazard occupancies, when using high-temperature sprinklers.

a. Not less than 2,000 square feet.

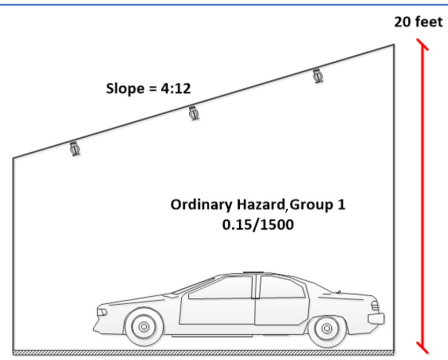
b. Do not revise density.

REMOTE AREA MODIFICATION EXAMPLE 1

- Given:
  - Car dealership showroom.
  - Wet pipe system.
  - Ordinary Hazard, Group 1 (0.15 gpm over 1,500 square feet).
  - Sloped roof heights up to peak of 20 feet.
  - The angle of the slope is 4:12.
- Are modifications required, and if so, what is the new remote area size?

Slide 6-56

REMOTE AREA MODIFICATION EXAMPLE 1 (cont'd)



Slide 6-57

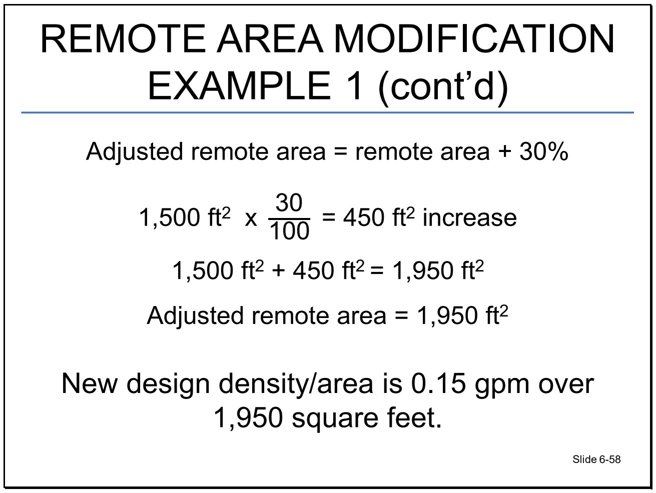
4. Remote area modification example 1.

a. Given:

- Car dealership showroom.
- Wet pipe system.
- Ordinary Hazard, Group 1 (0.15 gpm over 1,500 square feet).
- Sloped roof heights up to peak of 20 feet.
- The angle of the slope is 4:12.

b. Are modifications required, and if so, what is the new remote area size?

- The 0.15 density was chosen along the Ordinary Hazard design line with the smallest remote area. Typically, designers will use the smallest design area but with the largest gallons per square foot.



- Adjusted remote area equals remote area plus 30% of original remote area size.

- Remember that this is Ordinary Hazard, Group 1 (0.15 gpm over **1,500** square feet), and **30% of the remote area chosen** is required for a dry system.

Adjusted remote area = remote area + 30%

1,500 ft^2 x 30/100 = 450 ft^2 increase

1,500 ft^2 + 450 ft^2 = 1,950 ft^2

Adjusted remote area = 1,950 ft^2

New design density/area is 0.15 gpm over 1,950 square feet.

5. Remote area modification example 2.

a. Given:

- Storage area in laboratory.
- Wet pipe system.
- Extra Hazard, Group 1 (0.3 gpm over 2,500 square feet).
- Class A plastics storage height of 10 feet, 0 inches.
- High-temperature sprinklers (286 F).

b. Can the remote area be adjusted, and if so, what is the new remote area size?

- Remember that it is Extra Hazard, Group 1 (0.3 gpm over **2,500** square feet), and **25%** could be used for an Extra Hazard remote area equipped with high-temperature sprinklers. Remember that reductions are voluntary and not required. Increases are required.

  2,500 ft^2 x 25/100 = 625 ft^2 decrease

  2,500 ft^2 – 625 ft^2 = 1,875 ft^2

  Adjusted remote area = 1,875 ft^2

  New design density/area is 0.30 gpm over 1,875 square feet.

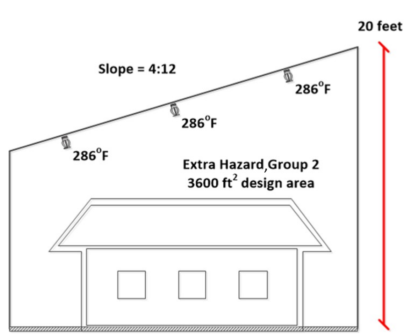
c. Extra Hazard remote area can never be less than 2,000 square feet, therefore, the new design density/area is 0.30 gpm over 2,000 square feet. The remote area cannot be adjusted in this example.

COMPOUNDING EXAMPLE

- All remote area adjustments may be compounded.
- Given:
  - Modular home builder.
  - Extra Hazard, Group 2.
  - Wet pipe system.
  - Slope roof with height up to 20 feet AFF.
  - The angle of the slope is 4:12.
  - High-temperature sprinklers (286 F).
  - Selected area of application: 3,600 square feet.

Slide 6-61

COMPOUNDING EXAMPLE (cont'd)



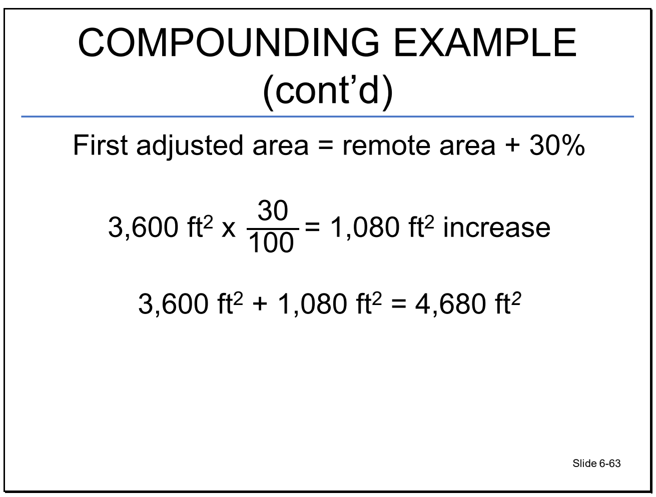
Slide 6-62

6. Compounding example.

   a. All remote area adjustments may be compounded.

   b. Given:

      - Modular home builder.
      - Extra Hazard, Group 2.
      - Wet pipe system.
      - Sloped roof heights up to peak of 20 feet.
      - The angle of the slope is 4:12.
      - High-temperature sprinklers (286 F).
      - Selected area of application: 3,600 square feet.



First adjusted area = remote area + 30%

$3{,}600\ ft^2 \times 30/100 = 1{,}080\ ft^2$ increase

$3{,}600\ ft^2 + 1{,}080\ ft^2 = 4{,}680\ ft^2$

COMPOUNDING EXAMPLE (cont'd)

Second adjusted area

= first adjusted area − 25%

$4{,}680\ ft^2 \times \frac{25}{100} = 1{,}170\ ft^2$ decrease

$4{,}680\ ft^2 - 1{,}170\ ft^2 = 3{,}510\ ft^2$

Final adjusted remote area = $3{,}510\ ft^2$

Slide 6-64

Second adjusted area = first adjusted area – 25%

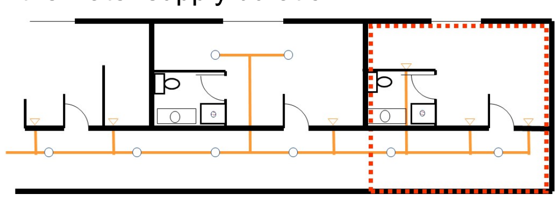
4.680 ft^2 x 25/100 = 1,170 ft^2 decrease

4,680 ft^2 – 1,170 ft^2 = 3,510 ft^2

Final adjusted remote area = 3,510 ft^2

ROOM DESIGN METHOD

- Based on the largest room.
- Enclosures and openings must be protected to a fire resistance rating equal to the water supply duration.

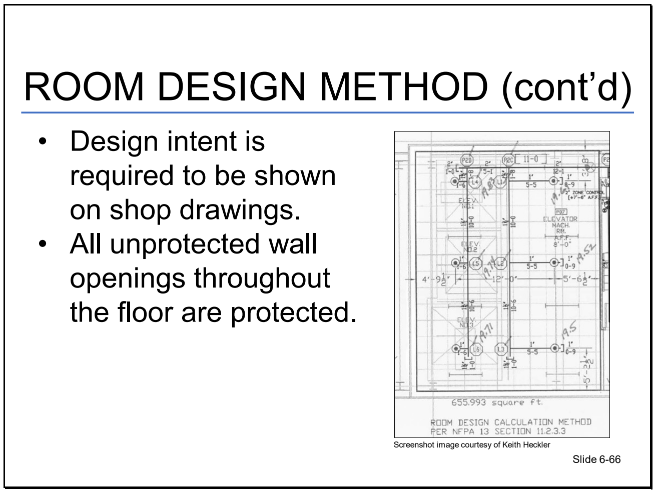


Slide 6-65

7. Room design method.

   a. Based on the largest room.

   b. Enclosures and the opening must be protected to a fire resistance rating equal to the water supply duration.



c. Design intent is required to be shown on shop drawings.

d. All unprotected wall openings throughout the floor are protected.

ACTIVITY 6.1

Verifying Adjusted Remote Areas

Purpose

Verify the appropriateness of the adjusted remote areas in the listed descriptions.

Directions

1. Read the following scenarios.
2. The instructor will walk through the first two scenarios with the class.
3. Make the appropriate adjustments to the remote area if any are due.
4. Responses should be whole numbers — no decimals or partial numbers. Your results should be within a margin of error of plus or minus 5%.
5. The instructor will review the correct answers with the class after the answers have been graded and provided back to you.

Scenarios

1. A school has a gymnasium that is designed for Light Hazard. The density is 0.1 over 1,500 square feet with QRSs. There is no ACT, and the roof structure is exposed at 22 feet, 0 inches. The roof is horizontal and flat with skylights and open steel bar joists. Can the remote area be adjusted, and if so, what is the area size?

   ____

   ____

   ____

2. In a church's sanctuary, the architectural feature has a sloped ceiling of 4 inches height for every 12 inches horizontally. The peak of the ceiling is 25 feet Above Finished Floor (AFF). The sanctuary is deemed to be Light Hazard with a 0.1 over 1,500 square feet design. QRSs will be installed with a wet pipe system. Are modifications required, and if so, what is the new remote area size?

   ____

   ____

   ____

3. An old warehouse is converted to an office building of Type 5B construction. The minimum roof height is 21 feet. A wet sprinkler system with QRSs is installed with a Light Hazard design of 0.1 over 1,500 square feet. The roof slope above the office spaces is 4:12 pitch. Are modifications required, and if so, what is the new remote area size?

____

____

____

4. At a car dealership's maintenance area, a wet system is installed for Ordinary Hazard, Group 1 design of 0.15 over 1,500 square feet. QRSs are installed. There is no drop ceiling, leaving the floor open to the roof deck. The gable roof is sloped from its exterior wall of 14 feet, 9 inches. The ceiling is 18 feet, 7 inches AFF at its midpoint peak and back down to 14 feet, 9 inches AFF at the opposite exterior wall. The width between the exterior walls is 66 feet, 0 inches. Can the remote area be adjusted, and if so, what is the new remote area size?

____

____

____

5. An outpatient urgent care facility has a wet pipe sprinkler system installed with QRSs and an ACT of 8 feet, 0 inches AFF. The design is for the Light Hazard of 0.1 over 1,500 square feet. Can the remote area be adjusted, and if so, what is the new remote area size?

____

____

____

6. The city woodshop has a wet pipe system designed as Ordinary Hazard, Group 2. The shop area is open to the roof deck located at 18 feet, 4 inches AFF with QRSs. Can the remote area be adjusted, and if so, what percentage is the reduction?

____

____

____

7. A restaurant of Type 5 construction has a dry system installed throughout the building. The design in the dining room is Light Hazard with 0.1 over 1,500 square feet with QRSs. The slope of the open roof deck to the dining area is 7:12. Are modifications required, and if so, what is the new remote area size?

____

____

____

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V. MEASURE SPRINKLER SPACING

MEASURE SPRINKLER SPACING

Task	Tool
Identify the design hazard classification.	NFPA 13 and Unit 2.
Identify the remote area and modifications.	Density area chart.
Measure sprinkler spacing.	Maximum sprinkler spacing chart.
Verify number of sprinklers in remote area.	Formula: Demand area of coverage divided by sprinkler coverage.
Verify the size of the rectangular demand area.	Formula: 1.2 times the square root of the demand area.
Determine number of sprinklers on branch line.	Formula: Length of rectangle divided by sprinkler spacing.
Verify adequate density is being discharged.	Formula: Sprinkler flow divided by area per sprinkler.
Verify flow from remote sprinkler.	Formula: K-factor multiplied by square root of sprinkler pressure.
What is minimum flow demand for system?	Formula: Density times remote area.

Slide 6-68

Measure sprinkler spacing using maximum sprinkler spacing chart.

MEASURE SPRINKLER SPACING (cont'd)

- Spacing of sprinklers.
  - Determined by the designer.
  - Configure the most economical way within the rules and tables in NFPA 13.
  - Conform to the sprinkler coverage chart according to hazard classification.

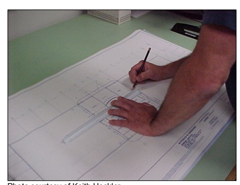


Photo courtesy of Keith Heckler

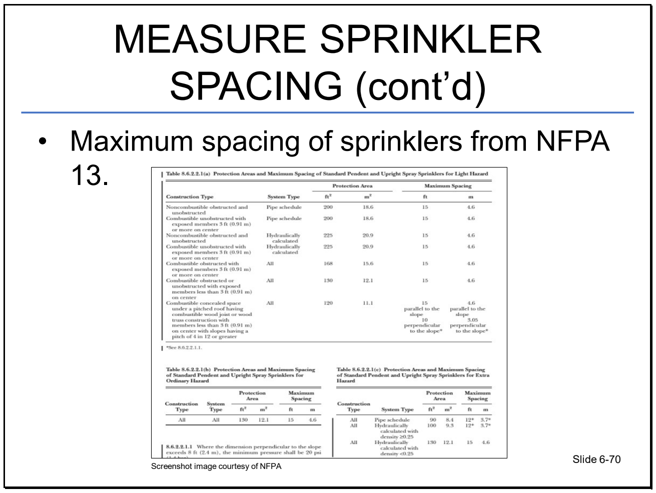
Slide 6-69

A. Determine the location of first standard sprinkler. Spacing of sprinklers:

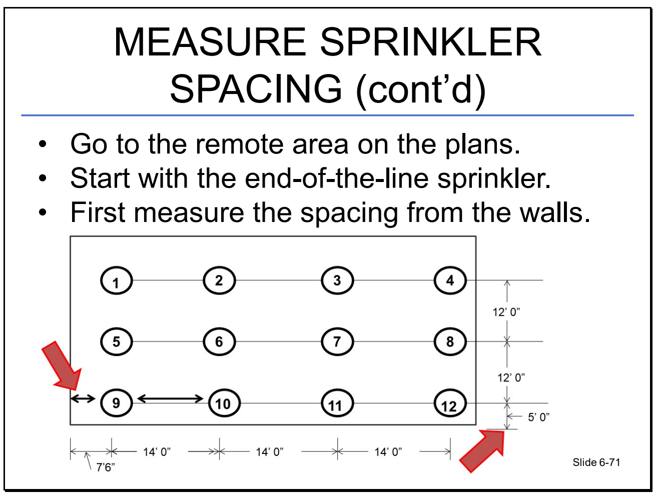
1. Determined by the designer.

2. Configure the most economical way within the rules and tables in NFPA 13.

3. Conform to the sprinkler coverage chart according to hazard classification.



B. Maximum spacing of sprinklers from NFPA 13.



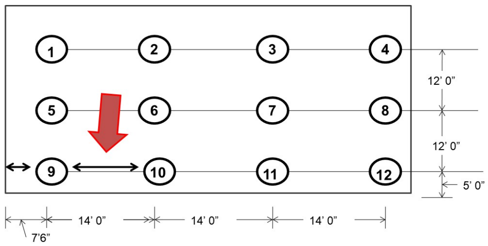
C. Go to the remote area on the plans.

D. Start with the end-of-the-line sprinkler.

E. First measure the spacing from the walls.

MEASURE SPRINKLER SPACING (cont'd)

- Then check the spacing of sprinklers on the branch lines.

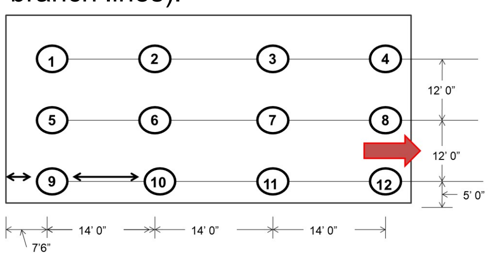


Slide 6-72

F. Then check the spacing of sprinklers on the branch lines.

MEASURE SPRINKLER SPACING (cont'd)

- Check the distance in the other direction (no more than half the spacing between branch lines).



Slide 6-73

G. Check the distance in the other direction (no more than half the spacing between branch lines).

MEASURE SPRINKLER SPACING (cont'd)

- Calculate the spacing.

$$A_S = S \times L$$

S = Greater of two times distance to wall or distance to next sprinkler

L = Greater of two times distance to wall or distance to next branchline

$$A_S = (2 \times 7\text{ ft } 6\text{ in}) \times 12\text{ ft } 0\text{ in}$$

$$A_S = 15\text{ ft} \times 12\text{ ft}$$

$$A_S = 180\text{ ft}^2$$

Slide 6-74

H. Calculate the spacing.

1. S = Greater of two times distance to wall or distance to next sprinkler.

2. L = Greater of two times distance to wall or distance to next branchline.

$A_s = S \times L$

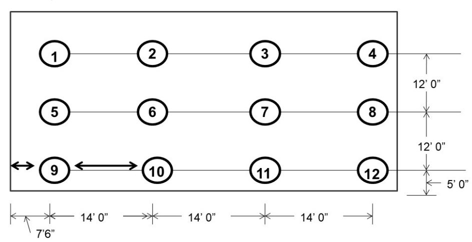
$A_s = (2 \times 7 \text{ ft } 6 \text{ in}) \times 12 \text{ ft } 0 \text{ in}$

$A_s = 15 \text{ ft} \times 12 \text{ ft}$

$A_s = 180 \text{ ft}^2$

MEASURE SPRINKLER SPACING (cont'd)

- Check the spacing for the remainder of the remote area and then all of the sprinklers in the system.



Slide 6-75

I. Check the spacing for the remainder of the remote area and then all of the sprinklers in the system.

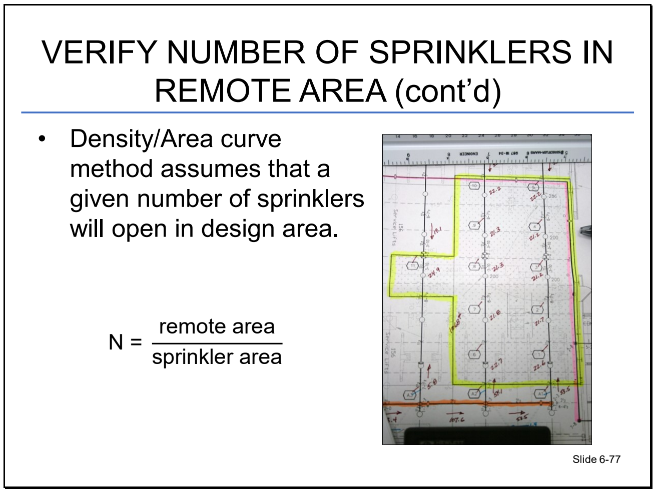
VI. VERIFY NUMBER OF SPRINKLERS IN REMOTE AREA

VERIFY NUMBER OF SPRINKLERS IN REMOTE AREA

Task	Tool
Identify the design hazard classification.	NFPA 13 and Unit 2.
Identify the remote area and modifications.	Density area chart.
Measure sprinkler spacing.	Maximum sprinkler spacing chart.
Verify number of sprinklers in remote area.	Formula: Demand area of coverage divided by sprinkler coverage.
Verify the size of the rectangular demand area.	Formula: 1.2 times the square root of the demand area.
Determine number of sprinklers on branch line.	Formula: Length of rectangle divided by sprinkler spacing.
Verify adequate density is being discharged.	Formula: Sprinkler flow divided by area per sprinkler.
Verify flow from remote sprinkler.	Formula: K-factor multiplied by square root of sprinkler pressure.
What is minimum flow demand for system?	Formula: Density times remote area.

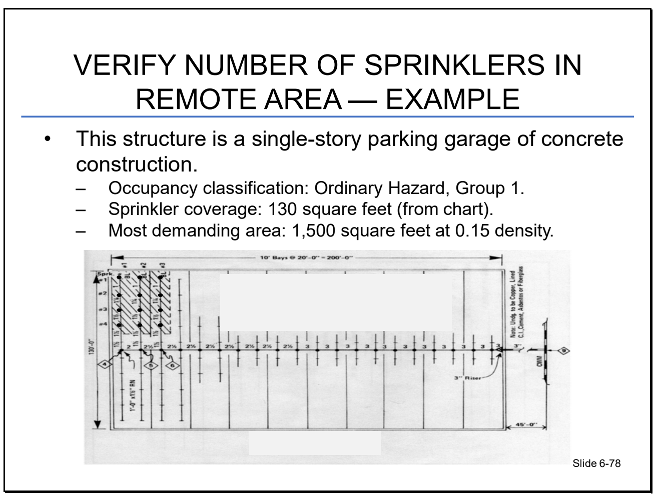
Slide 6-76

Verify number of sprinklers in remote area using the formula of demand area of coverage divided by sprinkler coverage.



A. Density/Area curve method assumes that a given number of sprinklers will open in the design area.

N = remote area/sprinkler area



B. Example: This structure is a single-story parking garage of concrete construction.

1. Occupancy classification: Ordinary Hazard, Group 1.

2. Sprinkler coverage: 130 square feet (from chart).

3. Most demanding area: 1,500 square feet at 0.15 density.

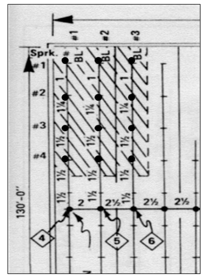
VERIFY NUMBER OF SPRINKLERS IN REMOTE AREA — EXAMPLE (cont'd)

- Calculate the number of sprinklers in the design area.

$$N = \frac{\text{remote area}}{\text{sprinkler area}}$$

$$N = \frac{1,500 \text{ ft}^2}{130 \text{ ft}^2}$$

N = 11.54 sprinklers → 12 sprinklers



Slide 6-79

C. Calculate the number of sprinklers in the design area.

N = remote area/sprinkler area

N = 1,500 ft^2/130 ft^2

N = 1,500/130 = 11.54 or, after rounding up, 12 sprinklers to calculate.

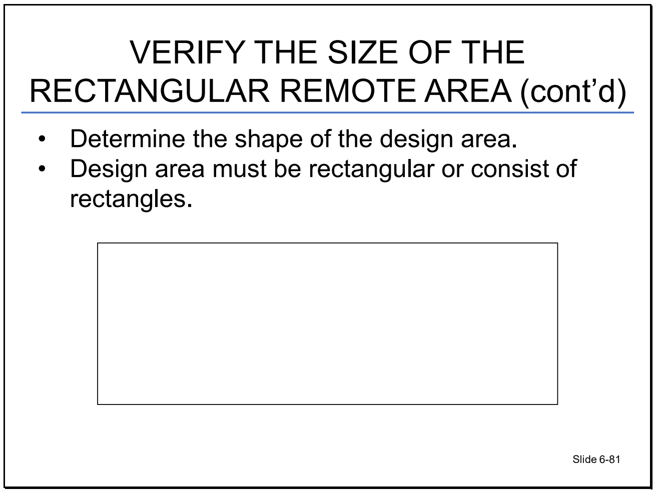
VII. VERIFY THE SIZE OF THE RECTANGULAR DEMAND AREA

VERIFY THE SIZE OF THE RECTANGULAR REMOTE AREA

Task	Tool
Identify the design hazard classification.	NFPA 13 and Unit 2.
Identify the remote area and modifications.	Density area chart.
Measure sprinkler spacing.	Maximum sprinkler spacing chart.
Verify number of sprinklers in remote area.	Formula: Demand area of coverage divided by sprinkler coverage.
Verify the size of the rectangular demand area.	Formula: 1.2 times the square root of the demand area.
Determine number of sprinklers on branch line.	Formula: Length of rectangle divided by sprinkler spacing.
Verify adequate density is being discharged.	Formula: Sprinkler flow divided by area per sprinkler.
Verify flow from remote sprinkler.	Formula: K-factor multiplied by square root of sprinkler pressure.
What is minimum flow demand for system?	Formula: Density times remote area.

Slide 6-80

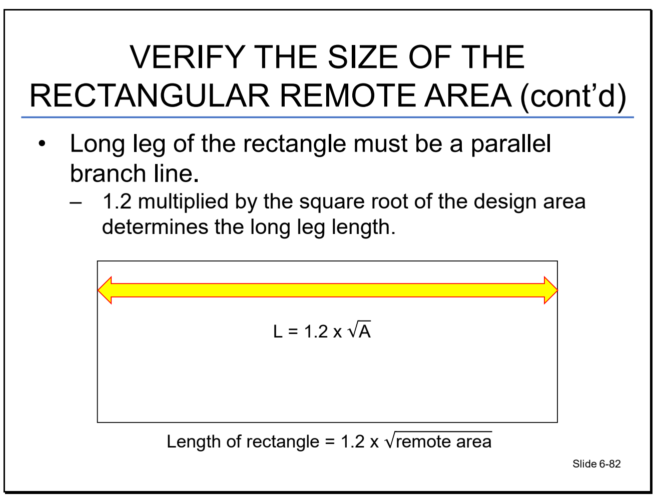
Verify the size of the rectangular demand area using the formula of 1.2 times the square root of the demand area.



A. Determine the shape of the design area.

B. Design area must be rectangular or consist of rectangles.

A rectangle is used because it is longer in the dimension parallel. We have to account for the branch lines and for the possibility that a fire could spread in this direction and open multiple sprinklers on a single branch line before opening sprinklers on other branch lines.



C. Long leg of the rectangle must be parallel to the branch lines.

1. 1.2 multiplied by the square root of the design area determines the long leg length.

2. Length of rectangle = 1.2 x √remote area.

   NFPA 13 defines the remote area as rectangular, so more sprinklers are defined to be operating on a branch line which makes it more demanding. NFPA 13 looks at the worst-case scenario.

VERIFY THE SIZE OF THE RECTANGULAR REMOTE AREA (cont'd)

- Creates the most demanding area because more sprinklers will be calculated on a branch line.
- Provides a minimum number of sprinklers on branch line to be calculated.
  - Calculation for the long side of the rectangle is not required to be shown on drawings.

Slide 6-83

3. This creates the most demanding area because more sprinklers will be calculated on a branch line.

4. Provides a minimum number of sprinklers on a branch line to be calculated.

   Calculation for the long side of the rectangle is not required to be shown on drawings.

VIII. DETERMINE NUMBER OF SPRINKLERS ON BRANCH LINE

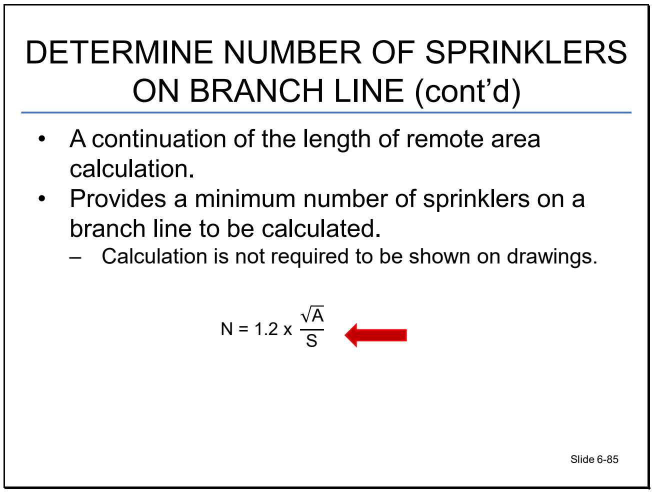
DETERMINE NUMBER OF SPRINKLERS ON BRANCH LINE

Task	Tool
Identify the design hazard classification.	NFPA 13 and Unit 2.
Identify the remote area and modifications.	Density area chart.
Measure sprinkler spacing.	Maximum sprinkler spacing chart.
Verify number of sprinklers in remote area.	Formula: Demand area of coverage divided by sprinkler coverage.
Verify the size of the rectangular demand area.	Formula: 1.2 times the square root of the demand area.
Determine number of sprinklers on branch line.	Formula: Length of rectangle divided by sprinkler spacing.
Verify adequate density is being discharged.	Formula: Sprinkler flow divided by area per sprinkler.
Verify flow from remote sprinkler.	Formula: K-factor multiplied by square root of sprinkler pressure.
What is minimum flow demand for system?	Formula: Density times remote area.

Slide 6-84

A. Determine if the location of the initial sprinkler is accurate and determine spacing using the formula of length of rectangle divided by sprinkler spacing.

B. When there are sprinklers above and below a drop ceiling, both are not added together because NFPA 13 states to consider sprinkler operation in only one of the protected areas. NFPA 13 states, "Water demand of sprinklers installed in concealed spaces shall not be required to be added to the ceiling demand" (NFPA, 2019, section 27.2.4.7.4). (The Learning Square restaurant plans show sprinklers above and below an acoustical ceiling.)

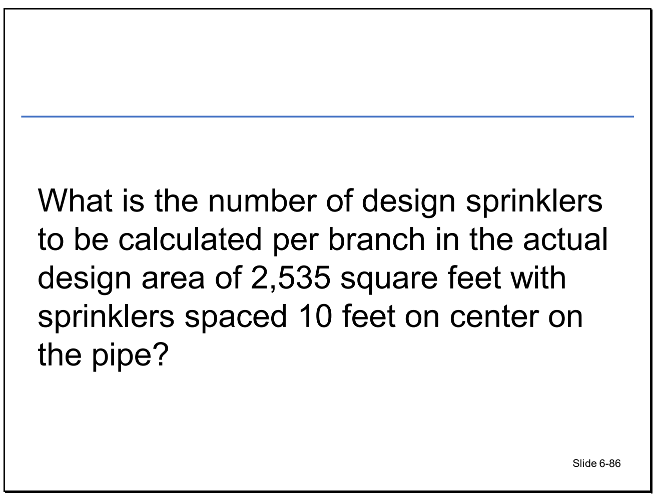


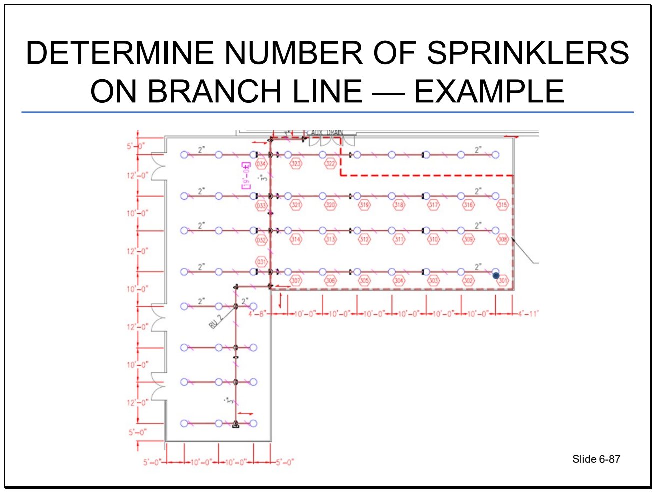
1. A continuation of the length of remote area calculation.

2. Provides a minimum number of sprinklers on branch line to be calculated.

   Calculation is not required to be shown on drawings.

   $N = 1.2 \times \sqrt{A}/S$





3. All this information has been chosen by the designer.

   a. Coverage area of 120 square feet.

   b. Sprinkler is spaced 4 feet, 11 inches by 5 feet, 0 inches from the corner.

   c. Less than one-half the maximum spacing of branch line and pipe spacing.

ACTIVITY 6.2

Determining the Minimum Length of Remote Area and the Minimum Number of Sprinklers in the Remote Area

Purpose

Practice determining the minimum length of remote area and the number of sprinklers appropriate in the remote area.

Directions

1. You will use a calculator for this activity.
2. Given the remote areas listed, calculate the minimum length of remote area in feet.
3. Calculate the minimum number of sprinklers required in the remote area.
4. Responses should be rounded to whole numbers.
5. The instructor will review the correct answers with the class after the answers have been graded and provided back.

	Remote area size	Minimum length	Area per sprinkler	Number of sprinklers required
1.	900		225	
2.	1,500		120	
3.	2,500		90	
4.	3,000		100	
5.	1,600		130	

OPTIONAL (not graded): If you require additional practice, calculate the minimum length of remote area and the minimum number of sprinklers required in the remote area for the following:

	Remote area size	Minimum length	Area per sprinkler	Number of sprinklers required
6.	1,200		126	
7.	2,250		80	
8.	1,035		196	
9.	1,080		168	
10.	2,000		125	

IX. VERIFY ADEQUATE DENSITY IS BEING DISCHARGED

VERIFY ADEQUATE DENSITY IS BEING DISCHARGED

Task	Tool
Identify the design hazard classification.	NFPA 13 and Unit 2.
Identify the remote area and modifications.	Density area chart.
Measure sprinkler spacing.	Maximum sprinkler spacing chart.
Verify number of sprinklers in remote area.	Formula: Demand area of coverage divided by sprinkler coverage.
Verify the size of the rectangular demand area.	Formula: 1.2 times the square root of the demand area.
Determine number of sprinklers on branch line.	Formula: Length of rectangle divided by sprinkler spacing.
Verify adequate density is being discharged.	Formula: Sprinkler flow divided by area per sprinkler.
Verify flow from remote sprinkler.	Formula: K-factor multiplied by square root of sprinkler pressure.
What is minimum flow demand for system?	Formula: Density times remote area.

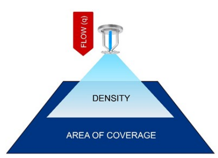
Slide 6-89

Verify adequate density is being discharged using the formula of sprinkler flow divided by area per sprinkler.

VERIFY ADEQUATE DENSITY IS BEING DISCHARGED (cont'd)

- Check the sprinklers in the remote area to verify that adequate density is being delivered.
  - Flow calculated.
  - Area of sprinkler.

$$\rho = \frac{Q \text{ (flow)}}{A \text{ (area of coverage)}}$$



Slide 6-90

A. Check the sprinklers in the remote area to verify that adequate density is being delivered.

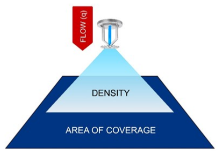
1. Flow calculated.

2. Area of sprinkler.

VERIFY ADEQUATE DENSITY IS BEING DISCHARGED (cont'd)

- Nothing to worry about! This equation is the same as before but rearranged!

$\rho = \frac{Q \text{ (flow)}}{A \text{ (area of coverage)}}$ $Q = \rho A$



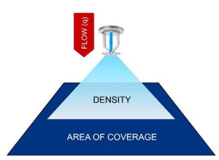
Slide 6-91

B. This equation is the same as before but rearranged.

ρ = Q (flow)/A (area of coverage)

Q = ρA

A sprinkler with a flow of 19.5 gpm with a coverage area of 130 square feet would provide what density?



Slide 6-92

X. VERIFY FLOW FROM REMOTE SPRINKLER

VERIFY FLOW FROM REMOTE SPRINKLER

Task	Tool
Identify the design hazard classification.	NFPA 13 and Unit 2.
Identify the remote area and modifications.	Density area chart.
Measure sprinkler spacing.	Maximum sprinkler spacing chart.
Verify number of sprinklers in remote area.	Formula: Demand area of coverage divided by sprinkler coverage.
Verify the size of the rectangular demand area.	Formula: 1.2 times the square root of the demand area.
Determine number of sprinklers on branch line.	Formula: Length of rectangle divided by sprinkler spacing.
Verify adequate density is being discharged.	Formula: Sprinkler flow divided by area per sprinkler.
Verify flow from remote sprinkler.	Formula: K-factor multiplied by square root of sprinkler pressure.
What is minimum flow demand for system?	Formula: Density times remote area.

Slide 6-93

Verify flow from a remote sprinkler using the formula of K-factor multiplied by square root of sprinkler pressure).

VERIFY FLOW FROM REMOTE SPRINKLER (cont'd)

- Check the most remote sprinkler to verify correct flow is being delivered.
  - K-factor.
  - Pressure.
- Remember: $Q = K\sqrt{P}$ where:
  - Q = gpm.
  - K = sprinkler K-factor.
  - P = flowing pressure.

Slide 6-94

A. Check the most remote sprinkler to verify that the correct flow is being delivered.

1. K-factor.

2. Pressure.

B. Remember that $Q = K\sqrt{P}$ where:

1. Q = gpm.

2. K = sprinkler K-factor.

3. P = flowing pressure.

XI. WHAT IS MINIMUM FLOW DEMAND FOR SYSTEM?

WHAT IS MINIMUM FLOW DEMAND FOR SYSTEM?

Task	Tool
Identify the design hazard classification.	NFPA 13 and Unit 2.
Identify the remote area and modifications.	Density area chart.
Measure sprinkler spacing.	Maximum sprinkler spacing chart.
Verify number of sprinklers in remote area.	Formula: Demand area of coverage divided by sprinkler coverage.
Verify the size of the rectangular demand area.	Formula: 1.2 times the square root of the demand area.
Determine number of sprinklers on branch line.	Formula: Length of rectangle divided by sprinkler spacing.
Verify adequate density is being discharged.	Formula: Sprinkler flow divided by area per sprinkler.
Verify flow from remote sprinkler.	Formula: K-factor multiplied by square root of sprinkler pressure.
What is minimum flow demand for system?	Formula: Density times remote area.

Slide 6-95

What is the minimum flow demand for the system? Use the formula of density times remote area.

WHAT IS MINIMUM FLOW DEMAND FOR SYSTEM? (cont'd)

- What is the density for the remote area?
- What is the size of the remote area?
  - This calculation is associated with how much water is needed for all of the sprinklers operating in the remote area at the same time.
  - It is a minimum needed.

Total flow = (density) x (remote area)

Slide 6-96

A. What is the density for the remote area?

B. What is the size of the remote area?

1. This calculation is associated with how much water is needed for all of the sprinklers operating in the remote area at the same time.

2. It is a minimum needed.

Total flow = (density) x (remote area)

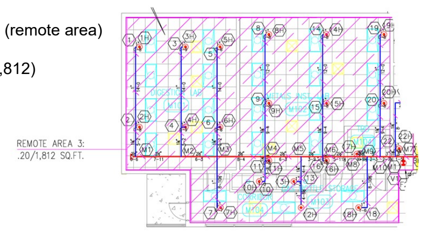
WHAT IS MINIMUM FLOW DEMAND FOR SYSTEM? — EXAMPLE

- 0.20 gpm per square foot over 1,812 square feet.

Total flow = (density) x (remote area)

Total flow = (0.20) x (1,812)

Total flow = 362.4 gpm



Slide 6-97

C. 0.20 gpm per square foot over 1,812 square feet.

Total flow = (density) x (remote area)

Total flow = 0.20 x 1,812

Total flow = 362.4 gpm

XII. SUMMARY

FEMA

SUMMARY

U.S. Fire Administration

- Checking system design.
- Fire protection systems.
- Fire protection plans.
- Occupancy hazard classifications.
- Methods of design objectives.

Slide 6-98

SUMMARY (cont'd)

- Basic methods of design.
- Steps for analyzing the remote area.
  - Identify the design hazard classification.
  - Identify the remote area and modifications.
  - Measure sprinkler spacing.
  - Verify number of sprinklers in remote area.
  - Verify the size of the rectangular demand area.

Slide 6-99

SUMMARY (cont'd)

- Determine number of sprinklers on branch line.
- Verify adequate density is being discharged.
- Verify flow from remote sprinkler.
- What is minimum flow demand for the system?

Slide 6-100

REFERENCE

National Fire Protection Association. (2019). *Standard for the installation of sprinkler systems*. (Standard no. 13). Retrieved from https://www.nfpa.org

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APPENDIX

SUPPLEMENTAL MATERIALS

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Remote Area Modifications

In addition to the remote area modifications allowed for wet pipe systems with quick-response sprinklers (QRSs) beneath low ceilings, there are other adjustments the code official may encounter.

These adjustments are listed below, with examples on the following pages.

1. **Remote area increase.** On **dry pipe** and **double interlock** systems, the remote area design from the density/area charts must be increased by 30%.

   This remote area increase is to account for the water application delay caused by the dry pipe design. When the sprinklers operate, incoming water pressure purges compressed air or nitrogen from the system so there will be an inherent delay in water application until the gas is expelled. Because no water is applied in those first few seconds or minutes, the delay may allow more sprinklers to open while the fire grows. The increased remote area results in more sprinklers being calculated to overcome this delay.

2. **Remote area increase.** In **non-storage occupancies** having a ceiling slope more than 1:6 (2 inches in 12 inches) using **standard spray, extended coverage, quick response** or **large drop sprinklers,** the remote area design from the density/area charts must be increased by 30%. (**Storage occupancies** having a ceiling slope more than 1:6 are outside the scope of National Fire Protection Association (NFPA) 13, *Standard for the Installation of Sprinkler Systems*, and should be evaluated through full-scale fire testing or supported by a technical report and opinion.)

   The required increase is because once a fire's thermal plume reaches the ceiling and becomes a ceiling jet, the fire spread rate across the sloped ceiling is greater than a smooth, flat ceiling. The increased remote that potentially includes more operating sprinklers anticipates this rapid fire spread.

3. **Remote area decrease.** In **Extra Hazard** occupancies using **high temperature sprinklers** (250 F to 350 F), the remote area design from the density/area charts may be reduced by 25% but to not less than 2,000 square feet.

   In this case, the design intent is to have **fewer** sprinklers open. While it may seem illogical to have fewer sprinklers open, experience has shown that under these design conditions, fewer operating sprinklers perform at higher operating pressures and are effective at controlling Extra Hazard occupancy fires.

4. **Compounding.** The remote area adjustments may be **compounded;** that is, depending upon the situation and design, **both** the remote area **increase** and **decrease** may be employed.

Examples

1. **Remote area increase (dry pipe).** An underground parking garage is proposed in a community where winter temperatures often are below freezing, so a dry pipe sprinkler system will be installed. The parking garage has a smooth, flat unobstructed ceiling.

   NFPA 13 classifies this as an Ordinary Hazard, Group 1 occupancy. The designer selects a density/area figure from the charts at 0.15 gallons per minute (gpm) over 1,500 square feet.

   Since it is a dry pipe system where delayed water application is expected, the 1,500 square foot remote area must be increased by 30%.

   $$1{,}500\ ft^2 \times 0.30 = 450\ ft^2 \text{ increase}$$
   $$1{,}500\ ft^2 + 450\ ft^2 = 1{,}950\ ft^2$$
   The adjusted design criteria is 0.15 gpm over 1,950 square feet.

2. **Remote area increase (sloped ceiling).** The regional library is adding a new wing to increase its juvenile material collection, reading area and activity space. In order to take advantage of natural sunlight, the ceiling is glass and sloped 1:3 (1 inch in 3 inches).

   NFPA 13 classifies this as Light Hazard occupancy. The designer selects a density/area figure from the charts at 0.09 gpm over 2,000 square feet using QRSs (175 F).

   Since the ceiling slope is greater than 1:6, the remote area must be increased 30%.

   $$2{,}000\ ft^2 \times 0.30 = 600\ ft^2$$
   $$2{,}000\ ft^2 + 600\ ft^2 = 2{,}600\ ft^2$$
   The adjusted design criteria is 0.09 gpm over 2,600 square feet.

3. **Remote area decrease (Extra Hazard) (Scenario 1).** A local paint distributor wants to add onto its warehouse to accommodate Class IB flammable liquids in one-gallon cans stored on pallets not more than one pallet load high. The warehouse has a smooth, flat unobstructed ceiling.

   NFPA 13 classifies this as an Extra Hazard, Group 1 occupancy. The designer selects a density/area figure from the charts at 0.25 gpm over 3,600 square feet using high-temperature (286 F) sprinklers.

   Since it is an Extra Hazard, Group 1 occupancy using high-temperature sprinklers, the remote area may be decreased by 25%.

   $$3{,}600\ ft^2 \times 0.25 = 900\ ft^2 \text{ decrease}$$
   $$3{,}600\ ft^2 - 900\ ft^2 = 2{,}700\ ft^2$$
   The adjusted design criteria is 0.25 gpm over 2,700 square feet.

4. **(Extra Hazard) (Scenario 2).** A local production plant wants to add space to store empty Class A plastic totes up 10 feet high. The room has a smooth, flat unobstructed ceiling.

NFPA 13 classifies this as an Extra Hazard, Group 1 occupancy. The designer selects a density/area figure from the charts at 0.295 gpm over 2,650 square feet using high-temperature (286 F) sprinklers.

Since it is an Extra Hazard, Group 1 occupancy using high-temperature sprinklers, the designer proposes reducing the remote area by 25%.

$$2{,}650 \text{ ft}^2 \times 0.25 = 662.5 \text{ ft}^2 \text{ decrease}$$
$$2{,}650 \text{ ft}^2 - 662.5 \text{ ft}^2 = 1{,}987.5 \text{ ft}^2$$

The designer proposes an adjusted design criteria is 0.25 gpm over 1,987.5 square feet. Is this design acceptable? **No,** according to the NFPA 13 density/area charts, Extra Hazard, Group 1 and 2 design areas must not be smaller than 2,500 square feet.

The adjusted design criteria should be 0.25 gpm over 2,500 square feet.

5. **Compounded adjustments.** A national trucking firm wants to build a specialized cold storage facility for handling extremely flammable liquids that must be refrigerated to prevent container failure. The 60-gallon containers are stored one container high in clusters of 12 with 8-foot aisles between the clusters. The warehouse has a smooth, flat unobstructed ceiling.

The fire code official requires that this be protected as an Extra Hazard, Group 2 occupancy. The designer selects a density/area figure from the charts at 0.355 gpm over 3,600 square feet using high-temperature (286 F) sprinklers on a dry pipe sprinkler system.

Step 1: *Increase* the remote area by 30% for the dry pipe system.

$$3{,}600 \text{ ft}^2 \times 0.30 = 1{,}080 \text{ ft}^2 \text{ increase}$$
$$3{,}600 \text{ ft}^2 + 1{,}080 \text{ ft}^2 = 4{,}680 \text{ ft}^2$$

Step 2: *Decrease* the adjusted area by 25% for high-temperature sprinklers.

$$4{,}680 \text{ ft}^2 \times 0.25 = 1{,}170 \text{ ft}^2 \text{ decrease}$$
$$4{,}680 \text{ ft}^2 - 1{,}170 \text{ ft}^2 = 3{,}510 \text{ ft}^2$$

The adjusted design criteria is 0.355 gpm over 3,510 square feet.

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UNIT 7: EVALUATING SPRINKLER HYDRAULIC CALCULATIONS

TERMINAL OBJECTIVE

The students will be able to:

7.1 *Evaluate if the calculation inputs are accurate given a set of plans with hydraulic calculations.*

ENABLING OBJECTIVES

The students will be able to:

7.1 *Conclude if minimum flow quantities from sprinkler outlets meet density requirements.*

7.2 *Conclude if minimum sprinkler pressure is provided at most remote sprinkler.*

7.3 *Distinguish the computer calculation's flow path, as indicated by shop drawing nodes.*

7.4 *Conclude if sprinkler piping diameter on plans matches diameter used in calculations.*

7.5 *Conclude if C-value used in calculations matches piping characteristics.*

7.6 *Conclude if elevation changes are incorporated into calculations.*

7.7 *Conclude if fixed loss influences are included in calculations.*

7.8 *Conclude if hose streams are incorporated into calculations in the appropriate location.*

7.9 *Conclude if total pressure and flow for sprinkler system is less demanding than water supply provided.*

7.10 *Compare and contrast system demand curve including safety margin with the water supply curve.*

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FEMA

U.S. Fire Administration

UNIT 7: EVALUATING SPRINKLER HYDRAULIC CALCULATIONS

Slide 7-1

TERMINAL OBJECTIVE

Evaluate if the calculation inputs are accurate given a set of plans with hydraulic calculations.

Slide 7-2

ENABLING OBJECTIVES

- Conclude if minimum flow quantities from sprinkler outlets meet density requirements.
- Conclude if minimum sprinkler pressure is provided at most remote sprinkler.
- Distinguish the computer calculation's flow path, as indicated by shop drawing nodes.

Slide 7-3

ENABLING OBJECTIVES (cont'd)

- Conclude if sprinkler piping diameter on plans matches diameter used in calculations.
- Conclude if C-value used in calculations matches piping characteristics.
- Conclude if elevation changes are incorporated into calculations.
- Conclude if fixed loss influences are included in calculations.

Slide 7-4

ENABLING OBJECTIVES (cont'd)

- Conclude if hose streams are incorporated into calculations in the appropriate location.
- Conclude if total pressure and flow for sprinkler system is less demanding than water supply provided.
- Compare and contrast system demand curve including safety margin with the water supply curve.

Slide 7-5

BASIC STEP PROCESS OF CALCULATION REVIEW

Step	Tool
1. Look for required information.	Calculations and National Fire Protection Association (NFPA) 13, *Standard for the Installation of Sprinkler Systems*.
2. Verify hazard classifications.	NFPA 13 and Unit 2: Hazards Classification.
3. Verify shape and dimensions of remote area.	NFPA 13 and formulas.
4. Check all hydraulic reference points (nodes).	Calculations and plans.
5. Validate sprinkler data.	Calculations, plans and manufacturer's product literature.
6. Verify pressure losses (P_e and P_f), including fixed loss devices.	Calculations and plans.
7. Verify hose stream.	Calculations, NFPA 13 and Unit 3: Water Supplies and Delivery Systems.
8. Validate water supplies.	Calculations, plans and water supply data information.

Slide 7-6

I. LOOK FOR REQUIRED INFORMATION

STEP 1: LOOK FOR REQUIRED INFORMATION

Step	Tool
1. Look for required information.	Calculations and NFPA 13.
2. Verify hazard classifications.	NFPA 13 and Unit 2.
3. Verify shape and dimensions of remote area.	NFPA 13 and formulas.
4. Check all hydraulic reference points (nodes).	Calculations and plans.
5. Validate sprinkler data.	Calculations, plans and manufacturer's product literature.
6. Verify pressure losses (P_e and P_f), including fixed loss devices.	Calculations and plans.
7. Verify hose stream.	Calculations, NFPA 13 and Unit 3.
8. Validate water supplies.	Calculations, plans and water supply data information.

Slide 7-7

Step 1: Look for required information using calculations and National Fire Protection Association (NFPA) 13, *Standard for the Installation of Sprinkler Systems*.

STEP 1: LOOK FOR REQUIRED INFORMATION (cont'd)

- Date, location, names of owner/occupants, building number.
- Description of hazard.
- Sprinkler contractor/designer name.
- Name of approving agency.

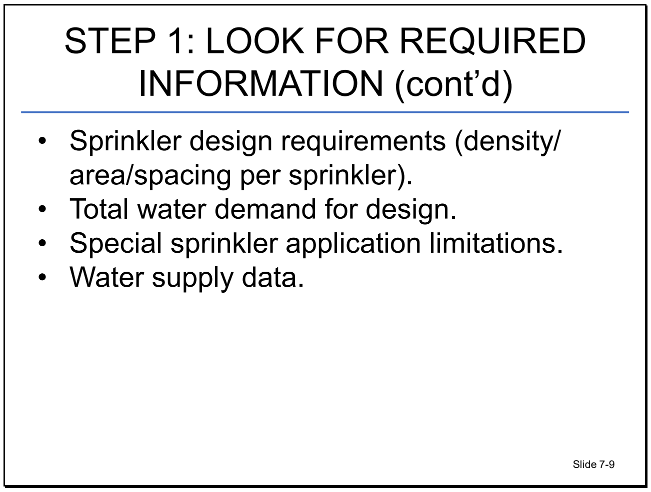
Slide 7-8

A. Date, location, names of owner/occupants, building number.

B. Description of hazard.

C. Sprinkler contractor/designer name.

D. Name of approving agency.

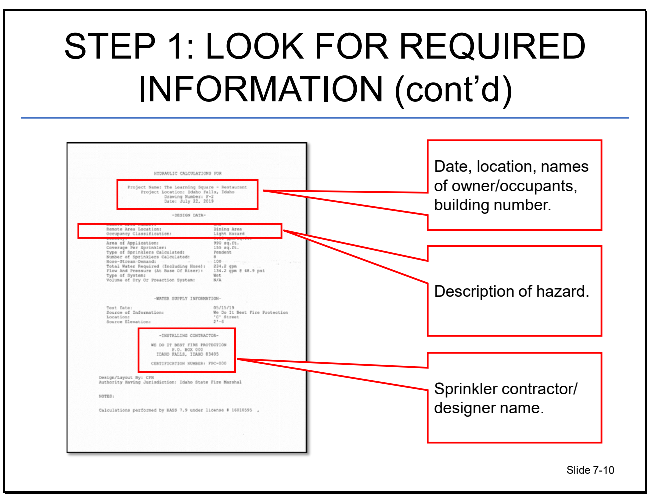


E. Sprinkler design requirements (density/area/spacing per sprinkler).

F. Total water demand for design.

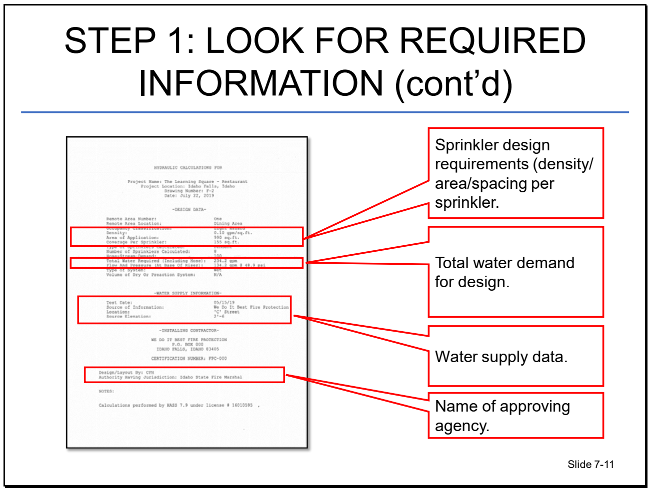
G. Special sprinkler application limitations.

H. Water supply data.



I. On the slide is an example of a hydraulic calculation cover sheet that shows:

1. Date, location, names of owner/occupants and building number.
2. Description of a hazard.
3. Sprinkler contractor/designer name.



J. On the slide is an example of a hydraulic calculation cover sheet that shows:

1. Sprinkler design requirements (density/area/spacing per sprinkler).

2. Total water demand for the design.

3. Water supply data.

4. Name of approving agency.

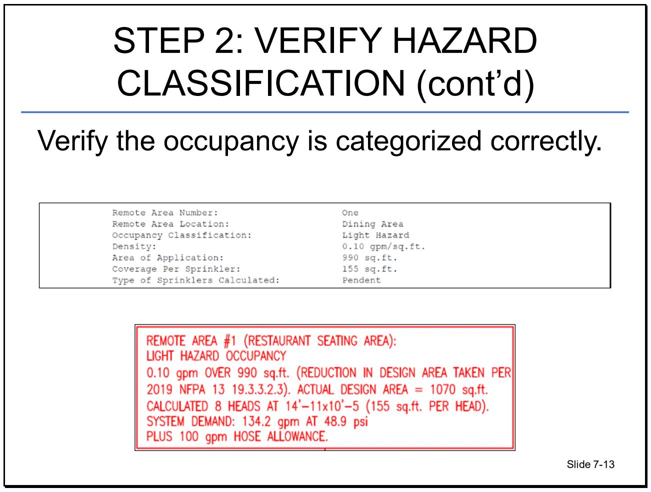
II. VERIFY HAZARD CLASSIFICATIONS

STEP 2: VERIFY HAZARD CLASSIFICATIONS

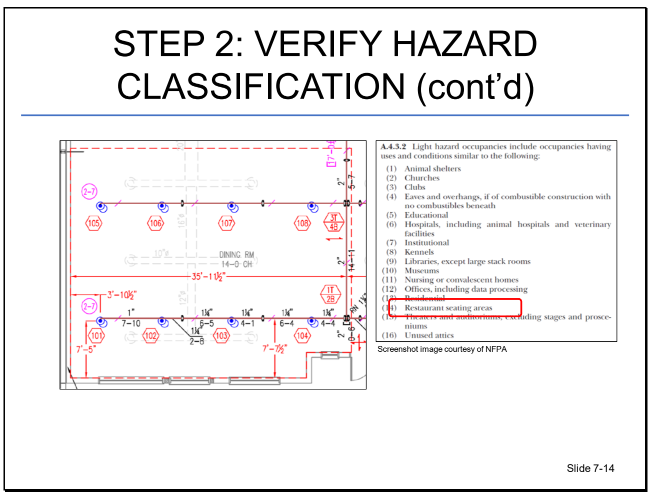
Step	Tool
1. Look for required information.	Calculations and NFPA 13.
2. Verify hazard classifications.	NFPA 13 and Unit 2.
3. Verify shape and dimensions of remote area.	NFPA 13 and formulas.
4. Check all hydraulic reference points (nodes).	Calculations and plans.
5. Validate sprinkler data.	Calculations, plans and manufacturer's product literature.
6. Verify pressure losses (P_e and P_f), including fixed loss devices.	Calculations and plans.
7. Verify hose stream.	Calculations, NFPA 13 and Unit 3.
8. Validate water supplies.	Calculations, plans and water supply data information.

Slide 7-12

Step 2: Verify hazard classifications using NFPA 13 and Unit 2: Hazard Classification.

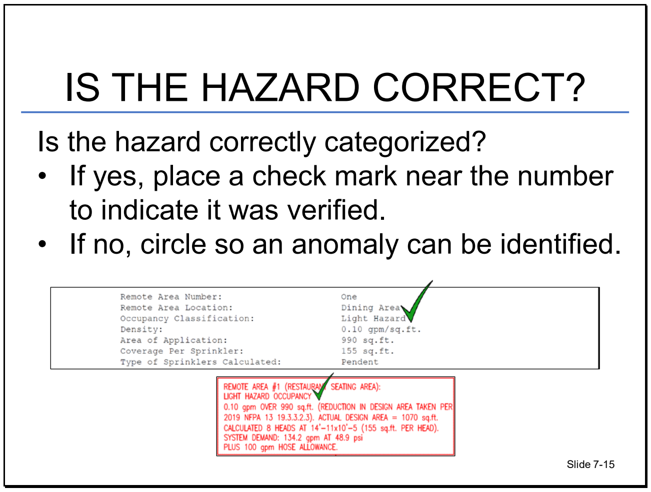


A. Verify the occupancy is categorized correctly.



1. One method of verifying the information is to check Annex A of NFPA 13 for examples, but remember that not all hazards are listed in the annex (refer back to Unit 2).

2. There are also differing degrees of each type of hazard, such as laboratories, high-piled storage and control areas.

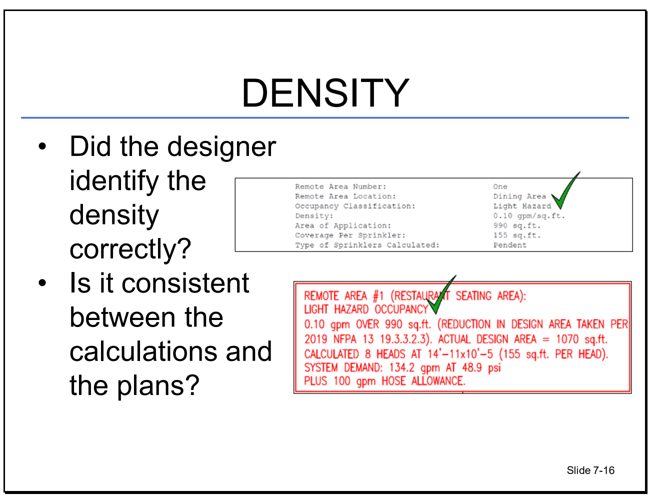


B. Is the hazard correctly categorized?

1. If yes, place a check mark near the number to indicate it was verified.

2. If no, circle so an anomaly can be identified.

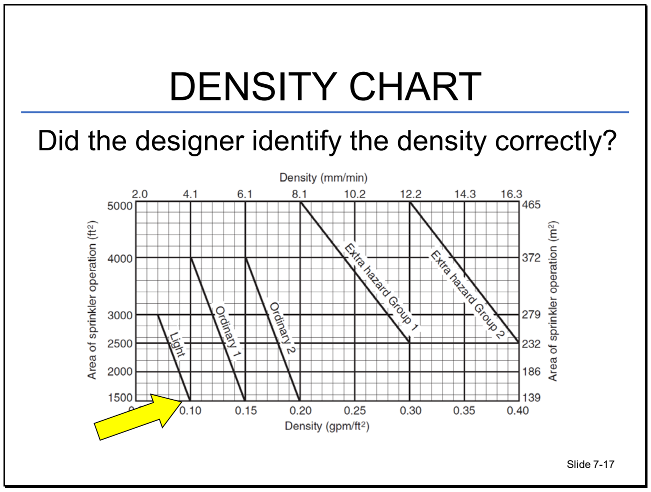
3. Simple check marks can serve as a useful tool to keep track of the review progress when dealing with distractions such as telephone calls, emails, customer visits and other interruptions.



C. Density.

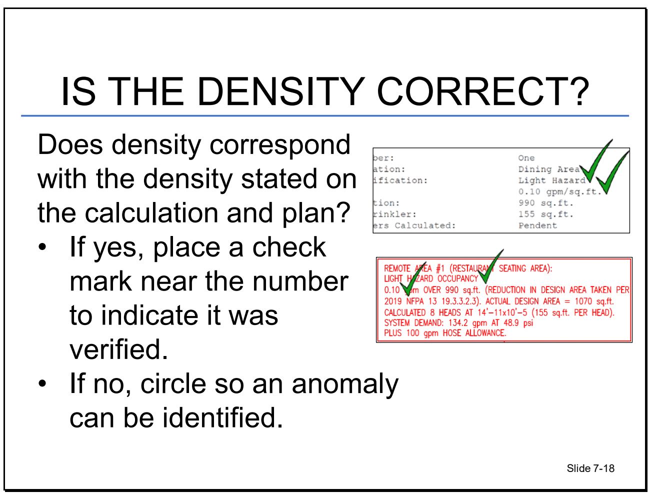
1. Did the designer identify the density correctly?

2. Is it consistent between the calculations and the plans?



D. Density chart.

Did the designer identify the density correctly?

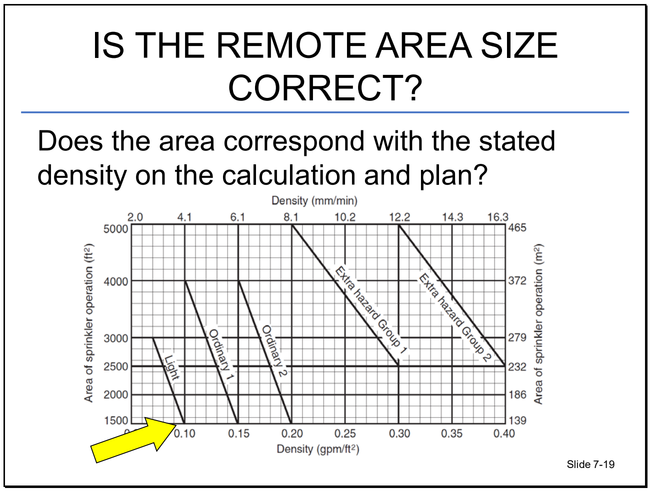


E. Is the density correct?

Does the density correspond with the density stated on the calculation cover sheet and plan?

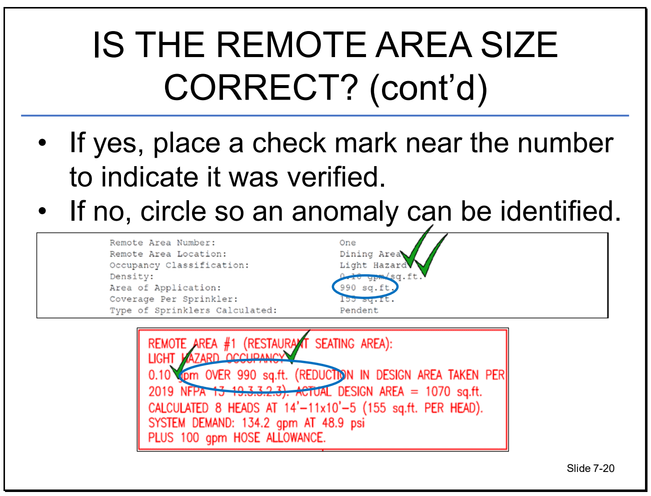
1. If yes, place a check mark near the number to indicate it was verified.

2. If no, circle so an anomaly can be identified.



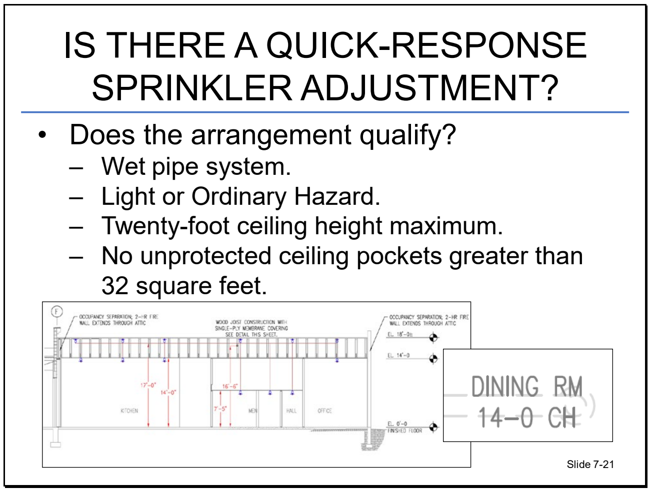
F. Is the remote area size correct?

Does the area correspond with the stated density on the calculation and plan?



1. If yes, place a check mark near the number to indicate it was verified.

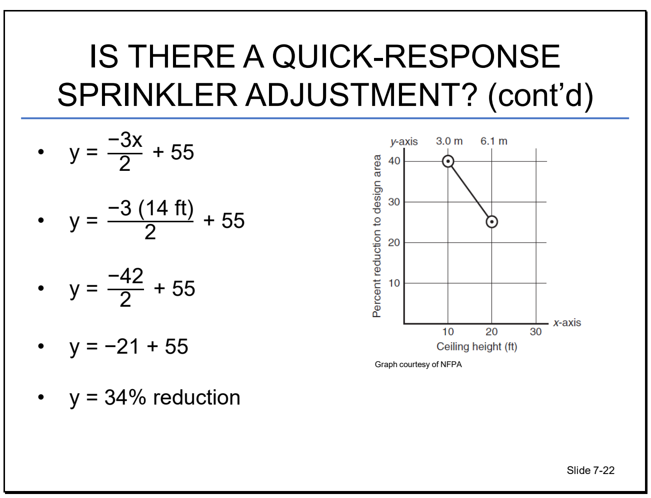
2. If no, circle so an anomaly can be identified.



G. Is there a quick-response sprinkler (QRS) adjustment?

Does the arrangement qualify?

1. Wet pipe system.
2. Light or Ordinary Hazard.
3. Twenty-foot ceiling height maximum.
4. No unprotected ceiling pockets greater than 32 square feet.



$$y = \frac{-3x}{2} + 55$$

$$y = \frac{-3\ (14\ \text{ft})}{2} + 55$$

$$y = \frac{-42}{2} + 55$$

$$y = -21 + 55$$

$$y = 34\% \text{ reduction}$$

IS THERE A QUICK-RESPONSE SPRINKLER ADJUSTMENT? (cont'd)

- 1,500 ft^2 x $\frac{34}{100}$ = 510 ft^2 reduction
- 1,500 ft^2 – 510 ft^2 = 990 ft^2
- Adjusted remote area = 990 ft^2

Slide 7-23

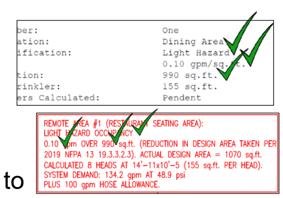
1,500 ft^2 x $\frac{34}{100}$ = 510 ft^2 reduction

1,500 ft^2 – 510 ft^2 = 990 ft^2

Adjusted remote area = 990 ft^2

IS THERE A QUICK-RESPONSE SPRINKLER ADJUSTMENT? (cont'd)

- Did the calculation match the specified remote area stated on the plan?
  - If yes, place a check mark near the number to indicate it was verified.
  - If no, circle so an anomaly can be identified.



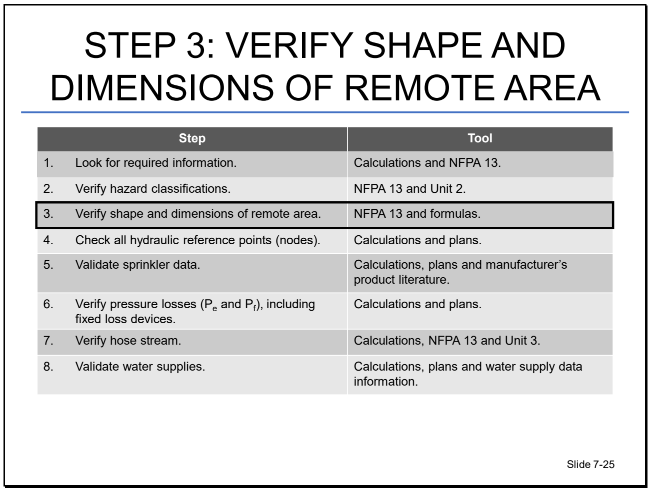
Slide 7-24

H. Did the calculation match the specified remote area stated on the plan?

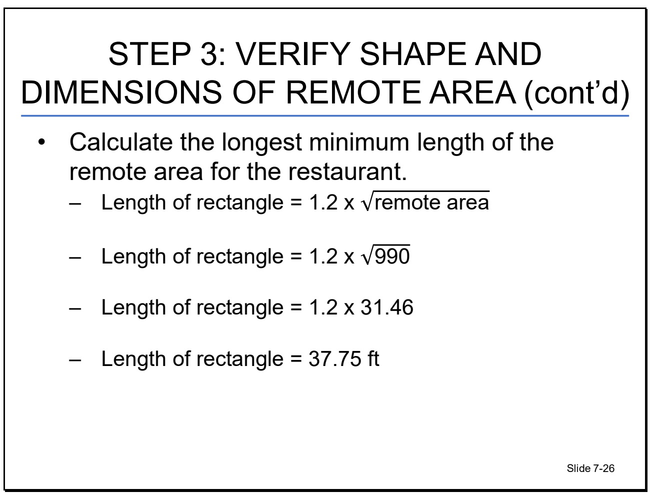
1. If yes, place a check mark near the number to indicate it was verified.

2. If no, circle so an anomaly can be identified.

III. VERIFY SHAPE AND DIMENSIONS OF REMOTE AREA



Step 3: Verify shape and dimensions of remote areas using NFPA 13 and formulas.



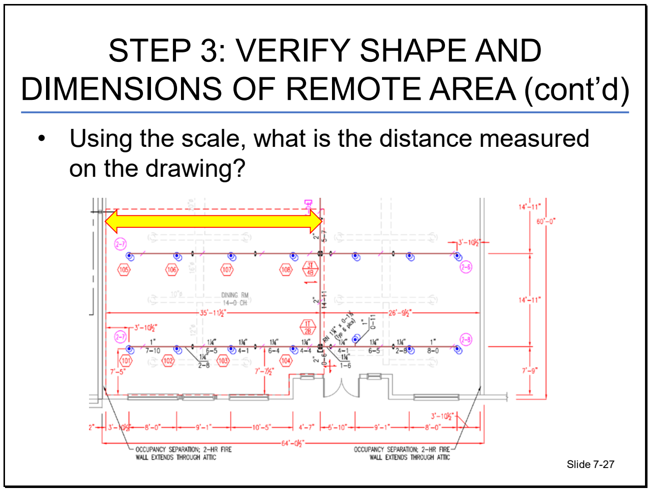
A. Calculate the longest minimum length of the remote area for the restaurant.

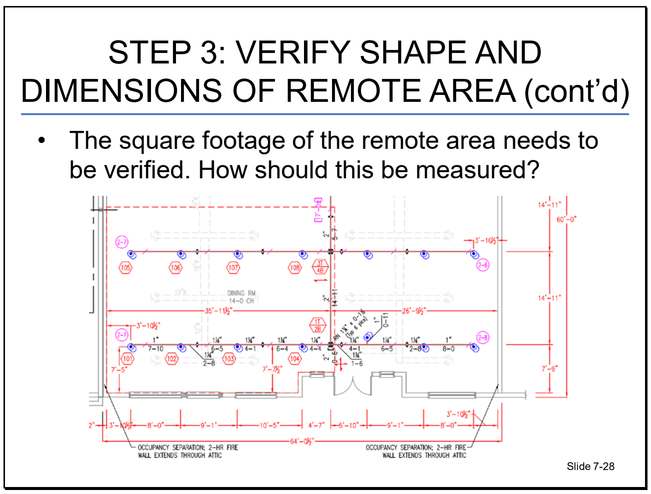
Length of rectangle = 1.2 x $\sqrt{\text{remote area}}$

Length of rectangle = 1.2 x $\sqrt{990}$

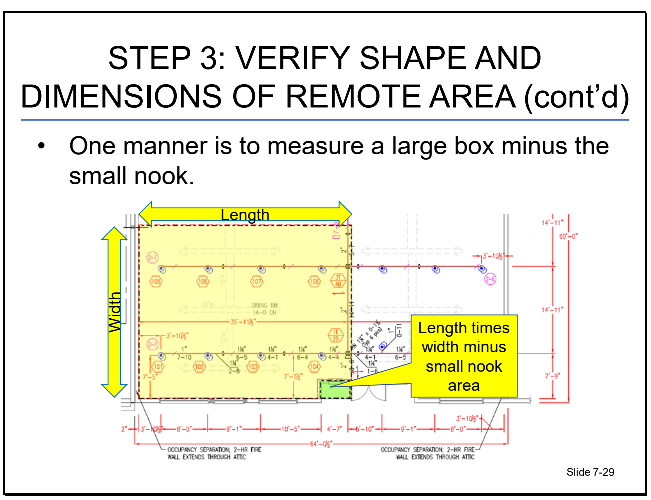
Length of rectangle = 1.2 x 31.46

Length of rectangle = 37.75 ft





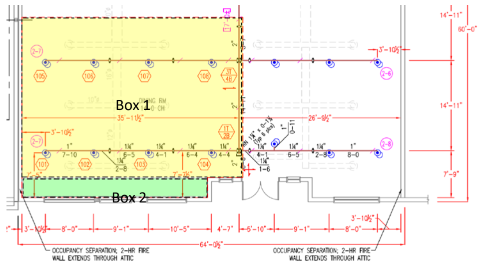
B. The square footage of the remote area needs to be verified. How should this be measured?



C. One manner is to measure a large box minus the small nook.

STEP 3: VERIFY SHAPE AND DIMENSIONS OF REMOTE AREA (cont'd)

- The other way is to measure two separate boxes and add them together.

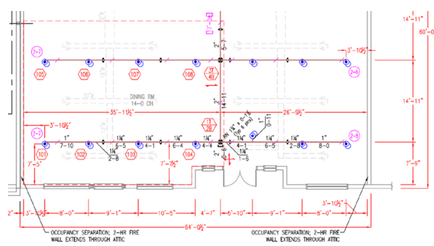


Slide 7-30

D. The other way is to measure two separate boxes and add them together.

STEP 3: VERIFY SHAPE AND DIMENSIONS OF REMOTE AREA (cont'd)

- Using a scale tool, measure the area of the remote area. What is the square footage?



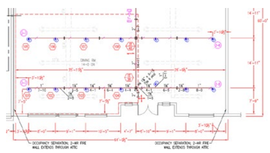
Slide 7-31

E. Using a scale tool, measure the area of the remote area. What is the square footage? Note: The remote area measurements are not always on the plans, and the plans reviewer may have to measure the area themselves.

STEP 3: VERIFY SHAPE AND DIMENSIONS OF REMOTE AREA (cont'd)

- Establish the minimum number of sprinklers in the design area.
  - Use the most demanding area to calculate the number of sprinklers needed.

$$\text{Number of sprinklers} = \frac{\text{Remote area}}{\text{Square footage per sprinkler}}$$



$S \times L = (A_S)$

Slide 7-32

F. Establish the minimum number of sprinklers in the design area.

Use the most demanding area to calculate the number of sprinklers needed.

$$\text{Number of sprinklers} = \frac{\text{Remote area}}{\text{Square footage per sprinkler}}$$

STEP 3: VERIFY SHAPE AND DIMENSIONS OF REMOTE AREA (cont'd)

- The minimum number of sprinklers in the design area is:
  - $\text{Number of sprinklers} = \frac{\text{Remote area}}{\text{Square footage per sprinkler}}$
  - $\text{Number of sprinklers} = \frac{\text{1,070 (actual design area)}}{155}$
  - Number of sprinklers = 6.9 sprinklers, ∴ → 7 sprinklers

Slide 7-33

G. The minimum number of sprinklers in the design area is:

$$\text{Number of sprinklers} = \frac{\text{Remote area}}{\text{Square footage per sprinkler}}$$

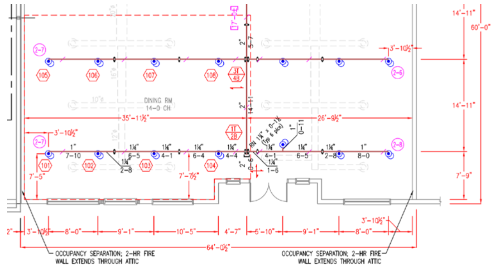
$$\text{Number of sprinklers} = \frac{\text{1,070 (actual design area)}}{155}$$

Number of sprinklers = 6.9 sprinklers, ∴ → 7 sprinklers

Note: The symbol ∴ signifies "therefore."

STEP 3: VERIFY SHAPE AND DIMENSIONS OF REMOTE AREA (cont'd)

- How many sprinklers are calculated in the remote area?



Slide 7-34

STEP 3: VERIFY SHAPE AND DIMENSIONS OF REMOTE AREA (cont'd)

- Calculate the minimum number of sprinklers on a branch line in the remote area.
  - A secondary manner to verify the rectangular shape of the design area.

$$\text{Number of sprinklers on branch line} = \frac{1.2 \times \sqrt{\text{remote area}}}{S}$$

Slide 7-35

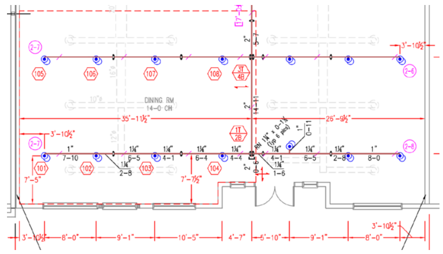
H. Calculate the minimum number of sprinklers on a branch line in the remote area.

1. A secondary manner to verify the rectangular shape of the design area.

$$\text{Number of sprinklers on branch line} = \frac{1.2 \times \sqrt{\text{remote area}}}{S}$$

STEP 3: VERIFY SHAPE AND DIMENSIONS OF REMOTE AREA (cont'd)

– In this example, nonuniform distances between sprinklers are used by the designer.



Slide 7-36

2. In this example, the designer uses nonuniform distances between sprinklers.

STEP 3: VERIFY SHAPE AND DIMENSIONS OF REMOTE AREA (cont'd)

– In a perfectly uniform design, distance is easily determined.
– Nonuniform designs require additional work.

$$A_s = S \times L$$

$$155 \text{ ft}^2 = S \times 14.92 \text{ ft}$$

$$S = \frac{155 \text{ ft}^2}{14.92 \text{ ft}}$$

S = 10.38 ft or 10 ft – 5 in

Slide 7-37

3. In a perfectly uniform design, distance is easily determined.

4. Nonuniform designs require additional work.

$A_s = S \times L$

a. S: larger of twice the distance to the wall/obstruction or distance to next sprinkler on branch line.

b. L: larger of twice the distance to the wall/obstruction or spacing between branch lines.

$155 \text{ ft}^2 = S \times 14.92 \text{ ft}$

$$S = \frac{155 \text{ ft}^2}{14.92 \text{ ft}}$$

$$S = 10.38 \text{ ft or } 10 \text{ ft, } 5 \text{ in}$$

STEP 3: VERIFY SHAPE AND DIMENSIONS OF REMOTE AREA (cont'd)

- Calculating the minimum number of sprinklers on a branch line in the remote area.
  - Number of sprinklers on branch line = $\frac{1.2 \text{ x } \sqrt{\text{remote area}}}{S}$
  - Number of sprinklers on branch line = $\frac{1.2 \text{ x } \sqrt{1{,}070}}{10.38}$
  - Number of sprinklers on branch line = 3.78, ∴ → 4

Slide 7-38

I. Calculating the minimum number of sprinklers on a branch line in the remote area.

$$\text{Number of sprinklers on branch line} = \frac{1.2 \text{ x } \sqrt{\text{remote area}}}{S}$$

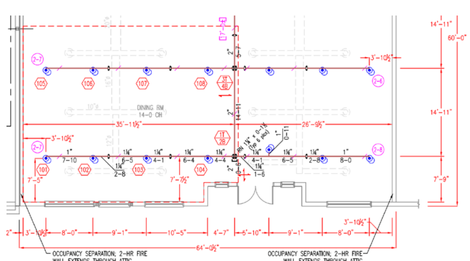
$$\text{Number of sprinklers on branch line} = \frac{1.2 \text{ x } \sqrt{1{,}070}}{10.38}$$

Number of sprinklers on branch line = 3.78, ∴ → 4

Check if there are at least four sprinklers on the branch line.

STEP 3: VERIFY SHAPE AND DIMENSIONS OF REMOTE AREA (cont'd)

- Verify the number of sprinklers on a branch line in the remote area.



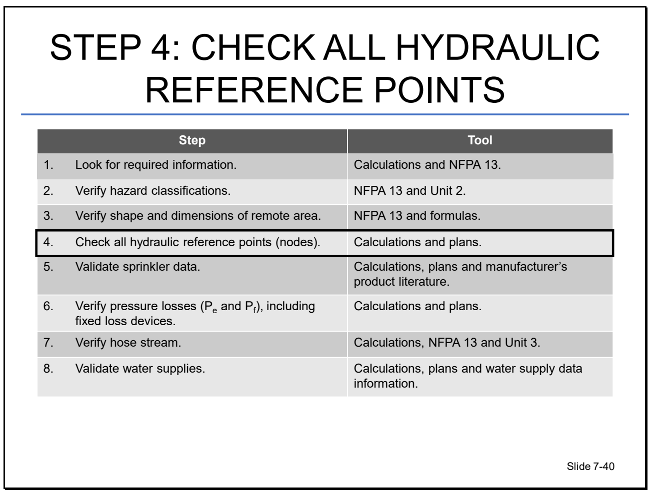
Slide 7-39

J. Verify the number of sprinklers on a branch line in the remote area.

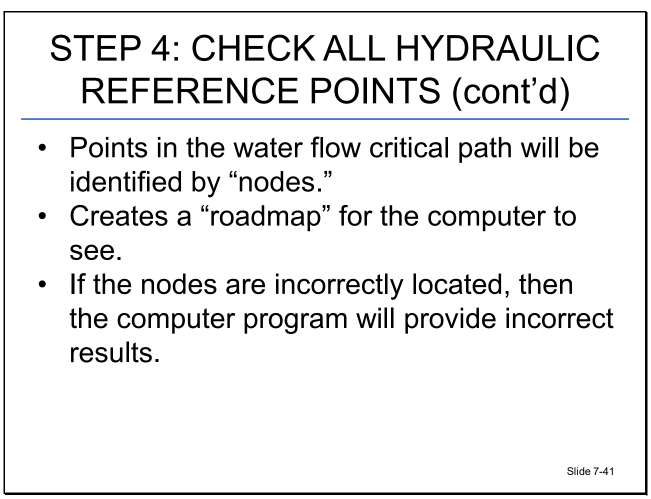
1. Note that there are eight sprinklers on the branch line with four serving below the acoustical ceiling tile (ACT) and four for the combustible concealed space.

2. Both are not added together because NFPA 13 states to consider sprinkler operation in only one of the protected areas. NFPA 13 states, "Water demand of sprinklers installed in concealed spaces shall not be required to be added to the ceiling demand" (NFPA, 2019, section 27.2.4.7.4).

IV. CHECK ALL HYDRAULIC REFERENCE POINTS



Step 4: Check all hydraulic reference points (nodes) using calculations and plans.



A. Points in the water flow critical path will be identified by "nodes."

B. This creates a "roadmap" for the computer to see.

C. If the nodes are incorrectly located, then the computer program will provide incorrect results.

STEP 4: CHECK ALL HYDRAULIC REFERENCE POINTS (cont'd)

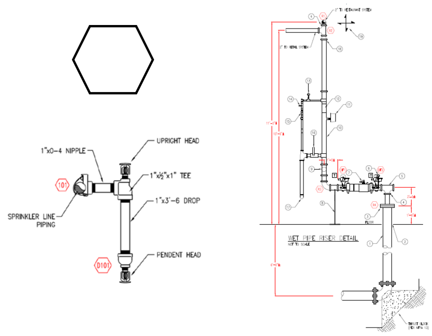
- Nodes represent points where the water flow calculation is affected:
  - Sprinklers.
  - Elbows.
  - Tees.
  - Fittings.
  - Valves.
  - Directional changes.

Slide 7-42

D. Nodes represent points where the water flow calculation is affected:

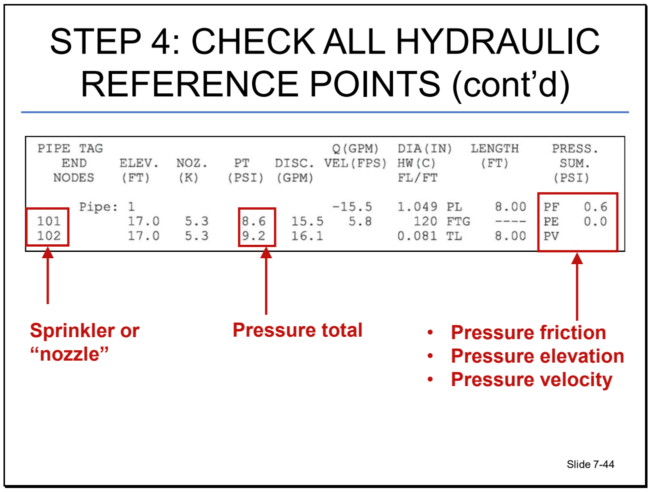
1. Sprinklers.
2. Elbows.
3. Tees.
4. Fittings.
5. Valves.
6. Directional changes.

STEP 4: CHECK ALL HYDRAULIC REFERENCE POINTS (cont'd)



Slide 7-43

E. The slide shows a hexagonal shape with distinctive nomenclature. This is an example of nodes. Note that there is no node identifying the tee elbow in the branch line. If its friction loss influence is shown in the calculations between the sprinkler and the branch line, it does not need to be identified.



F. Check the calculations.

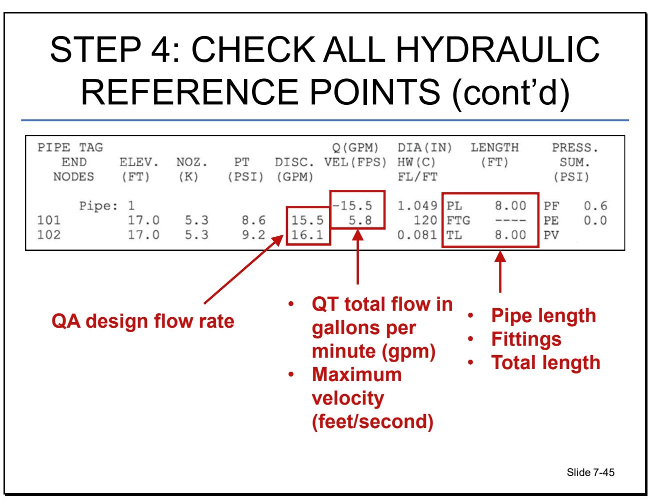
1. Sprinkler (nozzle).

2. Pressure total.

3. Pressure friction.

4. Pressure elevation.

5. Pressure velocity.



6. QA design flow rate.

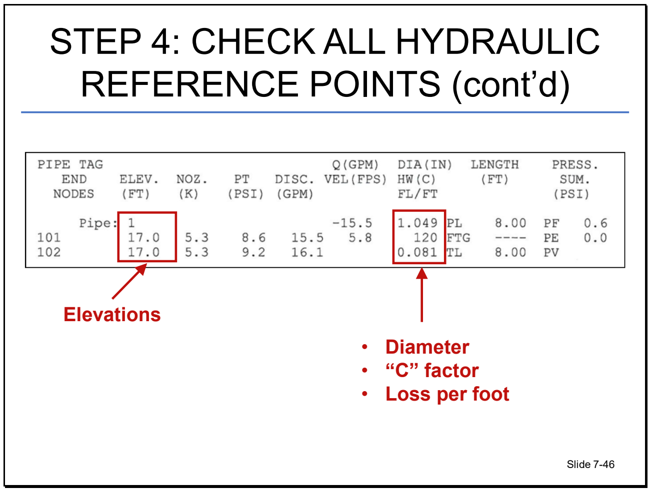
7. QT total flow in gallons per minute (gpm).

8. Maximum velocity (feet per second).

9. Pipe length.

10. Fittings.

11. Total length.

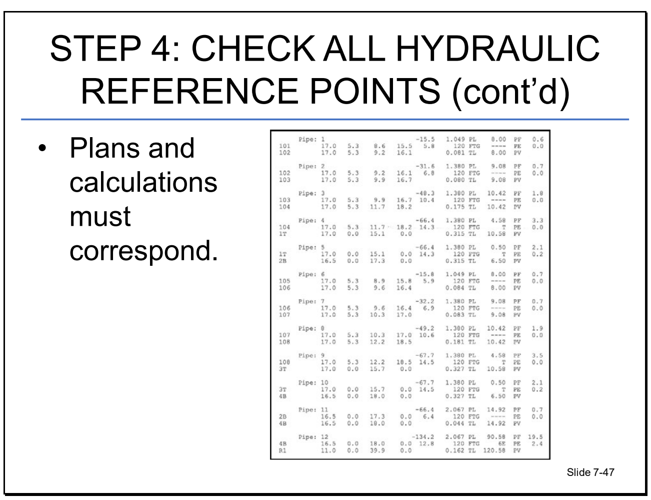


12. Elevations.

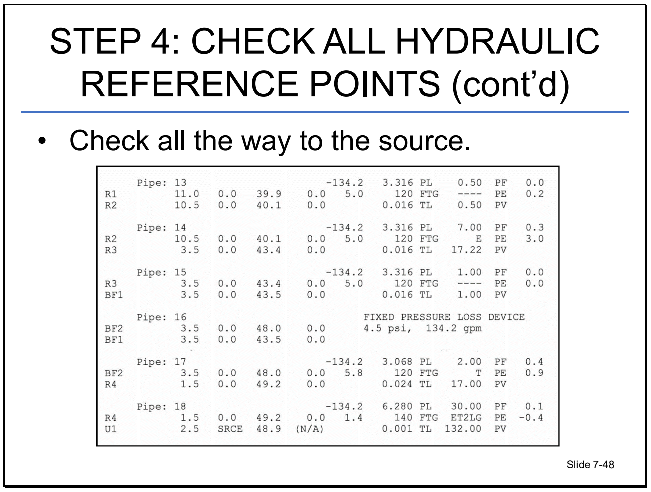
13. Diameter.

14. "C" factor.

15. Loss per foot.

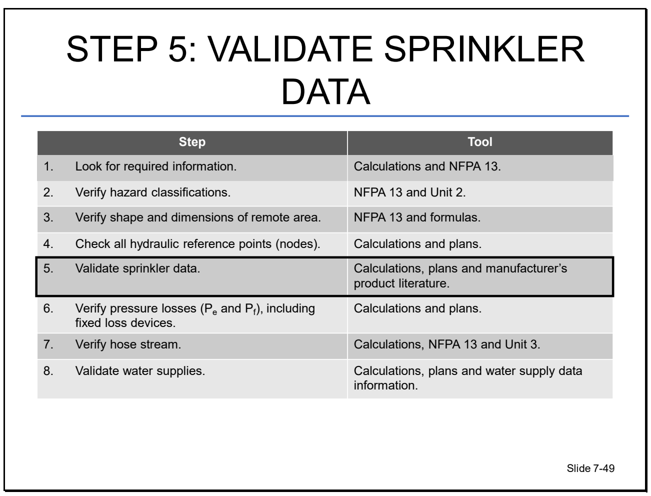


G. Plans and calculations must correspond.



H. Check all the way to the source.

V. VALIDATE SPRINKLER DATA



Step	Tool
1. Look for required information.	Calculations and NFPA 13.
2. Verify hazard classifications.	NFPA 13 and Unit 2.
3. Verify shape and dimensions of remote area.	NFPA 13 and formulas.
4. Check all hydraulic reference points (nodes).	Calculations and plans.
5. Validate sprinkler data.	Calculations, plans and manufacturer's product literature.
6. Verify pressure losses (P_e and P_f), including fixed loss devices.	Calculations and plans.
7. Verify hose stream.	Calculations, NFPA 13 and Unit 3.
8. Validate water supplies.	Calculations, plans and water supply data information.

Step 5: Validate sprinkler data using calculations, plans, manufacturer's product literature and Validating Sprinkler Data in Appendix: Supplemental Materials of this unit. Note: Steps 5 through 8 are iterative for evaluating the sprinkler pressures and flows in the remote area.

STEP 5: VALIDATE SPRINKLER DATA (cont'd)

- First step is to locate the sprinkler node analysis table in the calculations.

NODE ANALYSIS DATA

NODE TAG	ELEVATION (FT)	NODE TYPE	PRESSURE (PSI)	DISCHARGE (GPM)	NOTES
101	17.0	K= 5.30	8.6	15.5	
102	17.0	K= 5.30	9.2	16.1	
103	17.0	K= 5.30	9.9	16.7	
104	17.0	K= 5.30	11.7	18.2	
105	17.0	K= 5.30	8.9	15.8	
106	17.0	K= 5.30	9.6	16.4	
107	17.0	K= 5.30	10.3	17.0	
108	17.0	K= 5.30	12.2	18.5	
1T	17.0	- - - -	15.1	- - -	
2B	16.5	- - - -	17.3	- - -	
3T	17.0	- - - -	15.7	- - -	
4B	16.5	- - - -	18.0	- - -	
R1	11.0	- - - -	39.9	- - -	
R2	10.5	- - - -	40.1	- - -	
R3	3.5	- - - -	43.4	- - -	
BF1	3.5	- - - -	43.5	- - -	
BF2	3.5	- - - -	48.0	- - -	
R4	1.5	- - - -	49.2	- - -	
U1	2.5	SOURCE	48.9	134.2	

Slide 7-50

A. The first step is to locate the sprinkler node analysis table in the calculations.

STEP 5: VALIDATE SPRINKLER DATA (cont'd)

- Next is to transfer the sprinkler flows onto the plans to evaluate the flows.

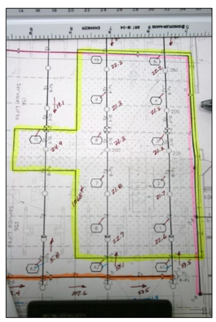


Photo courtesy of Keith Heckler

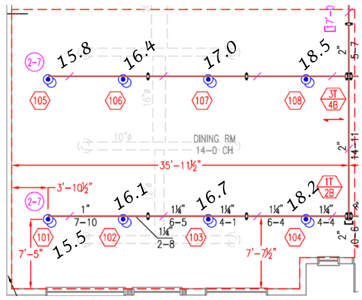
Slide 7-51

B. The next step is to transfer the sprinkler flows onto the plans to evaluate the flows.

A common best practice is highlighting the remote area box as shown on the slide. This helps to distinguish the remote area on the plan.

STEP 5: VALIDATE SPRINKLER DATA (cont'd)

- Write flows adjacent to corresponding node.



Slide 7-52

C. Write flows adjacent to the corresponding node.

STEP 5: VALIDATE SPRINKLER DATA (cont'd)

- Next, verify adequate flow for the required density at sprinkler node 101.
  - $Q = \rho A$
  - $\rho = \frac{Q}{A}$
  - $\rho = \frac{15.5\text{ gpm}}{155\text{ ft}^2}$
  - $\rho = 0.1\ \frac{\text{gpm}}{\text{ft}^2}$

Rearrange the equation.

Node 101 discharges 15.5 gpm, and the stated maximum coverage is 155 ft^2.

Slide 7-53

D. Next, verify adequate flow for the required density at sprinkler node 101.

$$Q = \rho A$$

$$\rho = \frac{Q}{A}$$

$$\rho = \frac{15.5\text{ gpm}}{155\text{ ft}^2}$$

$$\rho = 0.1\ \frac{\text{gpm}}{\text{ft}^2}$$

Since the sprinkler with the lowest flow meets the minimum density, then all other sprinklers have sufficient flow.

STEP 5: VALIDATE SPRINKLER DATA (cont'd)

- Next, verify starting pressure of sprinkler node 101.
  - $Q = K\sqrt{P}$
  - $P = \left(\frac{Q}{K}\right)^2$
  - $P = \left(\frac{15.5}{5.30}\right)^2$
  - $P = 8.5$

Slide 7-54

E. Next, verify the starting pressure of sprinkler node 101.

$$Q = K\sqrt{P}$$

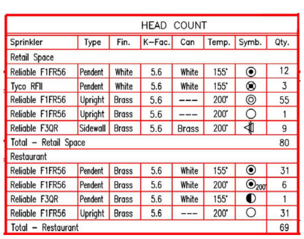
$$P = \left(\frac{Q}{K}\right)^2$$

$$P = \left(\frac{15.5}{5.30}\right)^2$$

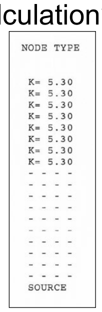
$$P = 8.5$$

STEP 5: VALIDATE SPRINKLER DATA (cont'd)

- Is conflicting K-factor data indicated between the shop drawings and the calculation?



HEAD COUNT							
Sprinkler	Type	Fin.	K–Fac.	Can	Temp.	Symb.	Qty.
Retail Space							
Reliable F1FR56	Pendent	White	5.6	White	155°	◉	12
Tyco RFII	Pendent	White	5.6	White	155°	⊠	3
Reliable F1FR56	Upright	Brass	5.6	---	200°	◎	55
Reliable F1FR56	Upright	Brass	5.6	---	200°	○	1
Reliable F3QR	Sidewall	Brass	5.6	Brass	200°	◁	9
Total – Retail Space							80
Restaurant							
Reliable F1FR56	Pendent	Brass	5.6	White	155°	◉	31
Reliable F1FR56	Pendent	Brass	5.6	White	200°	◉200°	6
Reliable F3QR	Pendent	Brass	5.6	White	155°	◐	1
Reliable F1FR56	Upright	Brass	5.6	---	200°	○	31
Total – Restaurant							69



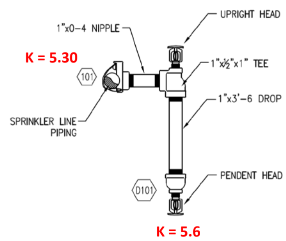
NODE TYPE
K= 5.30
K= 5.30
K= 5.30
K= 5.30
K= 5.30
K= 5.30
K= 5.30
K= 5.30
- - - -
- - - -
- - - -
- - - -
- - - -
- - - -
- - - -
- - - -
- - - -
- - - -
SOURCE

Slide 7-55

F. Is conflicting K-factor data indicated between the shop drawings and the calculation?

STEP 5: VALIDATE SPRINKLER DATA (cont'd)

- The equivalent "K" is calculated so the designer does not have to calculate every drop on the branch line in the demand area.



Slide 7-56

G. The equivalent "K" is calculated so the designer does not have to calculate every drop on the branch line in the demand area.

To save the designer time, instead of inputing multiple armovers' computer nodes into the hydraulic calculation, a single K-factor can be chosen based upon the diameter of pipe, length of pipe, and the number and types of fittings for that specific location in the piping. The sprinkler does not change its K-factor, but the theory is applied back to the outlet in the piping based on the flow and pressure at the sprinkler.

STEP 5: VALIDATE SPRINKLER DATA (cont'd)

- To calculate an equivalent K-factor:
  - Calculate the starting pressure for the sprinkler with the standard "K."
    - -- $Q = K\sqrt{P}$
    - -- $P = \left(\frac{Q}{K}\right)^2$
    - -- $P = \left(\frac{15.5}{5.6}\right)^2$
    - -- P = 7.66 pounds per square inch (psi)

Slide 7-57

H. To calculate an equivalent K-factor:

1. Calculate the starting pressure for the sprinkler with the standard "K."

$$Q = K\sqrt{P}$$

$$P = \left(\frac{Q}{K}\right)^2$$

$$P = \left(\frac{15.5}{5.6}\right)^2$$

P = 7.66 pounds per square inch (psi)

STEP 5: VALIDATE SPRINKLER DATA (cont'd)

– Use the Hazen-Williams equation to calculate the friction loss in the piping.

-- $p = \frac{(4.52)(Q^{1.85})}{(C^{1.85})\ (d^{4.87})}$

-- $p = \frac{(4.52)\ (15.5^{1.85})}{(120^{1.85})\ (1.087^{4.87})}$

-- p = 0.081 psi/ft

Slide 7-58

2. Use the Hazen-Williams equation to calculate the friction loss in the piping.

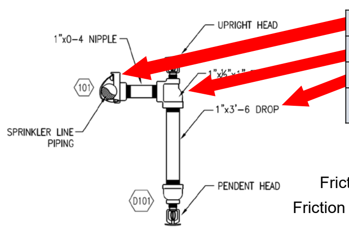
$$p = \frac{(4.52)(Q^{1.85})}{(C^{1.85})(d^{4.87})}$$

$$p = \frac{(4.52)(15.5^{1.85})}{(120^{1.85})(1.087^{4.87})}$$

p = 0.081 psi/ft

STEP 5: VALIDATE SPRINKLER DATA (cont'd)

– Account for length of piping.



1 "T" fitting	5'
1 elbow fitting	2'
Length of drop	3.83
Total length of piping	10.83'

Friction loss = p x total length

Friction loss = 0.081 psi/ft x 10.83 ft

Friction loss = 0.87 psi

Slide 7-59

3. Account for the length of the piping.

STEP 5: VALIDATE SPRINKLER DATA (cont'd)

– Add the additional pressure to the original start pressure.

	7.66 psi (starting pressure)
+	0.87 psi (calculated friction loss)
=	8.53 psi

Slide 7-60

4. Add the additional pressure to the original start pressure.

	7.66 psi (starting pressure)
+	0.87 psi (calculated friction loss)
=	8.53 psi

STEP 5: VALIDATE SPRINKLER DATA (cont'd)

– Use the new pressure to calculate a new K-factor.

-- $Q = K\sqrt{P}$

-- $K = \frac{Q}{\sqrt{P}}$

-- $K = \frac{15.5}{\sqrt{8.6}}$

-- $K = 5.30$

Slide 7-61

5. Use the new pressure to calculate a new K-factor.

$$Q = K\sqrt{P}$$

$$K = \frac{Q}{\sqrt{P}}$$

$$K = \frac{15.5}{\sqrt{8.6}}$$

$$K = 5.30$$

This K-factor will now be used throughout the entire calculation process.

STEP 5: VALIDATE SPRINKLER DATA (cont'd)

– Calculations will provide a miniature calculation to show the adjustment.

Equivalent K-Factor Calculator

Node Name	Sprinkler K-Factor	Pres. (psi)	Dia. (in)	Pipe Len. (ft)	Ftgs.	Total Len. (ft)	H-W coef.	Equivalent K-factor
101	5.60	7.00	1.049	3.83	ET	10.83	120.00	5.30

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6. Calculations will provide a miniature calculation to show the adjustment.

VERIFYING EQUIVALENT "K" CHANGE

Are the K-factors correct?

- If yes, place a check mark near the number to indicate it was verified.

NODE ANALYSIS DATA

NODE TAG	ELEVATION (FT)	NODE TYPE	PRESSURE (PSI)	DISCHARGE (GPM)
101	17.0	K= 5.30 ✓	8.6	15.5
102	17.0	K= 5.30 ✓	9.2	16.1
103	17.0	K= 5.30 ✓	9.9	16.7
104	17.0	K= 5.30 ✓	11.7	18.2
105	17.0	K= 5.30 ✓	8.9	15.8
106	17.0	K= 5.30 ✓	9.6	16.4
107	17.0	K= 5.30 ✓	10.3	17.0
108	17.0	K= 5.30 ✓	12.2	18.5
1T	17.0	- - - -	15.1	- - -
2B	16.5	- - - -	17.3	- - -
3T	17.0	- - - -	15.7	- - -
4B	16.5	- - - -	18.0	- - -
R1	11.0	- - - -	39.9	- - -
R2	10.5	- - - -	40.1	- - -
R3	3.5	- - - -	43.4	- - -
BF1	3.5	- - - -	43.5	- - -
BF2	3.5	- - - -	48.0	- - -
R4	1.5	- - - -	49.2	- - -
U1	2.5	SOURCE	48.9	134.2

- If no, circle so an anomaly can be identified.

Slide 7-63

7. Verifying equivalent "K" change.

Are the K-factors correct?

a. If yes, place a check mark near the number to indicate it was verified.

b. If no, circle so an anomaly can be identified.

VI. VERIFY PRESSURE LOSSES

STEP 6: VERIFY PRESSURE LOSSES

Step	Tool
1. Look for required information.	Calculations and NFPA 13.
2. Verify hazard classifications.	NFPA 13 and Unit 2.
3. Verify shape and dimensions of remote area.	NFPA 13 and formulas.
4. Check all hydraulic reference points (nodes).	Calculations and plans.
5. Validate sprinkler data.	Calculations, plans and manufacturer's product literature.
6. Verify pressure losses (P_e and P_f), including fixed loss devices.	Calculations and plans.
7. Verify hose stream.	Calculations, NFPA 13 and Unit 3.
8. Validate water supplies.	Calculations, plans and water supply data information.

Slide 7-64

A. Step 6: Verify pressure losses using calculations and plans.

WALKING THE CALCULATION

- Start at the beginning of the calculation.
- Verification of data input.

```
PIPE TAG                              Q(GPM)  DIA(IN)  LENGTH     PRESS.
  END     ELEV.  NOZ.   PT    DISC. VEL(FPS) HW(C)     (FT)       SUM.
 NODES    (FT)   (K)   (PSI) (GPM)           FL/FT               (PSI)

    Pipe: 1                           -15.5   1.049 PL    8.00  PF    0.6
101        17.0   5.3    8.6   15.5    5.8      120 FTG   ----  PE    0.0
102        17.0   5.3    9.2   16.1           0.081 TL    8.00  PV
```

Slide 7-65

1. Walking the calculation.

   a. Start at the beginning of the calculation.

   b. Verification of data input.

WALKING THE CALCULATION (cont'd)

- Place a check with the information already verified.

```
PIPE TAG                                   Q(GPM)   DIA(IN)   LENGTH     PRESS.
  END     ELEV.   NOZ.    PT    DISC.  VEL(FPS)  HW(C)      (FT)       SUM.
 NODES    (FT)    (K)   (PSI)  (GPM)            FL/FT                  (PSI)

     Pipe: 1                            -15.5 ✓  1.049 PL    8.00   PF    0.6
101         17.0   5.3 ✓  8.6 ✓  15.5    5.8      120 FTG   ----    PE    0.0
102         17.0   5.3 ✓  9.2    16.1            0.0[illegible]1 TL    8.00   PV
```

Do nodes 101 and 102 interconnect on the plans?

Are nodes 101 and 102 at 17 feet Above Finished Floor (AFF)?

Is this the correct pipe diameter and C value?

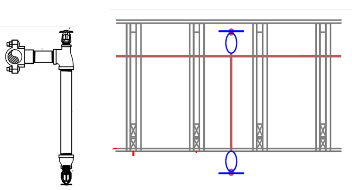
Is this the pipe length and fittings?

Slide 7-66

c. Place a check with the information already verified.

WALKING THE CALCULATION (cont'd)

- Although two sprinklers are shown for coverage purposes, only one is calculated as operating per NFPA 13.



NOTE:
UPRIGHT HEADS NOT CHOSEN FOR DESIGN AREA; HEIGHT OF ATTIC WOULD ALLOW FULL REDUCTION IN DESIGN AREA RESULTING IN DESIGN AREA OF 900 sq.ft. AND CALCULATION OF ONLY 7 HEADS AT 155 sq.ft. PER HEAD.

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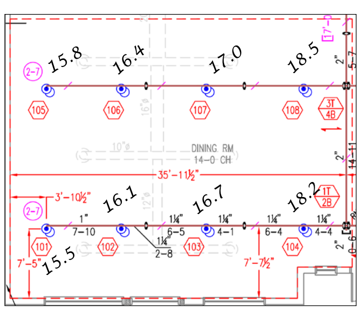
d. Although two sprinklers are shown for coverage purposes, only one is calculated as operating per NFPA 13.

WALKING THE CALCULATION (cont'd)

- Do nodes 101 and 102 interconnect on the plans?



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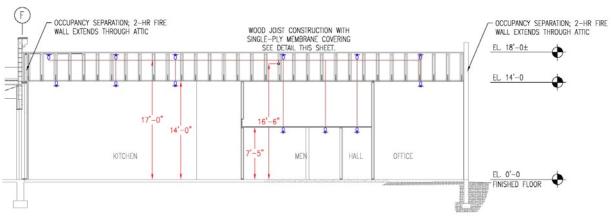
WALKING THE CALCULATION (cont'd)

- Are nodes 101 and 102 at 17 feet AFF?



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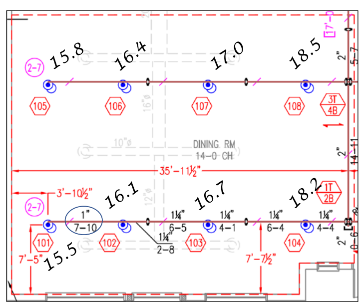
WALKING THE CALCULATION (cont'd)

- Is this the correct pipe diameter and C-value?



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PIPE DIAMETERS

- Pipe diameters are different than the common verbiage (i.e., 1-inch piping is not 1 inch in diameter).
- There are internal diameters and external diameters.
- The "schedule" of piping refers to the thickness of the piping wall.

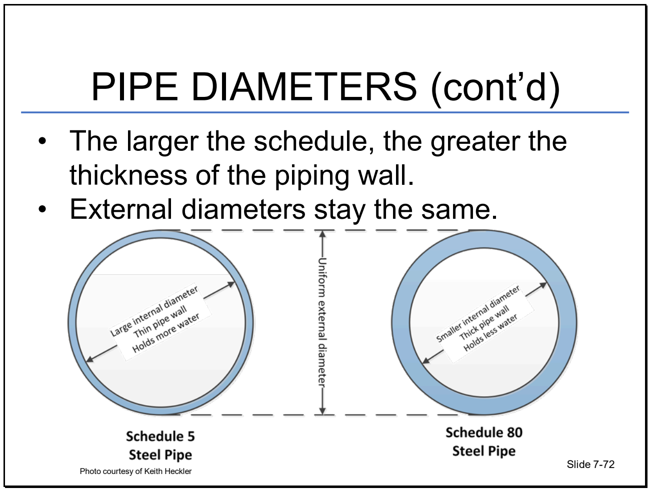
Slide 7-71

2. Pipe diameters.

   a. Pipe diameters are different than the common verbiage (i.e., 1-inch piping is not 1 inch in diameter).

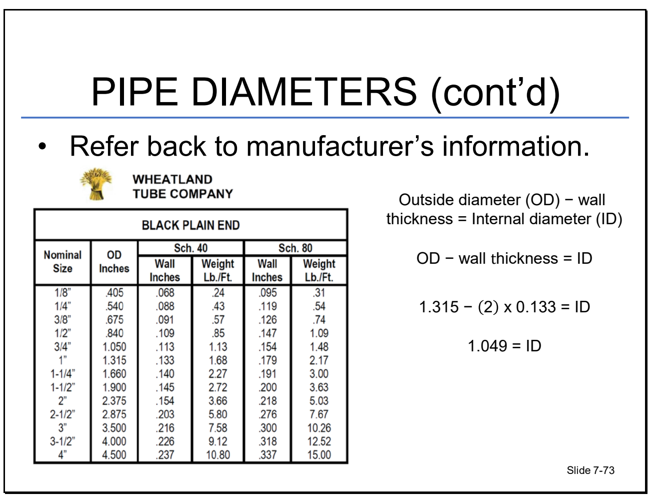
b. There are internal diameters and external diameters.

c. The "schedule" of piping refers to the thickness of the piping wall.



d. The larger the schedule, the greater the thickness of the piping wall.

e. External diameters stay the same.



BLACK PLAIN END					
Nominal Size	OD Inches	Sch. 40		Sch. 80	
		Wall Inches	Weight Lb./Ft.	Wall Inches	Weight Lb./Ft.
1/8"	.405	.068	.24	.095	.31
1/4"	.540	.088	.43	.119	.54
3/8"	.675	.091	.57	.126	.74
1/2"	.840	.109	.85	.147	1.09
3/4"	1.050	.113	1.13	.154	1.48
1"	1.315	.133	1.68	.179	2.17
1-1/4"	1.660	.140	2.27	.191	3.00
1-1/2"	1.900	.145	2.72	.200	3.63
2"	2.375	.154	3.66	.218	5.03
2-1/2"	2.875	.203	5.80	.276	7.67
3"	3.500	.216	7.58	.300	10.26
3-1/2"	4.000	.226	9.12	.318	12.52
4"	4.500	.237	10.80	.337	15.00

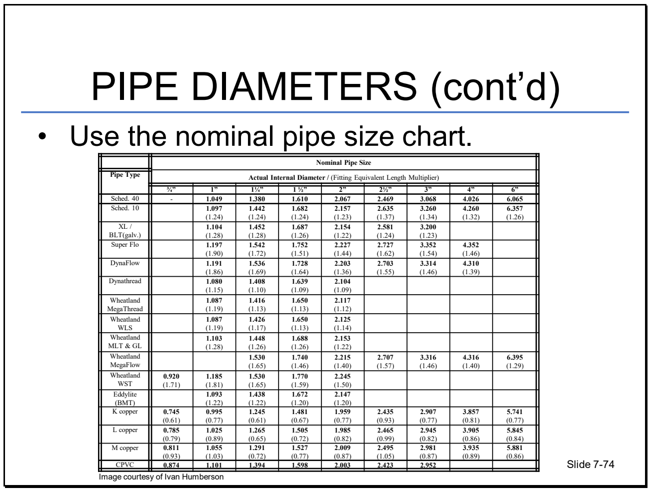
f. Refer back to manufacturer's information.

Outside diameter (OD) – wall thickness = Internal diameter (ID)

OD – wall thickness = ID

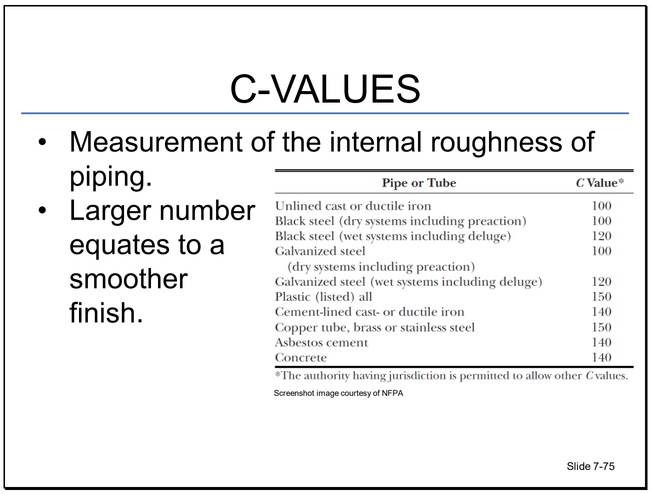
1.315 – (2) x 0.133 = ID

1.049 = ID



Pipe Type	Nominal Pipe Size — Actual Internal Diameter / (Fitting Equivalent Length Multiplier)								
	¾"	1"	1¼"	1 ½"	2"	2½"	3"	4"	6"
Sched. 40	-	**1.049**	**1.380**	**1.610**	**2.067**	**2.469**	**3.068**	**4.026**	**6.065**
Sched. 10		**1.097** (1.24)	**1.442** (1.24)	**1.682** (1.24)	**2.157** (1.23)	**2.635** (1.37)	**3.260** (1.34)	**4.260** (1.32)	**6.357** (1.26)
XL / BLT(galv.)		**1.104** (1.28)	**1.452** (1.28)	**1.687** (1.26)	**2.154** (1.22)	**2.581** (1.24)	**3.200** (1.23)		
Super Flo		**1.197** (1.90)	**1.542** (1.72)	**1.752** (1.51)	**2.227** (1.44)	**2.727** (1.62)	**3.352** (1.54)	**4.352** (1.46)	
DynaFlow		**1.191** (1.86)	**1.536** (1.69)	**1.728** (1.64)	**2.203** (1.36)	**2.703** (1.55)	**3.314** (1.46)	**4.310** (1.39)	
Dynathread		**1.080** (1.15)	**1.408** (1.10)	**1.639** (1.09)	**2.104** (1.09)				
Wheatland MegaThread		**1.087** (1.19)	**1.416** (1.13)	**1.650** (1.13)	**2.117** (1.12)				
Wheatland WLS		**1.087** (1.19)	**1.426** (1.17)	**1.650** (1.13)	**2.125** (1.14)				
Wheatland MLT & GL		**1.103** (1.28)	**1.448** (1.26)	**1.688** (1.26)	**2.153** (1.22)				
Wheatland MegaFlow			**1.530** (1.65)	**1.740** (1.46)	**2.215** (1.40)	**2.707** (1.57)	**3.316** (1.46)	**4.316** (1.40)	**6.395** (1.29)
Wheatland WST	**0.920** (1.71)	**1.185** (1.81)	**1.530** (1.65)	**1.770** (1.59)	**2.245** (1.50)				
Eddylite (BMT)		**1.093** (1.22)	**1.438** (1.22)	**1.672** (1.20)	**2.147** (1.20)				
K copper	**0.745** (0.61)	**0.995** (0.77)	**1.245** (0.61)	**1.481** (0.67)	**1.959** (0.77)	**2.435** (0.93)	**2.907** (0.77)	**3.857** (0.81)	**5.741** (0.77)
L copper	**0.785** (0.79)	**1.025** (0.89)	**1.265** (0.65)	**1.505** (0.72)	**1.985** (0.82)	**2.465** (0.99)	**2.945** (0.82)	**3.905** (0.86)	**5.845** (0.84)
M copper	**0.811** (0.93)	**1.055** (1.03)	**1.291** (0.72)	**1.527** (0.77)	**2.009** (0.87)	**2.495** (1.05)	**2.981** (0.87)	**3.935** (0.89)	**5.881** (0.86)
CPVC	**0.874**	**1.101**	**1.394**	**1.598**	**2.003**	**2.423**	**2.952**		

g. Use the nominal pipe size chart.



Pipe or Tube	*C* Value*
Unlined cast or ductile iron	100
Black steel (dry systems including preaction)	100
Black steel (wet systems including deluge)	120
Galvanized steel (dry systems including preaction)	100
Galvanized steel (wet systems including deluge)	120
Plastic (listed) all	150
Cement-lined cast- or ductile iron	140
Copper tube, brass or stainless steel	150
Asbestos cement	140
Concrete	140

*The authority having jurisdiction is permitted to allow other *C* values.

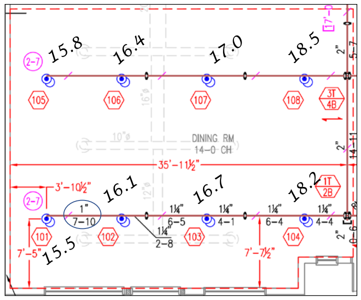
3. C-values.

a. Measurement of the internal roughness of piping.

b. Larger number equates to a smoother finish (for both internal and external piping).

WALKING THE CALCULATION (cont'd)

- Is this the correct pipe length?



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EQUIVALENT PIPE LENGTH

- When a change in the direction of the water occurs, the energy loss is measured by an equivalent straight length of pipe.
- Manufacturers of pipe, fittings and accessories will provide cut sheets with specific equivalent pipe lengths for the fittings they manufacture.

Slide 7-77

4. Equivalent pipe length.

   a. When a change in the direction of the water occurs, the energy loss is measured by an equivalent straight length of a pipe.

   b. Manufacturers of pipe, fittings and accessories will provide cut sheets with specific equivalent pipe lengths for the fittings they manufacture.

EQUIVALENT PIPE LENGTH (cont'd)

Table 22.4.3.1.1 Equivalent Schedule 40 Steel Pipe Length Chart

Fittings and Valves	Fittings and Valves Expressed in Equivalent Feet (Meters) of Pipe														
	½ in. (15 mm)	¾ in. (20 mm)	1 in. (25 mm)	1¼ in. (32 mm)	1½ in. (40 mm)	2 in. (50 mm)	2½ in. (65 mm)	3 in. (80 mm)	3½ in. (90 mm)	4 in. (100 mm)	5 in. (125 mm)	6 in. (150 mm)	8 in. (200 mm)	10 in. (250 mm)	12 in. (300 mm)
45° elbow	—	1 (0.3)	1 (0.3)	1 (0.3)	2 (0.6)	2 (0.6)	3 (0.9)	3 (0.9)	3 (0.9)	4 (1.2)	5 (1.5)	7 (2.1)	9 (2.7)	11 (3.4)	13 (4)
90° standard elbow	1 (0.3)	2 (0.6)	2 (0.6)	3 (0.9)	4 (1.2)	5 (1.5)	6 (1.8)	7 (2.1)	8 (2.4)	10 (3)	12 (3.7)	14 (4.3)	18 (5.5)	22 (6.7)	27 (8.2)
90° long-turn elbow	0.5 (0.2)	1 (0.3)	2 (0.6)	2 (0.6)	2 (0.6)	3 (0.9)	4 (1.2)	5 (1.5)	5 (1.5)	6 (1.8)	8 (2.4)	9 (2.7)	13 (4)	16 (4.9)	18 (5.5)
Tee or cross (flow turned 90°)	3 (0.9)	4 (1.2)	5 (1.5)	6 (1.8)	8 (2.4)	10 (3)	12 (3.7)	15 (4.6)	17 (5.2)	20 (6.1)	25 (7.6)	30 (9.1)	35 (10.7)	50 (15.2)	60 (18.3)
Butterfly valve	—	—	—	—	—	6 (1.8)	7 (2.1)	10 (3)	—	12 (3.7)	9 (2.7)	10 (3)	12 (3.7)	19 (5.8)	21 (6.4)
Gate valve	—	—	—	—	—	1 (0.3)	1 (0.3)	1 (0.3)	1 (0.3)	2 (0.6)	2 (0.6)	3 (0.9)	4 (1.2)	5 (1.5)	6 (1.8)
Swing check*	—	—	5 (1.5)	7 (2.1)	9 (2.7)	11 (3.4)	14 (4.3)	16 (4.9)	19 (5.8)	22 (6.7)	27 (8.2)	32 (9.3)	45 (13.7)	55 (16.8)	65 (20)

For SI units, 1 in. = 25.4 mm; 1 ft = 0.3048 m.
Note: Information on ½ in. pipe is included in this table only because it is allowed under 8.15.19.4 and 8.15.19.5.
*Due to the variation in design of swing check valves, the pipe equivalents indicated in this table are considered average.

Screenshot images courtesy of NFPA

Slide 7-78

c. On the slide is a chart directly from NFPA 13 and part of Appendix B: Fire Protection Ready Reference of the Student Manual (SM) showing the equivalent lengths of pipe associated with the type of fitting.

EQUIVALENT PIPE LENGTH (cont'd)

- Calculations list the values used.

```
 (6) PIPE FITTINGS TABLE

User Pipe Table Name: 3DPIPE.PIP

PAGE: A    MATERIAL: S40    HWC: 120
Diameter           Equivalent Fitting Lengths in Feet
  (in)        E      T      L      C      B      G      A      D      N
             Ell    Tee LngEll ChkVlv BfyVlv GatVlv AlmChk  DPVlv  NPTee
  1.049     2.00   5.00   2.00   5.00   6.00   1.00  10.00  10.00   5.00
  1.380     3.00   6.00   2.00   7.00   6.00   1.00  10.00  10.00   6.00
  2.067     5.00  10.00   3.00  11.00   6.00   1.00  10.00  10.00  10.00
  3.068     7.00  15.00   5.00  16.00  10.00   1.00  13.00  13.00  15.00

PAGE: D    MATERIAL: DIRON    HWC: 140
Diameter           Equivalent Fitting Lengths in Feet
  (in)        E      T      L      C      B      G      N
             Ell    Tee LngEll ChkVlv BfyVlv GatVlv  NPTee
  6.280    22.00  47.00  14.00  51.00  16.00   5.00  47.00
```

Slide 7-79

d. Calculations list the values used.

- The calculation has a database included that is printed after the calculation summary. This is how the computer reads the fittings that are inserted into the calculation. The values inserted must be checked to verify they are correct.

WALKING THE CALCULATION (cont'd)

- Place a check to show completion.
  - Remember, we are not calculating the system, just verifying inputs.
  - Let the computer do the work.

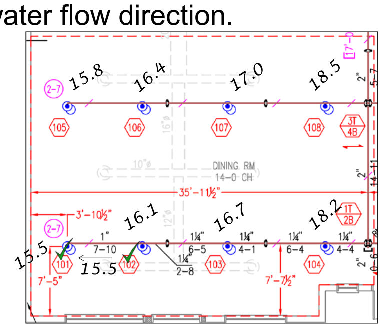
PIPE TAG END NODES	ELEV. (FT)	NOZ. (K)	PT (PSI)	DISC. (GPM)	Q(GPM) VEL(FPS)	DIA(IN) HW(C) FL/FT	LENGTH (FT)		PRESS. SUM. (PSI)
Pipe: 1					-15.5	1.049	PL	8.00	PF 0.6
101	17.0	5.3	8.6	15.5	5.8	120	FTG	----	PE 0.0
102	17.0	5.3	9.2	16.1		0.081	TL	8.00	PV

Slide 7-80

5. Place a check to show completion.

WALKING THE CALCULATION (cont'd)

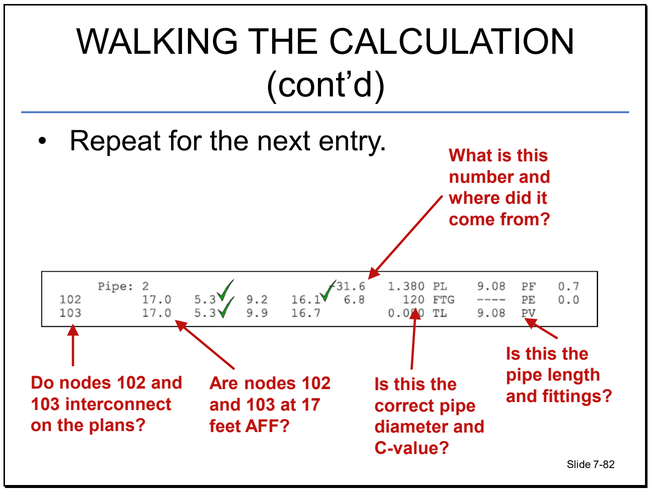
- Place check marks at the nodes and show the water flow direction.



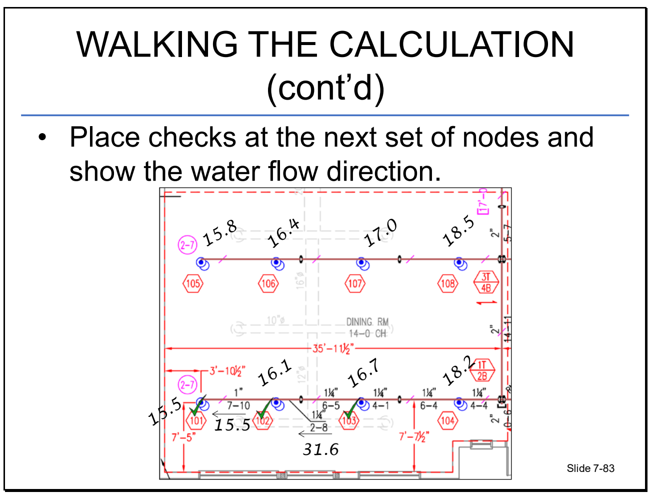
Slide 7-81

a. Place check marks at the nodes and show the water flow direction.

b. The negative number for Q (gpm) indicates the direction of the water flow (right to left).

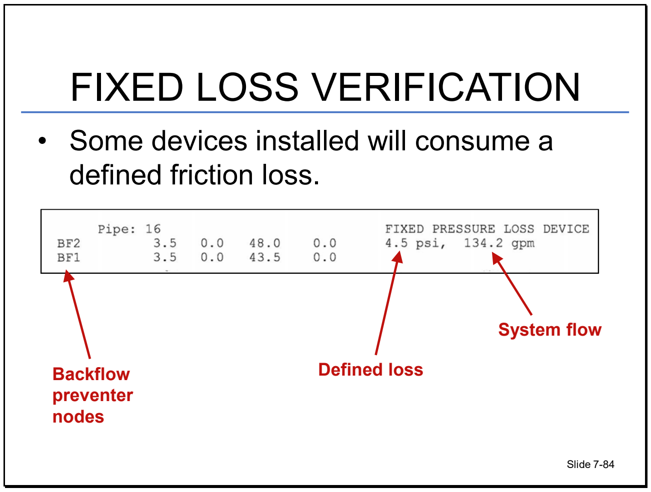


c. Repeat for the next entry (see the slide).

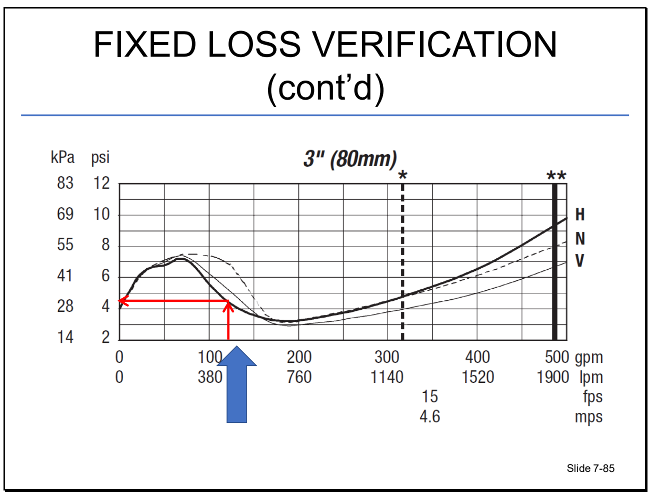


d. Place checks at the next set of nodes and show the water flow direction.

- The K-factor is 0.0 because there is no water discharge. The C-value is directly from NFPA 13.



B. Fixed loss verification.



C. The fixed pressure loss for this backflow preventer is predicated upon the flow that the system is calculated to be demanding.

VII. VERIFY HOSE STREAM

STEP 7: VERIFY HOSE STREAM

Step	Tool
1. Look for required information.	Calculations and NFPA 13.
2. Verify hazard classifications.	NFPA 13 and Unit 2.
3. Verify shape and dimensions of remote area.	NFPA 13 and formulas.
4. Check all hydraulic reference points (nodes).	Calculations and plans.
5. Validate sprinkler data.	Calculations, plans and manufacturer's product literature.
6. Verify pressure losses (P_e and P_f), including fixed loss devices.	Calculations and plans.
7. Verify hose stream.	Calculations, NFPA 13 and Unit 3.
8. Validate water supplies.	Calculations, plans and water supply data information.

Slide 7-86

Step 7: Verify hose stream using calculations, NFPA 13 and Unit 3: Water Supplies and Delivery Systems.

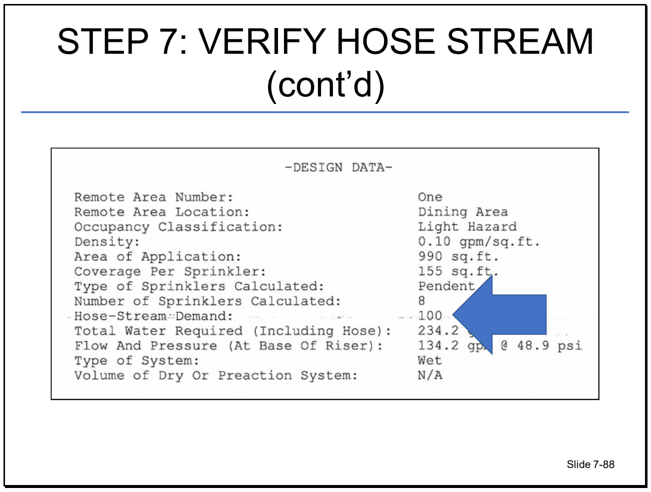
STEP 7: VERIFY HOSE STREAM (cont'd)

Occupancy	Inside hose (gpm)	Combined hose (gpm)	Duration (minutes)
Light	0, 50, 100	100	30
Ordinary — Supervised	0, 50, 100	250	60
Ordinary — Unsupervised	0, 50, 100	250	90
Extra — Supervised	0, 50, 100	500	90
Extra — Unsupervised	0, 50, 100	500	120

Slide 7-87

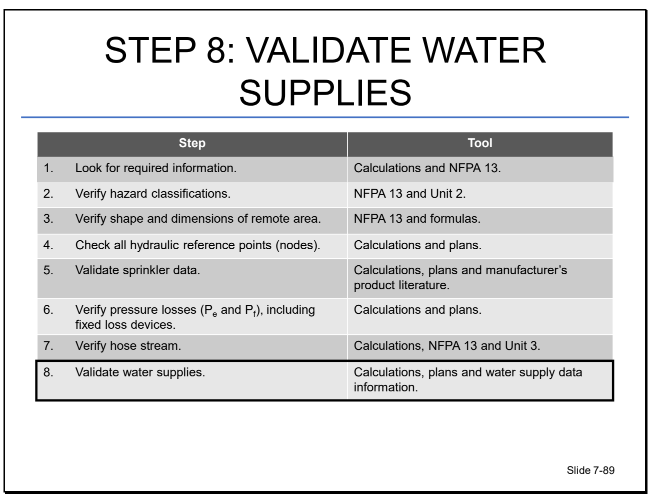
A. Note that the chart on the slide was first introduced in Unit 3 when calculating the total amount of water needed when using a tank or other stored water supply.

B. The information in this chart can also be used to verify if the amount of hose streams is accounted for in the calculation for fire department operations when the sprinkler system is also operating at the same time. The point where the water is added into the calculation is always at the point where the fire department will have the water discharge.

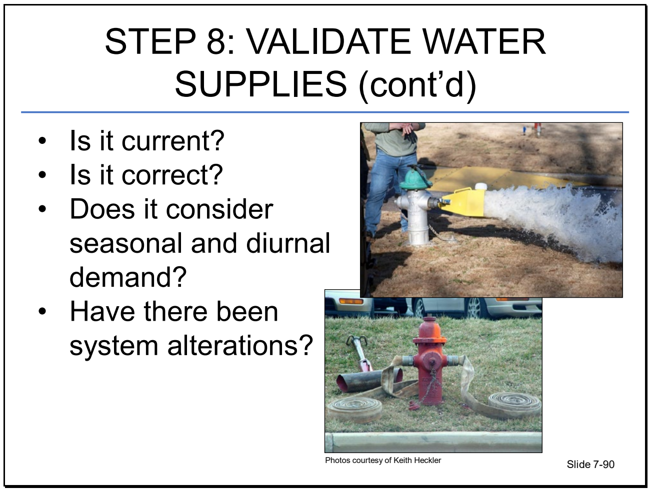


C. Hose stream demand is added into the calculation on the coversheet. Below the hose stream demand entry confirms that the hose stream was added to the sprinkler demand.

VIII. VALIDATE WATER SUPPLIES



Step 8: Validate water supplies using calculations, plans and water supply data information.

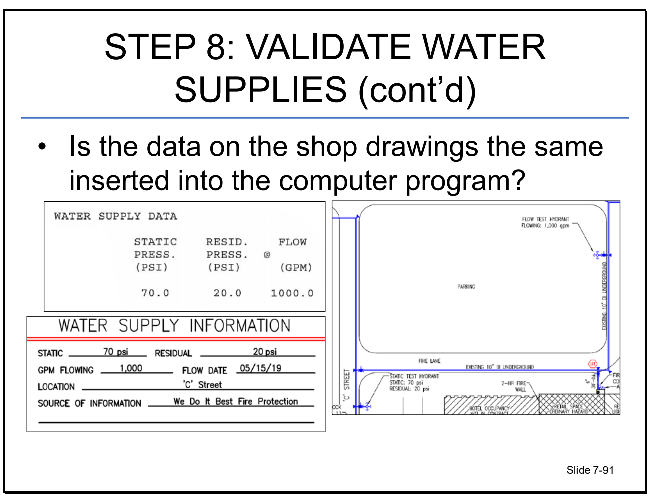


A. Is it current?

B. Is it correct?

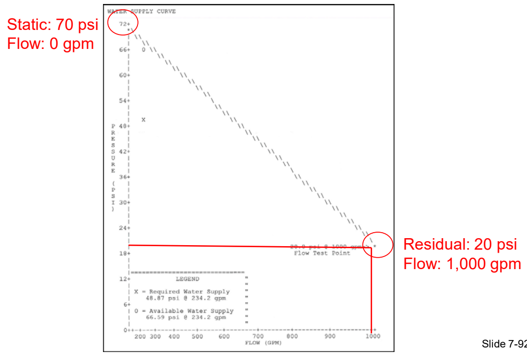
C. Does it consider seasonal and diurnal demand?

D. Have there been system alterations?



E. Is the data on the shop drawings the same inserted into the computer program? It is critically important to match this value when the flow test is conducted.

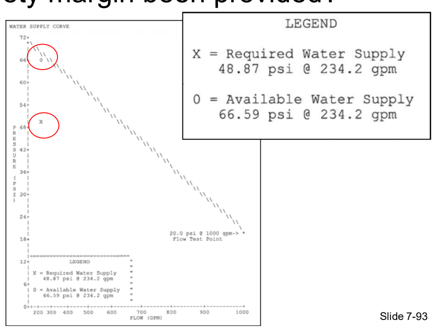
STEP 8: VALIDATE WATER SUPPLIES (cont'd)



Slide 7-92

STEP 8: VALIDATE WATER SUPPLIES (cont'd)

- Has a safety margin been provided?



Slide 7-93

ACTIVITY 7.1

Formula Exercise

Purpose

Use formulas to verify the remote area arrangement based on a set of sprinkler plans and associated hydraulic calculations.

Directions

1. Use The Learning Square plans and the equations used in this unit.

2. Determine if the remote area 1 in Retail Shell space is adequately designed.

3. Calculated answers should be rounded to two decimal points.

   a. Density over area (height adjustment).

   ____

   ____

   ____

   b. Length of rectangle.

   ____

   ____

   ____

   c. Minimum number of sprinklers in remote area.

   ____

   ____

   ____

d. Minimum number of sprinklers on branch line.

____

____

____

e. Verify density.

____

____

____

f. Verify starting pressure.

____

____

____

g. Verify minimum amount of water required.

____

____

____

4. The instructor will review the correct answers with the class at the end of the activity.

ACTIVITY 7.2

Hydraulic Calculations

Purpose

Verify that the calculation inputs used in a given set of calculations are in compliance with recognized standards and that sprinkler systems design calculations are accurate.

Directions

1. Use The Learning Square plans and the hydraulic calculations for remote area 1 used in this unit.

2. Review the calculations while following the information shown on the plans. Determine if the input data for the hydraulic calculations for remote area 1 in Retail Shell space is correct.

3. If found, incorrect calculation entries must be identified by circling, squaring or another manner for indicating that an anomaly has occurred.

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ACTIVITY 7.2 (cont'd)

Hydraulic Calculations for Remote Area 1

HYDRAULIC CALCULATIONS FOR

Project Name: The Learning Square - Retail Space
Project Location: Idaho Falls, Idaho
Drawing Number: F-2
Date: July 22, 2019

-DESIGN DATA-

Remote Area Number:	One
Remote Area Location:	Shell Space
Occupancy Classification:	Ordinary Hazard Group 2
Density:	0.15 gpm/sq.ft.
Area of Application:	1061 sq.ft.
Coverage Per Sprinkler:	130 sq.ft.
Type of Sprinklers Calculated:	Upright
Number of Sprinklers Calculated:	11
Hose-Stream Demand:	100 gpm
Total Water Required (Including Hose):	427.3 gpm
Flow And Pressure (At Base Of Riser):	327.3 gpm @ 65.9 psi
Type of System:	Wet
Volume of Dry Or Preaction System:	N/A

-WATER SUPPLY INFORMATION-

Test Date:	05/15/17
Source of Information:	We Do It Best Fire Protection
Location:	'C' Street
Source Elevation:	2'-6

-INSTALLING CONTRACTOR-

WE DO IT BEST FIRE PROTECTION
P.O. BOX 000
IDAHO FALLS, IDAHO 83405

CERTIFICATION NUMBER: FPC-000

Design/Layout By: CFH
Authority Having Jurisdiction: Idaho State Fire Marshal

NOTES:

Calculations performed by HASS 7.9 under license # 16010595 ,

SPRINKLER SYSTEM HYDRAULIC ANALYSIS Page 2

DATE: 5/7/2019ETAIL\HASS FILES\REMOTE AREA #1 SHELL SPACE WITH ERRORS.SDF

JOB TITLE: Remote #1 - Retail Space Shell

WATER SUPPLY DATA

SOURCE NODE TAG	STATIC PRESS. (PSI)	RESID. PRESS. (PSI)	@	FLOW (GPM)	AVAIL. PRESS. (PSI)	@	TOTAL DEMAND (GPM)	REQ'D PRESS. (PSI)
U1	70.0	30.0		1250.0	60.4		577.3	65.9

AGGREGATE FLOW ANALYSIS:

TOTAL FLOW AT SOURCE	577.3 GPM
TOTAL HOSE STREAM ALLOWANCE AT SOURCE	250.0 GPM
OTHER HOSE STREAM ALLOWANCES	0.0 GPM
TOTAL DISCHARGE FROM ACTIVE SPRINKLERS	327.3 GPM

NODE ANALYSIS DATA

NODE TAG	ELEVATION (FT)	NODE TYPE	PRESSURE (PSI)	DISCHARGE (GPM)
101	9.0	K= 7.46	12.1	26.0
102	9.0	K= 7.46	12.6	26.4
103	9.0	K= 7.46	14.1	28.0
104	9.0	K= 7.46	17.5	31.2
105	9.0	K= 7.45	12.4	26.2
106	9.0	K= 7.45	12.8	26.7
107	9.0	K= 7.45	14.4	28.2
108	9.0	K= 7.45	17.8	31.4
109	9.0	K= 7.43	20.2	33.4
110	9.0	K= 7.43	20.9	33.9
111	9.0	K= 7.43	23.3	35.9
1T	9.0	- - - -	39.0	- - -
2B	9.0	- - - -	39.3	- - -
3T	9.0	- - - -	39.6	- - -
4B	9.0	- - - -	40.0	- - -
5T	9.0	- - - -	41.9	- - -
6B	9.0	- - - -	42.2	- - -
8B	9.0	- - - -	46.7	- - -
10B	9.0	- - - -	51.2	- - -
R2	9.0	- - - -	58.8	- - -
R3	9.0	- - - -	58.9	- - -
BF1	9.0	- - - -	59.0	- - -
BF2	9.0	- - - -	61.0	- - -
R4	9.0	- - - -	63.0	- - -
U1	2.5	SOURCE	65.9	327.3

```
                    SPRINKLER SYSTEM HYDRAULIC ANALYSIS              Page 3
DATE: 5/7/2019ETAIL\HASS FILES\REMOTE AREA #1 SHELL SPACE WITH ERRORS.SDF
JOB TITLE: Remote #1 - Retail Space Shell

PIPE DATA

PIPE TAG                                Q(GPM)  DIA(IN)  LENGTH    PRESS.
  END    ELEV.  NOZ.    PT   DISC.  VEL(FPS) HW(C)      (FT)      SUM.
 NODES   (FT)   (K)   (PSI) (GPM)           FL/FT                (PSI)

     Pipe: 1                             -26.0   1.380 PL   10.00  PF   0.4
101         9.0   7.5   12.1   26.0   5.6     140 FTG   ----  PE   0.0
102         9.0   7.5   12.6   26.4          0.042 TL   10.00  PV

     Pipe: 2                             -52.4   1.380 PL   10.00  PF   1.5
102         9.0   7.5   12.6   26.4  11.2     140 FTG   ----  PE   0.0
103         9.0   7.5   14.1   28.0          0.153 TL   10.00  PV

     Pipe: 3                             -80.5   1.380 PL   10.00  PF   3.4
103         9.0   7.5   14.1   28.0  17.3     140 FTG   ----  PE   0.0
104         9.0   7.5   17.5   31.2          0.338 TL   10.00  PV

     Pipe: 4                            -111.6   1.380 PL   34.79  PF  21.5
104         9.0   7.5   17.5   31.2  23.9     140 FTG   ----  PE   0.0
1T          9.0   0.0   39.0    0.0          0.619 TL   34.79  PV

     Pipe: 5                            -111.6   1.380 PL    0.50  PF   0.3
1T          9.0   0.0   39.0    0.0  23.9     140 FTG   ----  PE   0.0
2B          9.0   0.0   39.3    0.0          0.619 TL    0.50  PV

     Pipe: 6                             -26.2   1.380 PL   10.00  PF   0.4
105         9.0   7.5   12.4   26.2   5.6     140 FTG   ----  PE   0.0
106         9.0   7.5   12.8   26.7          0.042 TL   10.00  PV

     Pipe: 7                             -52.9   1.380 PL   10.00  PF   1.6
106         9.0   7.5   12.8   26.7  11.3     140 FTG   ----  PE   0.0
107         9.0   7.5   14.4   28.2          0.155 TL   10.00  PV

     Pipe: 8                             -81.1   1.380 PL   10.00  PF   3.4
107         9.0   7.5   14.4   28.2  17.4     140 FTG   ----  PE   0.0
108         9.0   7.5   17.8   31.4          0.343 TL   10.00  PV

     Pipe: 9                            -112.5   1.380 PL   34.79  PF  21.9
108         9.0   7.5   17.8   31.4  24.1     140 FTG   ----  PE   0.0
3T          9.0   0.0   39.6    0.0          0.628 TL   34.79  PV

     Pipe: 10                           -112.5   1.380 PL    0.50  PF   0.3
3T          9.0   0.0   39.6    0.0  24.1     140 FTG   ----  PE   0.0
4B          9.0   0.0   40.0    0.0          0.628 TL    0.50  PV

     Pipe: 11                            -33.4   1.380 PL   10.00  PF   0.7
109         9.0   7.4   20.2   33.4   7.2     140 FTG   ----  PE   0.0
110         9.0   7.4   20.9   33.9          0.066 TL   10.00  PV

     Pipe: 12                            -67.3   1.380 PL   10.00  PF   2.4
110         9.0   7.4   20.9   33.9  14.4     140 FTG   ----  PE   0.0
111         9.0   7.4   23.3   35.9          0.243 TL   10.00  PV
```

```
                    SPRINKLER SYSTEM HYDRAULIC ANALYSIS              Page 4
DATE: 5/7/2019ETAIL\HASS FILES\REMOTE AREA #1 SHELL SPACE WITH ERRORS.SDF
JOB TITLE: Remote #1 - Retail Space Shell

PIPE TAG                                  Q(GPM)   DIA(IN)  LENGTH     PRESS.
  END     ELEV.  NOZ.    PT    DISC.  VEL(FPS)  HW(C)      (FT)       SUM.
 NODES    (FT)   (K)   (PSI)  (GPM)             FL/FT                 (PSI)

     Pipe: 13                             -103.2   1.380 PL   34.79  PF  18.6
111          9.0   7.4   23.3   35.9  22.1       140 FTG   ----   PE   0.0
5T           9.0   0.0   41.9    0.0           0.536 TL   34.79  PV

     Pipe: 14                             -103.2   1.380 PL    0.50  PF   0.3
5T           9.0   0.0   41.9    0.0  22.1       140 FTG   ----   PE   0.0
6B           9.0   0.0   42.2    0.0           0.536 TL    0.50  PV

     Pipe: 15                             -111.6   2.215 PL   10.00  PF   0.6
2B           9.0   0.0   39.3    0.0   9.3       140 FTG   ----   PE   0.0
4B           9.0   0.0   40.0    0.0           0.062 TL   10.00  PV

     Pipe: 16                             -224.1   2.215 PL   10.00  PF   2.2
4B           9.0   0.0   40.0    0.0  18.7       140 FTG   ----   PE   0.0
6B           9.0   0.0   42.2    0.0           0.224 TL   10.00  PV

     Pipe: 17                             -327.3   2.215 PL   10.00  PF   4.5
6B           9.0   0.0   42.2    0.0  27.3       140 FTG   ----   PE   0.0
8B           9.0   0.0   46.7    0.0           0.452 TL   10.00  PV

     Pipe: 18                             -327.3   2.215 PL   10.00  PF   4.5
8B           9.0   0.0   46.7    0.0  27.3       140 FTG   ----   PE   0.0
10B          9.0   0.0   51.2    0.0           0.452 TL   10.00  PV

     Pipe: 19                             -327.3   2.215 PL   16.71  PF   7.6
10B          9.0   0.0   51.2    0.0  27.3       140 FTG   ----   PE   0.0
R2           9.0   0.0   58.8    0.0           0.452 TL   16.71  PV

     Pipe: 20                             -327.3   4.260 PL    7.00  PF   0.1
R2           9.0   0.0   58.8    0.0   7.4       140 FTG   ----   PE   0.0
R3           9.0   0.0   58.9    0.0           0.019 TL    7.00  PV

     Pipe: 21                             -327.3   4.260 PL    1.00  PF   0.0
R3           9.0   0.0   58.9    0.0   7.4       140 FTG   ----   PE   0.0
BF1          9.0   0.0   59.0    0.0           0.019 TL    1.00  PV

     Pipe: 22                                 FIXED PRESSURE LOSS DEVICE
BF2          9.0   0.0   61.0    0.0      2.0 psi,  327.3 gpm
BF1          9.0   0.0   59.0    0.0

     Pipe: 23                             -327.3   3.068 PL    2.00  PF   2.0
BF2          9.0   0.0   61.0    0.0  14.2       140 FTG      T  PE   0.0
R4           9.0   0.0   63.0    0.0           0.093 TL   21.95  PV

     Pipe: 24                             -327.3   8.390 PL   30.00  PF   0.1
R4           9.0   0.0   63.0    0.0   1.9       140 FTG  ET2LG  PE   2.8
U1           2.5  SRCE   65.9  (N/A)           0.001 TL  171.00  PV
```

SPRINKLER SYSTEM HYDRAULIC ANALYSIS Page 5
DATE: 5/7/2019ETAIL\HASS FILES\REMOTE AREA #1 SHELL SPACE WITH ERRORS.SDF
JOB TITLE: Remote #1 - Retail Space Shell

NOTES (HASS):

(1) Calculations were performed by the HASS 8.8 computer program
in accordance with NFPA13 (2016)
under license no. 16010595 granted by
HRS Systems, Inc.
208 Southside Square
Petersburg, TN 37144
(931) 659-9760

(2) The system has been calculated to provide an average imbalance at each node of 0.003 gpm and a maximum imbalance at any node of 0.071 gpm.

(3) Total pressure at each node is used in balancing the system. Maximum water velocity is 27.3 ft/sec at pipe 19.

(4) Items listed in bold print on the cover sheet

are automatically transferred from the calculation report.

(5) Available pressure at source node U1 under full flow conditions is 60.86 psi with a flow of 562.71 gpm.

(6) PIPE FITTINGS TABLE

User Pipe Table Name: 3DPIPE.PIP

PAGE: * MATERIAL: S40 HWC: 120

Diameter (in)	E Ell	T Tee	L LngEll	C ChkVlv	B BfyVlv	G GatVlv	A AlmChk	D DPVlv	N NPTee
2.215	7.00	14.00	4.20	15.40	8.40	1.40	14.00	14.00	14.00
4.260	13.17	26.33	7.90	28.97	15.80	2.63	26.33	26.33	26.33

Equivalent Fitting Lengths in Feet

PAGE: A MATERIAL: S40 HWC: 120

Diameter (in)	E Ell	T Tee	L LngEll	C ChkVlv	B BfyVlv	G GatVlv	A AlmChk	D DPVlv	N NPTee
1.380	3.00	6.00	2.00	7.00	6.00	1.00	10.00	10.00	6.00
3.068	7.00	15.00	5.00	16.00	10.00	1.00	13.00	13.00	15.00

Equivalent Fitting Lengths in Feet

PAGE: D MATERIAL: DIRON HWC: 140

Diameter (in)	E Ell	T Tee	L LngEll	C ChkVlv	B BfyVlv	G GatVlv	N NPTee
8.390	31.00	59.00	22.00	76.00	20.00	7.00	59.00

Equivalent Fitting Lengths in Feet

```
                    SPRINKLER SYSTEM HYDRAULIC ANALYSIS            Page 7
DATE: 5/7/2019ETAIL\HASS FILES\REMOTE AREA #1 SHELL SPACE WITH ERRORS.SDF
JOB TITLE: Remote #1 - Retail Space Shell

WATER SUPPLY CURVE

   72+
     *
     |\
     | \
   66+  \   X
     |   \
     |    \
     |     \
   60+      0
     |       \
     |        \
     |         \
   54+          \
     |           \
     |            \
     |             \
 P 48+              \
 R   |               \
 E   |                \
 S   |                 \
 S 42+                  \
 U   |                   \
 R   |                    \
 E   |                     \
   36+                      \
 (   |                       \
 P   |                        \
 S   |                         \
 I 30+                          * <-30.0 psi @ 1250 gpm
 )   |                              Flow Test Point
     |
     |
   24+
     |
     |
     |
   18+
     |
     |
     |==============================
   12+           LEGEND            "
     |                             "
     | X = Required Water Supply   "
     |    65.92 psi @ 577.3 gpm    "
    6+                             "
     | 0 = Available Water Supply  "
     |    60.42 psi @ 577.3 gpm    "
     |                             "
    0++-+---+----+-----+------+--------+--------+---------+----------+
       400 600  800  1000   1200    1400     1600      1800       2000
                                  FLOW (GPM)
```

SPRINKLER SYSTEM HYDRAULIC ANALYSIS Page 8
DATE: 5/7/2019ETAIL\HASS FILES\REMOTE AREA #1 SHELL SPACE WITH ERRORS.SDF
JOB TITLE: Remote #1 - Retail Space Shell

Utility Report:

Equivalent K-Factor Calculator

Node Name	Sprinkler K-Factor	Pres. (psi)	Dia. (in)	Pipe Len.(ft)	Ftgs.	Total Len.(ft)	H-W coef.	Equivalent K-factor
101	8.00	7.00	1.000	1.75	T	5.71	120.00	7.46
105	8.00	7.00	1.000	1.92	T	5.88	120.00	7.45
109	8.00	7.00	1.000	2.17	T	6.13	120.00	7.43

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ACTIVITY 7.3

Reviewing Calculations for Plans

Purpose

Evaluate the calculations on the provided plans.

Directions

1. You will use The Learning Square plans, equations used in this unit and the hydraulic calculations for this activity.

2. Determine if remote areas 2 and 3 are adequately designed.

3. Calculated answers should be rounded to two decimal points.

4. Determine if the hydraulic calculations for remote areas 2 and 3 are correct.

   a. Remote area 2.

      - Start with remote area calculations.

      - Two-tenths gpm over 1,500 square feet.

        ____

        ____

        ____

      - Measure remote area.

        ____

        ____

        ____

      - Calculate the longest minimum length of the remote area for the restaurant.

        ____

        ____

        ____

- Length along branch lines is not possible without crossing over into Retail Shell Space. This is permitted because of one-hour fire rated occupancy separation. This creates the largest room rule.

  -- The minimum number of sprinklers in design area is:

  ___

  ___

  ___

- Next, verify adequate flow for the required density.

  ___

  ___

  ___

- Next, verify starting pressure.

  ___

  ___

  ___

- What is minimum total flow for design?

  ___

  ___

  ___

b. Remote area 3: You should have written the sprinkler flows at the nodes. You should be able to provide check marks at important data inputs on the calculations and draw the flows between the node points all the way to the water supply test.

- Start with remote area calculations.

- Two-tenths gpm per single line.

- Measure the remote area.

  ____

  ____

  ____

- Calculate the longest minimum length of the remote area for the restaurant.

  ____

  ____

  ____

- Next, verify adequate flow for the required density.

  ____

  ____

  ____

- Next, verify starting pressure.

  ____

  ____

  ____

- What is minimum total flow for design?

  ____

  ____

  ____

5. The instructor will review the correct answers with the class at the end of the activity.

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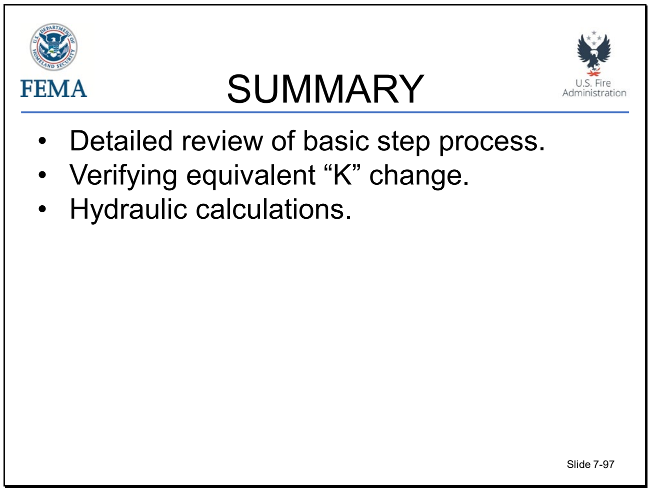
IX. SUMMARY


FEMA
SUMMARY
U.S. Fire Administration
• Detailed review of basic step process.
• Verifying equivalent "K" change.
• Hydraulic calculations.
Slide 7-97

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REFERENCE

National Fire Protection Association. (2019). *Standard for the installation of sprinkler systems*. (Standard no. 13). Retrieved from https://www.nfpa.org

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APPENDIX

SUPPLEMENTAL MATERIALS

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Validating Sprinkler Data

Validating sprinkler data is one of the steps (Step 5) in the basic step process for calculation review. To validate sprinkler data, use calculations, provided plans and manufacturer's product literature.

1. Locate the sprinkler node analysis table in the calculations.

2. Transfer the sprinkler flows onto the plans to evaluate the flows.

3. Write flows adjacent to corresponding node.

4. Verify adequate flow for the required density at sprinkler node 101.

$$Q = \rho A$$

$$\rho = \frac{Q}{A}$$

5. Verify starting pressure of sprinkler node 101.

$$Q = K \sqrt{P}$$

$$P = \left(\frac{Q}{K}\right)^2$$

6. To calculate an equivalent K-factor, calculate the starting pressure for the sprinkler with the standard "K." The equivalent "K" is calculated so the designer does not have to calculate every drop on the branch line in the demand area.

$$Q = K \sqrt{P}$$

$$P = \left(\frac{Q}{K}\right)^2$$

7. Use the Hazen-Williams equation to calculate the friction loss in the piping.

$$p = \frac{(4.52)\,(Q^{1.85})}{(C^{1.85})\,(d^{4.87})}$$

8. Make sure to account for length of piping.

9. Add the additional pressure to the original start pressure (starting pressure + calculated friction loss).

10. Use the new pressure to calculate a new K-factor.

$$Q = K\sqrt{P}$$

$$K = \frac{Q}{\sqrt{P}}$$

11. Calculations will provide a miniature calculation to show the adjustment.

12. Verify equivalent “K” change. If K-factors are correct, place a check mark near the number to indicate you have verified the number. If K-factors are incorrect, circle to mark the anomaly.

Pipe Type	Nominal Pipe Size Actual Internal Diameter / (Fitting Equivalent Length Multiplier)								
	¾”	1”	1¼”	1 ½”	2”	2½”	3”	4”	6”
Sched. 40	-	**1.049**	**1.380**	**1.610**	**2.067**	**2.469**	**3.068**	**4.026**	**6.065**
Sched. 10		**1.097** (1.24)	**1.442** (1.24)	**1.682** (1.24)	**2.157** (1.23)	**2.635** (1.37)	**3.260** (1.34)	**4.260** (1.32)	**6.357** (1.26)
XL / BLT(galv.)		**1.104** (1.28)	**1.452** (1.28)	**1.687** (1.26)	**2.154** (1.22)	**2.581** (1.24)	**3.200** (1.23)		
Super Flo		**1.197** (1.90)	**1.542** (1.72)	**1.752** (1.51)	**2.227** (1.44)	**2.727** (1.62)	**3.352** (1.54)	**4.352** (1.46)	
DynaFlow		**1.191** (1.86)	**1.536** (1.69)	**1.728** (1.64)	**2.203** (1.36)	**2.703** (1.55)	**3.314** (1.46)	**4.310** (1.39)	
Dynathread		**1.080** (1.15)	**1.408** (1.10)	**1.639** (1.09)	**2.104** (1.09)				
Wheatland MegaThread		**1.087** (1.19)	**1.416** (1.13)	**1.650** (1.13)	**2.117** (1.12)				
Wheatland WLS		**1.087** (1.19)	**1.426** (1.17)	**1.650** (1.13)	**2.125** (1.14)				
Wheatland MLT & GL		**1.103** (1.28)	**1.448** (1.26)	**1.688** (1.26)	**2.153** (1.22)				
Wheatland MegaFlow			**1.530** (1.65)	**1.740** (1.46)	**2.215** (1.40)	**2.707** (1.57)	**3.316** (1.46)	**4.316** (1.40)	**6.395** (1.29)
Wheatland WST	**0.920** (1.71)	**1.185** (1.81)	**1.530** (1.65)	**1.770** (1.59)	**2.245** (1.50)				
Eddylite (BMT)		**1.093** (1.22)	**1.438** (1.22)	**1.672** (1.20)	**2.147** (1.20)				
K copper	**0.745** (0.61)	**0.995** (0.77)	**1.245** (0.61)	**1.481** (0.67)	**1.959** (0.77)	**2.435** (0.93)	**2.907** (0.77)	**3.857** (0.81)	**5.741** (0.77)
L copper	**0.785** (0.79)	**1.025** (0.89)	**1.265** (0.65)	**1.505** (0.72)	**1.985** (0.82)	**2.465** (0.99)	**2.945** (0.82)	**3.905** (0.86)	**5.845** (0.84)
M copper	**0.811** (0.93)	**1.055** (1.03)	**1.291** (0.72)	**1.527** (0.77)	**2.009** (0.87)	**2.495** (1.05)	**2.981** (0.87)	**3.935** (0.89)	**5.881** (0.86)
CPVC	**0.874**	**1.101**	**1.394**	**1.598**	**2.003**	**2.423**	**2.952**		

IJH Nominal Pipe Size Chart October 18, 2006

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APPENDIX A

REMOTE AREA CHECKLIST

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REMOTE AREA CHECKLIST

Preliminary ☐ Date ____________________
Resubmittal ☐ Permit/File No. ____________________
Final ☐ Reviewer ____________________

PROJECT

Building/Tenant Space ____________________
Address ____________________
Fire Protection Contractor ____________________
NFPA Hazard Class(es) ☐ Light ☐ OH 1 ☐ OH 2 ☐ EH1 ☐ EH2 ☐ Other__________
Plan Date ____________________ Sheets ________ through ________

NOTE: This form is a *guide.* Always refer to the latest legally adopted version of the codes and standards in your jurisdiction.

1. Yes ☐ No ☐ N/A ☐ Is the submittal package adequate to review the plans?

FREQUENTLY USED FIRE PROTECTION INFORMATION*			
K = Fire sprinkler orifice constant Q = Flow (gallons per minute) p = Pounds per square inch v = Velocity in feet per second d = Diameter in inches Cn = Nozzle coefficient C = Friction loss coefficient (roughness) Qa = Available flow Qt = Test flow Ht = Pressure drop during test Ha = Pressure drop to assumed residual	1 US gallon = 231 cu. in. 1 US gallon = 0.1337 cu. ft. 1 cubic foot = 7.481 gallons Water weight = 8.33 lbs/gallon Fire pumps shall furnish 150% of rated capacity at not less than 65% of rated head. Shut-off head shall not exceed 120% of rated head.	Head in ft. = 2.31 p p = (head in feet) x .433 1" = 0.08' 2" = 0.17' 3" = 0.25' 4" = 0.33' 5" = 0.42' 6" = 0.50'	 7" = 0.58' 8" = 0.67' 9" = 0.75' 10" = 0.83' 11" = 0.92' 12" = 1'

*Always use abbreviations and symbol legends provided in the submittal.

NOTES/COMMENTS

____

____

____

____

2. Yes ☐ No ☐ N/A ☐ Using the NFPA 13 density/area curves, or special rulings, are the density and design area acceptable?

Density ________ gpm/ft² Design area __________ ft²

3. Yes ☐ No ☐ N/A ☐ Is the area of sprinkler coverage (A_s) accurate?

$$A_s = S \, x \, L$$

Where S = Larger of twice the distance to a wall/ obstruction or next sprinkler on same branch line.
L = Larger of twice the distance to a wall/ obstruction or distance between branch lines.

	LIGHT HAZARD		ORDINARY HAZARD		EXTRA HAZARD	
Construction type	Protection area ft²	Spacing (max) ft²	Protection area ft²	Spacing (max) ft²	Protection area ft²	Spacing (max) ft²
Noncombustible obstructed and unobstructed	225	15	130	15	100 Hydraulically calculated with density ≥0.25 130 Hydraulically calculated with density <0.25	12 15
Combustible unobstructed with exposed member 3 ft or more on center	225	15				
Combustible obstructed with exposed member 3 ft or more on center	168	15				
Combustible obstructed or unobstructed with exposed members less than 3 ft on center	130	15				
Combustible concealed space under pitched roof having combustible wood joist or wood truss construction with members less than 3 ft on center with slopes having a pitch of 4 in 12 or greater	120	15 parallel to the slope 10 perpendicular to the slope				

4. Yes ☐ No ☐ N/A ☐ Can the design area be reduced on a percentage basis in Light or Ordinary occupancy with quick response wet pipe sprinklers?

$$Y=\left(\frac{-3X}{2}\right)+55$$

Where X = Ceiling Height (≥ 10 ft and ≤ 20 ft)
Y = % reduction

5. Yes ☐ No ☐ N/A ☐ For *dry pipe, sloped ceilings* or *Extra Hazard* systems **ONLY**, has the remote area been adjusted?

6. Yes ☐ No ☐ N/A ☐ Is the number of sprinklers in the design correct?
Design area/Area per sprinkler = n

7. Yes ☐ No ☐ N/A ☐ Is the longest dimension* of the design area (A) correct?

$$1.2 \times \sqrt{A} = \_\_\_\_\_\_ \text{ ft}^2$$

*Dimension parallel to branch lines.

8. Yes ☐ No ☐ N/A ☐ Is the number of sprinklers per branch line correct?

$$1.2 \times \frac{\sqrt{\text{Remote Area}}}{S} = n$$

Where S = distance between sprinklers on a branch line.

9. Yes ☐ No ☐ N/A ☐ What is the flow in gallons per minute from the most remote sprinkler?

$$Q = K\sqrt{P}$$

Where Q = flow in gpm
K = sprinkler K-factor
P = flowing pressure

10. Yes ☐ No ☐ N/A ☐ Conversely, is the pressure adequate to supply the flow?

$$P = \left(\frac{Q}{K}\right)^2$$

Where P = flowing pressure
Q = flow in gpm
K = sprinkler K-factor

11. Yes ☐ No ☐ N/A ☐ Does the flow from the most remote sprinkler provide the needed density?

$$\frac{Q}{A} = \rho$$

Where Q = quantity
A = design area
ρ = gpm per sprinkler

12. Yes ☐ No ☐ N/A ☐ Are correct pipe internal diameters shown?
See Pipe Legends next page.

PIPE SIZE	3/8”	1/2”	3/4”	1”	1-1/4”	1-1/2”	2”	2-1/2”	3”	3-1/2”	4”	5”	6”	8”	10”	12”
SCH 40	.493	.622	.825	1.049	1.380	1.610	2.067	2.469	3.068	3.548	4.026	5.047	6.065	8.071	10.136	12.090
THINWALL	---	---	.884	1.097	1.442	1.682	2.157	2.635	3.260	3.767	4.260	5.295	6.357	8.249	10.370	12.390
MEGAFLOW	---	---	---	---	1.530	1.740	2.215	2.707	3.316	---	4.316	---	6.395	---	---	---
DYNAFLOW	---	---	---	1.191	1.536	1.728	2.203	2.703	3.314	---	4.310	---	---	---	---	---
EDDYFLOW	---	---	---	---	1.515	1.734	2.209	2.729	3.342	---	4.316	---	---	---	---	---
COPPER ‘K’	.402	.527	.745	.995	1.245	1.481	1.959	2.435	2.907	3.385	3.857	4.805	5.741	7.583	9.449	11.315
COPPER ‘L’	.430	.545	.785	1.025	1.265	1.505	1.985	2.465	2.945	3.425	3.905	4.875	5.845	7.725	9.625	11.565
CPVC	---	---	.874	1.101	1.394	1.598	2.003	2.423	2.952	---	---	---	---	---	---	---

UNDERGROUND	4”	6”	8”	10”	12”	14”	16”	18”	20”	24”
DUCTILE IRON 50	---	6.28	8.39	10.40	12.46	14.52	16.60	18.68	20.76	24.92
DUCTILE IRON 51	4.16	6.22	8.33	10.34	12.40	14.46	16.54	18.62	20.70	24.86
DUCTILE IRON 52	4.10	6.16	8.27	10.28	12.34	14.40	16.48	18.56	20.64	24.92
PVC C900 DR14	4.07	5.86	7.68	9.42	11.20	---	---	---	---	---

<u>HAZEN-WILLIAMS C-VALUES</u>

BLK STL (DRY & PRE-ACT)	=100
BLK STL (WET & DELUGE)	=120
GALVANIZED (ALL)	=120
DUCTILE & AC (TRANSITE)	=140
STAINLESS STEEL	=150
PVC & CPVC	=150
COPPER	=150

13.	Yes	☐	No	☐	N/A	☐	Has the flow in gpm per foot from the most remote node to the next upstream node been shown using the Hazen-Williams formula? $p = \frac{4.52\,Q^{1.85}}{C^{1.85}\,d^{4.87}}$ Where p = psi Q = flow in gpm C = friction loss co-efficient of roughness d = actual inside pipe diameter
14.	Yes	☐	No	☐	N/A	☐	Has the flow in gpm per foot from subsequent nodes upstream node been shown using the Hazen-Williams formula?
15.	Yes	☐	No	☐	N/A	☐	Where elevation changes occur, has the friction loss been added to the calculations? $p = e * 0.433$ Where p = pressure loss due to elevation e = elevation difference in feet from one node to another
16.	Yes	☐	No	☐	N/A	☐	Have elbows, fittings, tees, reducers and other features that affect water flow been addressed? See Equivalent Pipe Length Chart next page.

EQUIVALENT PIPE LENGTH CHART FOR VALVES AND FITTINGS - SCH 40 STEEL PIPE (In Feet)

Pipe Size (inches)	3/4”	1”	1-1/4”	1-1/2”	2”	2-1/2”	3”	3-1/2”	4”	5”	6”	8”	10”	12”
45° Elbow	1	1	1	2	2	3	3	3	4	5	7	9	11	13
90° Standard Elbow	2	2	3	4	5	6	7	8	10	12	14	18	22	27
90° Long Turn Elbow	1	2	2	2	3	4	5	5	6	8	9	13	16	18
Tee or Cross (Flow Turned 90°)	4	5	6	8	10	12	15	17	20	25	30	35	50	60
Butterfly Valve	---	---	---	---	6	7	10	---	12	9	10	12	19	21
Gate Valve	---	---	---	---	1	1	1	1	2	2	3	4	5	6
Swing Check Valve*	---	5	7	9	11	14	16	19	22	27	32	45	55	65

*Due to the variations in design of swing check valves, the pipe equivalents indicated in the above chart to be considered average.

Specific friction loss values or equivalent pipe lengths for alarm valve, dry-pipe valve, deluge valves, strainers, and other devices should be obtained from the manufacturer.

For other than Sch 40 steel pipe, multiply the figures in the table above by the following factor:

$$\left(\frac{\text{Actual inside diameter}}{\text{Inside diameter of Sch 40 steel pipe}}\right)^{4.87}$$

For other than Hazen and Williams’s C = 120, the figures in the table above should be multiplied by the factors indicated below:

Value of C	100	120	130	140	150
Multiplying Factor	0.713	1.00	1.16	1.33	1.51

17.	Yes ☐	No ☐	N/A ☐	Have all nodes been documented from the most remote point to the water supply effective point?

ADDITIONAL CONSIDERATIONS

18.	Yes ☐	No ☐	N/A ☐	Are all obvious sprinkler obstructions identified and noted for correction?
19.	Yes ☐	No ☐	N/A ☐	Is the sprinkler riser location approved?
20.	Yes ☐	No ☐	N/A ☐	Is the fire department connection location approved?
21.	Yes ☐	No ☐	N/A ☐	Are the fire department connection size and fittings approved?
22.	Yes ☐	No ☐	N/A ☐	Are the main drain and inspector's test discharge location approved?
23.	Yes ☐	No ☐	N/A ☐	Are the types and locations of sprinkler hangers approved?
24.	Yes ☐	No ☐	N/A ☐	Where provided, are the types and locations of seismic bracing approved?
25.	Yes ☐	No ☐	N/A ☐	Is the sprinkler system monitored at an approved location?
26.	Yes ☐	No ☐	N/A ☐	Are all control valves supervised?
27.	Yes ☐	No ☐	N/A ☐	Are spare sprinklers and sprinkler wrench shown in an approved location?
28.	Yes ☐	No ☐	N/A ☐	Are hydraulic calculation placards and general design information signs shown in approved locations?

ADDITIONAL NOTES/CORRECTIONS

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APPENDIX B

FIRE PROTECTION READY REFERENCE

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FIRE PROTECTION READY REFERENCE

PIPE SIZE	3/8"	1/2"	3/4"	1"	1-1/4"	1-1/2"	2"	2-1/2"	3"	3-1/2"	4"	5"	6"	8"	10"	12"
SCH 40	.493	.622	.825	1.049	1.380	1.610	2.067	2.469	3.068	3.548	4.026	5.047	6.065	8.071	10.136	12.090
THINWALL	---	---	.884	1.097	1.442	1.682	2.157	2.635	3.260	3.767	4.260	5.295	6.357	8.249	10.370	12.390
MEGAFLOW	---	---	---	---	1.530	1.740	2.215	2.707	3.316	---	4.316	---	6.395	---	---	---
DYNAFLOW	---	---	---	1.191	1.536	1.728	2.203	2.703	3.314	---	4.310	---	---	---	---	---
EDDYFLOW	---	---	---	---	1.515	1.734	2.209	2.729	3.342	---	4.316	---	---	---	---	---
COPPER 'K'	.402	.527	.745	.995	1.245	1.481	1.959	2.435	2.907	3.385	3.857	4.805	5.741	7.583	9.449	11.315
COPPER 'L'	.430	.545	.785	1.025	1.265	1.505	1.985	2.465	2.945	3.425	3.905	4.875	5.845	7.725	9.625	11.565
CPVC	---	---	.874	1.101	1.394	1.598	2.003	2.423	2.952	---	---	---	---	---	---	---

UNDERGROUND	4"	6"	8"	10"	12"	14"	16"	18"	20"	24"
DUCTILE IRON 50	---	6.28	8.39	10.40	12.46	14.52	16.60	18.68	20.76	24.92
DUCTILE IRON 51	4.16	6.22	8.33	10.34	12.40	14.46	16.54	18.62	20.70	24.86
DUCTILE IRON 52	4.10	6.16	8.27	10.28	12.34	14.40	16.48	18.56	20.64	24.92
PVC C900 DR14	4.07	5.86	7.68	9.42	11.20	---	---	---	---	---

HAZEN-WILLIAMS C-VALUES

BLK STL (DRY & PRE-ACT)	= 100
BLK STL (WET & DELUGE)	= 120
GALVANIZED (ALL)	= 120
DUCTILE & AC (TRANSITE)	= 140
STAINLESS STEEL	= 150
PVC & CPVC	= 150
COPPER	= 150

DESCRIPTIONS/INFORMATION FREQUENTLY USED IN FIRE PROTECTION:

K = CONSTANT
Q = FLOW (GALLONS PER MINUTE)
P = POUNDS PER SQUARE INCH
V = VELOCITY IN FEET PER SECOND
d = DIAMETER IN INCHES
Cn = NOZZLE COEFFICIENT
C = FRICTION LOSS COEFFICIENT
Qa = AVAILABLE FLOW
Qt = TEST FLOW
Ht = PRESSURE DROP DURING TEST
Ha = PRESSURE DROP TO ASSUMED RESIDUAL

1 US GALLON = 231 CU. INCHES
1 US GALLON = 0.1337 CU. FT.
1 CUBIC FOOT = 7.481 GALLONS
WATER WEIGHT = 8.33 LBS/GALLON

FIRE PUMPS SHALL FURNISH 150% OF RATED CAPACITY AT NOT LESS THAN 65% OF RATED HEAD. SHUT-OFF HEAD SHALL NOT EXCEED 120% OF RATED HEAD

HEAD IN FT = 2.31 P
P = (HEAD IN FEET) x .433

1" = 0.08'	7" = 0.58'
2" = 0.17'	8" = 0.67'
3" = 0.25'	9" = 0.75'
4" = 0.33'	10" = 0.83'
5" = 0.42'	11" = 0.92'
6" = 0.50'	12" = 1'

Rev 2... 09/13/12

AVAILABLE FLOW AT ANY PRESSURE:

$$Qa = Qt \frac{(Ha)^{0.54}}{(Ht)^{0.54}}$$

FLOW FROM A CIRCULAR OUTLET:

$$Q = 29.83\ Cn\ d^2\sqrt{P}$$

NUMBER OF SPRINKLERS ON BRANCH LINES FOR REMOTE AREAS:

$$\frac{1.2\sqrt{A}}{S}$$

A = Design Area
S = Distance Between Sprinklers

REDUCE DESIGN AREA:

$$Y = \left(\frac{-3X}{2}\right) + 55$$

X = Ceiling Height (≥10 ft and ≤20 ft)
Y = % reduction

BALANCING:

$$Q_2 = Q_1\sqrt{\left(\frac{P_1}{P_2}\right)}$$

Q_1 = Low Pressure Line
Q_2 = Adjusted Pressure
P_1 = Lower Pressure
P_2 = Higher Pressure

PIPE CAPACITIES:

$$\sqrt{\left(\frac{d_1}{d_2}\right)^5}$$

LONGEST DIMENSION REMOTE AREA:

$$1.2 \times \sqrt{A}$$

*Dimension parallel to branch lines

HAZEN-WILLIAMS FRICTION LOSS PER FOOT:

$$P = \frac{4.52\ Q^{1.85}}{C^{1.85}\ d^{4.87}}$$

REQUIRED PITOT FROM FLOW:

$$Pitot = \left(\frac{Q}{(29.84 \times cn \times d^2)}\right)^2$$

d = Outlet Diameter

VOLUME OF A TANK:

$$V = 3.14 \times r^2 \times D \times 7.48$$

V = Tank Volume in Gallons
r = Radius
D = Depth of Tank

OUTLET CONVERSION:

$$P = \left(\frac{Q}{K}\right)^2$$

$$Q = K\sqrt{P}$$

$$K = \frac{Q}{\sqrt{P}}$$

VELOCITY PRESSURE:

$$P_v = \frac{Q^2}{888d^4}$$

VELOCITY:

$$V = \frac{0.4084\ Q}{d^2}$$

CALCULATE EQUIVALENT K:

1. **Calculate 'P' for sprinkler head**
2. **Calculate friction loss through drop using Hazen-Williams Formula**
3. **Add friction loss to pressure for total 'P'**
4. **Calculate 'K'**

$$K = \frac{Q}{\sqrt{P}}$$

Rev 2… 09/13/12

MAXIMUM COVERAGE PER SPRINKLER
(NFPA 13 Standard Pendent and Upright Spray Sprinklers)

	LIGHT HAZARD		ORDINARY HAZARD		EXTRA HAZARD		HIGH PILED STORAGE	
CONSTRUCTION TYPE	PROTECTION AREA FT^2	SPACING (MAX) FT^2	PROTECTION AREA FT^2	SPACING (MAX) FT^2	PROTECTION AREA FT^2	SPACING (MAX) FT^2	PROTECTION AREA FT^2	SPACING (MAX) FT^2
NONCOMBUSTIBLE OBSTRUCTED AND UNOBSTRUCTED	225	15	130	15	100 Hydraulically calculated with density ≥0.25 130 Hydraulically calculated with density <0.25	12 15	100 Hydraulically calculated with density ≥0.25 130 Hydraulically calculated with density <0.25	12 15
COMBUSTIBLE UNOBSTRUCTED WITH EXPOSED MEMBER 3 FT OR MORE ON CENTER	225	15						
COMBUSTIBLE OBSTRUCTED WITH EXPOSED MEMBER 3 FT OR MORE ON CENTER	168	15						
COMBUSTIBLE OBSTRUCTED OR UNOBSTRUCTED WITH EXPOSED MEMBERS LESS THAN 3 FT ON CENTER	130	15						
COMBUSTIBLE CONCEALED SPACE UNDER PITCHED ROOF HAVING COMBUSTIBLE WOOD JOIST OR WOOD TRUSS CONSTRUCTION WITH MEMBERS LESS THAN 3 FT ON CENTER WITH SLOPES HAVING A PITCH OF 4 IN 12 OR GREATER	120	15 parallel to the slope 10 Perpendicular to the slope						

EQUIVALENT PIPE LENGTH CHART FOR VALVES AND FITTINGS - SCH 40 STEEL PIPE (In Feet)

Pipe Size (inches)	3/4"	1"	1-1/4"	1-1/2"	2"	2-1/2"	3"	3-1/2"	4"	5"	6"	8"	10"	12"
45^0 Elbow	1	1	1	2	2	3	3	3	4	5	7	9	11	13
90^0 Standard Elbow	2	2	3	4	5	6	7	8	10	12	14	18	22	27
90^0 Long Turn Elbow	1	2	2	2	3	4	5	5	6	8	9	13	16	18
Tee or Cross (Flow Turned 90^0)	4	5	6	8	10	12	15	17	20	25	30	35	50	60
Butterfly Valve	---	---	---	---	6	7	10	---	12	9	10	12	19	21
Gate Valve	---	---	---	---	1	1	1	1	2	2	3	4	5	6
Swing Check Valve*	---	5	7	9	11	14	16	19	22	27	32	45	55	65

*Due to the variations in design of swing check valves, the pipe equivalents indicated in the above chart to be considered average.

Specific friction loss values or equivalent pipe lengths for alarm valve, dry-pipe valve, deluge valves, strainers, and other devices should be obtained from the manufacturer.

For other than Sch 40 steel pipe, multiply the figures in the table above by the following factor:

$$\left(\frac{Actual\ inside\ diameter}{Inside\ diameter\ of\ Sch\ 40\ steel\ pipe}\right)^{4.87}$$

For other than Hazen and Williams's C = 120, the figures in the table above should be multiplied by the factors indicated below:

Value of C	100	120	130	140	150
Multiplying Factor	0.713	1.00	1.16	1.33	1.51

NFPA 13 requires that underground piping be tested to a flow necessary to provide a velocity of 10 ft/sec. <u>Pipe Size</u> — <u>Flow Rate (gpm)</u> 4” — 390 6” — 880 8” — 1560 10” — 2440 12” — 3520		

GLOSSARY/ACRONYMS

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GLOSSARY/ACRONYMS

Note: This glossary and acronym list was provided for this course. Always refer to legally adopted codes and standards for the definitions and glossary terms published in them.

User's Guide: Some terms are identified with their common terms ("fire-resistive assembly") or arranged with key words first ("assembly, fire-resistive"). You are encouraged to check all iterations.

Above Finished Floor (AFF)	The vertical distance between an object (e.g., sprinkler deflector, ceiling tile, roof member, etc.) and the finished floor below.
Above Finished Grade (AFG)	The vertical distance between an object (e.g., sprinkler deflector, ceiling tile, roof member, etc.) and the finished ground below (e.g., sidewalk, berm, planting, landscaped area).
accelerator	A quick-opening device installed on a dry pipe sprinkler system. The accelerator transfers air under pressure from the sprinkler system pipe to the dry pipe valve to speed its operation.
active fire protection system(s)	Fire protection equipment and devices designed, installed and maintained to function in the event of an emergency to detect, report, confine, control or suppress a fire, including, but not limited to, automatic sprinkler systems, automatic and manual fire detection and alarm systems, specialty fire suppression systems, and smoke management/smoke control. See **passive fire protection features.**
addressable	When used in conjunction with fire alarm systems, describes a method for installing programmable initiating devices so an alarm will correspond with the specific location and/or device (e.g., "Smoke detector Number 3, third-floor custodian's closet").
aerosol	A product that is dispensed from an aerosol container by a propellant.
aerosol, Level 1	Generally low hazard employing water-based product and mildly or nonflammable propellant.
aerosol, Level 2	Moderate hazard with flammable (usually alcohol-based) product and flammable propellant.
aerosol, Level 3	High hazard with petroleum-based product and propellant.

alarm check valve — The main water control valve on a wet pipe sprinkler system consisting of a pivoted “clapper” that swings open when water flows through an open sprinkler or drain. Contains connections for a retarding chamber and pressure gauges.

alarm verification — A feature of automatic fire detection and alarm systems intended to reduce unwanted, inadvertent or false alarms. When products of combustion are detected, the alarm system delays reporting for a given period of time until a second detector operates or the system confirms products of combustion are in a smoke detector sensing chamber.

Alternate Methods and Materials (AM&M) — In building construction and fire protection system design, an applicant-proposed design or product that may not meet the prescriptive code requirements but can be approved by the code official as being of equivalent strength, fire resistance, or performance and public safety.

American National Standards Institute (ANSI) — A professional association that evaluates design and performance standards for consistency and integrity.

American Society of Mechanical Engineers (ASME) — A professional organization that develops consensus standards, especially for fired and unfired pressure vessels such as boilers, liquefied and compressed gas storage vessels, and appurtenances.

American Water Works Association (AWWA) — A professional organization that develops consensus standards for the storage, transmission and distribution of water supplies, especially for public potable networks where health and safety are paramount.

annunciator — An electronic device containing lamps or light-emitting diodes, graphic displays, and/or alphanumeric characters to provide fire alarm status information, usually at a location remote from the main fire alarm control panel.

approved — Acceptable to the code enforcement official or authority having jurisdiction.

appurtenances — In fire protection systems, features that are added or connected to the main system. For example, appurtenances to an underground water main system include fire hydrants, valves and hose houses.

area of refuge — An area where people unable to use stairways can remain temporarily to await instructions or assistance during emergency evacuation. These areas usually are separated from the rest of the building by fire-resistive construction and have two-way communication to a central location in the building, such as a fire alarm control panel.

armover — In a fire sprinkler system, a horizontal pipe that extends from the branch line to a single sprinkler or a sprinkler above and below a ceiling.

array (storage) — In storage occupancies, the method in which the commodity (see **commodity**) is being stored. Storage arrays may include the following:

- **automated storage** — Carousels, computer-controlled robotics, vertical lift modules and unit load stackers.
- **palletized** — Products stored on wood, metal, plastic or other pallets.
- **rack** — Typically 4-by-8-foot storage surfaces supported by a metal structure (e.g., "big box" home improvement retail stores). Racks can be single row, double row, multiple row, flow through, moveable, portable, open shelf, closed shelf and more.
- **shelf** — Storage on shelves up to 15 feet in height. Shelves differ from racks in that they are less than 30 inches deep and not more than 36 inches apart vertically.
- **solid pile** — Self-supporting material in solid piles with narrow aisles for product movement and slowing fire spread.

assembly, fire-resistive — A combination of equipment, structural and architectural elements designed, constructed and maintained to resist fire and heat. Examples include fire walls, fire doors, fire dampers, floor/ceiling assemblies, roof/ceiling assemblies, fire barriers and fire partitions.

ASTM — A professional organization that develops consensus standards. Noted for developing replicable fire testing standards such as those for measuring fire resistance or flame spread.

atrium — As defined in the building codes, a large, open vertical space among two or more adjacent floors that share the same atmosphere. Commonly found in hotels, offices and multistory covered shopping malls.

authority having jurisdiction (AHJ)	In National Fire Protection Association codes and standards, a term used to identify the person or agency responsible for making project decisions regarding life safety and fire protection. It may include the fire chief, fire marshal, building official, electrical inspector, insurance inspection bureau, property owner or designee. Normally in code enforcement, the authority having jurisdiction is the building or fire official.
automatic	As applied to fire protection devices, equipment and systems, it is a feature that provides the emergency functions without the necessity of human interventions and is activated as a result of a response to temperature increase, rate of temperature increase or products of combustion.
balance	In hydraulic design, a pipe-sizing method to enhance the likelihood that a similar amount of water is discharging from each sprinkler.
base-of-riser	The point on the sprinkler system riser (see **system riser**) where the incoming water supply transitions from horizontal to vertical. The base-of-riser is an important reference point for hydraulically calculated and pipe-scheduled systems.
bracing	See **seismic bracing.**
branch line	In a fire sprinkler system, the pipes supplying sprinklers, either directly or through sprigs, drops, return bends or armovers.
building	Any structure used or intended for supporting or sheltering any use or occupancy.
building, high-rise	A building having occupied floors located more than 75 feet above the lowest level of fire department vehicle access.
building, low-rise	Used in reference to evaluating structural stability. An enclosed or partially enclosed building in which the mean roof height is less than or equal to 60 feet and does not exceed the building's smaller horizontal dimension. Thus, a structure that measures 60 feet by 30 feet with a 30-foot high roof would qualify as a low-rise building.

building, windowless — A structure that measures at least 1,500 square feet and is not provided with doors or windows for ventilation or rescue, sized and spaced in accordance with the building code. Generally, openings must be at least 30 inches wide, have 20 square feet of net clearance, be openable from the outside, and be located not more than 75 feet from the opposite wall.

bulk main — In a fire sprinkler system, the pipes supplying cross mains, either directly or through risers. Also known as a "feed main."

buoyancy — The physical characteristic of a heated fluid or gas to rise, such as smoke rising from above flames.

C-value — From Hazen-Williams friction loss formulas, C-value is a co-efficient of roughness for the inside of the water-carrying pipe or tube.

chase — An enclosed space extending horizontally through one story of a building, connecting openings on the same floor, or floors and ceiling space. See **shaft.**

churn — A condition in which a stationary fire pump is rotating (running) but is not discharging water. This condition may result in the fire pump overheating.

clapper — Slang term for the portion of a check valve that pivots on a stem to prevent water from flowing through an orifice. Commonly found in fire department connections and fire sprinkler alarm check valves.

clean agent — Electrically nonconducting, volatile or gaseous fire extinguishing agent that leaves no residue when it evaporates.

cockloft — A shallow space, usually without draft stops or other fire barriers, between the ceiling of the top floor of a building and the underside of the roof deck. In older construction, a cockloft may span several occupancies and may be separated by fire partitions.

combination fire/smoke damper — A listed device installed in ducts and air transfer openings designed to close automatically upon the detection of heat and also to resist the passage of air and smoke. The device is installed to operate automatically, is controlled by a smoke-detection system, and, where required, is capable of being positioned from a remote command station.

combination systems Generally refers to combined sprinkler and standpipe systems. Combination systems are automatic sprinkler systems with standpipe hose outlets. Depending upon the application, the hose outlets might be Class 1 for fire department use or Class 2 for occupant use. (This second application is called “small hose connections” in the sprinkler installation standards. They are employed mostly in warehouse and storage applications.)

combustible liquid A liquid that has a flashpoint of 100 F (37.8 C) or more under controlled laboratory test conditions.

commodity Combination of products, packing material and container holding the product, including conventional wood or steel pallets.

compartmentalization (passive) One of the oldest and most fundamental principles of fire protection. Buildings are segregated, or broken up, into multiple fire/smoke compartments and separated from adjacent fire/smoke compartments by fire-resistive construction that also is intended to restrict smoke migration.

compound gauge A compound gauge is a pressure gauge that displays both negative and positive gauge pressure measurements.

conduction Transfer of heat within solids or between solids in contact with each other.

construction, obstructed or unobstructed See **obstructed construction** and **unobstructed construction.**

controller, fire pump Electrical equipment arranged to manually or automatically start (and sometimes stop) a station fire pump assembly. Automatic starting usually is accomplished through the installation of a pressure-sensing switch that responds to a pressure decrease on the fire protection system that the pump supplies.

convection Transfer of heat energy by the movement of heated liquids or gases.

cross main In a fire sprinkler system, the pipes supplying the branch lines, either directly or through riser nipples.

cross-zoning Usually installed to control specialty system-releasing devices, an arrangement of automatic detectors installed so that two or more devices must operate before the agent is released. The first detector to operate will sound an alarm; when the second device operates, the fire suppression agent will discharge.

deflagration — Propagation of a combustion zone at a velocity that is less than the speed of sound in an unrestricted medium.

deluge sprinkler system — A sprinkler system employing open sprinklers that are attached to a water supply through a valve that is opened by the operation of a detection system installed in the same area as the sprinklers.

demand — Water consumption values over a specified time period. These demand values generally consider industrial, recreational and residential uses, but may not consider fire flow.

demand, diurnal — Daily (24 hour) water consumption values. These demand values generally consider industrial, recreational and residential uses, but not fire flow. Normally measured in millions of gallons per hour or millions of gallons per day.

demand, hydraulic — In water-based fire protection systems, the amount of water at a calculated volume and pressure needed to control or suppress a fire.

demand, peak — Highest water consumption over a specific time period.

demand, seasonal — Water consumption values influenced by weather conditions such as drought.

density — In hydraulic fire sprinkler design, the amount of water provided in gallons per minute per square foot needed to control or suppress a fire in the hydraulic remote area.

Common industry references include such examples as "0.01/1,500," representing "1/10 of a gallon of water per minute over each square foot of a 1,500 square foot remote area."

"design to the line" — In water-based fire protection system hydraulic calculations, a phrase describing the point where the fire protection system demand is equivalent to the available water supply. No margin of safety is provided. See **margin of safety.**

detail(s) — In engineering or architectural drafting, enlargement(s) of specific information to provide greater clarity.

detonation — Propagation of a combustion zone at a velocity that is greater than the speed of sound in an unrestricted medium.

draft stop	A material, device or construction installed to restrict the movement of air within open spaces of concealed areas of building components such as crawl spaces, floor/ceiling assemblies, roof/ceiling assemblies and attics.
driver, fire pump	The electric motor or internal combustion engine that operates a stationary fire pump. In older systems, steam may provide the power to drive the fire pump.
dry chemical extinguishing agent	A powder composed of small particles (usually sodium bicarbonate, potassium bicarbonate, urea-potassium-based bicarbonate, potassium chloride or monoammonium phosphate) used as a fire extinguishing medium.
dry pipe sprinkler system	A sprinkler system employing automatic sprinklers that are attached to a piping system containing air or nitrogen under pressure, the release of which (as from the opening of a sprinkler) permits the water pressure to open a valve known as a dry pipe valve, and the water then flows into the piping system and out the opened sprinklers.
ductile iron (DI)	A type of iron pipe that includes nodular graphite that gives it flexibility (ductility). Commonly used in underground water mains.
early suppression fast response (ESFR)	A sprinkler design criteria that acts more quickly than a standard sprinkler to deliver large quantities of water to suppress a fire. Usually used in "high challenge" environments such as rack storage warehouses.
effective point, water supply	In hydraulically designed fire protection systems, the point in a water supply system where the volume and pressure characteristics are known.
eutectic	A metal alloy blended to have a specific melting temperature. Most often used in heat detectors or the fusible links of automatic sprinklers.
exhauster	A quick-opening device attached to a dry pipe sprinkler system that releases air from the sprinkler system through the main drain pipe. Exhausting the air to the atmosphere helps the dry pipe valve operate more quickly.
exit passageway	An exit component that is separated from all other interior spaces of a building or structure by fire-resistive construction and opening protectives, and provides for a protected path of horizontal egress travel to the exit discharge or public way.

exit system

All elements of the means of egress from a building or facility to a public street, sidewalk or place. Includes doors, hallways, corridors, aisles, exit passageways, stairs and stair enclosures.

The exit system consists of the:

- Exit access: the space between any point of an occupied building and the exit.
- Exit: the space that is separated from all other spaces in a building by fire-resistive construction or fire protection systems.
- Exit discharge: the space between the termination of the exit and the public way.

explosive

Any chemical compound, mixture or device that has the purpose of bursting or rupturing an enclosure or container due to the development of internal pressure from a deflagration.

explosive range or limits

The upper and lower limits in which the ratio of flammable vapor to air will support combustion. See also **flammable range or limits.**

extinguishment

Extinguishment occurs when a fire is reduced to a heat release rate of zero. The only way to guarantee a fire has been extinguished is when a firefighter verifies that the fire is out.

facility

A building or use in a fixed location including exterior storage yards for flammable and combustible substances and hazardous materials, piers, wharves, tank farms and similar uses. The term includes recreational vehicle, mobile home and manufactured housing parks, sales and storage lots.

feed main

In a fire sprinkler system, the pipes supplying cross mains, either directly or through risers. Also known as a “bulk main.”

fire barrier

A fire-resistance-rated vertical or horizontal (wall or floor-ceiling) assembly of materials designed to restrict fire spread. Openings in the fire barrier are protected by fire-rated assemblies (fire doors and dampers). Fire barriers must be one-, two-, three- or four-hour rated depending upon their application.

fire command center

Also known as a fire control room, the location in a building where fire protection systems and equipment can be monitored and controlled.

fire control or fire control mode — When applied to sprinkler systems, fire control is achieved by prewetting combustibles surrounding the fire area and by cooling hot gases at the ceiling. In an actual warehouse fire, 20 or more control-mode sprinklers may be required for control.

fire load — An estimated measurement of the amount of total fuel per square foot based on occupancy. Also known as "fuel load."

fire partition — A vertical assembly (wall) of materials designed to restrict the spread of fire. Openings in the fire partition are protected by fire-rated assemblies (fire doors and dampers). Fire partitions have a one-hour fire-resistance rating.

fire protection systems — Approved devices, equipment, and systems or combinations of systems used to detect a fire, activate an alarm, extinguish or control a fire, control or manage smoke and products of a fire, or a combination thereof.

fire pump — See **pump, fire.**

fire pump controller — See **controller, fire pump.**

fire-resistance rating — A value (commonly ranging from 20 minutes to four hours) assigned to an assembly of materials that has been subjected to standard, laboratory-controlled fire tests.

fire safety functions — Building and fire control functions that are intended to increase the level of life safety for occupants or to control the spread of harmful effects of fire.

fire safing — A method or material — such as caulk, bags or pillows — installed to resist the passage of flame and heat through openings in a fire-rated partition, barrier or wall to accommodate cables, cable trays, conduit, tubes, pipes or similar items. Also known as "firestop" or "firestopping."

firestop — A material — such as caulk, bags or pillows — installed to resist the passage of flame and heat through openings in a fire-rated partition, barrier or wall to accommodate cables, cable trays, conduit, tubes, pipes or similar items.

fire wall — A fire-resistance-rated wall having protected openings, which restricts the spread of fire and extends continuously from the foundation through or to the roof, with sufficient structural stability under fire conditions to allow collapse of construction on either side without causing the wall to collapse. Fire walls have two-, three- or four-hour fire-resistance ratings depending on where they are used.

fixed pressure loss device — In hydraulically designed fire protection systems, an element for which the friction loss at a specific flow in gallons per minute is known, e.g., backflow prevention device, reduced pressure zone device, double detector check valve.

flammable liquid — A liquid that has a flashpoint of less than 100 F (37.8 C) under controlled laboratory test conditions.

flammable range or limits — The range in which the ratio of flammable vapor to air will support combustion. See also **explosive range or limits.**

flashover — The point at which room temperature at the ceiling of a compartment reaches 1,100 F (593 C) or higher and all combustible materials within the compartment ignite almost simultaneously.

flashpoint — The temperature at which a liquid fuel — when ignited — will flash momentarily but not sustain combustion.

foam sprinkler system — A sprinkler system employing open sprinklers that are attached to a water supply through a valve that is opened by the operation of a detection system installed in the same area as the sprinklers and equipped with special sprinklers that aerate a mixed foam/water solution at the point of discharge.

fuel load — See **fire load.**

fully developed fire — Steady or post-flashover fire at peak heat release rate.

gravity vent — See **smoke and heat vents.**

gridded sprinkler system — A sprinkler system in which parallel cross mains are connected by multiple branch lines, causing an operating sprinkler to receive water from both ends of its branch line while other branch lines help transfer water between cross mains.

halogenated extinguishing agent (halon) — A fire extinguishing medium using one or more of the atoms of an element from the halogen chemical family (iodine, bromine, fluorine, chlorine) to interrupt a fire's chemical chain reaction.

hangers In fire protection system installation, ferrous or other approved devices that support pipe from the structural frame of the building.

hazard Chemical or physical condition that has the potential for causing damage to people, property or the environment.

heating, ventilating, and air conditioning (HVAC) Industry abbreviation for heating, ventilating, and air conditioning systems and equipment.

heat of combustion Energy produced when a unit of fuel is completely burned with pure oxygen.

heat release rate (HRR) Mass heat loss rate times the heat of combustion and combustion efficiency (portion of the mass actually converted to energy). A measure of a fire's "ferocity."

high challenge occupancy A facility or building that, due to the nature, type, or array of contents or operations, creates a unique challenge for the fire protection system(s) to protect.

highly protected rate (or risk) (HPR) An insurance policy rate that provides a cost incentive based on the degree of fire protection available.

high-rise building A building having occupied floors located more than 75 feet above the lowest level of fire department vehicle access.

horizontal exit A fire-resistive barrier — having a minimum two-hour rating — that effectively divides an occupied space in half. According to the model building codes, once an occupant passes through the horizontal exit, he or she is presumed to be in a "separate building" even though he or she may still be within the same structure.

horizontal assembly A fire-resistance-rated (roof-ceiling or floor-ceiling) assembly of materials designed to restrict vertical fire spread. Openings in the horizontal assembly are protected by fire-rated assemblies (fire dampers). Horizontal assemblies must be one-, two-, three- or four-hour rated depending upon their application.

hose stream allowance The amount of water (in gallons per minute) needed for manual firefighting in sprinklered buildings. The hose stream allowance is added to the fire sprinkler system water demand to determine the total water supplies needed for a sprinklered building.

hydraulic nodes See **hydraulic reference point.**

hydraulic reference point In a hydraulically calculated fire protection system, an identifying symbol on plans that identifies a point where that element affects water flow characteristics such as a valve, sprinkler, nozzle, hose station, elbow, tee, fitting or elevation change. Also known as "hydraulic nodes."

hydraulic remote area In a hydraulically calculated sprinkler system, the design area where it is hydraulically most challenging to deliver water from the base-of-riser at the needed volume and pressure while overcoming pipe friction and elevation pressure losses. Based on system design, the hydraulic remote area may not be the physically most remote area from the base-of-riser.

May also be known as "design area," "remote area," "area of application" or similar terminology.

ignition temperature The minimum temperature to which a substance must be heated to ignite and sustain combustion.

Incident Commander (IC) The individual responsible for all incident activities, including the development of strategies and tactics and the ordering and releasing of resources. The Incident Commander has overall authority and responsibility for conducting incident operations and is responsible for the management of all incident operations at the incident site.

indicating appliance Also known as a "notification appliance." An audible, visual, tactical, textual or olfactory device intended to alert building occupants to an emergency condition.

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.

inspection In relation to fire protection systems and equipment, a visual check of the equipment or system to ensure that all components are in place, all operating functions are in a ready position, all gauges show appropriate pressures, and similar surveys.

intumescent A product such as paint, mastic or caulking that contains entrained carbon dioxide gas. When the material is heated, the gas expands to form a thick, marshmallow-like coating over the surface of the coated item to provide fire resistance.

jockey pump A small, nonrated pump assembly designed to maintain pressure on a fire protection system so the main fire pump does not operate prematurely.

labeled — Equipment or material to which has been attached a label, symbol or other identifying mark of a nationally recognized testing agency. See **listed.**

layout, sprinkler — See **sprinkler layout.**

listed — Equipment, materials or services that have been evaluated by an independent, third-party agency to verify that they perform as intended. The most common listing agencies are Underwriters Laboratories and Factory Mutual Global. See **labeled.**

looped sprinkler system — A sprinkler system in which multiple cross mains are tied together so as to provide more than one path for water to flow to an operating sprinkler and that branch lines are not tied together.

low-rise building — Used in reference to evaluating structural stability. An enclosed or partially enclosed building in which the mean roof height is less than or equal to 60 feet and does not exceed the building's smaller horizontal dimension.

Thus, a structure that measures 60 feet by 30 feet with a 30-foot high roof would qualify as a low-rise building.

maintenance — In relation to fire protection systems and equipment, regular service as specified by the manufacturer.

margin of safety — In water-based fire protection system hydraulic calculations, a point above the fire protection system demand compared to the available water supply curve that accounts for changes in the water supply such as daily (diurnal), seasonal or other added demands.

maximum foreseeable loss wall — Insurance industry term for a fire wall designed to stop the spread of an uncontrolled fire when there is an impairment to the property's fire protection system **and** manual firefighting is limited or delayed. The phrase is not used in model building codes.

microbiologically influenced corrosion (MIC) — The influence of microorganisms on the energy of corrosion processes in metals. Microbiologically influenced corrosion is caused by bacterial microbes in combination with four other environmental conditions: metals (host location), nutrients, water and oxygen (although some types of bacteria need only very small amounts of oxygen). In addition, some microbial reactions will only occur within certain temperature ranges. Microbiologically influenced corrosion can result in pipe obstructions or leaks.

model building code	A building safety regulatory document prepared by interested people that can be legally adopted with or without amendments by local jurisdictions. The current model building codes include the International Building Code published by the International Codes Council Inc. and National Fire Protection Association 5000, *Building Construction and Safety Code*.
model fire code	A fire safety regulatory document prepared by interested people that can be legally adopted with or without amendments by local jurisdictions. The current model fire codes include the International Fire Code published by the International Code Council Inc. and National Fire Protection Association 1, *Fire Code*.
National Fire Incident Reporting System (NFIRS)	A standard national reporting system used by United States fire departments to report fires and other incidents to which they respond and to maintain records of these incidents in a uniform manner.
National Institute for Certification in Engineering Technologies (NICET)	An organization established to create a recognized certification for engineering technicians and technologists within the United States. Candidates can obtain various levels of fire protection certification in areas such as fire sprinkler design and inspection, fire alarm system design and inspection, and special hazards.
Nationally Recognized Testing Laboratory (NRTL)	A Nationally Recognized Testing Laboratory is a private-sector organization that the U.S. Department of Labor Occupational Safety and Health Administration has recognized as meeting the legal requirements in 29 Code of Federal Regulations 1910.7 to perform testing and certification of products using consensus-based test standards.
node(s)	See **hydraulic reference point.**
notification appliances	Any equipment that is part of a fire alarm system and intended to notify building occupants of an emergency. Includes bells, horns, buzzers, klaxons, sirens, strobe lights, vibrating alerts (tactile) or smell alerts (olfactory). Also known as an "indicating appliance."
nuisance alarm	An alarm caused by mechanical failure, malfunction, improper installation or lack of proper maintenance, or an alarm activated by a cause that cannot be determined.
obstructed construction	For the purpose of fire sprinkler system design, panel construction and other construction where beams, trusses or other members impede heat flow or water distribution in a manner that materially affects the ability of sprinklers to control or suppress a fire.

opening protective — An assembly of components installed in the opening of a fire- or smoke-resistive barrier, partition or wall designed to close the opening during a fire. Examples include fire doors, fire dampers, smoke dampers, fire shutters, fire curtains, etc.

outrigger — Industry term for a dead-end branch line extending from a cross main in a looped or gridded system

parapet — In building construction, a portion of a fire wall that extends above the roof in the same plane as the wall.

passive fire protection features — Structural and construction elements designed, installed and maintained to control fire and smoke spread in a building and contribute to its structural stability. Includes, but is not limited to, fire walls, fire barriers, fire partitions, spray-on or otherwise applied fire-proofing, fire-resistive assemblies. See **active fire protection systems.**

peaking analysis — For gridded fire sprinkler designs, a mathematical process to verify that the selected remote area is the hydraulically most demanding. This is accomplished through a computer program that performs the analysis or by the submittal of additional hydraulic calculations for areas adjacent to the designated remote area.

performance-based design — An engineering approach to fire protection design based on established fire safety goals and objectives, deterministic and probabilistic analysis of fire scenarios, and quantitative assessment of design alternatives against the fire safety goals and objectives, using accepted engineering tools, methodologies and performance criteria.

pilot line, dry or wet — A detection system employed with preaction sprinkler systems that uses air under pressure (dry) or water under pressure (wet) in a small-diameter pipe equipped with small-diameter sprinklers in the same space as the fire control sprinklers.

pipe takeout — In sprinkler pipe branch line installations, a measurement that accounts for fittings for joining pipe.

pipe velocity — See **velocity, pipe.**

preaction sprinkler system

A sprinkler system employing automatic sprinklers that are attached to a piping system that contains air that might or might not be under pressure with a supplemental detection system installed in the same area as the sprinklers.

- Single interlock: Air in the pipe is not under pressure. Once the detection device senses a fire, the main sprinkler control valve opens and the pipe fills with water.

- Dual interlock: Air in the pipe is under pressure. Both the supplemental detection system **and** a sprinkler must operate to release air from the system and open the preaction valve to enable water to flow.

preincident planning

A process of information collection, sorting, evaluation and dissemination of facts, probabilities and mitigating factors relating to emergencies in buildings or facilities.

prescriptive codes or standards

A group of codes or standards which provide specific design, construction and maintenance requirements for buildings, fire prevention, mechanical systems, plumbing systems, energy conservation, barrier-free access and the like.

prescriptive design

An option within a code where compliance is achieved by demonstrating compliance with specified construction characteristics, limits on dimensions, protection systems or other features.

pressurization, smoke management/control (active)

The creation and maintenance of pressure levels in zones of a building including elevator shafts and stairwells that are higher than the pressure level at the smoke source, such pressure levels being produced by positive pressure of a supply of uncontaminated air, by exhausting air and smoke at the smoke source, or by a combination of these methods.

Note: Exhausting the zone of origin may be all that is necessary to achieve a fully compliant smoke control system.

primary factors chart

A tool that can be used by Command officers to organize and manage an emergency incident. The primary factors chart identifies:

- Pertinent factors about a building or hazard area.
- Incident objectives.
- Strategies to achieve incident objectives.
- Reminders to evaluate the effectiveness of the selected strategies continually.

project scope — Identification of the boundaries of the fire protection system design, including building use, design intent, project constraints, design and construction team organization, project schedules, and applicable regulations.

protected opening — A penetration through a wall, floor, ceiling or other fire-resistive barrier that is equipped with a device (fire door, fire damper, etc.) designed to close automatically and protect the integrity of the barrier.

pump, fire — Equipment that will deliver water from a static source or boost pressure from a dynamic supply to provide required minimum pressures on a fire protection system. Although they perform different functions, the terms "booster" and "fire" pump often are used interchangeably.

- **pump, booster** — A pressure-increasing pump installed in a dynamic supply (underground water mains, elevated tank, etc.) to increase normal head to that needed to supply the fire protection system at its design pressure.

- **pump, fire** — A pressure-increasing pump connected to static water supply (underground tank, pond, cistern, etc.) that provides both the flow and pressure needed to supply the fire protection system at its design pressure and volume.

- **pump, jockey** — A small, nonrated pump assembly designed to maintain pressure on a fire protection system so the main fire or booster pump does not operate prematurely.

pyrophoric — A chemical with an autoignition temperature in air at or below a temperature of 130 F (54.4 C).

quick-opening device — Equipment attached to a dry pipe sprinkler valve to aid the removal of air in the sprinkler system and speed the operation of the dry pipe valve. Quick-opening devices most commonly are exhausters or accelerators.

quick-response sprinkler head — Quick response is a listing for sprinklers that combines the deflector, frame and body of a spray sprinkler with a fast-response element to create a technology that will respond quickly in the event of a fire and deliver water in the same fashion as other types of spray sprinklers.

radiation — Transfer of heat energy from a hot surface to a cooler surface by electromagnetic waves.

radiation feedback	The condition of electromagnetic waves reflected from one heated surface to another.
recommended practice	With National Fire Protection Association, a document that is similar in content to a code or standard, but that contains only nonmandatory provisions using the word "should" to indicate recommendations.
residential sprinkler system	A sprinkler system installed in living spaces and adjacent corridors designed to control an incipient fire for the purpose of life safety. This is accomplished by wetting walls and the ceiling to prevent flashover in the room where the fire begins. Residential sprinkler systems are not designed for property protection; therefore, sprinkler protection may not be included in all parts of a structure.
retard chamber	A small vessel connected to an alarm check valve to collect water and regulate pressure from water surges to prevent unwanted water flow alarms. Also called a "retarding chamber."
return bend	In a fire sprinkler system, the piping arrangement for pendent sprinklers where piping stems from the top of the branch pipe (riser nipple), runs horizontally (armover) and then down to the sprinkler (drop).
risk	Mathematical probability that an event or sequence of events involving hazards will result in varying degrees of damage to people, property or the environment.
room design method	A sprinkler hydraulic design method where water supply requirements are based upon the room that creates the greatest demand.
rubric	In education, a document that articulates the expectations for an assignment by listing the criteria and describing levels of quality from excellent to poor.
saponification	The result of adding water and alkali to animal fats to create a soap-like product.
sectional control valve	An indicating control valve used to isolate one or more portions of a water-based fire suppression system. Sectional control usually is arranged to disable one portion of a system (such as an individual floor) while the rest of the system remains in service.

seismic bracing — In fire protection systems, rigid supports that are attached between the building and the fire protection system to ensure the equipment moves synchronously with the building in the event of an earthquake.

bracing, four-way — Seismic bracing installed at the top of fire protection system risers.

bracing, lateral — Seismic bracing installed generally perpendicular to the sprinkler pipe.

bracing, longitudinal — Seismic bracing installed generally parallel to the sprinkler pipe.

shaft — An enclosed space extending through one or more stories of a building, connecting vertical openings in successive floors or floors and roof. See **chase.**

shotgun riser — Industry term for a wet pipe sprinkler riser that consists solely of a control valve, pressure gauge, main drain and flow switch.

small room — A compartment of Light Hazard occupancy classification having unobstructed construction and a floor area not exceeding 800 square feet.

smoke — The airborne solid and liquid particulates and gases evolved when a material undergoes pyrolysis or combustion, including the quantity of air that is entrained or otherwise mixed into the mass.

smoke and heat vents — Passive devices installed to permit smoke and heat to escape from a building. Normally installed on roofs, these devices may be melt-out material operated by fusible link, manually operated or a combination of these methods.

smoke compartment — A space within a building enclosed by smoke barriers on all sides, including the top and bottom. Smoke compartments are frequently called smoke zones, and these terms are used interchangeably.

smoke control mode — A predefined operational configuration of a system or device for the purpose of smoke control. Synonymous with smoke "management."

smoke control system, dedicated — A "stand-alone" smoke control system where fans, controls and alarm features are independent of the building's heating, ventilating, and air conditioning system.

smoke control system, gravity — A method of smoke control that relies on natural ventilation forces to control or remove smoke. Usually used in reference to rooftop smoke and heat vents.

smoke control system, mechanical — An engineered system that uses mechanical fans to produce pressure differences across smoke barriers or establish airflows to limit and direct smoke movement.

smoke control system, nondedicated — A "combined" smoke control system where fans, controls and alarm features are integrated with the building's heating, ventilating, and air conditioning system.

smoke control system, passive — A system of smoke barriers arranged to limit the migration of smoke.

smoke damper — A listed device installed in ducts that is designed to resist the passage of air and smoke. The device is installed to operate automatically, controlled by a smoke detection system, and, where required, is capable of being positioned from a remote command station.

smoke detector, ionization principle — A smoke detection device that employs a small radioactive electron source. When small particles enter the smoke chamber, the particles are ionized. The ionized particles affect the electrical current flow in the sensing chamber, sounding an alarm.

smoke detector, photoelectric principle — A smoke detection device that employs a light source and light-sensitive target. When smoke interrupts or alters the light beam, an alarm is sounded. Photoelectric detectors may include light beam interruption (obscuration) or bending (refraction).

smoke exhaust system — A mechanical or gravity system intended to move smoke from the smoke zone to the exterior of the building. It includes smoke removal, purging and venting systems, as well as exhaust fans used to reduce the pressure in the smoke zone.

An approved gravity system may be automatically or manually operated smoke vents.

smoke-proof enclosure — An exit stairway designed and constructed so that the movement of the products of combustion produced by a fire occurring in any part of the building into the enclosure is limited.

smoke zones — A space within a building enclosed by smoke barriers on all sides, including the top and bottom. Smoke zones frequently are called smoke compartments, and these terms are used interchangeably. In rare cases, such as covered shopping malls, smoke zones may have no physical barriers other than the mall floor and ceiling.

specialty fire protection systems — Fixed fire protection systems employing special extinguishing agents or application techniques. Includes halogenated agents, halogen replacements (clean agent), dry and wet chemical, carbon dioxide, and water mist.

spot application — Used in relationship to specialty fire protection systems to describe a system that discharges to protect a two-dimensional hazard such as a printing press, a dip tank surface or commercial cooking surfaces.

sprig — In fire sprinkler systems, a pipe that rises vertically and supplies a single sprinkler.

Sprinkler Identification Number (SIN) — A five- or six-digit alphanumeric sequence that identifies a sprinkler's manufacturer, its orifice size, response classification, distribution characteristic and maximum working pressure.

sprinkler layout — The pipe configuration, as seen in plan view, that represents the relationship among feed and cross mains and branch lines.

- **sprinkler layout (grid)** — A sprinkler layout that consists of parallel cross mains with branch lines between them. The branch lines — usually all of the same diameter — connect to the cross mains at both ends allowing multidirectional water flow.

- **sprinkler layout (loop)** — A sprinkler layout that consists of cross mains connected at both ends to parallel cross mains. Branch lines are connected to the cross main, but generally not connected to one another.

- **sprinkler layout (tree)** — A sprinkler layout that consists of a single large cross main that serves branch lines. The branch lines' diameters decrease the farther they are from the system riser.

sprinkler system, automatic — An integrated system of underground and overhead piping, valves and sprinklers designed in accordance with fire protection engineering standards.

sprinkler system, deluge — A sprinkler system employing open sprinklers that are attached to a water supply through a valve that is opened by the operation of a detection system installed in the same area as the sprinklers.

sprinkler system, dry pipe — A sprinkler system employing automatic sprinklers that are attached to a piping system containing air or nitrogen under pressure, the release of which (as from the opening of a sprinkler) permits the water pressure to open a valve known as a dry pipe valve, and the water then flows into the piping system and out the opened sprinklers.

sprinkler system, foam — A sprinkler system employing open sprinklers that are attached to a water supply through a valve that is opened by the operation of a detection system installed in the same area as the sprinklers and equipped with special sprinklers that aerate a mixed foam/water solution at the point of discharge.

sprinkler system, preaction — A sprinkler system employing automatic sprinklers that are attached to a piping system that contains air that might or might not be under pressure with a supplemental detection system installed in the same area as the sprinklers.

sprinkler system, residential design — A sprinkler system installed in living spaces and adjacent corridors designed to control an incipient fire for the purpose of life safety. This is accomplished by wetting walls and the ceiling to prevent flashover in the room where the fire begins. Residential sprinkler systems are not designed for property protection; therefore, sprinkler protection may not be included in all parts of a structure.

sprinkler system, wet pipe — A sprinkler system employing automatic sprinklers connected 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.

standard — A document, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements, and which is in a form generally suited for mandatory reference by another standard or code for adoption into law.

standpipe system — An arrangement of piping, valves, hose connections and allied equipment installed in a building or structure with the hose connections located in such a manner that water can be discharged in streams or spray patterns through attached hoses and nozzles for the purpose of extinguishing a fire, thereby protecting a building or structure and its contents in addition to protecting the occupants. This is accomplished by means of pumps, tanks and other equipment necessary to provide an adequate supply of water to the hose connections.

Class 1 — Class 1 systems provide 2 1/2-inch hose outlet connections to supply water for use by fire departments and those trained in handling heavy fire streams. The systems must be designed to deliver a flow of not less than 500 gallons per minute at 100 pounds per square inch at the topmost hose outlet.

Class 2 — Class 2 systems provide 1 1/2-inch hose stations to supply water for use primarily by the building occupants, or by the fire department during initial response or mop-up. Class 2 systems — which often are connected to the building's potable water supply — must be designed to deliver 100 gallons per minute at 65 pounds per square inch at the outlet. Class 2 systems normally are not equipped with a fire department connection to supplement the flow and pressure.

Class 3 — Class 3 systems employ the features of both Class 1 and Class 2. They provide 1 1/2-inch hose stations to supply water for use by building occupants, and 2 1/2-inch hose connections to supply a larger volume of water for use by fire departments and those trained in handling heavy fire streams. The systems must be designed to deliver a flow of not less than 500 gallons per minute at 100 pounds per square inch at the topmost hose outlet.

standpipe, automatic (dry) — Automatic dry systems normally are filled with pressurized air, using a dry pipe valve that admits water into the system when a hose valve is opened. The air normally is discharged through the hoseline, so there will be a delay in receiving water in the line, not unlike water being supplied from a fire department pumper. They normally are installed where the piping is subject to freezing.

standpipe, automatic (wet) — Automatic wet systems are systems that are capable of supplying system demand automatically. They are supported by a water supply capable of meeting the firefighting water supply demand for a particular building or area. The water supply may be the municipal system, private water system, or one or more storage tanks in the building.

standpipe, manual — A standpipe system that is not connected to a water supply or has only a small priming water supply that is not capable of delivering the system demand and requires water from a fire department pumping apparatus to supply the system demand.

standpipe, semi-automatic (dry) — A dry system that uses a deluge valve or other device that admits water into the system upon activation of a remote control device located at a hose connection. A remote control device must be located at each hose connection.

storage array — See **array, storage.**

structure — That which is built or constructed.

supervisory signal — Used in conjunction with fire protection systems to identify "normal" and "off-normal" conditions, such as valve closure, high or low air pressure, high or low water temperature, or security features on a system. A supervisory signal is **not** a trouble signal.

suppression mode — When applied to sprinkler systems, describes automatic sprinklers, such as early suppression fast response, that are designed to suppress the fire to the point where there is no active combustion. See **fire control mode.**

system riser — For a fire sprinkler system, the aboveground horizontal or vertical pipe between the water supply and the mains (cross or feed) that contains a control valve (either directly or within its supply pipe), a pressure gauge, a main drain and a water flow alarm device.

takeout, pipe — In sprinkler pipe branch line installations, a measurement that accounts for fittings for joining pipe.

target hazard — Any building or potential incident site (e.g., outside hazardous materials storage site, bulk fuels storage facility) that has the potential for significant life loss, high property dollar loss and/or the ability to overwhelm local resources.

test header, fire pump — Equipment containing one or more 2 1/2-inch outlets with gate valves used to perform periodic performance testing on the fire pump. May be used in lieu of a flow meter.

testing — In relation to fire protection systems and equipment, a performance check where the system or equipment is exercised in compliance with the testing criteria outlined in the National Fire Protection Association codes and standards or manufacturer's requirements.

thermistor — Thermally sensitive resistors that have, according to type, a negative (negative temperature coefficient) or positive (positive temperature coefficient) resistance/temperature coefficient. Manufactured from the oxides of the transition metals — manganese, cobalt, copper and nickel — negative temperature coefficient thermistors are temperature-dependent semiconductor resistors.

total flooding — Used in relation to specialty fire protection systems to describe a system that discharges to protect a three-dimensional hazard such as a spray booth or computer room.

trouble signal — An alarm signal from a fire alarm control panel indicating an electronic failure of some kind, e.g., loss of main power, circuit interruption, disconnected device or ground fault. A trouble signal is **not** a supervisory signal.

truss — A framed structural unit made up of a group of triangles arranged in a single plane in such a manner that if the loads are applied at the points of intersection of the truss members, only compressive or tensile (nonbending) forces will result in the members.

unobstructed construction — For the purpose of fire sprinkler system design, construction where beams, trusses or other members do not impede heat flow or water distribution in a manner that materially affects the ability of sprinklers to control or suppress a fire. Unobstructed construction has horizontal structural members that are not solid where the openings are at least 70% of the cross-section area and the depth of the member does not exceed the least dimension of the openings, or all construction types where the spacing of structural members exceeds 7 1/2 feet on center.

valve, indicating — A water control valve that can be identified as "open" or "closed" without touching the valve. Usually used on water supplies to fire protection systems. Includes post indicators, wall indicators, quarter turn and butterfly valves.

valve, nonindicating — A water control valve that must be manipulated to determine its "open" or "closed" status. Usually used on fire protection systems for test or drain connections that are not critical to system operation. Includes globe, ball, check and gate valves.

velocity, pipe — Water movement speed in pipe. The transition point between laminar and turbulent flow is considered 20 feet per second. National Fire Protection Association 13, *Standard for the Installation of Sprinkler Systems*, states "Unless required by other NFPA standards, the velocity of water flow shall not be limited when hydraulic calculations are performed using the Hazen-Williams or Darcy Weisbach formulas" (National Fire Protection Association (NFPA), 2016, section 23.4.1.4).

venturi — A short tube with a tapering constriction in the middle that increases the velocity of the fluid flow and results in a corresponding downstream decrease in fluid pressure. Commonly used in the fire service for foam reduction.

view — In architecture and engineering, representation of a whole system from a variety of visual perspectives.

view, elevation — Building or structural rendering of the outside walls as if the observer was standing outdoors looking at the edifice.

view, isometric or orthographic — Building or structural rendering in three dimensions.

view, plan — Building or structural rendering from above as if the roof were removed, exposing the rooms.

view, section — Building or structural rendering as if there is an imaginary "slice" through the building and features from the footings/foundation through the roof can be observed.

water spray system — Similar to a deluge system, a water spray system employs normally open nozzles but discharges water in a fine mist. Usually used for exterior exposure protection such as for aboveground tanks or oil-filled electrical transformers.

water supply effective point — See **effective point.**

wet chemical extinguishing agent — A fire extinguishing agent made from a solution of water and potassium-carbonate-based chemical, potassium-acetate chemical or a combination of both.

wet pipe sprinkler system — An automatic sprinkler system employing automatic sprinklers connected 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.

windowless building — A structure that measures at least 1,500 square feet and is not provided with doors or windows for ventilation or rescue sized and spaced in accordance with the building code. Generally, openings must be at least 30 inches wide, have 20 square feet of net clearance, be openable from the outside, and be located not more than 75 feet from the opposite wall.

zoned — When used in conjunction with fire alarm systems, describes a method for installing initiating devices and circuits so an alarm will correspond with the general location and/or devices (e.g., second floor, gymnasium, smoke detectors, pull stations, etc.). See **addressable.**

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ACRONYMS

ABS	acrylonitrile butadiene styrene
AC	asbestos cement
ACT	acoustical ceiling tile
ADA	Americans with Disabilities Act
API	American Petroleum Institute
CLDI	concrete lined ductile iron
CPVC	chlorinated polyvinyl chloride
DOD	U.S. Department of Defense
ETL	Electrical Testing Laboratories
FDC	fire department connection
FIP	Fire Inspection Principles
FM	Factory Mutual
gpm	gallons per minute
IBC	International Building Code
ICC	International Code Council
ICS	Incident Command System
ID	Internal Diameter
IFC	International Fire Code
IG	Instructor Guide
IRC	International Residential Code
ISO	Insurance Services Office
NFA	National Fire Academy

NFPA	National Fire Protection Association
OD	Outer Diameter
PEI	Petroleum Equipment Institute
PEX	cross-linked polyethylene
PIV	post indicator valve
psi	pounds per square inch
PVC	polyvinyl chloride
QRS	quick-response sprinkler
SAW	Student Activity Worksheet
SM	Student Manual
UL	Underwriters Laboratories
ULC	Underwriters Laboratories of Canada
USFA	U.S. Fire Administration