Water-based Fire Protection System Plans Review

WBFPSPR-Student Manual

1st Edition, 3rd Printing-June 2018

FEMA

FEMA/USFA/NFA
WBFPSPR-SM
June 2018
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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:

Woody Stratton, Training Specialist
Leadership and Fire Risk Reduction Section
U.S. Fire Administration National Fire Academy
Emmitsburg, Maryland

Russell Kuck, Instructional Systems Specialist
Curriculum and Instruction Branch
U.S. Fire Administration National Fire Academy
Emmitsburg, Maryland

Karen Kent, Project Manager
Advanced Technical and Educational Consultants, Inc. (ATEC)
Emmitsburg, Maryland

Bill Lewis, Instructional Designer
Advanced Technical and Educational Consultants, Inc. (ATEC)
Emmitsburg, Maryland

Dr. Joe Saitta, Instructional Designer
Advanced Technical and Educational Consultants, Inc. (ATEC)
Emmitsburg, Maryland

Ken Bush
Subject Matter Expert
Easton, Maryland

Mark Bird
Subject Matter Expert
Frederick, Maryland

LaMar Hayward
Subject Matter Expert
Idaho Falls, Idaho

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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 and approval of plans for water-based fire protection systems in their jurisdictions.

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 water-based fire protection systems proposed as part of facility and occupancy construction plans. The course will enable students to perform a plan review to evaluate the suitability of the fire sprinkler, pump and standpipe plans and calculations in accordance with nationally recognized standards for design and installation. Course content covers fire protection standards, plan reading, water supplies, building envelope features, fire protection hydraulics mathematics, fire pumps, sprinkler systems, and standpipe systems.

Students should be familiar with water-based fire protection systems equipment and nomenclature and have prior experience in fire prevention inspection programs and community goals and priorities. It is recommended that students either possess International Code Council (ICC) or National Fire Protection Association (NFPA) Plan Examiner certifications or have attended the NFA course “Fire and Life Safety Plan Review” (R0132) or equivalent instruction. It is also recommended that students complete NFA’s online course, “Testing and Evaluation of Water Supplies for Fire Protection” (Q0218) prior to attending “Water-based Fire Protection System Plans Review” (WBFPSPR). The online course is available on the U.S. Fire Administration’s (USFA’s) NFA Online at usfa.fema.gov/nfa/nfaonline.

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

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SCHEDULE

TIME	DAY 1	DAY 2
8:00 - 9:00	Introduction, Welcome and Administrative	Unit 2: System Design
9:00 - 9:10	*Break*	*Break*
9:10 - 10:40	Unit 1: Basic Design Criteria Activity 1.1: Find and Identify on the Drawing by Grid or Drawing Designation	Activity 2.1: Sprinkler Hazard Classifications Unit 2: System Design (cont'd) Activity 2.2: Building Construction
10:40 - 10:50	*Break*	*Break*
10:50 - 11:55	Unit 1: Basic Design Criteria (cont'd)	Unit 2: System Design (cont'd) Activity 2.3: Obstructed Construction
11:55 - 12:55	*Lunch Break*	*Lunch Break*
12:55 - 2:20	Unit 1: Basic Design Criteria (cont'd) Activity 1.2: Selecting Standards	Unit 2: System Design (cont'd) Activity 2.4: Compartments and Small Rooms Unit 3: Water Supplies and Delivery Systems Activity 3.1: Available Stored Water Supply
2:20 - 2:35	*Break*	*Break*
2:35 - 5:00	Unit 1: Basic Design Criteria (cont'd)	Unit 3: Water Supplies and Delivery Systems (cont'd) Activity 3.2: Water Supplies for Combined Sprinkler and Standpipe Systems

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 4: System Components and Materials	Unit 5: Fire Protection System Plans Methods of Design
9:00 - 9:10	*Break*	*Break*
9:10 - 10:40	Unit 4: System Components and Materials (cont'd)	Unit 5: Fire Protection System Plans Methods of Design (cont'd) Activity 5.1: Determine Design Hazard Classification
10:40 - 10:50	*Break*	*Break*
10:50 - 11:55	Unit 4: System Components and Materials (cont'd) Activity 4.1: Verifying Sprinkler Water Flows	Unit 5: Fire Protection System Plans Methods of Design (cont'd)
11:55 - 12:55	*Lunch Break*	*Lunch Break*
12:55 - 2:20	Unit 4: System Components and Materials (cont'd)	Unit 5: Fire Protection System Plans Methods of Design (cont'd)
2:20 - 2:35	*Break*	*Break*
2:35 - 4:00	Activity 4.2: Pump Combination Curve Exercise Activity 4.3: Verifying Sprinkler Selection	Activity 5.2: Storage Exercise Activity 5.3: Exterior Shade Structure

TIME	DAY 5	DAY 6
8:00 - 9:00	Unit 6: Evaluating Sprinkler Hydraulic Calculations	Course Review
9:00 - 9:10	*Break*	*Break*
9:10 - 10:40	Unit 6: Evaluating Sprinkler Hydraulic Calculations (cont'd)	Final Exam
10:40 - 10:50	*Break*	*Break*
10:50 - 11:55	Activity 6.1: Formula Exercise Unit 6: Evaluating Sprinkler Hydraulic Calculations (cont'd)	Final Exam (cont'd)
11:55 - 12:55	*Lunch Break*	*Lunch Break*
12:55 - 2:20	Activity 6.2: Hydraulic Calculations	Administrative (Course evaluation)
2:20 - 2:35	*Break*	*Break*
2:35 - 4:00	Activity 6.2: Hydraulic Calculations (cont'd)	Administrative (Graduation)

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GRADING METHODOLOGY

The students' final grades will be computed using the final exam. The written final exam will include 25 multiple-choice questions. The exam covers all the information in the Student Manual (SM), as well as the concepts presented during presentations and class discussions.

Grade		Correct Answers
A	=	22-25
B	=	20-21
C	=	18-19
F	=	17 or less

Passing is a C (70 percent).

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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

Say What You Mean ...

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.

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UNIT 1: BASIC DESIGN CRITERIA

TERMINAL OBJECTIVE

The students will be able to:

1.1 Given a set of drawings and calculations, apply recognized mathematical calculations and formulas, and interpret and use standardized symbols and terminology in the review and approval process of plans for water-based fire protection systems.

ENABLING OBJECTIVES

The students will be able to:

1.1 Recognize common terms used within the National Fire Protection Association (NFPA) standards specific to water-based fire protection systems.

1.2 Identify accepted symbols used in the fire protection system plan process.

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

1.4 Verify the basic plan information to approve or reject submitted system designs.

1.5 Identify basic mathematical functions related to water-based fire protection systems.

1.6 Apply the appropriate mathematical functions necessary for the review and verification of system design.

1.7 Given the physical dimensions of a water storage tank and a volume formula, calculate the water storage capacity of a cylindrical suction tank.

1.8 Given the physical dimensions of a water storage reservoir and a volume formula, calculate the water storage capacity of a water storage reservoir.

1.9 Determine pressure losses due to friction loss and elevation changes.

1.10 Determine the size and orientation of the hydraulically most remote area.

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FEMA

U.S. Fire Administration

UNIT 1:
BASIC DESIGN CRITERIA

Slide 1-1

TERMINAL OBJECTIVE

Given a set of drawings and calculations, apply recognized mathematical calculations and formulas, and interpret and use standardized symbols and terminology in the review and approval process of plans for water-based fire protection systems.

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ENABLING OBJECTIVES

- Recognize common terms used within the National Fire Protection Association (NFPA) standards specific to water-based fire protection systems.
- Identify accepted symbols used in the fire protection system plan process.
- Explain plan symbols, notes and details found on site drawings and shop drawings.

Slide 1-3

ENABLING OBJECTIVES (cont'd)

- Verify the basic plan information to approve or reject submitted system designs.
- Identify basic mathematical functions related to water-based fire protection systems.

Slide 1-4

ENABLING OBJECTIVES (cont'd)

- Apply the appropriate mathematical functions necessary for the review and verification of system design.
- Given the physical dimensions of a water storage tank and a volume formula, calculate the water storage capacity of a cylindrical suction tank.

Slide 1-5

ENABLING OBJECTIVES (cont'd)

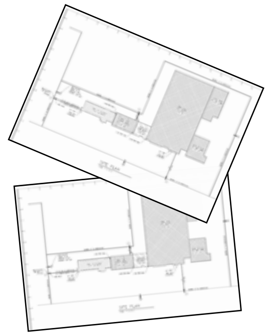
- Given the physical dimensions of a water storage reservoir and a volume formula, calculate the water storage capacity of a water storage reservoir.
- Determine pressure losses due to friction loss and elevation changes.
- Determine the size and orientation of the hydraulically most remote area.

Slide 1-6

I. PROPERLY SUBMITTED PLANS

PROPERLY SUBMITTED PLANS

- The quality of the submitted plans affects the quality of the plan review and ability to shorten turnaround time.
- Plans must be legible and to a suitable, standard scale.



Slide 1-7

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

B. Plans must be legible and to a suitable, standard scale.

PROPERLY SUBMITTED PLANS (cont'd)

- Plans may have to be prepared by a "registered design professional" if required by local and state laws.
- Where special conditions exist, the code official may require additional documents to be prepared by the design professional.

Slide 1-8

C. Plans may have to be prepared by a "registered design professional" if required by local and state laws.

Examples:

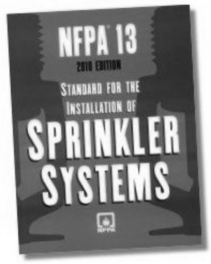
1. Professional engineer.
2. Fire protection engineer.
3. National Institute for Certification in Engineering Technologies (NICET) designer.

4. State-certified fire protection specialist.

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

NATIONAL FIRE PROTECTION ASSOCIATION 13

- List of minimum required information.
- Working plans must be drawn to an indicated scale.
- On sheets of uniform size.
- Have a plan of each floor.



Slide 1-9

E. National Fire Protection Association (NFPA) 13, *Standard for the Installation of Sprinkler Systems*.

1. List of minimum required information.

2. Working plans must be drawn to an indicated scale.

3. On sheets of uniform size.

4. Have a plan of each floor.

II. GENERAL INFORMATION PROVIDED WITH PLANS

GENERAL INFORMATION PROVIDED WITH PLANS

- Codes require specific information to be provided as part of the sprinkler plans to help the code enforcement officer ensure the sprinkler system meets all applicable codes.
- Three types of information provided with the submittal: plans, product information, and hydraulic calculations.

Slide 1-10

A. Codes require specific information to be provided as part of the sprinkler plans. The information is intended to help the code enforcement officer ensure that the sprinkler system meets all applicable codes.

B. There are three types of information provided with the submittal: plans, product (component) information, and hydraulic calculations (when necessary).

GENERAL INFORMATION PROVIDED WITH PLANS (cont'd)

- General information provided with the plans includes the following:
  - Name of owner and occupant.
  - Name and address of contractor.
  - Location, including street address.
  - Point of compass for orienting the structure.
  - Full height cross section or schematic diagram.

Slide 1-11

C. General information provided with the plans includes the following. (More information may be required by the authorities having jurisdiction (AHJs).)

1. Name of owner and occupant.
2. Name and address of contractor(s).
3. Location, including street address.
4. Point of compass for orienting the structure.
5. Full height cross section or schematic diagram.

GENERAL INFORMATION PROVIDED WITH PLANS (cont'd)

- Location of partitions and fire walls.
- Type of occupancy.
- Water supply.
- Drawing grid lines.
- Size and location of standpipe risers, hose outlets, hand hose, monitor nozzles, and related equipment.

Slide 1-12

6. Location of partitions and fire walls.

7. Type of occupancy.

8. Water supply.

   Examples:

   a. Tanks.

   b. Water mains.

   c. Hydrants.

   d. Pumps.

9. Drawing grid lines.

   Examples:

   a. Small closets.

   b. Bathrooms.

   c. Noncombustible concealed spaces.

10. Size and location of standpipe risers, hose outlets, hand hose, monitor nozzles, and related equipment.

GENERAL INFORMATION PROVIDED WITH PLANS (cont'd)

– Type and locations of hangers, sleeves, braces and methods of securing piping when applicable.
– All control valves, check valves, drain pipes and test connections.
– Size, location and piping arrangement of fire department connections.
– Test data.

Slide 1-13

11. Type and locations of hangers, sleeves, braces and methods of securing piping when applicable.

12. All control valves, check valves, drain pipes and test connections.

13. Size, location and piping arrangement of fire department connections.

14. Test data.

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ACTIVITY 1.1

Find and Identify on the Drawing by Grid or Drawing Designation

Purpose

To orient you with using grid and drawing designations.

Directions

Using the list of plan items below, work in your group and identify the location of each item by plan number and grid coordinates or section detail. Be prepared to explain your group's answer to the class.

1. Name of contract.

   ____

   ____

   ____

2. Name and address of contractor.

   ____

   ____

   ____

3. Location, including street address.

   ____

   ____

   ____

4. Point of compass for orienting the structure.

   ____

   ____

   ____

5. Full height cross section of hotel.

6. Location of occupancy separation between restaurant and retail.

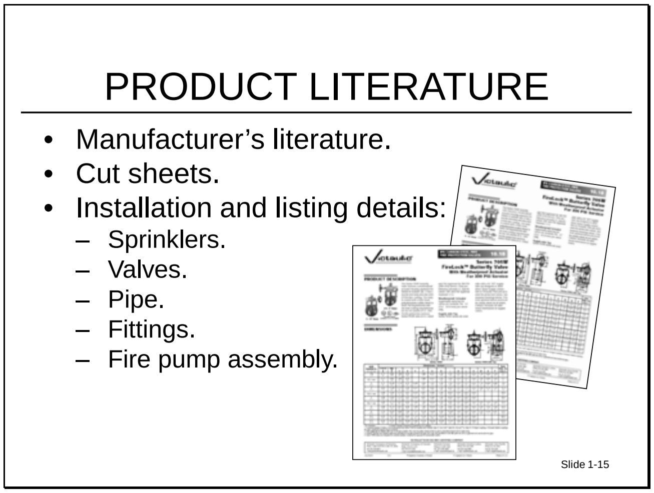
7. Design hazard classification of the shade structure of the retail bulk merchandising.

8. Water supply test hydrant.

9. Hotel main level manual wet standpipe valve location(s).

10. Hotel fire department connection.

II. GENERAL INFORMATION PROVIDED WITH PLANS (cont'd)



D. Product literature.

1. Manufacturer's literature.

2. Cut sheets.

3. Installation and listing details.

   a. Sprinklers.

   b. Valves.

   c. Pipe.

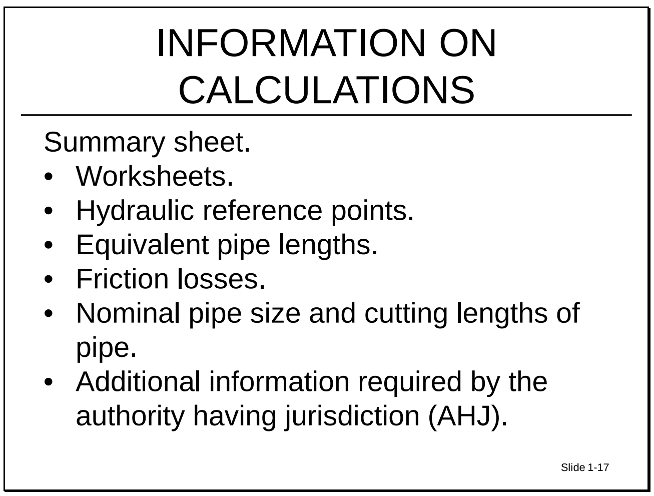
   d. Fittings.

   e. Fire pump assembly.

E. Key items.

All materials and devices essential to successful performance must be “listed” by an approved testing organization.

1. Underwriters Laboratories (UL).
2. UL Canada.
3. Factory Mutual (FM).
4. City and state agencies.

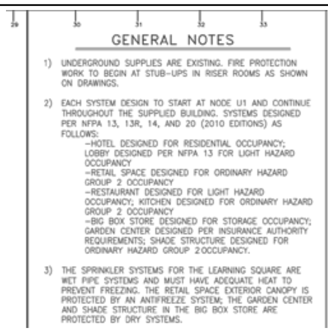


F. Information on calculations.

Summary sheet.

1. Worksheets.
2. Hydraulic reference points.
3. Equivalent pipe lengths.
4. Friction losses.
5. Nominal pipe size and cutting lengths of pipe.
6. Additional information required by the AHJ.

GENERAL NOTES



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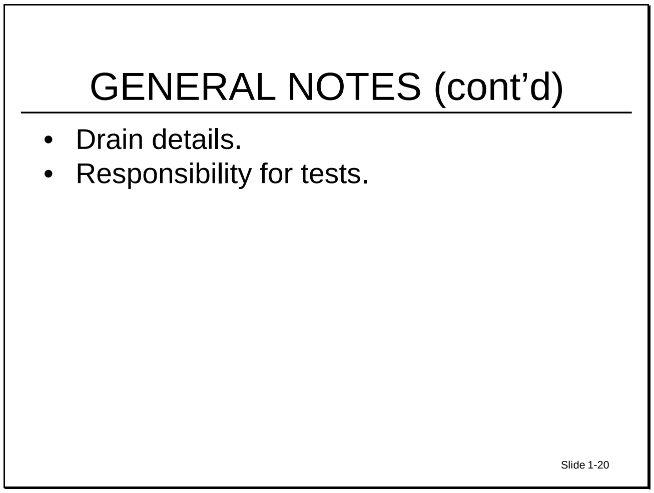
G. The general notes section provides additional details about the sprinkler system features and elements.

GENERAL NOTES (cont'd)

- Contractor's starting point.
- Hangers.
- Pipe details.
- Design criteria.
- Water supply data.
- Sprinkler selection.
- Backflow prevention device.
- Hose station details.

Slide 1-19

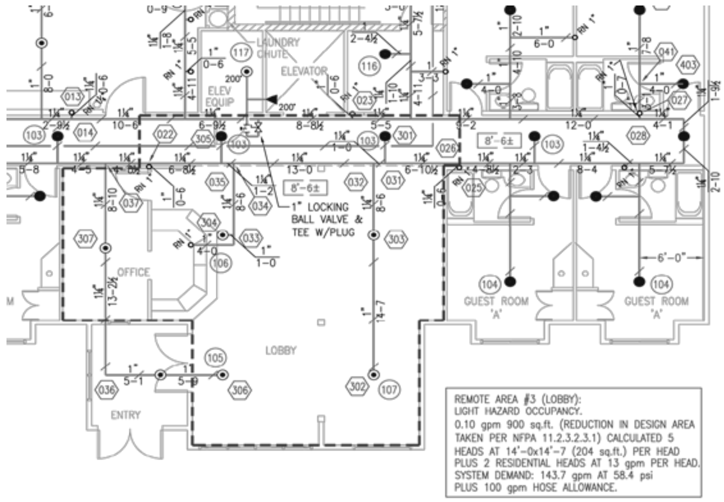
1. Contractor's starting point.
2. Hangers.
3. Pipe details.
4. Design criteria.
5. Water supply data.
6. Sprinkler selection.
7. Backflow prevention device.
8. Hose station details.



9. Drain details.

10. Responsibility for tests.

REMOTE AREA



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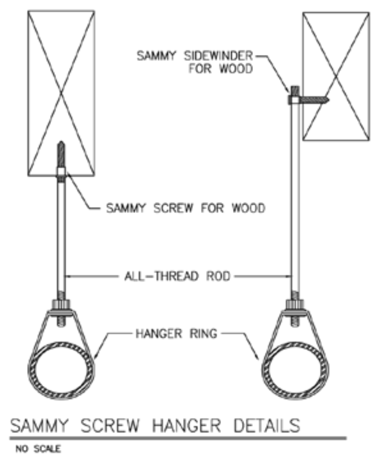
H. Sheet details.

1. Remote area.

HANGER DETAIL



Slide 1-22

2. Hanger detail.

SPRINKLER HEAD SPECIFICATION

HEAD COUNT								
Sprinkler	Type	Fin.	Orif.	K–Fac.	Can	Temp.	Symb.	Qty.
Reliable F1 Res	Pend	White	7/16	4.9	White	155°	●	45
Reliable F1 Res	Sidewall	White	7/16	4.2	White	155°	◁	156
Reliable F1FR	Pend	White	1/2	5.6	White	155°	⊙	22
Reliable F1FR	Pend	White	1/2	5.6	White	200°	⊙ 200°	1
Reliable F1FR	Sidewall	White	1/2	5.6	White	155°	◀	7
Reliable F1FR	Sidewall	Brass	1/2	5.6	---	200°	◀ 200°	2
							Total	233

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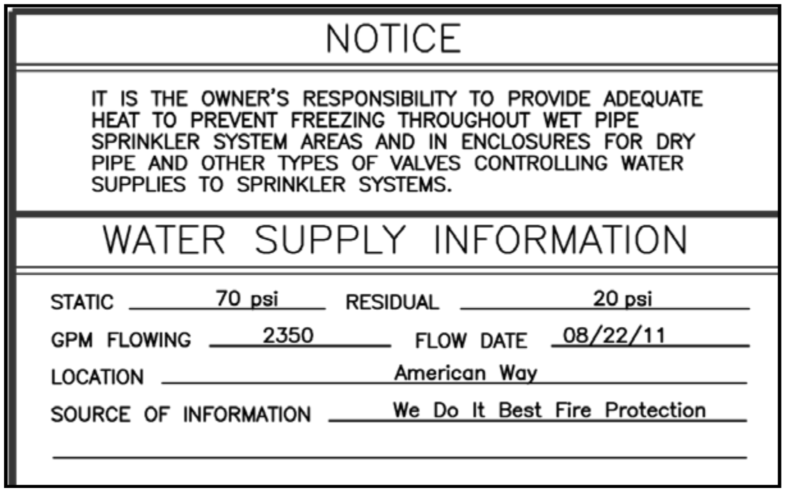
3. Sprinkler head specification.

   This specification adds details on sprinkler heads and supports.

WATER SUPPLY INFORMATION


NOTICE

IT IS THE OWNER'S RESPONSIBILITY TO PROVIDE ADEQUATE HEAT TO PREVENT FREEZING THROUGHOUT WET PIPE SPRINKLER SYSTEM AREAS AND IN ENCLOSURES FOR DRY PIPE AND OTHER TYPES OF VALVES CONTROLLING WATER SUPPLIES TO SPRINKLER SYSTEMS.

WATER SUPPLY INFORMATION

STATIC 70 psi RESIDUAL 20 psi

GPM FLOWING 2350 FLOW DATE 08/22/11

LOCATION American Way

SOURCE OF INFORMATION We Do It Best Fire Protection

Slide 1-24

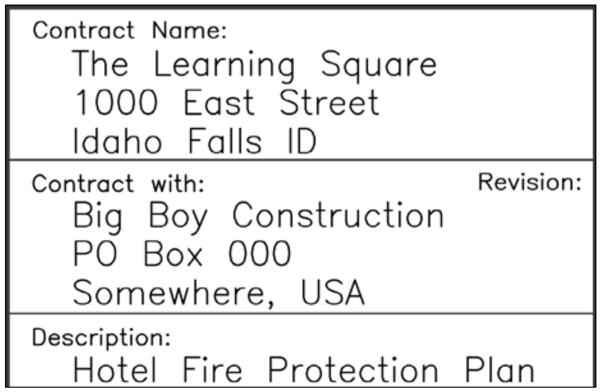
4. Water supply information.

   a. Water supply information includes the types of heads, orientation, finish, orifice size, K-factor, temperature rating, symbol and quantity.

   b. Standpipe hose.

      - This item includes static pressure, flow, location and source.

GENERAL BUILDING INFORMATION



Slide 1-25

5. General building information.

   This item includes scale, date, revision date and contract number.

OWNER'S CERTIFICATE

- Information given to designer (not AHJ).
- Building's intended use.
- Preliminary plan and design concepts.
- Special water supply knowledge.
- Assumed limitations.

Slide 1-26

I. Owner's certificate.

1. Information given to designer (not AHJ).
2. Building's intended use.
3. Preliminary plan and design concepts.
4. Special water supply knowledge.
5. Assumed limitations.

HYDRAULIC CALCULATIONS

- Show the hydraulic demand that the fire protection system needs to protect a specific hazard.
- Based on requirements within NFPA standards.
- Calculations must be in a standard form and clearly explain the requirements.

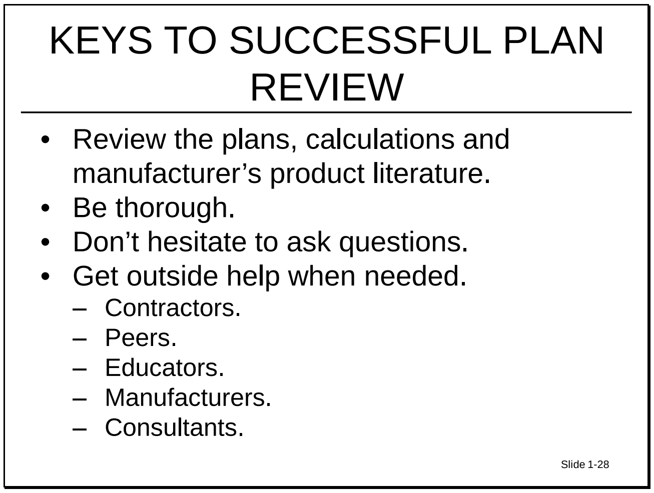
Slide 1-27

J. Hydraulic calculations.

1. Show the hydraulic demand that the fire protection system needs in order to protect a specific hazard.
2. Based on requirements within NFPA standards.

3. Calculations must be in a standard form and clearly explain the requirements.

III. DOCUMENTATION



A. Keys to successful plan review.

1. Take time to review the plans, calculations and manufacturer's product literature.

2. Be thorough.

3. Don't hesitate to ask questions.

4. Get outside help when needed.

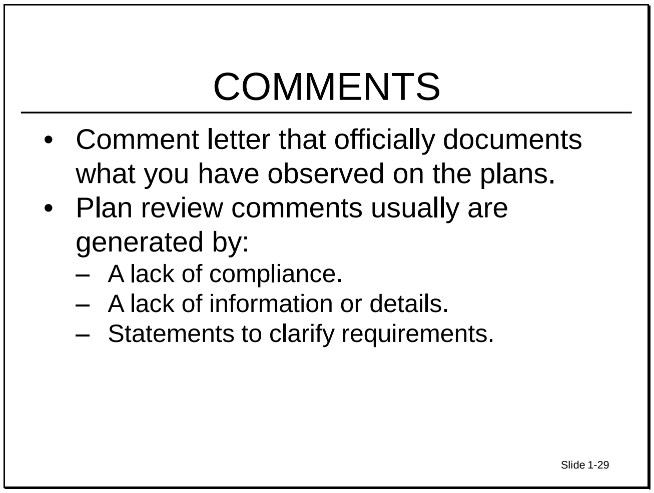
a. Contractors.

b. Peers.

c. Educators.

d. Manufacturers.

e. Consultants.



B. Comments.

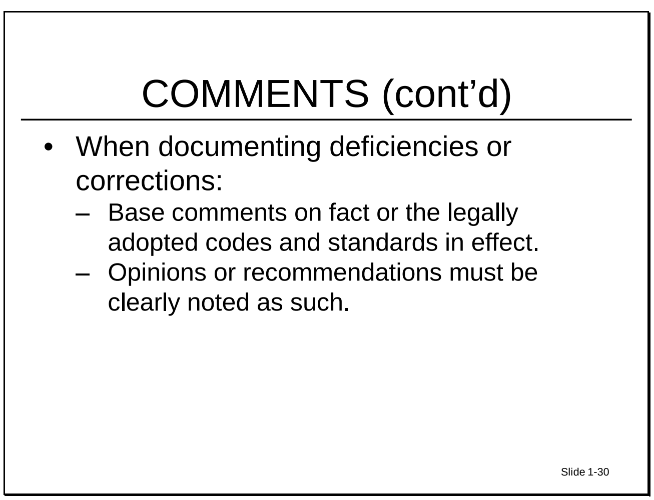
1. Comment letter that officially documents what you have observed on the plans.

2. Plan review comments usually are generated by:

   a. A lack of compliance.

   b. A lack of information or details.

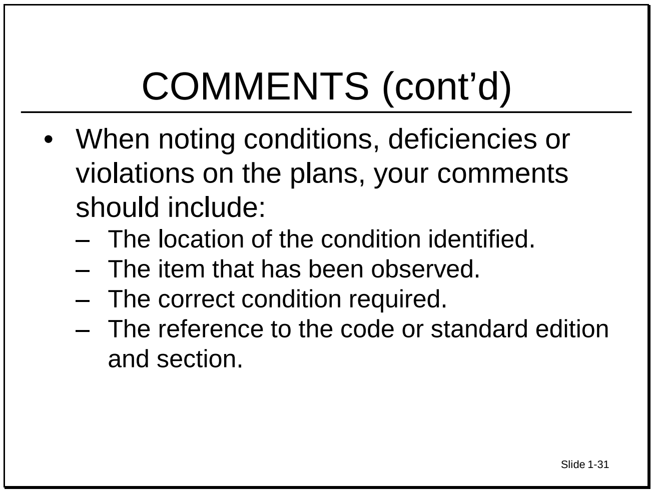
   c. Statements to clarify requirements.



3. When documenting deficiencies or corrections:

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

b. Opinions or recommendations must be clearly noted as such.



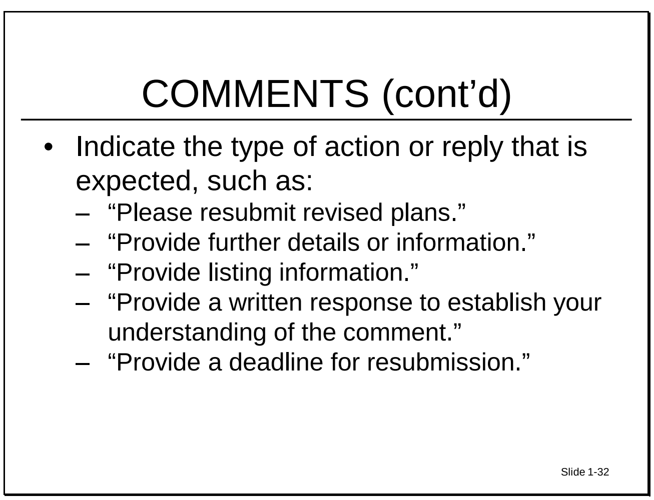
4. When noting conditions, deficiencies or violations on the plans, your comments should include:

   a. The location of the condition identified.

   b. The item that has been observed.

   c. The correct condition required.

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



5. Indicate the type of action or reply that is expected, such as:

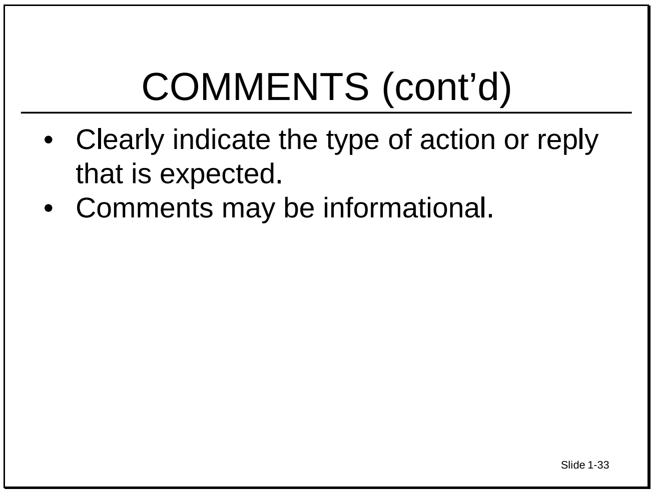
   a. "Please resubmit revised plans."

   b. "Provide further details or information."

c. “Provide listing information.”

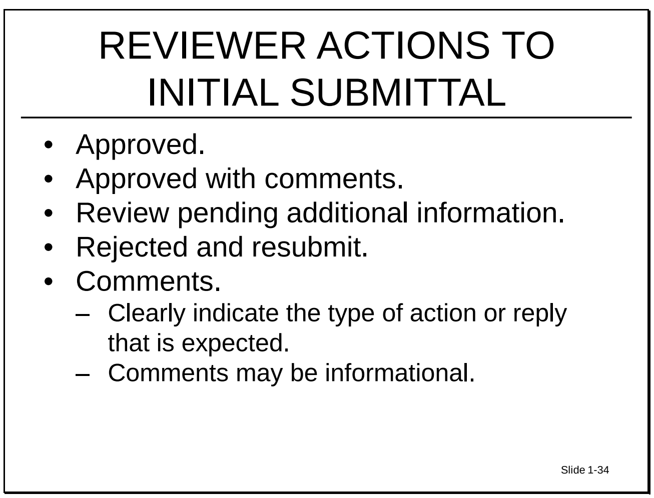
d. “Provide a written response to establish your understanding of the comment.”

e. “Provide a deadline for resubmission.”



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

7. Comments may be informational.



C. Reviewer actions to initial submittal.

1. Approved.

2. Approved with comments.

3. Review pending additional information.

4. Rejected and resubmit.

5. Comments.

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

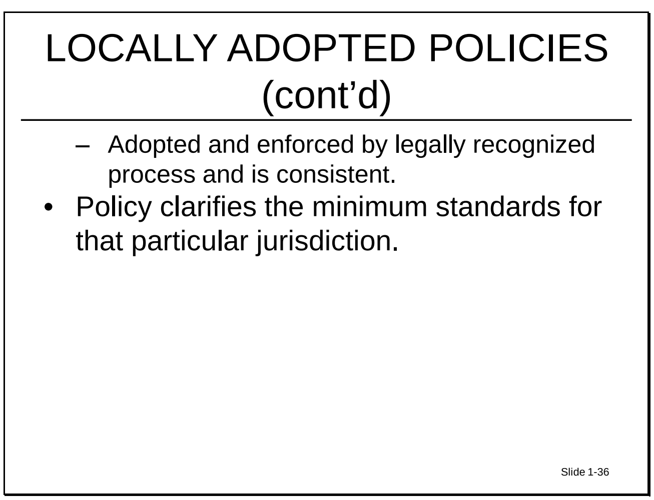
   b. Comments may be informational.

IV. LOCALLY ADOPTED POLICIES

A. The code requirement provides generic requirements.

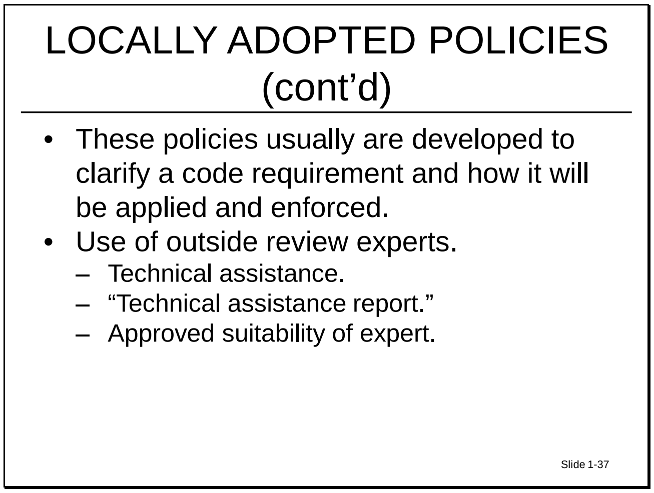
B. Locally adopted policy is applied and enforced as if it were legal requirements.

   1. Local jurisdictions are permitted to modify the standard to address specific conditions yet maintain an acceptable level of safety.



2. Adopted and enforced by a legally recognized process and is consistent.

C. Policy clarifies the minimum standards for that particular jurisdiction.



D. These policies usually are developed to clarify a code requirement and how it will be applied and enforced.

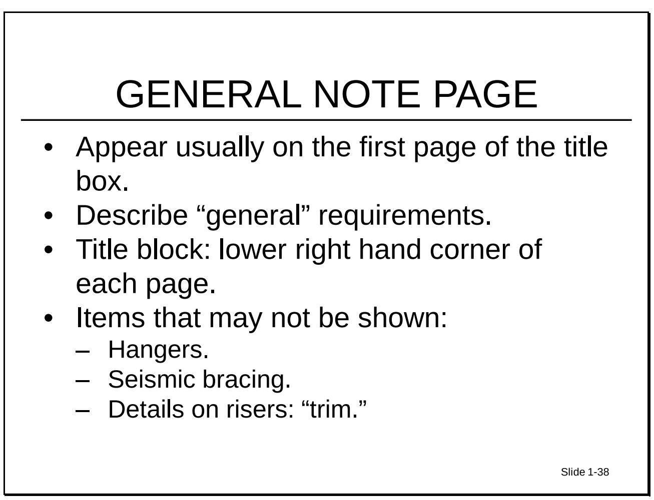
E. Use of outside review experts.

1. Technical assistance.

2. "Technical assistance report."

3. Approved suitability of expert.

V. PLANS, SYMBOLS, NOTES AND DETAILS



A. General note page.

1. Appear usually on the first page of the title box.

2. Describe “general” requirements.

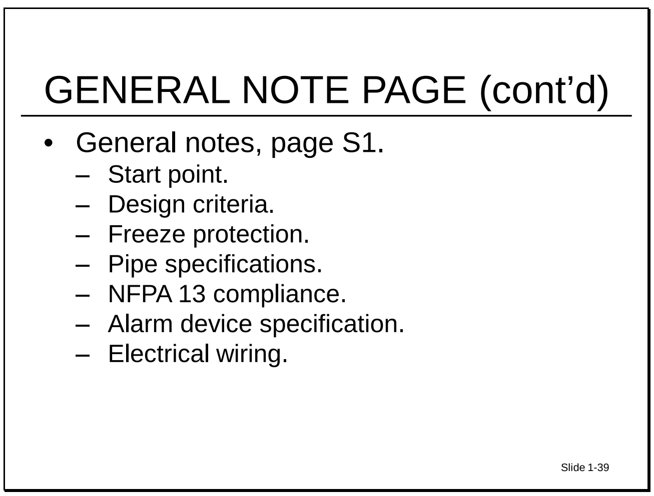
3. Title block: lower right hand corner of each page.

4. Items that may not be shown:

   a. Hangers.

   b. Seismic bracing.

   c. Details on risers are “trim.”



5. General notes, page S1.

   a. Start point.

   b. Design criteria (light, ordering, etc.).

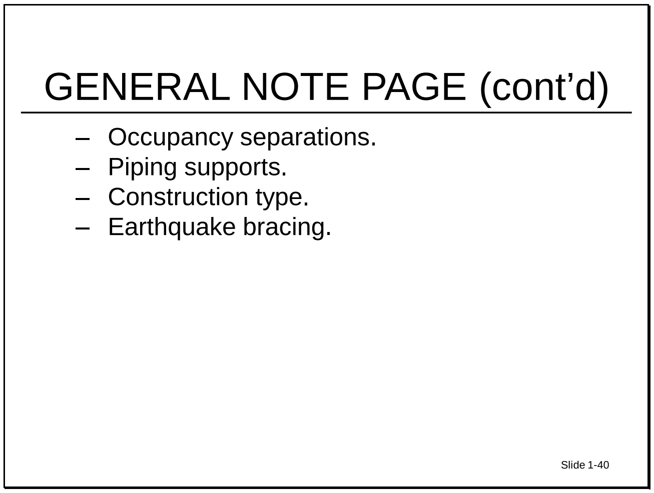
   c. Freeze protection (seasonal issues, areas of building, inside a walk-in freezer).

   d. Pipe specifications.

   e. NFPA 13 compliance.

   f. Alarm device specification.

   g. Electrical wiring.

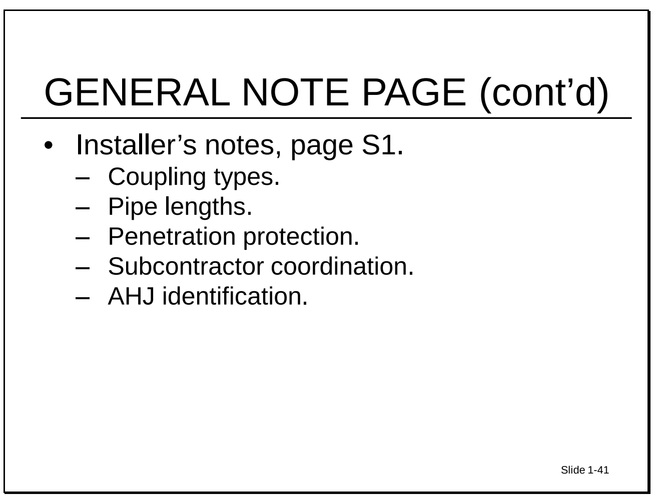


h. Occupancy separations.

i. Piping supports.

j. Construction type.

k. Earthquake bracing.



6. Installer's notes, page S1.

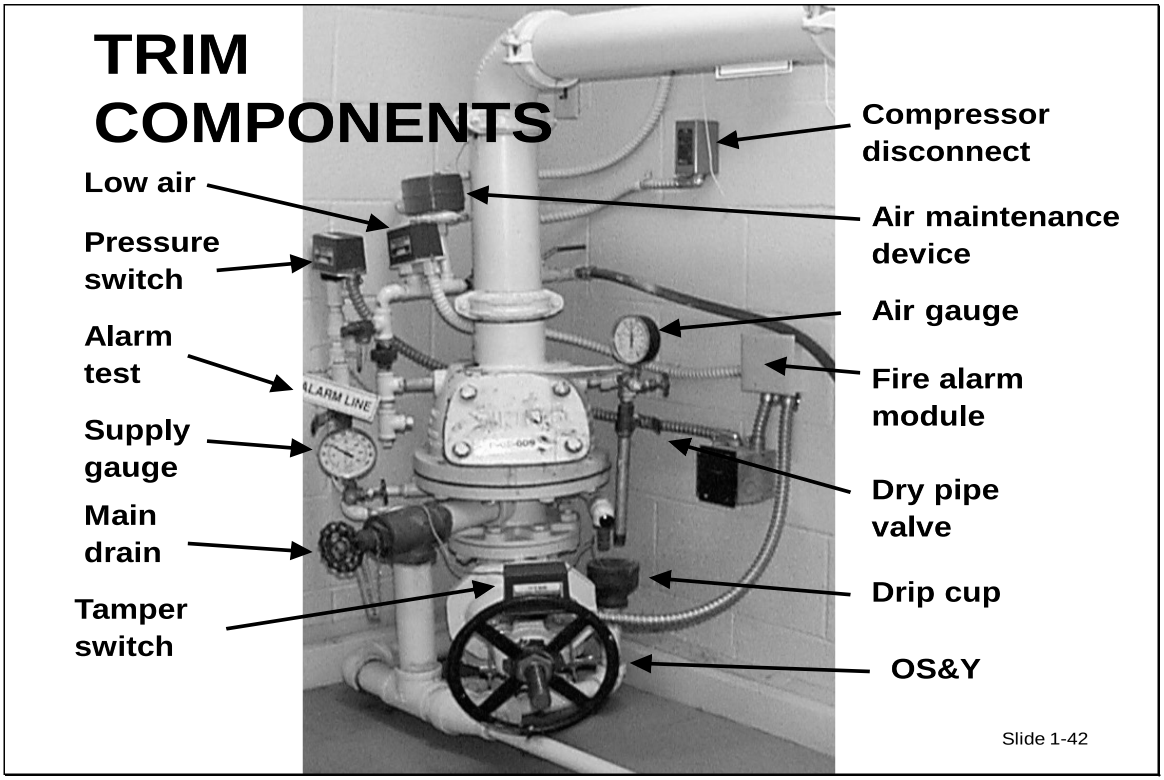
   a. Coupling types.

   b. Pipe lengths.

   c. Penetration protection.

   d. Subcontractor coordination.

   e. AHJ identification.



7. Trim components.

PIPE AND TUBE

- Pipe network that routes water from source to sprinkler.
  - Aboveground.
  - Underground.

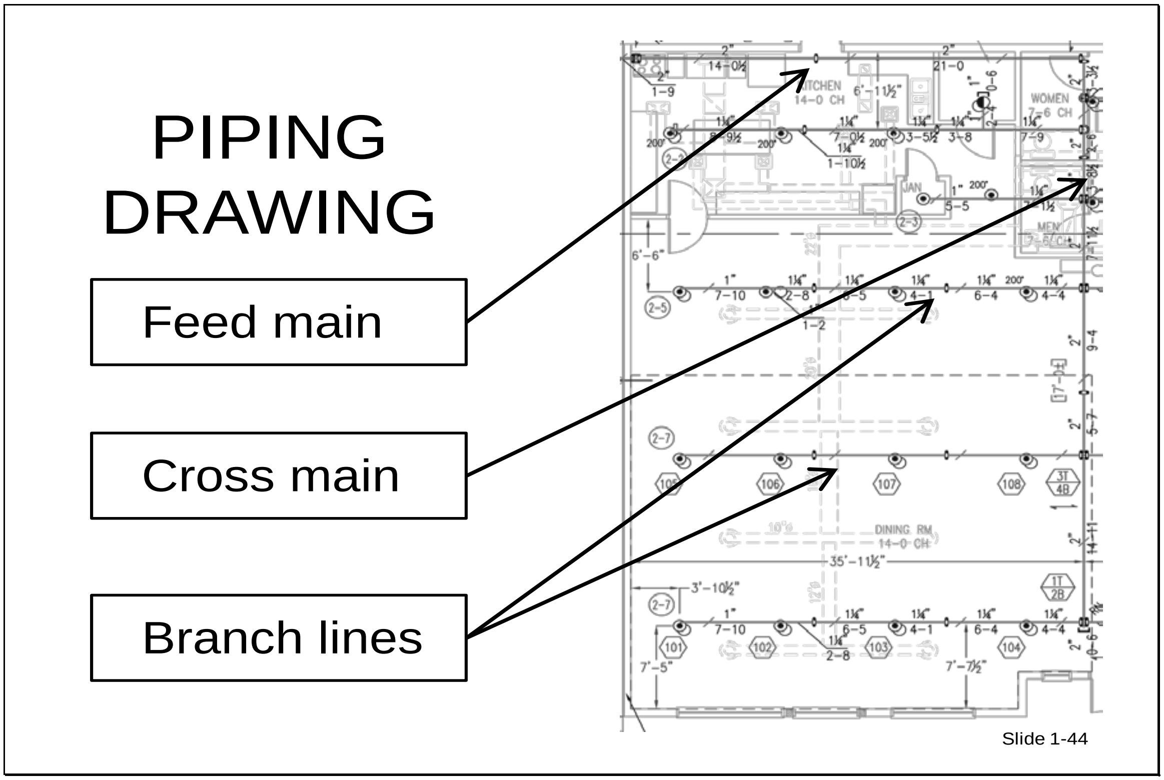
Slide 1-43

B. Pipe and tube.

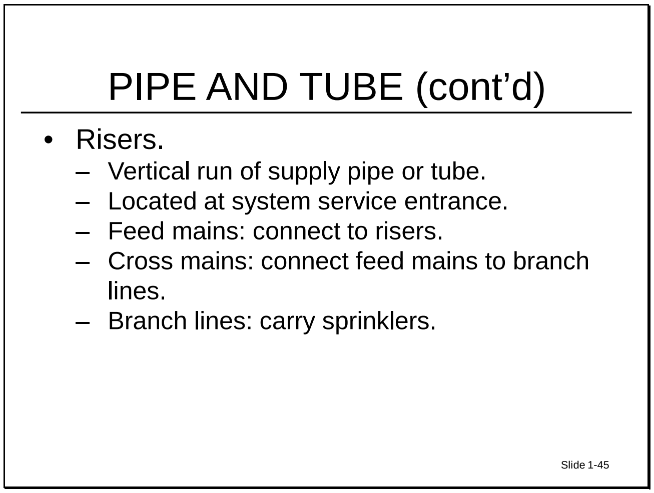
1. Pipe network that routes water from source to sprinkler.

a. Aboveground.

b. Underground.



2. Pipe drawing components page F3 of 8 remote area 1.



3. Risers.

   a. Vertical run of supply pipe or tube.

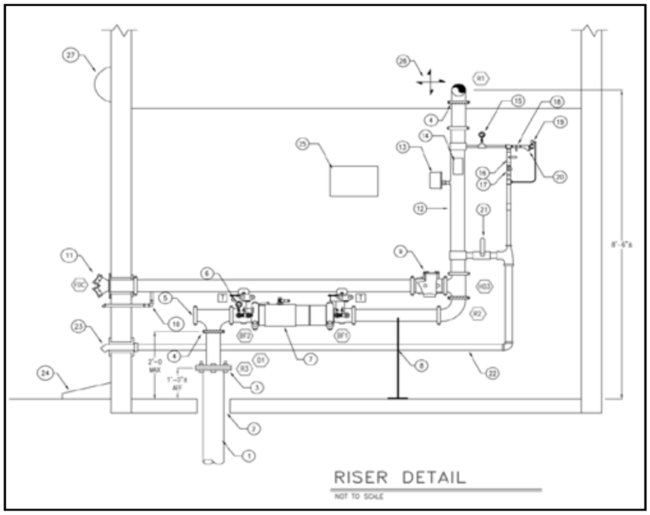
   b. Located at system service entrance.

   c. Feed mains: connect to risers.

   d. Cross mains: connect feed mains to branch lines.

   e. Branch lines: carry sprinklers.

RISER DETAILS



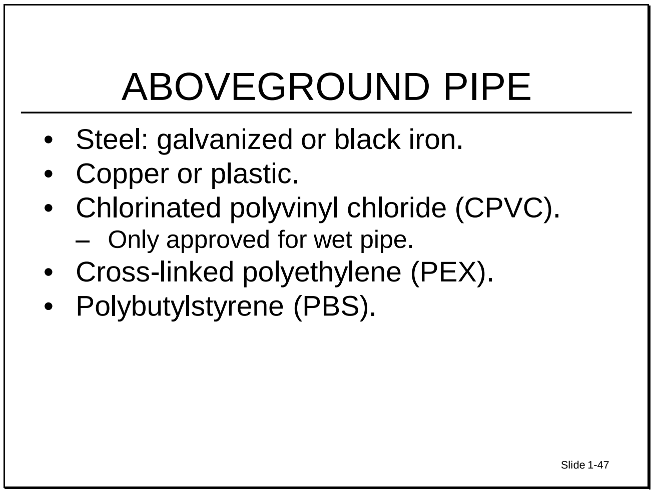
RISER LEGEND

NOTE: ALL ELECTRICAL ALARM WIRING OR WIRING OF ANY KIND TO BE BY OTHERS.

1. 6" UNDERGROUND TO BE FLUSHED & TESTED PRIOR TO CONNECTION
2. 2" CLEAR SPACE AROUND RISER
3. 4"x11" REDUCING FLANGE
4. FLEXIBLE COUPLING (TYPICAL)
5. 4" CAPPED TEE FOR FLUSHING
6. SUPPLY SIDE PRESSURE GAUGE
7. 4" DOUBLE CHECK BACKFLOW PREVENTER WITH TAMPERED BUTTERFLY VALVES
8. PIPE STAND
9. 4" CHECK VALVE
10. BALL DRIP
11. FIRE DEPARTMENT CONNECTION
12. 4" RISER MANIFOLD
13. WATERFLOW SWITCH
14. HYDRAULIC CALCULATIONS PLACARD
15. SYSTEM SIDE PRESSURE GAUGE
16. 1" BALL VALVE
17. SITE GLASS
18. 1/2" BALL VALVE
19. PRESSURE RELIEF VALVE
20. 1/2" STRAINER
21. 2" BALL VALVE
22. 2" MAIN DRAIN TO EXTERIOR
23. 2" MAIN DRAIN
24. SPLASH BLOCK
25. SPRINKLER HEAD CABINET WITH SPARE SPRINKLER HEADS AND WRENCH
26. SEISMIC BRACE PER NFPA 13
27. A/V UNIT (BY OTHERS)

Slide 1-46

4. Riser detail page F2 of 8.



C. Aboveground pipe.

1. Steel: galvanized or black iron pipe.

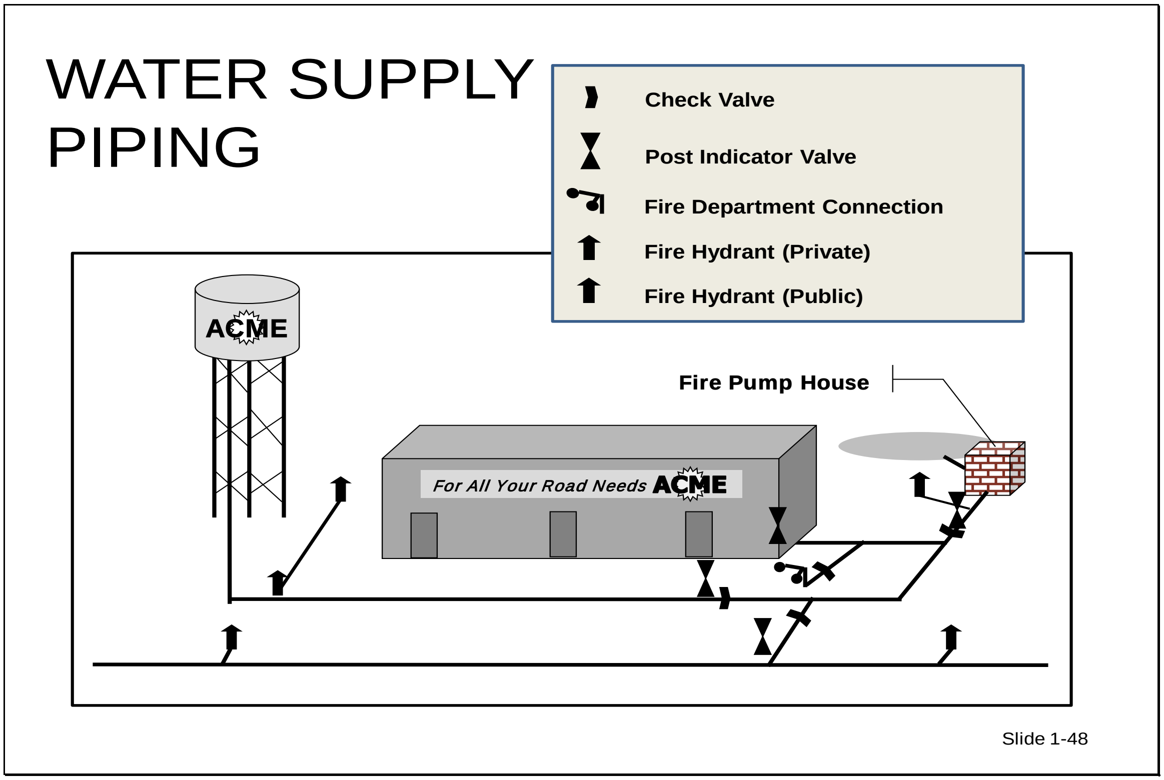
2. Copper or plastic.

3. Chlorinated polyvinyl chloride (CPVC).

   CPVC is only approved for wet pipe.

4. Cross-linked polyethylene (PEX).

5. Polybutylstyrene (PBS).



D. Water supply piping.

VALVES

- Each supply pipe or tube must be provided with an indicating type valve.
- Where indicating valves are installed, they should be:
  - In a cutoff valve room.
  - At least 40 feet from a building if they are post indicator valves, wall indicator valves, or key-operated valves.

Slide 1-49

E. Valves.

1. Each supply pipe or tube must be provided with an indicating type valve.

2. Where indicating valves are installed, they should be:

   a. In a cutoff valve room.

   b. At least 40 feet from a building if they are post indicator valves, wall indicator valves, or key-operated valves.

VALVES (cont'd)

- Valves shall be supervised.
- Check valves are required between each source of water supply.

Slide 1-50

3. Valves shall be supervised.

4. Check valves are required between each source of water supply.

OTHER PLAN COMPONENTS

- Fittings should be a tee or 90 degree elbow.
- Hydraulic demand area — identified with dotted or dashed line.
- Water supply test information.
- Sprinklers to be used on the project.

Slide 1-51

F. Other plan components.

1. Fittings should be a tee or 90 degree elbow.
2. Hydraulic demand area is identified with dotted or dashed line.
3. Water supply test information.
4. Sprinklers to be used on the project.

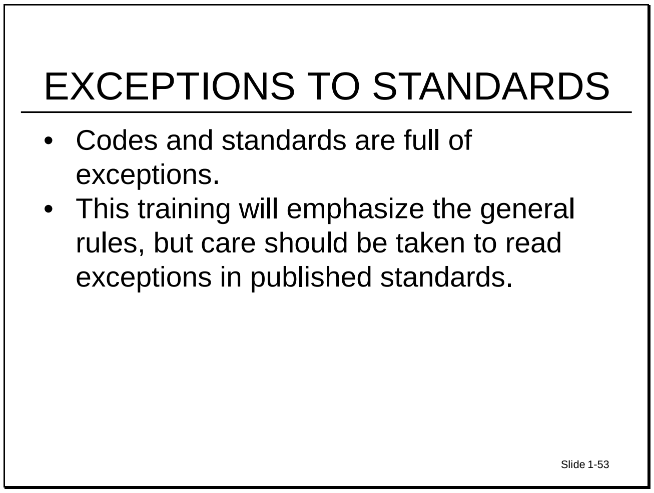
OTHER PLAN COMPONENTS (cont'd)

- Cross-contamination protection device.
- Scale.
- Number and type of sprinklers.
- Draftsperson's name or initials.
- Revisions.

Slide 1-52

5. Cross-contamination protection device.
6. Scale.
7. Number and type of sprinklers.
8. Draftsperson's name or initials.
9. Revisions.

VI. EXCEPTIONS TO STANDARDS



A. Codes and standards are full of exceptions to accommodate circumstances the code writers may not have been able to foresee.

B. This training will emphasize the general rules, and students should take care to read the exceptions in the published design and installation standards.

VII. SELECTING DESIGN AND INSTALLATION STANDARDS

A. It is very important to select the correct standard.

B. Standards to be studied and used in this course are:

1. NFPA 13, *Standard for the Installation of Sprinkler Systems* (2010).

2. NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes* (2013).

3. NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies* (2013).

SELECTING DESIGN AND INSTALLATION STANDARDS (cont'd)

- NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*.
- NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*.
- NFPA 22, *Standard for Water Tanks for Private Fire Protection*.
- NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*.

Slide 1-55

4. NFPA 14, *Standard for the Installation of Standpipe and Hose Systems* (2010).

5. NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection* (2013).

6. NFPA 22, *Standard for Water Tanks for Private Fire Protection* (2008).

7. NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances* (2013).

VIII. STORAGE OCCUPANCY HAZARDS

STORAGE OCCUPANCY HAZARDS

- Highly specialized, covered in NFPA 13.
- Not covered in this course. For information on NFPA 13 training, contact:
  - NFPA.
  - American Fire Sprinkler Association (AFSA).
  - National Fire Sprinkler Association (NFSA).
  - FM Global.
  - Property insurance companies.

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A. Storage occupancies are a highly specialized field of fire protection covered in NFPA 13.

B. They are outside the scope of this course. Persons interested in obtaining additional training and education in storage occupancy fire protection should contact:

1. NFPA.

2. American Fire Sprinkler Association (AFSA).

3. National Fire Sprinkler Association (NFSA).

4. FM Global.

5. Property insurance companies that specialize in storage occupancies.

IX. NATIONAL FIRE PROTECTION ASSOCIATION STANDARDS APPLICABLE TO THIS COURSE

A. NFPA 13, *Standard for the Installation of Sprinkler Systems*.

Scope: “Minimum requirements for design and installation of automatic sprinkler systems and exposure protection sprinkler systems covered within this standard” (NFPA 13, 2010, p. 13-13).

NFPA STANDARDS APPLICABLE TO THIS COURSE (cont'd)

- NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*.
  - Scope: "Design and installation of automatic sprinkler systems for protection against fire hazards in residential occupancies up to and including four stories in height."

Slide 1-58

B. NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*.

1. Scope: "Design and installation of automatic sprinkler systems for protection against fire hazards in residential occupancies up to and including four stories in height" (NFPA 13R, 2013, p. 13R-6).

NFPA STANDARDS APPLICABLE TO THIS COURSE (cont'd)

- NFPA 13R does not define "stories." That is up to the local building code.

Slide 1-59

2. NFPA 13R does not define "stories." That is up to the local building code.

NFPA STANDARDS APPLICABLE TO THIS COURSE (cont'd)

- NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*.
  - Scope: "Design and installation of automatic sprinkler systems for protection against fire hazards in one- and two-family dwellings and manufactured homes."

Slide 1-60

C. NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*.

Scope: "Design and installation of automatic sprinkler systems for protection against fire hazards in one- and two-family dwellings and manufactured homes" (NFPA 13D, 2013, p. 13D-6).

NFPA STANDARDS APPLICABLE TO THIS COURSE (cont'd)

- NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*.
  - Scope: "The minimum requirements for the installation of standpipes and hose systems."

Slide 1-61

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

Scope: "The minimum requirements for the installation of standpipes and hose systems" (NFPA 14, 2010, p. 14-4).

NFPA STANDARDS APPLICABLE TO THIS COURSE (cont'd)

- NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*.
  - Scope: "The selection and installation of pumps supplying liquid for private fire protection … operation." (Please reference text for topics included in this standard.)

Slide 1-62

E. NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*.

Scope: "The selection and installation of pumps supplying liquid for private fire protection and this document shall include liquid supplies; suction, discharge, and auxiliary equipment; power supplies, including power supply arrangements; electric drive and control; diesel engine drive and control; steam turbine drive and control; and acceptance tests and operation" (NFPA 20, 2013, p. 20-6).

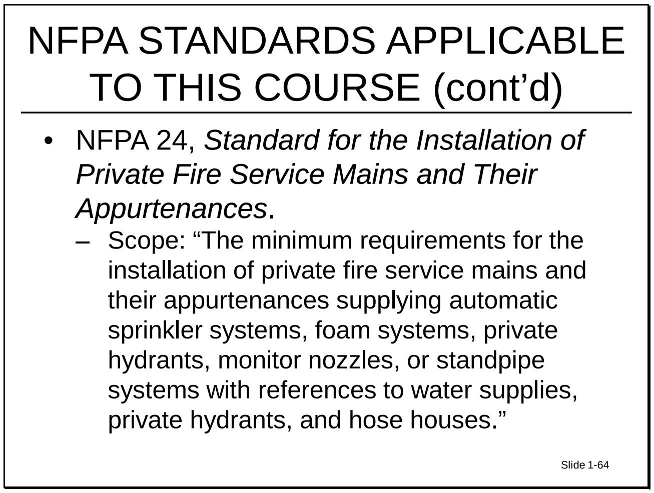
NFPA STANDARDS APPLICABLE TO THIS COURSE (cont'd)

- NFPA 22, *Standard for Water Tanks for Private Fire Protection*.
  - Scope: "The minimum requirements for the design, construction, installation and maintenance of tanks and accessory equipment that supply water for fire protection."

Slide 1-63

F. NFPA 22, *Standard for Water Tanks for Private Fire Protection*.

Scope: "The minimum requirements for the design, construction, installation and maintenance of tanks and accessory equipment that supply water for fire protection" (NFPA 22, 2008, p. 22-5).



G. NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*.

Scope: "The minimum requirements for the installation of private fire service mains and their appurtenances supplying automatic sprinkler systems, foam systems, private hydrants, monitor nozzles or standpipe systems with references to water supplies, private hydrants, and hose houses" (NFPA 24, 2013, p. 24-5).

ACTIVITY 1.2

Selecting Standards

Purpose

To select the appropriate design and installation standards for fire protection systems.

Directions

1. You will be reviewing a series of slides depicting different occupancies or fire protection system installations.

2. You will select from the list of standards on the slides the appropriate design and installation standards for fire protection systems for each application.

3. Mark the selections on your SAW.

4. Be prepared to discuss your responses in class.

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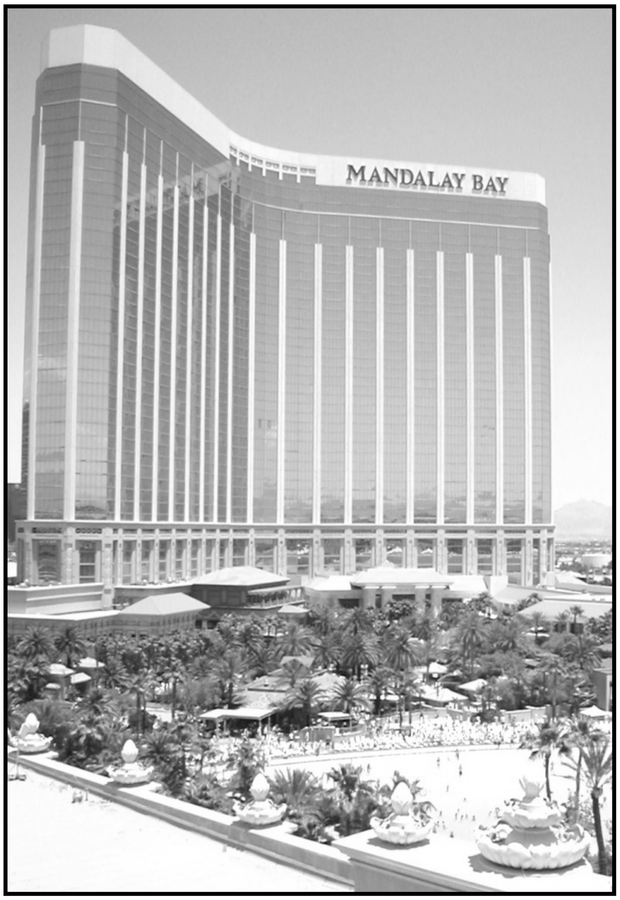
ACTIVITY 1.2 (cont'd)

Selecting Standards

Place a check mark next to the standard(s) that would apply to the situation that is illustrated.

1. High-rise hotel.



- ☐ NFPA 13, *Standard for the Installation of Sprinkler Systems*.
- ☐ NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*.
- ☐ NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*.
- ☐ NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*.

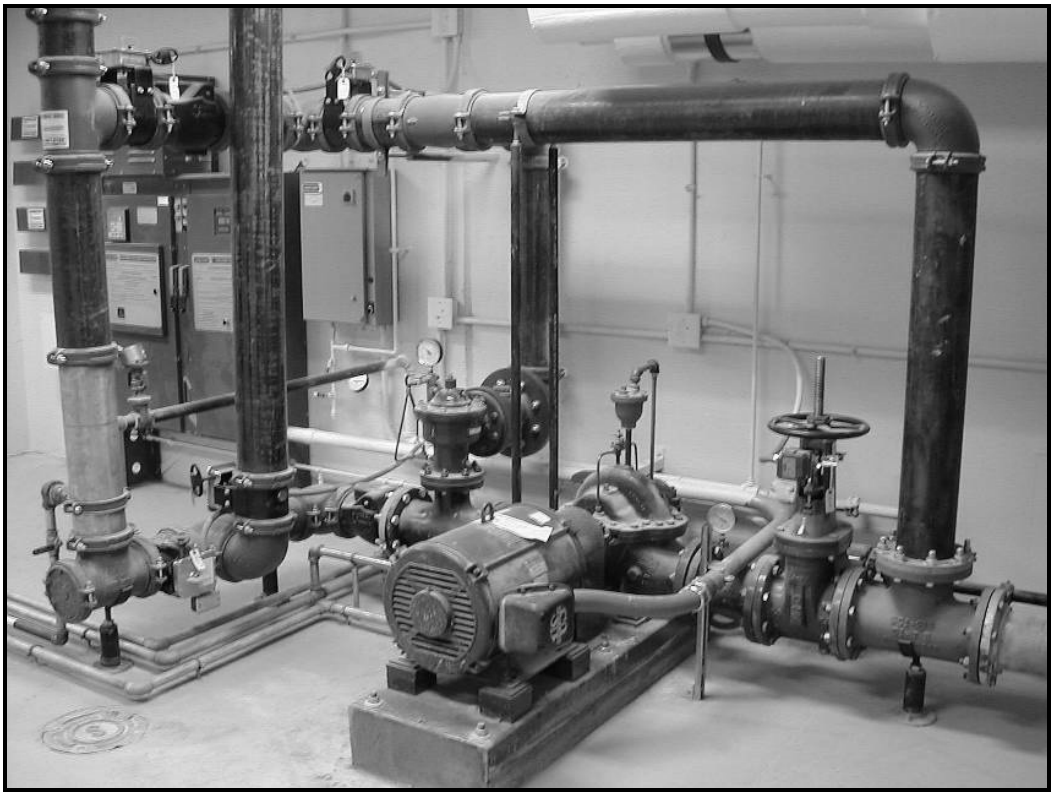
2. Single-family dwelling.

- ☐ NFPA 13, *Standard for the Installation of Sprinkler Systems*.
- ☐ NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*.
- ☐ NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*.
- ☐ NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*.

3. Private underground water main.

- ☐ NFPA 22, *Standard for Water Tanks for Private Fire Protection*.
- ☐ NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*.
- ☐ NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*.
- ☐ NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*.

4. Fire pump assembly in high-rise office.



- ☐ NFPA 22, *Standard for Water Tanks for Private Fire Protection*.
- ☐ NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*.
- ☐ NFPA 13, *Standard for the Installation of Sprinkler Systems*.
- ☐ NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*.

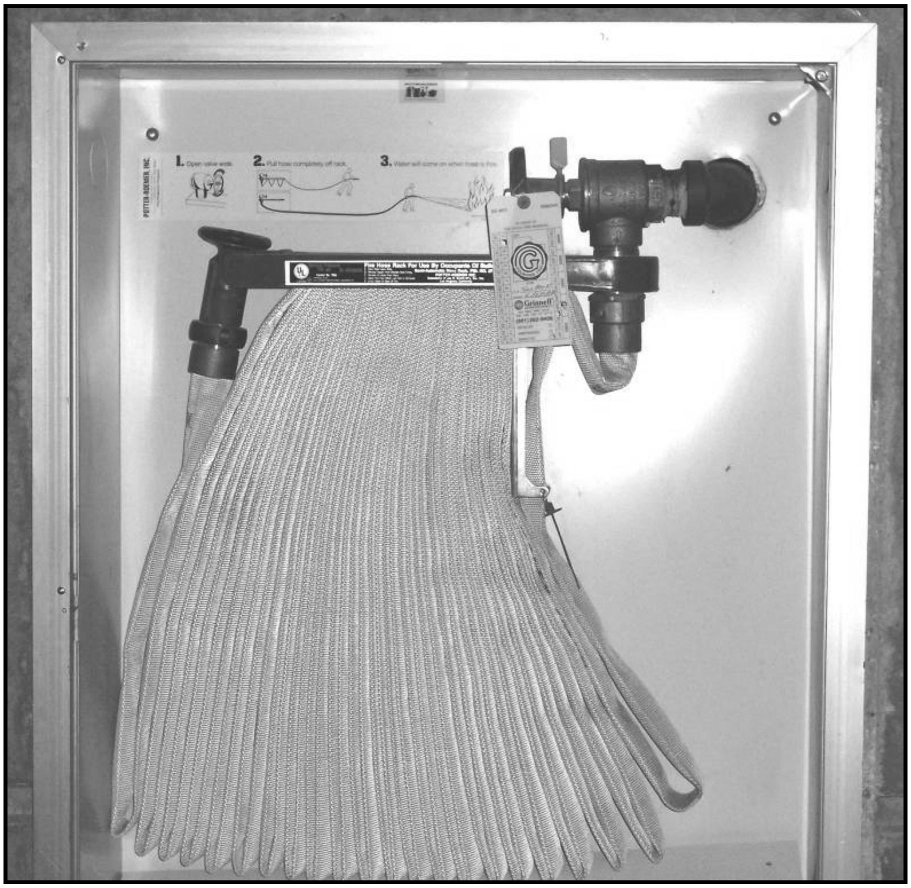
5. Flammable liquid dispensing room.

- ☐ NFPA 13, *Standard for the Installation of Sprinkler Systems*.
- ☐ NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*.
- ☐ NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*.
- ☐ NFPA 30, *Flammable and Combustible Liquids Code*.

6. Mixed occupancy midrise.

- ☐ NFPA 13, *Standard for the Installation of Sprinkler Systems*.
- ☐ NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*.
- ☐ NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*.
- ☐ NFPA 22, *Standard for Water Tanks for Private Fire Protection*.

7. Class 2 standpipe hose station.



- ☐ NFPA 13, *Standard for the Installation of Sprinkler Systems*.
- ☐ NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*.
- ☐ NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*.
- ☐ NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*.

8. Private water tank and hydrant system at covered shopping mall.

- ☐ NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*.
- ☐ NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*.
- ☐ NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*.
- ☐ NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*.

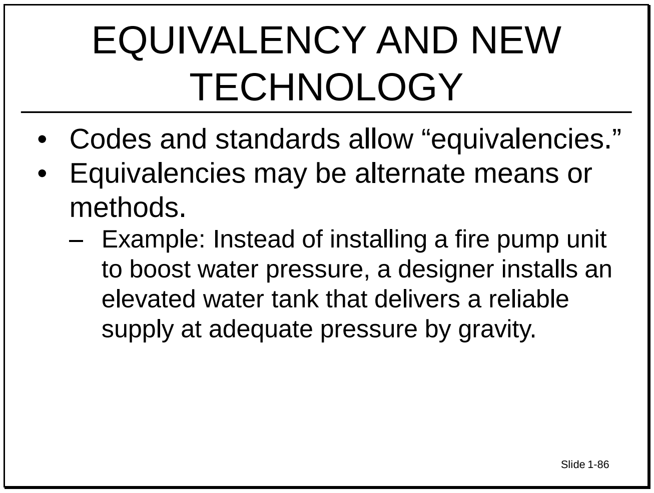
9. Open parking garage (unsprinklered).

- ☐ NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*.
- ☐ NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*.
- ☐ NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*.
- ☐ NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*.

10. Church.

- ☐ NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*.
- ☐ NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*.
- ☐ NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*.
- ☐ NFPA 13, *Standard for the Installation of Sprinkler Systems*.

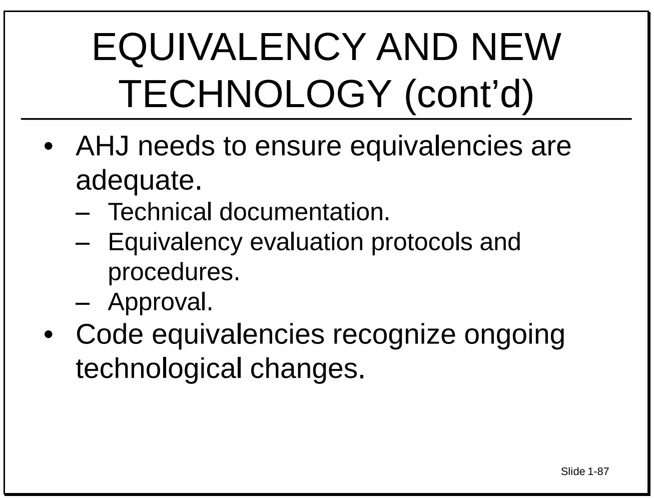
X. EQUIVALENCY AND NEW TECHNOLOGY



A. Codes and standards allow "equivalencies" to fire protection systems.

B. Equivalencies may be alternate means or methods that are "equivalent to or of superior quality, strength, fire resistance, effectiveness, durability and safety" over those specified in a standard.

Example: Instead of installing a fire pump unit to boost water pressure, a designer might choose to install an elevated water tank that delivers a reliable supply at adequate pressure by gravity.

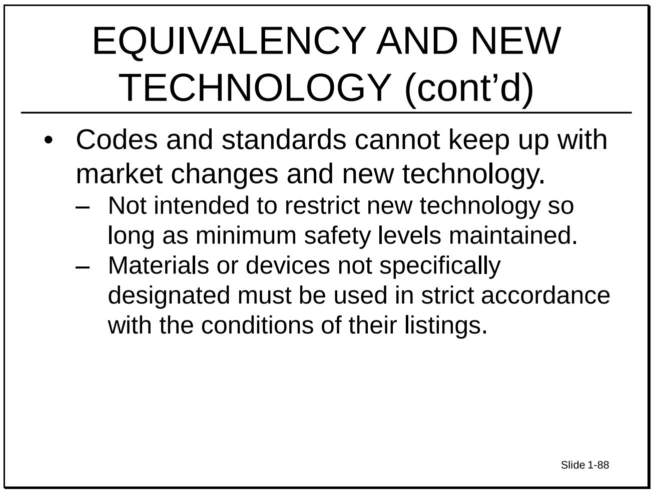


C. AHJ needs to ensure equivalencies are adequate.

1. The AHJ or code official should insist on getting technical documentation that shows the proposed alternative is equivalent.

2. The AHJ or code official should develop a protocol or procedure on how to evaluate the proposed equivalency. (See "Performance-based Design" in the next section.)

3. The proposed equivalency may be approved by the AHJ or code official for its intended purpose.



D. Development of codes and standards cannot keep up with market changes and new technology.

1. Nothing written in codes and standards is intended to restrict new technology or alternate arrangements, as long as minimum safety levels are not reduced.

2. Materials or devices not specifically designated in the codes or standards must be used in strict accordance with the conditions of their listings.

   Example: In some applications, NFPA 13 restricts the area of coverage of a single sprinkler to 400 square feet. If a product developer can get a sprinkler listed for 600 square feet of coverage, the AHJ or code official may approve it if used in strict accordance with the conditions of its listing.

XI. PERFORMANCED-BASED DESIGN

PERFORMANCE-BASED DESIGN

- Most codes and standards are "prescriptive."
- A new approach is "performance-based."
- Uses "design objectives."
  - Developed by a qualified engineer.
  - Alternate materials or methods.
  - Requires AHJ approval.
  - Documentation important.

Slide 1-89

A. Most codes and standards in force today and the resulting designs are "prescriptive." That is, they prescribe exactly what must be done to achieve compliance.

B. In recent decades, European and South Pacific countries have explored "performance-based" designs and codes. They are gaining favor in the U.S. for some special circumstances.

C. Performance-based design uses "design objectives" rather than prescriptive rules.

   Example: Where the prescriptive NFPA 14 requires Class 1 standpipe hose outlets at every floor level, a performance-based design may simply require "an adequate number of Class 1 hose outlets so all portions of the occupancy can be reached by 100 feet of hose."

   1. "Design objectives" usually are developed by a qualified engineer working with the owner and AHJ or code official.

   2. The design objectives may involve alternate materials or methods.

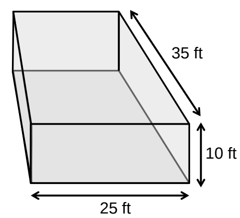
   3. The design objectives must be approved by the AHJ. The objectives are unique to that building project or fire protection system, and each must be evaluated on its own merits.

   4. Proper documentation is very important.

XII. BASIC HYDRAULIC CALCULATIONS

BASIC HYDRAULIC CALCULATIONS

- Volume of a reservoir:
  - Length x width x depth.
    - Example: The size of the reservoir is 35 feet by 25 feet and is 10 feet deep.
  - Multiply by 7.48 to convert cubic feet to gallons.



35 x 25 x 10 = 8,750 Cubic Feet

8,750 Cubic Feet x 7.48 = 65,450 gallons

Slide 1-90

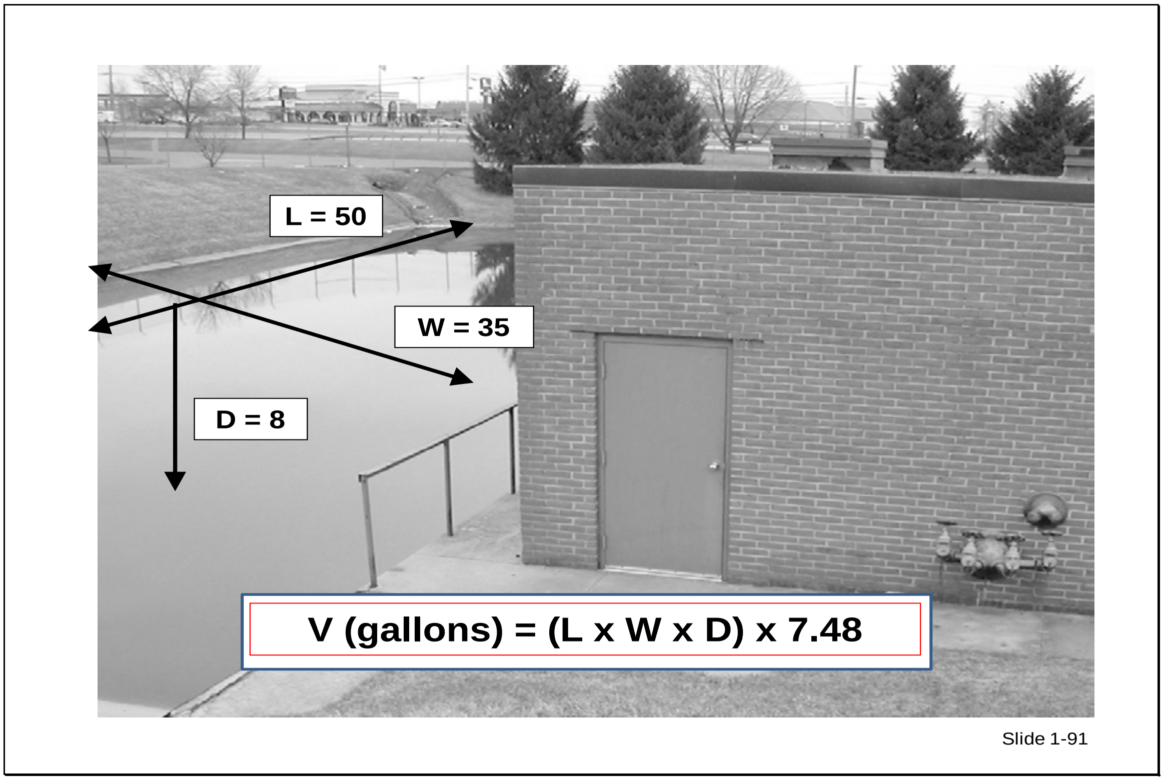
A. Calculating volume of a reservoir.

1. Length x width x depth.

   Example: The size of the reservoir is 35 feet by 25 feet and is 10 feet deep.

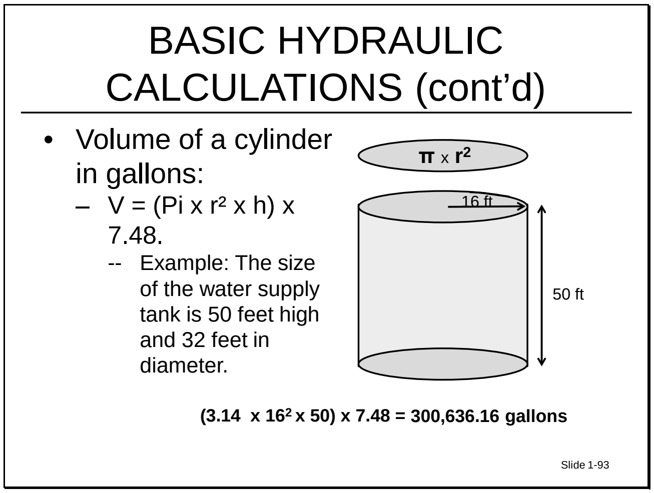
2. Multiply by 7.48 to convert cubic feet to gallons.

   Solution: V (gallons) = (35 x 25 x 10) x 7.48 = 65,450 gallons.



B. Sample reservoir problem.

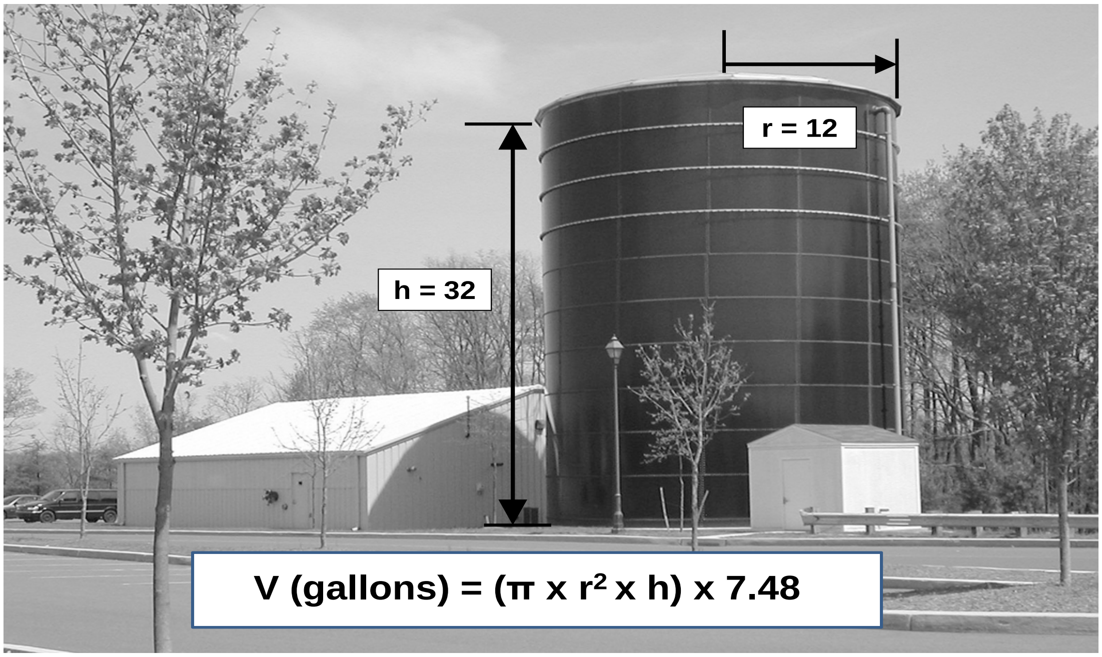
L = 50, W = 35, D = 8.



C. Calculating volume of a cylinder in gallons.

1. V = (Pi x r^2 x h) x 7.48.

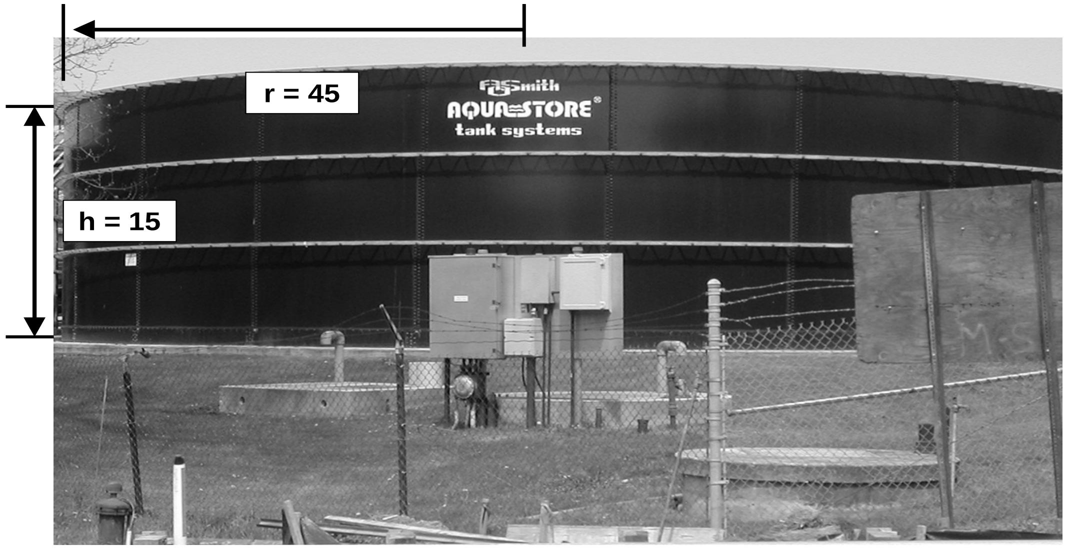
2. Example: The size of the water supply tank is 50 feet high and 32 feet in diameter. (Radius is half the diameter.)



Slide 1-94

D. Sample cylinder tank problem.

H = 32 feet, r = 12 feet.



V (gallons) = (π x r² x h) x 7.48

$$V\ (\text{gallons}) = (\pi \times r^2 \times h) \times 7.48$$

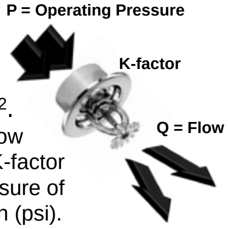
Slide 1-96

E. Second sample cylinder tank problem.

H = 15 feet, r = 45 feet.

BASIC HYDRAULIC CALCULATIONS (cont'd)

- Pressure and flow.
  - $Q = K \times \sqrt{P}$.
- Solve for each variable.
  - $K = Q \times \sqrt{P}$ and $P = (Q/K)^2$.
    - Example: Determine the flow from a sprinkler having a K-factor of 5.6 at an operating pressure of 7.0 pounds per square inch (psi).
    - $Q = K \sqrt{P}$ so $Q = (5.6)(\sqrt{7}) = 14.8$ gpm.



Slide 1-98

F. Basic hydraulic calculations.

1. Pressure and flow.

   $Q = K \times \sqrt{P}$.

2. Solve for each variable: $K = Q \times \sqrt{P}$ and $P = (Q/K)^2$.

3. Example: Determine the flow from a sprinkler having a K-factor of 5.6 at an operating pressure of 7.0 pounds per square inch (psi).

BASIC HYDRAULIC CALCULATIONS (cont'd)

- Pressure loss from friction.
  - FL = coefficient x distance.
  - Example: Determine the friction loss from flow through a pipe having a coefficient of friction of 0.03 psi/foot over a distance of 12 feet.

Slide 1-99

G. Calculating pressure loss from friction.

1. FL = coefficient x distance.

2. Example: Determine the friction loss from flow through a pipe having a coefficient of friction of 0.03 psi/foot over a distance of 12 feet.

BASIC HYDRAULIC CALCULATIONS (cont'd)

- Pressure difference from elevation.
  - FL = 0.433 psi/foot x distance.
  - Example: Determine the pressure difference from elevation in a pipe with an elevation change of 12 feet.

Slide 1-100

H. Calculating pressure difference from elevation.

1. FL = 0.433 x distance.

2. Example: Determine the pressure distance from elevation in a pipe with an elevation change of 12 feet.

BASIC HYDRAULIC CALCULATIONS (cont'd)

- Design area coverage.
  - Area = length x width.
  - Total water flow demand = density x area.
  - Example: Determine the total water flow demand for a remote area having dimensions of 50 feet by 35 feet with a design density of 0.15 gallons per minute (gpm)/square foot.

Slide 1-101

I. Calculating design area coverage.

1. Area = length x width.

2. Total water flow demand = density x area.

3. Example: Determine the total water flow demand for a remote area having dimensions of 50 feet by 35 feet with a design density of 0.15 gpm/square foot.

J. Hydraulic calculation example.

Ordinary hazard.

1. Hypothetical hydraulic remote area is determined to need 12 sprinklers.

2. The calculations show that each sprinkler will flow 22.6 gpm.

3. The flow requirement for sprinklers in the remote area is **approximately** 271.2 gpm (12 x 22.6).

4. The total remote area demand will be somewhat higher because the system will need additional flow to fill the riser, feed main, cross main, and branch lines that go to the remote area.

5. For this example, the hypothetical additional amount might be 64.3 gpm. The total hypothetical sprinkler system demand is 335.5 gpm (271.2 + 64.3 = 335.5).

HYDRAULIC CALCULATIONS EXAMPLE (cont'd)

- Example of a hydraulic calculation.
  - Need to know the fire sprinkler flow for remote area: 459 gallons.
  - Need to know duration: 60 minutes.
- Solution.
  - Flow (459 gallons) x duration (60 minutes) = water supply.

Slide 1-104

6. Example of a hydraulic calculation.

   a. Need to know fire sprinkler flow for remote area: 459 gpm.

   b. Need to know duration: 60 minutes.

7. Solution.

   a. Flow (459 gallons) x duration (60 minutes) = water supply.

   b. Water supply = 27,540 gallons.

HYDRAULIC CALCULATIONS EXAMPLE (cont'd)

- Example of a fire protection system calculation.
  - Fire sprinkler demand plus hose demand.
  - Pipe schedule.
    - Sprinkler (850) + hose demand (250) x duration (60).
    - (850 + 250) x 60 = fire protection system supply.

Slide 1-105

K. Example of a fire protection system calculation.

1. Fire sprinkler demand plus hose demand.

2. Pipe schedule.

a. Sprinkler (850) + hose demand (250) x duration (60).

b. (850 + 250) x 60 = fire protection system supply.

c. 66,000 gallons.

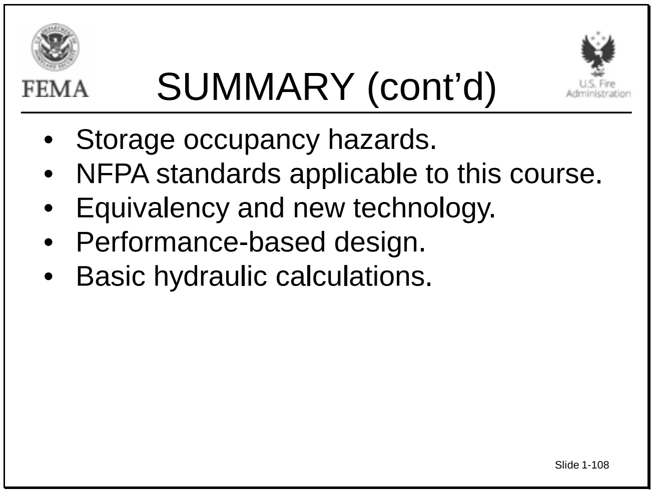
3. Hydraulic.

a. Sprinkler (459) + hose demand (250) x duration (60).

b. (459 + 250) x 60.

c. 42,540 gallons.

XIII. SUMMARY


FEMA
SUMMARY (cont'd)
U.S. Fire Administration
• Storage occupancy hazards.
• NFPA standards applicable to this course.
• Equivalency and new technology.
• Performance-based design.
• Basic hydraulic calculations.
Slide 1-108

UNIT 2: SYSTEM DESIGN

TERMINAL OBJECTIVE

The students will be able to:

2.1 Given a set of national standards, fire protection system plans, and occupancy identification, verify that the selected fire protection system design is matched to the occupancy classification and provides appropriate levels of protection in accordance with recognized water-based fire protection standards and equipment listings and limitations due to types of construction and other physical obstructions.

ENABLING OBJECTIVES

The students will be able to:

2.1 Given the hazard class of a specific occupancy, verify that the intended water-based fire protection system provides the appropriate levels of protection.

2.2 Given a set of plans, relate actual occupancy uses with standard classification terminology.

2.3 Given the intended use of a specific area of occupancy, verify that the extent of the water-based fire protection system is intended for installation in all areas of the hazard as required.

2.4 Given the intended construction types and arrangements, verify that the design of the water-based fire protection system provides adequate coverage for all areas as required.

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FEMA

U.S. Fire Administration

UNIT 2:
SYSTEM DESIGN

Slide 2-1

TERMINAL OBJECTIVE

Given a set of national standards, fire protection system plans, and occupancy identification, verify that the selected fire protection system design is matched to the occupancy classification and provides appropriate levels of protection in accordance with recognized water-based fire protection standards and equipment listings and limitations due to types of construction and other physical obstructions.

Slide 2-2

ENABLING OBJECTIVES

- Given the hazard class of a specific occupancy, verify that the intended water-based fire protection system provides the appropriate levels of protection.
- Given a set of plans, relate actual occupancy uses with standard classification terminology.

Slide 2-3

ENABLING OBJECTIVES (cont'd)

- Given the intended use of a specific area of occupancy, verify that the extent of the water-based fire protection system is intended for installation in all areas of the hazard as required.

Slide 2-4

ENABLING OBJECTIVES (cont'd)

- Given the intended construction types and arrangements, verify that the design of the water-based fire protection system provides adequate coverage for all areas as required.

Slide 2-5

I. HAZARD CLASSIFICATIONS

HAZARD CLASSES

- NFPA 13, *Standard for the Installation of Sprinkler Systems*, assigns fire risks to various hazard classes.
- Primarily content-based.
  - Hazard class selection established requirements for water supply.
    - -- Water supply.
    - -- Volume and duration.
    - -- Sprinkler selection.
    - -- Sprinkler spacing.
    - -- Pipe sizes.

Slide 2-6

A. Hazard classes.

1. For the purposes of selecting design and installation criteria for predominantly nonresidential structures, National Fire Protection Association (NFPA) 13, *Standard for the Installation of Sprinkler Systems*, assigns fire risks to various hazard classes.

2. Hazard classes are primarily content-based (fire dynamics and fuel geometry), and they are the foundation for proper application of the design standard.

   a. Hazard class selection established requirements for water supply.

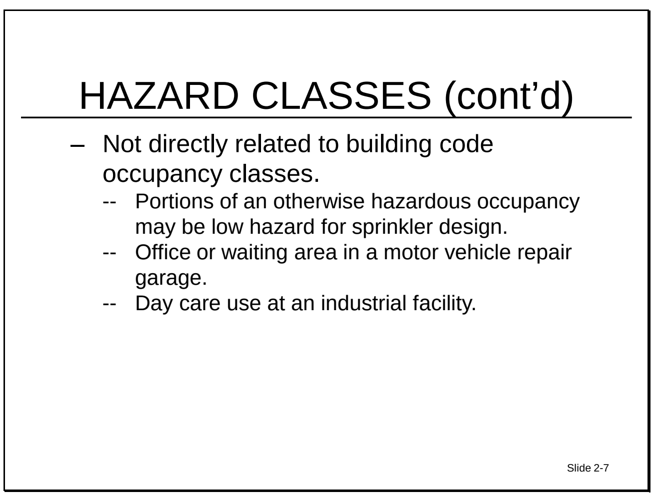
      - Water supply.

      - Volume and duration.

      - Sprinkler selection.

      - Sprinkler spacing.

      - Pipe sizes.

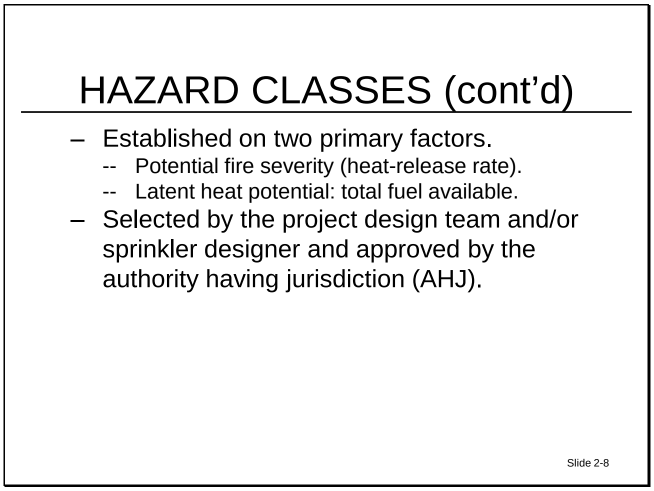


   b. Hazard classes are not directly related to building code occupancy classes.

      - Portions of an otherwise hazardous occupancy may be low hazard for sprinkler design.

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

      - Day care use at an industrial facility.

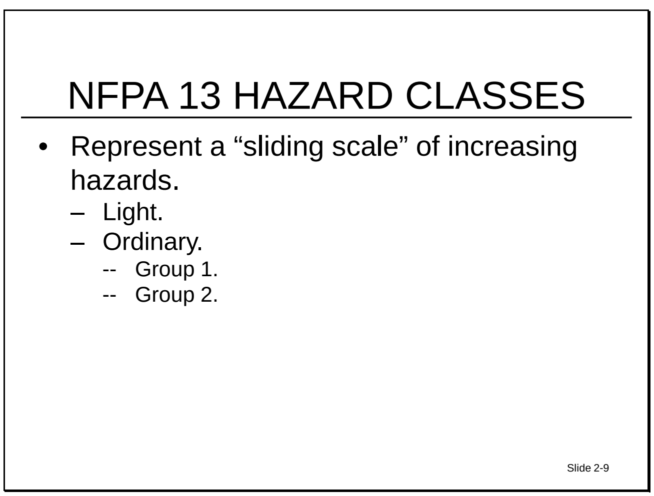


c. Hazard classes are established on two primary factors:

- Potential fire severity (heat-release rate).

- Latent heat potential: the amount of total fuel available for consumption.

d. Hazard class is selected by the project design team and/or sprinkler designer and approved by the authority having jurisdiction (AHJ).



B. NFPA 13 hazard classes.

1. These hazard classes represent a "sliding scale" of increasing hazard; there is no absolute or clearly defined break between any two classes.

a. Light.

b. Ordinary.

- Group 1.

- Group 2.

  -- Ordinary Hazard Group 3 no longer exists; merged into Ordinary Hazard Group 2 in 1991.

  -- Some existing systems and records may appear as Ordinary Hazard Group 3.

NFPA 13 HAZARD CLASSES (cont'd)

– Extra.
  -- Group 1.
  -- Group 2.
– Special occupancy hazard classifications.
  -- NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*.
  -- NFPA 59, *Utility LP-Gas Plant Code*.
  -- NFPA 99/99B, *Health Care Facilities Code/ Standard for Hypobaric Facilities*.
  -- NFPA 150, *Standard on Fire and Life Safety in Animal Housing Facilities*.

Slide 2-10

c. Extra.

- Group 1.

- Group 2.

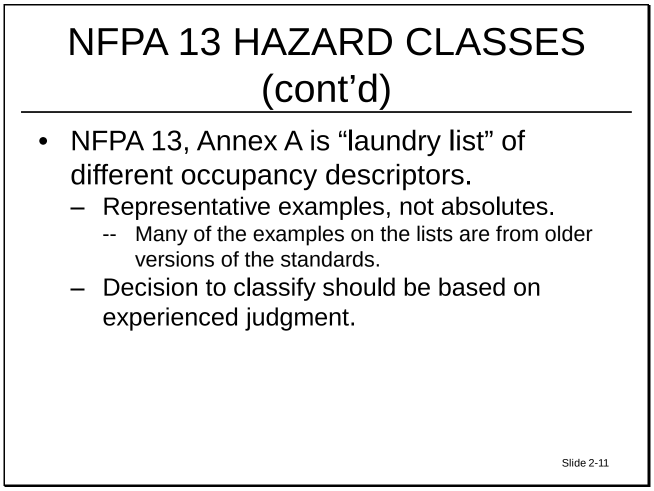
d. Special occupancy hazard classifications.

- NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*.

- NFPA 59, *Utility LP-Gas Plant Code*.

- NFPA 99/99B, *Health Care Facilities Code/Standard for Hypobaric Facilities*.

- NFPA 150, *Standard on Fire and Life Safety in Animal Housing Facilities*.



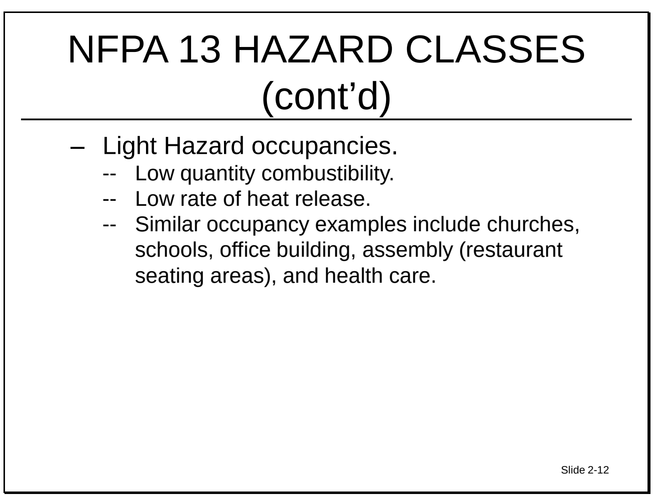
2. NFPA 13, Annex A, provides a "laundry list" of different occupancy descriptors.

a. These lists are provided as representative examples, not absolutes.

- Many of the examples on the lists are from older versions of the standards.

-- For example, "bottling plants" now use large quantities of combustible plastics rather than noncombustible glass containers.

b. The decision to classify an occupancy into a certain hazard class should be based on experienced judgment.



c. Light Hazard occupancies.

- Content's quantity and combustibility is low.

- Low rates of heat release are expected.

- Similar occupancy examples include churches, schools, office building, assembly (restaurant seating areas), and health care.

NFPA 13 HAZARD CLASSES (cont'd)

– Ordinary Hazard Group 1 occupancies.
  - -- Low to moderate amount of combustibles.
  - -- Moderate rates of heat release.
  - -- Storage less than 8 feet high.
  - -- Includes automobile parking and showrooms, beverage manufacturing, laundries, and restaurant service areas.

Slide 2-13

d. Ordinary Hazard Group 1 occupancies.

- Low to moderate amount of combustibles.

- Moderate rates of heat release.

- Storage less than 8 feet high.

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

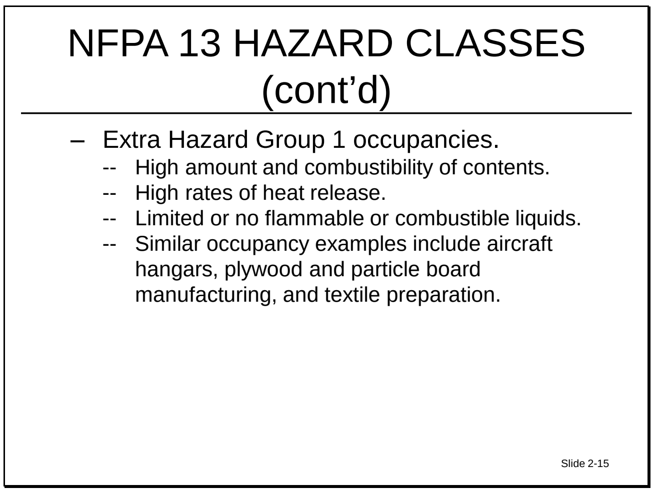
NFPA 13 HAZARD CLASSES (cont'd)

– Ordinary Hazard Group 2 occupancies.
  - -- Moderate combustible load.
  - -- Moderate rates of heat release.
  - -- Storage less than 12 feet high.
  - -- Includes dry cleaners, mercantile, printing and publishing, wood products, and machining and assembly.

Slide 2-14

e. Ordinary Hazard Group 2 occupancies.

- Moderate combustible load.
- Moderate rates of heat release.
- Storage less than 12 feet high.
- Includes dry cleaners, mercantile, printing and publishing, wood products, and machining and assembly.



f. Extra Hazard Group 1 occupancies.

- High amount and combustibility of contents.
- High rates of heat release.
- Limited or no flammable or combustible liquids.
- Similar occupancy examples include aircraft hangars, plywood and particle board manufacturing, and textile preparation.

g. Extra Hazard Group 2 occupancies.

- High rates of heat release.
- High amount and combustibility of contents.
- Moderate to substantial flammable or combustible liquids.
- Similar occupancy examples include flammable liquid spraying, flow coating, plastics processing, open dipping operations, and combustible shielding.

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ACTIVITY 2.1

Sprinkler Hazard Classifications

Purpose

Given an occupancy description, you will determine the appropriateness of the selected sprinkler system hazard class.

Directions

1. You will be shown a series of pictures of different occupancies.

2. You are the AHJ, and you have been asked to make a ruling on the hazard classification for a sprinkler system designer.

3. You may research NFPA 13, the Activity 2.1 table, or make the ruling based on what you see in the pictures. You might not find the specific occupancy listed in NFPA 13 and will then have to make a ruling on your best judgment.

4. Once you have determined the occupancy hazard class that you think is most suitable, provide a brief justification for your answers.

5. Be prepared to discuss your responses.

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ACTIVITY 2.1 (cont'd)

Sprinkler Hazard Classifications

Occupancy examples in the listings, as shown in the various hazard classifications, are intended to represent the norm for those occupancy types. Unusual or abnormal fuel loadings or combustible characteristics and susceptibility for changes in these characteristics for a particular occupancy are considerations that should be weighed in the selection and classification.

Light Hazard	Light Hazard occupancies shall be defined as occupancies or portions of other occupancies where the quantity and/or combustibility of contents are low. Fires with relatively low rates of heat release are expected.
	Animal shelters, churches, clubs, eaves and overhangs (of combustible construction with no combustibles beneath), educational, hospitals (including animal hospitals and veterinary facilities), institutional, kennels, libraries (except large stack rooms), museums, nursing or convalescent homes, offices (including data processing), residential, restaurant seating areas, theaters and auditoriums (excluding stages and prosceniums), unused attics.
Ordinary Hazard Group 1	Ordinary Hazard Group 1 occupancies shall be defined as occupancies or portions of other occupancies where combustibility is low; quantity of combustibles is moderate; stockpiles of combustibles do not exceed 8 feet (2.4 meters (m)); and fires with moderate rates of heat release are expected.
	Automobile parking and showrooms, bakeries, beverage manufacturing, canneries, dairy products manufacturing and processing, electronic plants, glass and glass products manufacturing, laundries, restaurant service areas.
Ordinary Hazard Group 2	Ordinary Hazard Group 2 occupancies shall be defined as occupancies or portions of other occupancies where the quantity and combustibility of contents is moderate to high; where stockpiles of contents with moderate rates of heat release do not exceed 12 feet (3.66 m); and stockpiles of contents with high rates of heat release do not exceed 8 feet (2.4 m).

Ordinary Hazard Group 2 (cont'd)	Agricultural facilities, barns and stables, cereal mills, chemical plants – ordinary, confectionary products, distilleries, dry cleaners, exterior loading docks, feed mills, horse stables, leather goods manufacturing, libraries (large stock room areas), machine shops, metal working, mercantile, paper and pulp mills, paper process plants, piers and wharves, post offices, printing and publishing, racetrack stable/kennel areas, repair garages, resin application areas, stages, textile manufacturing, tire manufacturing, tobacco products manufacturing, wood machining, wood product assembly.
Extra Hazard Group 1	Extra Hazard Group 1 occupancies shall be defined as occupancies or portions of other occupancies where the quantity and combustibility of contents are very high and dust, lint or other materials are present, introducing the probability of rapidly developing fires with high rates of heat release but with little or no combustible or flammable liquids.
	Aircraft hangars, combustible hydraulic fluid use areas, die casting, metal extruding, plywood and particle board manufacturing, printing (using inks having flash points below 100 F (38 C)), rubber (reclaiming, compounding, drying, milling, vulcanizing), saw mills, textile (picking, opening, blending, garnetting or carding), combining of cotton, synthetics, wool shoddy, or burlap, upholstering with plastic foams.
Extra Hazard Group 2	Extra Hazard Group 2 occupancies shall be defined as occupancies or portions of other occupancies with moderate to substantial amounts of flammable or combustible liquids or occupancies where shielding of combustibles is extensive.
	Asphalt saturating, flammable liquids spraying, flow coating, manufactured home or modular building assemblies (where finished enclosure is present and has combustible interiors), open oil quenching, plastics processing, solvent cleaning, varnish and paint dipping.

(NFPA 13, 2010, p. 13-25)

ACTIVITY 2.1 (cont'd)

Sprinkler Hazard Classifications

1. Restaurant seating area.

   a. NFPA 13 hazard classification.

   ____

   ____

   ____

   b. Justification.

   ____

   ____

   ____

2. Retail sales.

   a. NFPA 13 hazard classification.

   ____

   ____

   ____

   b. Justification.

   ____

   ____

   ____

3. Medical office storage.

   a. NFPA 13 hazard classification.

   ____

   ____

   ____

   b. Justification.

   ____

   ____

   ____

4. Hotel lobby.

   a. NFPA 13 hazard classification.

   ___

   ___

   ___

   b. Justification.

   ___

   ___

   ___

5. Nursing home boiler room.

   a. NFPA 13 hazard classification.

   ____

   ____

   ____

   b. Justification.

   ____

   ____

   ____

6. Retail sales exterior canopy.

   a. NFPA 13 hazard classification.

   ____

   ____

   ____

   b. Justification.

   ____

   ____

   ____

II. CONSTRUCTION INFLUENCES

A. Factors in building design and construction that influence system installation.

Influences.

1. Combustible.

2. Noncombustible.

3. Limited combustible.

4. Obstructed construction.

5. Unobstructed construction.

B. Combustible or limited combustible.

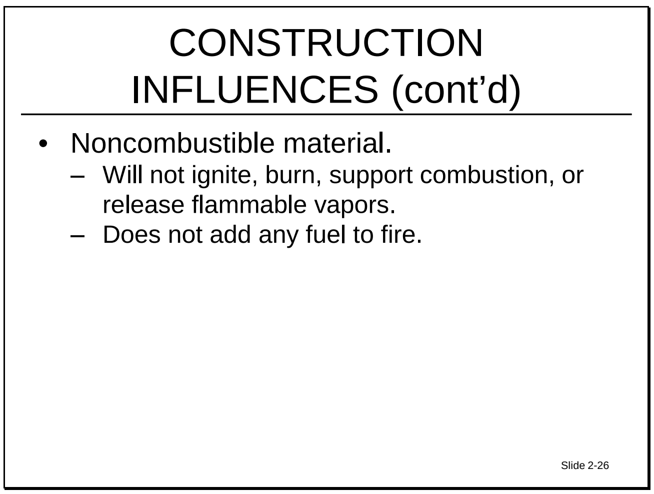
1. Structural elements will add fuel to fire.

2. Limited combustible.

   a. Potential heat value less than 3,500 British thermal unit (Btu)/ pound (lb.).

   b. Noncombustible structural base with less than one-eighth-inch surface material with flame spread less than 50 (gypsum wallboard).

   c. Materials having flame spread less than 25 or ones that show no progressive combustion (insulation materials).



C. Noncombustible material.

1. Will not ignite, burn, support combustion, or release flammable vapors.

2. Does not add any fuel to fire.

ACTIVITY 2.2

Building Construction

Purpose

Given PowerPoint descriptions of building construction, you will determine the appropriateness of the selected sprinkler system hazard class.

Directions

You will view the slides and as a large group identify the type(s) of construction of each.

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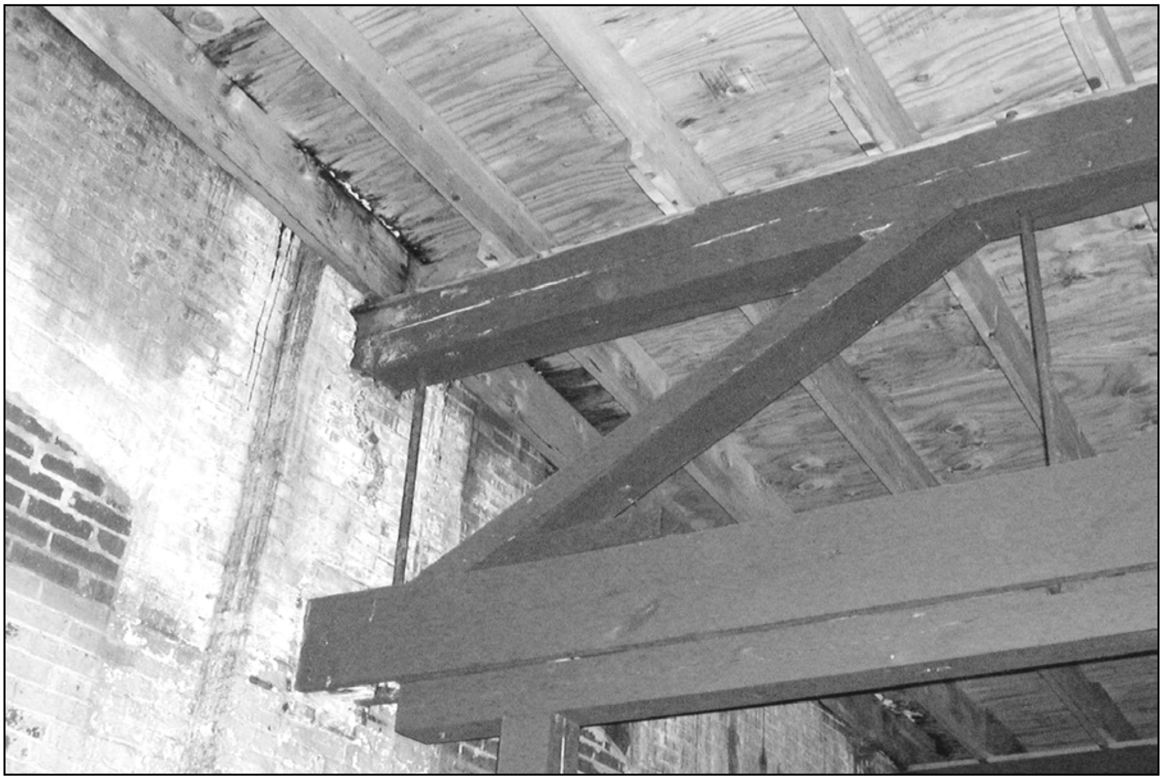
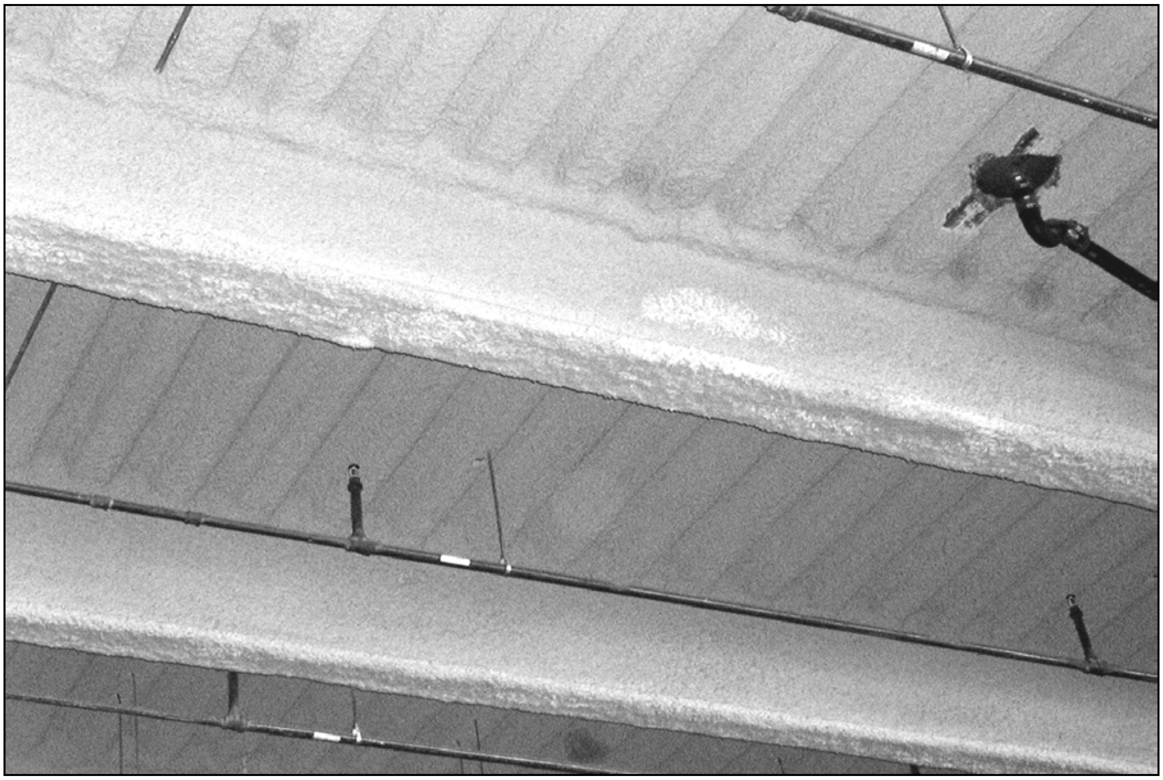
ACTIVITY 2.2 (cont'd)

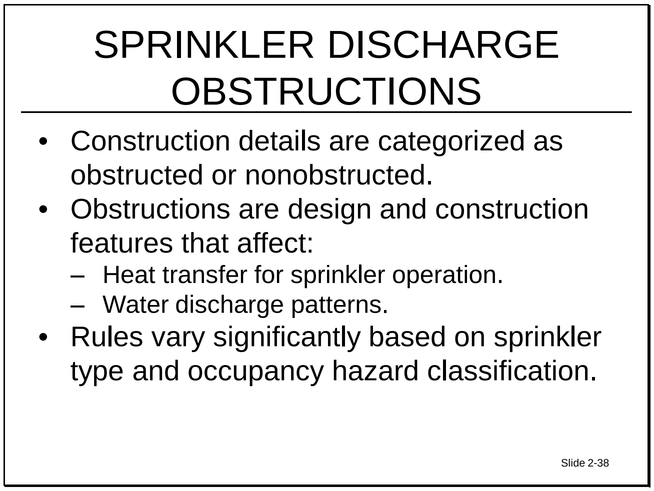
Building Construction




RETAIL COMING
SOON
NORTHWEST
BUSINESS BANK



III. SPRINKLER DISCHARGE OBSTRUCTIONS



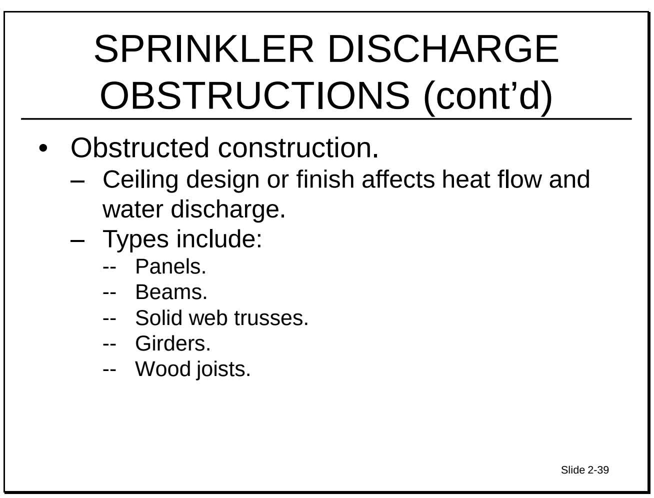
A. Construction details are categorized as obstructed or nonobstructed.

B. Obstructions are design and construction features that affect:

1. Heat transfer for sprinkler operation.

2. Water discharge patterns.

C. Rules vary significantly based on sprinkler type and occupancy hazard classification.



D. Obstructed construction.

1. Ceiling design or finish affects heat flow and water discharge.

2. Types include:

    a. Panels.

    b. Beams.

    c. Solid web trusses.

    d. Girders.

    e. Wood joists.

SPRINKLER DISCHARGE OBSTRUCTIONS (cont'd)

- Unobstructed construction.
  - Ceiling design and finish does not interfere with heat transfer time or sprinkler discharge.
  - Types include:
    - -- Smooth ceiling.
    - -- Open bar joists (limitation per NFPA 13).
    - -- Open grid ceilings.
    - -- Open wood trusses (limitation per NFPA 13).

Slide 2-40

E. Unobstructed construction.

1. Ceiling design and finish does not interfere with heat transfer time or sprinkler discharge.

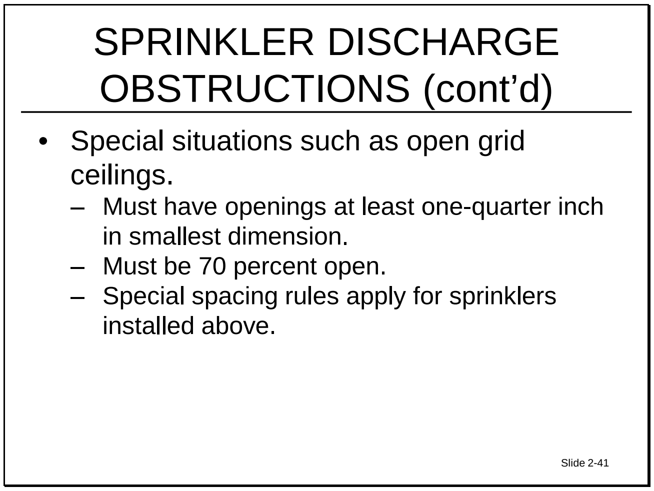
2. Types include:

    a. Smooth ceiling.

    b. Open bar joists (limitation per NFPA 13).

    c. Open grid ceilings.

    d. Open wood trusses (limitation per NFPA 13).

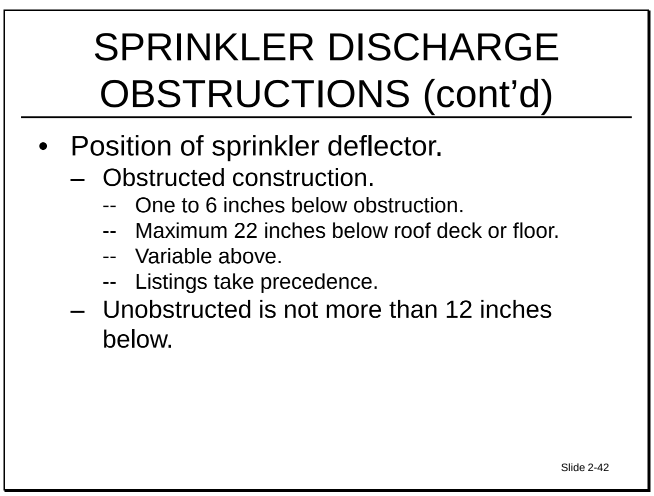


F. Special situations such as open grid ceilings.

1. Must have openings at least one-quarter inch in smallest dimension.

2. Must be 70 percent open.

3. Special spacing rules apply for sprinklers installed above.



G. Position of sprinkler deflector.

1. Obstructed construction.

a. One to 6 inches below obstruction.

b. Maximum 22 inches below roof deck or floor above.

c. Variable above.

d. Listings take precedence.

2. Unobstructed is not more than 12 inches below.

SPRINKLER DISCHARGE OBSTRUCTIONS (cont'd)

– Continuous obstructions.
  - -- Permanent construction interrupts heat flow and water discharge.
  - -- Continuous means no breaks.
  - -- Sprinkler moves away from obstruction and discharge pattern improves.
  - -- Maximum allowable distance of sprinkler deflector above bottom of obstructions is based on the sprinkler type.

Slide 2-43

3. Continuous obstructions.

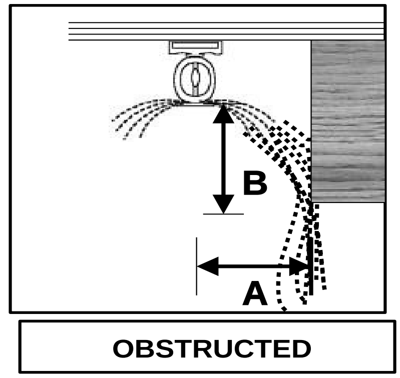
   a. Permanent construction interrupts heat flow and water discharge.

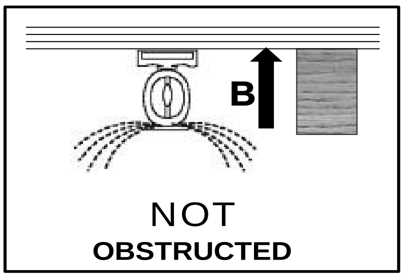
   b. Continuous means no breaks.

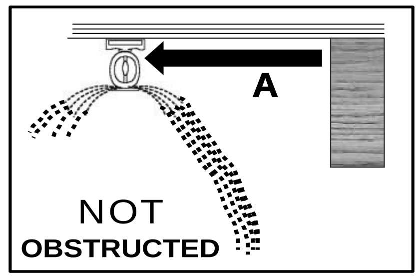
   c. Sprinkler moves away from obstruction and discharge pattern improves.

   d. Maximum allowable distance of sprinkler deflector above bottom of obstructions is based on sprinkler type.

C_L Sprinkler to Obstruction (A)	Deflector to Obstruction Bottom (B) (Maximum)
< 1 ft.	0 in.
1 ft. to < 1 ft. 6”	2 ½ - in.
1 ft. 6” to < 2 ft.	3 ½ - in.

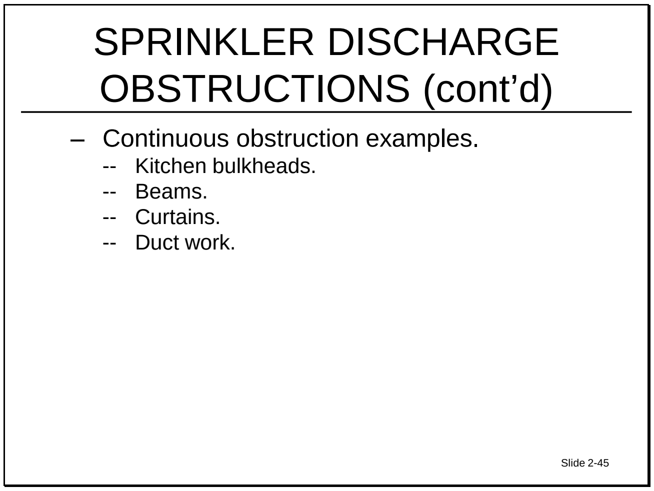






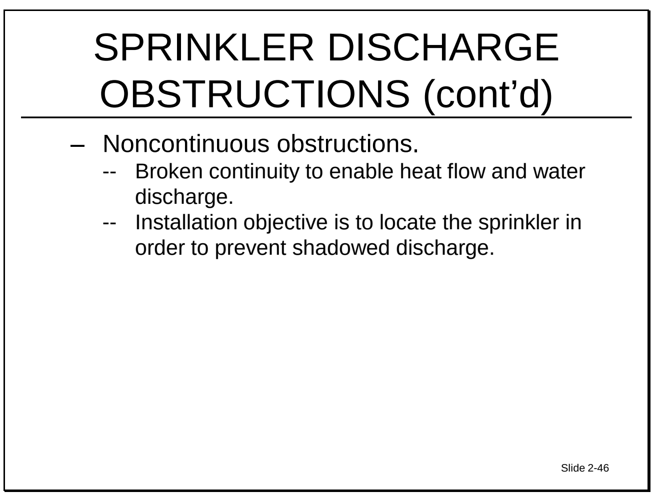
Slide 2-44

e. Relationship of distance of sprinkler to obstruction (A) and distance from deflector to obstruction bottom (B) on obstruction.



f. Continuous obstruction examples.

- Kitchen bulkheads.
- Beams.
- Curtains.
- Duct work.

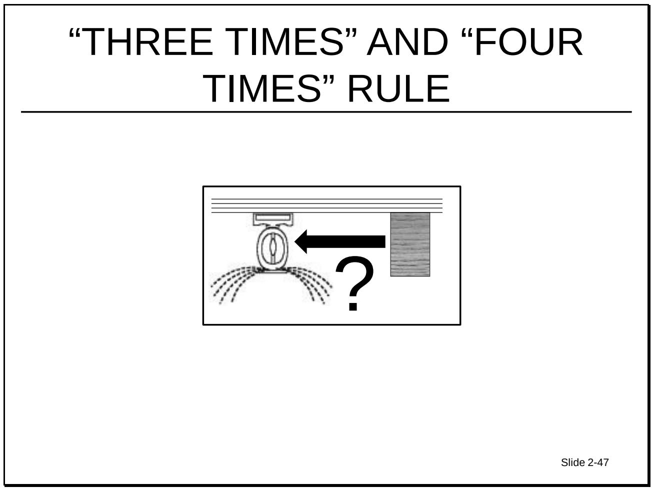


4. Noncontinuous obstructions.

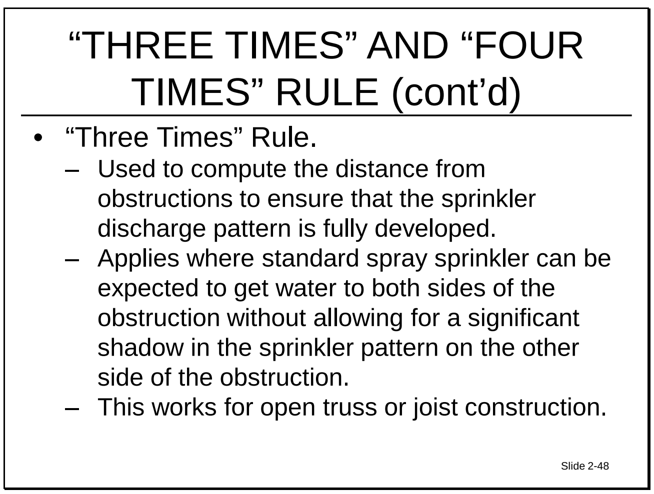
   a. Broken continuity to enable heat flow and water discharge.

      - Columns.
      - Pipe fixtures.

b. Installation objective is to locate sprinkler to prevent “shadowed” discharge.



H. “Three Times” and “Four Times” Rule.



1. “Three Times” Rule.

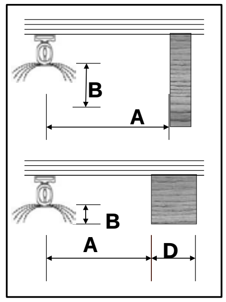
   a. Used to compute distance from obstructions to ensure that **sprinkler discharge pattern is fully developed**.

   b. Applies where standard spray sprinkler can be expected to get water to both sides of the obstruction without allowing for a significant shadow in the sprinkler pattern on the other side of the obstruction.

   c. This works for open truss or joist construction.

"THREE TIMES" AND "FOUR TIMES" RULE (cont'd)

- Applies to standard sprinklers.
- The distance away from the obstruction would be three times the obstruction (width or height — whichever is greater).



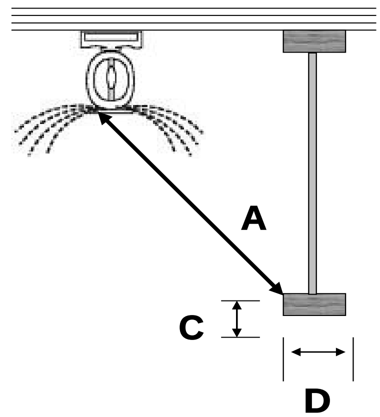
Slide 2-49

d. Applies to standard sprinklers.

e. The distance away from the obstruction would be three times the obstruction (width or height — whichever is greater).

"THREE TIMES" AND "FOUR TIMES" RULE (cont'd)

- Noncontinuous.
  - Open web trusses, pipes, light fixtures.
    - Use "Three Times" Rule to sprinkler centerline.
    - "A" $\geq$ 3"C" or 3"D".
  - Whichever is greater.
    - A = Maximum 24 inches.
    - If 24 inches or greater, no longer an "obstruction."

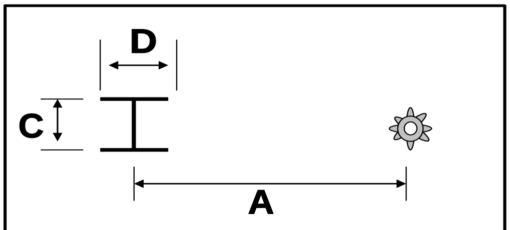


Elevation view of open web truss

Slide 2-50

"THREE TIMES" AND "FOUR TIMES" RULE (cont'd)

- Noncontinuous.
  - Columns.
    - -- Use "Three Times" Rule to sprinkler centerline.
    - -- "A" $\geq$ 3"C" or 3"D".
  - Whichever is greater.
    - -- A = Maximum 24 inches.
    - -- If 24 inches or greater, no longer an "obstruction."



Plan view of steel W-flange column

Slide 2-51

"THREE TIMES" AND "FOUR TIMES" RULE (cont'd)

- "Four Times" Rule.
  - Used for extended coverage sprinklers.
  - Applies to obstructions where the extended coverage sprinkler can be expected to get water to both sides of the obstruction without allowing for a significant shadow in the sprinkler pattern on the other side of the obstruction.
  - This works for open truss or joist construction.

Slide 2-52

2. "Four Times" Rule.

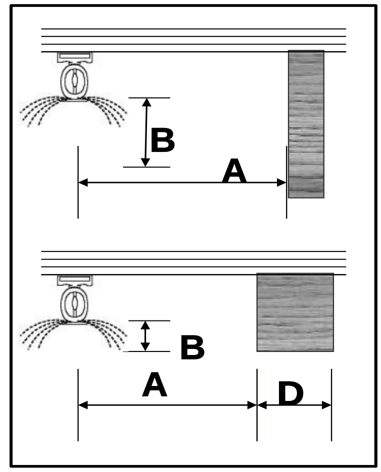
   a. Used for extended coverage sprinklers.

   b. Applies to obstructions where the extended coverage sprinkler can be expected to get water to both sides of the obstruction without allowing for a significant shadow in the sprinkler pattern on the other side of the obstruction.

   c. This works for open truss or joist construction.

“THREE TIMES” AND “FOUR TIMES” RULE (cont’d)

- Applies to extended coverage sprinklers.
- The distance away from the obstruction would be four times the obstruction (width or height — whichever is greater).
- The maximum clear distance is 36 inches.



Slide 2-53

d. Applies to extended coverage sprinklers.

e. The distance away from the obstruction would be four times the obstruction (width or height — whichever is greater).

f. The maximum clear distance is 36 inches.

OTHER OBSTRUCTION CONSIDERATIONS

- See NFPA 13, Chapter 8 for special considerations and requirements.
  - Sidewall standard spray sprinklers.
  - Sidewall extended coverage sprinklers.
  - Residential sprinklers.

Slide 2-54

I. Other obstruction considerations.

1. See NFPA 13, Chapter 8 for special considerations and requirements.

   a. Sidewall standard spray sprinklers.

   b. Sidewall extended coverage sprinklers.

   c. Residential sprinklers.

OTHER OBSTRUCTION CONSIDERATIONS (cont'd)

- Sprinklers must be installed beneath fixed obstructions more than 4 feet wide.
  - Ducts.
  - Decks.
  - Open grate flooring.
  - Cutting tables.
  - Overhead doors.

Slide 2-55

2. Sprinklers must be installed beneath fixed obstructions more than 4 feet wide.

   Examples:

   a. Ducts.

   b. Decks.

c. Open grate flooring.

d. Cutting tables.

e. Overhead doors.

ACTIVITY 2.3

Obstructed Construction

Purpose

Given PowerPoint descriptions of obstructed construction, you will determine why it is considered obstructed construction.

Directions

1. You will use NFPA 13, Chapter 8.

2. Working as a small group, you will view the examples and perform calculations to identify why it is considered obstructed construction.

3. Your answers will be reviewed as a large group.

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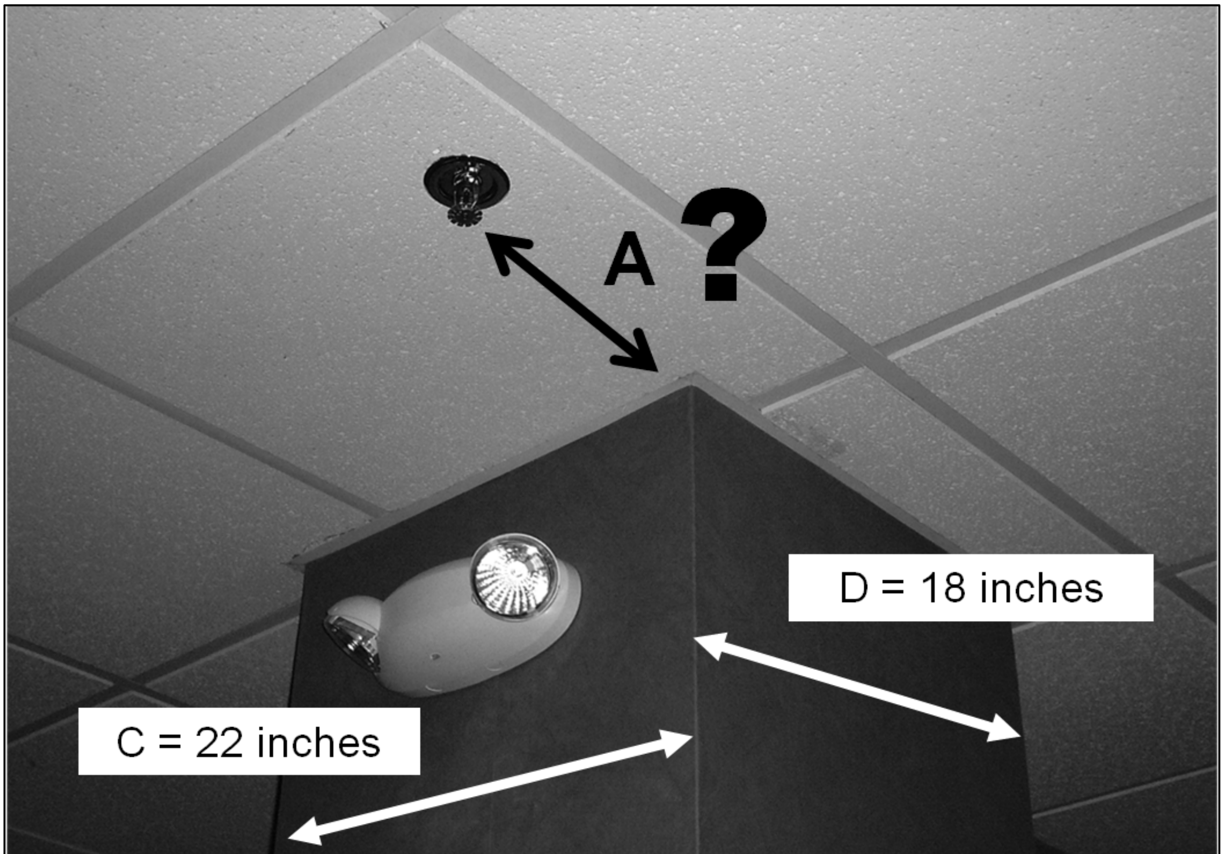
ACTIVITY 2.3 (cont'd)

Obstructed Construction

Example 1



What is the required minimum clearance (A) from this column obstruction? **Solve for A.**

___

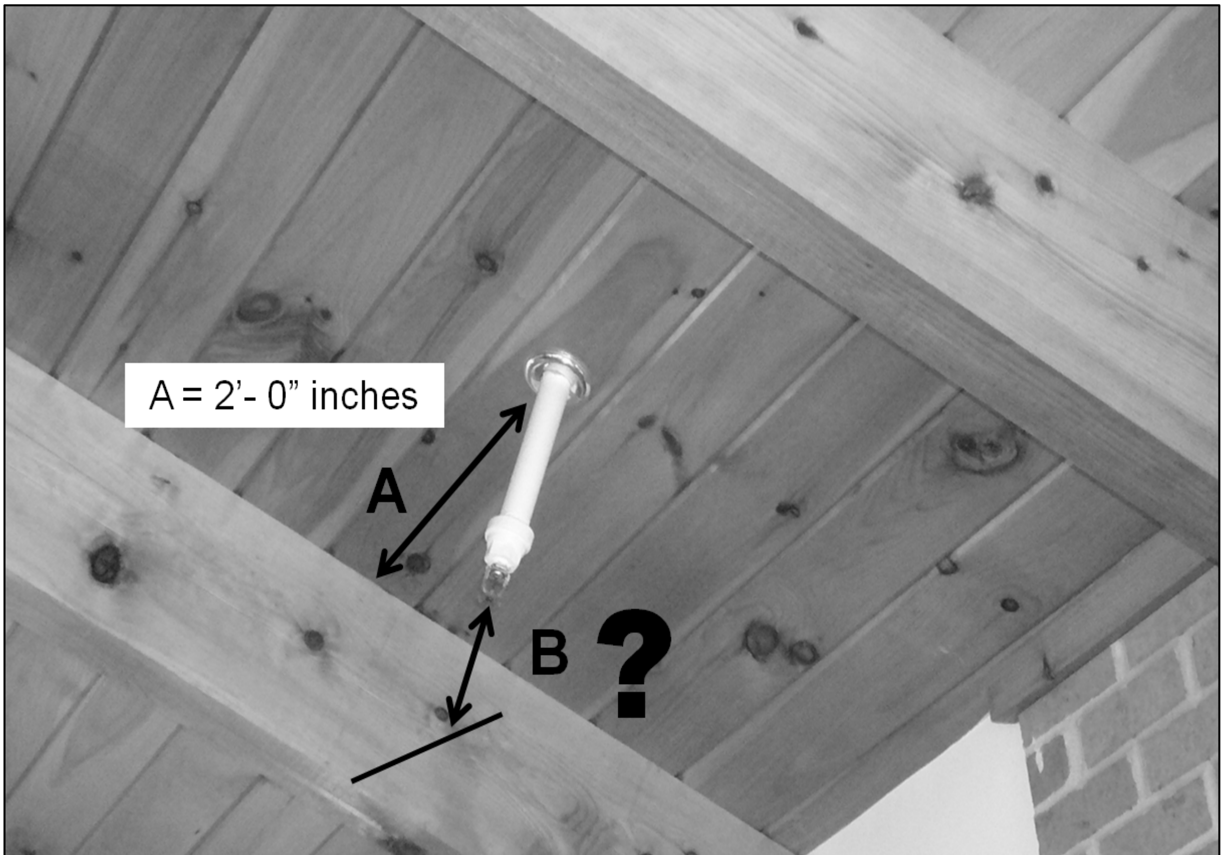
___

___

ACTIVITY 2.3 (cont'd)

Obstructed Construction

Example 2

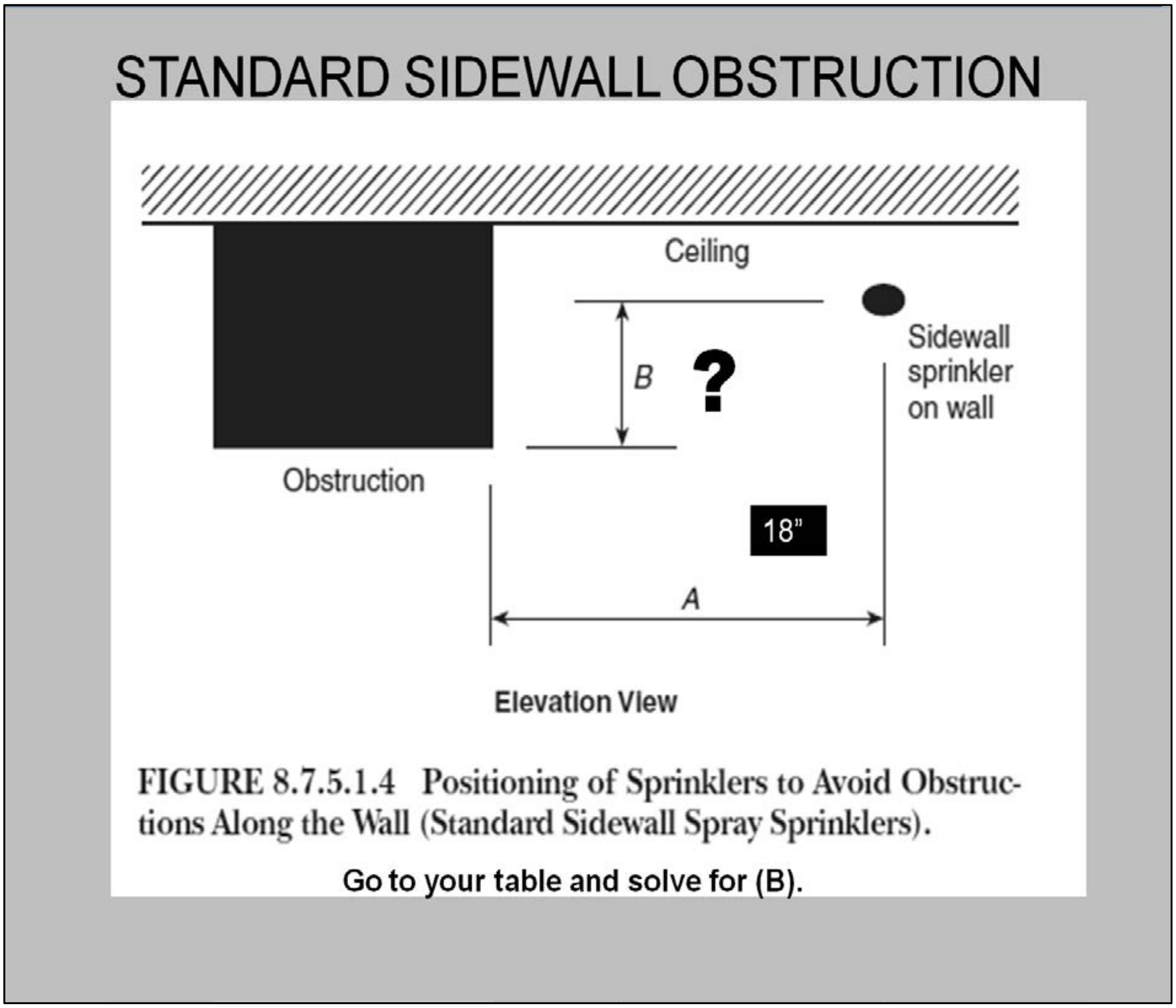


What is the maximum deflector distance (B) above the bottom of the beam? **Solve for B.**

ACTIVITY 2.3 (cont'd)

Obstructed Construction

Example 3



ACTIVITY 2.3 (cont'd)

Obstructed Construction

Example 4

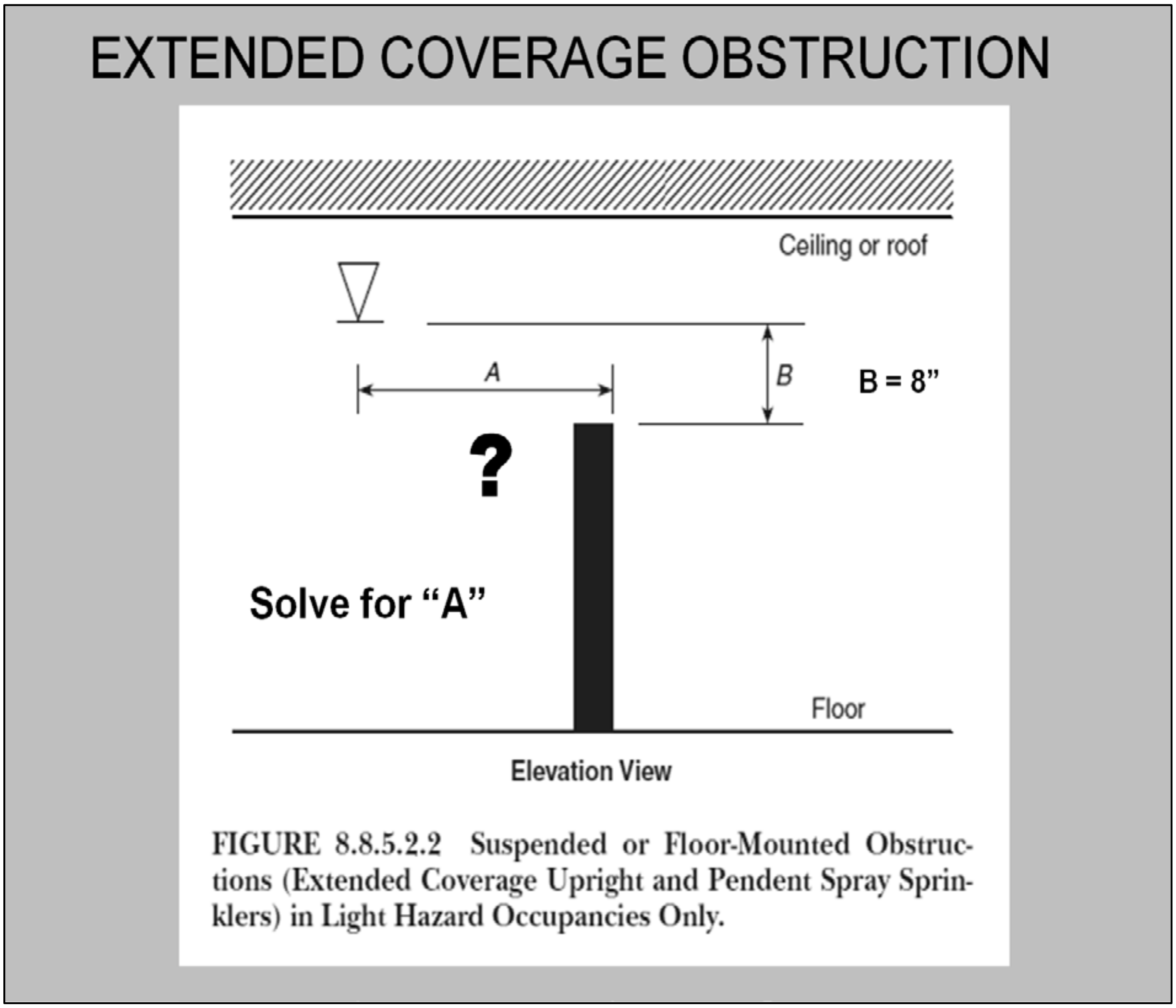


FIGURE 8.8.5.2.2 Suspended or Floor-Mounted Obstructions (Extended Coverage Upright and Pendent Spray Sprinklers) in Light Hazard Occupancies Only.

IV. SPECIAL SITUATIONS

SPECIAL SITUATIONS

- Service chutes (laundry, garbage, etc.).
  - Top.
  - Lowest service opening.
  - Alternate floors with combustible surfaces.
  - Terminal room.

Slide 2-62

A. Service chutes (laundry, garbage, etc.).

1. Top.

2. Lowest service opening.

3. Alternate floors with combustible surfaces.

4. Terminal room.

SPECIAL SITUATIONS (cont'd)

- Shafts.
  - One sprinkler at the top of shaft, except:
    - -- Noncombustible or limited combustible nonaccessible shaft.
    - -- Noncombustible or limited combustible mechanical or electrical shaft.
  - In combustible shafts, install at alternate floor levels.

Slide 2-63

B. Shafts.

1. One sprinkler at the top of shaft except:

a. Noncombustible or limited combustible nonaccessible shaft.

b. Noncombustible or limited combustible mechanical or electrical shaft.

2. In combustible shafts, install at alternate floor levels.

C. Stairs.

1. Beneath all combustible stairs.

2. Top of shaft and under first landing at bottom of shaft in noncombustible stairs.

D. Escalators, moving stairways, or similar openings.

1. Closely spaced sprinklers with draft curtains.

2. Exception for large openings found in shopping malls, atrium buildings and similar structures:

a. When fully equipped with sprinklers.

b. Opening less than 20 feet across in any dimension.

c. Not more than 1,000 square feet.

E. Fixed obstructions >4 feet wide.

1. Ducts.

2. Decks.

3. Open grate flooring.

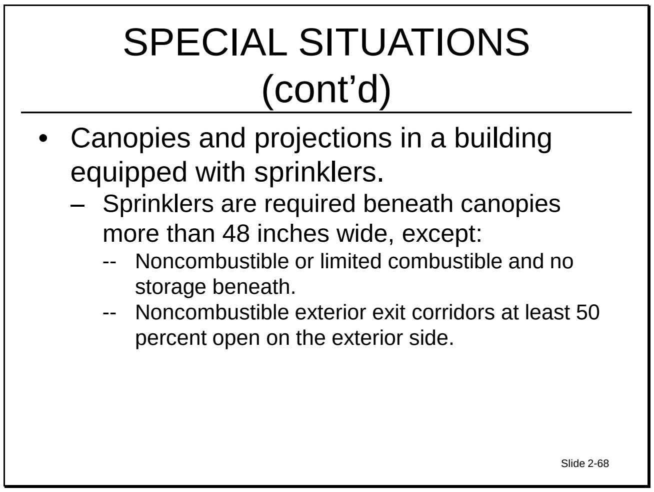
a. Intermediate rack.

b. Shielded.

F. Drop out ceilings.

1 Must be listed.

2. No sprinklers installed below drop out ceilings.

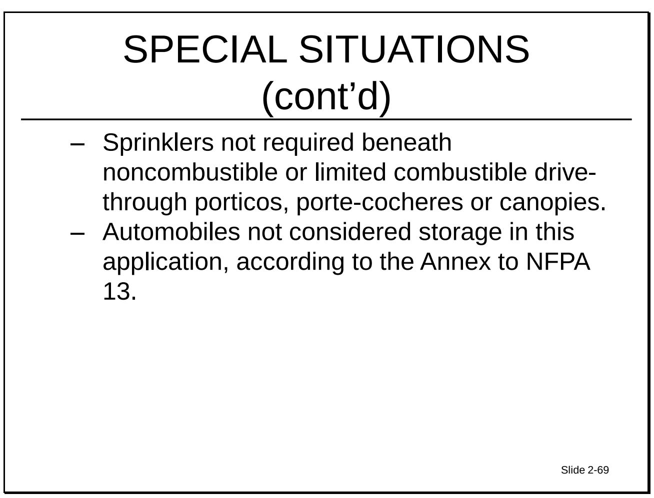


G. Canopies and projections in a building equipped with sprinklers.

1. Sprinklers required beneath canopies more than 48 inches wide except:

a. Noncombustible or limited combustible and no storage beneath.

b. Noncombustible exterior exit corridors at least 50 percent open on the exterior side.



2. Sprinklers not required beneath noncombustible or limited combustible drive-through porticos, porte-cocheres or canopies.

3. Automobiles are not considered **storage** in this application according to the Annex to NFPA 13.

H. Concealed spaces.

1. Generally, NFPA 13 requires sprinklers in concealed combustible spaces.

2. Refer to NFPA 13.

I. Compartments.

1. Space completely enclosed by walls and a ceiling.

2. Enclosure permitted to have openings in walls to adjoining space.

a. If the opening has minimum lintel depth of 8 inches from the ceiling and does not exceed 8 feet in width.

b. Single opening of 36 inches or less in width without lintel is permitted when there are no other openings to adjoining spaces.

SPECIAL SITUATIONS (cont'd)

- When quick-response sprinklers are installed, all sprinklers within same compartment must be quick-response.

Slide 2-72

3. When quick-response sprinklers are installed, all sprinklers within the same compartment must be quick-response sprinklers.

SPECIAL SITUATIONS (cont'd)

- Small rooms.
  - Light Hazard occupancy.
  - Unobstructed construction and floor areas not exceeding 800 square feet.
  - Enclosed by walls and a ceiling.
  - Openings in walls not exceeding 8 feet in width permitted if minimum lintel depth is 8 inches from ceiling.
  - Single opening of 36 inches or less in width.

Slide 2-73

J. Small rooms.

1. Light Hazard occupancy.

2. Unobstructed construction and floor areas not exceeding 800 square feet.

3. Enclosed by walls and a ceiling.

4. Openings in walls not exceeding 8 feet in width permitted if minimum lintel depth is 8 inches from ceiling.

5. Single opening of 36 inches or less in width.

SPECIAL SITUATIONS (cont'd)

- Sprinkler spacing limits do not apply within small rooms.
  - Sprinklers may be permitted at locations no more than 9 feet from any single wall.
- Pipe schedule systems limited to single sprinkler in small room; hydraulic systems may have up to four sprinklers in a single small room.

Slide 2-74

6. Sprinkler spacing limits do not apply within small rooms.

   Sprinklers may be permitted at locations no more than 9 feet from any single wall.

7. Pipe schedule systems limited to single sprinkler in small room; hydraulic systems may have up to four sprinklers in a single small room.

SPECIAL SITUATIONS (cont'd)

- Sprinklers may be omitted in bathrooms that are located in dwelling units.
  - Exposed products are fire-retardant treated wood.
  - Rigid materials used have a flame spread rating of 25 or less and demonstrate that they do not propagate flame.

Slide 2-75

8. Sprinklers may be omitted in bathrooms that are located in dwelling units.

   a. Exposed products are fire-retardant treated wood.

   b. Rigid materials used that have a flame spread rating of 25 or less and demonstrate that they do not propagate flame.

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ACTIVITY 2.4

Compartments and Small Rooms

Purpose

Given a copy of NFPA 13, you will 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 given four examples of spaces that might appear on a set of plans. The dashed lines on the drawings represent construction elements behind the view plane.

2. Using NFPA 13, complete your answers on the student worksheet.

3. Be prepared to discuss your responses in class.

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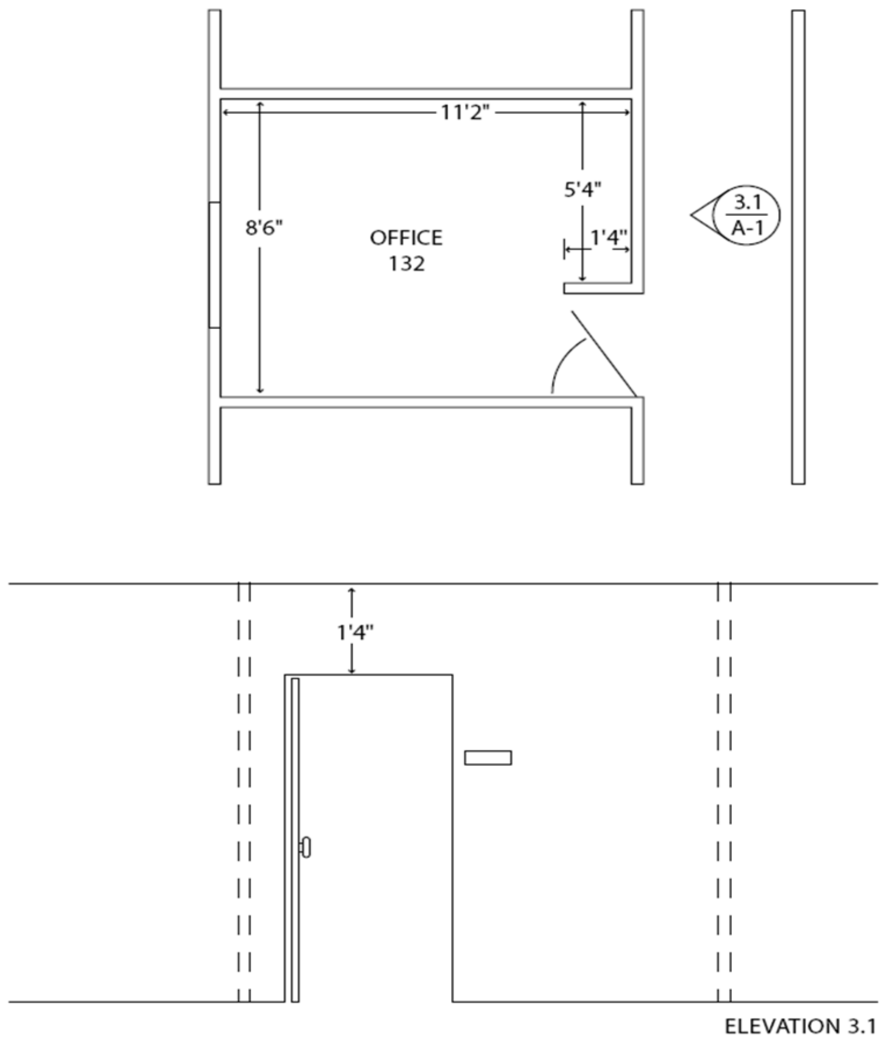
ACTIVITY 2.4 (cont'd)

Compartments and Small Rooms

Example 1



EXAMPLE 1

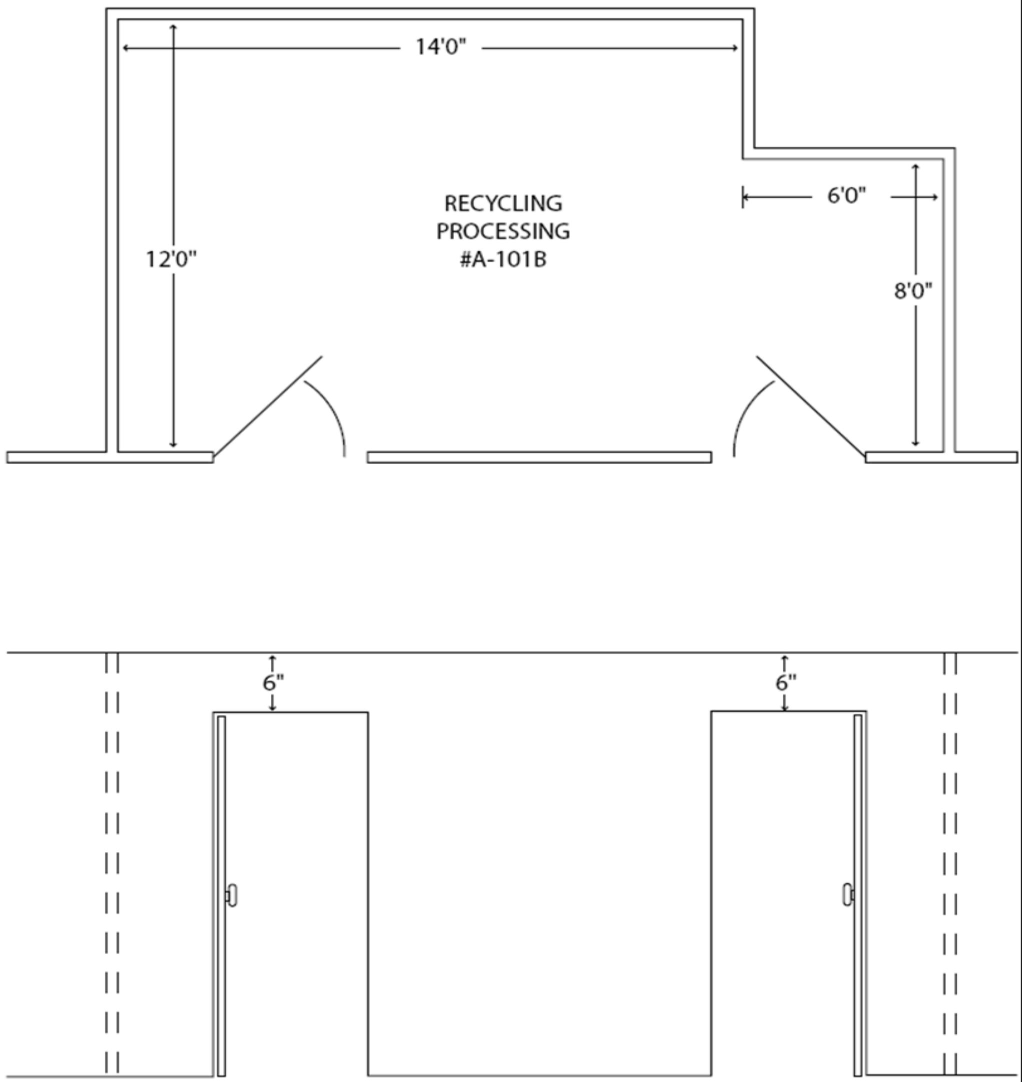
Conditions: Office No. 132 is part of a new office building that is being erected. The office will contain a desk/computer workstation, rolling chair, credenza and two upholstered armchairs. The building is combustible construction.

Questions

1. Does this room meet the NFPA 13 definition of a “compartment”?

2. Does this room qualify as a “small room” in accordance with the definitions in NFPA 13? Why or why not?

Example 2



EXAMPLE 2

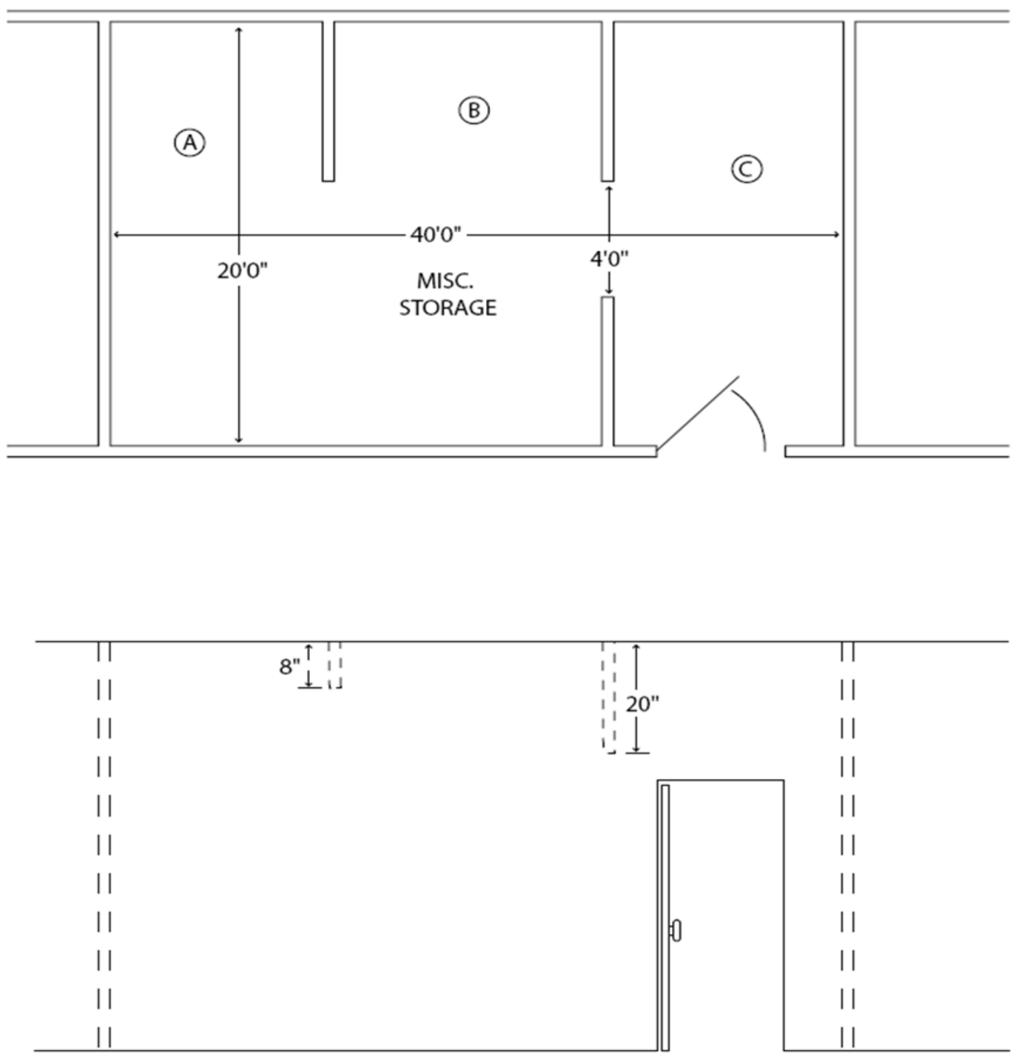
Conditions: The local auto parts store offers a parts, lube oil, and antifreeze recycling service. Customers may bring in small quantities (not to exceed 5 quarts for lube oil or 5 gallons of other nonflammable fluids) in metal or plastic containers. The store's staff members will take the products and transfer them to larger containers (55-gallon drums for the lube oil; 100-gallon portable tanks for the nonflammable fluids). The building is noncombustible construction.

Questions

1. Is the recycling processing room a different compartment from the adjacent space?

2. Does this room qualify as a "small room" in accordance with the definitions in NFPA 13? Why or why not?

Example 3



EXAMPLE 3

Conditions: 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.

Questions

1. Is space A part of the same compartment as space B? Why or why not?

____

____

____

2. Is space B part of the same compartment as space C? Why or why not?

____

____

____

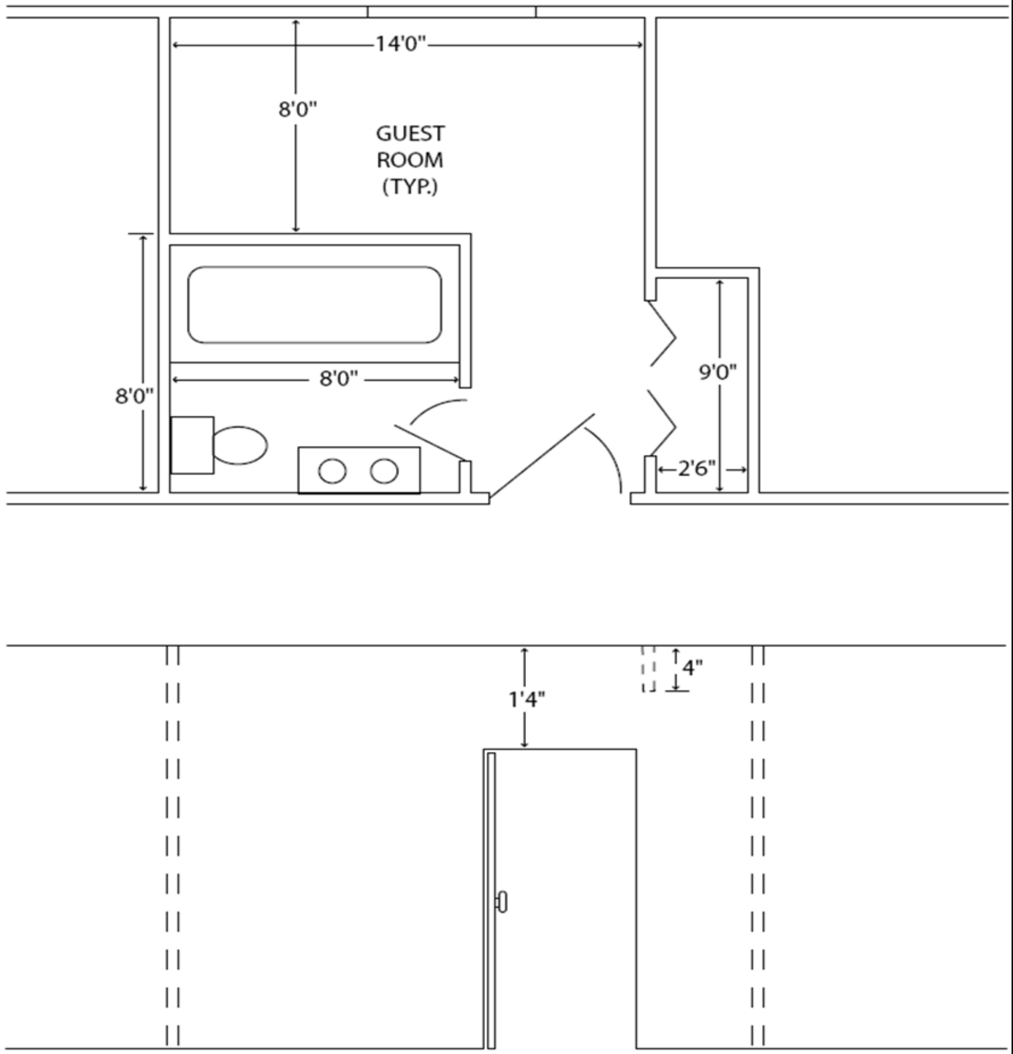
3. Does this room qualify as a “small room” in accordance with the definitions in NFPA 13? Why or why not?

____

____

____

Example 4



EXAMPLE 4

Conditions: 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.

Questions

1. Is the closet part of the same compartment as the remainder of the room? Why or why not?

___

___

___

2. Is the guest room part of the same compartment as the adjacent corridor? Why or why not?

___

___

___

3. Does the bathroom qualify as a “small room” in accordance with the definitions in NFPA 13? Why or why not?

___

___

___

V. SUMMARY

FEMA

SUMMARY

U.S. Fire Administration

- Hazard classifications.
- Construction influences.
- Sprinkler discharge obstructions.
- Special situations.

Slide 2-81

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UNIT 3: WATER SUPPLIES AND DELIVERY SYSTEMS

TERMINAL OBJECTIVE

The students will be able to:

3.1 Given the design criteria of a water supply system and a set of plans, evaluate the water supply system to ensure it is in compliance with nationally recognized standards for a fire protection system.

ENABLING OBJECTIVES

The students will be able to:

3.1 Given a copy of National Fire Protection Association (NFPA) 13, Standard for the Installation of Sprinkler Systems, *and 14,* Standard for the Installation of Standpipe and Hose Systems, *compare the volume, reliability, functionality and features of the sources available to supply fire pumps, standpipes and sprinklers.*

3.2 Given a copy of NFPA 13 and 14, identify the minimum required water supply for a combined sprinkler and standpipe system.

3.3 Given the physical dimensions of a water storage tank and a volume formula, calculate the water storage capacity of a cylindrical suction tank.

3.4 Given a set of plans, identify the components of the private water supply system and their interrelationship.

3.5 Given a site plan, verify the installation details and flow capabilities of fire hydrants.

3.6 Given the contractor's material and test certificate documentation, verify that the underground piping provided meets nationally recognized standards.

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FEMA

U.S. Fire Administration

UNIT 3: WATER SUPPLIES AND DELIVERY SYSTEMS

Slide 3-1

TERMINAL OBJECTIVE

Given the design criteria of a water supply system and a set of plans, evaluate the water supply system to ensure it is in compliance with nationally recognized standards for a fire protection system.

Slide 3-2

ENABLING OBJECTIVES

- Given a copy of National Fire Protection Association (NFPA) 13, *Standard for the Installation of Sprinkler Systems* and 14, *Standard for the Installation of Standpipe and Hose Systems*, compare the volume, reliability, functionality and features of the sources available to supply fire pumps, standpipes and sprinklers.

Slide 3-3

ENABLING OBJECTIVES (cont'd)

- Given a copy of NFPA 13 and 14, identify the minimum required water supply for a combined sprinkler and standpipe system.
- Given the physical dimensions of a water storage tank and a volume formula, calculate the water storage capacity of a cylindrical suction tank.

Slide 3-4

ENABLING OBJECTIVES (cont'd)

- Given a set of plans, identify the components of the private water supply system and their interrelationship.
- Given a site plan, verify the installation details and flow capabilities of fire hydrants.
- Given the contractor's material and test certificate documentation, verify that the underground piping provided meets nationally recognized standards.

Slide 3-5

I. APPROVED AUTOMATIC WATER SOURCES

APPROVED AUTOMATIC WATER SOURCES

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

Slide 3-6

A. National Fire Protection Association (NFPA) recognizes four types of automatic water sources that can be connected to a fire protection system.

1. Public and private.

2. Fire pump assemblies.

3. Pressure tanks.

4. Gravity or suction tanks.

APPROVED AUTOMATIC WATER SOURCES (cont'd)

- Public and private generally an open water source or a pumped groundwater system.
  - Public.
    - -- Domestic, industrial and fire.
    - -- Separate domestic and fire.
  - Private.
    - -- Owner designed and maintained.
    - -- Private water purveyors.

Slide 3-7

B. Public and private water works systems are generally an open water source (pond, lake and reservoir) or a pumped groundwater system that is treated for public health and distributed through a network of water mains.

1. Public.

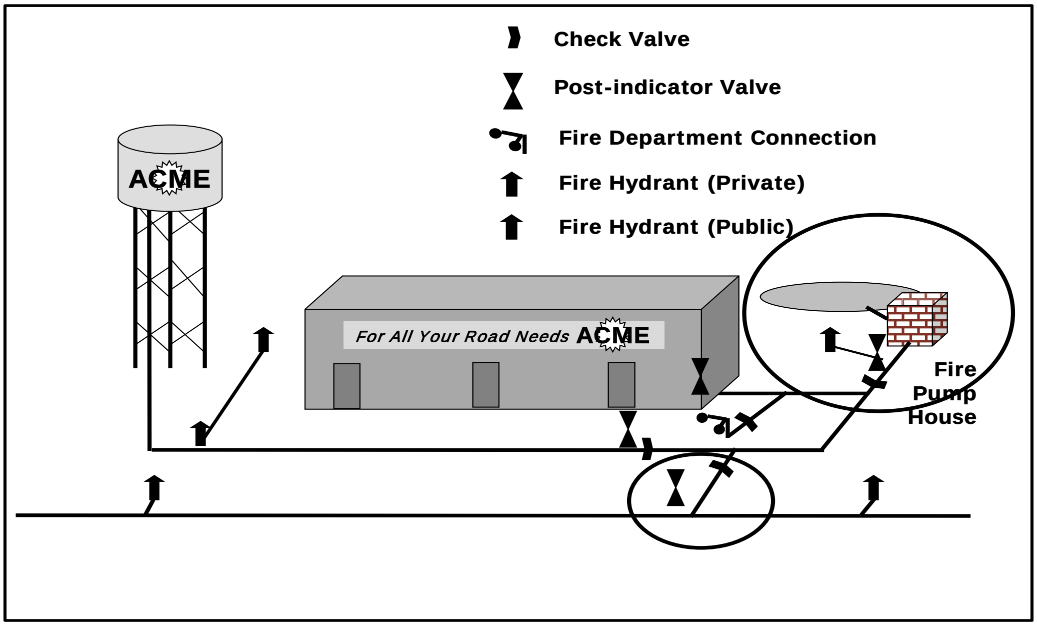
   a. Combination of domestic, industrial and fire.

   b. Separate domestic and fire.

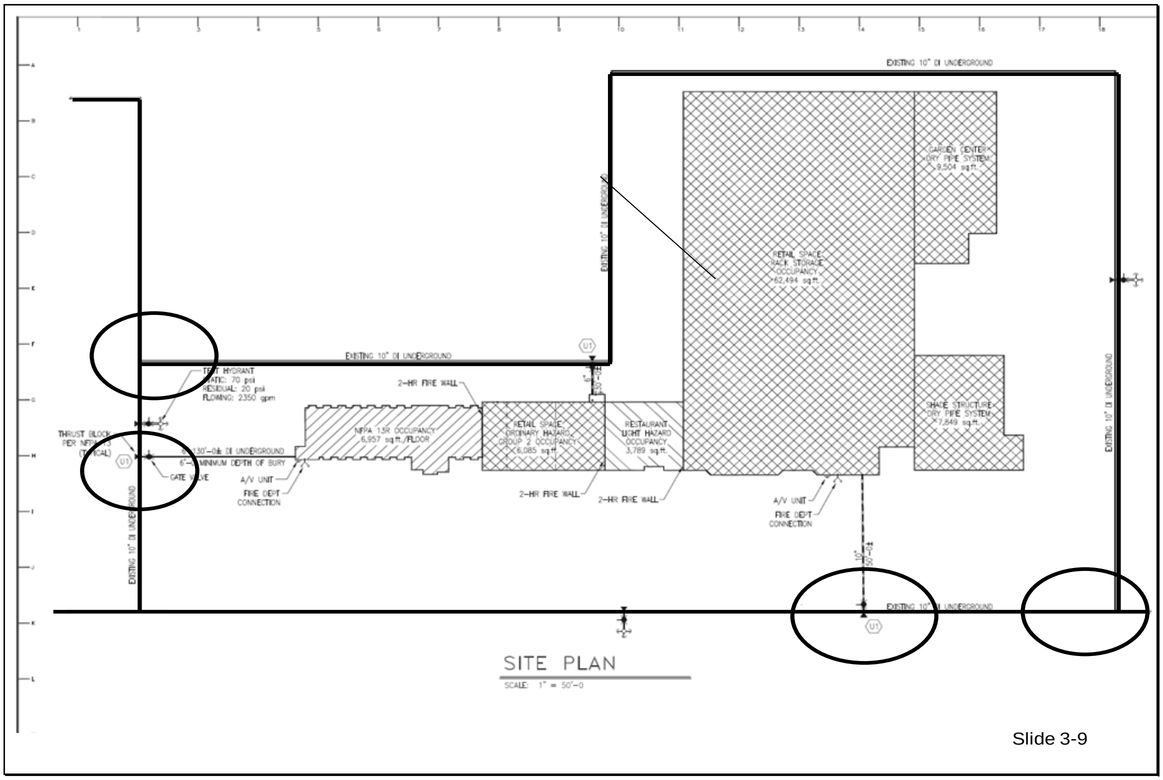
2. Private.

   a. Owner designed and maintained.

   b. Private water purveyors.


Check Valve
Post-indicator Valve
Fire Department Connection
Fire Hydrant (Private)
Fire Hydrant (Public)
ACME
For All Your Road Needs ACME
Fire
Pump
House

Slide 3-8


EXISTING 10" DI UNDERGROUND
GARDEN CENTER
DRY PIPE SYSTEM
9,504 sq.ft.
RETAIL SPACE
RACK STORAGE
OCCUPANCY
62,494 sq.ft.
EXISTING 10" DI UNDERGROUND
U1
EXISTING 10" DI UNDERGROUND
TEST HYDRANT
STATIC: 70 psi
RESIDUAL: 20 psi
FLOWING: 2350 gpm
2-HR FIRE WALL
NFPA 13R OCCUPANCY
6,957 sq.ft./FLOOR
RETAIL SPACE
ORDINARY HAZARD
GROUP 2 OCCUPANCY
6,085 sq.ft.
RESTAURANT
LIGHT HAZARD
OCCUPANCY
3,789 sq.ft.
SHADE STRUCTURE
DRY PIPE SYSTEM
7,849 sq.ft.
THRUST BLOCK
PER NFPA 13
(TYPICAL)
U1
GATE VALVE
6'-0" MINIMUM DEPTH OF BURY
A/V UNIT
FIRE DEPT
CONNECTION
2-HR FIRE WALL
2-HR FIRE WALL
A/V UNIT
FIRE DEPT
CONNECTION
EXISTING 10" DI UNDERGROUND
EXISTING 10" DI UNDERGROUND
EXISTING 10" DI UNDERGROUND
U1
SITE PLAN
SCALE: 1" = 50'-0
Slide 3-9

APPROVED AUTOMATIC WATER SOURCES (cont'd)

- Fire pump assemblies connected to raw water sources.
  - Reliability.
    - Drought or freezing.
    - Leakage.
    - Testing and maintenance.
  - Contamination.
  - Compliance with NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection.*

Slide 3-10

C. Fire pump assemblies connected to raw water sources such as ponds, lakes, open reservoirs, rivers, wells, aquifers and outdoor swimming pools.

1. Reliability.

   a. Subject to drought or freezing.

   b. Leakage through soil percolation.

   c. Reliant on fire pump design, installation, testing and maintenance to assure that a reliable operation takes place.

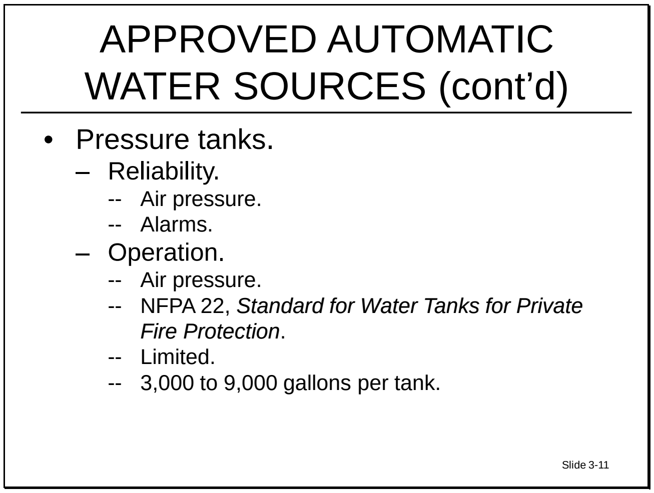
2. Contamination can be a problem for walls of water mains and the distribution system (valves, drains and pumps).

   a. Silt, algae and chemicals will cause encrustations from the progressive growth of rust deposits of the iron pipes. These deposits are a result of the biological reactions present in the water supply.

   b. Sedimentation will be caused from deposits of the heavier material settling in pipes and tanks and then clogging pumps and drains.

   c. The design phase should consider these issues as part of the water supply system.

3. Pump assembly must be in compliance with NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*.



D. Pressure tanks.

1. Reliability.

   a. Requires automatic means to maintain air pressure.

   b. Requires low air and low water level alarms to notify of potential problems.

2. Operation.

   a. Employs air pressure to expel tank contents when fire protection system operates.

   b. Must be installed in accordance with NFPA 22, *Standard for Water Tanks for Private Fire Protection*.

   c. Limited to sprinkler system supplies and hose systems attached to sprinkler piping.

   d. Capacities range from 3,000 to 9,000 gallons per tank.

   e. Greater water demands usually use more tanks.

APPROVED AUTOMATIC WATER SOURCES (cont'd)

- Considerations.
  - -- Seismic design.
  - -- Antifreeze solution or tank heating.

Slide 3-12

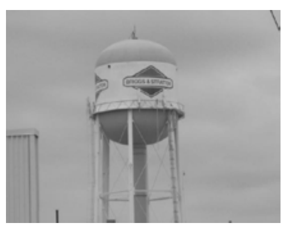
3. Regional considerations.

   a. Seismic design.

   b. May require antifreeze solution, tank heating or insulation.

APPROVED AUTOMATIC WATER SOURCES (cont'd)

- Gravity or suction tanks.
  - Water storage tanks.
  - Operation.
    - -- Gravity or fire pump.
    - -- NFPA 22.
  - Regional considerations.
    - -- Seismic design.
    - -- Tank heating or insulation.



Slide 3-13

E. Gravity or suction tanks.

1. Water storage tanks such as aboveground, elevated and underground (enclosed swimming pools).

2. Operation.

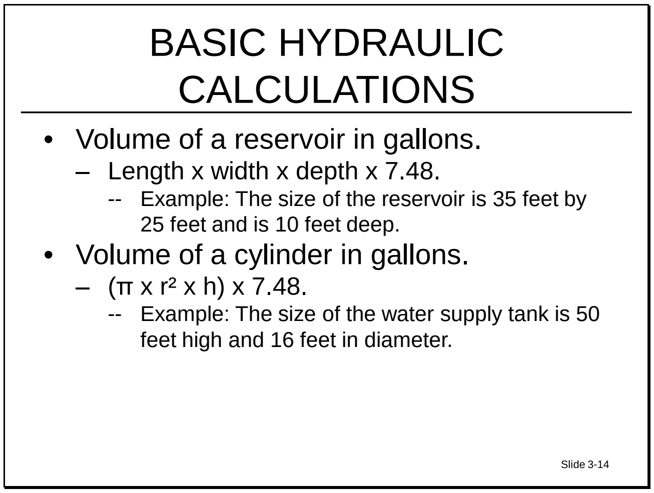
   a. Employs gravity or fire pump (suction tank) to dispel water to fire protection systems.

   b. Must be installed in accordance with NFPA 22 or AWWA standards if part of public infrastructure.

3. Regional considerations.

    a. Seismic design.

    b. May require tank heating or insulation.



F. Basic hydraulic calculations.

1. Volume of a reservoir in gallons.

    a. Length x width x depth x 7.48.

    b. Example: The size of the reservoir is 35 feet by 25 feet and is 10 feet deep.

2. Volume of a cylinder in gallons.

    a. (π x r^2 x h) x 7.48.

    b. Example: The size of the water supply tank is 50 feet high and 16 feet in diameter.

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ACTIVITY 3.1

Available Stored Water Supply

Purpose

Given a depiction of a scene with mixed water capability and the dimensions of the stored water sources, you will calculate the amount of stored water available.

Directions

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

2. Each table will be asked to provide the answer to the problem. The instructor will then review the correct answer and discuss any discrepancies.

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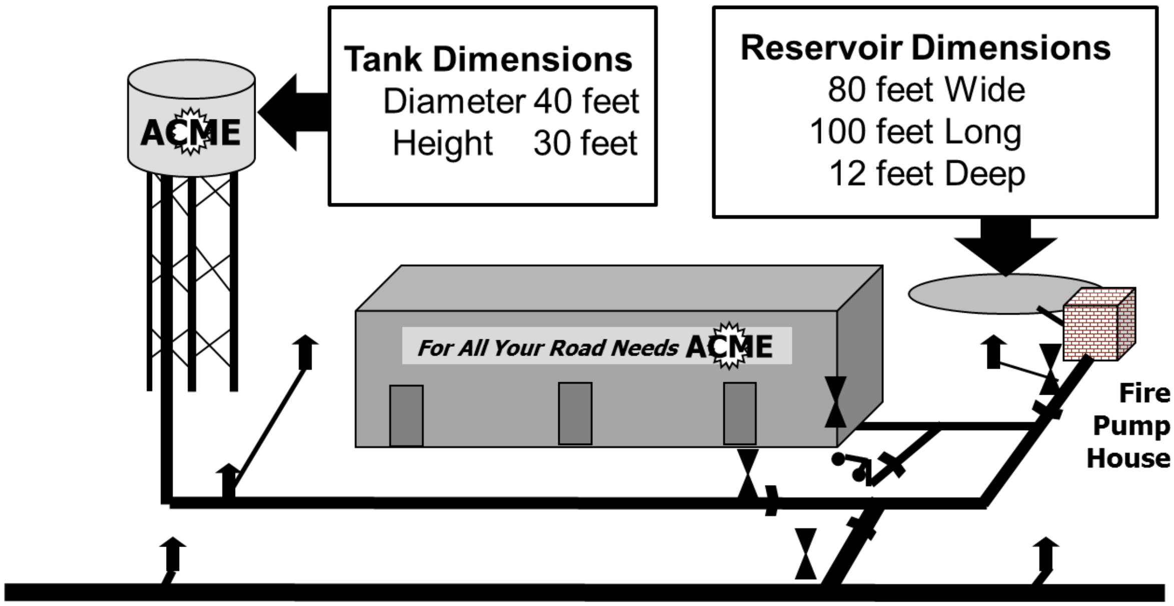
ACTIVITY 3.1 (cont'd)

Available Stored Water Supply



Calculate the total available stored water

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II. MINIMUM REQUIRED WATER SUPPLY

MINIMUM REQUIRED WATER SUPPLY

- Must be adequate to control or suppress fire.
  - Based on NFPA 13 and14 standards.
  - For sprinkler systems, based on hazard class.
  - For standpipe systems, based on number of risers.
  - For combination standpipe and sprinkler, based on hazard class and number of risers.

Slide 3-18

A. Water supply for a fire protection system must adequately control and suppress a fire.

1. Quantities and duration are based on requirements from NFPA 13, *Standard for the Installation of Sprinkler Systems* and 14 standards.

   a. "Fire flow" requirements found in model fire codes are intended for manual fire suppression operations, not fire protection systems.

   b. Where automatic sprinklers are installed, model fire codes allow lower fire flow rates based on the assumption that the sprinkler will control the fire.

   c. Water supply requirements for fire protection systems are not "additives" to model code fire flow requirements.

      - Example: If a fire code requires 1,500 gallons per minute (gpm) for manual suppression and the sprinkler system requires 650 gpm, then the two values are not added.

2. Quantities (gpm or total) and duration for sprinkler systems are based on hazard classifications (Light, Ordinary and Extra).

   Storage occupancies have additional requirements but are not within the scope of this course.

3. Quantities (gpm or total) and duration for standpipe systems are based on the number of standpipe risers that will be installed in the building.

4. Quantities (gpm or total) and duration for combination sprinkler and standpipe systems are based on the hazard classification and number of standpipe risers that will be installed in the building.

MINIMUM REQUIRED WATER SUPPLY (cont'd)

- For fire pump water supplies; the requirements are established by sprinkler or standpipe demand.
- Code official has authority to require more than what standards say.

Slide 3-19

5. There is no specific quantity or duration requirements for fire pump water supplies; the requirements are established by sprinkler or standpipe demand.

6. Code official has authority to require more than what standards say. These values are the minimum.

SPRINKLER SYSTEM WATER DEMAND

- Derived from NFPA 13.
- Amount of water to supply sprinkler system will be determined by design method.
  - Pipe schedule.
  - Hydraulically calculated.

Slide 3-20

B. Sprinkler system water demand.

1. Derived from NFPA 13.

2. Amount of water to supply sprinkler system will be determined by design method.

a. Pipe schedule (Table 11.2.2.1).

b. Hydraulically calculated (Table 11.2.3.1.2).

SPRINKLER SYSTEM WATER DEMAND (cont'd)

Table 11.2.2.1 Water Supply Requirements for Pipe Schedule Sprinkler Systems

Occupancy Classification	Minimum Residual Pressure Required		Acceptable Flow at Base of Riser (Including Hose Stream Allowance)		Duration (minutes)
	psi	bar	gpm	L/min	
Light hazard	15	1	500–750	1893–2839	30–60
Ordinary hazard	20	1.4	850–1500	3218–5678	60–90

(1) Additions or modifications to existing pipe schedule systems sized according to the pipe schedules of Section 22.5
(2) Additions or modifications to existing extra hazard pipe schedule systems
(3) New systems of 5000 ft^2 (465 m^2) or less
(4) New systems exceeding 5000 ft^2 (465 m^2) where the flows required in Table 11.2.2.1 are available at a minimum residual pressure of 50 psi (3.4 bar) at the highest elevation of sprinkler

Slide 3-21

3. Pipe schedule method.

a. Light Hazard occupancy.

- 500 to 750 gpm at base of riser.
- Minimum 15 pounds per square inch (psi) at highest sprinkler.
- 30 to 60 minutes.

b. Ordinary Hazard occupancy.

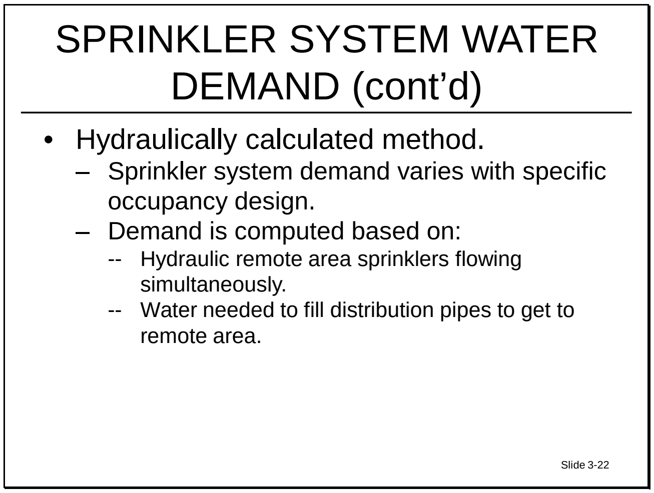
- 850 to 1500 gpm at base of riser.
- Minimum 20 psi at highest sprinkler.
- 60 to 90 minutes.

c. Lower flow rate acceptable if building is:

- Noncombustible.
- Fire areas limited to 3,000 square feet in Light Hazard and 4,000 square feet in Ordinary Hazard.

d. Lesser duration allowed only when remote or central station water flow alarm service is provided.

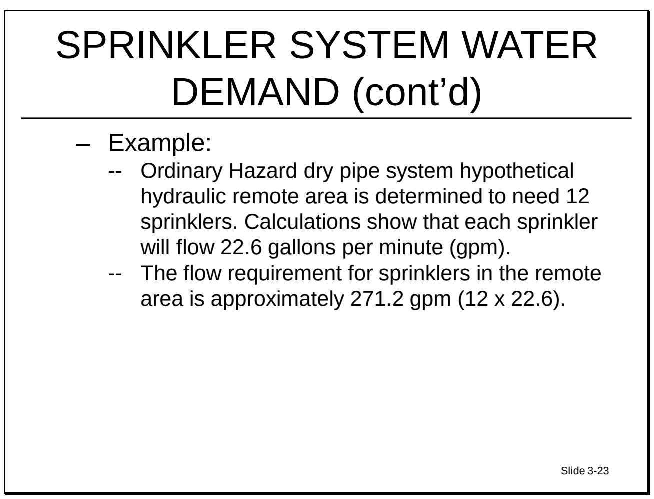
- Current model fire codes require remote water flow monitoring.



4. Hydraulically calculated method.

   a. Sprinkler system demand varies depending upon specific occupancy design.

   b. Demand is computed based on the anticipation that all sprinklers in the hydraulic remote area (design area) are flowing simultaneously (wet systems), plus the idea that water is needed to fill distribution pipes to get to a remote area (dry systems).



   c. Example:

      - A particular Ordinary Hazard dry pipe system hypothetical hydraulic remote area is determined to need 12 sprinklers. The calculations show that each sprinkler will flow 22.6 gpm.

      - The flow requirement for sprinklers in the remote area is approximately 271.2 gpm (12 x 22.6).

SPRINKLER SYSTEM WATER DEMAND (cont'd)

- -- The total remote area demand will be somewhat higher.
- -- The hypothetical additional amount might be 64.3 gpm, so the total hypothetical sprinkler system demand is 335.5 gpm (271.2 + 64.3 = 335.5).

Slide 3-24

- The total remote area demand will be somewhat higher because the system will need additional flow to fill the riser and feed the main, cross main, and branch lines that go to the remote area.

- For this example, the hypothetical additional amount might be 64.3 gpm, so the total hypothetical sprinkler system demand is 335.5 gpm (271.2 + 64.3 = 335.5).

HOSE STREAM DEMAND

- "Hose stream demand" is the amount of water that must be added to the sprinkler system demand so the fire suppression forces will have water for manual fire control.

Table 11.2.3.1.2 Hose Stream Allowance and Water Supply Duration Requirements for Hydraulically Calculated Systems

Occupancy	Inside Hose		Total Combined Inside and Outside Hose		Duration (minutes)
	gpm	L/min	gpm	L/min	
Light hazard	0, 50, or 100	0, 189, or 379	100	379	30
Ordinary hazard	0, 50, or 100	0, 189, or 379	250	946	60–90
Extra hazard	0, 50, or 100	0, 189, or 379	500	1893	90–120

Slide 3-25

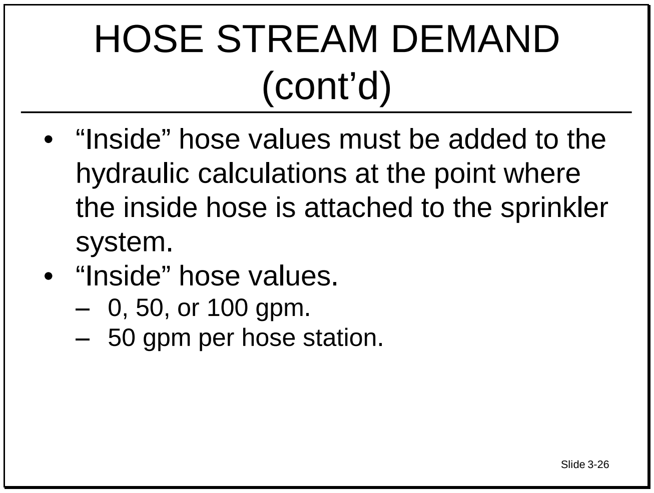
C. Hose stream demand.

1. "Hose stream demand" is the amount of water that must be added to the sprinkler system demand so the fire suppression forces will have water for manual fire control.

2. Values are derived from a table that identifies "inside" hose demand and "total combined inside and outside hose" demand.

a. 0, 50, or 100 gpm.

b. 50 gpm per hose station.



3. "Inside" hose is the value that must be added if the sprinkler system has small hose stations attached to it for initial fire control or mop-up.

4. "Inside" hose values must be added to the hydraulic calculations at the point where the inside hose is attached to the sprinkler system.

a. The 50 gpm figure is added based on the idea that if a person inside the building uses the small hose to try to control the incipient stages of a fire, there will remain adequate water in the piping network to supply the sprinklers in the remote area.

b. If no inside hose stations are attached to the sprinkler system, the "inside hose" value is zero. If two or more hose stations are attached, the maximum "inside hose" value that is applied (regardless of number of hose stations) is 100 gpm.

STANDPIPE SYSTEM DEMAND

- NFPA 14.
- Class 1 and 3.
  - Minimum flow rate is 500 gpm for 30 minutes.
  - Add 250 gpm additional flow rate for each standpipe to a maximum of 1,000 gpm for sprinklered throughout and 1,250 gpm for buildings not equipped with sprinklers throughout.

Slide 3-27

D. Standpipe system demand.

1. Derived from NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*.

2. Class 1 and 3 standpipe systems (NFPA 14, 2010, p. 14-17).

   a. Minimum flow rate for the hydraulically most remote standpipe is 500 gpm for at least 30 minutes (up to three standpipes).

   b. Minimum flow rate for additional standpipes is 250 gpm (per standpipe riser, with the total not to exceed 1,250 gpm for at least 30 minutes. Maximum 1,000 gpm for buildings equipped with sprinklers throughout).

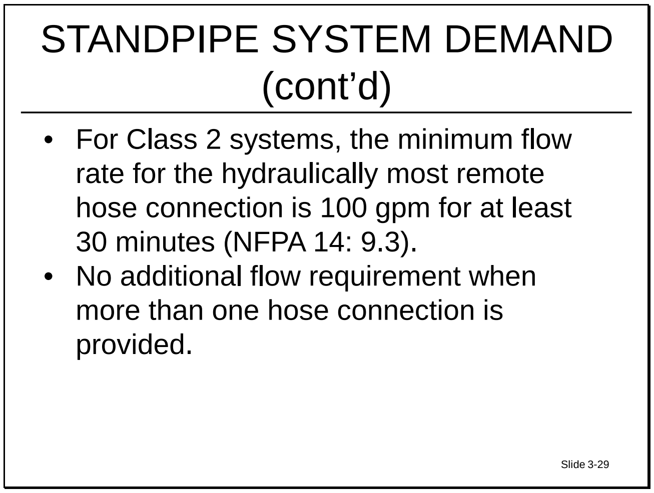
STANDPIPE SYSTEM DEMAND (cont'd)

- Minimum flow rate for the hydraulically most demanding horizontal standpipe is 750 gpm.
- When the floor area exceeds 80,000 square feet, the second most remote standpipe must be designed to accommodate 500 gpm.

Slide 3-28

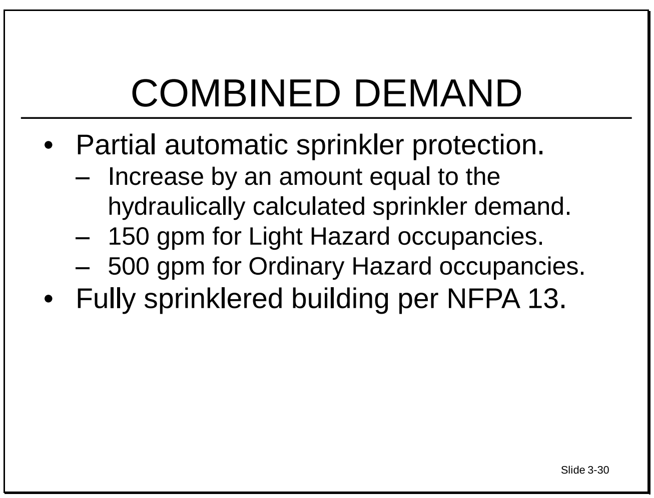
   c. Horizontal standpipe on a Class 1 and Class 3 system supplies three or more hose connections on any floor. The minimum flow rate for the hydraulically most demanding horizontal standpipe is 750 gpm.

d. When the floor area exceeds 80,000 square feet, the second most remote standpipe must be designed to accommodate 500 gpm.



3. For Class 2 systems, the minimum flow rate for the hydraulically most remote hose connection is 100 gpm for at least 30 minutes (NFPA 14: 9.3).

4. There is no additional flow requirement, when more than one hose connection is provided.



E. Combined demand.

1. Partial automatic sprinkler protection.

a. Increase by an amount equal to the hydraulically calculated sprinkler demand.

b. For Light Hazard occupancies, 150 gpm.

c. For Ordinary Hazard occupancies, 500 gpm.

2. Building equipped with sprinklers per NFPA 13.

F. Duration.

1. Duration is the amount of time in minutes the water supply must last.

2. Current model fire codes require remote water flow monitoring.

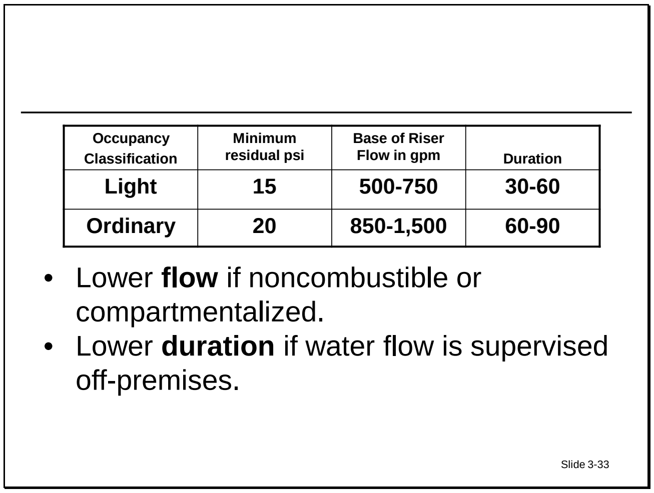
3. Duration can be used to compute the size of water supply tanks for systems not connected to municipal water supply.

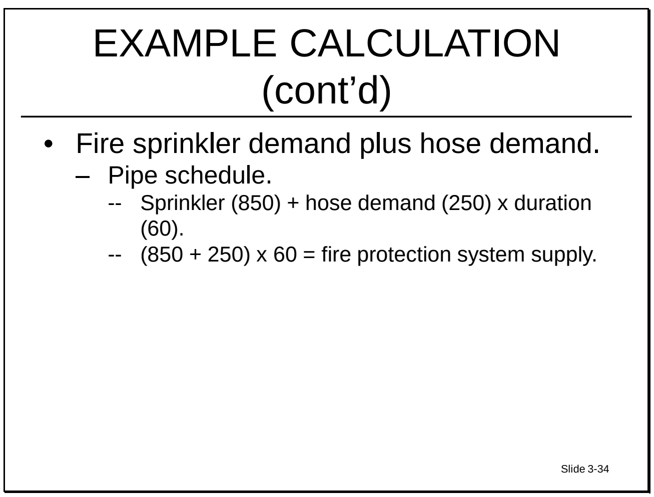
(sprinkler + hose demand) x duration = fire protection system water supply.

G. Example calculation.

1. The retail space on drawing four of eight remote area one (retail shell space) is Ordinary Hazard Group 2 and has a remote monitoring system.

2. Calculate the water supply requirements for a pipe schedule and hydraulically calculated systems.





3. Fire sprinkler demand plus hose demand.

a. Pipe schedule.

- Sprinkler (850) + hose demand (250) x duration (60).
- (850 + 250) x 60 = fire protection system supply.
- 66,000 gallons.

EXAMPLE CALCULATION (cont'd)

– Hydraulic.
  - -- Sprinkler (239.0) + hose demand (250) x duration (60).
  - -- (239.0 + 250) x 60.

Slide 3-35

b. Hydraulic.

- Sprinkler (239.0) + hose demand (250) x duration (60).
- (239.0 + 250) x 60.
- 29,340 gallons.

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ACTIVITY 3.2

Water Supplies for Combined Sprinkler and Standpipe Systems

Purpose

Given a copy of NFPA 13 and 14, you will identify the minimum required water supply for a combined sprinkler and standpipe system.

Directions

1. This is an evening assignment, which will be debriefed in class in the morning following the assignment.

2. You will be given 11 examples of occupancy hazard class, sprinkler system demand, number of Class 1 or 3 standpipes, and Class 2 standpipe hose stations.

3. Using NFPA 13 and NFPA 14 standards, you are to determine the total water supply needed to supply the fire protection system.

4. 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.

5. Working individually, you are to:

   a. Identify the duration (in minutes) of the required water supply.

   b. Calculate the total volume (in gallons) of the required water supply.

6. Your results should be within a margin of error of ± 5 percent.

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ACTIVITY 3.2 (cont'd)

Water Supplies for Combined Sprinkler and Standpipe Systems

Results should be within a margin of error of ± 5 percent.

No.	Occupancy Hazard Class	Sprinkler Demand (gpm)	Hose Stream Allowance	No. Class 1 or 3 Standpipe Risers	Standpipe flow (500 for first – 250 for each additional to 1,250 gpm)	No. Class 2 Hose Stations	Class 2 Demand (0, 50, 100)	Min. Required Duration (minutes)	Formula	Total Water Supply Needed (gallons)
1.	Light	123.67	100	0	0	0	0			
2.	Ordinary Group 1	153.60	250	2	750	0	0			
3.	Extra Group 2	262.54	500	2	750	0	0			
4.	Ordinary Group 2	163.44	250	0	0	2	100			
5.	Extra Group 1	194.37	500	2	750	0	0			
6.	Extra Group 1	201.05	500	0	0	2	100			

No.	Occupancy Hazard Class	Sprinkler Demand (gpm)	Hose Stream Allowance	No. Class 1 or 3 Standpipe Risers	Standpipe flow (500 for first – 250 for each additional to 1,250 gpm)	No. Class 2 Hose Stations	Class 2 Demand (0, 50, 100)	Min. Required Duration (minutes)	Formula	Total Water Supply Needed (gallons)
7.	Light, Ordinary Group 2	171.63	250	0	0	1	50			
8.	Light, Partial Sprinkler System	150	100	2	750	0	0			
9.	No Fire Sprinkler System	0	0	4	1,250	0	0			

III. WATER DELIVERY SYSTEM COMPONENTS

MAINS

- Generally, public water systems are designed as a grid to provide an interlocking network.
- Networks consist of three types.
  - Primary feeders.
  - Secondary feeders.
  - Distributors.

Slide 3-37

A. Mains.

1. Generally, public water systems are designed as a grid to provide an interlocking network of main to provide maintenance of water pressure and volume to system customers.

2. The network consists of three types of water mains.

   a. Primary feeders, also known as arterial mains, conveying water to various points of the system.

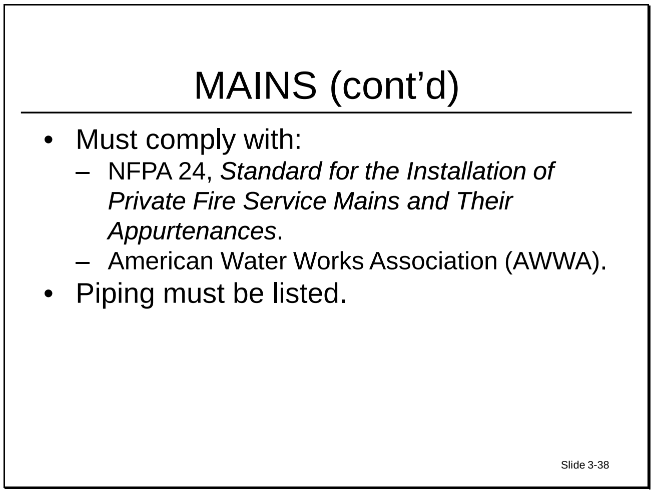
      - These large pipes begin at 16 inches and extend up to 72 inches in diameter.

      - Generally, only secondary feeders and distributors are directly connected to these arterial mains.

   b. Secondary feeders are intermediate pipes connected to the primary feeders to create a grid.

      - They are 12 to 14 inches in diameter.

   c. Distributors are small water mains 6 to 8 inches in diameter that serve public fire hydrants and system customers.

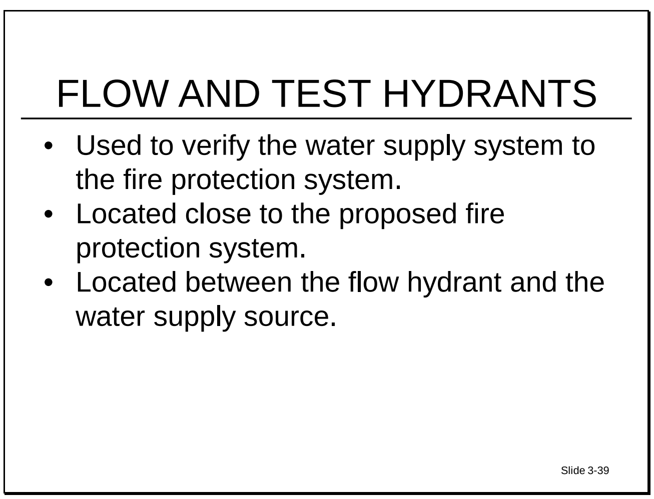


3. Must comply with:

   a. NFPA 24.

   b. AWWA.

4. Pipe or tube must be listed. (Refer to Underwriters Laboratories (UL) or Factory Mutual (FM) Global directories.)

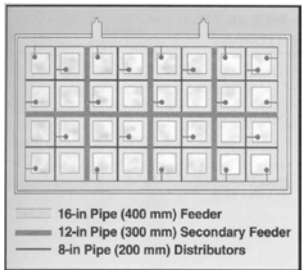


B. Flow and test hydrants.

1. Flow and test hydrants are used to verify the water supply system to the fire protection system.

2. The test hydrant should be located close to the proposed fire protection system.

3. The test hydrant should also be located between the flow hydrant and the water supply source.



4. In a grid system, it is often hard to tell the direction of water flow since it often flows from each side without any change.

5. In a dead end main, the flow hydrant should be downstream from the test hydrant.

C. Tapping sleeves.

1. Used to tap into the public water systems without shutting down areas of the system.

2. The tapping sleeve is attached to the feeder main and a tapping valve is attached.

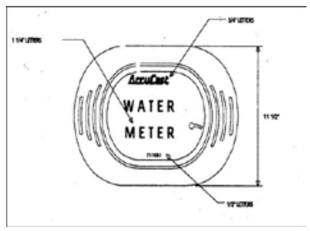
   a. The connection is made by drilling into the feeder main. After partially pulling the drill and coupon out, the tapping valve is closed to remove the drill and feeder coupon.

b. The underground pipe is connected to this tapping valve.

3. This valve is a gate type valve. This information is generally not included on plan sets.

METER BOX

- Used to hold water meter that measures water usage.
- Constructed from steel, cast iron, concrete or plastic.
- Reviewer must ensure proper meter size.



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D. Meter box.

1. Is used to house the water meter and valve assembly in order to measure the water usage to the private water system.

2. These boxes are generally constructed from concrete or plastic, though cast iron and steel units are available. Information regarding the meter box will be included on the plan set.

3. Reviewer must ensure proper meter size for adequate water supply to private water system.

UNDERGROUND PIPING

- Types of underground piping.
  - All must be listed for fire protection service.
  - Must meet AWWA standards.
    - -- Ductile iron.
    - -- Steel.
    - -- Concrete.
    - -- Plastic (polyvinyl chloride (PVC) and polyethylene (PE) type).
    - -- Copper.

Slide 3-43

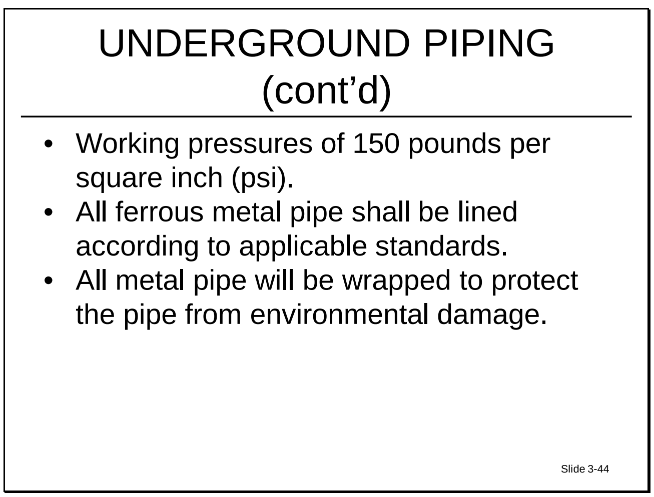
E. Underground piping.

1. Types of underground piping.

a. All underground piping must be listed for fire protection service where it supplies the fire protection system.

b. Public water distribution piping must meet AWWA and American Society for Testing and Materials (ASTM) standards.

- Ductile iron.
- Steel.
- Concrete.
- Plastic (polyvinyl chloride (PVC) or polyethylene (PE)).
- Copper.



2. Working pressures for underground pipe must be designed to withstand a minimum working pressure of 150 psi.

3. All ferrous metal pipes shall be lined according to applicable standards.

4. Most metal pipes will be wrapped to protect the pipe from environmental damage.

UNDERGROUND PIPING
(cont'd)

- Depth of coverage.
  – Measure from top of pipe to finish grade.
  – Consider future final grade and nature of the soil.
  – The minimum depth is 2 1/2 feet to prevent mechanical damage.

Slide 3-45

5. Depth of coverage.

   a. Minimum depth of coverage is measured from the top of the pipe and the finished/final grade.

   b. Consideration will need to be made for the future final grade and nature of the soil.

   c. The minimum depth is 2 1/2 feet to prevent mechanical damage (except in areas subject to freezing and established frost lines).

UNDERGROUND PIPING
(cont'd)

– Special situations for depth of coverage.
  -- Under driveways, a minimum of 3 feet.
  -- Under railroad tracks, a minimum of 4 feet.
  -- Pipes shall not be run underneath buildings.

Slide 3-46

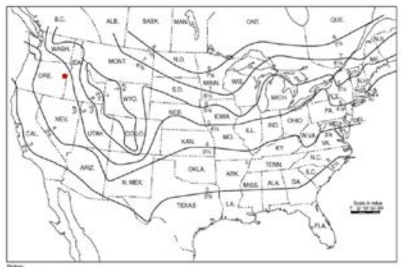
   d. Special situations require minimum depths.

      - Pipes under driveways must be buried at a minimum depth of 3 feet.

      - Pipes under railroad tracks shall be buried at a minimum depth of 4 feet.

- Pipes shall not be run underneath buildings.

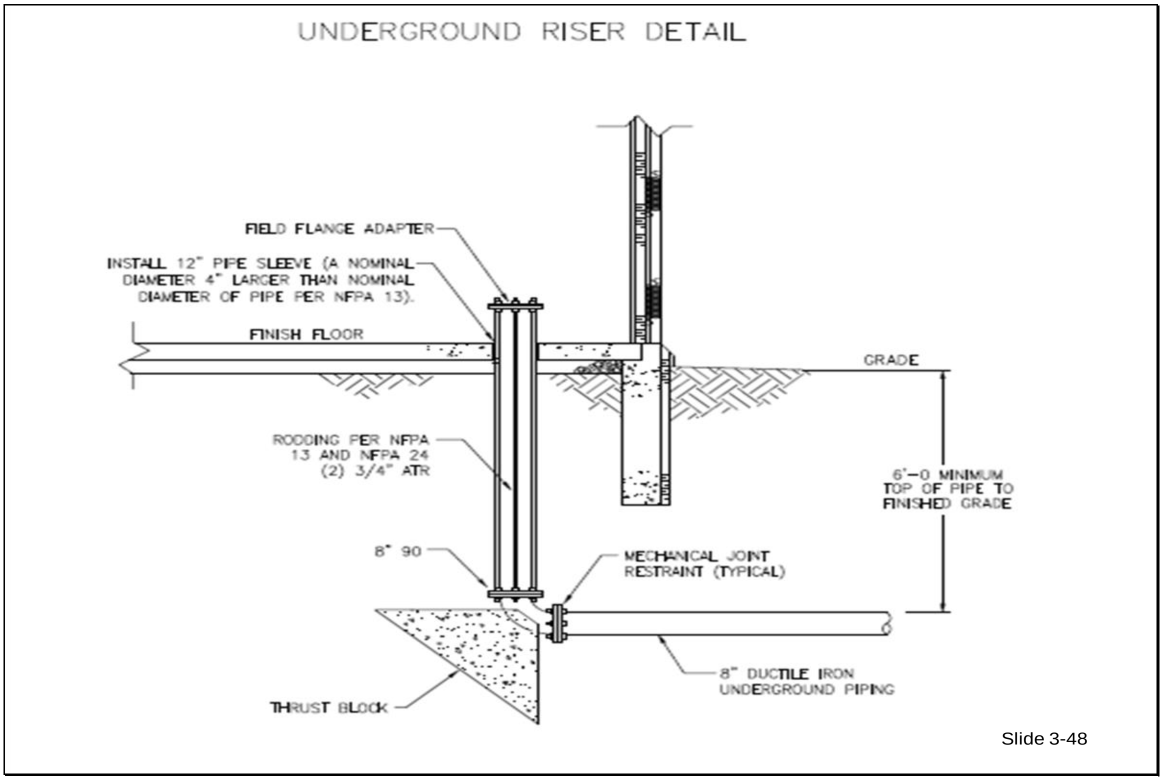
DEPTH OF COVER ABOVE TOP OF UNDERGROUND MAINS



Notes:
1. For SI Units, 1 in. = 25.4 mm; 1 ft = 0.304 m.
2. Where frost penetration is a factor, the depth of cover shown averages 6 in. greater than that usually provided by the municipal waterworks. Greater depth is needed because of the absence of flow in yard mains.

FIGURE A.10.4.1 Recommended Depth of Cover (in feet) Above Top of Underground Yard Mains.

Slide 3-47


UNDERGROUND RISER DETAIL
FIELD FLANGE ADAPTER
INSTALL 12" PIPE SLEEVE (A NOMINAL DIAMETER 4" LARGER THAN NOMINAL DIAMETER OF PIPE PER NFPA 13).
FINISH FLOOR
GRADE
RODDING PER NFPA 13 AND NFPA 24 (2) 3/4" ATR
6'-0 MINIMUM TOP OF PIPE TO FINISHED GRADE
8" 90
MECHANICAL JOINT RESTRAINT (TYPICAL)
8" DUCTILE IRON UNDERGROUND PIPING
THRUST BLOCK
Slide 3-48

UNDERGROUND PIPING (cont'd)

- Pipe installation beneath structures.
  - Limitations in NFPA 13 Section 10-6-1.

10.6 Protection Against Damage. [**24:**10.6]

10.6.1 Pipe shall not be run under buildings. [**24:**10.6.1]

10.6.2 Where pipe must be run under buildings, special precautions shall be taken, including the following:

(1) Arching the foundation walls over the pipe
(2) Running pipe in covered trenches
(3) Providing valves to isolate sections of pipe under buildings

[**24:**10.6.2]

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6. Pipe installation beneath structures.

   a. Limitations on pipe installations beneath structures.

      - See Protection Against Damage (NFPA 13, 2010, p. 13-110).

UNDERGROUND PIPING (cont'd)

- Foundation settling and notching foundation.
- Special situations and precautions.
  - Arching the foundation walls over the pipe.
  - Running pipe in covered trenches.
  - Providing valves to isolate sections of pipe under buildings.

Slide 3-50

   b. Foundation settling and how to notch a foundation.

   c. Special situations may require installation underneath buildings. Special precautions must be taken.

      - Arching the foundation walls over the pipe.

      - Running pipe in covered trenches.

      - Providing valves to isolate sections of pipe under buildings.

UNDERGROUND PIPING (cont'd)

- Special loading conditions.
  - Main running under railroad carrying heavy cargo.
  - Main running under large piles of heavy commodities.
  - Main located in areas subject to heavy shock or vibration.

Slide 3-51

7. Special loading conditions may require evaluation and protection.

   a. Main running under railroad carrying heavy cargo.

   b. Main running under large piles of heavy commodities.

   c. Main located in areas subject to heavy shock or vibration.

UNDERGROUND PIPING (cont'd)

- Protection from freezing.
  - Mains shall be located no less than 1 foot below the frost line.
  - Determined by the locality for the maximum depth of frost.
  - Located below the frost line where entering streams or other bodies of water.

Slide 3-52

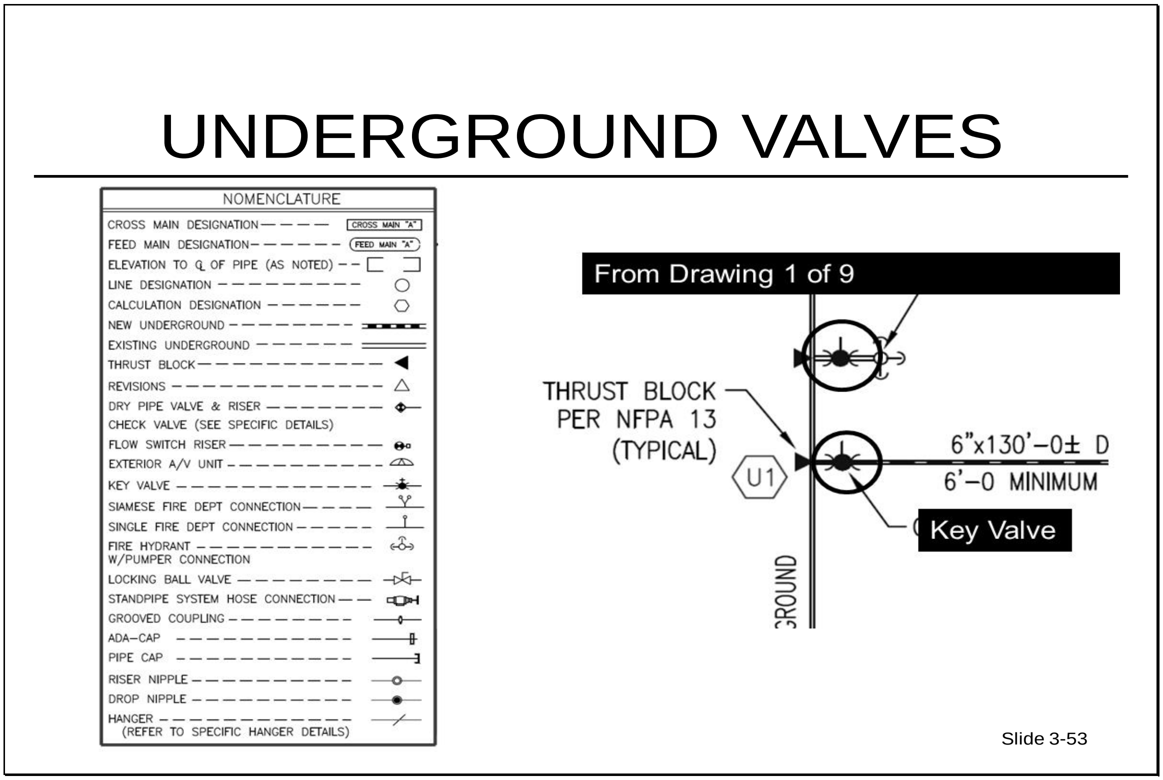
8. Protection from freezing.

   a. Mains shall be located no less than 1 foot below the frost line.

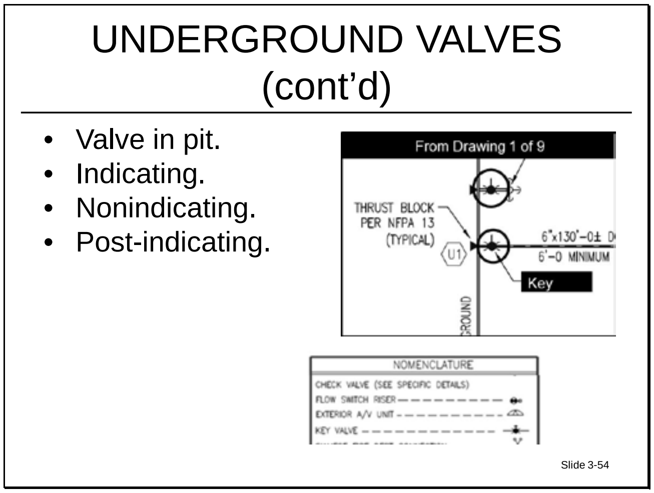
   b. Often determined by the locality for the maximum depth of frost penetration.

   c. Located below the frost line where entering streams or other bodies of water.

- Bury at least 1 foot below bed of the waterway.
- Located proper distance from bank and embankment walls to prevent freezing through side of bank.



F. Underground valves.

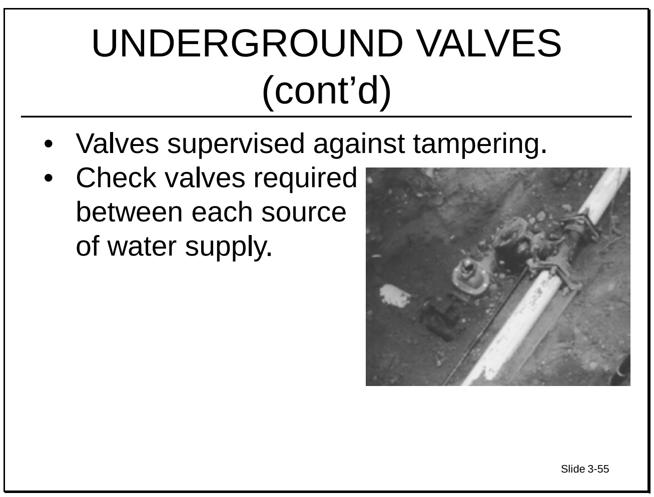


1. Valve in pit.

2. Indicating.

3. Nonindicating.

4. Post-indicating valve.

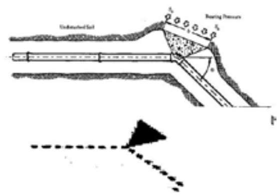


5. Valves supervised against tampering.

6. Check valves required between each source of water supply.

THRUST BLOCKS

- One type of engineered design method for providing resistance to thrust forces.



Thrust Block Symbol

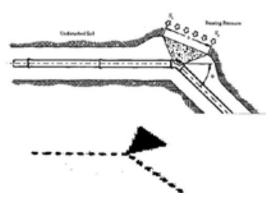
Slide 3-56

G. Thrust blocks.

1. One type of the engineered design methods for providing resistance to thrust forces.

THRUST BLOCKS (cont'd)

- Placed between undisturbed earth and the fitting to be restrained.
- Thrust blocks are constructed of concrete mix.



Thrust Block Symbol

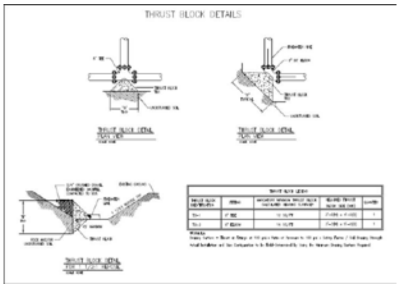
Slide 3-57

2. Placed between undisturbed earth and the fitting to be restrained.

3. Constructed of specific concrete mix.

THRUST BLOCKS (cont'd)

- The plan reviewer needs to know the size of the thrust block in locations as needed.



Slide 3-58

4. The plan reviewer needs to know the size of the thrust block in locations as needed.

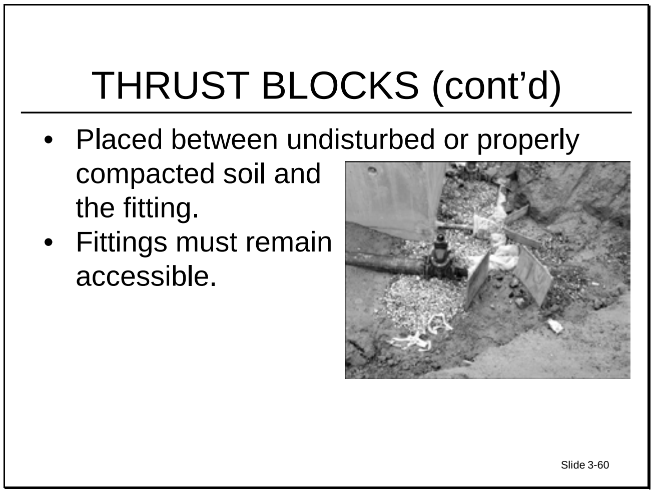
THRUST BLOCKS (cont'd)

- Only where soil is suitable.
- Poured-in-place concrete.

Slide 3-59

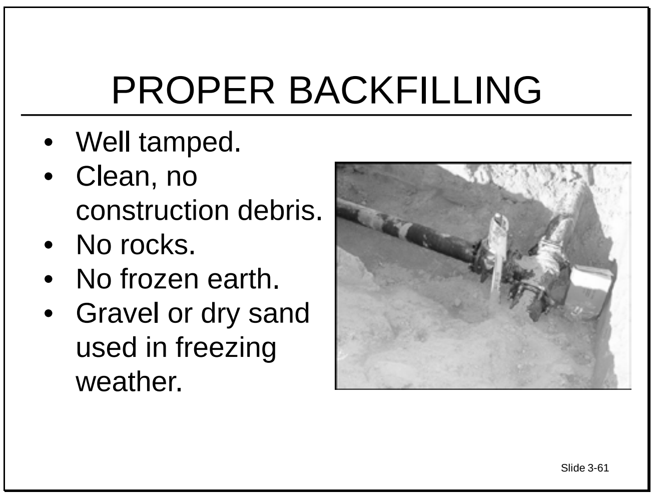
5. Used only where soil is suitable.

6. Poured-in-place concrete.



7. Placed between undisturbed or properly compacted soil and the fitting.

8. Fittings must remain accessible.



H. Proper backfilling.

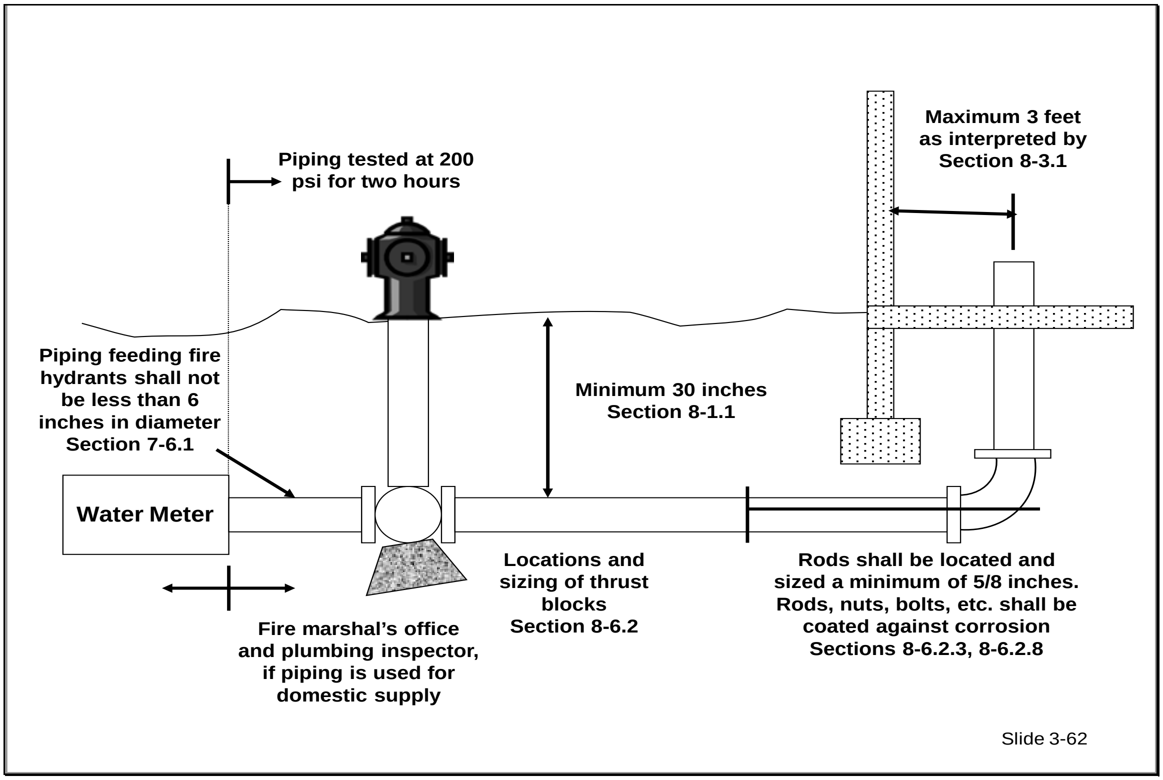
1. Well tamped.

2. Clean, no construction debris.

3. No rocks.

4. No frozen earth.

5. Gravel or dry sand used in freezing weather.



6. Diagram of backfilled underground system.

RESTRAINED JOINT SYSTEMS

- Locking mechanical or push-on joints.
- Mechanical joints utilizing setscrew retainer glands.
- Bolted flange joints.
- Heat-fused or welded joints.
- Pipe clamps and tie rods.
- Other approved methods or devices.

Slide 3-63

I. Restrained joint systems.

1. Locking mechanical or push-on joints.

2. Mechanical joints utilizing setscrew retainer glands.

3. Bolted flange joints.

4. Heat-fused or welded joints.

5. Pipe clamps and tie rods.

6. Other approved methods or devices.

FIRE DEPARTMENT ACCESS

- Fire department connections.
- Private hydrants.
- Supply and valves.

Slide 3-64

J. Fire department access.

1. Fire department connections.

2. Private hydrants.

3. Supply and valves.

PRIVATE WATER STORAGE

- Elevated tanks.
- Suction tanks.
- Pressure tanks.
- Reservoir.

Slide 3-65

K. Private water storage.

1. Elevated tanks.

2. Suction tanks.

3. Pressure tanks.

4. Reservoir.

BACKFLOW PREVENTION DEVICE

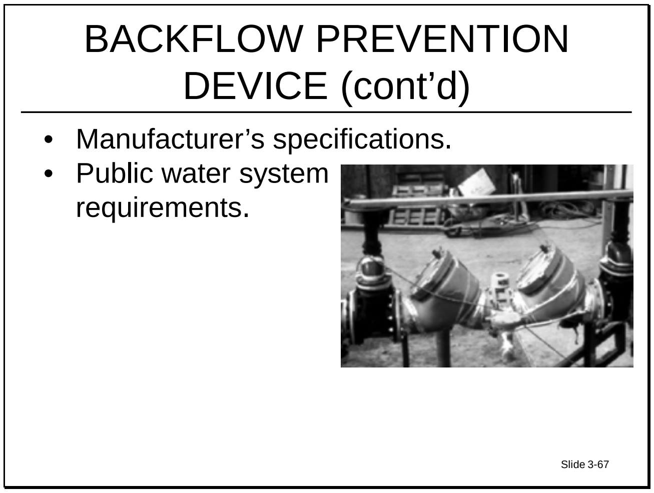
- Protect potable supply from potential contamination.
- Vertical and horizontal installations.

Slide 3-66

L. Backflow prevention device.

1. Protect potable supply from potential contamination.

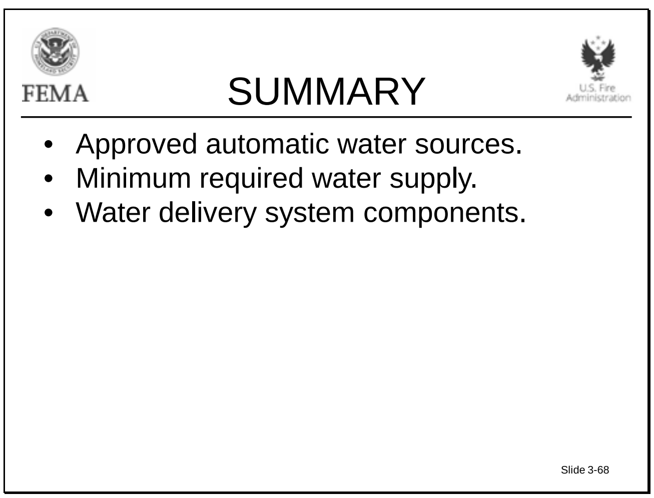
2. Vertical and horizontal installations.



3. Manufacturer's specifications.

4. Public water system requirements.

IV. SUMMARY



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UNIT 4: SYSTEM COMPONENTS AND MATERIALS

TERMINAL OBJECTIVE

The students will be able to:

4.1 Given the design criteria of a water supply system and a set of plans, verify the adequacy of water-based fire protection system components for the intended use and compliance with recognized listings, standards and manufacturers' specifications.

ENABLING OBJECTIVES

The students will be able to:

4.1 Verify that specified pipe meets all requirements and listings for its intended use and installation in accordance with recognized codes and standards.

4.2 Identify the characteristics and limitations of various types of pipe in accordance with the listings and approvals.

4.3 Interpret the information on a product data sheet in relation to required specifications and listings intended for use as a part of a water-based fire protection system design.

4.4 Recognize and interpret the differences and limitations of information provided by those documents supplied from a variety of recognized testing and approval agencies.

4.5 Use provided data sheets to identify the corresponding components and equipment on system design drawings.

4.6 Determine the arrangement of the fire pump.

4.7 Verify the appropriate size of the pump for required pressure and flow characteristics of the design of the water-based fire protection system.

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FEMA

U.S. Fire Administration

UNIT 4: SYSTEM COMPONENTS AND MATERIALS

Slide 4-1

TERMINAL OBJECTIVE

Given the design criteria of a water supply system and a set of plans, verify the adequacy of water-based fire protection system components for the intended use and compliance with recognized listings, standards and manufacturers' specifications.

Slide 4-2

ENABLING OBJECTIVES

- Verify that specified pipe meets all requirements and listings for its intended use and installation in accordance with recognized codes and standards.
- Identify the characteristics and limitations of various types of pipe in accordance with the listings and approvals.

Slide 4-3

I. TECHNICAL COMPONENTS

A. Riser details.

1. Riser.

2. Flow switch.

3. Trim.

4. Alarm valve.

5. To dry switch.

6. Drain line.

7. Indicating valve.

8. Backflow device.

9. Scale.

10. Butterfly system control valve.

TECHNICAL COMPONENTS (cont'd)

- Piping detail of the fire department connection.
  – Ball drip valve.
  – Check valve.

Slide 4-7

B. Piping detail of the fire department connection.

1. Ball drip valve.

2. Check valve.

TECHNICAL COMPONENTS (cont'd)

- The sprinkler system trunk or principal feed main usually contains the alarm valve, main drain, alarm components, and normally a vertical section.

Slide 4-8

C. The sprinkler system trunk or principal feed main usually contains the alarm valve, main drain, alarm components, and normally a vertical section.

SYSTEM PIPING SPECIFICATIONS

- Table 6.3.1.1 of National Fire Protection Association (NFPA) 13, *Standard for the Installation of Sprinkler Systems*.
- Manufacturer's system specifications.
- Manufacturer's submittal data.

Table 6.3.1.1 Pipe or Tube Materials and Dimensions

Materials and Dimensions	Standard
Ferrous Piping (Welded and Seamless)	
Specification for black and hot-dipped zinc-coated (galvanized) welded and seamless steel pipe for fire protection use	ASTM A 795
Specification for welded and seamless steel pipe	ANSI/ASTM A 53
Wrought steel pipe	ANSI/ASME B36.10M
Specification for electric-resistance-welded steel pipe	ASTM A 135
Copper Tube (Drawn, Seamless)	
Specification for seamless copper tube	ASTM B 75
Specification for seamless copper water tube	ASTM B 88
Specification for general requirements for wrought seamless copper and copper alloy tube	ASTM B 251
Fluxes for soldering applications of copper and copper alloy tube	ASTM B 813
Brazing filler metal (classification BCuP-3 or BCuP-4)	AWS A5.8
Solder metal, Section 1: Solder alloys containing less than 0.2% lead and having solidus temperatures greater than 400°F	ASTM B 32
Alloy materials	ASTM B 446

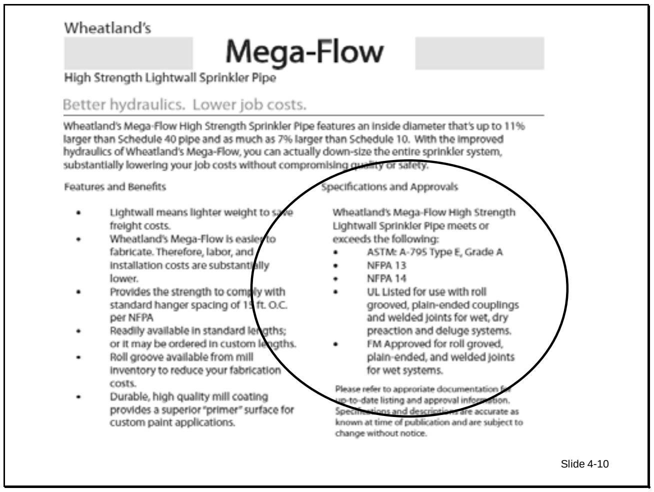
Slide 4-9

D. System piping specifications.

1. Table 6.3.1.1 (National Fire Protection Association (NFPA) 13, *Standard for the Installation of Sprinkler Systems*, 2010, p. 13-29).

2. Manufacturer's system specifications.

3. Manufacturer's submittal data.


Wheatland's

Mega-Flow

High Strength Lightwall Sprinkler Pipe

Better hydraulics. Lower job costs.

Wheatland's Mega-Flow High Strength Sprinkler Pipe features an inside diameter that's up to 11% larger than Schedule 40 pipe and as much as 7% larger than Schedule 10. With the improved hydraulics of Wheatland's Mega-Flow, you can actually down-size the entire sprinkler system, substantially lowering your job costs without compromising quality or safety.

Features and Benefits

- Lightwall means lighter weight to save freight costs.
- Wheatland's Mega-Flow is easier to fabricate. Therefore, labor, and installation costs are substantially lower.
- Provides the strength to comply with standard hanger spacing of 15 ft. O.C. per NFPA
- Readily available in standard lengths; or it may be ordered in custom lengths.
- Roll groove available from mill inventory to reduce your fabrication costs.
- Durable, high quality mill coating provides a superior "primer" surface for custom paint applications.

Specifications and Approvals

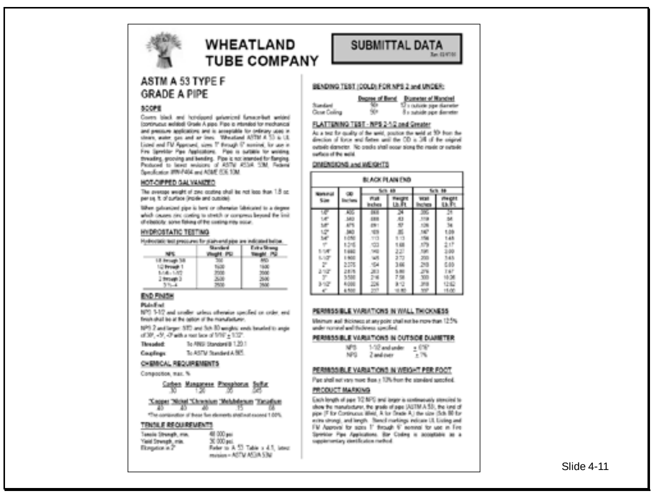
Wheatland's Mega-Flow High Strength Lightwall Sprinkler Pipe meets or exceeds the following:

- ASTM: A-795 Type E, Grade A
- NFPA 13
- NFPA 14
- UL Listed for use with roll grooved, plain-ended couplings and welded joints for wet, dry preaction and deluge systems.
- FM Approved for roll groved, plain-ended, and welded joints for wet systems.

Please refer to approriate documentation for up-to-date listing and approval information. Specifications and descriptions are accurate as known at time of publication and are subject to change without notice.

Slide 4-10

4. Mega-Flow: example of manufacturer data and standards that this pipe meets or exceeds.



5. Wheatland Tube Company: example of manufacturer data.

"C" VALUES AND CONVERSION CHARTS

- Chart shows "C" values of different pipes.

Table 22.4.7 Hazen-Williams *C* Values

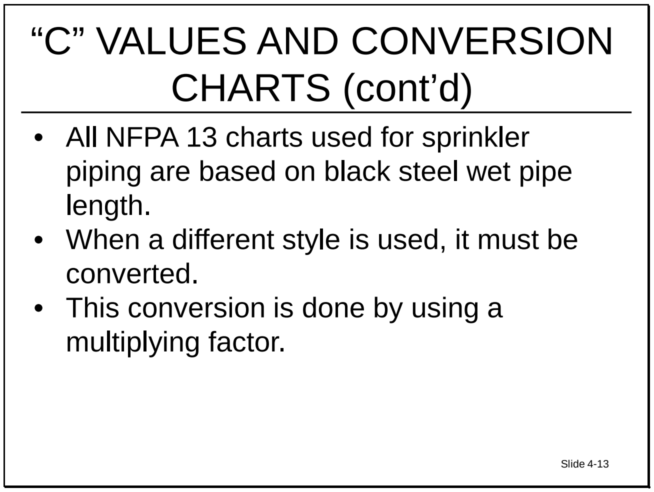
Pipe or Tube	*C* Value*
Unlined cast or ductile iron	100
Black steel (dry systems including preaction)	100
Black steel (wet systems including deluge)	120
Galvanized (all)	120
Plastic (listed) all	150
Cement-lined cast or ductile iron	140
Copper tube or stainless steel	150
Asbestos cement	140
Concrete	140

*The authority having jurisdiction is permitted to consider other *C* values.

Slide 4-12

E. “C” values and conversion charts. Table 22.4.4.7 Hazen-Williams C Values (NFPA 13, 2010, p. 13-227).

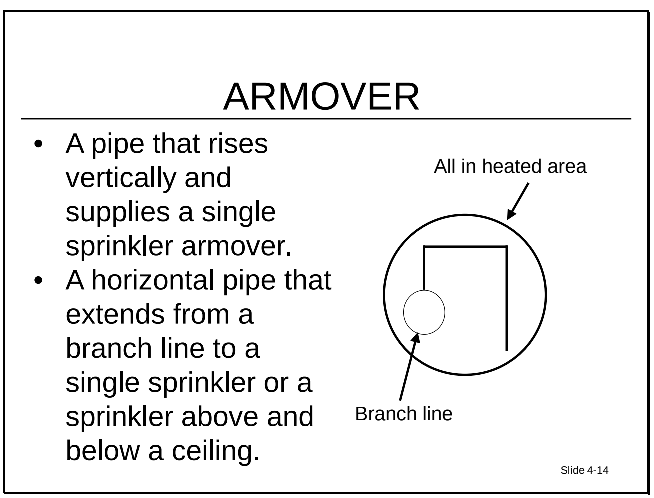
1. Chart shows “C” values of seven different pipes.



2. All NFPA 13 charts that are used for sprinkler piping are based on the black steel wet pipe length.

3. When a different style of pipe is used, it must be converted into black steel wet pipe.

4. This conversion is done by using a multiplying factor.



F. Armover.

1. A pipe that rises vertically and supplies a single sprinkler armover. This helps to protect against freezing.

2. A horizontal pipe that extends from a branch line to a single sprinkler or a sprinkler above and below a ceiling.

UNSUPPORTED ARMOVER LENGTH

- “Armover” is three pipe lengths connected at right angles for the branch line.
- Total horizontal length of unsupported armover to sprinkler, sprinkler drop, or sprig must not exceed 24 inches for steel pipe or 12 inches for copper tube.
- 100 pounds per square inch (psi) rule for pendent heads.

Slide 4-15

3. Unsupported armover length.

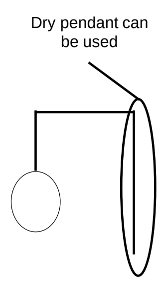
   a. “Armover” is three pipe lengths connected at right angles for the branch line.

   b. Total horizontal length of an unsupported armover to a sprinkler, sprinkler drop, or sprig must not exceed 24 inches for steel pipe or 12 inches for copper tube.

   c. When the maximum static or flowing pressure (other than from the fire department connection) exceeds 100 pounds per square inch (psi) and a branch line above a ceiling supplies sprinklers in a pendent position below the ceiling, the hanger assembly supporting the pipe supplying an end sprinkler in a pendent position must be of a type that prevents upward movement of the pipe.

RETURN BEND

- A series of pipes used to redirect the flow of water from upward to downward. Used on systems that take their water supply from a raw source like a pond or stream.



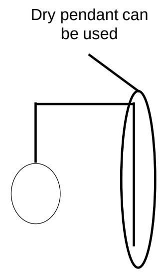
Slide 4-16

G. Return bend.

1. A series of pipes used to redirect the flow of water from upward to downward. Used on systems that take their water supply from a raw source like a pond or stream.

RETURN BEND (cont'd)

- Purpose is to prevent sediment from collecting.
- Also used on dry systems to prevent accumulation or water drops.



Slide 4-17

2. The purpose is to prevent sediment from collecting in the drop nipple. Return bends are used to center sprinklers in ceiling grids or tiles.

3. Return bends are also used with limitations on dry systems to help prevent accumulation or water drops from happening.

RETURN BEND (cont'd)

- Piping hydraulic calculation considerations.
  - Pressure losses created by pipe fittings.
    - -- Interaction of water with surface of pipe.
    - -- Turbulence created by water flow direction changes.
  - Pressure loss per foot based upon pipe size and coefficient of friction.
  - Pressure losses also depend on actual water flow.
  - Pipe coefficients are provided on calculations by the designer.

Slide 4-18

4. Piping hydraulic calculation considerations.

   a. Pressure losses created by pipe fittings.

      - Interaction of water with surface of pipe.

      - Turbulence created by water flow direction changes.

b. Pressure loss per foot is based upon pipe size and coefficient of friction.

c. Pressure losses also depend on actual water flow.

d. Pipe coefficients are provided on calculations by designer. May need to check the calculations periodically.

RETURN BEND (cont'd)

– Friction loss per foot of pipe using Hazen-Williams formula.

Hazen-Williams Formula

$$FL = \frac{4.52 \times q^{1.85}}{C^{1.85} \times D^{4.87}}$$

FL – friction head loss in feet of water per 1 foot of pipe.
C – Hazen-Williams roughness constant.
q – volume flow (gallons per minute (gpm)).
D – inside hydraulic diameter (inches).

Slide 4-19

e. Friction loss per foot of pipe using Hazen-Williams formula. Table 22.4.4.7 Hazen-Williams C Values (NFPA 13, 2010, p. 13-227).

- FL — friction head loss in feet of water per 1 foot of pipe.
- C — Hazen-Williams roughness constant.
- q — volume flow (gallons per minute (gpm)).
- D — inside hydraulic diameter (inches).

"C" VALUES AND CONVERSION CHARTS (cont'd)

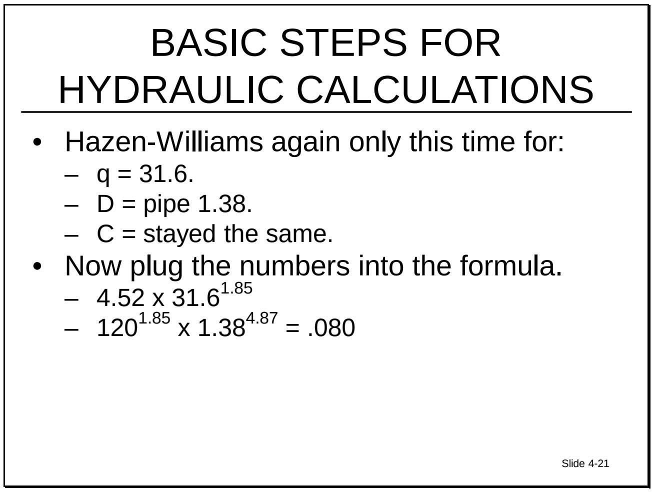
Table 22.4.4.7 Hazen-Williams *C* Values

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 (all)	120
Plastic (listed) all	150
Cement-lined cast or ductile iron	140
Copper tube or stainless steel	150
Asbestos cement	140
Concrete	140

*The authority having jurisdiction is permitted to consider other *C* values.

Slide 4-20

- Using the conversion chart, the “C” value is 120.



- Hazen-Williams again only this time for:

  -- q = 31.6.

  -- D = pipe 1.38.

  -- C = stayed the same.

  -- Now plug the numbers into the formula.

NOMINAL INSIDE PIPE DIAMETER COMPARISONS

The chart below compares the I.D.s of Mega-Flow versus Schedule 10 and Schedule 40 sprinkler pipe.

Specifications

NPS	Nominal O.D.	Nominal Inside Diameter			UL CRR*		Wheatland's Mega-Flow	
		Mega-Flow	Sch.10	Sch. 40	Mega-Flow	Sch. 40	Nom. Wt./Ft.	Pcs/Lift
1 1/4	1.660	1.530	1.442	1.380	1.80	1.00	1.108	61
1 1/2	1.900	1.740	1.682	1.610	2.64	1.00	1.556	61
2	2.375	2.215	2.157	2.067	2.14	1.00	1.961	37
2 1/2	2.875	2.707	2.635	2.469	1.43	1.00	2.504	30
3	3.500	3.316	3.260	3.068	1.34	1.00	3.349	19
4	4.500	4.316	4.260	4.026	1.00	1.00	4.331	19
6	6.625	6.395	6.357	6.065	.75	1.00	8.000	10

* Calculated using Standard UL CRR formula, UL Fire Protection Directory, Category VIZY

* The CRR is a ratio value used to measure the ability of a pipe to withstand corrosion. Schedule 40 steel pipe is used as the benchmark (value of 1.0).

Slide 4-22

STANDARD BLACK STEEL (WET) PIPE

- Hazen-Williams again only this time for:
  - q = 52.1.
  - D = pipe 1.38.
  - C = stayed the same.
- Now plug the numbers into the formula.
  - $4.52 \times 52.1^{1.85}$
  - $120^{1.85} \times 1.38^{4.87} = .201$

Slide 4-23

- Standard black steel (wet) pipe.
  - q = 52.1.
  - D = pipe 1.38.
  - C = stayed the same.
  - Now plug the numbers into the formula.

SCHEDULE 7 MEGA-FLOW PIPE

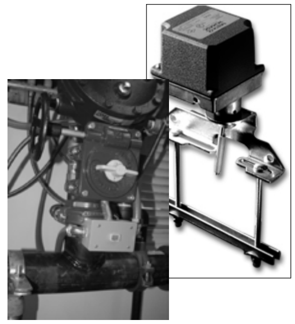
- Hazen-Williams again only this time for:
  - q = 52.1.
  - D = pipe 1.53.
  - C = stayed the same.
- Now plug the numbers into the formula.
  - $4.52 \times 52.1^{1.85}$
  - $120^{1.85} \times 1.53^{4.87} = .122$

Slide 4-24

- Schedule 7 Mega-Flow pipe.
  - q = 52.1.
  - D = pipe 1.53.
  - C = stayed the same.
  - Now plug the numbers into the formula.

WATER FLOW DETECTION

Pressure switches, flow switches, or a water motor gong
is used to detect flow or pressurization of the system.



Slide 4-25

H. Water flow detection.

Pressure switches, flow switches, or a water motor gong is used to detect the flow or pressurization of the system and used to notify occupants and/or alarm the monitoring service.

CONTROL VALVE

- Connections should be under control of an outside listed control valve.
- Each system shall be provided with a listed control valve.

Slide 4-26

I. Control valve.

1. Water supply connections should be under the control of an outside listed control valve (post-indicating valve (PIV)).

2. Each sprinkler system shall be provided with a listed control valve located to control all automatic water sources.

Slide 4-27

3. Valve positioning depends on the type of system and if multiple systems share manifold water supply riser.

CONTROL VALVE (cont'd)

- Indicating.
- Nonindicating.

Slide 4-28

4. Any control valve located overhead shall be installed in a way that allows a visualization of the indicating device from the floor below.

MAIN DRAIN

- Required on all systems to allow for drainage of piping.
- Main drains are essential in evaluating the condition of a water supply system.
- Drains need to discharge outside unless the floor drain can handle the full flow.

Slide 4-29

J. Main drain.

1. Required on all systems to allow for drainage of piping.

2. Main drains are essential for evaluating the condition of the water supply system.

3. Drains need to discharge outside unless the floor drain can handle the full flow.

MAIN DRAIN (cont'd)

- Installed above the alarm check valve.
- Size of drain determined by size of riser.
  - Riser < 2 inch = 3/4-inch drain.
  - Riser 2 1/2 to 3 1/2 inches = 1 1/4-inch drain.
  - Riser 4 inches or larger = 2-inch drain.

Slide 4-30

4. Installed above the alarm check valve.

5. Size of drain determined by size of riser:

   a. Riser < 2 inch = 3/4-inch drain.

   b. Riser 2 1/2 to 3 1/2 = 1 1/4-inch drain.

   c. Riser 4 inch or larger = 2-inch drain.

BACKFLOW FORWARD TESTING

- Provides a means for flow testing of backflow prevention devices, as required by NFPA 13 Section 8.17.4.6.1.
- Ensure that adequate flow is available from supply piping and that backflow device's performance has not degraded over time.

Slide 4-31

K. Backflow forward testing (flow testing of backflow prevention devices).

1. Provides a means for flow testing of backflow prevention devices, as required by NFPA 13 Section 8.17.4.6.1.

2. The purpose is to ensure that adequate flow is available from the supply piping and that the backflow device's performance has not degraded over time.

BACKFLOW FORWARD TESTING (cont'd)

- The flow shall not be less than the system demand, including hose streams.

Slide 4-32

3. 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.
- Need to have pressure range at least twice the anticipated system working pressure.

Slide 4-33

L. Gauges.

1. Must be listed for sprinkler service and are to be installed:

a. Above and below the alarm check valve on wet systems.

b. Above and below the clapper, air line, accelerators, and exhausters on dry systems.

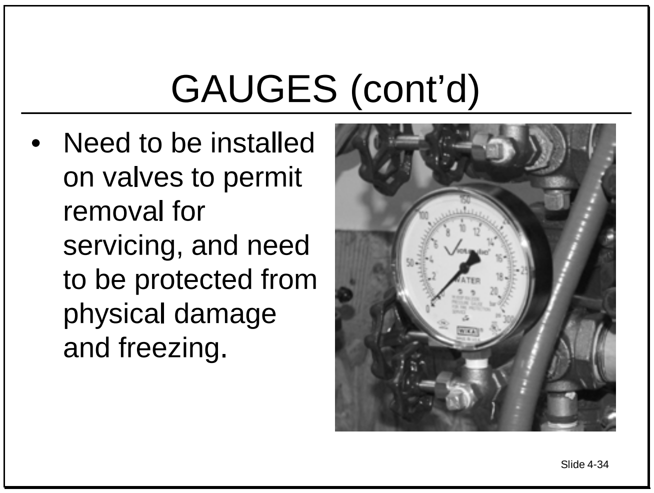
c. Above and below the preaction valve and on the air supply.

d. Below the deluge valve.

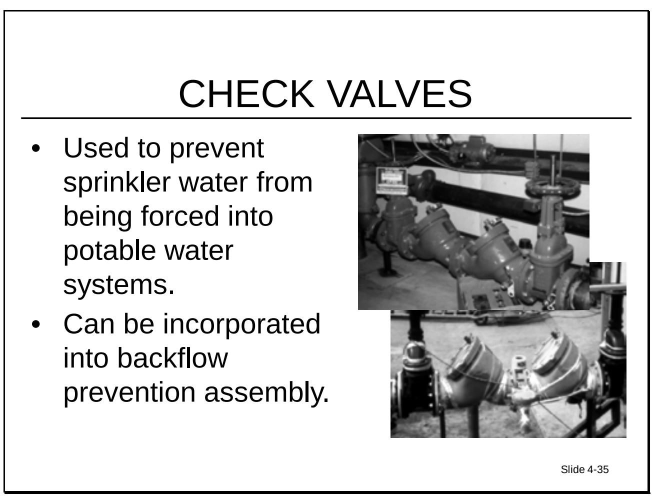
e. Before and after any pressure regulating device.

f. At the top of each standpipe riser.

2. Gauges need to have a pressure range at least twice the anticipated system working pressure.



3. Gauges need to be installed on valves to permit removal for servicing, and they need to be protected from physical damage and freezing.



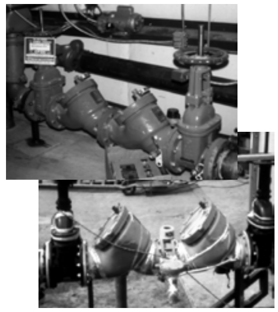
M. Check valves.

1. Used to prevent sprinkler water from being forced into potable water systems.

2. System check valves can be incorporated into the backflow prevention assembly as used in a shotgun riser.

CHECK VALVES (cont'd)

- Cannot be used to subdivide dry sprinkler systems to avoid water delivery time required by NFPA 13 Section 7.2.



Slide 4-36

3. Check valves cannot be used to subdivide dry sprinkler systems into smaller sections to avoid the water delivery time required by NFPA 13 Section 7.2.

FIRE DEPARTMENT CONNECTIONS

- Must be conveniently located.
- May be in local code.
- Proper size and hose connections.

Slide 4-37

N. Fire department connections.

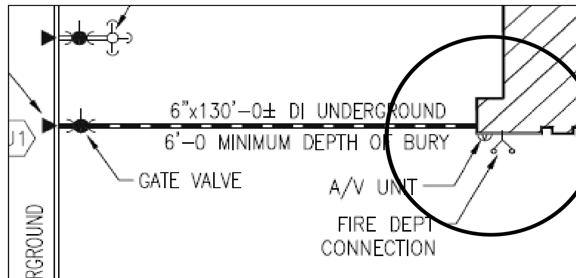
1. Must be conveniently located.

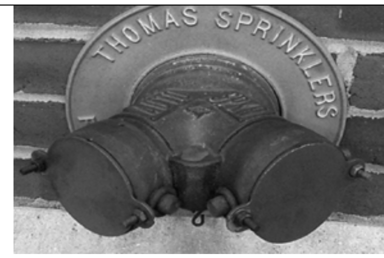
2. May be in local code.

3. Proper size and hose connections.

FIRE DEPARTMENT CONNECTIONS (cont'd)

- Supplements pressure and volume.



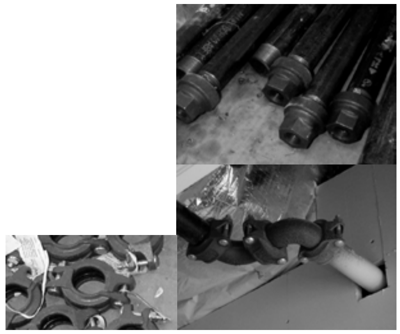


Slide 4-38

4. Supplements pressure and volume.

FITTINGS

Fitting types.
- Threaded.
- Grooved.



Slide 4-39

O. Fittings.

1. Fitting types.

   a. Threaded.

   b. Grooved.

2. Fitting materials and dimensions.

FITTING MATERIALS AND DIMENSIONS

- American Society of Mechanical Engineers (ASME) reference.

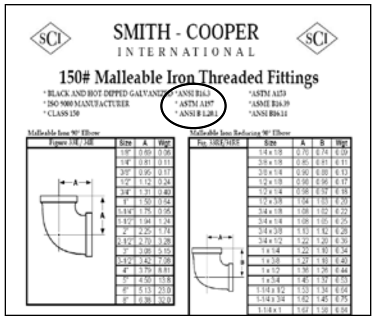
Cast Iron	
Cast Iron threaded fittings	ASME B 16.4
Cast Iron pipe flanges	ASME B 16.1
Malleable Iron	
Malleable Iron threaded fittings	ASME B 16.3
Factory made Wrought Steel	ASME B 16.9
Buttwelding Ends	ASME B 16.25
Wrought Carbon Steel and Alloy	ASME A 234
Steel Pipe	ASME B 16.5
Forged Steel	ASME B 16.11
Wrought Copper and Copper Alloy	ASME B 16.22
Cast Copper Alloy	ASME B 16.18
Specially Listed	
CPVC for Schedule 80 threaded	ASTM F 437
CPVC for Schedule 40 Socket	ASTM F 438
CPVC for Schedule 80 Socket	ASTM F 439

Slide 4-40

   a. American Society of Mechanical Engineers (ASME) reference (from Learning Square Reference Data).

FITTING MATERIALS AND DIMENSIONS (cont'd)

- Manufacturer American National Standards Institute (ANSI) reference.



Slide 4-41

b. Manufacturer American National Standards Institute (ANSI) reference (from Learning Square Reference Data).

FITTING PRESSURE LIMITS

- Permitted where pressures do not exceed 300 psi.
  - Cast iron fittings up to 2 inches in diameter.
  - Malleable fittings up to 6 inches in diameter.
- Listed fittings shall be permitted up to limits of listing.
- Screwed union allowed in piping up to 2 inches in diameter.

Slide 4-42

P. Fitting pressure limits.

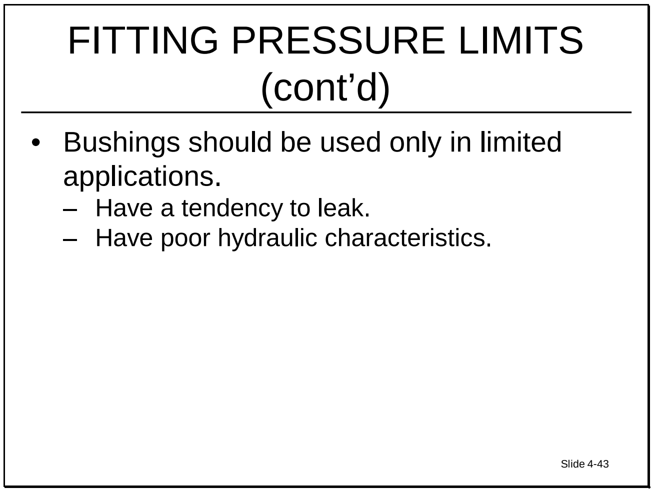
1. Permitted where pressures do not exceed 300 psi.

    a. Cast iron fittings up to 2 inches in diameter.

    b. Malleable fittings up to 6 inches in diameter.

2. Listed fittings shall be permitted up to limits of listing.

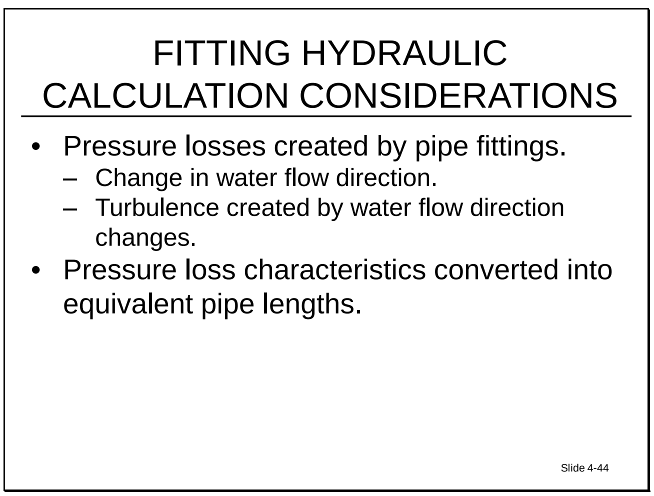
3. Screwed union allowed in piping up to 2 inches in diameter.



4. Bushings should be used only in limited applications.

   a. Have a tendency to leak.

   b. Have poor hydraulic characteristics.



Q. Fitting hydraulic calculation considerations.

1. Pressure losses created by pipe fittings.

   a. Change in water flow direction.

   b. Turbulence created by water flow direction changes.

2. Pressure loss characteristics converted into equivalent pipe lengths.

FITTING HYDRAULIC CALCULATION CONSIDERATIONS (cont'd)

- Based upon the size of fittings and fitting purpose.
  - Change in direction flow with tee.
  - Flow split and change in direction with elbow/cross.
- Equivalent pipe lengths also depend on actual water flow.
- Pipe lengths provided on calculations by designer.

Slide 4-45

3. Based upon the size of fittings and fitting purpose.

   a. Change in direction flow with tee.

   b. Flow split and changes in direction with elbow/cross.

4. Equivalent pipe lengths also depend on actual water flow.

5. Pipe lengths are provided on calculations by designer.

TEST/DRAIN CONNECTIONS

- Inspector's test — verify presence and location on plans.
  - Wet system — anywhere.
  - Dry system — highest; most remote.

Slide 4-46

R. Test/Drain connections.

Inspector's test — verify presence and location on plans.

1. Wet system — anywhere.

2. Dry system — highest; most remote.

TEST/DRAIN CONNECTIONS (cont'd)

– The inspector's test must simulate the opening of one sprinkler head and should have a reducing orifice equal to the smallest head on the system being tested.

Slide 4-47

3. The inspector's test must simulate the opening of one sprinkler head and should have a reducing orifice equal to the smallest head on the system being tested.

TEST/DRAIN CONNECTIONS (cont'd)

- Auxiliary drains required on trapped pipe.
- Small isolated sections may remove single pendent head.

Slide 4-48

4. Auxiliary drains required on trapped pipe.

5. Small isolated sections may remove single pendent head.

TEST/DRAIN CONNECTIONS (cont'd)

- Dry systems require additional drains.
- Drum drips to be accessible.

Slide 4-49

6. Dry systems require additional drains.

7. Drum drips to be accessible.

TEST/DRAIN CONNECTIONS (cont'd)

- Prefabricated units.

Slide 4-50

8. Prefabricated units.

AUXILIARY DRAINS

- Directional change allows draining.
- No direct connection to sewers.

Slide 4-51

S. Auxiliary drains.

1. Directional change allows draining.

2. No direct connection to sewers.

HANGERS

- Essential components that connect fire protection system to building.
- Support weight of water-filled pipe.
  - Must support 5 times the weight of pipe plus 250 pounds (lbs).
  - Building must be designed to support load points.
  - Except for mild steel rods, all hangers must be listed.

Slide 4-52

T. Hangers.

1. Hangers are the essential components that connect the fire protection system to the building.

2. Hangers support the weight of the water-filled pipe.

   a. Hangers must be able to support five times the weight of the water-filled pipe, plus 250 pounds (lbs).

   b. Building must be designed to support these point loads.

   c. May need a structural engineer's report or concurrence (sealed and signed calculations) to verify load carrying capacity.

   d. Except for mild steel rods, all hangers must be listed.

HANGERS (cont'd)

- Minimum number of hangers.
  - Generally, at least one hanger for each section of pipe.
  - Exceptions:
    - -- Sprinklers spaced less than 6 feet apart.
    - -- Starter lengths less than 6 feet do not require a hanger.
  - "Starter length" is first branch line off cross main.

Slide 4-53

3. Minimum number of hangers.

   a. Generally, there must be at least one hanger for each section of pipe.

      Exceptions:

      - When sprinklers are spaced less than 6 feet apart, hangers spaced up to a maximum of 12 feet are permitted.

      - Starter lengths less than 6 feet do not require a hanger, unless on the end line of a side-feed system or where an intermediate cross main hanger has been omitted.

   b. A "starter length" is the first branch line off the cross main. (The cross main hanger carries the load.)

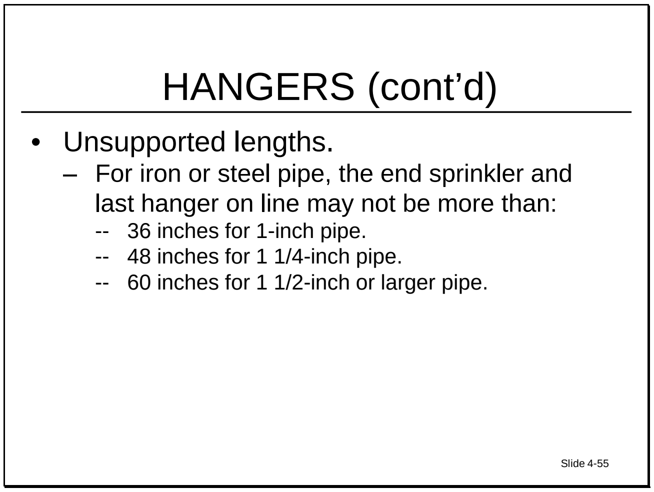
HANGERS (cont'd)

- Clearance to hangers.
  - 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.

Slide 4-54

4. Clearance to hangers.

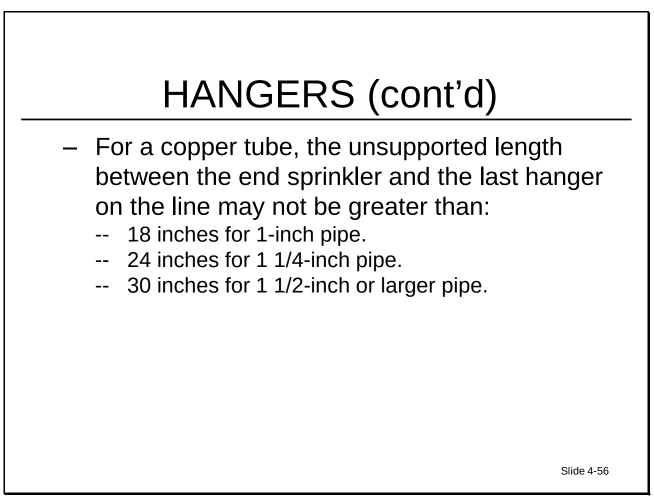
The distance between a hanger and the centerline of an upright sprinkler must not be less than 3 inches to prevent the hanger from creating a "shadow" in the water spray pattern.



5. Unsupported lengths (general).

a. For iron or steel pipe, the unsupported length between the end sprinkler and the last hanger on the line may not be more than:

- 36 inches for 1-inch pipe.
- 48 inches for 1 1/4-inch pipe.
- 60 inches for 1 1/2-inch or larger pipe.

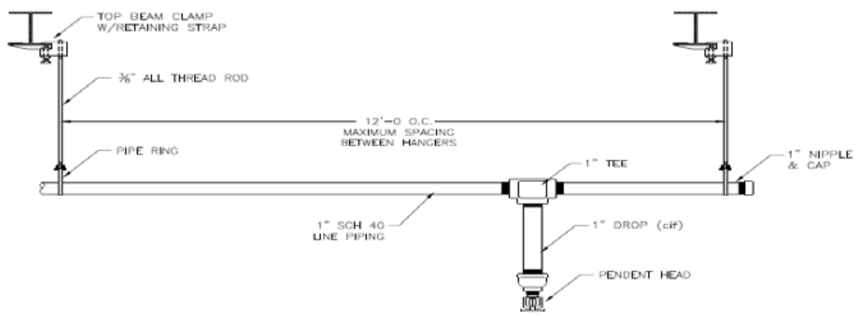


b. For copper tube, the unsupported length between the end sprinkler and the last hanger on the line may not be greater than:

- 18 inches for 1-inch pipe.
- 24 inches for 1 1/4-inch pipe.
- 30 inches for 1 1/2-inch or larger pipe.

HANGERS (cont'd)

– Where these limits are exceeded, the pipe must be extended beyond the end sprinkler and must be supported by an additional hanger.



Slide 4-57

c. When these limits are exceeded, the pipe must be extended beyond the end sprinkler and must be supported by an additional hanger.

HANGERS (cont'd)

- Restraints for high water pressures.
  - Maximum static or flowing pressure exceeds 100 psi.
  - A branch line above ceiling supplies sprinklers in a pendent position below ceiling.
  - Hanger assembly supporting pipe must be of a type that prevents upward movement of pipe.

Slide 4-58

6. Restraints for high water pressures.

   a. When the maximum static or flowing pressure (other than from the fire department connection) exceeds 100 psi.

   b. A branch line above a ceiling supplies sprinklers in a pendent position below the ceiling.

   c. The hanger assembly supporting the pipe supplying an end sprinkler in a pendent position must be of a type that prevents upward movement of the pipe.

HANGERS (cont'd)

  - 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 or 6 inches for copper pipe.

Slide 4-59

   d. 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 or 6 inches for copper pipe.

SPRIGS

- Nipple between branch line and sprinkler that is vertical.
- Sprigs 4 feet or longer must be restrained against lateral movement.

Slide 4-60

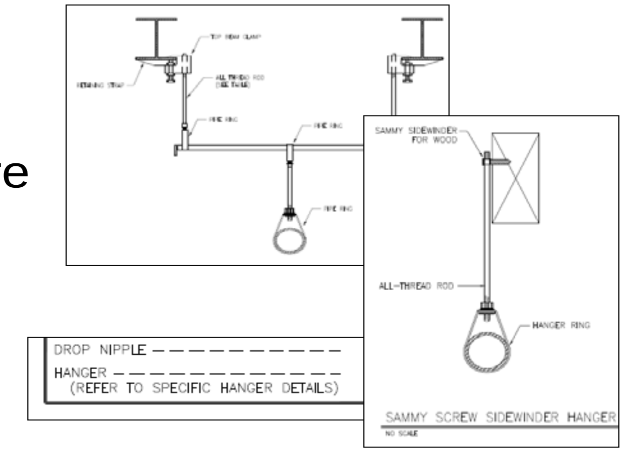
U. Sprigs.

1. A nipple between the branch line and sprinkler that is vertical.

2. Sprigs 4 feet or longer must be restrained against lateral movement.

LOCATION OF HANGERS ON MAINS

One hanger is required on each section of cross mains, but there are exceptions.



Slide 4-61

V. Location of hangers on mains.

One hanger required on each section of cross mains, except:

1. For cross mains in steel pipe systems in bays having **two** branch lines, the intermediate hanger may be omitted. Then a hanger attached to a purlin must be installed on each branch line located as near to the cross main as the location of the purlin permits.

2. For cross mains in steel pipe systems only in bays having **three** branch lines, either side or center feed, only one intermediate hanger may be omitted, provided that a hanger attached to a purlin is installed on each branch line located as near to the cross main as the location of the purlin permits.

3. For cross mains in steel pipe systems only in bays having **four** or more branch lines, either side or center feed, two intermediate hangers may be omitted, provided the maximum distance between the hangers does not exceed the required distance. A hanger attached to a purlin on each branch line is located as near to the cross main as the purlin permits.

4. At the end of the main, intermediate trapeze hangers must be installed, unless the main is extended to the next framing member with a hanger installed on it.

RISER SUPPORTS

- Standpipe and sprinkler main risers must be supported to prevent movement.
  - Riser clamps or hangers located on horizontal connections within 24 inches of centerline of riser.
  - Riser clamps anchored to walls using hanger rods in horizontal position may not support risers.

Slide 4-62

W. Riser supports.

1. Standpipe and sprinkler main risers must be supported to prevent movement.

   a. Riser clamps or hangers located on the horizontal connections within 24 inches of the centerline of the riser.

   b. Riser clamps anchored to walls using hanger rods in the 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.

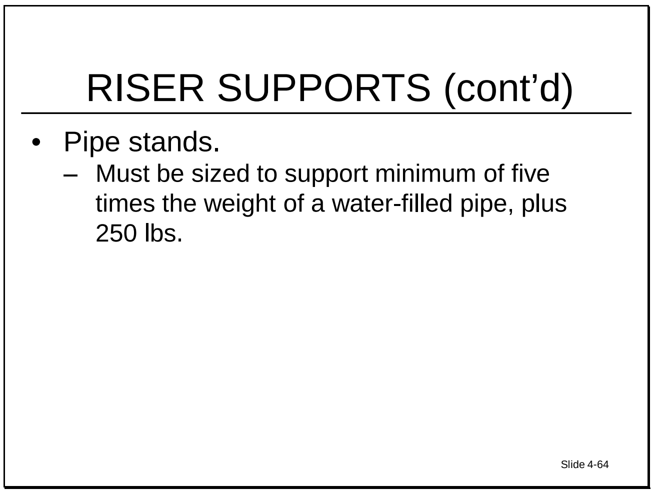
Slide 4-63

2. Multistory buildings.

   a. In multistory buildings, 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 also restrain the pipe to prevent movement by an upward thrust where flexible fittings are used.

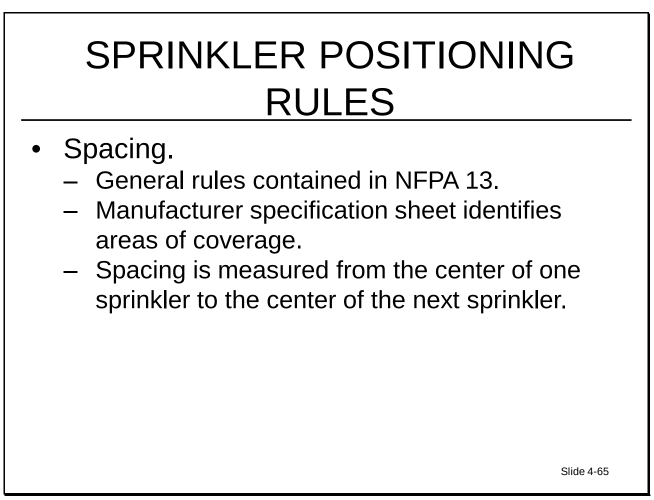
   c. Distance between supports for risers is not to exceed 25 feet.



3. Pipe stands.

   Pipe stands must be sized to support a minimum of five times the weight of the water-filled pipe, plus 250 lbs.

II. SPRINKLER POSITIONING RULES

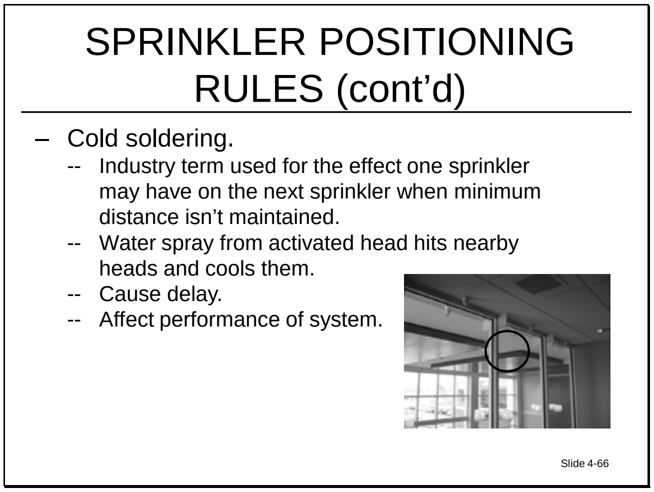


A. Spacing.

1. General rules contained in NFPA 13.

2. Manufacturer 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 the minimum distance is not maintained.

b. Problem is that the water spray from the activated head would hit the nearby heads that are under the minimum distance, thus cooling the sprinkler fusible link or bubble.

c. This would cause a delay or prevent the head from fusing and opening.

d. Since the system is engineered, it would affect the performance of the system and cause for additional heads away from the fire source to open.

SPRINKLER POSITIONING RULES (cont'd)

- Water curtains becoming more prevalent.
  - Especially where openings are required.
  - Codes recognize areas or spaces but have not looked at problems where common areas are shared. The buildings could be sold separately in the future.

Slide 4-67

5. Use of water curtains is becoming more prevalent in areas to address design areas and the building codes.

    a. Especially prevalent where openings are required between buildings that share spaces.

    b. Building codes recognize areas or spaces, but they have not looked at problems where common areas are shared. The buildings could be sold separately in the future.

        - For example: a building complex with a parking garage underneath two buildings currently built by one owner, but with separate property surveys and loans.

SPRINKLER POSITIONING RULES (cont'd)

- Clearance from obstructions.
  - General rule is 18 inches from storage.
  - Specific rules for beam- and floor-mounted obstructions.

Slide 4-68

B. Clearance from obstructions.

1. General rule is 18 inches from storage.

2. Specific rules for beam- and floor-mounted obstructions.

SPRINKLER POSITIONING RULES (cont'd)

- Specific rules for Early Suppression Fast Response (ESFR) heads are 36 inches.

Slide 4-69

3. Specific rules for Early Suppression Fast Response (ESFR) heads are 36 inches.

III. SPRINKLERS SIMPLIFIED

SPRINKLER IDENTIFICATION NUMBER

- Effective 2001, sprinkler manufacturers use proprietary five- to six-character identification for:
  - Manufacturer.
  - K-factor.
  - Application (use).

Intermediate Level Upright Rack Storage Head

Slide 4-70

A. Sprinkler Identification Number (SIN).

1. Effective 2001, sprinkler manufacturers use proprietary five- to six-character code to identify sprinklers for:

   a. Manufacturer.

   b. K-factor.

   c. Application (use).

SPRINKLER IDENTIFICATION NUMBER (cont'd)

- Response characteristics.
- Refer to manufacturer for guidance.
- Master list available at www.UL.com.

Intermediate Level Upright Rack Storage Head

Slide 4-71

d. Response characteristics.

2. Must have manufacturer's table or information sheet to interpret.

3. Master list available at www.UL.com.

The Reliable Automatic Sprinkler Co., Inc.
Sprinkler Identification Number (SIN)

R XX X K

K — ***Assigned Numbers, K-factors***

1	*1.10*	*2.82*	*3.00*	*5.40*	*11.40*	*16.00*	*22.40*
2	*1.98*	*2.72*	*3.90*	*5.50*	*8.00*	*14.20*	
3	*1.81*	*3.70*	*4.24*	*14.50*			
4	*2.57*	*4.10*	*5.60*				
5	*3.45*	*4.20*	*5.62*				
6	*4.90*	*5.70*	*7.96*	*11.21*			
7	*2.75*	*4.15*	*6.40*	*8.20*			
8	*5.53*	*7.00*					
9	*Reserve*						
0							

X — ***Deflector style***

1 *Pendent*
2 *Upright*
3 *Horizontal*
4 *EC pendent*
5 *EC upright*
6 *EC horizontal*
7 *Conventional*
8 *Vertical*
9 *Others*

XX — ***Last two digits of bulletin***

R — ***Reliable Automatic Sprinkler Co.***

Sidewall and Upright

Slide 4-72

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	

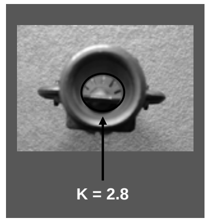
Reliable	Bulletin 17	Conventional	8.0 K-factor
R	**17**	**7**	**2**

Slide 4-73

B. Comparative example of SIN.

ORIFICE SIZE: K-FACTOR

- Constant coefficient of orifice area.
- Higher K-factor means lower friction loss/greater flow.
- Lower K-factor means higher friction loss/ lesser flow.



Slide 4-74

C. Orifice size: K-factor.

1. Coefficient of discharge orifice size used in hydraulic calculations. The numerical designation of the hydraulic waterway within the sprinkler is based on diameter.

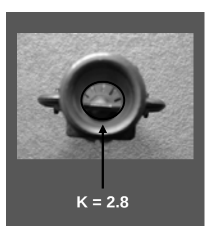
2. Higher K-factor means less friction loss, larger diameter orifice, and greater flow.

3. Lower K-factor means more friction loss and less flow.

   Small K-factor heads must be used only where K5.6 or larger heads operating at 7 psi will not work.

ORIFICE SIZE: K-FACTOR (cont'd)

- No more references to orifice size.

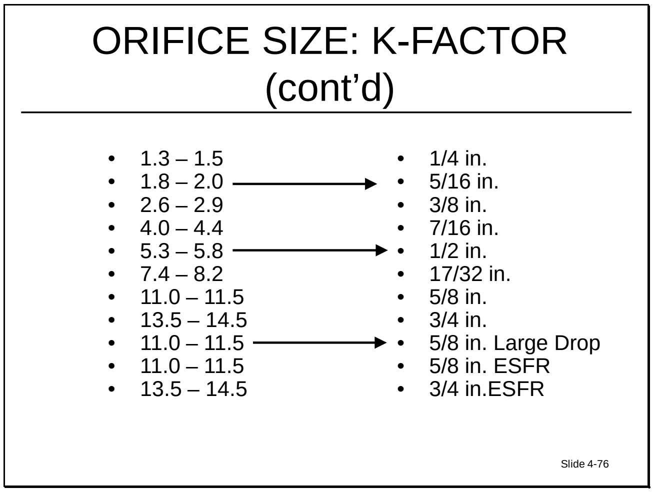


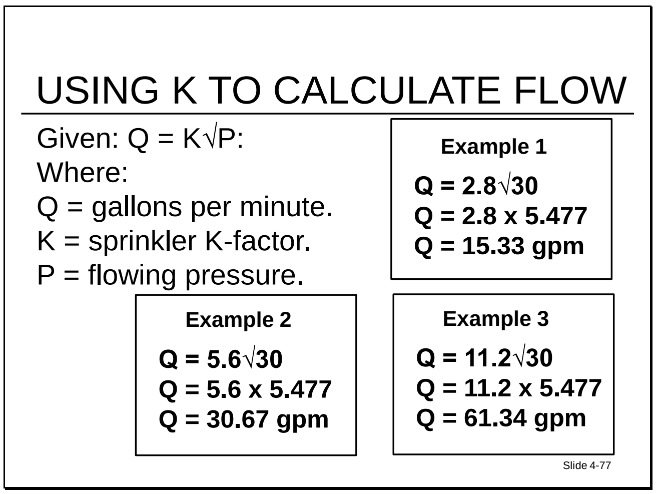
Slide 4-75

4. Sprinklers now are described by K-factor rather than orifice size.

   a. Obsolete reference: "one-half inch orifice."

   b. Current description: "5.6 K-factor."





D. Using "K" to calculate flow. (The flow from a sprinkler can be calculated with the formula).

1. $Q = K\sqrt{P}$.

   Q = flow in gallons per minute.

   K = sprinkler K-factor.

   P = flowing pressure.

2. Given a constant flowing pressure of 30 psi:

   a. Example 1: $Q = 2.8\sqrt{30}$

      $Q = 2.8 \times 5.477$

      Q = 15.33 gpm

b. Example 2: $Q = 5.6\sqrt{30}$

$Q = 5.6 \times 5.477$

$Q = 30.67$ gpm

c. Example 3: $Q = 11.2\sqrt{30}$

$Q = 11.2 \times 5.477$

$Q = 61.34$ gpm

LISTING DETAILS

- Temperature ratings.
- Coverage area.
- Minimum flow.
- Cover plate temperature rating.
- Distance below ceiling.

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	135,156	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 4-78

E. Listing details (from Learning Square Reference Data).

1. Temperature ratings.

2. Coverage area.

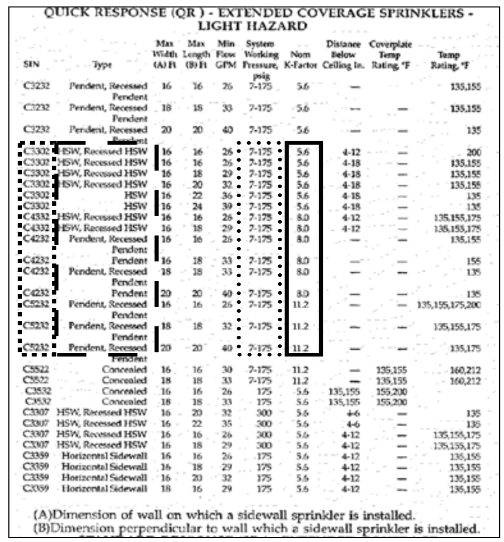
3. Minimum flow.

4. Cover plate temperature rating.

5. Distance below ceiling.

LISTING DETAILS (cont'd)

- Model (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 4-79

6. Model (SIN).

7. Type.

8. Working pressure.

9. Orifice size (K).

IV. UNDERWRITERS LABORATORIES STANDARDS FOR SPRINKLER PERFORMANCE TESTING AND LISTINGS

UNDERWRITERS LABORATORIES STANDARDS FOR SPRINKLER PERFORMANCE TESTING AND LISTINGS

- Underwriters Laboratories (UL) Standard 199, *Automatic Sprinklers for Fire-Protection Service*.
- UL Standard 1626, *Residential Sprinklers for Fire-Protection Service*.

Slide 4-80

A. Underwriters Laboratories (UL) Standard 199, *Automatic Sprinklers for Fire-Protection Service*.

1. Fire control mode.

2. Fire suppression mode.

3. Outside sprinklers.

B. UL Standard 1626, *Residential Sprinklers for Fire-Protection Service*.

Residential sprinklers.

UNDERWRITERS LABORATORIES STANDARD 199

- Sprinklers primarily for property protection.
  - "Fire control mode."
  - Wetting adjacent combustibles.
    - -- Standard spray.
    - -- Large drop.
  - "Fire Suppression Mode."
    - -- ESFR.
    - -- Quick response.
- Use in NFPA 13 and 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*.

Slide 4-81

C. UL Standard 199 — sprinklers primarily for **property** protection.

1. "Fire control mode."

    a. Control fire.

    b. Wet adjacent combustibles.

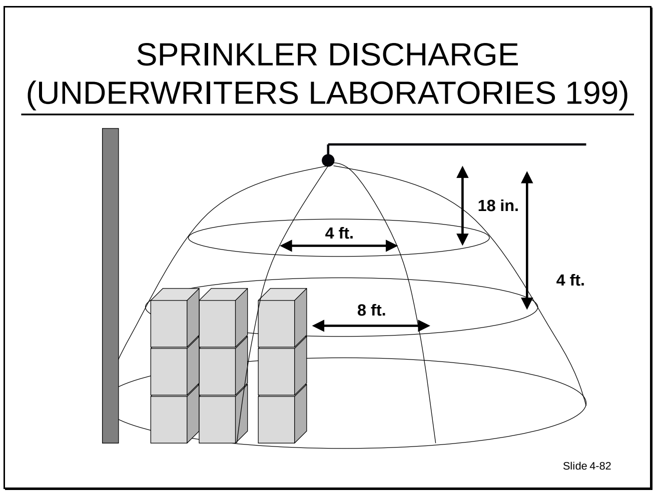
    - Standard spray.
    - Large drop.

2. "Fire suppression mode."

    a. Early Suppression Fast Response (ESFR).

    b. Quick response, early suppression.

3. Use in systems designed to NFPA 13 and 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*.



UNDERWRITERS LABORATORIES STANDARD 1626

- Primarily for life safety.
  - Prevent flashover in room of ignition.
  - Wet ceiling and walls.
  - Keep carbon monoxide levels low.
  - Maintain tenable environment for escape.
- Must be labeled "Residential Sprinkler" or "Res. Spkr."

Slide 4-83

D. UL Standard 1626.

1. Sprinklers primarily for **life safety**.

   a. Prevent flashover in room of ignition.

   b. Wet ceiling and walls.

   c. Keep carbon monoxide levels low.

   d. Maintain tenable environment for escape.

2. Must be labeled “Residential Sprinkler” or “Res. Spkr.”

UNDERWRITERS LABORATORIES STANDARD 1626 (cont’d)

- Use in NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes* and 13R.
- Okay in NFPA 13 where residential allowed.

Slide 4-84

3. Use in NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and manufactured Home*s and 13R.

4. Okay in NFPA 13 where **residential** sprinklers are allowed, like hotel sleeping rooms, apartment dwelling units, etc.

MANUFACTURER’S INFORMATION

- Called technical data sheets, technical sheets, and catalog cut sheets.
- Available from designer, installer or online.

Slide 4-85

E. Manufacturer’s information.

1. Called technical data sheets, technical sheets, and catalog cut sheets.

2. Available from designer, installer or online.

3. Verify make, model name and number. Confirm SIN number.

Sprinkler Temperature Classification	Nominal Sprinkler Temp. Rating (Fusing Point)	Maximum Ambient Ceiling Temperature[1]	Bulb Color[2]
Ordinary	135 °F (57 °C)	100 °F (38 °C)	Orange
Ordinary	155 °F (68 °C)	100 °F (38 °C)	Red
Intermediate	175 °F (79 °C)	150 °F (65 °C)	Yellow

Sprinkler Finishes: Brass, Chrome-Enloy® (patents pending), White Poly finish, Navajo White Polyester, and Black Polyester

Corrosion-Resistant Coating[3]: White Poly finish, Navajo White Polyester, and Black Polyester

Footnotes

[1] Based on NFPA-13. Other limits may apply, depending on fire loading, sprinkler location, and other requirements of the Authority Having Jurisdiction. Refer to specific installation standards.

[2] The temperature rating is stamped on the deflector.

[3] The corrosion-resistant coatings have passed standard corrosion tests required by particular approving agencies. Refer to the approval chart on page 81 b. These tests cannot and do not represent all possible corrosive environments. Prior to installation, verify through the end-user that the coatings are compatible with or suitable for the proposed environment. The coatings indicated are applied to the exposed exterior surfaces only.

NOTE: The spring is exposed on the Polyester-Coated sprinkler.

Table 1

4. Take note that this is identified as Light Hazard occupancies only.

5. Manufacturer’s information regarding temperature.

    a. Temperature classification.

    b. Operating element temperatures.

    c. Maximum ambient ceiling temperature.

6. Sprinkler finishes.

    a. Ornamental.

    b. Corrosion resistant.

MANUFACTURER'S INFORMATION (cont'd)

Approval Chart
Microfast® Standard Response/Quick Response
Extended Coverage Pendent Sprinklers

KEY: A1X — A: Temperature; 1: Finish; X: Escutcheon (if applicable)

NPT Thread Size Inch	NPT Thread Size mm	Orifice Size	Nominal K-Factor U.S.[10]	Nominal K-Factor metric[6]	Overall Length Inch	Overall Length mm	Sprinkler Base Part No.[1]	Sprinkler Identification No.[10]
½	15	Standard	5.6	8,1	2-5/16	58,7	06778B	VK600
3/4	20	Large	8.0	11,5	2-3/8	60	07077	VK602

Standard Response Applications

Sprinkler Base Part No.[1]	SIN[10]	Maximum Areas of Coverage[5]	Nominal K-Factor U.S.[10]	Nominal K-Factor metric[6]	Minimum Water Supply Requirements[5]	Listings and Approvals[2] cULus[3]	NYC[7]	FM[4]
07077	VK602	16' Wide x 16' Throw (4,9 m x 4,9 m)	8.0	11,5	26 gpm @ 10.6 psi (98,4 L/min @ 72,8 kPa)	–	–	C2Z
06778B	VK600	16' Wide x 16' Throw (4,9 m x 4,9 m)	5.6	8,1	26 gpm @ 21.6 psi (98,4 L/min @ 148,6 kPa)	–	–	C2Z
07077	VK602	18' Wide x 18' Throw (5,5 m x 5,5 m)	8.0	11,5	33 gpm @ 17.0 psi (124,9 L/min @ 117,3 kPa)	–	–	C2Z
06778B	VK600	18' Wide x 18' Throw (5,5 m x 5,5 m)	5.6	8,1	33 gpm @ 34.7 psi (124.9 L/min @ 239,4 kPa)	–	–	C2Z
07077	VK602	20' Wide x 20' Throw (6,1 m x 6,1 m)	8.0	11,5	40 gpm @ 25.0 psi (151,4 L/min @ 172,4 kPa)	B1Z	B1Y	C2Z
06778B	VK600	20' Wide x 20' Throw (6,1 m x 6,1 m)	5.6	8,1	40 gpm @ 51.0 psi (151,4 L/min @ 351,8 kPa)	B1Z	B1Y	C2Z

Slide 4-87

7. Manufacturer's information regarding sprinkler specifications (from Learning Square Reference Data).

   a. Orifice sizes.

   b. SIN.

   c. Used in "standard response applications."

      - Cut sheets include data for "quick response applications."

   d. Note differences in flowing pressure required for SIN numbers to obtain same flow in gpm.

MANUFACTURER'S INFORMATION (cont'd)

Standard Response Applications

Sprinkler Base Part No.[1]	SIN[10]	Maximum Areas of Coverage[5]	Nominal K-Factor U.S.[10]	Nominal K-Factor metric[6]	Minimum Water Supply Requirements[5]	Listings and Approvals[2] cULus[3]	NYC[7]	FM[4]
07077	VK602	16' Wide x 16' Throw (4,9 m x 4,9 m)	8.0	11,5	26 gpm @ 10.6 psi (98,4 L/min @ 72,8 kPa)	–	–	C2Z
06778B	VK600	16' Wide x 16' Throw (4,9 m x 4,9 m)	5.6	8,1	26 gpm @ 21.6 psi (98,4 L/min @ 148,6 kPa)	–	–	C2Z
07077	VK602	18' Wide x 18' Throw (5,5 m x 5,5 m)	8.0	11,5	33 gpm @ 17.0 psi (124,9 L/min @ 117,3 kPa)	–	–	C2Z
06778B	VK600	18' Wide x 18' Throw (5,5 m x 5,5 m)	5.6	8,1	33 gpm @ 34.7 psi (124.9 L/min @ 239,4 kPa)	–	–	C2Z
07077	VK602	20' Wide x 20' Throw (6,1 m x 6,1 m)	8.0	11,5	40 gpm @ 25.0 psi (151,4 L/min @ 172,4 kPa)	B1Z	B1Y	C2Z
06778B	VK600	20' Wide x 20' Throw (6,1 m x 6,1 m)	5.6	8,1	40 gpm @ 51.0 psi (151,4 L/min @ 351,8 kPa)	B1Z	B1Y	C2Z

Approved Temperature Ratings
A - 135 °F (57 °C) and 155 °F (68 °C)
B - 155 °F (68 °C) and 175 °F (79 °C)
C - 175 °F (79 °C)
D - 135 F° (57 °C)
E - 135 °F (57 °C), 155 °F (68 °C), and 175 °F (79 °C)

Approved Finishes
1 - Brass, Bright Brass, Chrome-Enloy®, White Poly finish[8], Navajo White Polyester[8], and Black Polyester[8]
2 - Brass, Bright Brass, Chrome-Enloy®, and White Poly finish

Approved Escutcheons
Y - Standard surface-mounted escutcheons or the Viking Microfast® Model F-1 Adjustable Escutcheon[9]
Z - Standard surface-mounted escutcheons or the Viking Microfast® Model F-1 Adjustable Escutcheon[9], or recessed with the Micromatic® Model E-1 Recessed Escutcheon

Slide 4-88

   e. Approved temperature ratings.

   f. Approved finishes.

   g. Approved escutcheons.

OTHER CALCULATION CONSIDERATIONS

Pressure loss from elevation changes.

- Calculated at loss of 0.433 psi/ft.
- Must be considered at pipe length of actual change.
- May result in pressure loss (from water flow in upward direction) or pressure increase (from water flow in downward direction).

Slide 4-89

F. Other calculation considerations.

Pressure loss from elevation changes.

1. Calculated at loss of 0.433 psi per foot.

2. Must be considered at pipe length of actual change.

3. May result in pressure loss (from water flow in upward direction) or pressure increase (from water flow in downward direction).

ACTIVITY 4.1

Verifying Sprinkler Water Flows

Purpose

Determining the adequacy of water supplies.

Directions

Using the formula provided, you will work individually to calculate the following equations for sprinkler flow and pressure.

1. What is the flow from a single Recessed Central Sprinkler Model 3296 covering an area of 12 feet by 14 feet (from UL Listing Directory)?

   K-factor — 5.3; head pressure — 20.5 psi

   $Q = K\sqrt{P}$

2. What is the required pressure for a Globe GL4231 Horizontal Sidewall Sprinkler required to flow 24 gpm (from UL Listing Directory)?

   K-factor — 4.2

   $P = (Q/K)^2$

3. What is the required pressure for a Viking VK 350 Upright Sprinkler required to flow 18 gpm (from UL Listing Directory)?

   K-factor — 8.0

   $P = (Q/K)^2$

4. What is the required pressure for a Tyco TY9128 Extended Coverage Sprinkler required to protect a 12 foot by 12 foot area flowing 125.65 gpm (from UL Listing Directory)?

   K-factor — 25.2

   $P = (Q/K)^2$

5. What is the pressure required for a Tyco TY 2235 Concealed Pendant Sprinkler to protect an area of 19 feet by 18 feet (from UL Listing Directory)?

K-factor — 4.8

$P = (Q/K)^2$

V. FIRE PUMP OVERVIEW

FIRE PUMPS

- If the designer does not have enough pressure to supply his or her system adequately then a fire pump is needed.
- Fire pumps can only create pressure and do not increase water supply.

Slide 4-96

A. Fire pumps.

1. If the designer does not have enough pressure to supply his or her system adequately then a fire pump is needed.

2. Fire pumps can only create pressure and do not increase water supply.

NATIONAL FIRE PROTECTION ASSOCIATION 20

- *Standard for the Installation of Stationary Pumps for Fire Protection*.
- Selection and installation of pumps for private fire protection.
- Covers water supplies, power supplies, electric and internal engine drivers and controls, acceptance tests, and operation.

Slide 4-97

B. NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection*.

1. Selection and installation of pumps for private fire protection.

2. Covers water supplies, power supplies, electric and internal engine drivers and controls, acceptance tests, and operation.

NATIONAL FIRE PROTECTION ASSOCIATION 20 (cont'd)

- Pumps increase pressure for fire protection systems.
- NFPA 20 covers all aspects of a pump operation.
- Engine drivers, controllers, power supplies, acceptance testing, and operation.

Slide 4-98

3. Pumps increase pressure for fire protection systems.

4. NFPA 20 covers all aspects of a pump operation.

5. Engine drivers, controllers, power supplies, acceptance testing, and operation.

SELECTION OF THE PUMP

- Must be based upon the conditions under which it will be installed and utilized.
- Rated capacity and pressure can be determined by the manufacturer's pump characteristic curve.
- Information on selection criteria can be found in Fire Protection Handbook, Fire Pump Handbook, and Pumps for Fire Protection Systems.

Slide 4-99

C. Selection of the pump.

1. Must be based upon the conditions under which it will be installed and utilized. Pump selection will be based on needed pressure and capability to move water.

2. Rated capacity and pressure can be determined by the manufacturer's pump characteristic curve.

3. Information on selection criteria can be found in Fire Protection Handbook, Fire Pump Handbook, and Pumps for Fire Protection Systems.

WATER SUPPLY

- Pump can only produce pressure; it cannot make water.
- Source must be adequate in quality, quantity and pressure.
- NFPA 20 requires water supply "... to be determined and evaluated prior to the specification and installation ..."

Slide 4-100

D. Water supply.

1. Pump can only produce pressure; it cannot make water.

2. Source must be adequate in quality, quantity and pressure.

3. NFPA 20 requires water supply "... to be determined and evaluated prior to the specification and installation ..."

RESIDUAL PRESSURE

- Pump operation must not drop suction intake head (residual) below minimum permitted by water authority.
- Pressure is what is maintained in the water supply main after domestic demand is met.
- In most instances, minimum is 20 psi.

Slide 4-101

E. Residual pressure.

1. Pump operation must not drop suction intake head (residual) below minimum permitted by water authority.

2. Pressure is what is maintained in the water supply main after the domestic demand is met.

3. In most instances, minimum is 20 psi.

VI. LOCATION OF FIRE PUMP

LOCATION OF FIRE PUMP

- Protected against possible interruption of service.
- Explosion, fire, flood, earthquake, rodents, insects, windstorm, freezing, vandalism and other adverse conditions.
- Two-hour rated room if no sprinkler protection provided. One hour if sprinkler protected.

Slide 4-102

A. Location.

1. Protected against possible interruption of service.

2. Explosion, fire, flood, earthquake, rodents, insects, windstorm, freezing, vandalism and other adverse conditions.

3. Two-hour rated room if no sprinkler protection is provided. One hour if sprinkler is protected.

LOCATION OF FIRE PUMP (cont'd)

- Applies only to new construction or installation.
- Room must have a sprinkler if the pump is protecting a fully sprinkler-equipped building.
- Pumps located so they do not freeze and cannot be vandalized or flood.

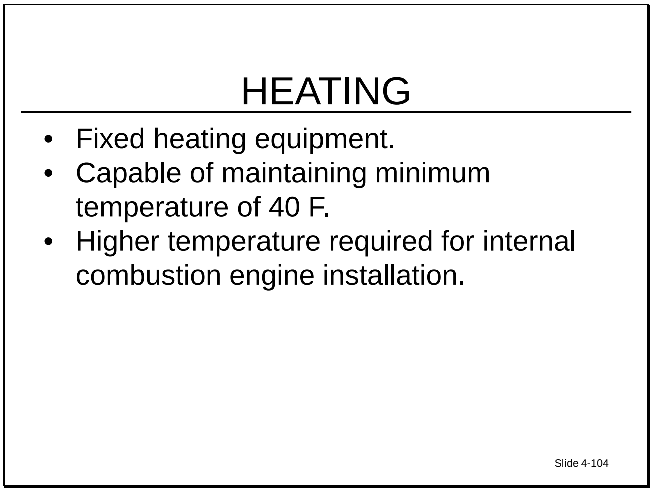
Slide 4-103

4. Applies only to new construction or installation.

5. Room must have a sprinkler if pump is protecting a fully sprinkler-equipped building.

6. Pumps must be located so they do not freeze and cannot be vandalized or flood.

7. Room must also be protected from fire.

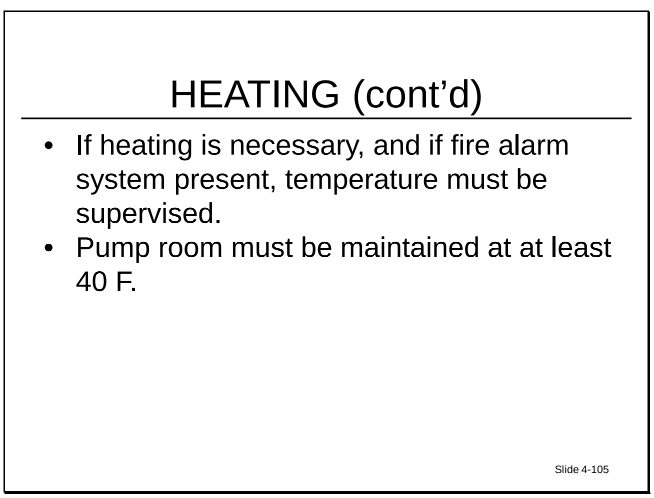


B. Heating.

1. Fixed heating equipment.

2. Capable of maintaining minimum temperature of 40 F.

3. Higher temperature may be required for internal combustion engine installation according to engine manufacturer's specifications.



4. If heating is necessary, and if fire alarm system present, temperature must be supervised.

5. Pump room must be maintained at at least 40 F.

VENTILATION

- Ventilation to reduce excessive ambient temperatures and humidity.
- Care must be taken to ensure that ventilation and heating system do not counteract one another.

Slide 4-106

C. Ventilation.

1. Ventilation to reduce excessive ambient temperatures and humidity.

2. Care must be taken to ensure that the ventilation and heating system do not counteract one another.

VENTILATION (cont'd)

- Additional ventilation for internal engine drivers (combustion air).
- Ventilation is needed to keep temperature at manageable levels.
- Ventilation is also needed with internal combustion engines.

Slide 4-107

3. Additional ventilation for internal engine drivers.

4. Ventilation is needed to keep temperature at manageable levels.

5. Ventilation is also needed with internal combustion engines.

VII. FIRE PUMP COMPONENTS

SUCTION SUPPLY VALVE

- Indicating listing type valve.
- Outside Screw and Yoke (OS&Y).
- Butterfly type valve may be used only if located 50 feet or more upstream from pump intake.
- Eccentric piping on intake side.
- Supervision required.

Slide 4-108

A. Suction supply valve.

1. Indicating listing type valve.

2. Outside Screw and Yoke (OS&Y).

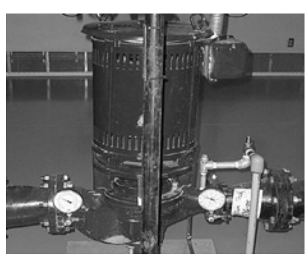
3. Butterfly type valve may be used only if located 50 feet or more upstream from pump intake.

4. Eccentric piping must be on intake side.

5. Supervision required.

PRESSURE GAUGES

- On suction side of pump, compound gauge.
- On discharge side, pressure gauge only.



Slide 4-109

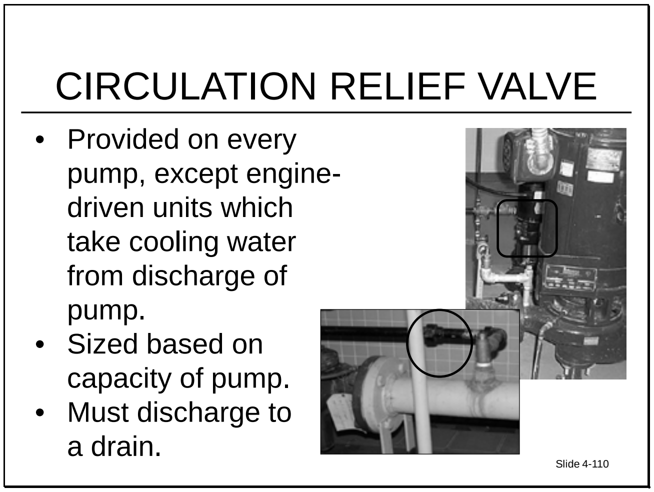
B. Pressure gauges.

1. On suction side of pump, compound gauge.

Compound gauge shows pressure and vacuum.

2. On discharge side, pressure gauge only.

Discharge gauge on to start side of the pump to show outgoing pressure.

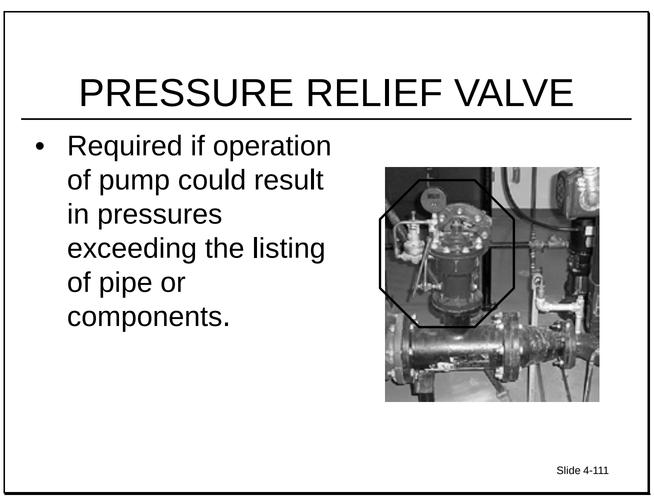


C. Circulation relief valve.

1. Provided on every pump, except engine-driven units which take cooling water from discharge of pump.

2. Sized based on capacity of pump.

3. Must discharge to a drain.

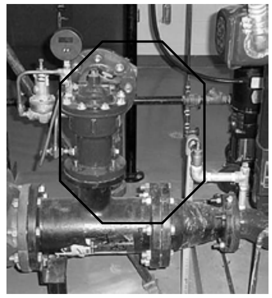


D. Pressure relief valve.

1. Required if operation of pump could result in pressures exceeding listing of pipe or components.

PRESSURE RELIEF VALVE
(cont'd)

- Discharge must be readily visible or detectable by pump operator.
- Size is based upon pump capacity.
- Pressure relief valves are required for safety of the pump.



Slide 4-112

2. Discharge must be readily visible or detectable by pump operator.

3. Size based upon pump capacity.

4. Pressure relief valves are required for safety of the pump.

BYPASS LINE

- Required when suction supply is of "sufficient pressure to be of material value without the pump" (NFPA 20, 2010).
- Serves two functions: maintenance and emergency.
- At least as large as discharge piping and equipped with a control valve and check valve.

Slide 4-113

E. Bypass line.

1. NFPA standards indicate that without a pump you are required to have sufficient pressure that is also of material value (NFPA 20, 2010).

2. Serves two functions: maintenance and emergency.

3. At least as large as discharge piping and equipped with a control valve and check valve.

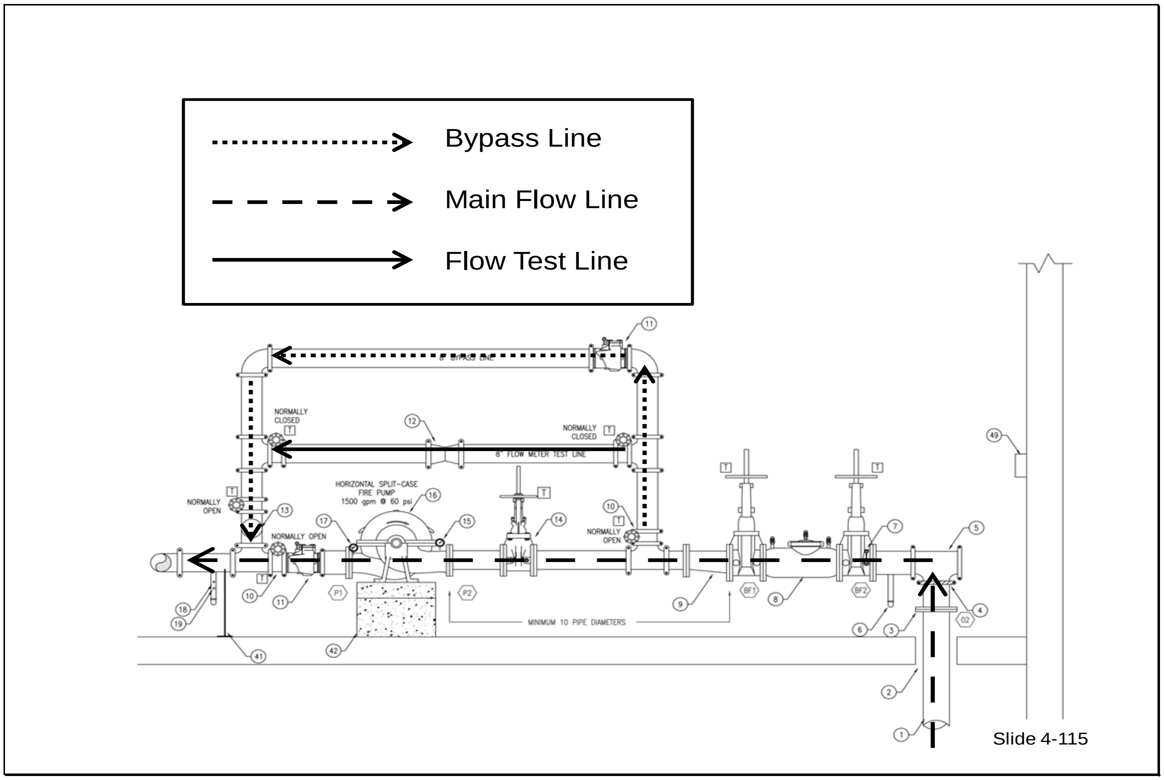
BYPASS LINE (cont'd)

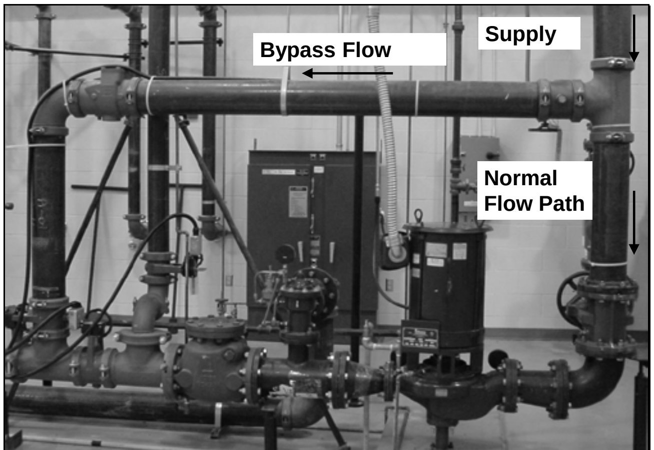
- Valve must remain open and be supervised.
- Bypass lines are installed, so for either maintenance of the pump, or if the pump fails, there is still water available in the system.

Slide 4-114

4. Valve must remain open and be supervised.

5. Bypass lines are installed, so for either maintenance of the pump, or if the pump fails, there is still water available in the system.


Bypass Line
Main Flow Line
Flow Test Line
NORMALLY CLOSED
8" FLOW METER TEST LINE
NORMALLY CLOSED
HORIZONTAL SPLIT-CASE FIRE PUMP 1500 gpm @ 60 psi
NORMALLY OPEN
NORMALLY OPEN
NORMALLY OPEN
MINIMUM 10 PIPE DIAMETERS
P1
P2
BF1
BF2
02
Slide 4-115



Slide 4-116

ACTIVITY 4.2

Pump Combination Curve Exercise

Purpose

To familiarize you with a fire pump curve and how a fire pump adds pressure to the system.

Directions

1. You will plot a fire pump curve on the sheet provided as instructed in class.

2. You will then show that the system will operate at the correct pressure and volume.

Scenario

The sprinkler demand is above the domestic water supply on the chart. Therefore, a pump is needed to increase the pressure. The pump pressure and the gallons per minute it can push in combination with the domestic water supply gives us enough pressure to supply the system. It must be noted that pumps only create pressure; they do not create water. The water must be available at the site to supply the system.

This system has 2,275 gallons at 20 pounds pressure available. All that needs to be done is to move at least 1,904 gallons at 40.39 pounds pressure from the pump to the system plus 250 gallons for hose allowance. The pump has the water coming through it. It just needs to add pressure to make everything work.

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ACTIVITY 4.2 (cont'd)

Pump Combination Curve Exercise

HYDRAULIC CALCULATIONS FOR

Project Name: The Learning Square - Big Box Store
Project Location: Idaho Falls, Idaho
Drawing Number: F-6
September 11, 2012 - Revision 3.0

-DESIGN DATA-

Remote Area Number:	One
Remote Area Location:	North Overhead System
Occupancy Classification:	Rack Storage 30'-0 Building Height 25'-0 Max Storage Height
Density:	ESFR - 15 psi/head
Area of Application:	12 ESFR Overhead Sprinklers
Coverage Per Sprinkler:	As Shown
Type of Sprinklers Calculated:	Pendent
Number of Sprinklers Calculated:	12
Hose-Stream Demand:	250
Total Water Required (Including Hose):	1434.2 gpm
Flow And Pressure (At Pump):	1184.2 gpm @ 65.71 psi
Type of System:	Wet
Volume of Dry Or Preaction System:	N/A

-WATER SUPPLY INFORMATION-

Test Date:	07/02/11
Source of Information:	Fire Department
Location:	Easy Street
Source Elevation:	2'-6

-INSTALLING CONTRACTOR-

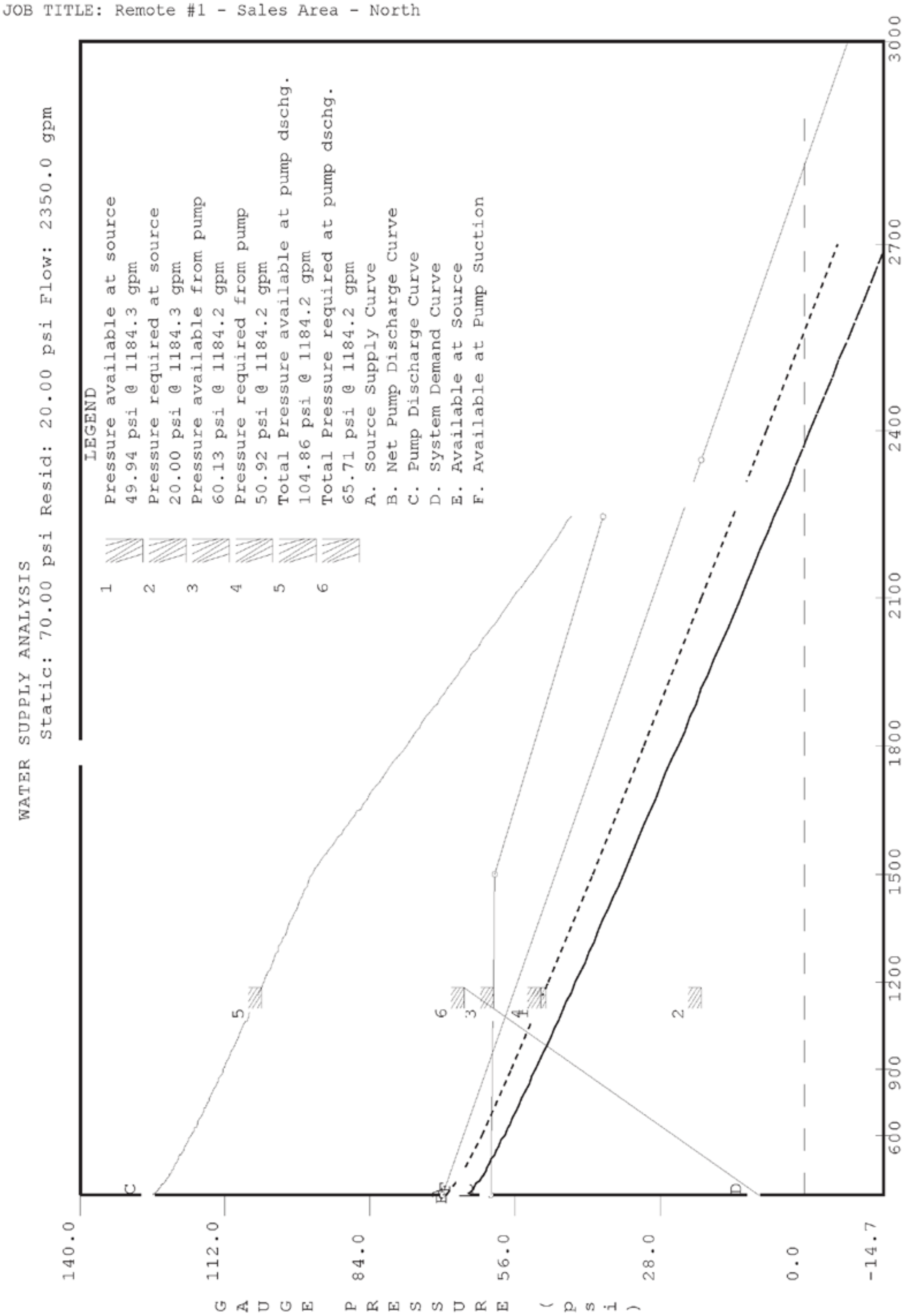
WE DO IT BEST FIRE PROTECTION
P.O. BOX 000
IDAHO FALLS, IDAHO 83405

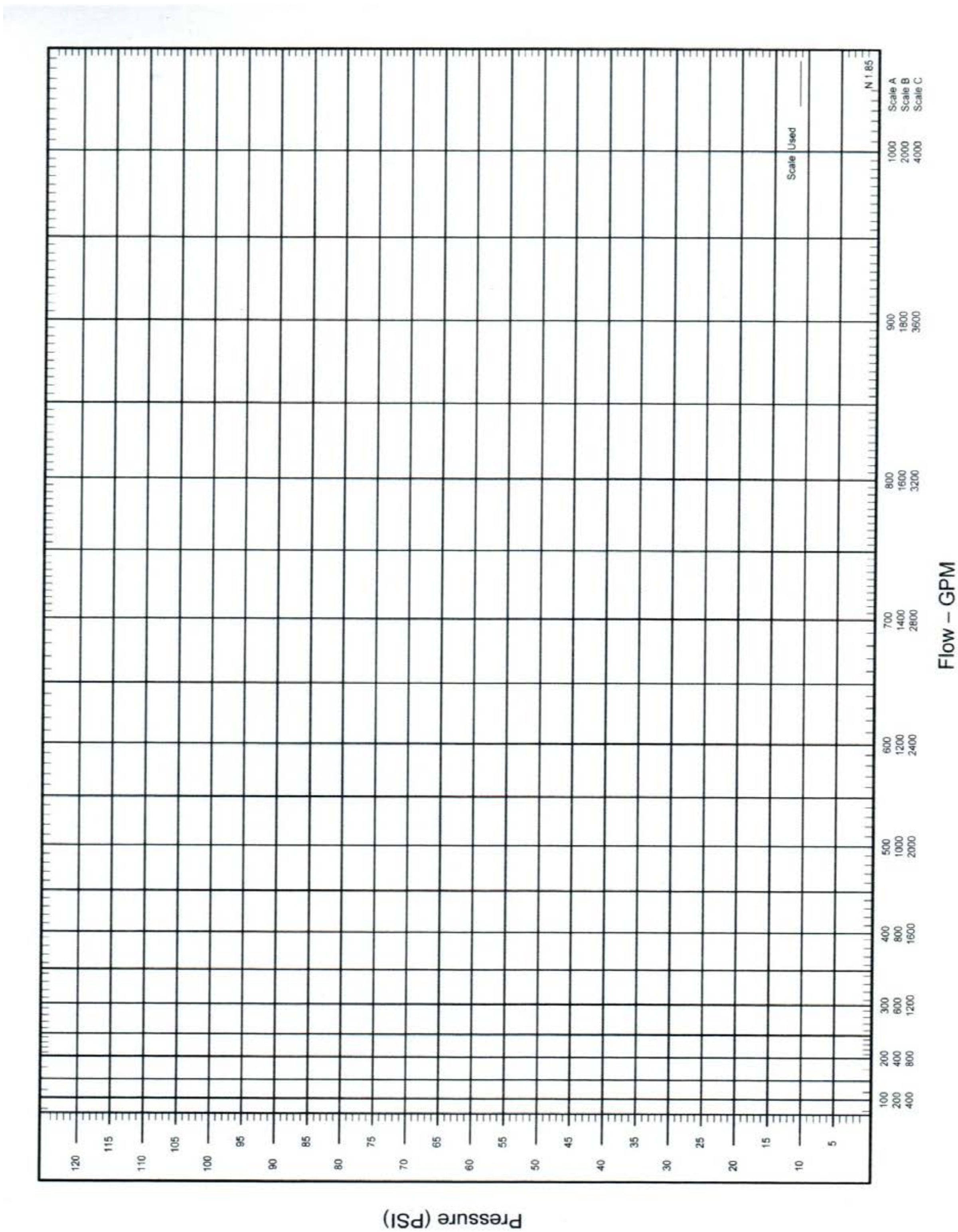
CERTIFICATION NUMBER: FPC-000

Design/Layout By: CFH
Authority Having Jurisdiction: Idaho State Fire Marshal

NOTES:

SPRINKLER SYSTEM HYDRAULIC ANALYSIS Page 2
DATE: 9/12/2012ONS\BIG BOX STORE\REMOTE #1 REV3.0 - NORTH ESFR SYSTEM.SDF
JOB TITLE: Remote #1 - Sales Area - North




Flow – GPM
Pressure (PSI)
Scale Used
N 1.85
Scale A
Scale B
Scale C
100 200 300 400 500 600 700 800 900 1000
200 400 600 800 1000 1200 1400 1600 1800 2000
400 800 1200 1600 2000 2400 2800 3200 3600 4000
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120

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ACTIVITY 4.3

Verifying Sprinkler Selection

Purpose

To verify that the correct sprinkler has been selected for the application.

Directions

1. You will use the material extracted from the UL Fire Protection Equipment Directory.

2. Working individually, you will answer the following questions and verify the correct sprinkler has been selected for the situation described in the question.

   a. What color is the glass bulb for a spray sprinkler with a temperature rating of 400 to 475 F?

   ____

   ____

   ____

   b. A designer submits a drawing with Reliable R5845 recessed pendent extended coverage standard response sprinklers in a Light Hazard occupancy. The drawing proposes that the maximum coverage area is 380 square feet. Is this permitted? Why or why not?

   ____

   ____

   ____

   c. The designer's hydraulic calculations show a flow of 26 gpm needed to obtain this coverage. Does this comply?

   ____

   ____

   ____

d. A portion of this project needs dry sprinklers that will be attached to the wet pipe system and extended into walk-in freezers. The design calls for standard response sprinklers. Which of the following sprinklers may be used in this walk-in freezer: R5314, R5334, R5714 or R5734?

____

____

____

e. Horizontal and vertical sidewall sprinklers are intended for installation at minimum distances between sprinklers of _____ feet or as specified in manufacturer's installation and design parameter instructions.

____

____

____

3. You should be prepared to discuss your responses in class.

VIII. SUMMARY

FEMA

U.S. Fire Administration

SUMMARY

- Technical components.
- Sprinkler positioning rules.
- Sprinklers simplified.
- UL standards for sprinkler performance testing and listings.
- Fire pump overview.
- Location of fire pump.
- Fire pump components.

Slide 4-121

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UNIT 5: FIRE PROTECTION SYSTEM PLANS METHODS OF DESIGN

TERMINAL OBJECTIVE

The students will be able to:

5.1 *Given a set of design drawings and occupancy hazard classification, verify that the design of the water-based fire protection system provides adequate coverage and required levels of protection in compliance with recognized standards.*

ENABLING OBJECTIVES

The students will be able to:

5.1 *Given intended use and occupancy, identify the appropriate design method for the intended use area (room/area/storage).*

5.2 *Given a set of plans, identify the hydraulically most demanding area based upon the use, occupancy and location of the space.*

5.3 *Given a set of plans, determine whether the system design provides adequate protection for the intended hazard classification.*

5.4 *Given a set of plans and hydraulic calculations, verify the consistency of information shown on the design documents for that water-based fire protection system.*

5.5 *Given a set of sprinkler plans and design area characteristics and sprinkler components, identify design area modifications (reductions and increases) as identified in the recognized codes and standards.*

5.6 *Given a set of sprinkler plans and occupancy hazard classification, determine the appropriate water flow rate in order to satisfy required levels of protection based on design density or area application as per recognized standards.*

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FEMA

U.S. Fire Administration

UNIT 5: FIRE PROTECTION SYSTEM PLANS METHODS OF DESIGN

Slide 5-1

TERMINAL OBJECTIVE

Given a set of design drawings and occupancy hazard classification, verify that the design of the water-based fire protection system provides adequate coverage and required levels of protection in compliance with recognized standards.

Slide 5-2

ENABLING OBJECTIVES

- Given intended use and occupancy, identify the appropriate design method for the intended use area (room/area/storage).
- Given a set of plans, identify the hydraulically most demanding area based upon the use, occupancy and location of the space.

Slide 5-3

ENABLING OBJECTIVES (cont'd)

- Given a set of plans, determine whether the system design provides adequate protection for the intended hazard classification.
- Given a set of plans and hydraulic calculations, verify the consistency of information shown on the design documents for that water-based fire protection system.

Slide 5-4

ENABLING OBJECTIVES (cont'd)

- Given a set of sprinkler plans and design area characteristics and sprinkler components, identify design area modifications (reductions and increases) as identified in the recognized codes and standards.

Slide 5-5

ENABLING OBJECTIVES (cont'd)

- Given a set of sprinkler plans and occupancy hazard classification, determine the appropriate water flow rate in order to satisfy required levels of protection based on design density or area application as per recognized standards.

Slide 5-6

I. CHECKING SYSTEM DESIGN

CHECKING SYSTEM DESIGN

- When you check the plans submitted, check at least the following:
  - Occupancy class; density and area of application; coverage per sprinkler and number of heads calculated; hose allowance; branch line and head spacing; and length (L) and size (S) calculation.
  - Calculation node verifications.
  - Verify the correct sprinkler heads.

Slide 5-7

A. When you check the plans submitted, check at least the following:

1. Occupancy class; density and area of application; coverage per sprinkler and number of heads calculated; hose allowance; branch line and head spacing; and length (L) and size (S) calculation.

2. Calculation node verifications.

3. Verify the correct sprinkler heads.

CHECKING SYSTEM DESIGN (cont'd)

- Verify the correct pipe type and system component listings.
- The first as well as another sprinkler head flow on first branch line.
- Pressure balance across the cross main if needed.
- One branch line flow with change of K-factor.
- The riser flow.
- The total flow and pressure needed.

Slide 5-8

4. Verify the correct pipe type and system component listings.

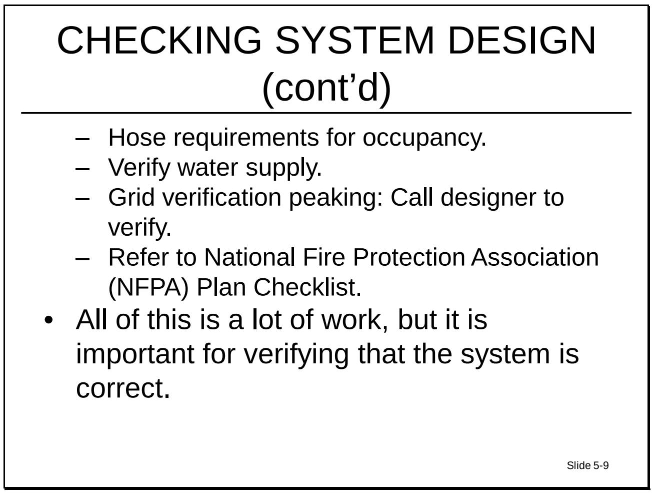
5. The first as well as another sprinkler head flow on the first branch line.

6. Pressure balance across the cross main, if needed.

7. One branch line flow with change of K-factor.

8. The riser flow.

9. The total flow and pressure needed.



10. Hose requirements for occupancy.

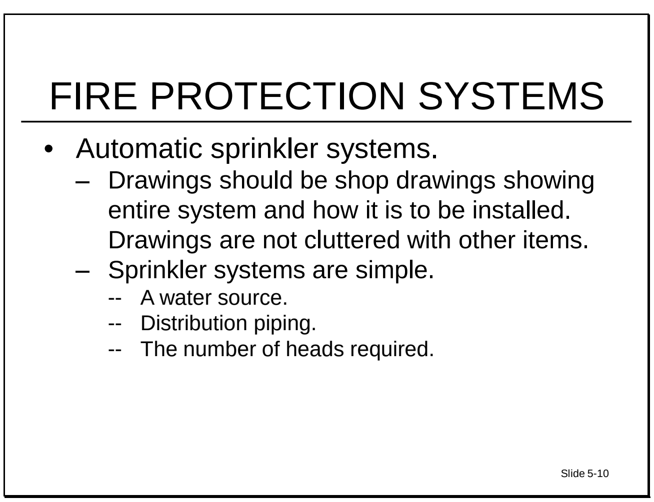
11. Verify water supply.

12. Grid verification peaking: Call designer to verify.

13. Refer to National Fire Protection Association (NFPA) Plan Checklist.

B. This will be a lot of work, but it is important to remember that all of this will verify that the system is correct.

II. FIRE PROTECTION SYSTEMS



A. Automatic sprinkler systems.

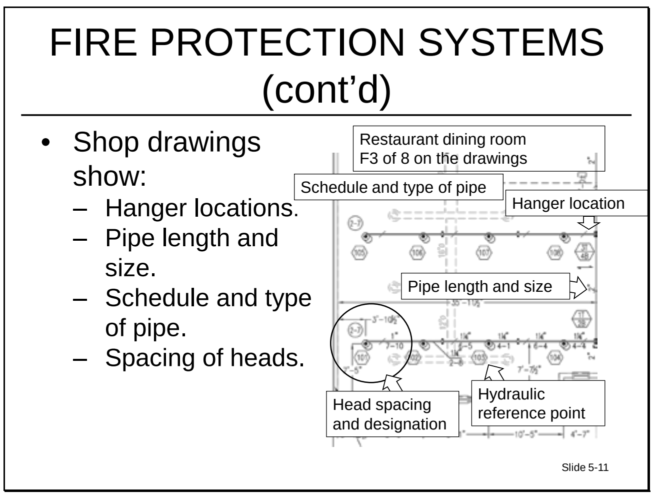
1. Drawings should be shop drawings that show the entire system and how it is to be installed. These drawings are not cluttered with other items.

2. Sprinkler systems are simple.

   a. A water source.

   b. Distribution piping.

   c. The number of heads required.



3. Shop drawings show:

   a. Hanger locations.

   b. Pipe length and size.

   c. Schedule and type of pipe.

   d. Spacing of heads.

FIRE PROTECTION SYSTEMS (cont'd)

- Sprinkler system design.
  - Occupancy hazard and building construction determine sprinkler system design in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*.
  - NFPA 13 regulates majority of systems.
  - NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*.
    -- Residential occupancies up to four stories.

Slide 5-12

B. Sprinkler system design.

1. Occupancy hazard and building construction determine sprinkler system design in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*.

2. NFPA 13 regulates the majority of systems.

3. NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*.

   Residential occupancies up to four stories.

FIRE PROTECTION SYSTEMS (cont'd)

- NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*.
  -- One- and two-family dwellings.

Slide 5-13

4. NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*.

   One- and two-family dwellings.

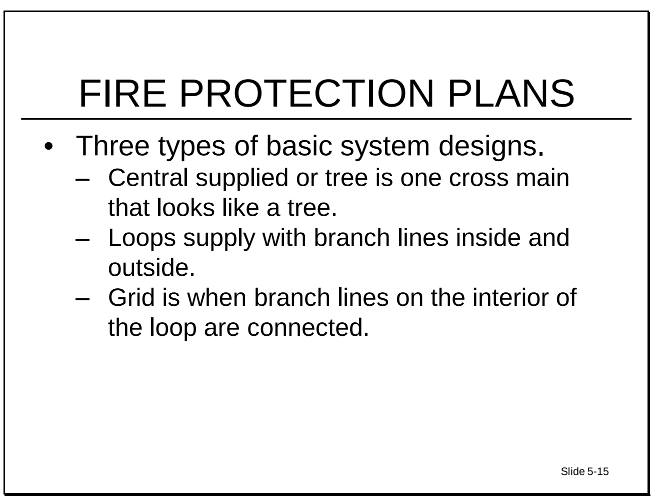
C. NFPA 13.

1. NFPA 13 is a commercial application.

2. Multiple systems to protect different occupancies in one building.

3. Commercial buildings with combination systems of sprinklers and standpipe.

III. FIRE PROTECTION PLANS

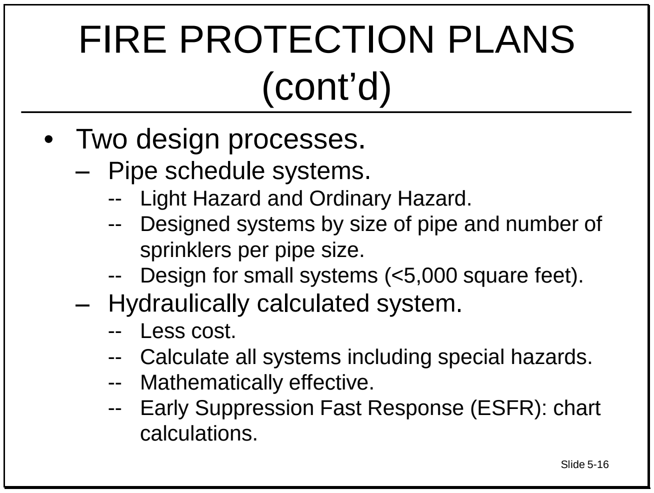


A. Three types of basic system designs.

1. Central supplied or tree is one cross main that looks like a tree.

2. Loops supply with branch lines inside and outside.

3. Grid is when branch lines on the interior of the loop are connected.



B. Two design processes.

1. Pipe schedule systems.

a. Light Hazard and Ordinary Hazard.

b. Designed systems by size of pipe and number of sprinklers per pipe size.

c. Design for small systems (<5,000 square feet).

2. Hydraulically calculated system.

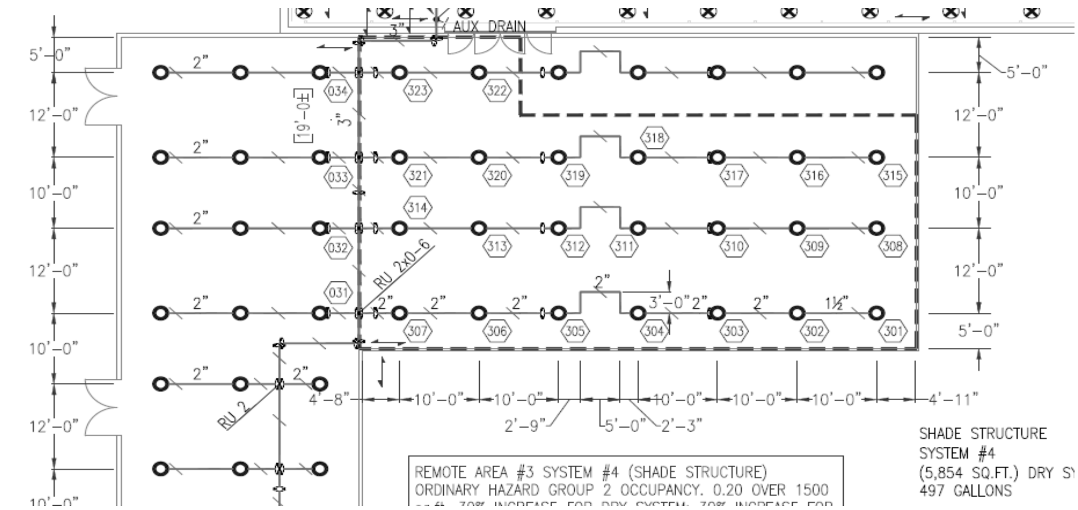
a. Less cost.

b. Calculate all systems including special hazards.

c. Mathematically effective.

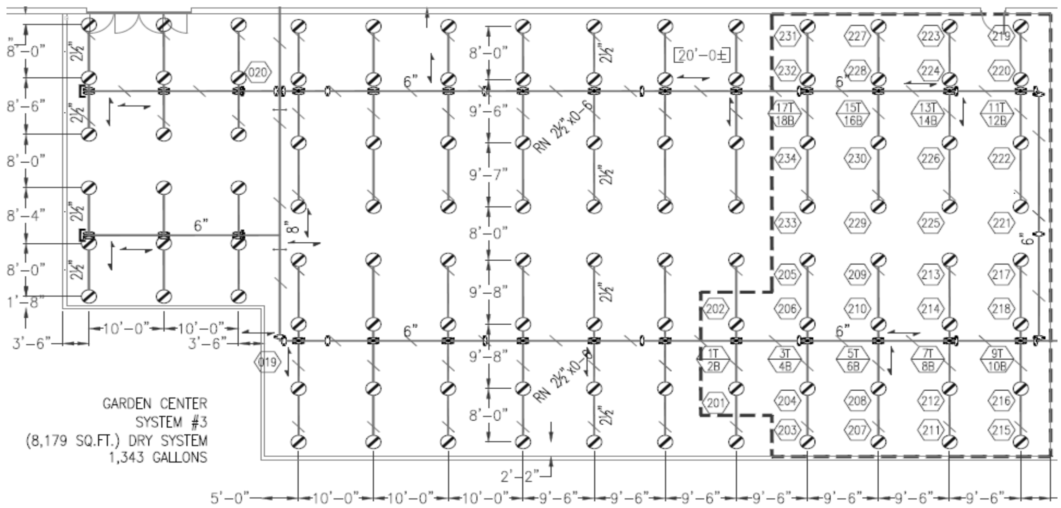
d. Early Suppression Fast Response (ESFR): chart calculations.

SHADE STRUCTURE ON F5 OF 8 SYSTEM 4



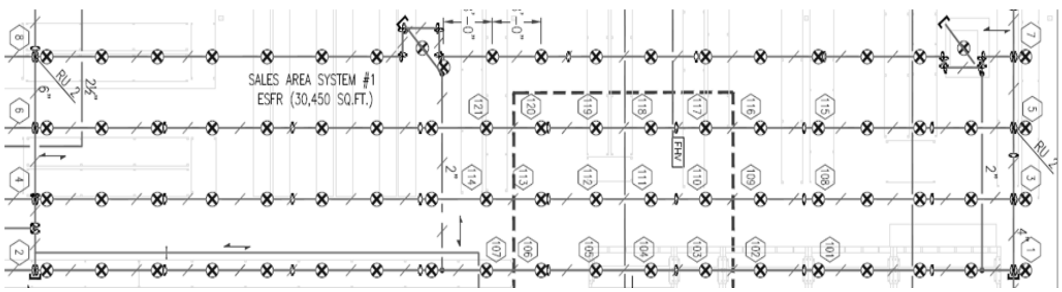
Slide 5-17

GARDEN CENTER F5 OF 8
SYSTEM 3 (LOOP SYSTEM)



Slide 5-18

SALES AREA BULK MERCHANDISING F5 OF 8 SYSTEM 1



Slide 5-19

VERIFICATION PROCESS

TASK	TOOL
Identify the Design Hazard Classification	***Chapter 5 of NFPA 13***
Determine Most Demanding Area and Sprinkler Maximum Coverage	***Density Chart***
Determine Maximum Head Spacing	***Maximum Head Spacing Chart***
Determine Number of Heads in Protection Area	***Formula: Demand Area of Coverage Divided by Sprinkler Head Coverage***
Determine the Size of the Rectangular Demand Area	***Formula: 1.2 Times the Square Root of the Demand Area***
Determine Location of Initial Head is Accurate and Determine Spacing	***L x S Rule and Designer Preference***
Determine Number of Heads on Branch Line	***Formula: Length of Rectangle Divided by Head Spacing***

Slide 5-20

IV. OCCUPANCY HAZARDS CLASSIFICATIONS

FIVE OCCUPANCY HAZARDS CLASSIFICATIONS

- Light Hazard: low heat release.
  - Churches, clubs, educational facilities, museums, nursing homes, offices, institutional libraries.
- Ordinary Hazard.
  - Group 1: moderate rate of heat release.
    - -- Bakery, cannery, automotive parking and showroom, beverage manufacturers, glass production, electronics plants, restaurant services area.

Slide 5-21

Five occupancy hazards classifications.

A. Light Hazard: low heat release.

Examples:

1. Churches.
2. Clubs.
3. Educational facilities.
4. Museums.
5. Nursing homes.
6. Offices.
7. Institutional libraries.

B. Ordinary Hazard.

1. Group 1: moderate rate of heat release.

   Examples:

   a. Bakery.

   b. Cannery.

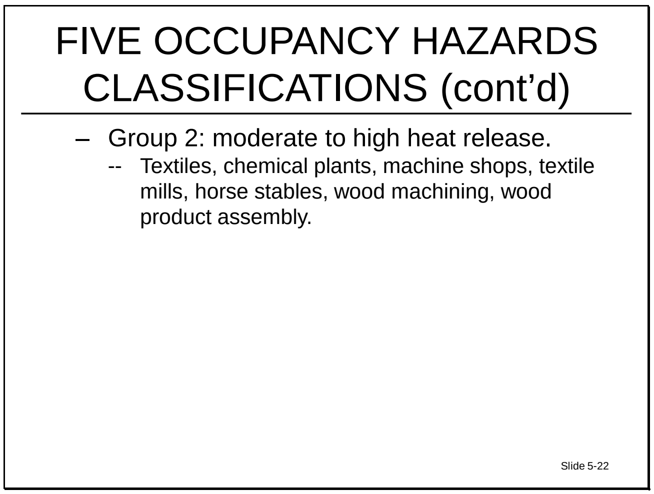
c. Automotive parking and showroom.

d. Beverage manufacturers.

e. Glass production.

f. Electronics plants.

g. Restaurant services area.



2. Group 2: moderate to high heat release.

Examples:

a. Textiles.

b. Chemical plants.

c. Machine shops.

d. Textile mills.

e. Horse stables.

f. Wood machining.

g. Wood product assembly.

What is the hazard classification?

Light Hazard?
Ordinary Hazard Group 1?
Ordinary Hazard Group 2?

Slide 5-23

What is the hazard classification?

Light Hazard?
Ordinary Hazard Group 1?
Ordinary Hazard Group 2?

Slide 5-24

FIVE OCCUPANCY HAZARDS CLASSIFICATIONS (cont'd)

- Extra Hazard.
  - Group 1: high rate of heat release.
    - -- Aircraft hangers (metal extruded), plywood/ particle board manufacturing, rubber reclamation plant, saw mill, upholstering plant (dust or particle production).
  - Group 2: moderate to high volumes of flammable liquids.
    - -- Oil baths, open cooling vats, heat treating plants, asphalt saturation, flammable liquid spraying, flow coating, open oil quenching, solvent cleaning, paint dipping.

Slide 5-25

C. Extra Hazard occupancies.

1. Group 1: high rate of heat release.

Examples:

a. Aircraft hangers (metal extruded).

b. Plywood/Particle board manufacturing.

c. Rubber reclamation plant.

d. Saw mill.

e. Upholstering plant (dust or particle production).

2. Group 2: moderate to high volumes of flammable liquids.

Examples:

a. Oil baths.

b. Open cooling vats.

c. Heat treating plants.

d. Asphalt saturation.

e. Flammable liquid spraying.

f. Flow coating.

g. Open oil quenching.

h. Solvent cleaning.

i. Paint dipping.

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ACTIVITY 5.1

Determine Design Hazard Classification

Purpose

You will be introduced to the essential components of a sprinkler plan review.

Directions

Determine the occupancy classification of these occupancies:

1. Church.

   ____

2. Glass production factory.

   ____

3. Feed mill.

   ____

4. Tire manufacturer.

   ____

5. Restaurant (dining area).

   ____

6. Automotive spray booth.

   ____

7. Unused attic area.

   ____

8. Dry cleaner.

   ____

9. Museum.

 ____

10. Solvent cleaner warehouse.

 ____

11. Elementary classroom.

 ____

12. Theater.

 ____

13. Pharmacy.

 ____

14. Big box store.

 ____

15. Laundry.

 ____

16. Train and bus station.

 ____

17. Post office.

 ____

V. METHODS OF DESIGN OBJECTIVES

METHODS OF DESIGN OBJECTIVES

- Control mode.
  - **3.6.4.1* Control Mode Specific Application (CMSA) Sprinkler.** A type of spray sprinkler that is capable of producing characteristic large water droplets and that is listed for its capability to provide fire control of specific high-challenge fire hazards.

Slide 5-27

A. Control mode.

3.6.4.1* Control Mode Specific Application (CMSA) Sprinkler. A type of spray sprinkler that is capable of producing characteristic large water droplets and that is listed for its capability to provide fire control of specific high-challenge fire hazards.

METHODS OF DESIGN OBJECTIVES (cont'd)

- Suppression mode (ESFR) for total suppression.
  - **3.6.4.2* ESFR Sprinkler.** A type of fast-response sprinkler that is listed for its capability to provide fire suppression of specific high-challenge fire hazards.

Slide 5-28

METHODS OF DESIGN OBJECTIVES (cont'd)

– It is important to realize that the effectiveness of these highly tested and engineered sprinklers depends on the combination of fast response and the quality and uniformity of the sprinkler discharge. It should also be realized that ESFR sprinklers cannot be relied upon to provide fire control, let alone suppression.

Slide 5-29

B. Suppression mode (ESFR) for total suppression.

3.6.4.2* ESFR Sprinkler. A type of fast-response sprinkler that is listed for its capability to provide fire suppression of specific high-challenge fire hazards. It is important to realize that the effectiveness of these highly tested and engineered sprinklers depends on the combination of fast response and the quality and uniformity of the sprinkler discharge. It should also be realized that ESFR sprinklers cannot be relied upon to provide fire control, let alone suppression.

VI. BASIC METHODS OF DESIGN

BASIC METHODS OF DESIGN

- Pipe schedule method.
- The density/area method.
- Specially listed sprinklers with specific gallons per minute (gpm).
  – Extended coverage.
  – Residential.

Slide 5-30

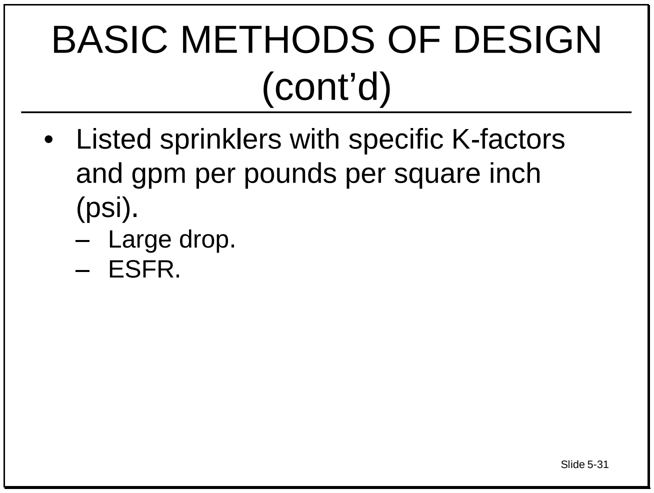
A. Pipe schedule method.

B. The density/area method.

C. Specially listed sprinklers with specific gallons per minute (gpm) (ESFR, in rack sprinklers).

1. Extended coverage.

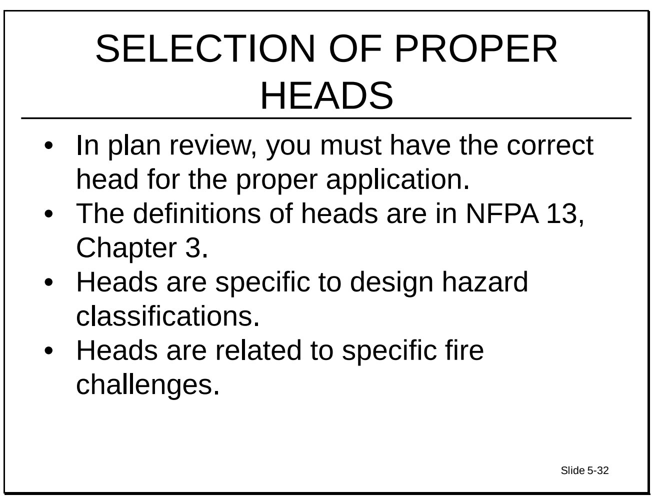
2. Residential.



D. Listed sprinklers with specific K-factors and gpm per pounds per square inch (psi).

1. Large drop.

2. ESFR.



E. Selection of proper heads.

1. In plan review, you must have the correct head for the proper application.

2. The definitions of heads are in NFPA 13, Chapter 3.

3. Heads are specific to design hazard classifications.

4. Heads are related to specific fire challenges.

SELECTION OF PROPER HEADS (cont'd)

- Wall wetting.
  - Example: Residential heads are for high wall wetting, retarding flashover, and life safety application.
- Content wetting.
  - Example: Fuel load potential for office space is a lesser hazard versus high-challenge materials in rack storage.

Slide 5-33

a. Wall wetting.

- Residential heads are for high wall wetting, retarding flashover, and life safety application.

b. Content wetting.

- Fuel load potential for office space is a lesser hazard versus high-challenge materials in rack storage.

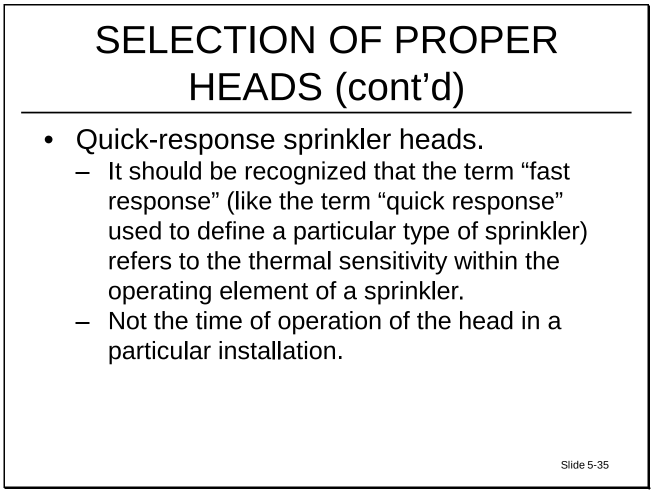
SELECTION OF PROPER HEADS (cont'd)

- Large area wetting.
  - Example: Use of ESFR sprinklers for high pile and rack storage is recognized to penetrate the fire plume and extinguish the fire from higher elevations.

Slide 5-34

c. Large area wetting.

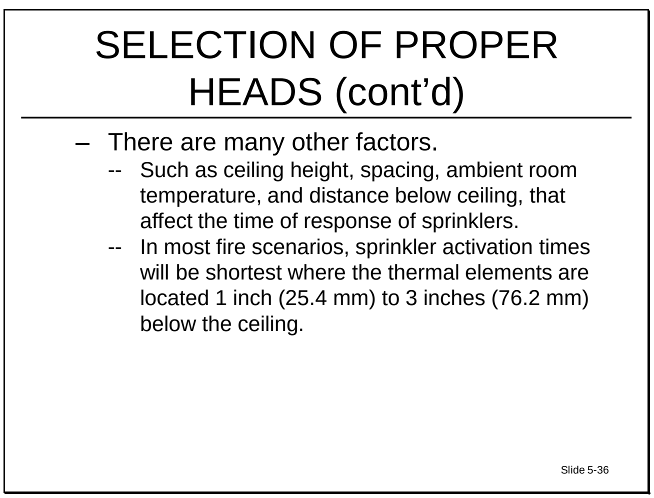
- Use of ESFR sprinklers for high pile and rack storage is recognized to penetrate the fire plume and extinguish the fire from higher elevations.



5. Quick-response sprinkler heads.

   a. It should be recognized that the term **fast response** (like the term **quick response** used to define a particular type of sprinkler) refers to the thermal sensitivity within the operating element of a sprinkler.

   b. Not the time of operation of the head in a particular installation.



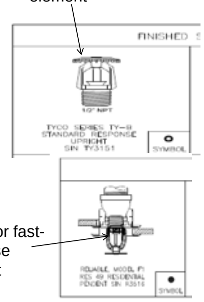
   c. There are many other factors.

      - Examples include ceiling height, spacing, ambient room temperature, and distance below ceiling that affect the time of response of sprinklers.

      - In most fire scenarios, sprinkler activation times will be shortest where the thermal elements are located 1 inch (25.4 mm) to 3 inches (76.2 mm) below the ceiling.

SELECTION OF PROPER HEADS (cont'd)

– Heads with the thinner bulb will fuse at 155 F as will the standard head with the thick bulb. The thinner bulb will fuse faster.



Slide 5-37

6. Heads with the thinner bulb will fuse at 155 F as will the standard head with the thick bulb. The thinner head bulb will fuse faster.

VERIFICATION PROCESS (cont'd)

TASK	TOOL
Identify the Design Hazard Classification	*Chapter 5 of NFPA 13*
Determine Most Demanding Area and Sprinkler Max Coverage	***Density Chart***
Determine Maximum Head Spacing	*Maximum Head Spacing Chart*
Determine Number of Heads in Protection Area	*Formula: Demand Area of Coverage Divided by Sprinkler Head Coverage*
Determine the Size of the Rectangular Demand Area	*Formula: 1.2 Times the Square Root of the Demand Area*
Determine Location of Initial Head is Accurate and Determine Spacing	*L x S Rule and Designer Preference*
Determine Number of Heads on Branch Line	*Formula: Length of Rectangle Divided by Head Spacing*

Slide 5-38

VII. DETERMINING THE MOST DEMANDING AREA AND SPRINKLER MAXIMUM COVERAGE

DENSITY/AREA CURVE METHOD SPRINKLER HEAD FLOW

- How much water do we need?
- Density/Area curve method is still the most widely used method.
- Flow of sprinkler head is density multiplied by the area of sprinkler coverage.
  - A sprinkler head with a coverage area of 130 square feet and a design density of .15 would require 19.5 gallons.

Slide 5-39

A. Density/Area curve method sprinkler head flow.

1. How much water do we need?

2. Density/Area curve method is still the most widely used method.

3. Flow of sprinkler head is density multiplied by the area of sprinkler coverage.

   Example: A sprinkler head with a coverage area of 130 square feet and a design density of .15 would require 19.5 gallons.

DENSITY/AREA CURVE METHOD SPRINKLER HEAD FLOW (cont'd)

- Water flow out of a sprinkler to cover a certain floor area.

Slide 5-40

4. Water flow out of a sprinkler to cover a certain floor area.

Example: Sprinkler flow of 30 gpm/200 square feet = density of .15 gallons per square feet.

MOST DEMANDING AREA PRINCIPLE

If sprinklers can control fire in most remote and hydraulically challenging areas, anything upstream will be protected adequately.

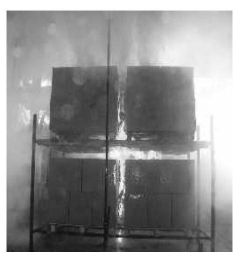
Slide 5-41

5. Most demanding area principle.

If sprinklers can control fire in most remote and hydraulically challenging areas, anything **upstream** will be protected adequately.

DEMANDING AREA/AREA OF APPLICATION

- Not necessarily physically most remote.
- Occupancy driven: Based on estimated fire challenge and the predicted number of operating sprinklers.



Slide 5-42

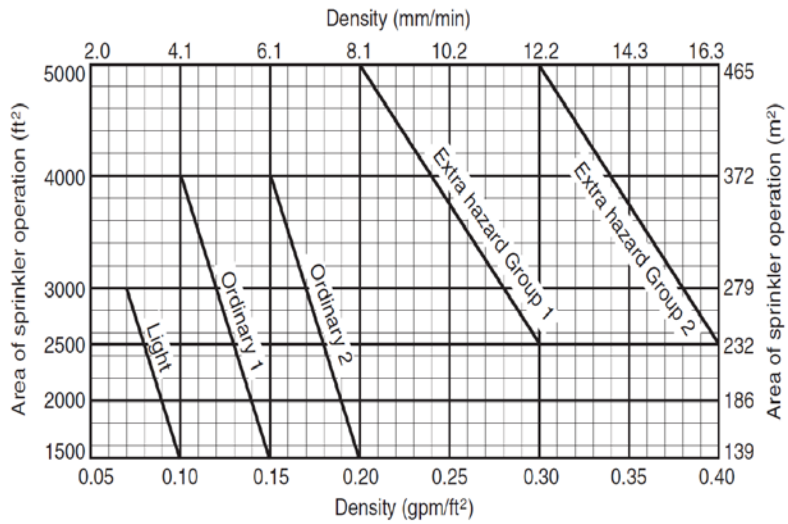
6. Demanding area/Area of application.

   a. Not necessarily **physically** most remote.

      - Example: Light Hazard occupancy requires minimal sprinkler discharge (20 gallons per 225 square feet). Ordinary Hazard Group 2 sprinkler discharge (45 gallons per 130 square feet).

- Both occupancies are in the same building: Light Hazard is most remote, Ordinary Group 2 is most demanding and therefore would be the calculated flow.

b. Occupancy driven: Based on estimated fire challenge and the predicted number of operating sprinklers.



DENSITY/AREA CURVE METHOD

- Determine the amount of water and area coverage of a head to start the hydraulic calculation.
- Any point on the curve on the chart can be used with the appropriate hazard classification.
- Using the greatest density and the smallest area of coverage is usually found to be the most economical.

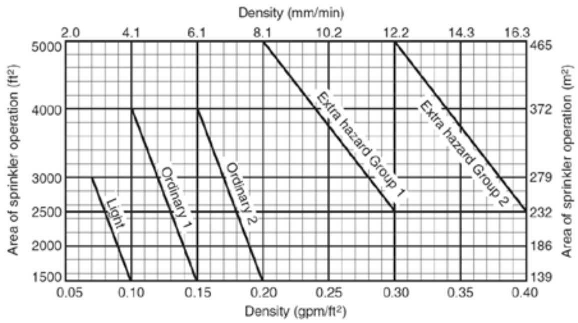
Slide 5-43

7. Determine the amount of water and area coverage of a head to start the hydraulic calculation.

8. Any point on the curve on the chart can be used with the appropriate hazard classification.

9. Using the greatest density and the smallest area of coverage is usually found to be the most economical.

DENSITY CHART



Slide 5-44

B. Density chart examples (NFPA 13, 2010, p. 13-118).

1. Ordinary Hazard Group 1 at area sprinkler operation of 2,000 square foot density is .14 gallons/square foot.

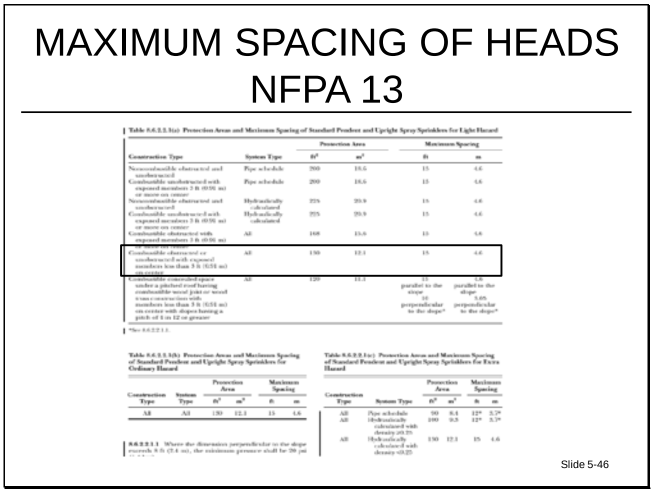
2. Extra Hazard Groups 1 and 2 have a minimum area of sprinkler operation 2,500 square feet.

VERIFICATION PROCESS (cont'd)

TASK	TOOL
Identify the Design Hazard Classification	*Chapter 5 of NFPA 13*
Determine Most Demanding Area and Sprinkler Maximum Coverage	*Density Chart*
Determine Maximum Head Spacing	***Maximum Head Spacing Chart***
Determine Number of Heads in Protection Area	*Formula: Demand Area of Coverage Divided by Sprinkler Head Coverage*
Determine the Size of the Rectangular Demand Area	*Formula: 1.2 Times the Square Root of the Demand Area*
Determine Location of Initial Head is Accurate and Determine Spacing	*L x S Rule and Designer Preference*
Determine Number of Heads on Branch Line	*Formula: Length of Rectangle Divided by Head Spacing*

Slide 5-45

VIII. DETERMINE MAXIMUM HEAD SPACING



A. Maximum spacing of heads NFPA 13, Table 8.6.2.2.1(a) (NFPA 13, 2010, p. 13-52).

1. Maximum sprinkler head spacing tables for Light, Ordinary and Extra hazard classifications.

2. Chart must be examined carefully to ensure the proper maximum head coverage.

   Example: An unoccupied combustible attic area with wood trusses 2 feet on center would be considered a Light Hazard occupancy normally with a sprinkler head coverage of 225 square feet. But due to the rule above, it would be reduced to 130 square feet.

3. Some reviewers will make up the room chart to make reading easier.

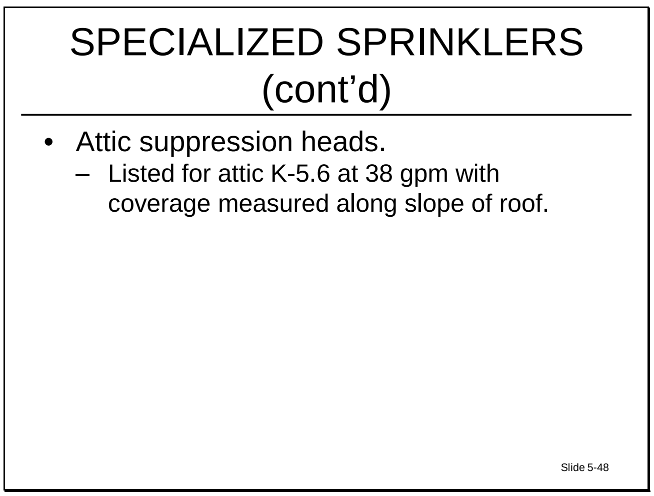
4. Specialized sprinklers are specific to application and gpm flow.

   a. Extended coverage heads.

      - Listed for Light Hazard K-8.0 at 32.4 gpm covering 18 feet by 18 feet.

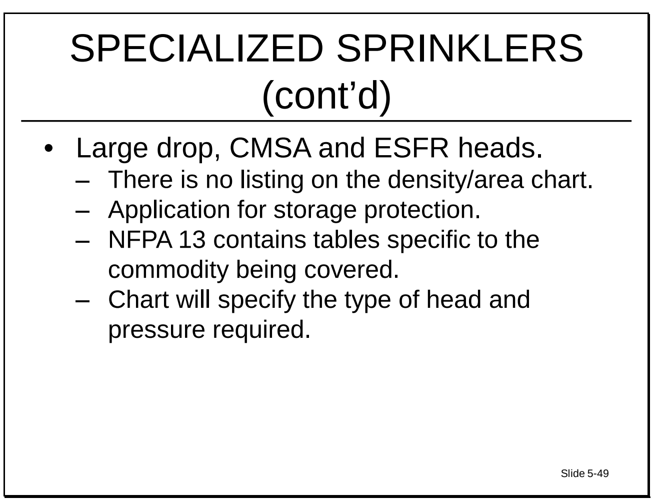
   b. Residential heads.

      - Listed for residential K-4.9 at 13 gpm covering 15 feet by 15 feet.



   c. Attic suppression heads.

      - Listed for attic K-5.6 at 38 gpm with coverage measured along slope of roof.



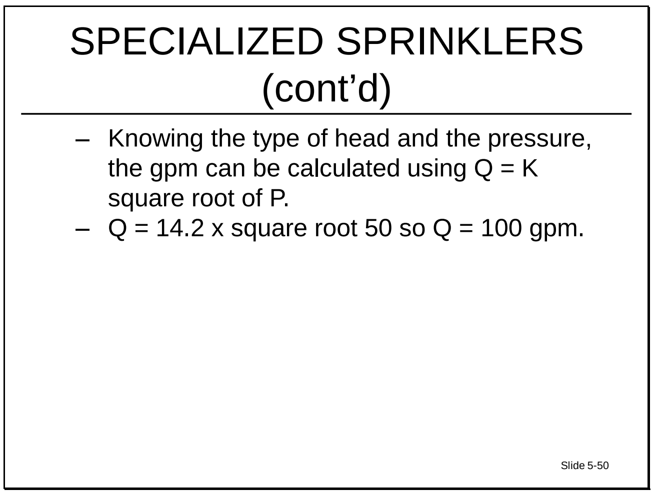
d. Large drop, CMSA and ESFR heads are for commodity storage requiring specific amounts of water application to contain and/or extinguish fire.

- There is no listing on the density/area chart.

- Application for storage protection.

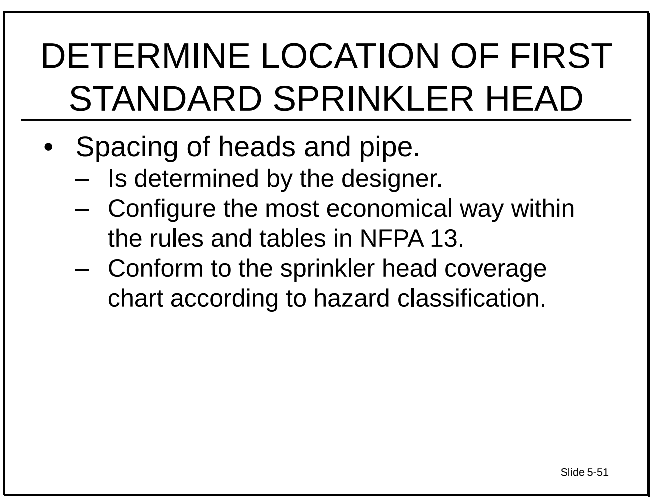
- NFPA 13 contains tables specific to the commodity being covered.

- Chart will specify the type of head and pressure required.



-- Knowing the type of head and the pressure, the gpm can be calculated using Q = K square root of P.

-- Q = 14.2 x square root 50 so Q = 100 gpm.



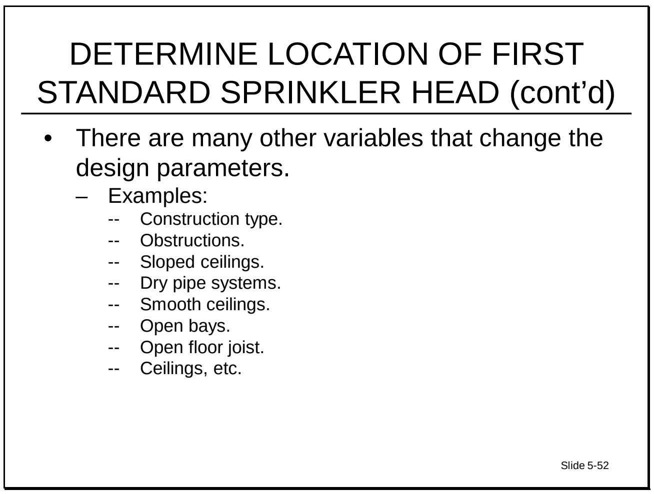
B. Determine location of first standard sprinkler head.

1. Spacing of heads and pipe.

   a. Determined by the designer.

   b. Configure the most economical way within the rules and tables in NFPA 13.

   c. Has to conform to the sprinkler head coverage chart according to hazard classification.



2. There are many other variables that change the design parameters.

   Examples:

   a. Construction type.

   b. Obstructions.

   c. Sloped ceilings.

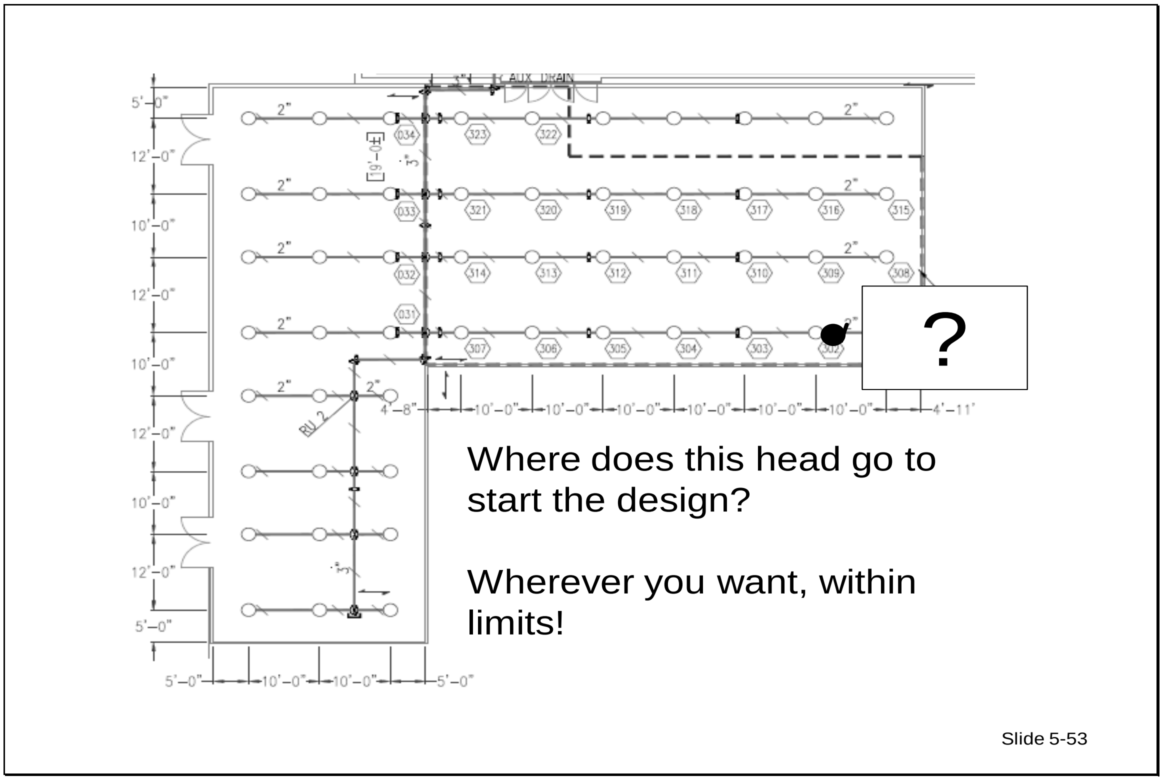
   d. Dry pipe systems.

   e. Smooth ceilings.

   f. Open bays.

   g. Open floor joist.

   h. Ceilings, etc.



3. Where does this head go to start the design? Wherever you want, within limits! Look at all aspects of the space you're trying to protect and use good judgment plus rules to establish your first sprinkler head.

DETERMINE LOCATION OF FIRST STANDARD SPRINKLER HEAD (cont'd)

- Sprinkler head maximum coverage area.
  - Hazard classification.
    - Light 225.
    - Ordinary 130.
    - Extra 100 square feet.
    - ESFR 100 square feet.

Slide 5-54

4. Sprinkler head maximum coverage area.

   Hazard classification.

   a. Light 225.

   b. Ordinary 130.

   c. Extra 100 square feet.

   d. ESFR 100 square feet.

DETERMINE LOCATION OF FIRST STANDARD SPRINKLER HEAD (cont'd)

- End-of-the-line head spacing from wall is no more than one-half of the maximum spacing of heads on the branch lines, and in the other direction it is no more than one-half the spacing between branch lines.

Slide 5-55

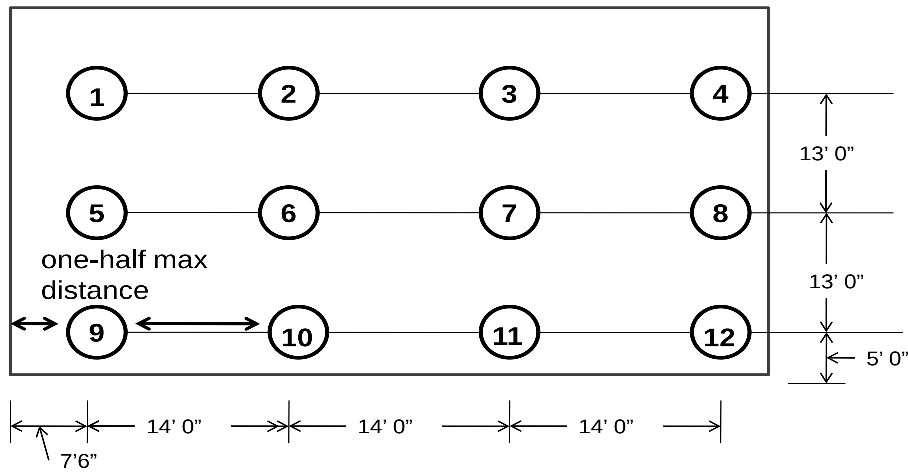
5. End-of-the-line head spacing from wall is no more than one-half maximum spacing of heads on the branch lines. In the other direction, it is no more than one-half the spacing between branch lines.

DETERMINE LOCATION OF FIRST STANDARD SPRINKLER HEAD (cont'd)

- Exception: If spacing between heads chosen is less than the maximum, the designer can still use one-half of the maximum spacing to the wall if he or she wants to.

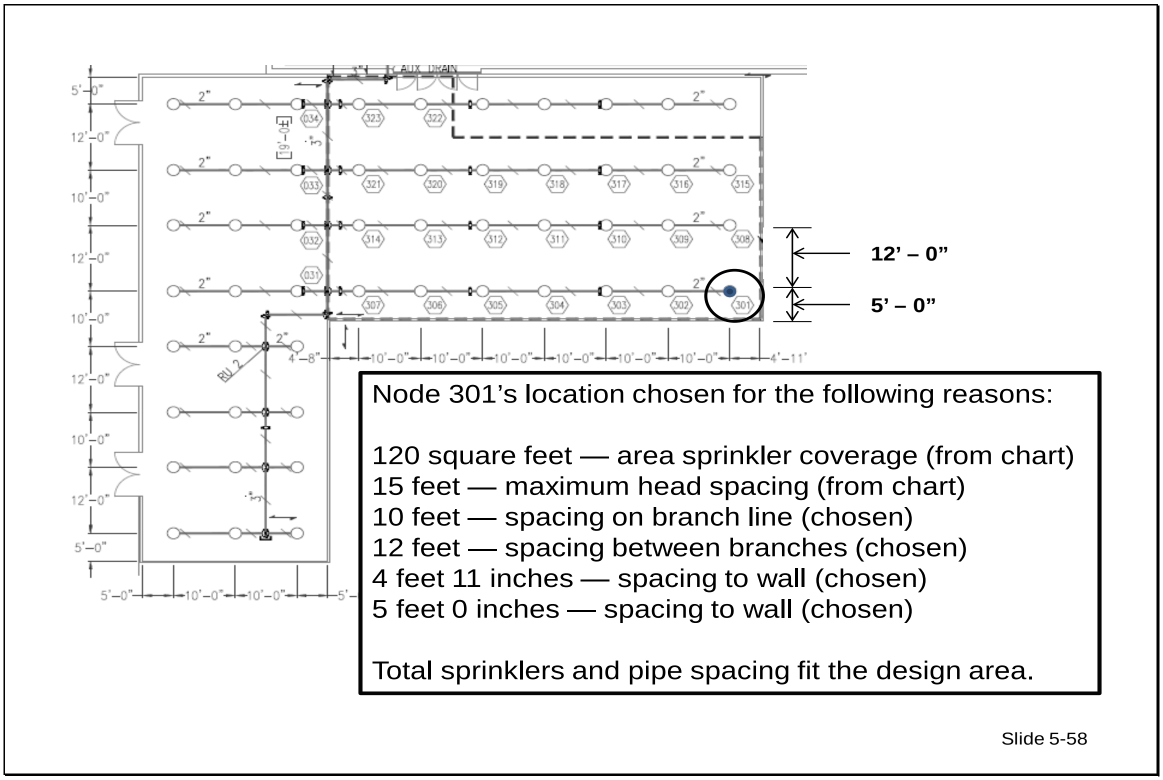
Slide 5-56

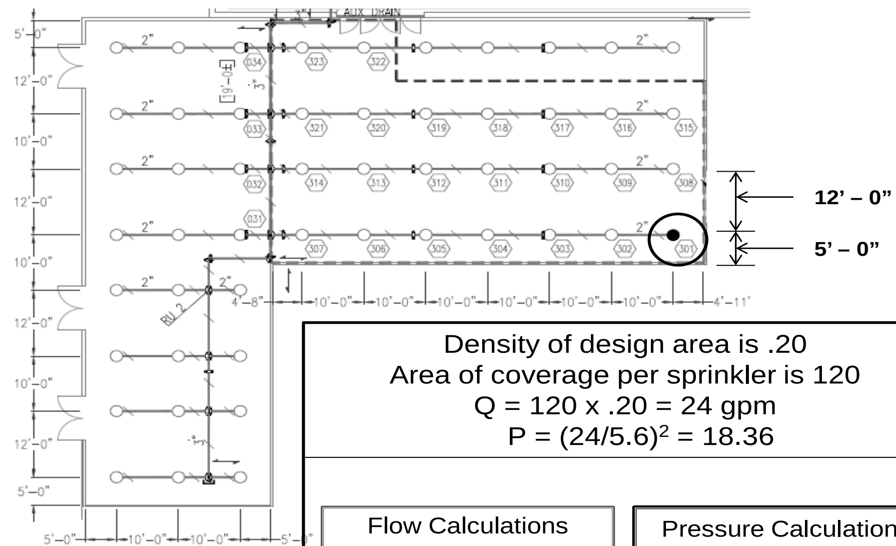
Exception: If spacing between the chosen heads is less than the maximum, the designer can still use one-half maximum spacing to wall if he or she wants to.



Head coverage area is max 225 feet.
Maximum spacing between heads is 15 feet.
Spacing on branch line: This case is 14 feet.
Max to wall 7 feet 6 inches can still be used — does not exceed head coverage required of 15 feet.

Slide 5-57


12' – 0"
5' – 0"
Node 301's location chosen for the following reasons:
120 square feet — area sprinkler coverage (from chart)
15 feet — maximum head spacing (from chart)
10 feet — spacing on branch line (chosen)
12 feet — spacing between branches (chosen)
4 feet 11 inches — spacing to wall (chosen)
5 feet 0 inches — spacing to wall (chosen)
Total sprinklers and pipe spacing fit the design area.
Slide 5-58



Density of design area is .20
Area of coverage per sprinkler is 120
Q = 120 x .20 = 24 gpm
P = $(24/5.6)^2$ = 18.36

Flow Calculations

Q = Area of coverage x density

Pressure Calculation

P = $(Q/K)^2$

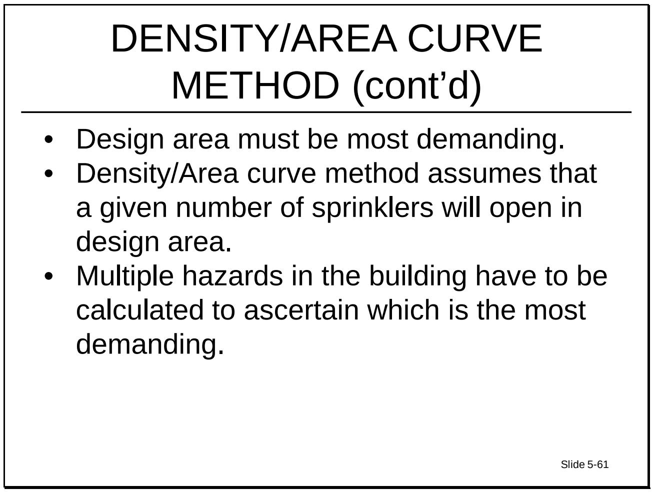
Slide 5-59

VERIFICATION PROCESS (cont'd)

TASK	TOOL
Identify the Design Hazard Classification	*Chapter 5 of NFPA 13*
Determine Most Demanding Area and Sprinkler Maximum Coverage	*Density Chart*
Determine Maximum Head Spacing	*Maximum Head Spacing Chart*
Determine Number of Heads in Protection Area	***Formula: Demand Area of Coverage Divided by Sprinkler Head Coverage***
Determine the Size of the Rectangular Demand Area	*Formula: 1.2 Times the Square Root of the Demand Area*
Determine Location of Initial Head is Accurate and Determine Spacing	*L x S Rule and Designer Preference*
Determine Number of Heads on Branch Line	*Formula: Length of Rectangle Divided by Head Spacing*

Slide 5-60

IX. DETERMINE NUMBER OF HEADS IN DESIGN COVERAGE AREA

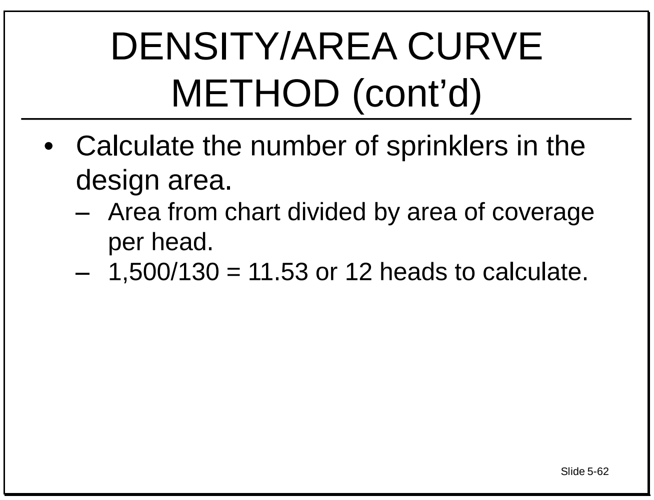


Density/Area curve method.

A. Design area must be most demanding.

B. Density/Area curve method assumes that a given number of sprinklers will open in design area.

C. Multiple hazards in the building have to be calculated to ascertain which is the most demanding.

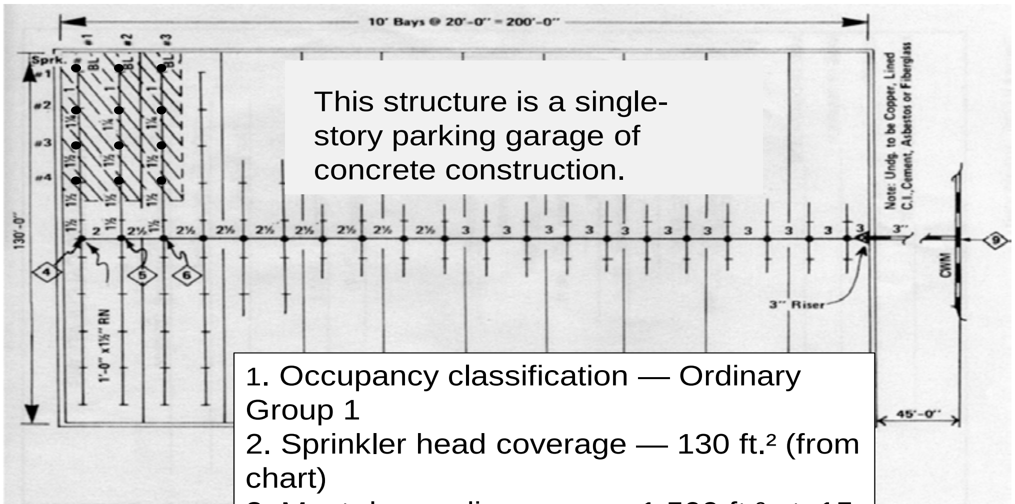


D. Calculate the number of sprinklers in the design area.

   1. Area from chart divided by area of coverage per head.

   2. 1,500/130 = 11.53 or 12 heads to calculate.

DENSITY/AREA CURVE METHOD (cont'd)



This structure is a single-story parking garage of concrete construction.

1. Occupancy classification — Ordinary Group 1
2. Sprinkler head coverage — 130 ft.² (from chart)
3. Most demanding area — 1,500 ft.² at .15 Density

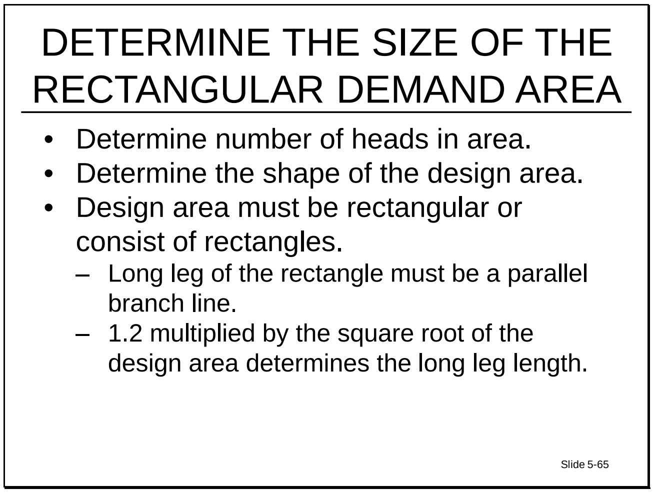
Slide 5-63

VERIFICATION PROCESS (cont'd)

TASK	TOOL
Identify the Design Hazard Classification	*Chapter 5 of NFPA 13*
Determine Most Demanding Area and Sprinkler Maximum Coverage	*Density Chart*
Determine Maximum Head Spacing	*Maximum Head Spacing Chart*
Determine Number of Heads in Protection Area	*Formula: Demand Area of Coverage Divided by Sprinkler Head Coverage*
Determine the Size of the Rectangular Demand Area	***Formula: 1.2 Times the Square Root of the Demand Area***
Determine Location of Initial Head is Accurate and Determine Spacing	*L x S Rule and Designer Preference*
Determine Number of Heads on Branch Line	*Formula: Length of Rectangle Divided by Head Spacing*

Slide 5-64

X. DETERMINE THE SIZE OF THE RECTANGULAR DEMAND AREA



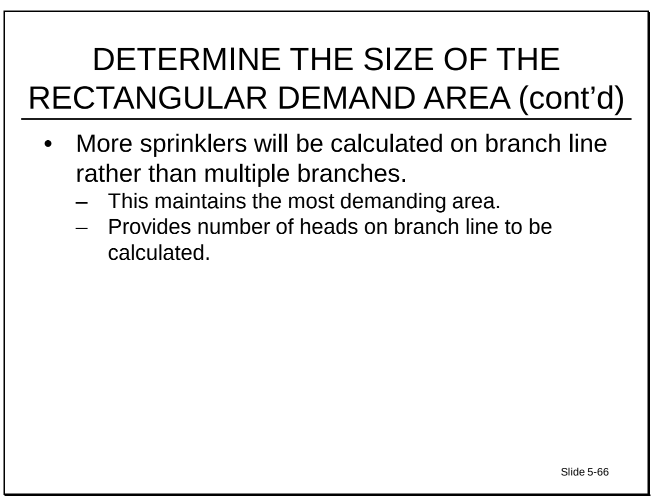
A. Determine number of heads in area.

B. Determine the shape of the design area.

C. Design area must be rectangular or consist of a group of rectangles.

1. Long leg of the rectangle must be a parallel branch line of the sprinkler system.

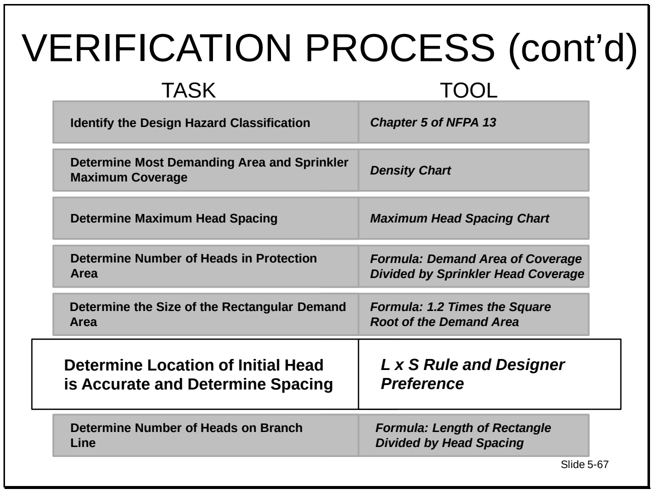
2. 1.2 multiplied by the square root of the design area will determine the long leg length.



D. More sprinklers will be calculated on branch line rather than multiple branches.

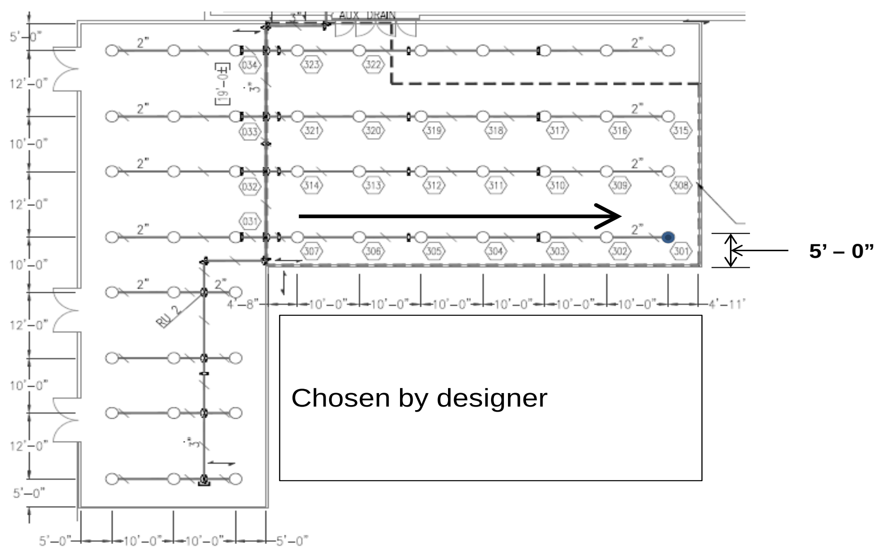
1. This maintains the most demanding area.

2. Provides number of heads on branch line to be calculated.



XI. DETERMINE LOCATION OF INITIAL HEAD IS ACCURATE AND DETERMINE SPACING

Utilize L x S Rule.

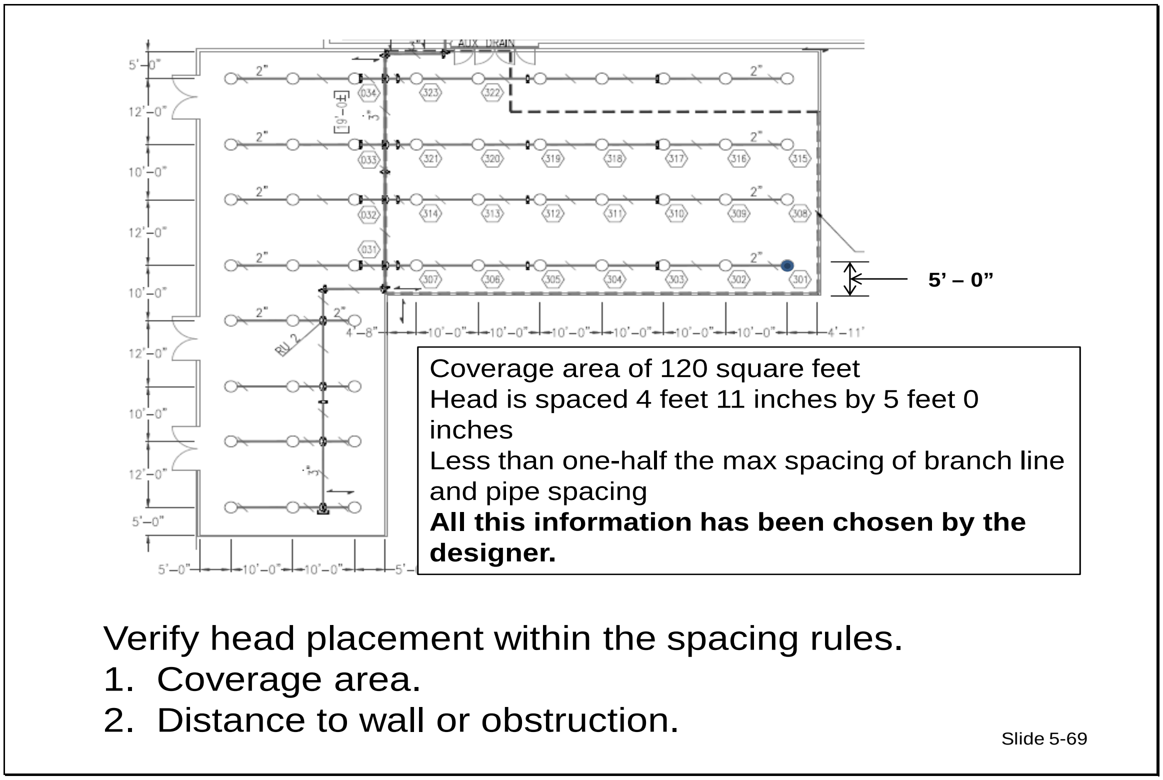


First, verify the direction the branch line will run.

Slide 5-68

A. First verify the direction the branch line will run.

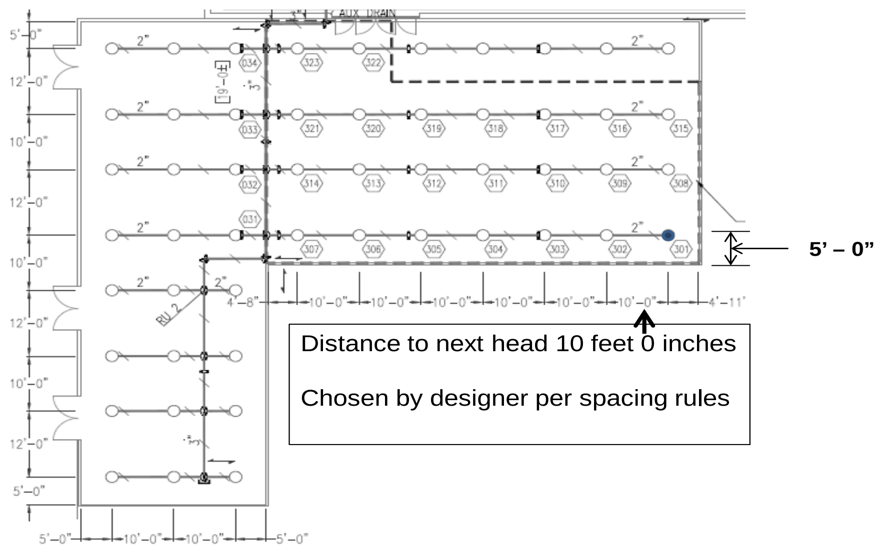
This is chosen by the designer.



B. Verify head placement within the spacing rules.

1. Coverage area.

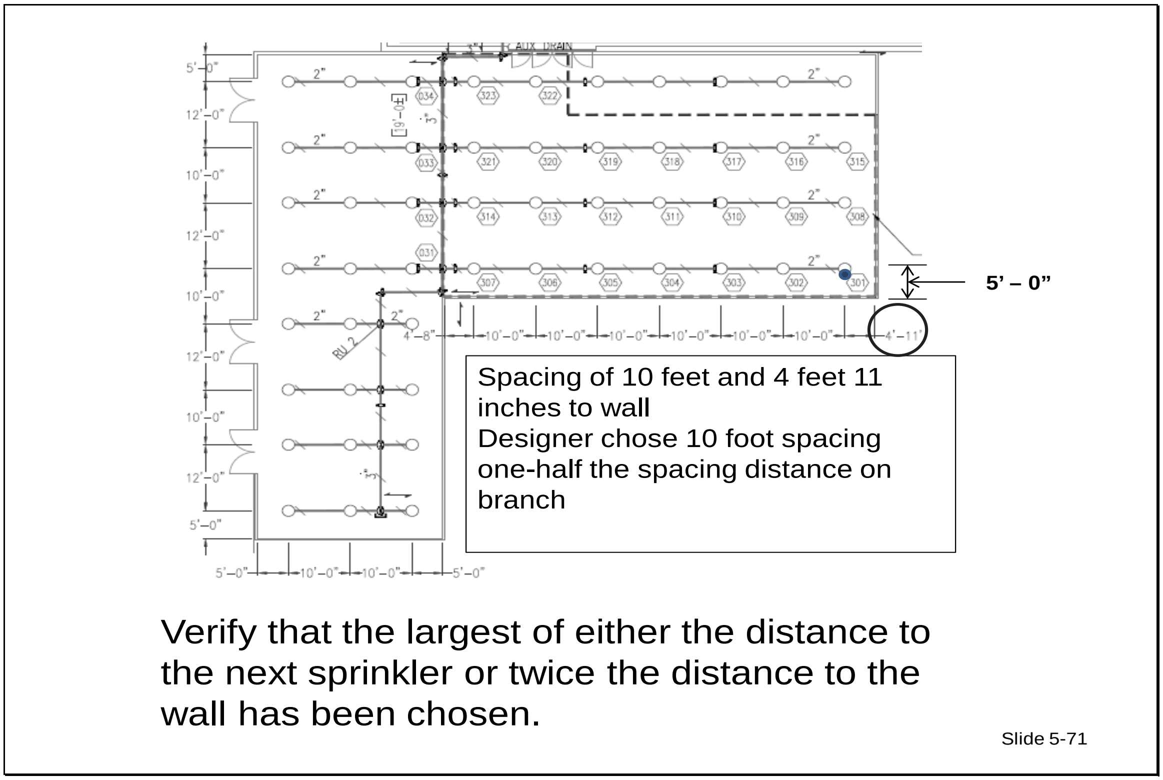
2. Distance to wall or obstruction.



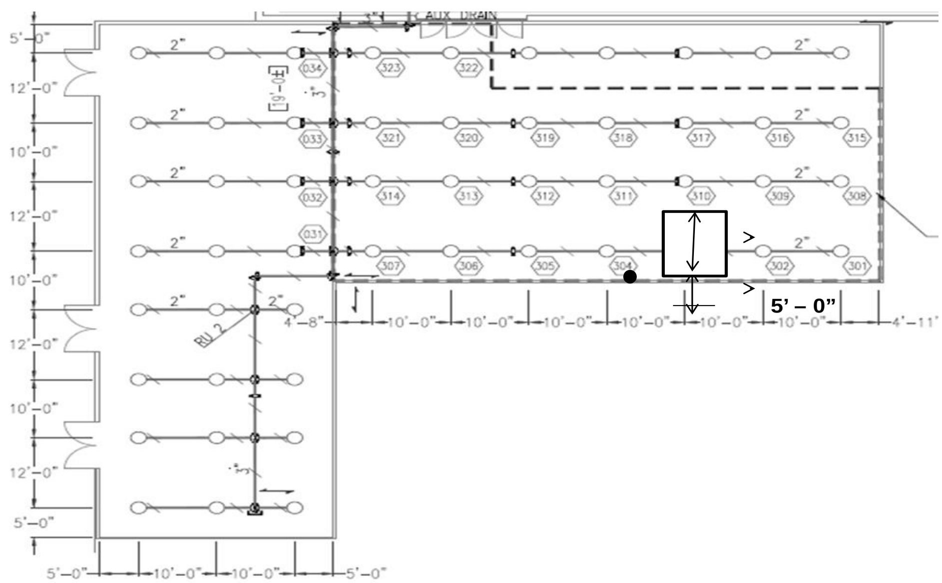
Verify the distance to the next head.

Slide 5-70

C. Verify the distance to the next head.



D. Verify that the largest of either the distance to the next sprinkler or twice the distance to the wall has been chosen.

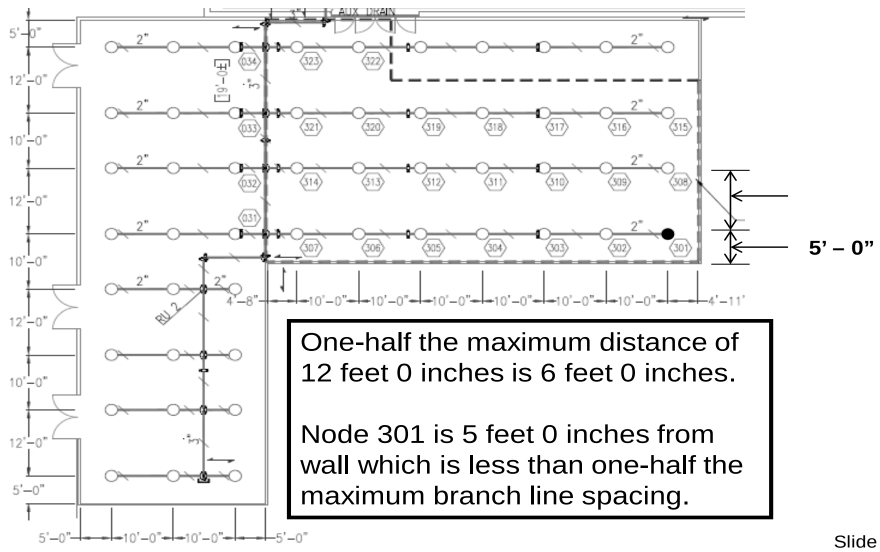


Verify the perpendicular distance to the sprinkler head on the adjacent branch line (distance between branch line heads).

Slide 5-72

E. Verify the perpendicular distance to the sprinkler head on the adjacent branch line (distance between branch line heads).

Choose the larger of either twice the distance to the wall of the first head or the maximum distance between the two said sprinkler branch lines.



Slide 5-73

F. Choose the larger of either twice the distance to the wall of the first head or the maximum distance between the two said sprinkler branch lines.

VERIFICATION PROCESS (cont'd)

TASK	TOOL
Identify the Design Hazard Classification	*Chapter 5 of NFPA 13*
Determine Most Demanding Area and Sprinkler Maximum Coverage	*Density Chart*
Determine Maximum Head Spacing	*Maximum Head Spacing Chart*
Determine Number of Heads in Protection Area	*Formula: Demand Area of Coverage Divided by Sprinkler Head Coverage*
Determine the Size of the Rectangular Demand Area	*Formula: 1.2 Times the Square Root of the Demand Area*
Determine Location of Initial Head is Accurate and Determine Spacing	*L x S Rule and Designer Preference*
Determine Number of Heads on Branch Line	***Formula: Length of Rectangle Divided by Head Spacing***

Slide 5-74

XII. DETERMINE NUMBER OF HEADS ON BRANCH LINE FOR DIFFERENT APPLICATIONS

NUMBER OF SPRINKLERS TO BE CALCULATED ON BRANCH LINE

- What is the number of design sprinklers to be calculated per branch in the actual design area of 2,535 square feet with sprinklers spaced 10 feet on center on the pipe?
  - (1.2 x √2,535)/10.
  - (1.2 x 50.35)/10.
  - 60.42/10.
  - 6.04 or 7 heads on branch line.

Slide 5-75

A. What is the number of design sprinklers to be calculated per branch in the actual design area of 2,535 square feet with sprinklers spaced 10 feet on center on the pipe?

1. (1.2 x √2,535)/10.

2. (1.2 x 50.35)/10.

3. 60.42/10.

4. 6.04 or 7 heads on branch line.

SMALL ROOM RULE

- Rules change in small room calculations.
  - Maximum spacing from wall 9 feet from only one wall.
  - All other wall spacing must comply with spacing requirements of NFPA 13.
  - Room must be considered Light Hazard.
  - Room must be 800 square feet or less.
  - Ceiling must be of unobstructed construction.

Slide 5-76

B. Utilizing NFPA 13 rules for a small room calculation.

1. Rules change in small room calculations.

   a. Maximum spacing from wall 9 feet from only one wall.

   b. All other wall spacing must comply with the spacing requirements of NFPA 13.

   c. Room must be Light Hazard.

   d. Room must be 800 square feet or less.

   e. Ceiling must consist of unobstructed construction.

   f. Room must be surrounded with rated walls and ceiling.

SMALL ROOM RULE (cont'd)

- Room must be surrounded with rated walls and ceiling.
- The rating must correspond to the flow rating of the sprinkler system.
- Openings in walls must have a header depth of 8 inches or more to trap heat.

- Small room rule allows designers to move heads away from lights or heat vents and still provide coverage.

Slide 5-77

g. The rating must correspond to the flow rating of the sprinkler system.

h. Openings in walls must have a header depth of 8 inches or more to trap heat.

2. Small room rule allows designers to move heads away from lights or heat vents and still provide coverage.

SMALL ROOM RULE (cont'd)

- Special calculations for sprinkler coverage.
  - Averaging technique.
  - 225 square foot maximum head coverage.
  - Total square footage of room divided by number of heads in room must be less than 225 square feet.
  - Example: next slide.
    - -- 672 square foot room/three heads = 224 square feet.

Slide 5-78

3. Special calculations for small room rule sprinkler coverage.

Averaging technique.

a. 225 square foot maximum head coverage.

b. Total square footage of room divided by number of heads in room must be less than 225 square feet.

- Example: 672 square foot room/three heads = 224 square feet.

EXTENDED COVERAGE HEAD SPACING RULES

- Designed and tested by the manufacturer.
- Approved by the authority having jurisdiction (AHJ).
- Coverage must be in 2-foot increments.
- Total area of coverage is 400 square feet.
- Maximum distance between heads is 20 feet.
- Spacing of pendent and upright sprinkler heads is the same in both directions:
  - Example 20 feet x 20 feet.

Slide 5-79

C. Extended coverage head spacing rules.

1. Designed and tested by the manufacturer.

2. Approved by the authority having jurisdiction (AHJ).

3. Coverage must be in 2-foot increments.

   Example: 18 feet x 18 feet or 20 feet x 20 feet.

4. Total area of coverage is 400 square feet.

5. Maximum distance between heads is 20 feet.

6. Spacing of pendent and upright sprinkler heads is the same in both directions.

   Example: 20 feet x 20 feet = 400 square feet.

EXTENDED COVERAGE HEAD SPACING RULES (cont'd)

- Sidewall heads extended coverage is 28 feet one way or the other:
  - Example 14 feet width 28 foot throw or 14 feet x 28 feet.
- Upright and pendent must meet the one-half the distance to the wall rule:
  - 18 x 18 coverage — no further than 9 feet to wall.

Slide 5-80

7. Sidewall heads extended coverage is 28 feet one way or the other.

   Example: 14 foot width 28 foot throw or 14 feet x 28 feet.

8. Upright and pendent must meet the "one-half the distance to the wall" rule.

   Example: 18 x 18 coverage cannot be any further than 9 feet to wall.

EXTENDED COVERAGE HEAD SPACING RULES (cont'd)

- Sidewall heads must not exceed one-half the distance to the wall for their width distance.
  - 14 x 28 coverage — no further than 7 feet to the wall.

Slide 5-81

9. Sidewall heads must not exceed one-half the distance to the wall for their width distance.

   Example: 14 x 28 coverage cannot be any further than 7 feet to the wall.

EXTENDED COVERAGE HEAD SPACING RULES (cont'd)

- 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 5-82

10. Construction: flat, smooth, unobstructed.

    If used in web truss construction.

    a. Web members must be less than 1 inch wide.

b. Trusses have to be 7 1/2 feet on center.

c. Ceilings: smooth flat ceiling is considered a 4/12 pitch or less.

d. Noncombustible construction in some cases.

ACTIVITY 5.2

Storage Exercise

Purpose

To determine maximum height of storage in relation to sprinkler coverage.

Directions

You will individually review the four examples and determine if the stacked height and ceiling height is correct per charts in NFPA 13, Chapters 12 to 20.

1. Cartons of Aerosol stacked 16 feet high with a ceiling height of 26 feet.

   ____

   ____

   ____

2. Polyethylene stored in drums stacked 3 drums high with a ceiling height of warehouse 20 feet.

   ____

   ____

   ____

3. Cartons of polystyrene drink cups stacked on racks of a 13-foot high roof with a height of 25 feet.

   ____

   ____

   ____

4. Rubber tires stacked in the garage storage area 5 feet high and 12 feet squared. Roof is 15 feet high.

ACTIVITY 5.3

Exterior Shade Structure

Purpose

This culminating activity draws together all of the lessons learned in this unit.

Directions

Using the given example, you will identify and calculate the following:

1. Occupancy classification.

   ____

   ____

   ____

2. Type of system.

   ____

   ____

   ____

3 Sprinkler head coverage.

   ____

   ____

   ____

4. Most demanding area square footage.

   ____

   ____

   ____

5. Number of heads.

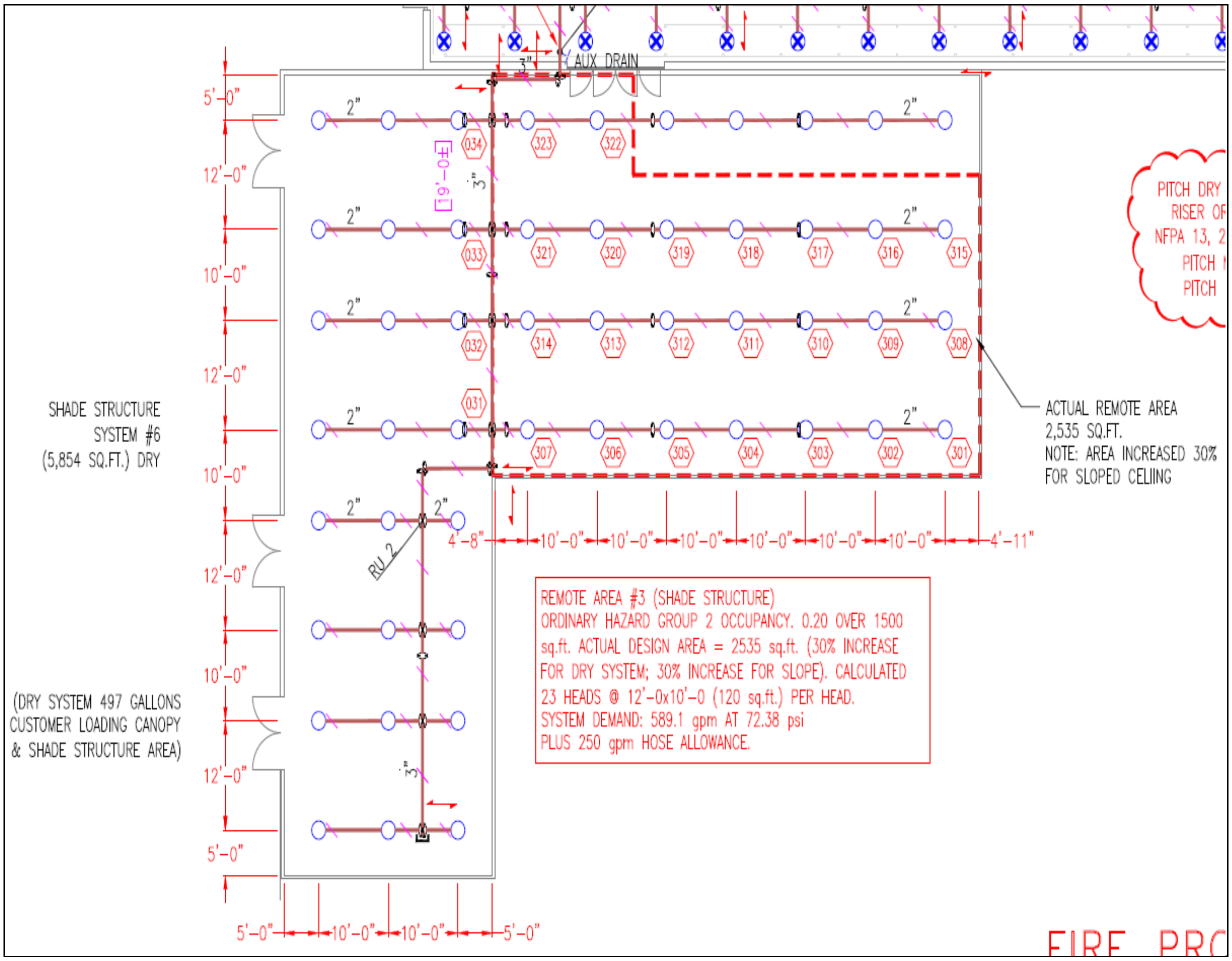
6. Compounding of area.

7. Long dimension of rectangular demand area.

8. Number of heads per branch line.

ACTIVITY 5.3 (cont'd)

Exterior Shade Structure



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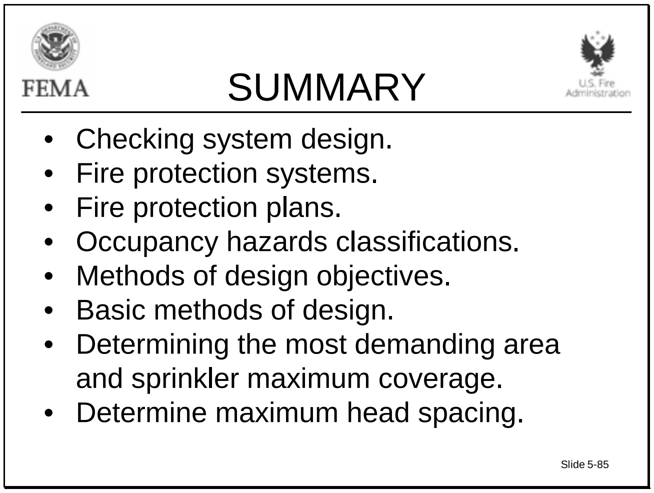
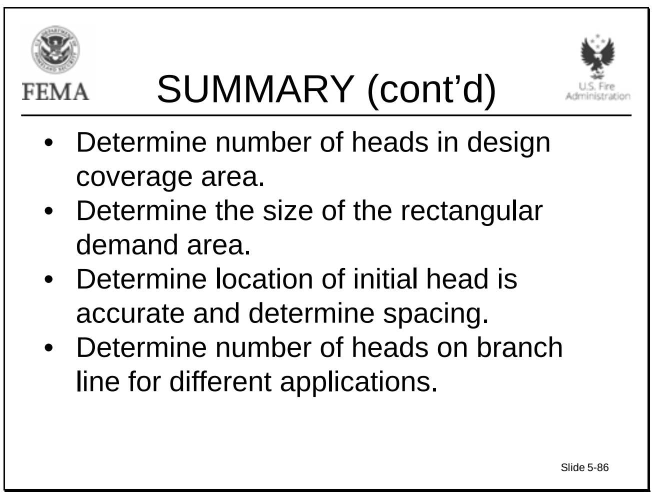
XIII. SUMMARY





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UNIT 6: EVALUATING SPRINKLER HYDRAULIC CALCULATIONS

TERMINAL OBJECTIVE

The students will be able to:

6.1 Given a set of plans with hydraulic calculations, verify that the calculation methods are in compliance with recognized standards and that water-based fire protection systems design calculations are accurate.

ENABLING OBJECTIVES

The students will be able to:

6.1 Given a set of sprinkler plans and associated hydraulic calculations, complete a basic hydraulic calculation.

6.2 Given a set of sprinkler plans and associated hydraulic calculations, calculate the flow characteristics from each identified node point based on required system densities and associated pressure losses due to friction and elevation.

6.3 Given a set of plans and hydraulic calculations, evaluate the design of the water-based fire protection system from remote area to water supply source for approval or rejection.

6.4 Given a set of plans and hydraulic calculations, recognize certain optional methods which may not be incorporated into the design process but which are accepted by recognized standards.

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FEMA

U.S. Fire Administration

UNIT 6: EVALUATING SPRINKLER HYDRAULIC CALCULATIONS

Slide 6-1

TERMINAL OBJECTIVE

Given a set of plans with hydraulic calculations, verify that the calculation methods are in compliance with recognized standards and that water-based fire protection systems design calculations are accurate.

Slide 6-2

ENABLING OBJECTIVES

- Given a set of sprinkler plans and associated hydraulic calculations, complete a basic hydraulic calculation.
- Given a set of sprinkler plans and associated hydraulic calculations, calculate the flow characteristics from each identified node point based on required system densities and associated pressure losses due to friction and elevation.

Slide 6-3

ENABLING OBJECTIVES (cont'd)

- Given a set of plans and hydraulic calculations, evaluate the design of the water-based fire protection system from remote area to water supply source for approval or rejection.
- Given a set of plans and hydraulic calculations, recognize certain optional methods which may not be incorporated into the design process but which are accepted by recognized standards.

Slide 6-4

I. PLACEMENT AND SPACING OF SPRINKLER HEADS

PLACEMENT OF HEADS

- Where to put the sprinkler head?
- Considerations:
  - Type of sprinkler: upright, pendant, sidewall.
  - Spray, Early Suppression Fast Response (ESFR), large drop, extended coverage, residential.
  - Ceiling construction, allowable distance plan sprinklers, place on walls, hazard classification of occupancy, obstructions, heat sources.

Slide 6-5

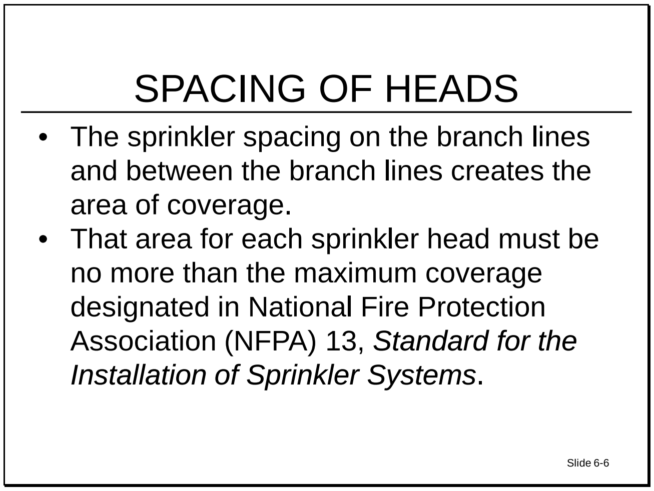
Where to put the sprinkler head?

A. Considerations:

1. Type of sprinkler head: upright, pendant, sidewall.

2. Spray, Early Suppression Fast Response (ESFR), large drop, extended coverage, residential.

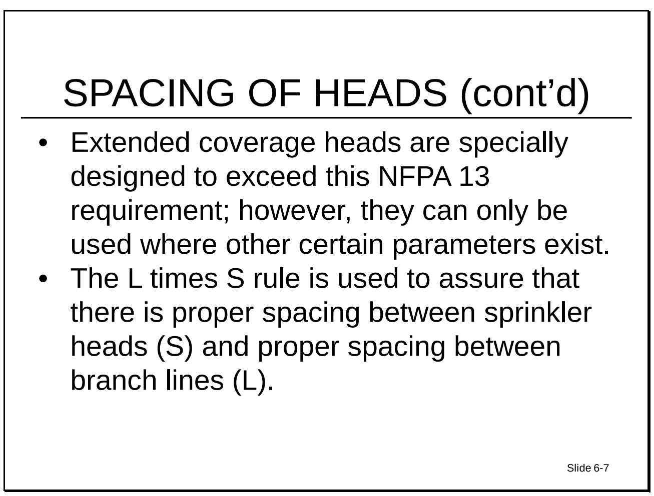
3. Ceiling construction, allowable distance plan sprinklers, place on walls, hazard classification of occupancy, obstructions, heat sources.



B. Spacing of heads.

1. The sprinkler spacing on the branch lines and between the branch lines creates the area of coverage.

2. That area for each sprinkler head must be no more than the maximum coverage designated in National Fire Protection Association (NFPA) 13, *Standard for the Installation of Sprinkler Systems*.



3. Extended coverage heads are specially designed to exceed this NFPA 13 requirement; however, they can only be used where other certain parameters exist.

4. The L times S rule is used to assure that there is proper spacing between sprinkler heads (S) and proper spacing between branch lines (L).

II. BALANCING

BALANCING

- When two branch lines are connected to one cross main and there are more heads on one side of the cross main than the other, in the demand area, the system must be balanced.
- There can never be two different pressures at the same point in the cross main.

Slide 6-8

A. When two branch lines are connected across one cross main and there are more heads on one side of the cross main than the other, in the demand area, the system must be balanced.

B. There can never be two different pressures at the same point in the cross main.

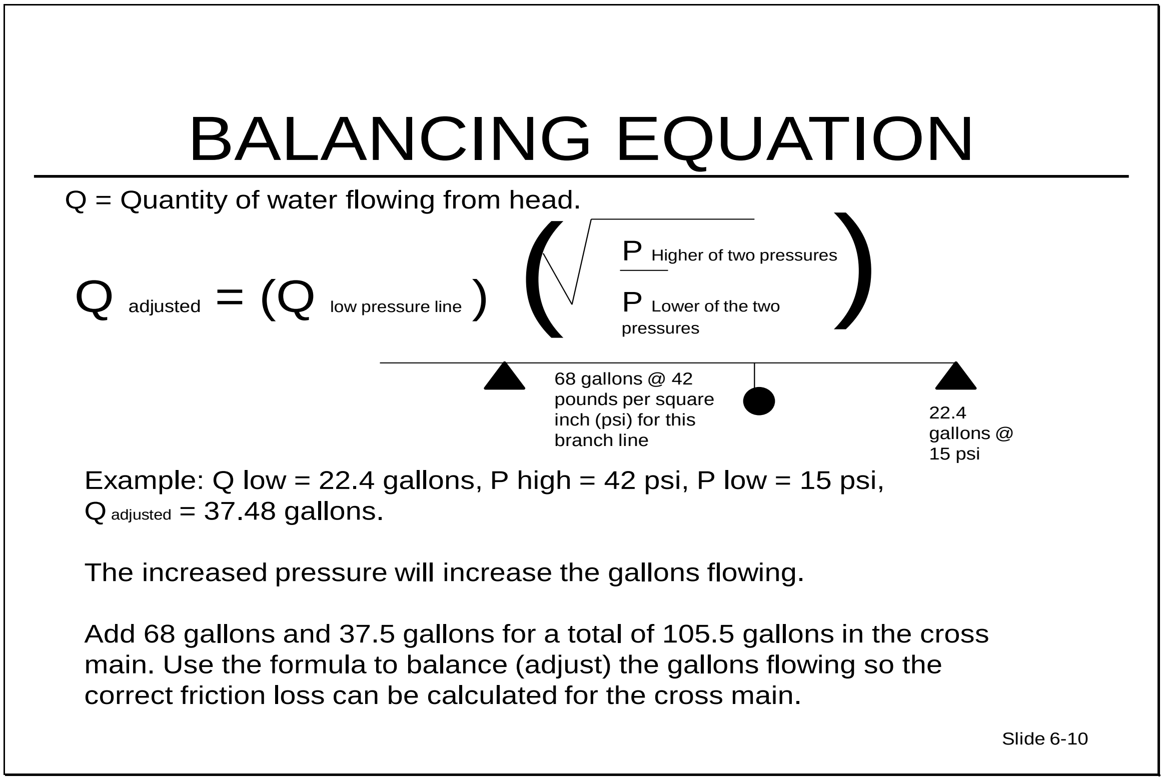
BALANCING (cont'd)

- The branch line with more heads is going to require more pressure.
- That pressure is going to go to the other branch line.

Slide 6-9

C. The branch line with more heads is going to require more pressure.

D. That pressure is going to go to the other branch line.



E. Balancing equation.

Example:

1. Q low = 22.4 gallons, P high = 42 pounds per square inch (psi), P low = 15 psi.

2. Q adjusted = 37.48 gallons.

3. The increased pressure will increase the gallons flowing.

4. Add 68 gallons and 37.5 gallons for a total of 105.5 gallons in the cross main.

5. Use the formula to balance (adjust) the gallons flowing so the correct friction loss can be calculated for the cross main.

III. PEAKING

PEAKING

- Peaking is used to determine if the remote area is correctly located in a grid system.
- The designer has a choice because water is supplied from two directions.
- It is preferable to shade your grid to the smaller cross main side because less water is available.
- The designer has certain number of heads in the demand area to calculate.

Slide 6-11

A. Peaking is used to determine if the remote area is correctly located in a grid system. Peaking is a process by which 12 sprinkler heads in a design area are calculated.

B. The designer has a choice because water is supplied from two directions.

C. It is preferable to shade your grid design area toward the smaller cross main side of the system because less water is available.

D. The designer has certain number of heads in the demand area to calculate (12 heads are standard).

PEAKING (cont'd)

- The designer will node heads to the main sides of the design area.
- The designer will shift the demand area by turning off and on nodes to see where the best water and pressure calculations are.
- Three sets of calculations are required.
- This is done very easily with a computer program.

Slide 6-12

E. The designer will node heads to the main sides of the design area.

F. The designer will shift the demand area by turning off and on nodes to see where the best water and pressure calculations are. Three sets of calculations are required.

G. This is done very easily with a computer program.

PEAKING (cont'd)

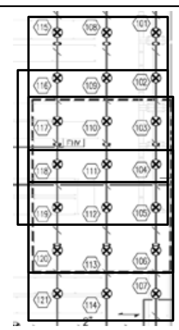
- This is a trial and error method that was done by hand before computers.
- However, you can verify that the system has been peaked and if necessary contact the designer and have him or her explain the process used.

Slide 6-13

H. This is a trial and error method that was done by hand before computers.

I. However, you can verify that the system has been peaked and if necessary contact the designer and have him or her explain the process used.

PEAKING EXAMPLE



Slide 6-14

J. Peaking example.

1. Test 1: Designers start with the node 115 side of the design area and then check the 12 heads in the design area 115 to 118 to 104 to 101, and then they will determine gallons and pressure.

2. Test 2: Designers will then move them to 116 to 119 to 105 to 102 and determine the pressure and gallons for that design area.

3. Test 3: Designers will then do a third set of calculations for 117 to 120 to 106 to 103 and determine the gallons and pressure.

4. Test 4: Finally, designers do the fourth set of calculations from 118 to 121 to 107 to 104 and determine the pressure and gallons.

Designers will choose the most demanding design area for their demand area.

EARLY SUPPRESSION FAST RESPONSE METHOD

For ESFR sprinklers, the design area shall consist of the most hydraulically demanding area of 12 sprinklers, consisting of four sprinklers on each of three branch lines, unless other specific numbers of design sprinklers are required in other sections of this standard (NFPA 13, Section 22.4.4.3, 2010).

Slide 6-15

K. ESFR method.

For ESFR sprinklers, the design area shall consist of the most hydraulically demanding area of 12 sprinklers, consisting of four sprinklers on each of three branch lines, unless other specific numbers of design sprinklers are required in other sections of this standard (NFPA 13, Section 22.4.4.3, 2010).

IV. HYDRAULIC CALCULATIONS

BASIC STEP PROCESS OF CALCULATION REVIEW

1. Look for the required information.
2. Hazard classifications.
3. Size and shape of remote area.
   - Modifications of remote area if required.
   - Slope ceilings, dry systems, quick response and high temperature heads, etc.
4. Identify hydraulic reference points.

Slide 6-16

Basic step process of calculation review.

A. Look for the required information.

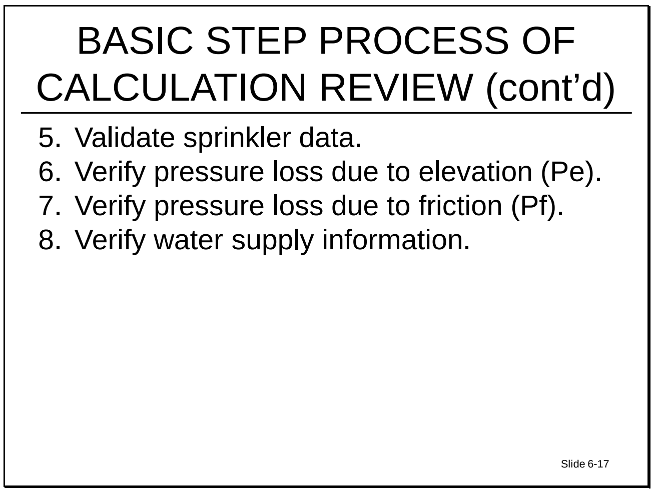
B. Hazard classifications.

C. Size and shape of remote area.

1. Modifications of remote area if required.

2. Slope ceilings, dry systems, quick response and high temperature heads, etc.

D. Identify hydraulic reference points.



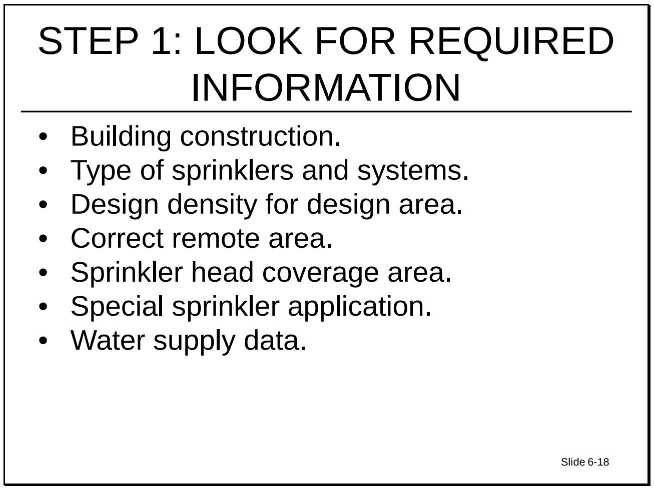
E. Validate sprinkler data.

F. Verify pressure loss due to elevation (Pe).

G. Verify pressure loss due to friction (Pf).

H. Verify water supply information.

V. DETAILED REVIEW OF BASIC STEP PROCESS



A. Step 1: Look for required information.

1. Building construction.

2. Type of sprinklers and systems.

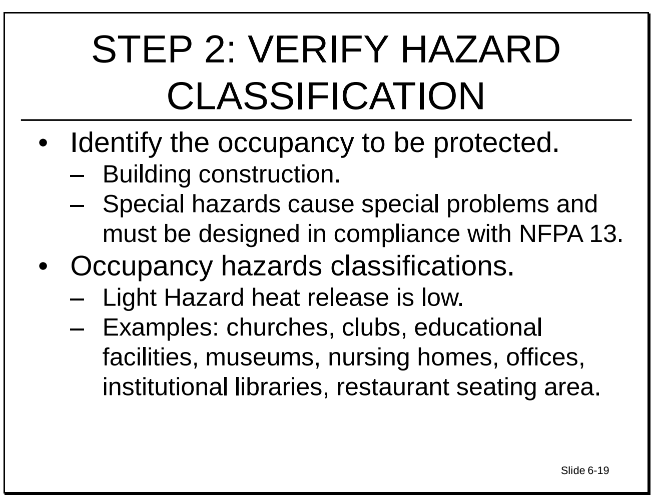
3. Design density for design area.

4. Correct remote area.

5. Sprinkler head coverage area.

6. Special sprinkler application.

7. Water supply data.



B. Step 2: Verify hazard classification.

1. Identify the occupancy to be protected.

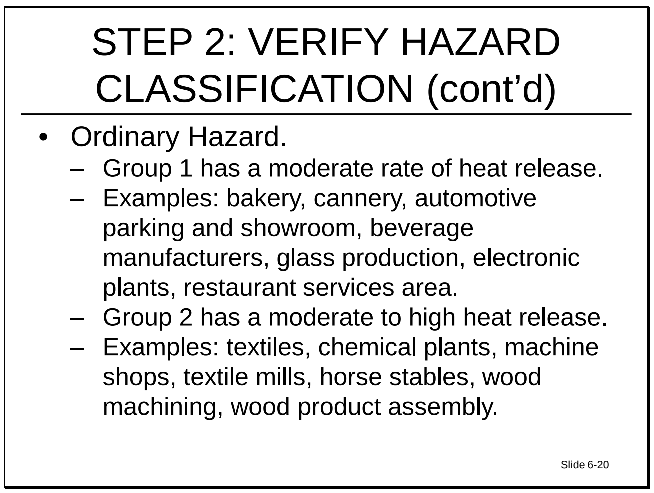
a. Building construction.

b. Special hazards cause special problems and must be designed in compliance with NFPA 13.

2. Occupancy hazards classifications.

a. Light Hazard heat release is low.

Examples: churches, clubs, educational facilities, museums, nursing homes, offices, institutional libraries, restaurant seating area.



b. Ordinary Hazard.

- Group 1 has a moderate rate of heat release.

Examples: bakery, cannery, automotive parking and showroom, beverage manufacturers, glass production, electronics plants, restaurant services area.

- Group 2 has a moderate to high heat release.

Examples: textiles, chemical plants, machine shops, textile mills, horse stables, wood machining, wood product assembly.

STEP 2: VERIFY HAZARD CLASSIFICATION (cont'd)

- Extra Hazard.
  - Group 1 has a high rate of heat release.
  - Examples: aircraft hangers (metal extruded), plywood/particle board manufacturing, rubber reclamation plant, saw mill, upholstering plant (dust or particle production).

Slide 6-21

c. Extra Hazard.

- Group 1 has a high rate of heat release.

  Examples: aircraft hangers (metal extruded), plywood/ particle board manufacturing, rubber reclamation plant, saw mill, upholstering plant (dust or particle production).

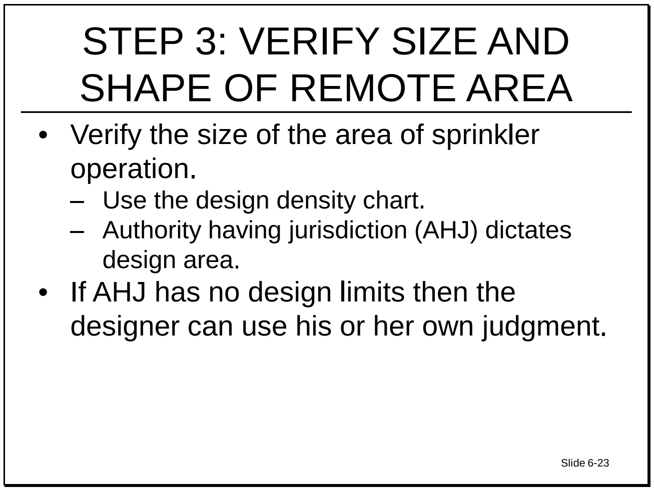
STEP 2: VERIFY HAZARD CLASSIFICATION (cont'd)

- Group 2 has moderate to high volumes of flammable liquids.
- Examples: oil baths, open cooling vats, heat treating plants, asphalt saturation, flammable liquid spraying, flow coating, open oil quenching, solvent cleaning, paint dipping.

Slide 6-22

- Group 2 has moderate to high volumes of flammable liquids.

  Examples: oil baths, open cooling vats, heat treating plants, asphalt saturation, flammable liquid spraying, flow, coating, open oil quenching, solvent cleaning, paint dipping.

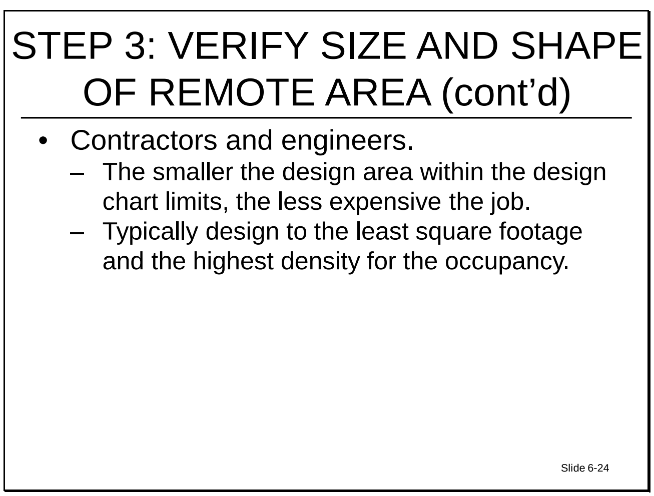


C. Step 3: Verify size, shape and remote area.

1. Design density chart.

a. Authority having jurisdiction (AHJ) dictates design area.

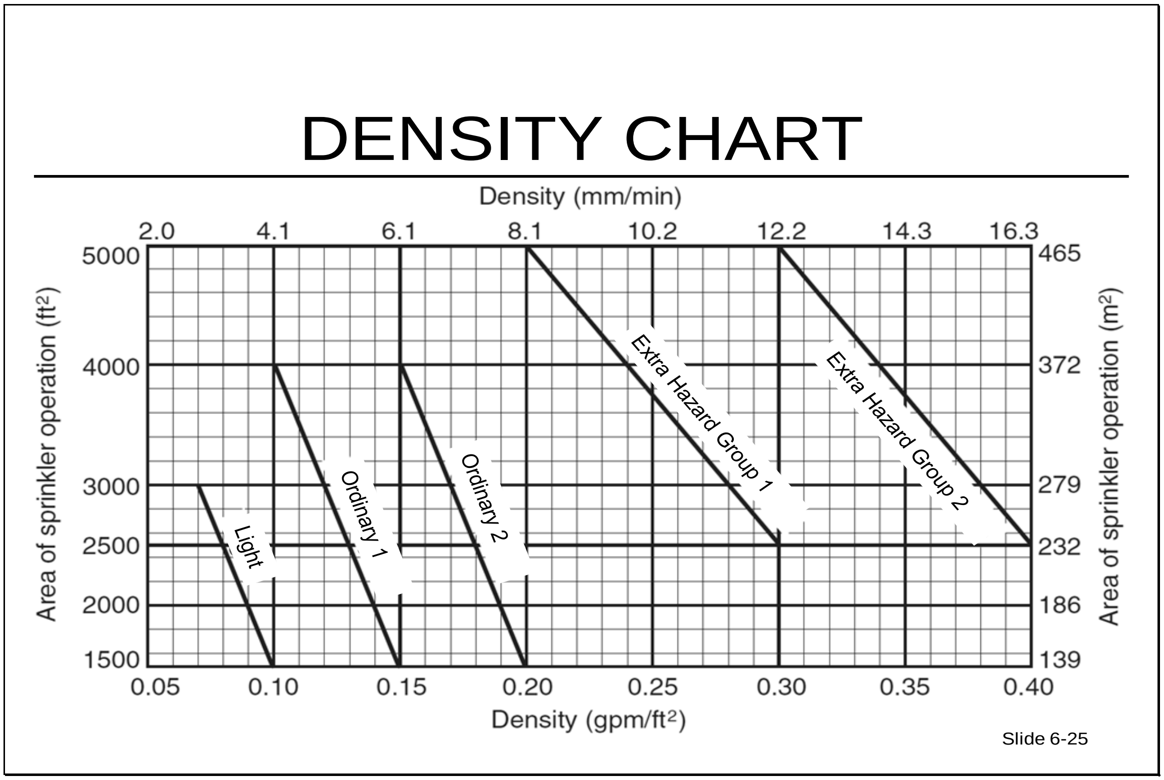
b. If AHJ has no design limits, then the designers can use their own judgment. AHJ may dictate design area.



c. Contractors and engineers.

- The smaller the design area within the design chart limits, the less expensive the job.

- Design to the least square footage and the highest density for the occupancy.



d. Design density is from NFPA 13, 2010, p. 13-118.

e. Contractors will try to design systems that cost the least.

STEP 3: VERIFY SIZE AND SHAPE OF REMOTE AREA (cont'd)

- Light Hazard at 1,500 square feet at 10 gallons per minute (gpm)/square foot.
  - Reductions in design area can be taken for quick-response sprinkler head application.
  - Reduction from 1,500 square feet to 990 square feet maximum reduction for use of quick-response sprinkler heads.
  - Reduction calculation: Y = -3X/2 + 55 where X is the ceiling height and Y will be the percentage of reduction.

Slide 6-26

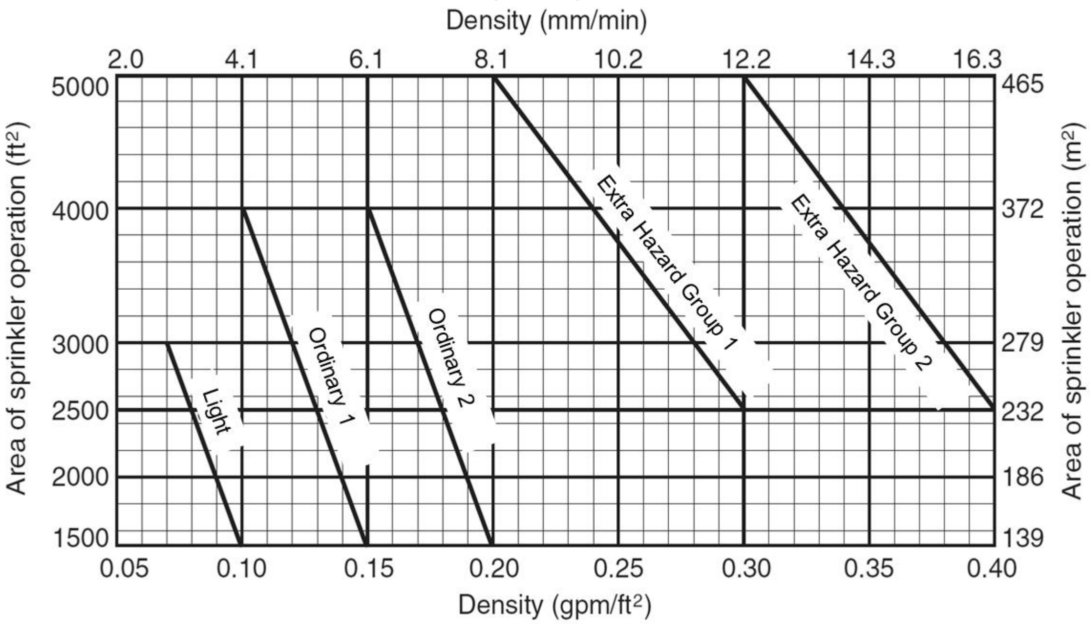
2. Light Hazard at 1,500 square feet at 10 gallons per minute (gpm)/square foot.

   a. Reductions in design area can be taken for quick-response sprinkler head application.

   b. Reduction from 1,500 square feet to 990 square feet maximum reduction for use of quick-response sprinkler heads.

   c. Reduction calculation: Y = -3X/2 +55 where X is the ceiling height and Y will be the percentage of reduction.

DENSITY CHART



d. Horizontal line from the determined design area to the chosen occupancy hazard curve.

e. Example: Light Hazard at 1,500 square feet at 10 gpm/square foot.

f. Reduction from 1,500 square feet to 990 square feet maximum reduction for use of quick-response sprinkler heads.

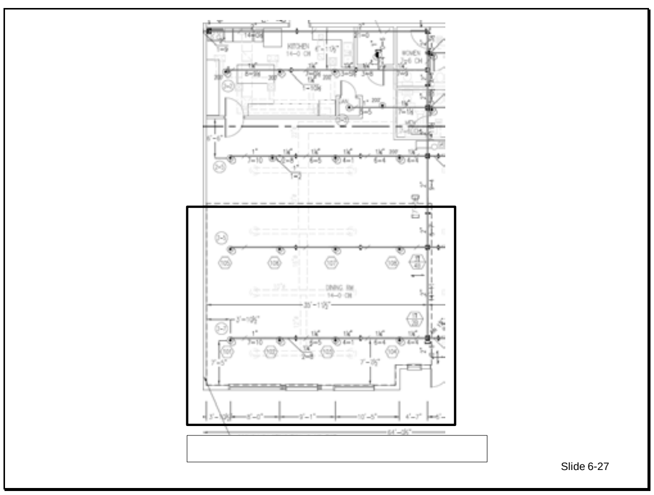
g. Calculation: Y = -3X/2 +55 where X is the ceiling height and Y will be the percentage of reduction.

- Design density calculation from chart.

- Reduction calculation for use of quick-response sprinkler heads.

  -- Example: Ordinary Hazard Group 2 at area sprinkler operation of 1,500 square feet density is .20 gallons/ square foot.

- Note: Extra Hazard Group 1 and 2 have a minimum area of sprinkler operation 2,500 square feet.



3. Verify sprinkler heads correspond with all information on drawings.

4. Verify that the heads are the same from the design area as in the calculation sheet.

STEP 3: VERIFY SIZE AND SHAPE OF REMOTE AREA (cont'd)

- Establish number of sprinklers in design area.
  - Use most demanding area to calculate the number of heads needed.
  - 1,070 square feet (actual design area)/155 square feet coverage per head.
    - -- Example: 1,070 square feet/155 square feet = 6.9 heads or 7.
  - The designer in this case chose to calculate 8 heads.

Slide 6-28

5. Establish number of sprinklers in design area.

   a. Use most demanding area to calculate the number of heads needed.

   b. 1,070 square feet (actual design area)/155 square feet coverage per head.

      Example: 1,070 square feet/155 square feet = 6.9 heads or 7.

   c. The designer in this case chose to calculate 8 heads because of requirement of minimum of 8 heads due to square footage of head coverage.

STEP 3: VERIFY SIZE AND SHAPE OF REMOTE AREA (cont'd)

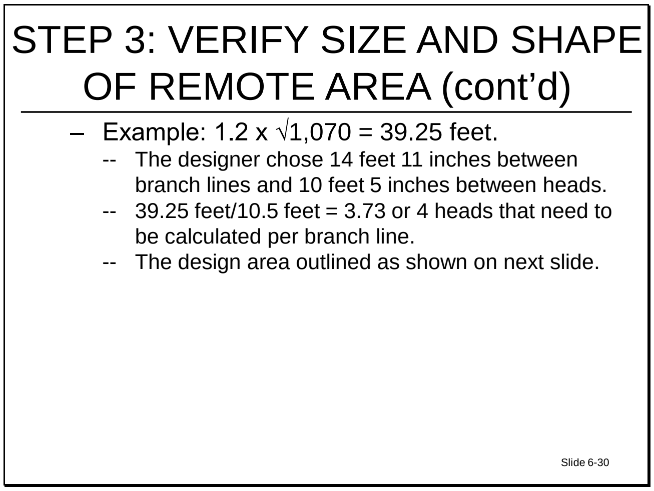
- Calculate the number of heads on the branch line.
  - Shape of design area must be a rectangle or rectangles.
  - The width of the rectangle must be parallel to the branch lines and 1.2 times the square root of the area of sprinkler operation.

Slide 6-29

6. Calculate the number of heads on the branch line.

   a. Shape of design area must be a rectangle or rectangles.

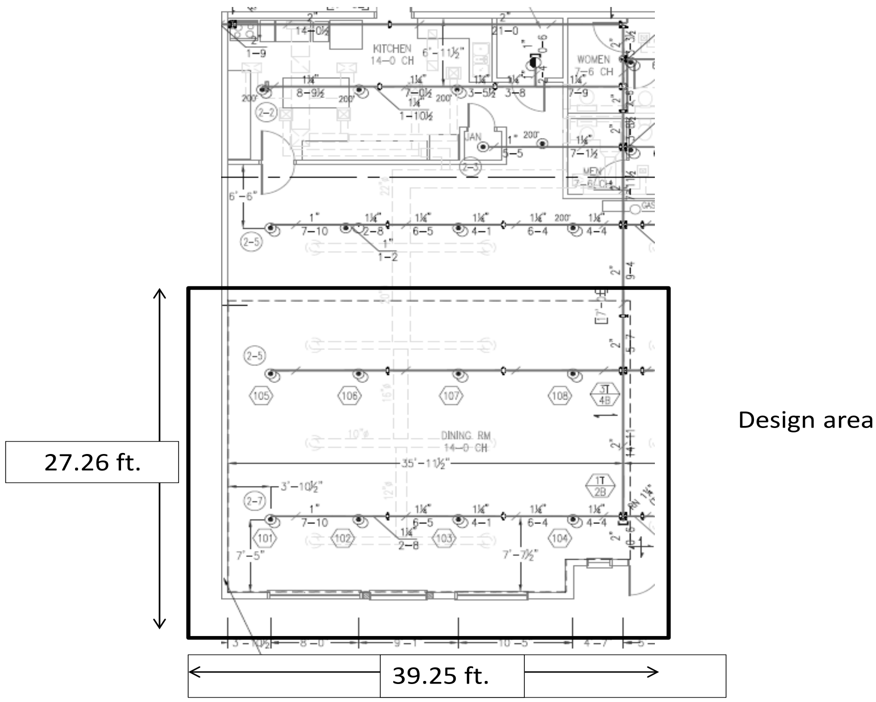
b. The width of the rectangle must be parallel to the branch lines and 1.2 times the square root of the area of sprinkler operation.



c. Example: 1.2 x $\sqrt{1{,}070}$ = 39.25 feet.

- The designer chose 14 feet 11 inches between branch lines and 10 feet 5 inches between heads.

- 39.25 feet/10.5 feet = 3.73 or 4 heads that need to be calculated per branch line.



Slide 6-31

7. Verifying shape of demand area.

   a. Shape must be a rectangle or series of rectangles.

   b. Long edge of rectangle must be parallel branch lines.

   c. Calculation will determine number of heads on branch line to be calculated.

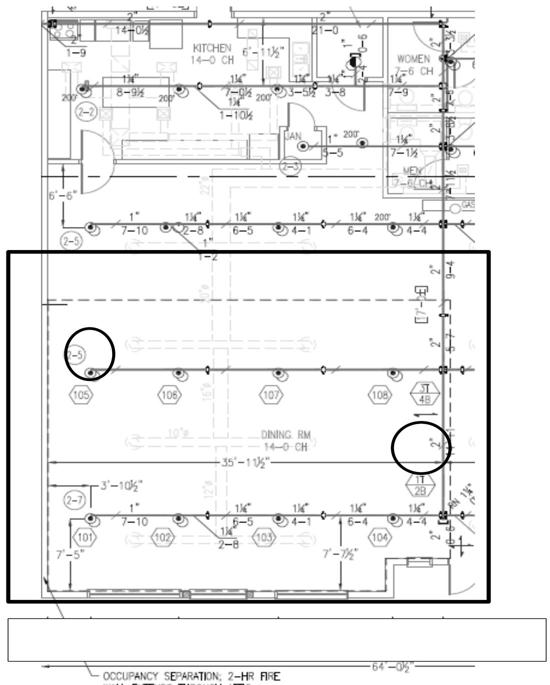
8. Long dimension of demand area is parallel to branch line.

9. Short dimension of demand area is calculated by taking the total square footage of the demand area divided by the long dimension.

STEP 4: CHECK ALL HYDRAULIC REFERENCE (NODE) POINTS

Slide 6-32

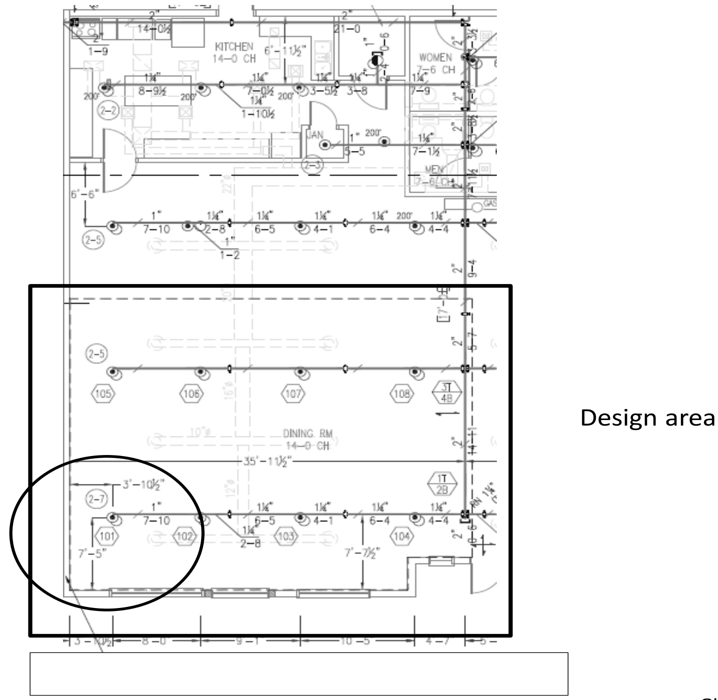
D. Step 4: Check all hydraulic reference (node) points.



Slide 6-33

1. Check all reference nodes against sheet.

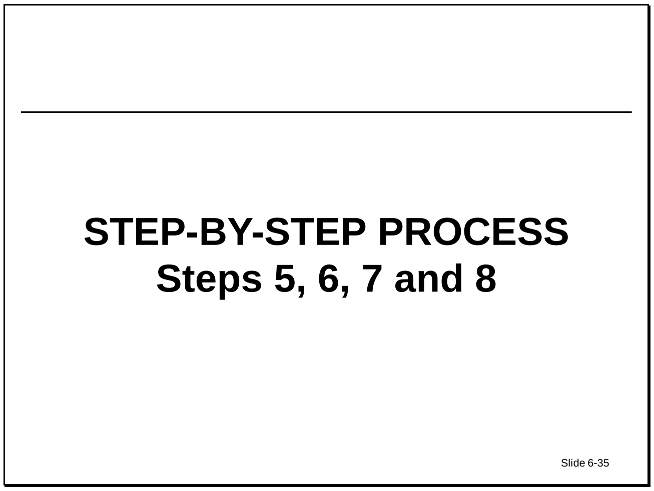
2. Check head spacing to the wall in both directions to ensure it is within the L x S rule. Verify all head spacing between branch lines and heads.



Slide 6-34

3. Check distance from last head perpendicular to wall to ensure that it is not more than one-half the maximum spacing required by NFPA 13.

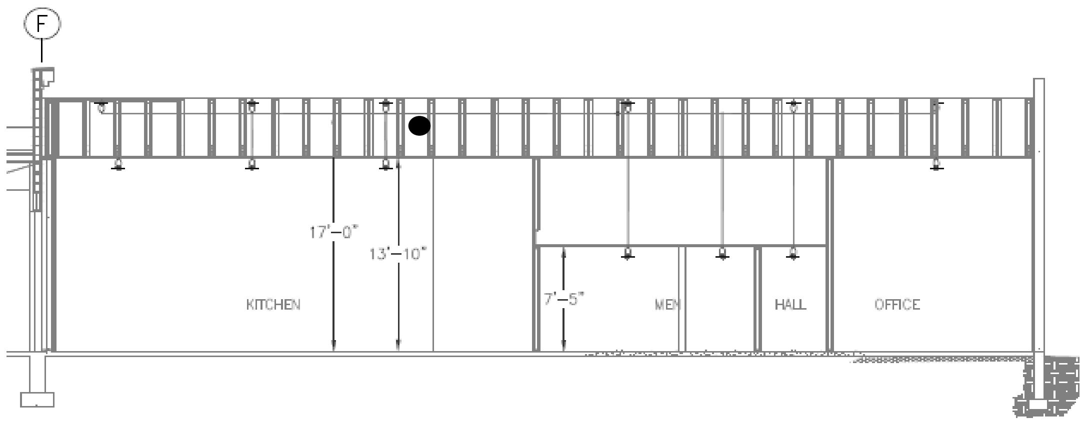
4. Check the distance from the last head to the wall parallel with the branch line to ensure that it is not more than one-half the maximum spacing.



E. Hydraulic calculations.

1. Validate sprinkler data on the plans and calculation sheets.

ELEVATION DRAWINGS F3 OF 8 ON PLANS

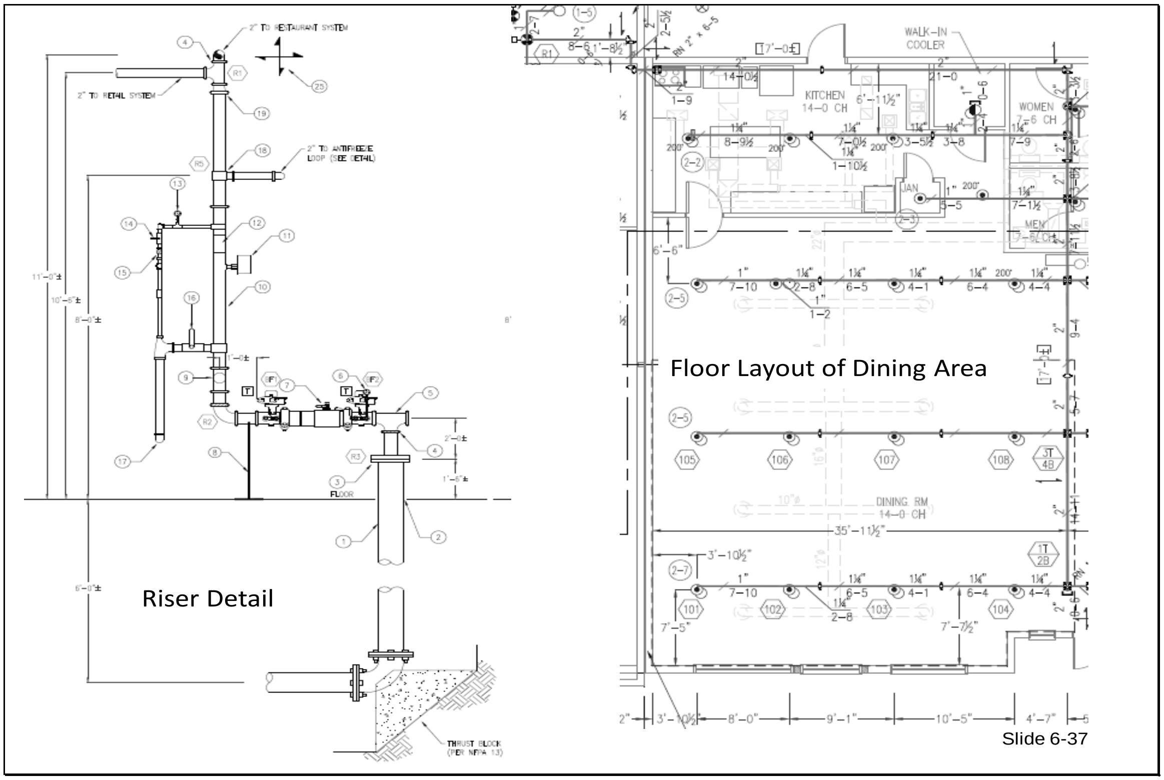


Slide 6-36

a. Elevation drawings.

- Elevation drawings to show ceiling height, height of roof, and structure above ceiling.

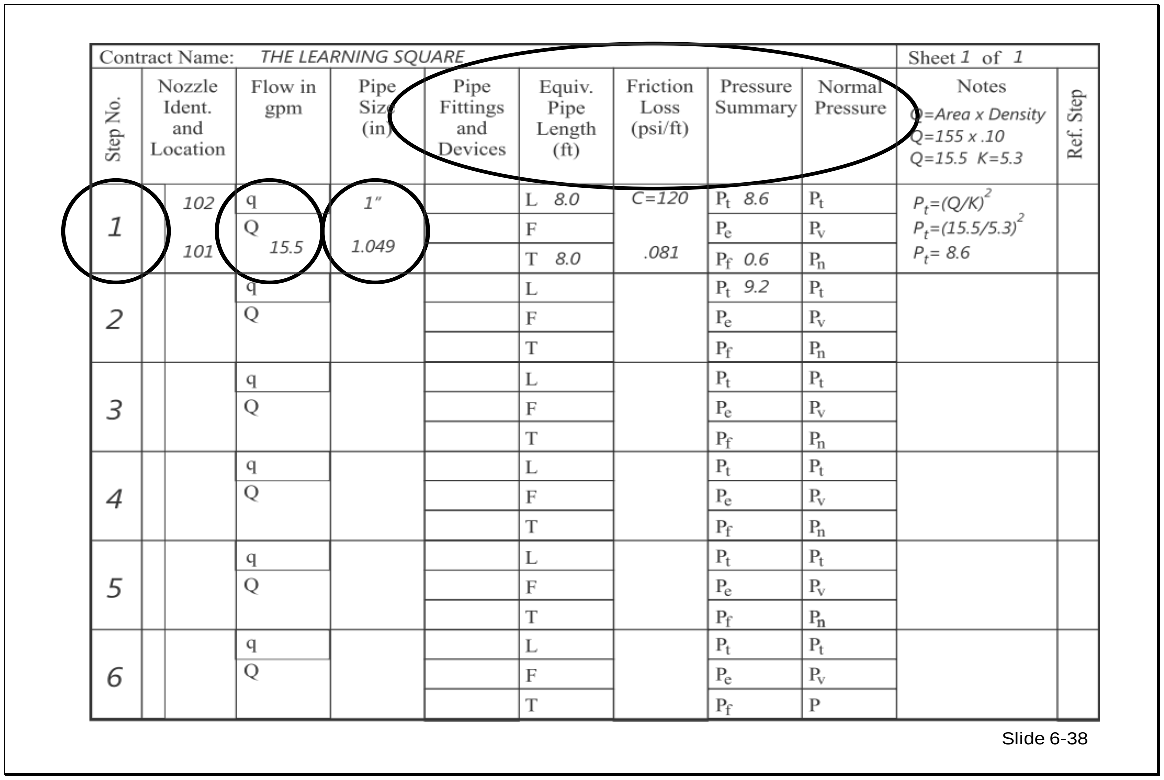
- This occupancy has pinheads below ceiling and upright heads above ceiling.



b. Floor plan.

- Floor plan showing layout of sprinklers, branch lines, cross main and feeds.

- Riser detail showing elevation, pipe and fittings, and underground.



Contract Name: *THE LEARNING SQUARE* — Sheet *1* of *1*

Step No.	Nozzle Ident. and Location	Flow in gpm	Pipe Size (in)	Pipe Fittings and Devices	Equiv. Pipe Length (ft)	Friction Loss (psi/ft)	Pressure Summary	Normal Pressure	Notes	Ref. Step
									Q=Area x Density *Q=155 x .10* *Q=15.5 K=5.3*	
1	*102* *101*	q Q *15.5*	*1"* *1.049*		L *8.0* F T *8.0*	*C=120* *.081*	P_t *8.6* P_e P_f *0.6*	P_t P_v P_n	$P_t=(Q/K)^2$ $P_t=(15.5/5.3)^2$ $P_t= 8.6$	
2		q Q			L F T		P_t *9.2* P_e P_f	P_t P_v P_n		
3		q Q			L F T		P_t P_e P_f	P_t P_v P_n		
4		q Q			L F T		P_t P_e P_f	P_t P_v P_n		
5		q Q			L F T		P_t P_e P_f	P_t P_v P_n		
6		q Q			L F T		P_t P_e P_f	P_t P_v P		

Slide 6-38

2. There are "givens" to start the hydraulic calculations.

   a. Density from chart.

   b. K-factor from either cut sheet or reduction calculation.

   c. Coefficient of pipe from NFPA 13.

   d. Length of pipe chosen by designer.

      - By size chosen by designer.

      - Actual pipe diameter from chart NFPA 13.

3. Other information for hydraulic calculations is determined by use of formulas.

ACTIVITY 6.1

Formula Exercise

Purpose

Given a set of sprinkler plans and associated hydraulic calculations, you will complete a basic hydraulic calculation.

Directions

You will complete the following:

1. Given: C = 120, q = 15.5 gallons, D = 1.049, FL = _______ pounds per foot of pipe.
2. Given: Area of coverage = 155 feet^2, Density = .10 feet^2, q = ________ gallons.
3. Given: q = 15.5 gallons, K = 5.3 to 5.6, P = ________ psi.
4. Given: .433 = 1 foot rise, 10 feet up = ________ pounds.
5. Given: Q = 66.4 gallons, Pt = 9.2, K = ________ K-factor conversion.

Hazen-Williams	$FL = \frac{4.52 \times q^{1.85}}{C^{1.85} \times D^{4.87}}$
Flow calculations for one sprinkler head or small area	q = Area of coverage x density
Pressure calculations	$P = (q/K)^2$
Pressure evaluation	# feet x .433
Changing "K" factors	$K = Q \sqrt{P_t}$
Flow calculation for total quantities	$Q = K\sqrt{P_t}$

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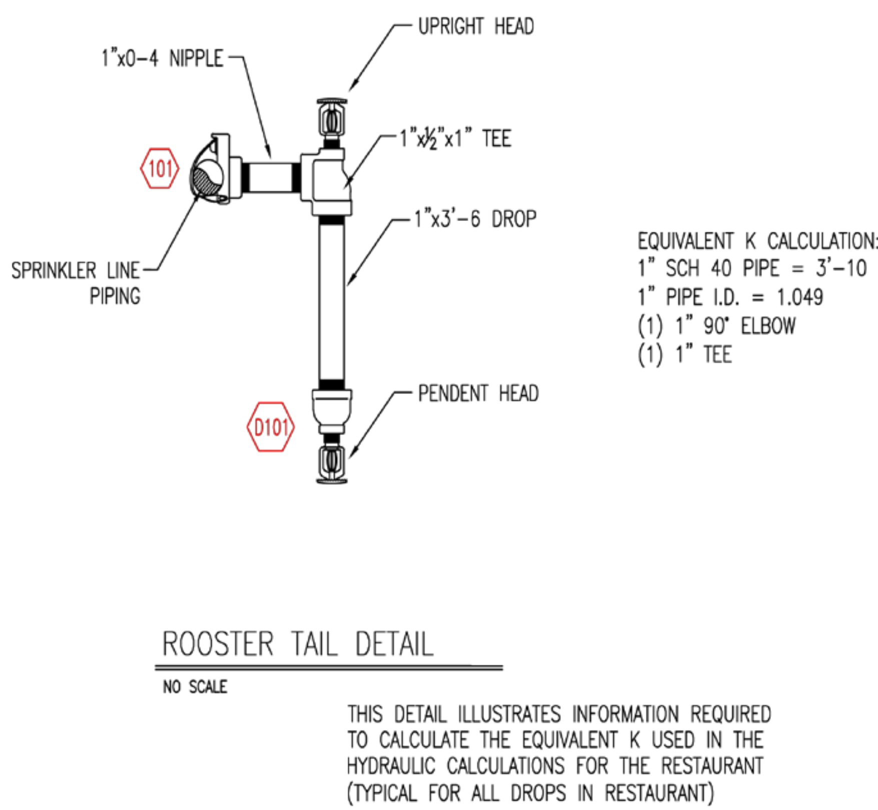
VI. VERIFYING EQUIVALENT "K" CHANGE

VERIFYING EQUIVALENT "K" CHANGE

- The equivalent "K" is calculated so the designer does not have to calculate every drop on the branch line in the demand area.
- Step 1: gallons head (Q) is flowing at "K" to establish the pressure.
  (15.5/5.6) squared = P so P = 7.66.

Slide 6-40

A. The equivalent "K" is calculated so the designer does not have to calculate every drop on the branch line in the demand area.



B. Step 1: Gallons head (Q) is flowing at "K" to establish the pressure.

(15.5/5.6) squared = P so P = 7.66.

C. Step 2: Hazen-Williams formula to establish friction loss in drop.

1. 1 elbow + 1 "T" + 3.83 feet of pipe = 10.83 feet of pipe length.

2. .081 psi per foot x 10.83 = .87 psi.

3. Utilize equivalent K-factor calculator (from Learning Square Reference Data).

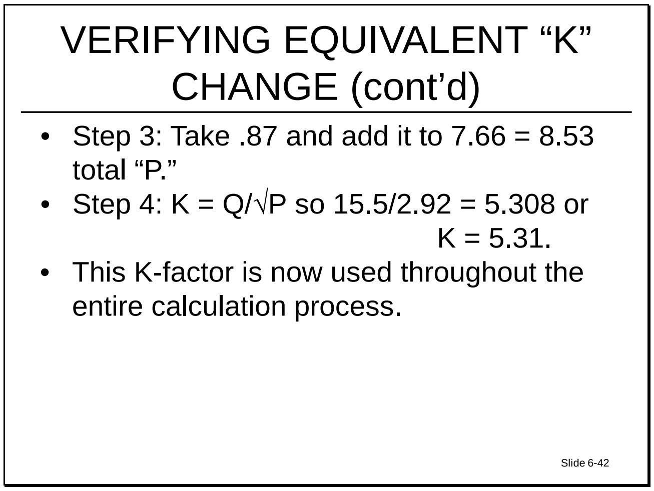
Equivalent K-Factor Calculator

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	8.50	1.049	3.83	ET	10.83	120.00	5.31

4. Equivalent pipe length.

a. 1 inch T = 4 feet of pipe.

b. 1 inch elbow = 3 feet of pipe.



D. Step 3: Take .87 and add it to 7.66 = 8.53 total "P."

E. Step 4: $K = Q/\sqrt{P}$ so 15.5/2.92 = 5.308 or K = 5.31.

This K-factor is now used throughout the entire calculation process.

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ACTIVITY 6.2

Hydraulic Calculations

Purpose

Given a set of plans with hydraulic calculations, you shall verify that the calculation methods are in compliance with recognized standards and that water-based fire protection systems design calculations are accurate.

Directions

1. You will refer to the completed calculation sheet while the instructor demonstrates how to complete a set of calculations.

2. After each step, you will refer to the plans and as a table group repeat the process using the blank calculation sheet that the instructor will provide for you.

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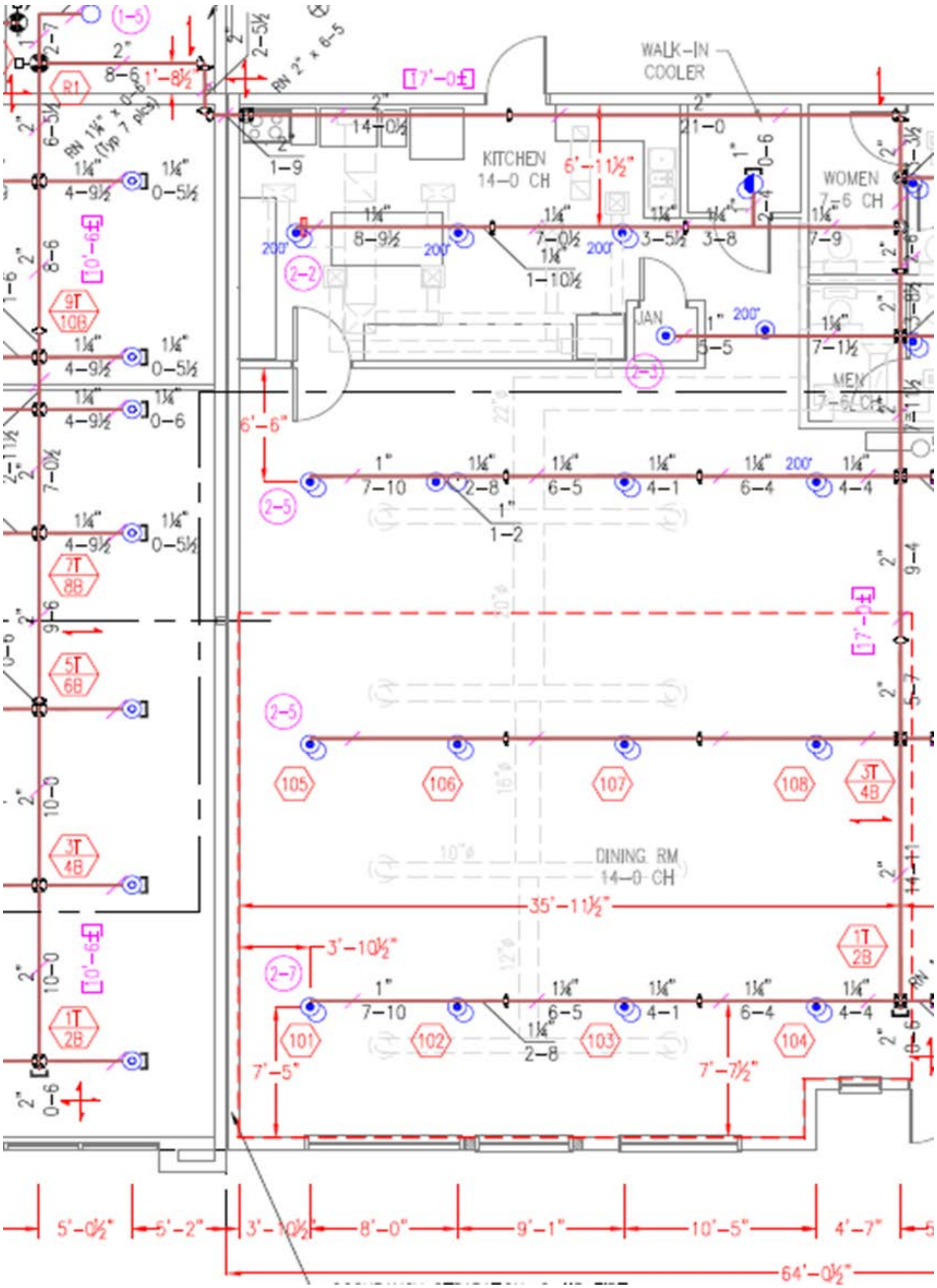
ACTIVITY 6.2 (cont'd)

Hydraulic Calculations

Contract Name:					*The Learning Square*					Sheet 1 of 1	
Step No.	Nozzle Indent. And Location		Flow in gpm	Pipe Size (in)	Pipe Fittings and Devices	Equiv. Pipe Length (ft)	Friction Loss (psi/ft)	Pressure Summary	Normal Pressure	Notes	Ref. Step
1			q			L		P_t	P_t		
			Q			F		P_e	P_v		
						T		P_f	P_n		
2			q			L		P_t	P_t		
			Q			F		P_e	P_v		
						T		P_f	P_n		
3			q			L		P_t	P_t		
			Q			F		P_e	P_v		
						T		P_f	P_n		
4			q			L		P_t	P_t		
			Q			F		P_e	P_v		
						T		P_f	P_n		
5			q			L		P_t	P_t		
			Q			F		P_e	P_v		
						T		P_f	P_n		
6			q			L		P_t	P_t		
			Q			F		P_e	P_v		
						T		P_f	P_n		

7			q			L		P_t	P_t		
			Q			F		P_e	P_v		
						T		P_f	P_n		
8			q			L		P_t	P_t		
			Q			F		P_e	P_v		
						T		P_f	P_n		
9			q			L		P_t	P_t		
			Q			F		P_e	P_v		
						T		P_f	P_n		
10			q			L		P_t	P_t		
			Q			F		P_e	P_v		
						T		P_f	P_n		
11			q			L		P_t	P_t		
			Q			F		P_e	P_v		
						T		P_f	P_n		
12			q			L		P_t	P_t		
			Q			F		P_e	P_v		
						T		P_f	P_n		
								P_t			


WALK-IN COOLER
KITCHEN
14-0 CH
WOMEN
7-6 CH
JAN
MEN
DINING RM
14-0 CH
35'-11½"
3'-10½"
7'-5"
7'-7½"
6'-6"
6'-11½"
5'-0½"
5'-2"
3'-10½"
8'-0"
9'-1"
10'-5"
4'-7"
64'-0½"
RN 1¼" x 0-6 (Typ 7 plcs)
RN 2" x 6-5
105
106
107
108
101
102
103
104

Equivalent Pipe Length

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.

Table 22.4.3.2.1 *C* Value Multiplier

Value of *C*	100	130	140	150
Multiplying factor	0.713	1.16	1.33	1.51

Note: These factors are based upon the friction loss through the fitting being independent of the *C* factor available to the piping.

(NFPA 13, 2010, p. 13-225)

VERIFY THE INITIAL GPM AND PRESSURE

Calculate the required flow of the first sprinkler head.

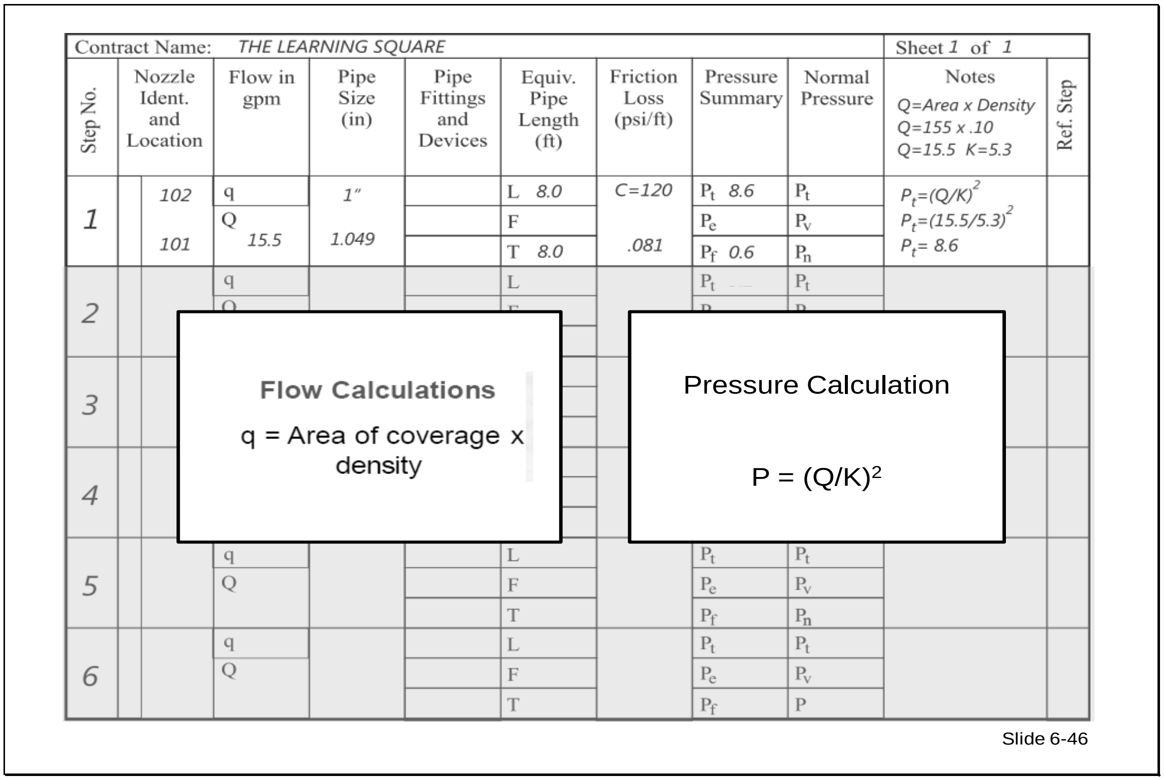
- Design density x area of coverage per head.
  - .10 gallons/square foot x 155 square feet = 15.5 gallons coverage per head.
  - Plot on calculation sheet.
- K-factor discharge coefficient of head = 5.3.

Slide 6-44

VERIFY THE INITIAL GPM AND PRESSURE (cont'd)

- C factor of the pipe type — 120 = C for schedule 40 steel pipe (wet).
- q = will be the sprinkler head flow.
- Q = will be the total flow to that numbered head.
- P = required pressure at head; q = area x density = 15.5 gallons.
- Calculations: P = (q/k)(15.5/5.3) = 8.6 psi.

Slide 6-45



CALCULATE FRICTION LOSS IN PIPING

Hazen-Williams formula.

- Calculates friction loss in piping.
- Pipe size must be actual inside pipe diameter.
- FL = <u>4.52 x q</u>
- C x D
- FL = 4.52 x 15.5.
- 120 x 1.049 = .081 friction loss per foot.
- .081 x 8 feet 0 inches of 1-inch pipe = .6 friction loss.
- Plot all this information on the calculation sheet.

Slide 6-47

Contract Name: *THE LEARNING SQUARE*									Sheet *1* of *1*	
Step No.	Nozzle Ident. and Location	Flow in gpm	Pipe Size (in)	Pipe Fittings and Devices	Equiv. Pipe Length (ft)	Friction Loss (psi/ft)	Pressure Summary	Normal Pressure	Notes *Q=Area x Density* *Q=155 x .10* *Q=15.5 K=5.3*	Ref. Step
1	*102* *101*	q Q *15.5*	*1"* *1.049*		L *8.0* F T *8.0*	*C=120* *.081*	P_t *8.6* P_e P_f *0.6*	P_t P_v P_n	$P_t=(Q/K)^2$ $P_t=(15.5/5.3)^2$ $P_t= 8.6$	
2		q Q			L F		P_t *9.2* P_e	P_t P_v		
3							P_f	P_n		
4							P_e	P_v		
5					T					
6		q Q			L F T		P_t P_e P_f	P_t P_v P		

Hazen-Williams

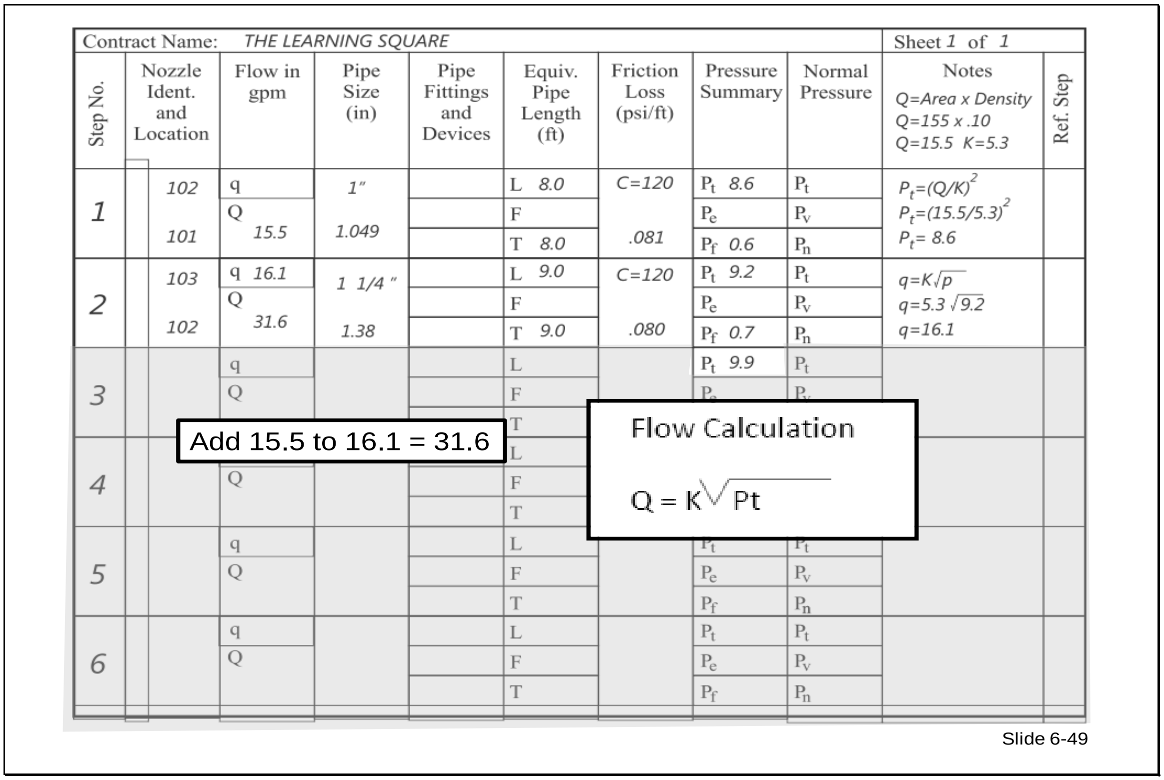
$$FL = \frac{4.52 \times q^{1.85}}{C^{1.85} \times D^{4.87}}$$

.081 friction loss per foot x 8 foot of pipe = .6 psi Pf.

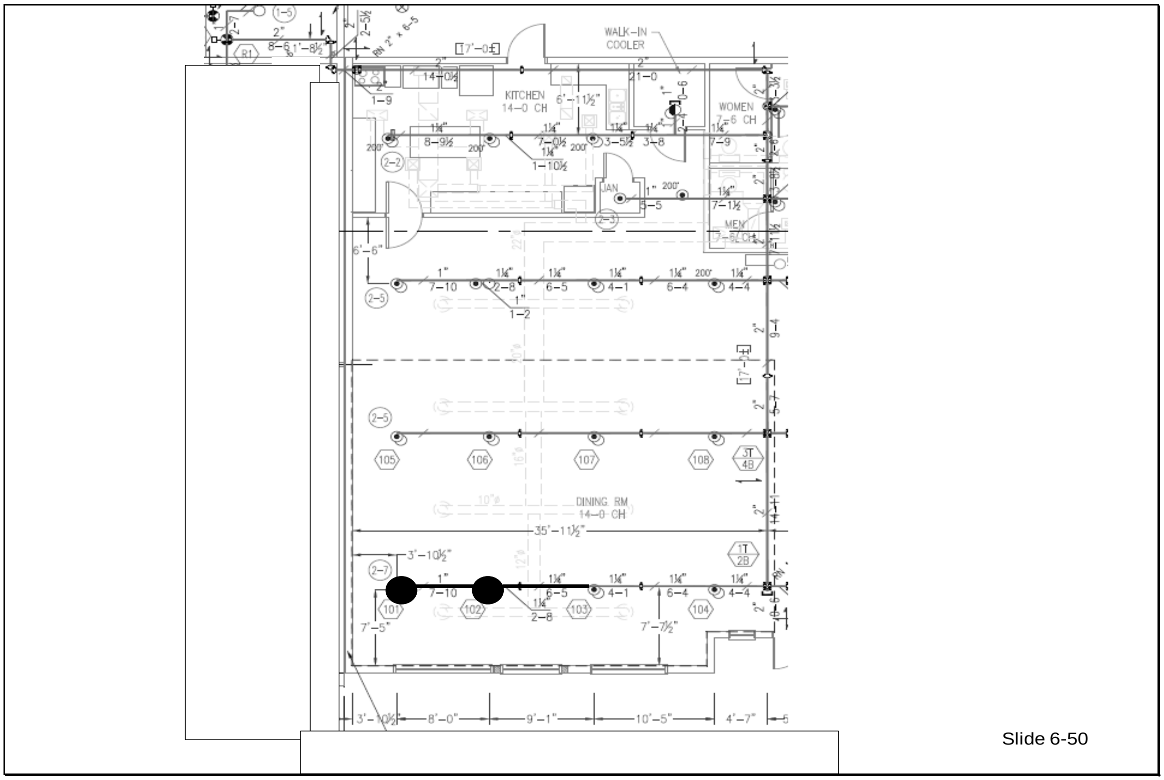
Add 8.6 to .6 = 9.2 psi

Next go to Step 2 and calculate the flow of node 102.

Slide 6-48



Contract Name: *THE LEARNING SQUARE*									Sheet *1* of *1*	
Step No.	Nozzle Ident. and Location	Flow in gpm	Pipe Size (in)	Pipe Fittings and Devices	Equiv. Pipe Length (ft)	Friction Loss (psi/ft)	Pressure Summary	Normal Pressure	Notes *Q=Area x Density* *Q=155 x .10* *Q=15.5 K=5.3*	Ref. Step
1	*102*	q	*1"*		L *8.0*	*C=120*	P_t *8.6*	P_t	$P_t=(Q/K)^2$	
		Q *15.5*			F		P_e	P_v	$P_t=(15.5/5.3)^2$	
	101		*1.049*		T *8.0*	*.081*	P_f *0.6*	P_n	$P_t= 8.6$	
2	*103*	q *16.1*	*1 1/4"*		L *9.0*	*C=120*	P_t *9.2*	P_t	$q=K\sqrt{p}$	
		Q *31.6*			F		P_e	P_v	$q=5.3\sqrt{9.2}$	
	102		*1.38*		T *9.0*	*.080*	P_f *0.7*	P_n	$q=16.1$	
3		q			L		P_t *9.9*	P_t		
		Q			F		P_e	P_v		
					T					
4					L					
		Q			F					
					T					
5		q			L		P_t	P_t		
		Q			F		P_e	P_v		
					T		P_f	P_n		
6		q			L		P_t	P_t		
		Q			F		P_e	P_v		
					T		P_f	P_n		

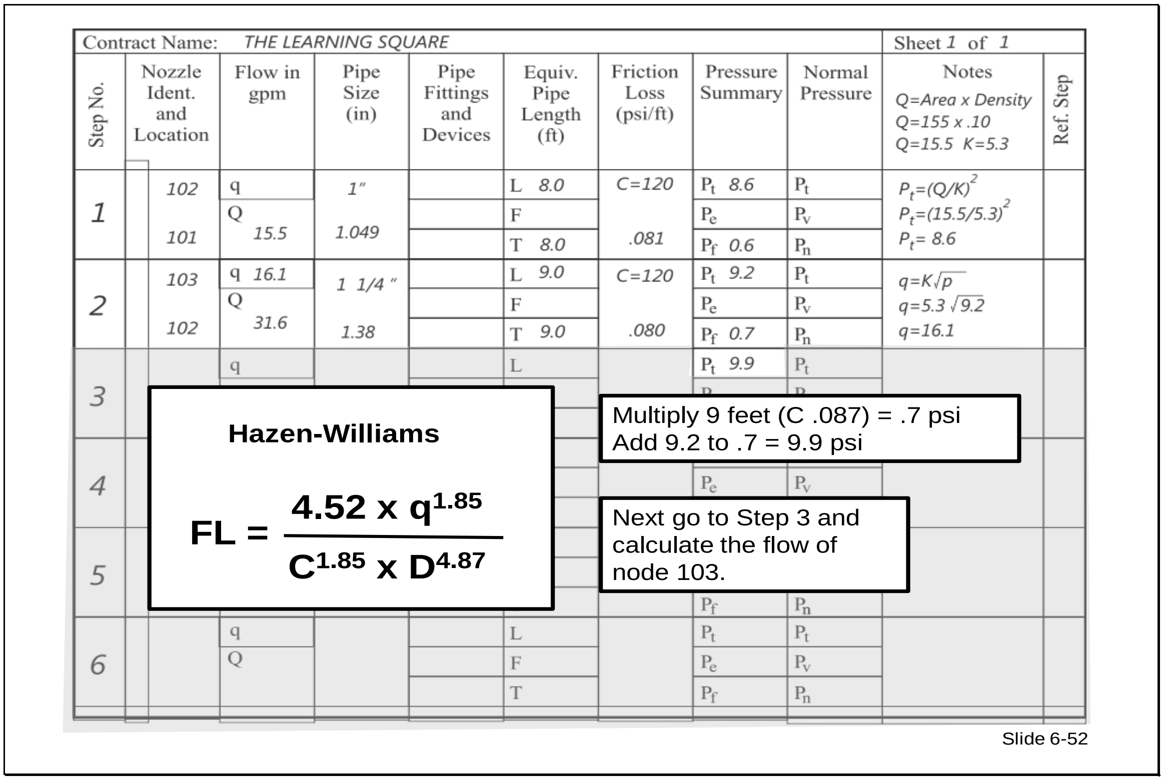


HYDRAULIC CALCULATIONS STEP 2

- Hazen-Williams again only this time for Q = 31.6.
  - D = pipe 1.38.
  - C = stayed the same.
- Now plug the numbers into the formula.

$$\frac{4.52 \times 31.6^{1.85}}{120^{1.85} \times 1.38^{4.87}} = .087$$

Slide 6-51


Contract Name: THE LEARNING SQUARE
Sheet 1 of 1
Step No.
Nozzle Ident. and Location
Flow in gpm
Pipe Size (in)
Pipe Fittings and Devices
Equiv. Pipe Length (ft)
Friction Loss (psi/ft)
Pressure Summary
Normal Pressure
Notes
Ref. Step
Q=Area x Density
Q=155 x .10
Q=15.5 K=5.3
1
102
101
q
Q 15.5
1"
1.049
L 8.0
F
T 8.0
C=120
.081
Pt 8.6
Pe
Pf 0.6
Pt
Pv
Pn
Pt=(Q/K)2
Pt=(15.5/5.3)2
Pt= 8.6
2
103
102
q 16.1
Q 31.6
1 1/4"
1.38
L 9.0
F
T 9.0
C=120
.080
Pt 9.2
Pe
Pf 0.7
Pt
Pv
Pn
q=K√p
q=5.3 √9.2
q=16.1
3
q
L
Pt 9.9
Pt
4
Pe
Pv
5
Pf
Pn
6
q
Q
L
F
T
Pt
Pe
Pf
Pt
Pv
Pn
Hazen-Williams
FL = 4.52 x q1.85 / C1.85 x D4.87
Multiply 9 feet (C .087) = .7 psi
Add 9.2 to .7 = 9.9 psi
Next go to Step 3 and calculate the flow of node 103.
Slide 6-52

Contract Name: *THE LEARNING SQUARE* — Sheet *1* of *1*

Step No.	Nozzle Ident. and Location	Flow in gpm	Pipe Size (in)	Pipe Fittings and Devices	Equiv. Pipe Length (ft)	Friction Loss (psi/ft)	Pressure Summary	Normal Pressure	Notes: *Q=Area x Density, Q=155 x .10, Q=15.5 K=5.3*	Ref. Step
1	*102*	q	*1"*		L *8.0*	*C=120*	P_t *8.6*	P_t	$P_t=(Q/K)^2$	
		Q *15.5*			F		P_e	P_v	$P_t=(15.5/5.3)^2$	
	101		*1.049*		T *8.0*	*.081*	P_f *0.6*	P_n	$P_t= 8.6$	
2	*103*	q *16.1*	*1 1/4"*		L *9.0*	*C=120*	P_t *9.2*	P_t	$q=K\sqrt{p}$	
		Q *31.6*			F		P_e	P_v	$q=5.3\sqrt{9.2}$	
	102		*1.38*		T *9.0*	*.080*	P_f *0.7*	P_n	$q=16.1$	
3	*104*	q *16.7*	*1 1/4"*	*10' 5"*	L *10.41*	*C=120*	P_t *9.9*	P_t	$q=K\sqrt{p}$	
		Q *48.3*			F		P_e	P_v	$q=5.3\sqrt{9.9}$	
	103		*1.38*		T *10.41*	*.175*	P_f *1.8*	P_n	$q=16.7$	
4		q			L		P_t *11.7*	P_t		
		Q			F					
5										
		Q			F					
					T					
6		q			L		P_t	P_t		
		Q			F		P_e	P_v		
					T		P_f	P_n		

Add 31.6 and 16.7 = 48.3

Flow Calculation

$Q = K\sqrt{Pt}$

Slide 6-53

ELEVATION AND EQUIVALENT PIPE LENGTH

- In the next sequence of slides we will deal with elevation changes and equivalent pipe length for fittings.
- The chart we will use to determine equivalent pipe length is from NFPA 13 and is in your Student Manual (SM).

Slide 6-54

ELEVATION AND EQUIVALENT PIPE LENGTH (cont'd)

- Manufacturers of pipe, fittings and accessories will provide cut sheets with specific equivalent pipe lengths for the fittings they manufacture.

Slide 6-55

EQUIVALENT PIPE LENGTH

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)

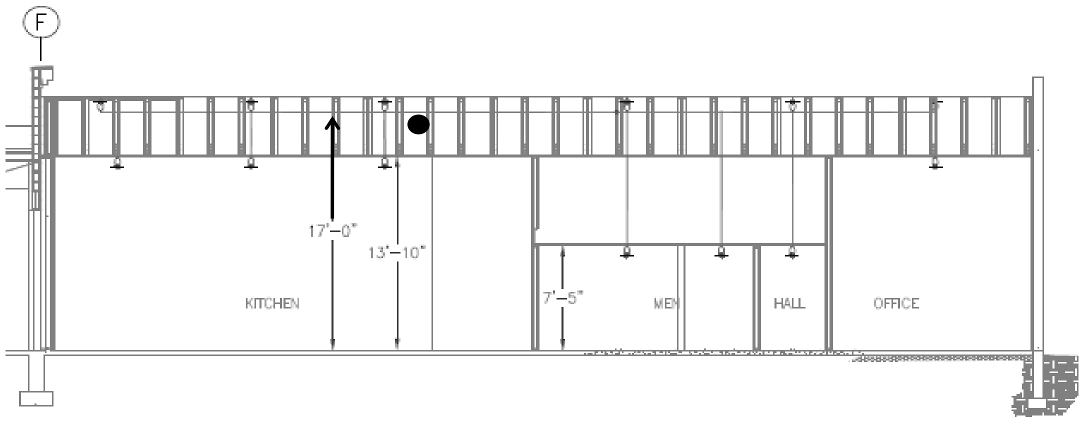
Table 22.4.3.2.1 *C* Value Multiplier

Value of *C*	100	130	140	150
Multiplying factor	0.713	1.16	1.33	1.51

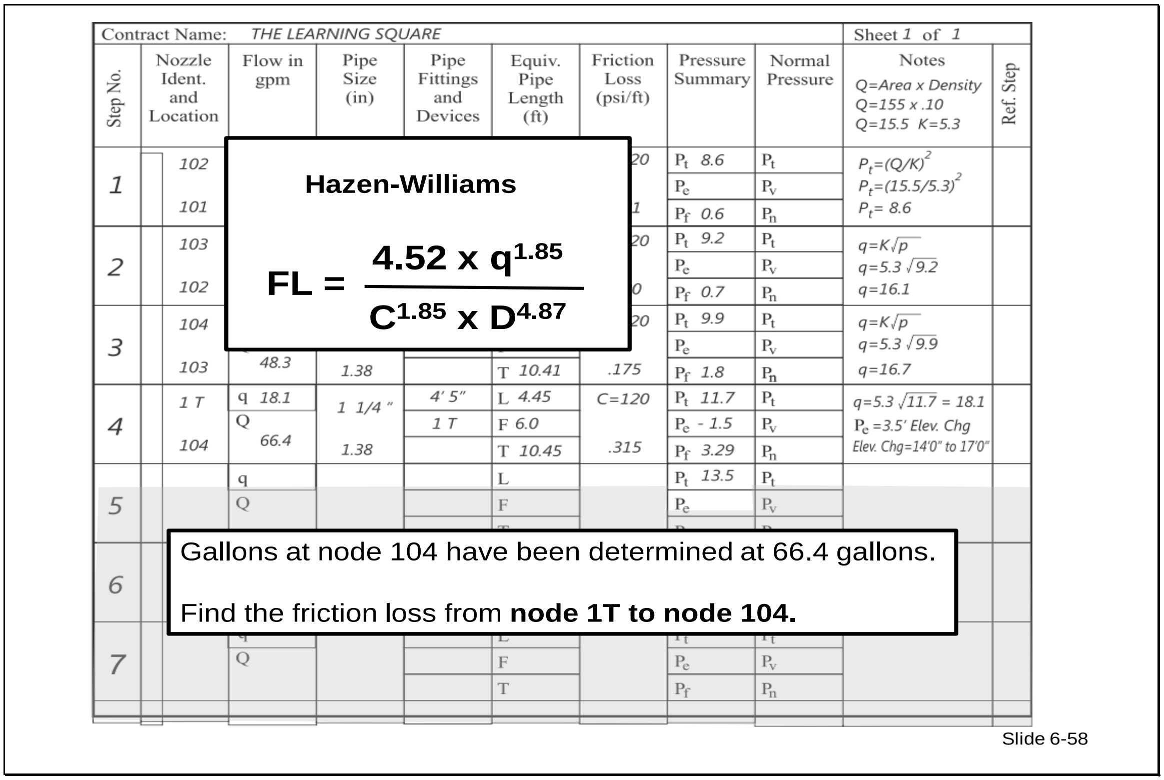
Note: These factors are based upon the friction loss through the fitting being independent of the *C* factor available to the piping.

Slide 6-56

ELEVATION DRAWINGS F3 OF 8 ON PLANS



Slide 6-57



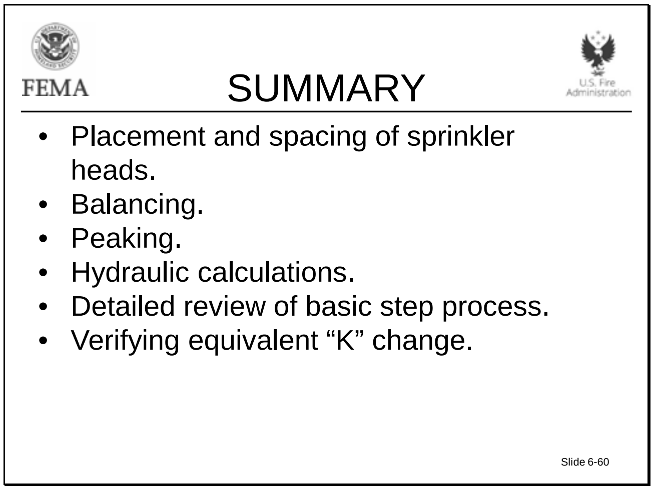
HYDRAULIC CALCULATIONS STEP 4

- Hazen-Williams again only this time for:
  - Q = 66.4.
  - D = pipe 1.38.
  - C = stayed the same.
- Now plug the numbers into the formula:

$$\frac{4.52 \times 66.4^{1.85}}{120^{1.85} \times 1.38^{4.87}} = .315.$$

Slide 6-59

VII. SUMMARY


FEMA
SUMMARY
U.S. Fire Administration
• Placement and spacing of sprinkler heads.
• Balancing.
• Peaking.
• Hydraulic calculations.
• Detailed review of basic step process.
• Verifying equivalent “K” change.
Slide 6-60

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REFERENCES

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REFERENCES

National Fire Protection Association. (2010). *NFPA 13: Standard for the Installation of Sprinkler Systems.* Quincy, MA: Author.

National Fire Protection Association. (2013). *NFPA 13D: Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes.* Quincy, MA: Author.

National Fire Protection Association. (2013). *NFPA 13R: Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies.* Quincy, MA: Author.

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GLOSSARY/ACRONYMS

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GLOSSARY

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").

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 detect operates or the system confirms products of combustion are in a smoke detector sensing chamber.

American National Standards Institute (ANSI) — A professional association that evaluates design and performance standards for consistency.

American Society for Testing and Materials (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.

Annunciator — An electronic device containing lamps or light-emitting diodes (LEDs), 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 (AHJ).

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.

Assembly, Fire-Resistive — A combination of equipment, structural, and architectural elements designed, constructed, and maintained to resist fire and heat. Examples include firewalls, fire doors, fire dampers, floor/ceiling assemblies, roof/ceiling assemblies, fire barriers, and fire partitions.

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 (NFPA) 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 AHJ 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.

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.

Buoyancy — The physical characteristic of a heated fluid or gas to rise, such as smoke rising from above flames.

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.

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-Zoning Usually installed to control specialty system-releasing devices, an arrangement of automatic detectors installed so 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.
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.
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. Also known as ESFR.
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; and
- 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 Limits or Range.”

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 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.

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 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-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.

Firewall — 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. Firewalls have two-, three- or four-hour fire-resistance ratings, depending on where they are used.

Flammable Liquid A liquid that has a flashpoint of less than 100 F 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.

Fully Developed Fire Steady or post-flashover fire at peak heat-release rate.

Gravity Vent See “Smoke and Heat Vents.”

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.

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 Mass heat loss rate times the heat of combustion and combustion efficiency (portion of the mass actually converted to energy).

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.

Hose Stream Allowance The amount of water (in gallons per minute (gpm)) 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.

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 IC 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."

Listed — Equipment, materials or services that have been evaluated by an independent, third-party agency to verify they perform as intended. The most common listing agencies are Underwriters Laboratories (UL) and Factory Mutual (FM) Global. See "Labeled."

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.

Maximum Foreseeable Loss Wall — Insurance industry term for a firewall 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.

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 (ICC), Inc., and NFPA 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 ICC, Inc., and NFPA 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.

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.

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.

Parapet
In building construction, a portion of a firewall 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, firewalls, fire barriers, fire partitions, spray-on or otherwise applied fire-proofing, fire-resistive assemblies. See "**Active** Fire Protection Systems."

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.

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.

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; and
- reminders to evaluate the effectiveness of the selected strategies continually.

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, Jockey

A small, nonrated pump assembly designed to maintain pressure on a fire protection system so the main fire 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 NFPA, 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.”
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.
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.

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.

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 HVAC 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 HVAC 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.
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 hose 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 gpm at 100 pounds per square inch (psi) 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 gpm at 65 psi 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 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 gpm at 100 psi 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.
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 ESFR, that are designed to suppress the fire to the point where there is no active combustion. See "Fire Control Mode."
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 NFPA codes and standards or manufacturer's requirements.

Thermistor	Thermally sensitive resistors that have, according to type, a negative (NTC), or positive (PTC) resistance/temperature coefficient. Manufactured from the oxides of the transition metals — manganese, cobalt, copper and nickel, NTC 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: i.e., 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.
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.
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.
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.
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 (i.e., second floor, gymnasium, smoke detectors, pull stations, etc.). See "Addressable."

ACRONYMS

AFSA	American Fire Sprinkler Association
AHJ	authority having jurisdiction
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
Btu	British thermal unit
CMSA	Control Mode Specific Application
CPVC	chlorinated polyvinyl chloride
EPBD	Evaluating Performance-based Designs
ESFR	Early Suppression Fast Response
FM	Factory Mutual
gpm	gallons per minute
HPR	Highly Protected Rate or Risk
HVAC	heating, ventilating and air conditioning
IC	Incident Commander
ICC	International Code Council
IG	Instructor Guide
LED	light-emitting diode
LP	liquid propane
MAQ	maximum allowable quantities
NFA	National Fire Academy

NFIRS	National Fire Incident Reporting System
NFPA	National Fire Protection Association
NFPCA	National Fire Prevention and Control Administration
NFSA	National Fire Sprinkler Association
NICET	National Institute for Certification in Engineering Training
OS&Y	Outside Screw and Yoke
PBS	polybutylstyrene
PEX	cross-linked polyethylene
PIV	post-indicating valve
psi	pounds per square inch
Pt	pressure total
SAW	Student Activity Worksheet
SIN	Sprinkler Identification Number
SM	Student Manual
UL	Underwriters Laboratories
USFA	U.S. Fire Administration
WBFPSPR	Water-based Fire Protection System Plans Review