Fire Inspection Principles 2: Inspection of Structures and Systems

FIP 2: ISS-Student Manual

1st Edition, 3rd Printing-May 2023

FEMA

FEMA/USFA/NFA
FIP 2: ISS-SM
May 2023
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ACKNOWLEDGMENTS

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

There are many players in 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:

Russell Kuck, Instructional Systems Specialist
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Emmitsburg, Maryland

Woody Stratton, Training Specialist (retired)
U.S. Fire Administration, National Fire Academy
Emmitsburg, Maryland

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COURSE GOAL

The goal of the course is to provide students with a clear understanding of the different types of fire protection systems and how they impact safety inspection processes.

AUDIENCE, SCOPE AND COURSE PURPOSE

This course teaches fire inspection principles at the basic and intermediate levels. Upon completion of the course, students will develop the skills and attitudes needed to meet the basic performance requirements of their job.

Particular focus is placed on proper and accurate documentation and documentation control and retention in each of the following areas:

- Fire alarm systems.
- Smoke management.
- Automatic fire sprinklers.
- Water mist systems.
- Standpipe systems.
- Fire pumps.
- Commercial ventilation and fire protection.
- Special agents.

The course is designed for those individuals currently conducting fire inspection/code enforcement.

GRADING METHODOLOGY

Course Grade

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

The following course grading plan should be used to determine the assigned course grade for each student in the class.

Final Numerical Score	Letter Grade
100 – 90	A
89 - 80	B
79 – 70	C
69 or below	F

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SCHEDULE

TIME	DAY 1	DAY 2
8:00 - 9:00	Introduction	Unit 2: Fire Alarm Systems (cont'd)
9:00 - 9:10	*Break*	*Break*
9:10 - 10:00	Introduction (cont'd)	Unit 2: Fire Alarm Systems (cont'd)
10:00 - 10:15	*Break*	*Break*
10:15 - 12:00	Unit 1: Introduction to Life Safety Systems	Unit 2: Fire Alarm Systems (cont'd)
12:00 - 1:00	*Lunch*	*Lunch*
1:00 - 2:15	Unit 1: Introduction to Life Safety Systems (cont'd)	Unit 3: Smoke Management
2:15 - 2:30	*Break*	*Break*
2:30 - 5:00	Unit 2: Fire Alarm Systems	Unit 3: Smoke Management (cont'd)

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 3: Smoke Management (cont'd)	Unit 4: Automatic Fire Sprinklers (cont'd)
9:00 - 9:10	*Break*	*Break*
9:10 - 10:00	Unit 4: Automatic Fire Sprinklers	Unit 4: Automatic Fire Sprinklers (cont'd)
10:00 - 10:15	*Break*	*Break*
10:15 - 12:00	Unit 4: Automatic Fire Sprinklers (cont'd)	Unit 5: Water Mist Systems
12:00 - 1:00	*Lunch*	*Lunch*
1:00 - 2:15	Unit 4: Automatic Fire Sprinklers (cont'd)	Unit 5: Water Mist Systems (cont'd)
2:15 - 2:30	*Break*	*Break*
2:30 - 5:00	Unit 4: Automatic Fire Sprinklers (cont'd)	Unit 6: Standpipe Systems

TIME	DAY 5	DAY 6
8:00 - 9:00	Unit 6: Standpipe Systems (cont'd)	Unit 8: Commercial Cooking: Ventilation and Fire Protection (cont'd)
9:00 - 9:10	*Break*	*Break*
9:10 - 10:00	Unit 7: Fire Pumps	Unit 9: Special Agent Systems
10:00 - 10:15	*Break*	*Break*
10:15 - 12:00	Unit 7: Fire Pumps (cont'd)	Unit 9: Special Agent Systems (cont'd)
12:00 - 1:00	*Lunch*	*Lunch*
1:00 - 2:15	Unit 8: Commercial Cooking: Ventilation and Fire Protection	Course Review Final Exam
2:15 - 2:30	*Break*	*Break*
2:30 - 5:00	Unit 8: Commercial Cooking: Ventilation and Fire Protection (cont'd)	Graduation

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FIREFIGHTER CODE OF ETHICS

Background

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

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

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

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

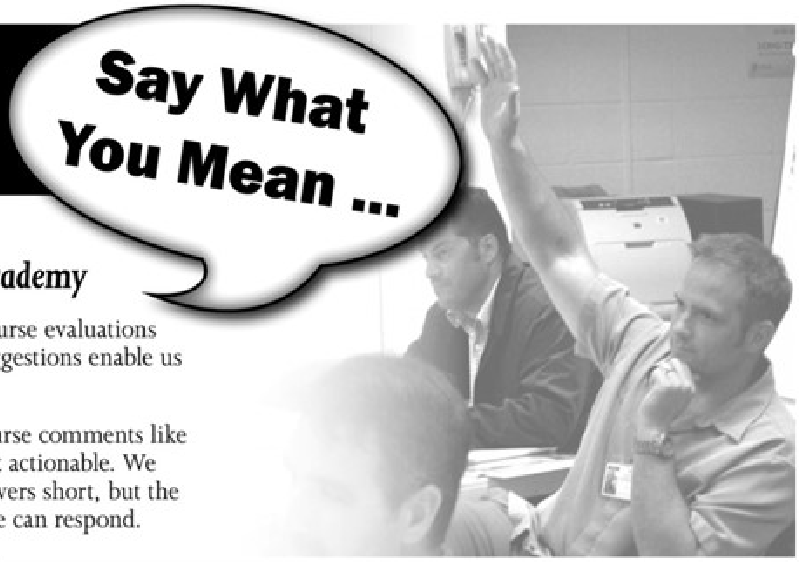
FIREFIGHTER CODE OF ETHICS

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

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

Developed by the National Society of Executive Fire Officers

A Student Guide to End-of-course Evaluations



Ten Things You Can Do to Improve the National Fire Academy

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

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

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

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UNIT 1: INTRODUCTION TO LIFE SAFETY SYSTEMS

TERMINAL OBJECTIVE

The students will be able to:

1.1 *Analyze system components and established performance requirements for water-based fire protection systems.*

ENABLING OBJECTIVES

The students will be able to:

1.1 *Identify the applicable standards for water-based fire protection systems.*

1.2 *Explain the functions of water-based fire protection systems and equipment.*

1.3 *Explain the in-service testing process for water-based fire protection systems.*

1.4 *Explain the annual inspection and maintenance processes for water-based fire protection systems.*

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FEMA

U.S. Fire Administration

UNIT 1: INTRODUCTION TO LIFE SAFETY SYSTEMS

Slide 1-1

TERMINAL OBJECTIVES

Analyze system components and established performance requirements for water-based fire protection systems.

Slide 1-2

ENABLING OBJECTIVES

- Identify the applicable standards for water-based fire protection systems.
- Explain the functions of water-based fire protection systems and equipment.
- Explain the in-service testing process for water-based fire protection systems.

Slide 1-3

ENABLING OBJECTIVES (cont'd)

- Explain the annual inspection and maintenance processes for water-based fire protection systems.

Slide 1-4

I. INTRODUCTION

REFERENCE STANDARDS

- National Fire Protection Association (NFPA) 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.*
- NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*, does not require compliance with NFPA 25.

Slide 1-5

REFERENCE STANDARDS (cont'd)

- NFPA 750, *Standard on Water Mist Fire Protection Systems.*
- Additional requirements are contained in the International Fire Code (IFC).
  - Additional requirements may be in locally adopted code, even if they are more or less restrictive.
  - Those requirements take precedence over NFPA 25 even if less stringent.

Slide 1-6

II. MAINTENANCE OF WATER-BASED FIRE PROTECTION SYSTEMS

MAINTENANCE OF WATER-BASED FIRE PROTECTION SYSTEMS

Slide 1-7

The minimum requirements for the ongoing testing and maintenance of water-based fire protection systems are set forth in National Fire Protection Association (NFPA) 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.* Water-based fire protection systems include automatic sprinkler systems, standpipe systems, combined standpipe and sprinkler systems, private fire service mains, fire pumps, water tanks, water spray, and foam-water systems. The provisions of NFPA 25 do not apply to sprinkler systems designed and installed in accordance with NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*, and water mist systems designed and installed in accordance with NFPA 750, *Standard on Water Mist Fire Protection Systems.*

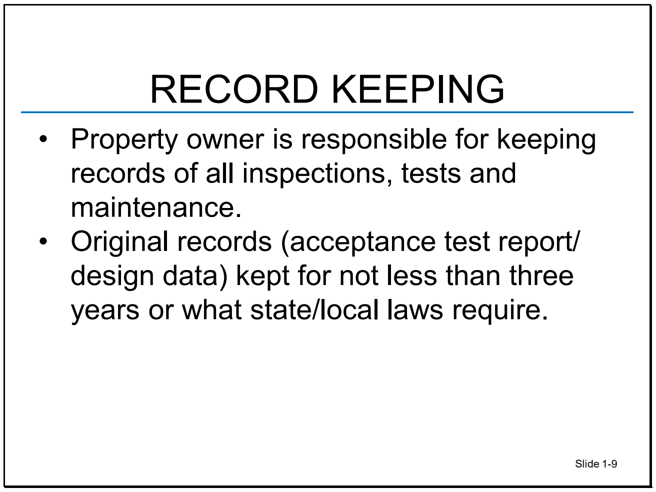
WHO IS RESPONSIBLE?

- Owner.
- When owner is not occupant, owner may pass on authority.
- Transfer must be written.

Slide 1-8

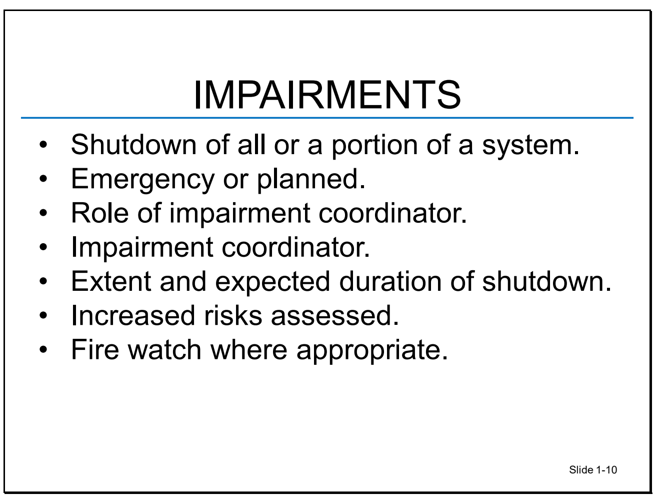
A. Who is responsible?

It is the responsibility of the property owner to properly maintain all water-based fire protection systems. When the owner is not the occupant, the owner is permitted to pass on the authority for inspecting, testing and maintaining the fire protection systems to the occupant, management firm or managing individual through specific provisions in the lease, written use agreement or management contract.



B. Record keeping.

The property owner is required to keep records of all inspections, tests and maintenance of the systems. Such records are to be made available to the authority having jurisdiction (AHJ) upon request. The records must indicate the procedure performed, the organization that performed the work, the results and the date. Original records (acceptance test report/design criteria) must be retained for not less than three years, or what state/local laws require after the next required inspection, test or maintenance. Records shall be permitted to be stored and accessed electronically.



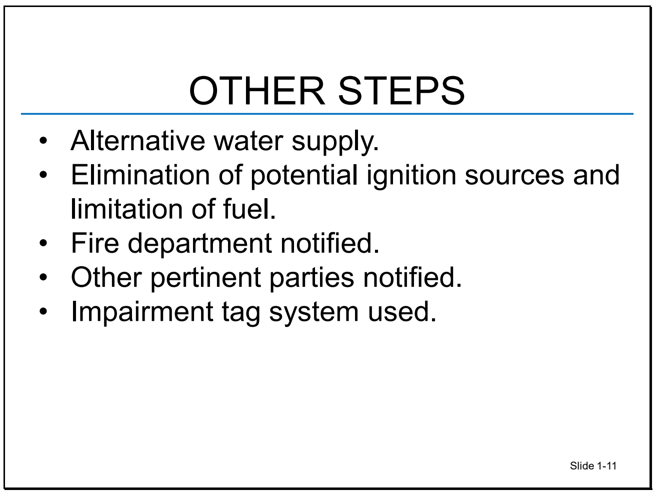
C. Impairments.

1. A shutdown of a system or portion thereof. The two types of impairments are as follows:

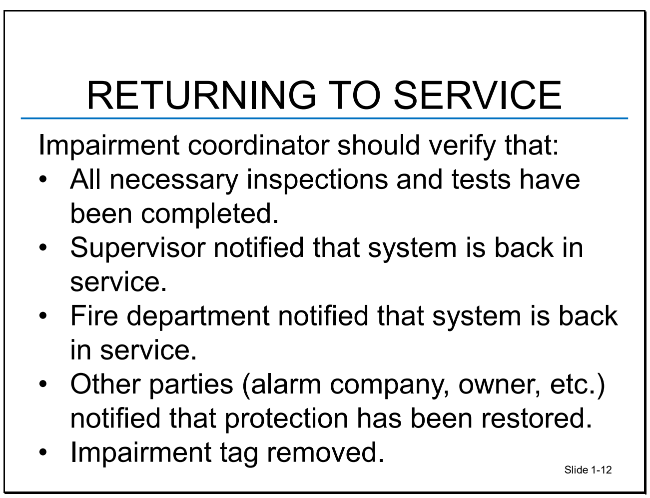
   a. Emergency: a condition where a water-based fire protection system or portion thereof is out of service due to an unexpected occurrence, such as a ruptured pipe, an operated sprinkler or an interruption of the water supply to the system.

b. Planned: a condition where a water-based fire protection system or portion thereof is out of service due to work that has been planned in advance, such as revisions to the water supply or sprinkler system piping.

2. NFPA 25 requires that the property owner or designated representative must assign an impairment coordinator, and in the absence of a specific designee, the property owner or designated representative will be considered the impairment coordinator.



D. Other steps.



E. Returning to service.

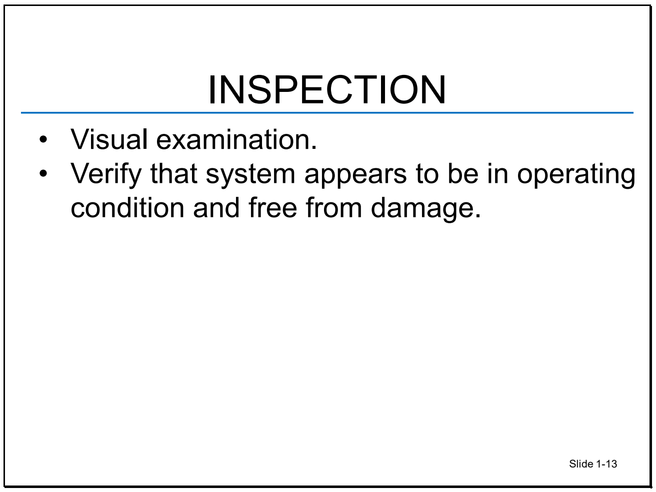
1. All necessary inspections and tests have been completed.

2. Supervisor is notified that the system is back in service.

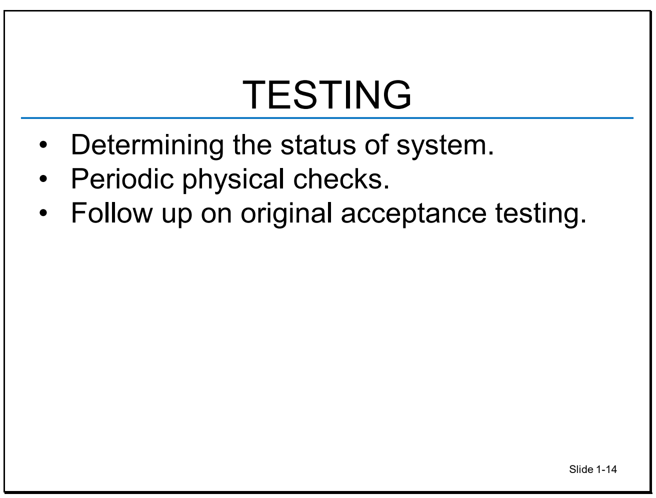
3. Fire department is notified that the system is back in service.

4. Other parties (alarm company, owner, etc.) are notified that protection has been restored.

5. Impairment tag is removed.



F. Inspection: a visual examination of a water-based fire protection system or portion thereof to verify that it appears to be in operating condition and is free of physical damage.



G. Testing: a procedure used to determine the status of a system as intended by conducting periodic physical checks on water-based fire protection systems, such as water flow tests, fire pump tests, and trip tests of dry pipe, deluge or preaction valves. These tests follow up on the original acceptance test at intervals specified in the appropriate chapter of NFPA 25.

MAINTENANCE

- Work necessary to keep equipment/system operable.
- Repairs.

Slide 1-15

H. Maintenance: work performed to keep equipment operable or to make repairs.

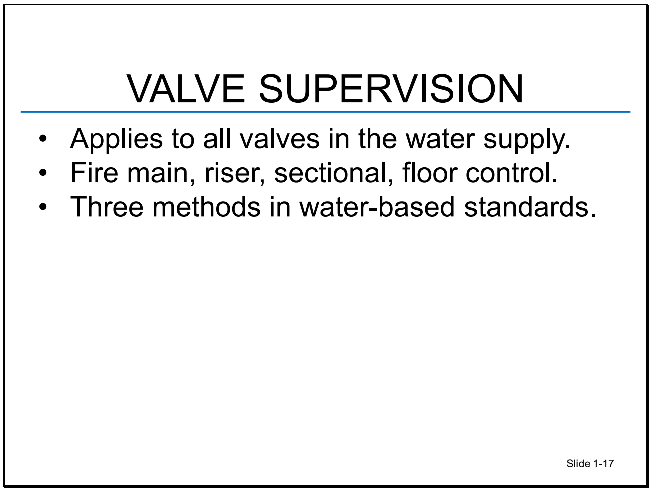
INSPECTION, TESTING AND MAINTENANCE SERVICE

- Provided by a qualified contractor or owner's representative.
- Qualifications determined by authority having jurisdiction (AHJ), regulation or statute.
- Inspect and test at required times.
- Provide necessary maintenance.
- Logging and retention of records.

Slide 1-16

I. Inspection, testing and maintenance service: a service program provided by a qualified contractor or owner's representative (with qualifications determined by the AHJ, regulation or statute) in which all components unique to the property's systems are inspected and tested at the required times and necessary maintenance is provided. This program includes logging and retention of relevant records.

III. COMMON COMPONENTS OF WATER-BASED SYSTEMS

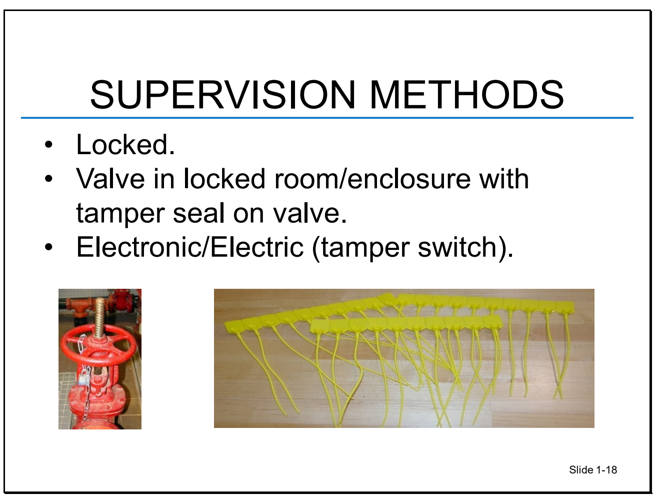


A. Valve supervision.

1. Applies to all valves in the water supply.

2. Fire main, riser, sectional, floor control.

3. Three methods in water-based standards.



B. Supervision methods.

All control valves shall be provided with identification signs. All control valves must also be "supervised." Under the provisions of NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, such supervision may be:

1. Central station, proprietary or remote signaling service.

2. Local electrical supervision which causes the sounding of an audible signal at a constantly attended point.

3. Locking valves in the correct position with monthly recorded inspections.

4. Sealing of valves and approved weekly recorded inspection when valves are located within fenced enclosures under the control of the owner.

C. Fire alarm.

D. International Building Code (IBC)/International Fire Code (IFC) requirements.

International Residential Code (IRC) P2904.

INTERNATIONAL BUILDING CODE/ INTERNATIONAL FIRE CODE EXCEPTIONS

- NFPA 13D.
- Limited area systems with less than six sprinklers.
- NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*, with common supply main where no separate shut-off valve is provided for domestic.
- Jockey pump valves that are sealed or locked.

Slide 1-21

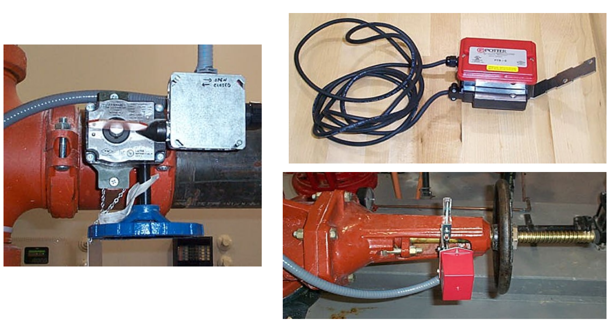
INTERNATIONAL BUILDING CODE/ INTERNATIONAL FIRE CODE EXCEPTIONS (cont'd)

- Control valves to commercial kitchen hoods, paint spray booths or dip tanks that are sealed or locked.
- Valves controlling fuel supply to fire pump that are sealed or locked.
- Trim valves to pressure switches in dry, preaction or deluge that are sealed or locked.

Slide 1-22

E. IBC/IFC exceptions.

TAMPER SWITCHES



Slide 1-23

F. Tamper switches.

IV. REQUIREMENTS FOR UNDERGROUND FIRE SERVICE MAINS

REQUIREMENTS FOR UNDERGROUND FIRE SERVICE MAINS

Slide 1-24

STANDARDS

- NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances.*
- NFPA 13, *Standard for the Installation of Sprinkler Systems.*

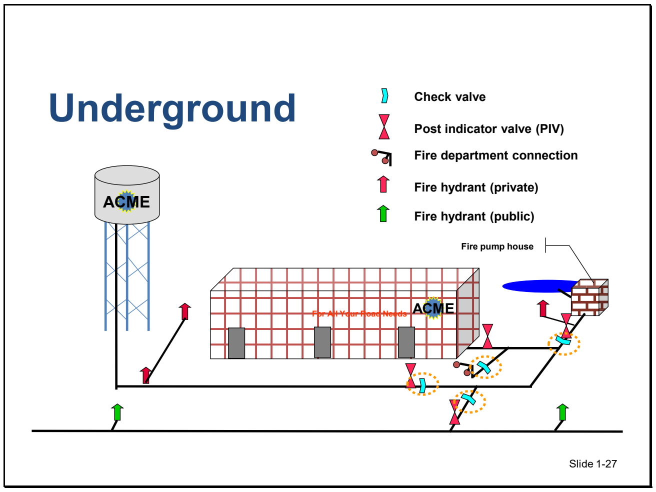
Slide 1-25

A. Standards.

DEFINED AS…

- Water source and base of a riser.
- Water source and inlets to foam-making equipment.
- Inlet side of check valve on gravity or pressure tank.
- Source of water and the base elbow of private hydrants or monitor nozzles.
- Fire pump suction and discharge piping not within a building.

Slide 1-26



NATIONAL FIRE PROTECTION ASSOCIATION 13

"This standard shall also apply to 'combined service mains' used to carry water for both fire service and other uses…"

— NFPA 13, 2016, Section 1.3.2

Slide 1-28

PRESSURE REGULATION VALVES AND METERS

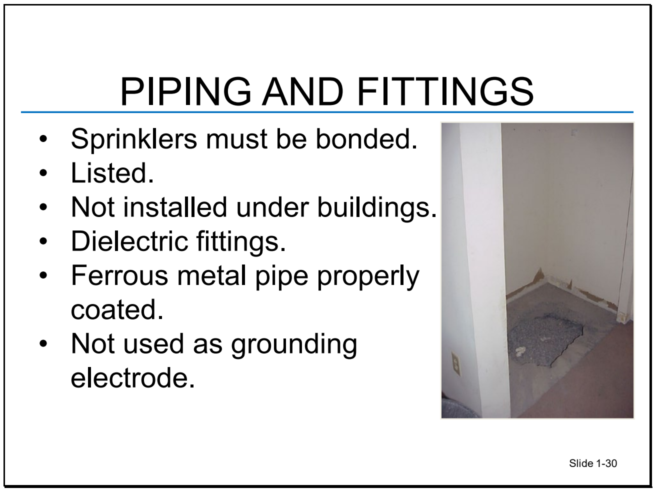
Must be listed for fire service.

Slide 1-29

B. Pressure regulation valves.

1. NFPA 24, Section 5.3.1.1: "Pressure regulating valves shall be permitted to be used when acceptable to the AHJ."

2. NFPA 24, Section 5.3.2: "Where meters are required, they shall be listed for fire protection service" (2016).



C. Piping and fittings.

1. Sprinklers must be bonded.

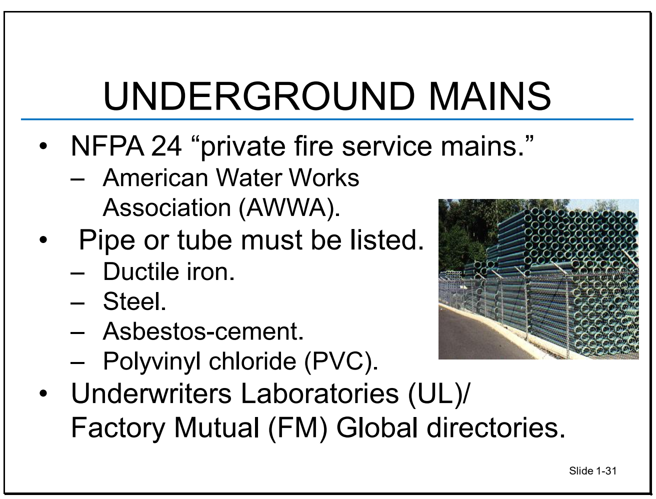
2. Listed.

3. Not installed under buildings.

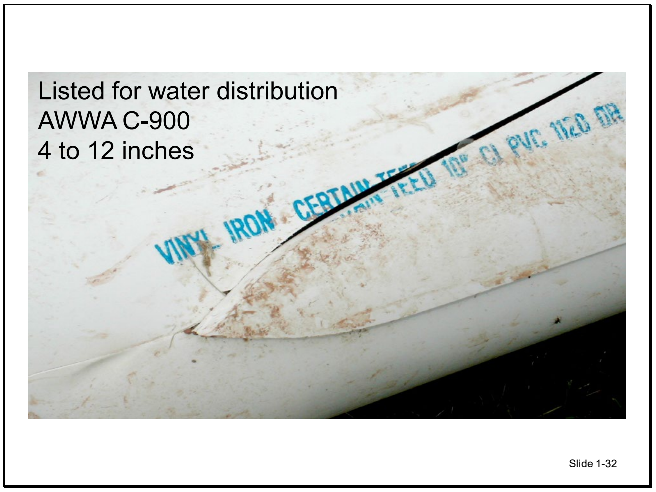
4. Dielectric fittings.

5. Ferrous metal pipe properly coated.

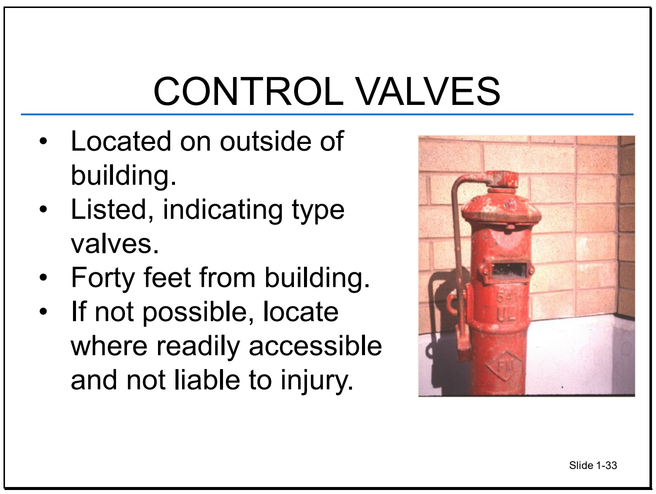
6. Not used as grounding electrode.



D. Underground mains.



All piping is required to be listed for fire protection service. Steel piping is not permitted to be used in underground private fire service main applications. Listed types of piping include: cast-iron and ductile-iron pipe, asbestos-cement pipe and couplings, copper pipe, fiberglass filament-wound epoxy pipe and couplings, polyethylene pipe, and polyvinyl chloride (PVC) pipe and couplings.



E. Control valves.

1. Connections to public water systems must be controlled by post indicator valves (PIVs) located not less than 40 feet from the protected building. If the valve cannot be placed at this distance, it is permissible to locate the valve closer to the building or use a wall-mounted valve, provided that they are located by blank walls where the possibility of injury by falling walls is unlikely and from which people are not likely to be driven by smoke or heat. PIVs must be set so that the top of the post is 32 inches to 40 inches (800 millimeters to 1 meter) above the final grade. Valves may also be installed within pits when approved by the AHJ.

EXCEPTION

A listed, nonindicating valve, such as an underground gate valve, including a T-wrench, shall be permitted in a roadway box when acceptable to the AHJ.

Slide 1-34

2. Exception.

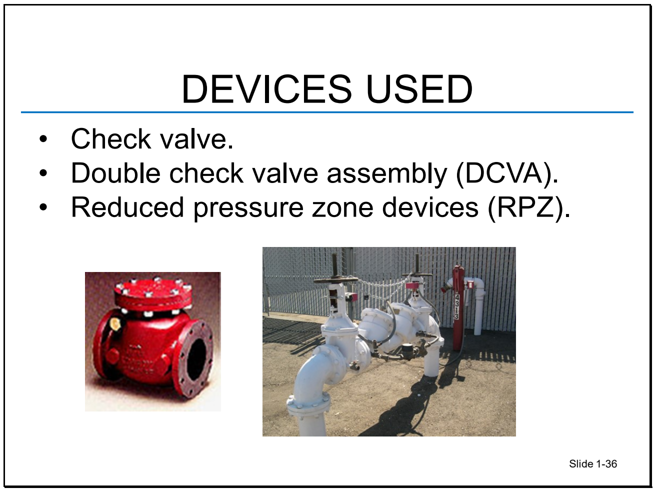
   The AHJ may also permit the use of a street or roadway box in lieu of the listed, indicating control valve. If the street or roadway box is permitted, then a T-wrench must be provided in a clearly identified and readily accessible location on the premises. Prior to allowing the use of a street or roadway box, the AHJ should consider other factors, such as weather conditions, traffic patterns, security, service reliability and access. In many areas of the United States, snow and ice accumulations or heavy vehicle traffic could prevent quick and easy location and operation of such a valve. Valves located in paved roadways are also susceptible to being covered by pavement during resurfacing operations.

BACKFLOW PROTECTION

NFPA 24 and NFPA 13 recognize that where connections are made from a public water supply, it might be necessary to guard against possible contamination of water supply.

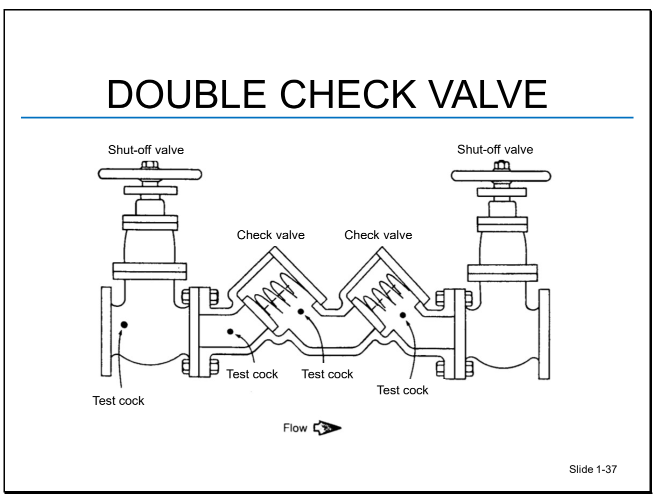
Slide 1-35

F. Backflow protection.



G. Devices used.

Protection against backflow can be provided by check valves, detector check valves, double check valve assemblies (DCVAs), or reduced pressure zone devices (RPZ). Check valves are valves that permit flow in only one direction from the supply to the end use. Detector check valves are valves that combine the one-way flow feature of a check valve with a bypass arrangement capable of detecting flow through the valve and measuring some or all of such flow.



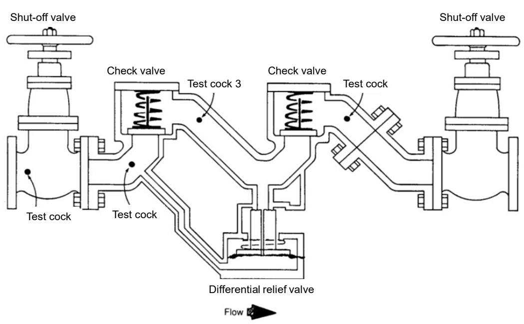
DOUBLE CHECK VALVE (cont'd)

Slide 1-38

1. Double check valve.

DCVA is an assembly consisting of two single, independently acting approved check valves. The unit also includes test cocks and shut-off valves at each end of the assembly.

REDUCED PRESSURE ZONE DEVICES



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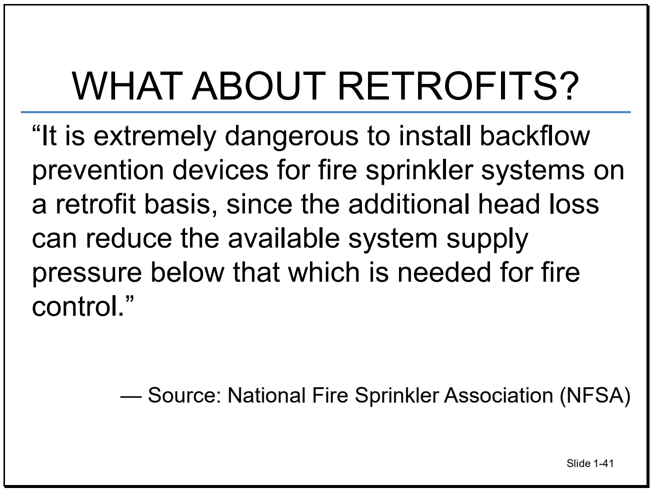
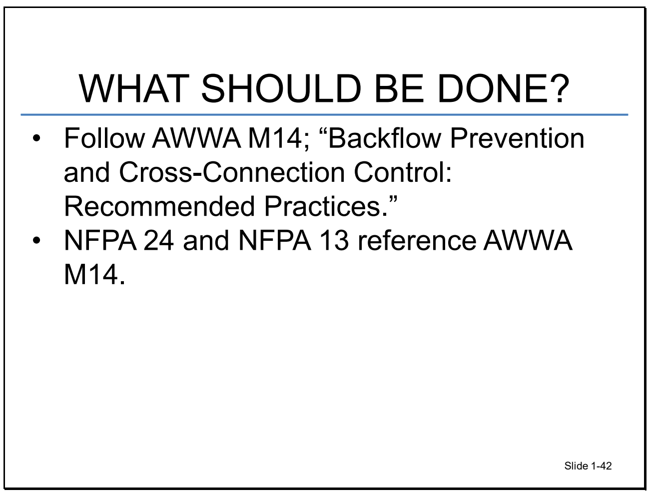
REDUCED PRESSURE ZONE DEVICES (cont'd)

Slide 1-40

2. RPZ are devices containing two independently acting approved check valves held together with a hydraulically operating, mechanically independent pressure relief valve located between the check valves and at the same time below the first check valve. The unit also includes test cocks and shut-off valves at each end of the assembly.





3. Retrofits.

While the provisions of NFPA 24 and NFPA 13 do not provide specific requirements for backflow protection, direct reference is made to the American Water Works Association (AWWA) Manual 14; “Backflow Prevention and Cross-Connection Control: Recommended Practices.” This document provides guidance to establish when possible contamination can occur in a wide variety of circumstances including fire protection systems.

TESTING OF BACKFLOW PREVENTION DEVICES

- NFPA 13 governs requirements to install a method for forward flow testing.
- NFPA 25 governs testing and maintenance.
- Must be tested at time of installation.
- Must be inspected weekly to ensure that the relief port is not discharging.
- Tested annually at the designed flow rate of the fire protection system.

Slide 1-43

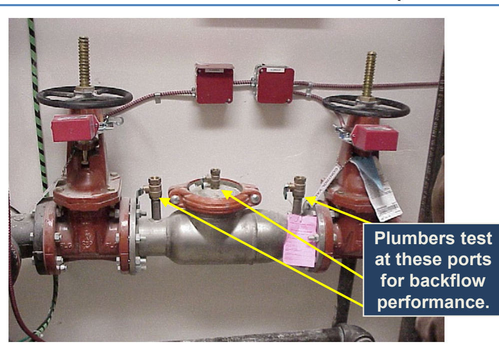
TESTING OF BACKFLOW PREVENTION DEVICES (cont'd)

- Manufacturer's specifications may only provide testing for backflow.
- Three ways to perform forward flow testing.
  - Fire pump test (when a fire pump is located past the backflow preventer).
  - Main drain test.
  - Dedicated water flow test (when sprinkler water flow demand is greater than main drain test can flow).

Slide 1-44

H. Testing of backflow prevention devices.

TESTING OF BACKFLOW PREVENTION DEVICES (cont'd)



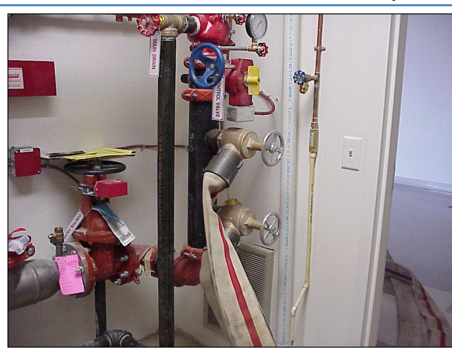
Slide 1-45

TESTING OF BACKFLOW PREVENTION DEVICES (cont'd)

Water must be flowed through the backflow prevention device to verify the demand for the sprinkler system is met.

Slide 1-46

TESTING OF BACKFLOW PREVENTION DEVICES (cont'd)



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TESTING OF BACKFLOW PREVENTION DEVICES (cont'd)

Slide 1-48

TESTING OF BACKFLOW PREVENTION DEVICES (cont'd)

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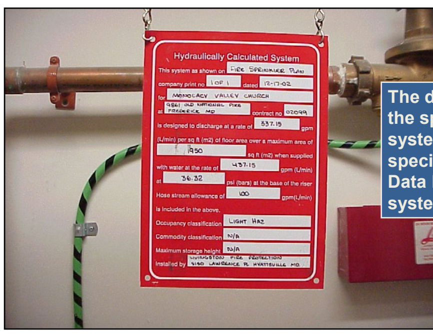
TESTING OF BACKFLOW PREVENTION DEVICES (cont'd)



Slide 1-50

V. INSTALLATION REQUIREMENTS

DEPTH OF COVER/PROTECTION

- At least:
  - 1 foot below local frost line.
  - 2 1/2 feet if **no** frost concerns.
  - 3 feet below driveways.
  - 4 feet below railroad tracks.
- Will not be allowed to run under buildings.

Slide 1-51

A. Depth of cover/protection.

The depth of cover of the private fire service main is determined by the maximum frost penetration in the locality where the pipe is laid. A table displaying the frost line levels for the United States is included in the appendix of NFPA 24. The top of the pipe must be buried not less than 1 foot below the frost line for the locality. In those locations where frost is not a factor, the depth of cover may not be less than 2 1/2 feet. Piping installed under driveways must be buried at a minimum depth of 3 feet, and under railroad tracks, the minimum depth is 4 feet. The depth of cover is measured from the top of the pipe to the finished grade, and piping is not allowed to run under buildings.

B. Restrained against movement.

1. Where connections are made of pipes of dissimilar metals, the joint must be insulated by an approved dielectric fitting. In no case will a private fire service main be used for grounding of electrical services. This does not prohibit the proper bonding of all piping as required by NFPA 70, *National Electrical Code*® (NEC).

2. All tees, plugs, caps and bend, and hydrant branches must be restrained against movement. Restraint methods include pipe clamps and tie-rods, thrust blocks, locked mechanical or push-on joints, and mechanical joints using setscrew retainer glands.

THRUST BLOCKS

- Only where soil is suitable.
- Poured-in-place concrete.
- Placed between undisturbed or properly compacted soil and the fitting.
- Fittings must remain accessible.
- Details in NFPA 13.

Slide 1-53

C. Thrust blocks.

Thrust blocks may only be used where the soil is suitable. Thrust blocks are to be placed between undisturbed soil and the fitting. Where this is not possible, the soil must be compacted to at least a 90% standard proctor density. The concrete mix must not be leaner than 1 part cement, 2 1/2 parts sand and 5 parts stone.

PROPER BACKFILLING

- Well tamped.
- Clean, no construction debris.
- No rocks.
- No frozen earth.
- Gravel or dry sand used in freezing weather.

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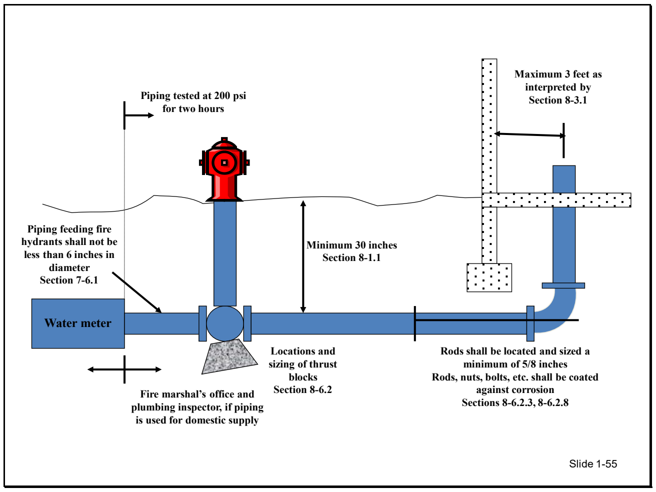

D. Proper backfilling.

The backfill must be well tamped in layers under and around the pipe to prevent settlement or lateral movement. The backfill must be clean and not contain ashes, cinders, rocks, refuse, organic matter or other corrosive materials. Frozen earth is not permitted to be used for backfilling. Cover joints with bituminous paint to address corrosion. Apply plastic wrap in order to facilitate the installation of piping. In freezing temperatures, it is acceptable to backfill under and around the pipe with gravel.

Slide 1-57

VI. FLUSHING REQUIREMENTS

UNDERGROUND PIPING

All new underground piping must be properly flushed.

Slide 1-58

All new underground private fire service mains must be properly flushed to remove any foreign matter that might have entered during the course of the installation or that might have been present in existing piping. All fire service mains must be completely flushed before connection is made to the sprinkler or standpipe piping.

DEBRIS LOCATED INSIDE OF PIPE

Slide 1-59

FLOW RATES

One of the following methods:
- Demand rate of fire protection system.
- Velocity of 10 feet per second (fps).
- Maximum flow rate available under fire conditions (residual pressure of 20 pounds per square inch (psi)).

Slide 1-60

A. Flow rates.

The minimum flow rate must be one of the following:

1. The hydraulically calculated water demand rate of the system including any hose requirements.

2. The flow necessary to provide a velocity of 10 feet per second (fps). (Flow rates are set forth in a table in both NFPA 24 and NFPA 13.)

3. The maximum flow available to the system under fire conditions (flow available at 20 pounds per square inch (psi) residual).

DURATION

Flushing operation shall be continued until water flow is clear of all debris.

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B. Duration.

The flushing operation must continue for a sufficient time to ensure thorough cleaning.

HYDROSTATIC TESTING

- Before piping is covered.
- Cover placed between joints is acceptable and recommended.
- Must be hydrostatically tested at gauge pressure of 200 psi or 50 psi over the maximum operating pressure, whichever is greater, and shall maintain that pressure at gauge pressure of ±5 psi for two hours.
- Some leakage is permitted.

Slide 1-62

C. Hydrostatic testing.

All new private fire service mains must be tested hydrostatically at not less than 200 psi for two hours or 50 psi over the maximum static pressure, whichever is greater. The amount of leakage permitted cannot exceed two quarts per hour per 100 gaskets or joints. Additional leakage of one fluid ounce per inch valve diameter per hour is also permitted. The amount of leakage permitted must be measured at the specified test pressure by pumping from a calibrated container.

WITNESSING OF TESTS

All tests should be witnessed by AHJ or representative of owner.

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D. Witnessing of tests.

VII. SUMMARY

FEMA

SUMMARY

U.S. Fire Administration

- Maintenance of water-based fire protection systems.
- Common components of water-based systems.
- Requirements for underground fire service mains.
- Installation requirements.
- Flushing requirements.

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QUESTIONS?

Slide 1-65

REFERENCES

ICC. (2015). *International building code*. Washington, DC: Author.

ICC. (2015). *International fire code*. Washington, DC: Author.

NFPA. (2016). *Standard for the installation of private fire service mains and their appurtenances.* (Standard No. 24). Retrieved from www.nfpa.org

NFPA. (2016). *Standard for the installation of sprinkler systems.* (Standard No. 13). Retrieved from www.nfpa.org

UNIT 2:
FIRE ALARM SYSTEMS

TERMINAL OBJECTIVE

The students will be able to:

2.1 Evaluate if alarm and detection systems or equipment are operational, adequate, maintained and tested.

ENABLING OBJECTIVES

The students will be able to:

2.1 Identify the applicable standards for alarm and notification systems.

2.2 Explain the functions of alarm and notification systems and equipment.

2.3 Explain the in-service testing process for alarm and notification systems.

2.4 Explain the annual inspection and maintenance processes for alarm and notification systems.

2.5 Determine operational capabilities of alarm and notification systems.

2.6 Analyze alarm and notification system test documentation for accuracy, completeness and code compliance.

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FEMA

U.S. Fire Administration

UNIT 2: FIRE ALARM SYSTEMS

Slide 2-1

TERMINAL OBJECTIVE

Evaluate if alarm and detection systems or equipment are operational, adequate, maintained and tested.

Slide 2-2

ENABLING OBJECTIVES

- Identify the applicable standards for alarm and notification systems.
- Explain the functions of alarm and notification systems and equipment.
- Explain the in-service testing process for alarm and notification systems.

Slide 2-3

ENABLING OBJECTIVES (cont'd)

- Explain the annual inspection and maintenance processes for alarm and notification systems.
- Determine operational capabilities of alarm and notification systems.
- Analyze alarm and notification system test documentation for accuracy, completeness and code compliance.

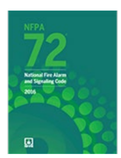
Slide 2-4

I. INTRODUCTION

A fire alarm and detection system is a key element of any building's overall fire protection features. Properly designed, installed, operated and maintained, a fire alarm system can help reduce life loss from fire and limit fire damage in buildings.

APPLICABLE STANDARDS

- National Fire Protection Association (NFPA) 72, *National Fire Alarm and Signaling Code*®.
  - Installation.
  - Inspection.
  - Testing.
  - Maintenance.
- NFPA 70, *National Electric Code*® (NEC).
  - Wiring.



Slide 2-5

A. Applicable standards.

FUNDAMENTAL RULES

- Manufacturer's recommendations or listing requirements take precedence over NFPA 72.
- Primary standard is NFPA 72 with additional requirements in the International Building Code (IBC) and International Fire Code (IFC) and answers questions where others are silent.

Slide 2-6

B. Fundamental rules.

II. FIRE DETECTION AND ALARM SYSTEM FUNCTIONS

FIRE DETECTION AND ALARM SYSTEM FUNCTIONS

Slide 2-7

FIRE DETECTION

- Fire signatures.
- Heat.
- Smoke.
- Fire or industrial gases.
- Infrared (IR) or ultraviolet (UV) emissions.

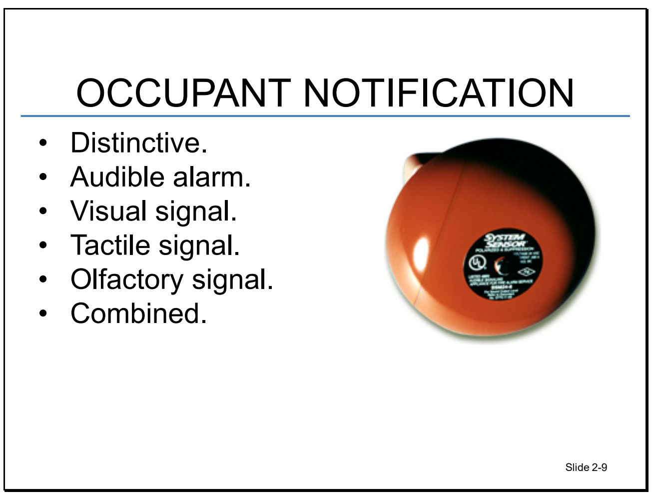
Slide 2-8

A. Fire detection.

1. Automatic initiating devices contribute to life safety, fire protection and property conservation. The fire detection function can be used solely to notify occupants, or it can be used to initiate some related action, such as to summon the fire suppression forces, operate a fire suppression system or close automatic fire barriers.

2. Detection devices are engineered to sense "fire signatures" — changes in the ambient atmosphere that suggest an abnormal condition. Heat, smoke, flame, pressure increases, toxic gases or radiant energy each generates a different signature that detection devices can be manufactured to sense. A chart depicting the different fire effects and detection methods is included later in this section.

3. Detection can be for life safety (such as smoke detectors) or related to the operation of a fire protection system, such as deluge or preaction sprinklers, total flooding clean agent systems, or spot application dry chemical or similar agents. They can also be part of the operation of smoke control or exhaust features.



B. Occupant notification.

1. One of the primary functions of a fire alarm system is to provide warning for occupant evacuation or relocation. By having early notification of potential fire threats, occupants can take appropriate action to protect themselves and others within a building. The preferred occupant protection method is evacuation to a safe location (usually outdoors), but when that is not feasible due to infirmities, building height or travel distances, relocation to areas of refuge may be an acceptable alternate.

2. Fire alarm signals — audible, visual, tactile or other sensory — are intended to provide that early warning. Signals can be initiated automatically, manually or both. The most common occupant notification signals consist of horns, bells or similar devices with or without visual alerting devices (strobes).

SIGNAL REPORTING

Transmitting signal from protected premises to a location where action will occur:
- Fire station.
- Police station.
- Guard shack.
- Protected premises.
- Central station.
- Remote station.
- Proprietary station.
- Auxiliary station.

Slide 2-10

C. Signal reporting.

FIRE PROTECTION (ACTUATION)

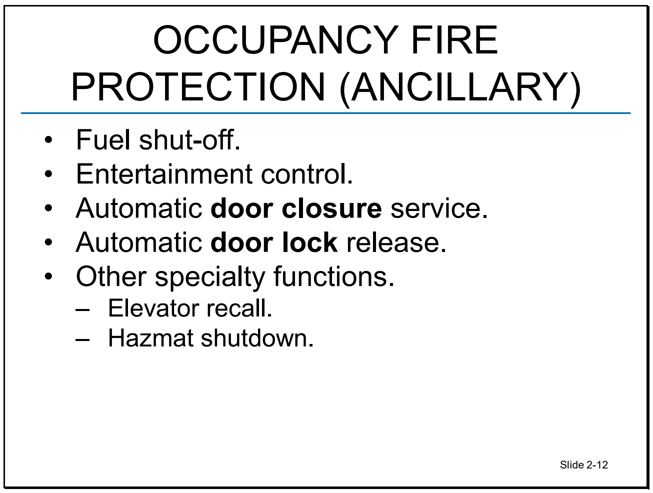
- Sprinkler systems.
  - Deluge.
  - Preaction.
- Special agents.
  - FM200 clean agent.
  - Carbon dioxide (CO_2).
- Smoke control systems.

Slide 2-11

D. Fire protection (actuation).

1. Some fire alarm and detection systems aid in fire control by being an integral part of a building's other fire protection features, such as fire sprinkler systems, special agent fire suppression systems, smoke control and management systems, elevators, fire barriers, and process equipment.

2. Smoke, heat or radiant detection devices can be connected to deluge or preaction sprinkler systems to release main control valves that permit water to fill the fire protection system. Fire detection equipment often is employed to notify occupants of a potential fire so they may take appropriate action before the building's overall fire suppression system is activated. If a wastebasket fire in a computer room can be doused with a glass of water, why wait for the fire sprinkler system to operate with its attendant damage and operational downtime?



E. Occupancy fire protection (ancillary).

There are many other types of fire safety control features that can be interconnected to a fire detection and alarm system. These sometimes are called "ancillary" functions. Each of these contributes in some way to the life safety and fire protection features of a building.

1. **Operation of fuel and process product shut-offs.** In some applications, it may be desirable for the building's fuel gas or a production gas (i.e., chlorine, silane) to be discontinued automatically in the event of an alarm. The fire detection system can signal an automatic valve to close to prevent product flow.

2. **Automatic door release service for fire-rated assemblies.** The building codes allow the installation of doors in fire barriers and firewalls. These doors must be able to close automatically in the event of a fire to prevent heat and flame from passing through the opening.

3. **Automatic door lock release.** This is commonly found on exit doors that open into stairways, particularly in high-rise buildings. National Fire Protection Association (NFPA) 101, *Life Safety Code*®, and the model building codes allow these doors to be locked on the stairway side of the door to prevent reentry from the stairway into the building. The activation of the building fire alarm system must deactivate these locking devices automatically so fire suppression personnel have access to all floors.

4. **Operation of smoke control fans and smoke dampers.** The building codes specify that some occupancies have smoke control systems. Buildings that have atriums, high-rise buildings, and some health care facilities commonly are equipped with fans to pressurize stairways and/or purge smoke to enhance life safety and fire suppression efforts. Smoke detection devices are used to initiate their operation as well as to sound an occupant notification alarm.

5. **Elevator recall.** In order to prevent building occupants from getting trapped in an elevator shaft during a fire, most codes require that elevators are recalled to a safe location when a smoke detector near the elevator operates. Usually, the first, or main, floor is considered the "homing" floor, and the elevator is arranged to go to an alternate floor if that detector is the one in alarm.

SUPERVISORY SERVICE

- Control valve tampering.
- Storage tank water temperature.
- Tank high/low status.
- Air pressure on dry pipe systems.
- Fire pump supervision.

Slide 2-13

F. Supervisory service.

A fire alarm and detection system can provide many different types of supervisory service related to the fire protection systems in the building. A supervisory alarm is one that indicates that an abnormal condition exists with a fire protection system. Examples include:

1. **Sprinkler system water control valve opened or closed (tampering).** A leading cause of fire sprinkler system failure is closed water supply valves. When valves are equipped with a "tamper" switch, the monitoring service where the signal is received can determine whether someone has opened or closed a valve and can check on the valve status if it remains abnormal longer than expected.

2. **Water temperature or water level for fire protection water tanks.** Some fire sprinkler systems are equipped with pressurized or elevated water tanks, cisterns or reservoirs. Should the temperature drop near freezing, or the tank lose a portion of its contents, it is important that a responsible person be informed to take corrective action.

3. **High and low air pressure for dry sprinkler systems.** Excess air pressure in a dry pipe system may prevent it from operating in a timely fashion, and an air pressure loss might cause a dry system to fill with water, so verifying that the compressed air pressure is within its prescribed limits is essential.

4. **Fire pump supervision.** This may include power loss, phase reversal and pump running. A stationary fire pump is a critical component in a facility's fire protection program, especially when it draws water from a static source to supply a fire suppression system. If the pump loses its main electrical power — or the electrical service suffers a phase reversal that causes the pump to run in reverse — a supervisory alarm should be transmitted to a responsible person so maintenance personnel can investigate and correct the problem.

III. FIRE ALARM SYSTEM FUNDAMENTALS

A. Fire Alarm Control Unit (FACU).

1. Systems are outfitted with an FACU (formerly known as the Fire Alarm Control Panel (FACP)) that is considered the "brain" of the system. The FACU takes inputs from the various alarm and supervisory devices that may be located throughout a protected property, interprets the inputs, and processes outputs in the form of audible/visible (A/V) alarm signals, ancillary actions, and reports to monitoring services to summon the necessary human intervention to identify and solve the fire problem.

2. FACUs can be simple or very complex. They may consist of a cabinet that houses small microprocessors, electrical terminals, batteries, light-emitting diodes (LEDs), relays and fuses, or they may be a sophisticated computerized terminal that employs touch-screen technology and provides controls for an endless variety of fire protection and life safety systems within a building.

FIRE ALARM CONTROL UNIT LOCATION

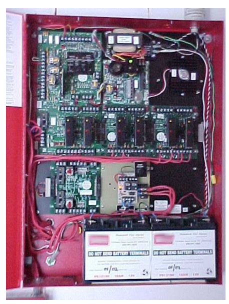
- Open area.
  - Reception, entry, office, etc.
- Electrical or communications closet.
- As approved by authority having jurisdiction (AHJ).
  - In areas not occupied **continuously,** smoke detection must be provided above panel.
- Fire Command Center.

Slide 2-15

3. FACU location.

CHECKING THE CONTROL UNIT

- Fuses.
  - Proper size and rating.
  - Per manufacturer.
- Lamps and light-emitting diodes (LEDs).
  - Properly illuminated.
- Terminals.
  - Wires secure.
  - Complete.
  - Wired correctly.



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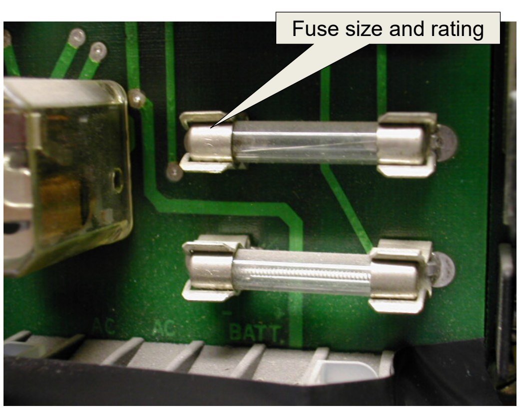


Slide 2-17

4. Checking the control unit.

POWER SUPPLY

- Primary.
  - Building electrical service.
- Secondary power.
  - Battery, generator or combination.
- Duration determined by type of system signaling and monitoring.

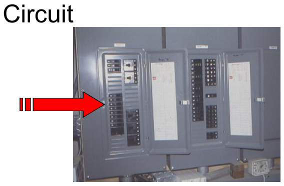
Slide 2-18

B. Power supply.

1. Fire alarm systems must be provided with at least two independent and reliable power supplies: one primary that powers the system in normal mode and a secondary power source to take over in the event of failure of the first (standby mode).

PRIMARY POWER SUPPLY

- On a dedicated branch circuit.
  - High degree of reliability.
  - Mechanically protected.
- Circuit disconnect means must:
  - Be labeled "Fire Alarm Circuit Control."
  - Have **red** marking.
  - Have limited access.
    - -- Locked panel.
    - -- Locked tab.

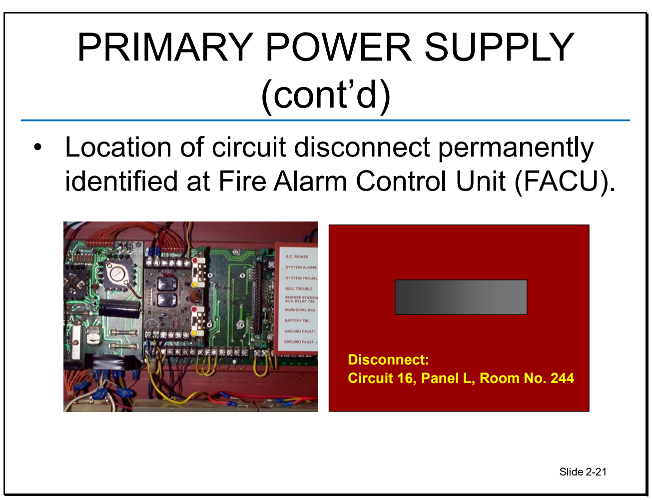


Slide 2-19

2. Primary power.

a. An FACU connected to an electrical service must be on a dedicated branch circuit. No other electrical equipment may be on the same circuit. The circuit must be protected by an appropriately sized fuse or circuit breaker (circuit disconnect means) to protect the wiring and equipment from excess electrical current. The circuit disconnect must be clearly identified and protected from tampering. This is accomplished by:

- Marking the disconnect in red.
- Labeling it “Fire Alarm Circuit Control.”
- Locking the circuit breaker or fuse panel to prevent unauthorized access.



b. The location of the circuit disconnecting means must be identified within the FACU. Normally the installer will write the location in indelible ink on the inside of the fire alarm panel door, e.g., "FA Disconnect Circuit 16, Panel L, Room No. 244."

SECONDARY POWER SUPPLY

- One or more batteries.
- Single automatic starting generator.
  - With batteries.
- Multiple generators.
  - One automatic.
- Uninterruptible power supplies (UPSs) or batteries for transfer.

Slide 2-22

3. Secondary power.

a. Secondary power may consist of one or more batteries, an automatic starting generator with batteries, multiple generators (one of which must be automatic starting), or uninterruptible power supplies (UPSs).

SECONDARY POWER SUPPLY (cont'd)

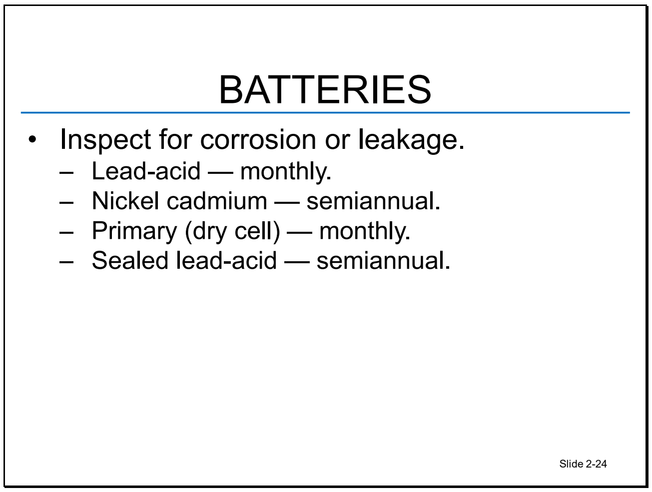
- Supply energy within 10 seconds.
- Upon electric currency alternating current (AC) loss or drop.
- Operate system for at least 24 hours at maximum **normal quiescent (nonalarm) load.**
- Operate all building alarms for at least five minutes.

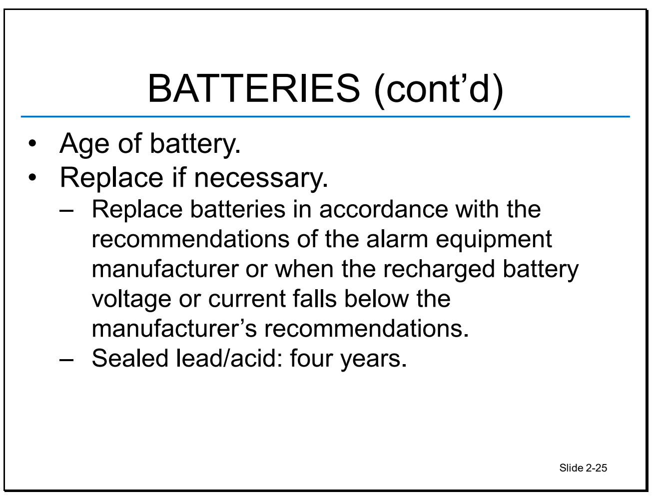
Slide 2-23

b. The secondary power supply shall automatically provide power to the protected premises' system within 10 seconds whenever the primary power supply voltage is insufficient for required system operation.

- The secondary power shall have sufficient capacity to operate the system under quiescent load (system operating in a nonalarm condition) for a minimum of 24 hours and, at the end of that period, shall be capable of operating all alarm notification appliances used for evacuation or to direct aid to the location of an emergency for five minutes.

c. Standby power demands are based on the type of fire alarm system that is employed.





4. Batteries.

NATIONAL ELECTRICAL CODE®

- **Emergency** power.
  - On in 10 seconds.
  - Lasts 90 minutes.
- **Standby** power.
  - On in 60 seconds.
  - No specific duration.
- **Secondary** power.
  - Applies only to fire alarm.
  - On in 10 seconds, no signal loss.
  - Operates at least 24 hours.


Courtesy: Onan Generators

Slide 2-26

C. NFPA 70, *National Electrical Code*® (NEC).

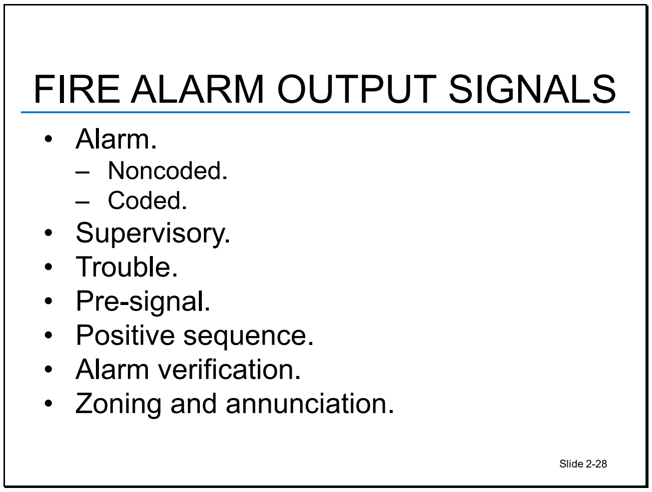
IV. FIRE ALARM SIGNALS

FIRE ALARM SIGNAL BASIC TYPES

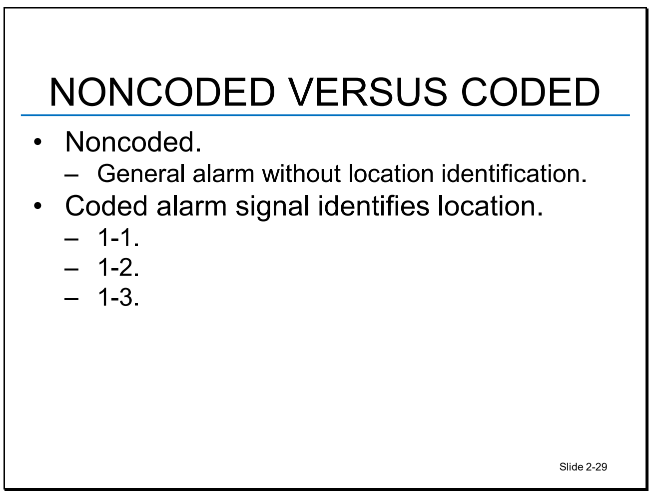
- Alarm signal.
  - Fire alarm signal.
  - Evacuation signal.
- Supervisory signal.
  - Ancillary systems.
  - Guard's tour supervisory signal.
  - Delinquency signal.
- Trouble signal.

Slide 2-27

A. Basic types.



B. Fire alarm output signals.



C. Noncoded versus coded.

1. When an FACU receives a signal that indicates an emergency or dangerous condition exists, it processes that signal into an alarm output. These outputs may be noncoded or coded.

2. Noncoded alarm signals are those that sound continuously, have voice commands or include what is called the standard "audible emergency evacuation signal." These signals are described as "noncoded" because the signal output does not identify where the alarm is originating.

3. In some occupancies, the alarm output from the fire alarm system may be coded for staff and responding personnel to identify the area where the alarm is originating. **This is different from the standard evacuation signal which is discussed later in this unit.**

ALARM SIGNAL SILENCING

- Silencing permitted.
  - Key activated.
  - Locked cabinet.
- Visual and audible at panel.
- Second initiating device.
- Signal timers.
  - Auto silence after five minutes.

Slide 2-30

D. Alarm signal silencing.

1. NFPA 72, *National Fire Alarm and Signaling Code*®, allows an alarm signal deactivation (silencing) device in the FACU as long as the device is key-operated, located within a locked fire alarm cabinet, or otherwise protected from unauthorized use. This switch is permitted only if visual and audible alarm signals remain at the panel when the system is silenced, and any other alarms that are detected will cause the alarm signal to reactivate.

2. Some systems are arranged with signal timers that automatically silence the fire alarm signal after a specific amount of time. Unless otherwise permitted by the authority having jurisdiction (AHJ), an automatically silenced alarm must return to a sounding condition within five minutes.

SUPERVISORY SIGNALS

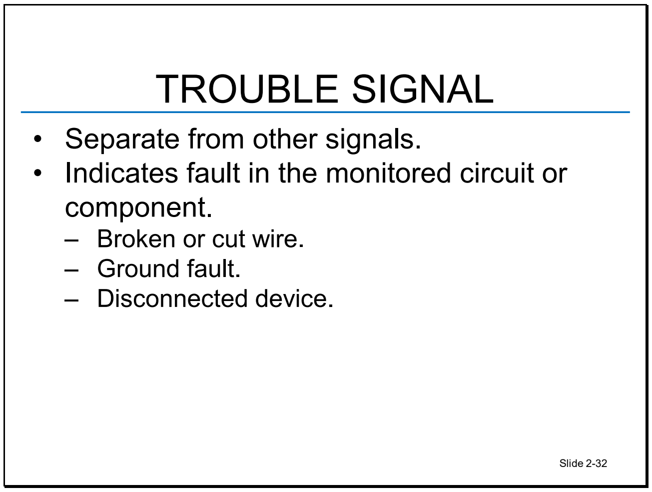
Identify “normal” and “off-normal” modes.

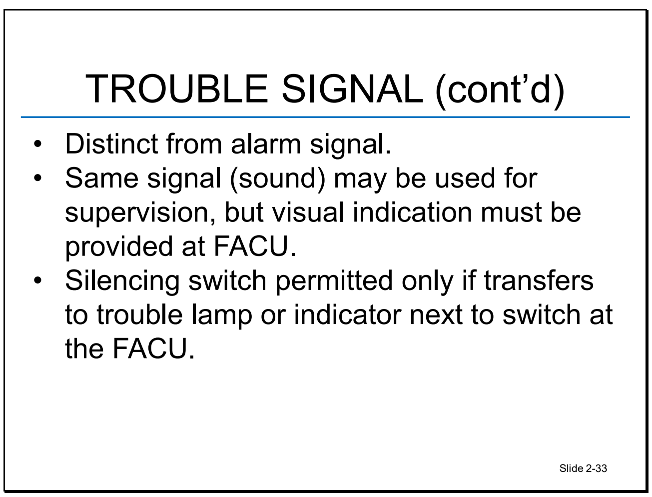
- Valve open/closed.
- High/Low air.
- High/Low temperature.
- Fire pump.
  - Pump running.
  - Power loss.
  - Phase reversal.

Slide 2-31

E. Supervisory signals.

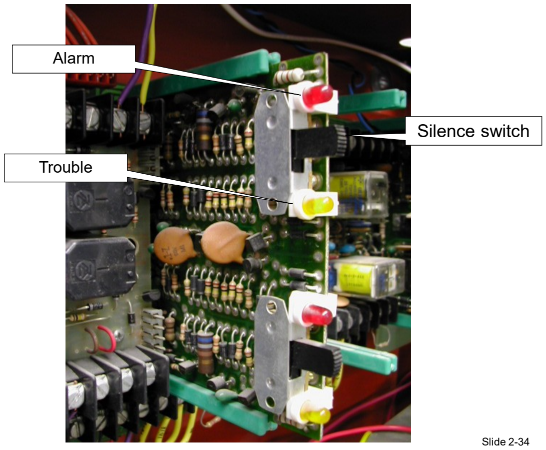
Supervisory signals — those that indicate an “off-normal” condition of a fire protection system (such as a closed water control valve) — are used to monitor the integrity of important fire protection features. Supervisory signals may be a single, noncoded signal or consist of two rounds of a coded signal and one round of the signal to indicate the system has been restored to normal status. An “off-normal” supervisory signal, and the return to normal condition signal, must report to the FACU within 90 seconds of the status change.





F. Trouble signal.

1. If an alarm system suffers some sort of failure (such as a power loss, ground fault, disconnected device or damaged wire), the FACU must respond with a “trouble” signal within 200 seconds of the problem. The trouble signal must be clearly audible to attract attention. Often it is a shrill tone or buzzer that notifies someone nearby so that person can take corrective action. It must be a sound distinctive from any other sound from the FACU.



Slide 2-34

2. The trouble signal may be silenced with a switch or keypad device, but if it is turned off, there must be a visual signal that serves as a reminder that the system is disabled. Furthermore, the audible trouble signal must re-sound at least once every 24 hours until the fault condition has been repaired and the system returned to normal. Disabling the trouble signal must not prevent supervisory signals from reporting. (Supervisory signals include tamper switches, low air alarms, fire pump running, etc.)

PRE-SIGNAL/POSITIVE SEQUENCE

- **Pre-signal** requires human intervention.
  - Offices/Security areas.
- **Positive sequence.**
  - Fifteen-second delay for acknowledgement.
  - One hundred eighty-second delay when acknowledged.

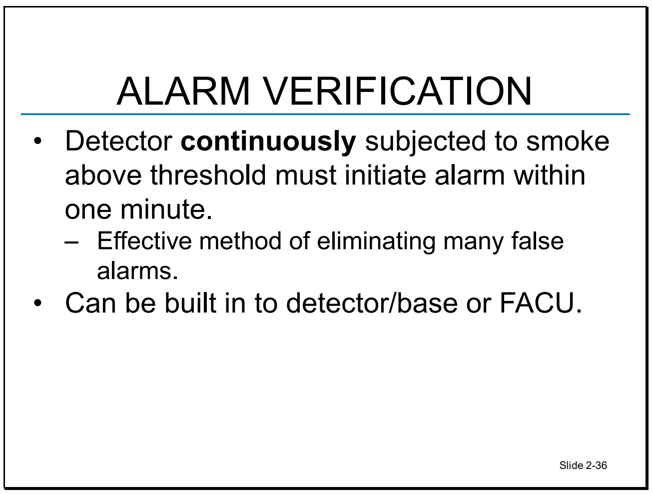
Slide 2-35

G. Pre-signal/Positive sequence.

1. In "pre-signal" systems, activation of the fire alarm system does not sound an alarm throughout the building immediately. There is either a built-in delay of at least one minute from system activation, or the initial fire alarm signals sound only in department offices, control rooms, fire brigade stations or other constantly attended central locations. Then, someone must intervene to sound a general fire alarm. This gives someone on the premises time to investigate the source of the signal before sounding a general evacuation alarm. Because of the need for human intervention, pre-signal systems may be undesirable and therefore require the special approval of the AHJ.

2. “Positive alarm sequence” systems, on the other hand, are delayed alarms under specific controlled conditions that eventually default to a full general alarm. In a positive alarm sequence system, system activation must be acknowledged electronically by trained personnel at the control panel within 15 seconds of receiving the alarm, or the alarm system automatically and immediately goes into general evacuation alarm.

3. If the system activation is acknowledged within the first 15 seconds, the system goes into a “hold” mode for 180 seconds while the trained personnel investigate the source of the alarm. If the system is not reset during this 180-second period, or if another device detects fire conditions, all building alarm signals are sounded automatically and immediately.



H. Alarm verification.

1. With the alarm verification feature, once a detector goes into alarm, the FACU receives the signal and delays the alarm output, usually by de-energizing the detector. Then, after a period of time not exceeding 30 seconds, the detector is re-energized and it re-samples the atmosphere around it. If the detector has reset itself because the condition has cleared, the panel restores and acts as if nothing happened. If, within the next 30 seconds, the detector has not cleared, the panel interprets the signal as a fire condition and goes into alarm.

2. Alarm verification has been introduced into FACU technology to minimize the frequency of false fire alarms.

ZONING/ANNUNCIATION

Aids in rapid signal interpretation and response.

- Building area.
- Floors.
- Fire zones.
- Sprinklers.
- Air handling.
- Pressure loss.
- Pump running.

Slide 2-37

I. Zoning/Annunciation

1. In large or multistory buildings, fire alarm systems often are zoned to identify the area from which the alarm is initiated. Zoning enables the responding fire personnel to find the area from where the fire is reported more quickly. Zones may correspond to floors, fire separations, smoke barriers, fire walls or other subdivisions, or may be used to indicate related fire protection equipment, such as sprinkler water flow, fire pump status, or the actuation of a wet- or dry-chemical fire protection system.

2. Zones must be identified visually on the FACU or remote annunciator. “Addressable” fire alarm and detection systems do not employ traditional “zones.” In addressable systems, each detection device (heat or smoke detector), manual pull station, flow switch, supervisory switch or other fire alarm system component is provided a unique electronic “address” that the FACU can interpret and report.

ZONING RECOMMENDATIONS

- At least one zone per floor.
- If floor is greater than 20,000 square feet and subdivided, follow fire separations.
- If floor is greater than 20,000 square feet and **not** subdivided, consult with AHJ.

Slide 2-38

ZONING RECOMMENDATIONS (cont'd)

- For sprinkler or heating, ventilating, and air conditioning (HVAC), if serving multiple floors, areas greater than 20,000 square feet, or do not follow detection zones.
  - Individual waterflow and in-duct detectors.
- Zone should not exceed 300 feet in any dimension.
- If sprinklered, zones should follow layout.

Slide 2-39

J. Zoning recommendations.

V. FIRE ALARM INITIATION DEVICES

FIRE ALARM INITIATION DEVICES

- Automatic — respond to fire signatures.
  - Heat, rising or elevated temperatures.
  - Smoke, visible and invisible components.
  - Fire or industrial gas, presence.
  - IR or UV light, discriminated presence.
  - Visible light spectrum, light pattern changes.
  - Protection system activation, pressure/flow.
- Manual by a person seeing or smelling fire.

Slide 2-40

FIRE ALARM INITIATION DEVICES (cont'd)

- Pull stations.
- Heat detectors.
- Smoke detectors.
- Gas detectors.
- Flame detectors.
- Pressure detectors.
- Video detection.

Slide 2-41

A. Fire detection devices operate in a variety of ways. To simply say that a smoke detector activates when it senses smoke is an oversimplification of the operating principles for which it is designed.

B. Fire detection devices (smoke detectors, heat detectors, radiant energy detectors, gas detectors) are designed to detect changes in the atmosphere produced by changes resulting from a fire. These changes are known as “fire signatures,” and can be measured by various detection devices.

COVERAGE/INSTALLATION

NFPA 72 address four levels.

- Total.
- Partial.
- Selective.
- Supplementary (nonrequired).

Slide 2-42

C. Coverage/Installation.

TOTAL COVERAGE

- “If required,” **total coverage** means:
  - Rooms.
  - Halls, basements, closets.
  - Attics, lofts.
  - Above suspended ceilings.
  - Shafts, chutes.
- Exceptions for “inaccessible” areas.

Slide 2-43

1. Total coverage.

PARTIAL COVERAGE

Common areas and work spaces.

- Corridors.
- Lobbies.
- Storage and equipment rooms.
- "Tenantless" spaces.

Slide 2-44

2. Partial coverage.

SELECTIVE COVERAGE

As specified by other codes, standards, laws or AHJs.

Slide 2-45

3. Selective coverage.

SUPPLEMENTARY (NONREQUIRED)

Where installed, must still meet requirements of NFPA 72 **except** spacing.

Slide 2-46

4. Supplementary.

RESIDENTIAL SMOKE ALARM NOTE

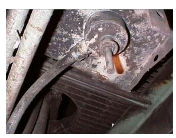
- If "system" smoke detectors are installed (i.e., as part of a security system), then **all** areas required to be protected by detection must be protected by smoke detectors connected to the system.
- Single station smoke alarms may remain as supplement.

Slide 2-47

5. Residential smoke alarm.

HEAT DETECTORS

- Fixed temperature.
- Combination rate of rise and fixed temperature.
- Rate of rise.
- Rate compensation.



Slide 2-48

D. Heat detectors.

1. Thermal detection devices operate on a variety of principles: fixed temperature, rate-of-rise, rate-of-rise/fixed temperature and rate compensated. Detectors may be either a spot-type (located in a single location, or "spot" on a ceiling or wall) or line-type (a continuous line or loop of wire that measures heat).

2. These are devices that change in some way when the temperature at the detector reaches its design operating point. Due to the fact that heat detectors respond to temperature increases and not to conditions that are immediately dangerous to life or health (IDLH), they are not considered to be a life safety device.

3. Heat detectors are manufactured to respond to a range of temperatures from 135 to 519 F (57 to 271 C). Ordinarily, heat detectors are intended for locations where the ceiling temperature normally is less than 100 F (38 C). The most commonly selected detectors operate in the 135 to 190 F (57 to 88 C) range, with higher temperature rated detectors used in special applications. Detection devices installed in atmospheres that normally are heated, such as in heat-generating industrial processes, may use higher operating temperature elements.

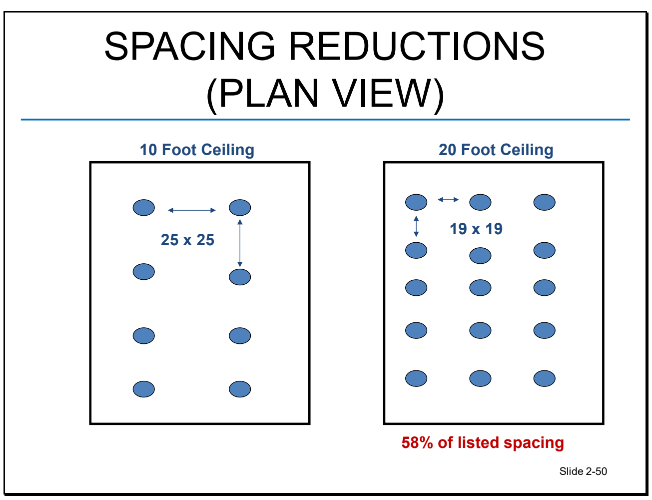
PLACEMENT STANDARDS: HEAT DETECTORS

- Heat detectors are not considered life safety devices — property protection device only.
- Used where smoke detectors are unsuitable.
- Use listed spacing.
  - Adjustments for ceiling height.

Slide 2-49

E. Placement standards: heat detectors.

Heat detectors are listed for specific spacing arrangements depending upon their performance during testing. Common spacing limitations include smooth ceiling areas of 15 feet by 15 feet, 25 feet by 25 feet, or 50 feet by 50 feet. These spacing requirements are based on a test ceiling height of 15 feet 9 inches and a room in which there is little air movement. NFPA 72 — as well as manufacturer's listing data — provides a table for adjusting spacing based on taller ceilings. Generally, for every increase in ceiling height, the spacing between detectors must be reduced.



PLACEMENT STANDARDS: HEAT DETECTORS (cont'd)

- Maximum ceiling temperature has to **be 20 F or more below** detector temperature rating.
- Temperature difference should be kept as small as possible.

Slide 2-51

TEMPERATURE RATINGS

Surface ring or label.

Rating	Range F	Ceiling Max. F	Color
Low	100 to 134	20 below ambient	Uncolored
Ordinary	135 to 174	100	Uncolored
Intermediate	17 to 249	150	White
High	250 to 324	225	Blue
Extra high	325 to 399	300	Red
Very extra high	400 to 499	375	Green
Ultra high	500 to 575	475	Orange

Slide 2-52

F. Temperature ratings.

1. Heat detectors should be selected so the rated temperature is as close as possible to the expected ambient ceiling temperature, but not so high that thermal lag results in a tragic consequence.

2. Generally, heat detectors that are installed are rated 20 degrees above the anticipated ambient temperature of the space. For example, if the expected ceiling temperature in a room is 135 F, a detector rated at 155 F (68 C) should be installed. This will accommodate temperature spikes in the room without causing the detector to operate.

FIXED TEMPERATURE: SPOT TYPE

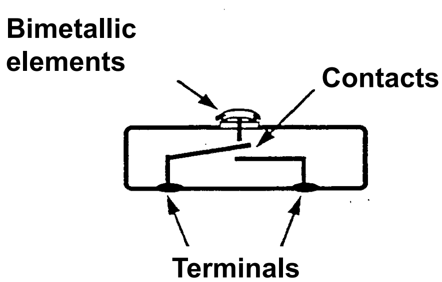
- Operate in range of **135** to **575** F.
- Operate when **sensing device reaches prescribed temperature.**
- Device is either **restorable** or **nonrestorable (disposable).**

Slide 2-53

G. Fixed temperature: spot type.

A fixed temperature heat detector is among the simplest operational principles and designs. They may be designed as “restorable” or “nonrestorable.” A nonrestorable detector is single use; once it has operated, it must be replaced.

FIXED TEMPERATURE: BIMETALLIC RESPONSE



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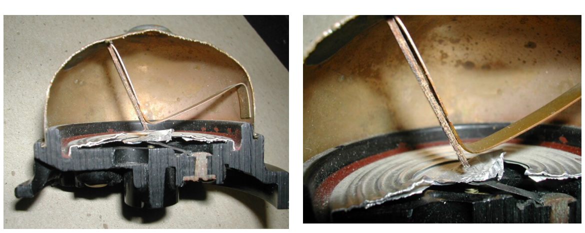
FIXED TEMPERATURE: BIMETALLIC RESPONSE (cont’d)



Slide 2-55

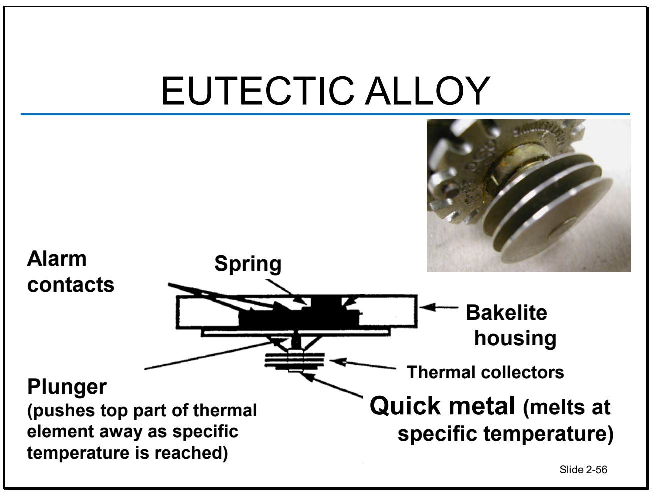
1. Bimetallic response.

   a. Restorable heat detectors commonly employ bimetallic strips: two metals with different thermal expansion rates that are bonded together.

   b. As heat causes the metals to expand at different rates, the bonded metallic strip bends.

   c. As the metallic strip bends, it closes a “normally open” circuit that sounds an alarm.

   d. When the ambient temperature drops, the metals cool and contract, restoring the circuit to its open status and silencing the alarm.

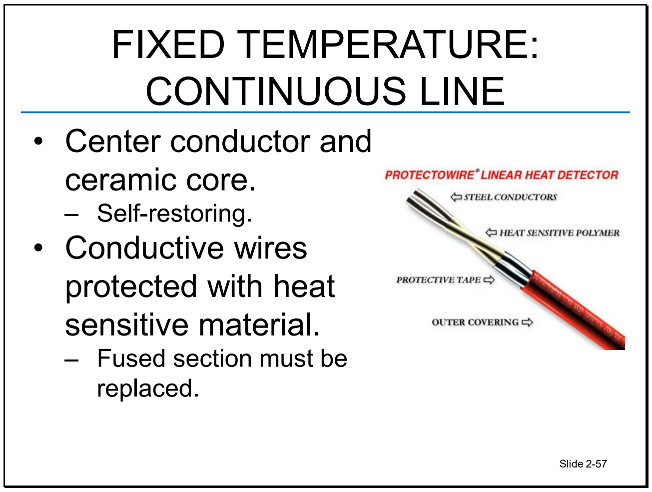


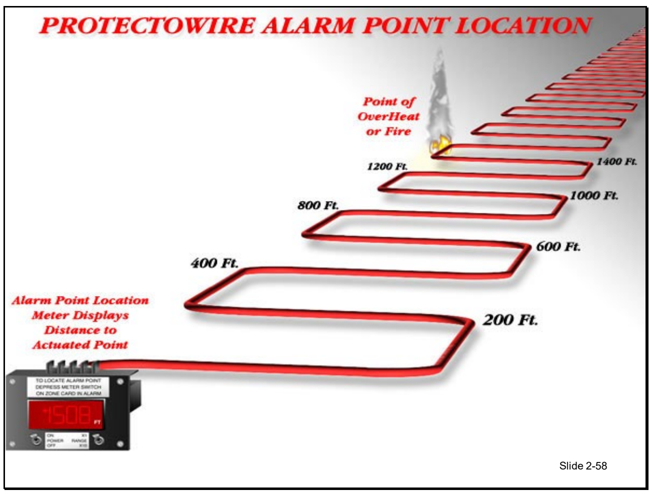
2. Eutectic alloy.

   a. A nonrestorable heat detector works when the air temperature around the device reaches its design temperature and the quick metal heat collector melts and gives way.

   b. The spring pressure within the device pushes the top portion of the thermal element away, allowing the electrical alarm contacts to close, thus closing the circuit that sounds the alarm.

   c. After the detector has been activated, either the detector or heat collector must be replaced to restore it to normal.





3. Continuous line.

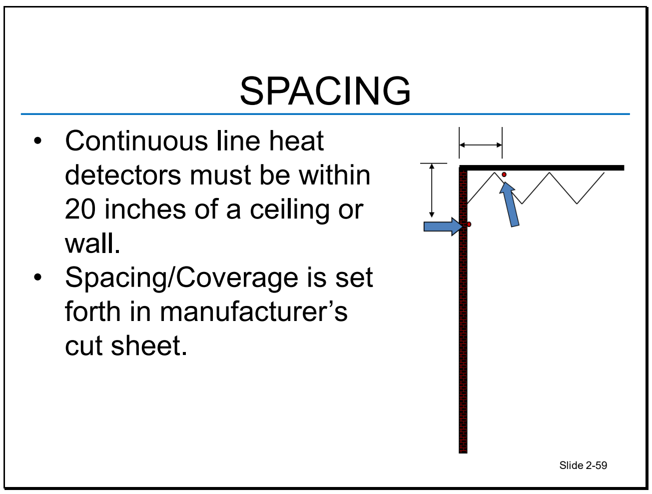
   a. Spot detectors — those that are installed on a specific ceiling location and protect an area of listed spacing — may not be suitable for all applications. For example, if an electric utility wanted detection in its cable trays, or a wood processor on its conveyor, or even a bulk flammable liquid storage operator around its tanks and valves, spot detectors would not be suitable.

   b. In those cases, and similar unique situations, a line-type heat detector may be an appropriate selection. Line-type detectors are installed in a looped, continuous configuration from the FACU, throughout the protected asset or premises, and back to the FACU.

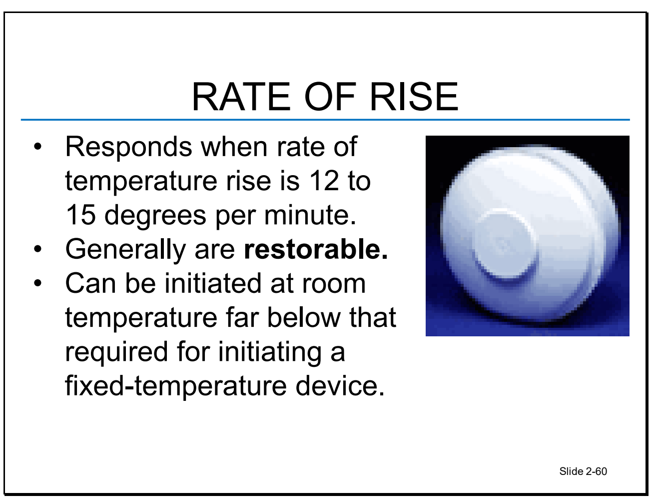
   c. There are two prominent styles of line-type heat detectors: coaxial conductor and paired wire.

- A coaxial conductor line detector uses a semiconductor material inside a stainless steel capillary tube. The tube contains a coaxial center conductor separated from the tube wall by a temperature-sensitive material. Under normal conditions, a small amount of electrical current — below the alarm threshold — flows through the line circuit. As the temperature rises, the electrical resistance of the temperature-sensitive material (called “thermistor”) decreases, and more current flows to initiate an alarm.

- The paired wire line-type detector consists of a parallel pair of steel wires wrapped in a braided-sheath outer cable. The two wires are separated by thermally sensitive insulating material that is manufactured to melt at a specific temperature.

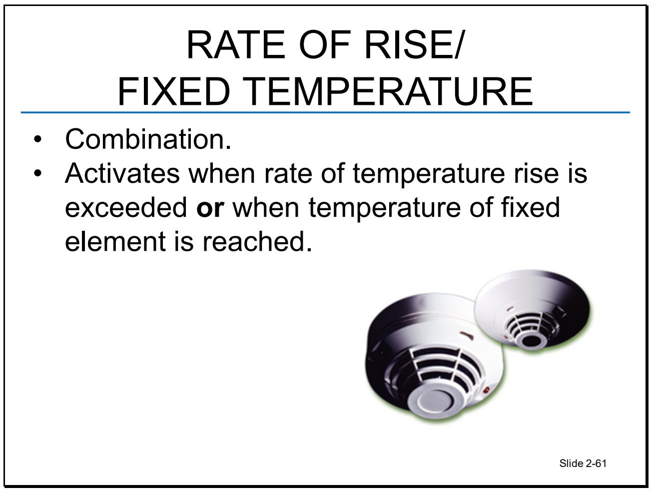


4. Spacing.



H. Rate of rise.

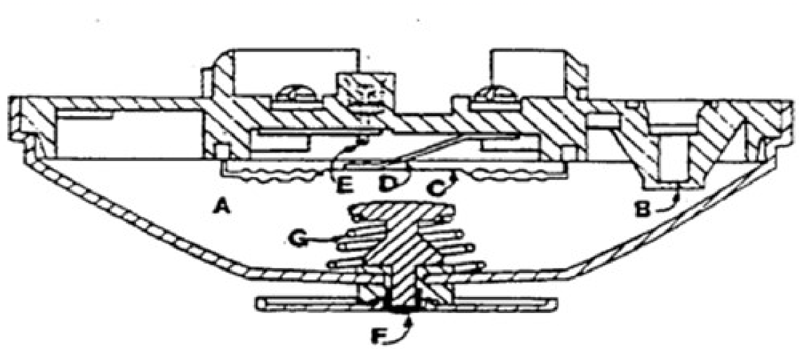
Rate-of-rise detectors are designed to detect temperature changes over a specific period of time, usually from 12 to 15 degrees per minute. If the temperature increases at a faster rate, the detector will sound.



I. Rate-of-rise and fixed-temperature detectors.

1. The combination rate-of-rise and fixed-temperature detectors employ the features of both detection styles. Either a rapid temperature increase or the air temperature reaching the predetermined set point, or both, will cause an alarm to occur.

Diagram of internal components of a rate-of-rise detector



2. In the example above, for rate-of-rise operation:

   a. Air in the chamber [**A**] expands more rapidly than it can escape from the compensated vent [**B**].

   b. This pressure increase causes the diaphragm [**C**] to be displaced toward the electrical contact [**D**], which closes the circuit at [**E**] and sounds an alarm.

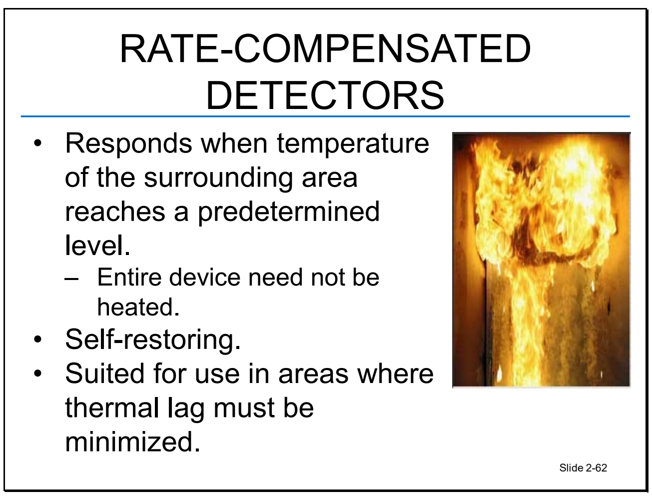
   c. The rate-of-rise feature will restore itself automatically when the temperature returns to normal.

3. For fixed-temperature operation:

   a. Heat causes the fusible alloy [**F**] to melt.

   b. The spring [**G**] is released, which depresses the diaphragm [**C**] against the electrical contact [**D**].

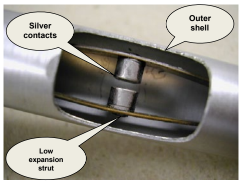
   c. When the fusible alloy has melted, the entire detector must be replaced.

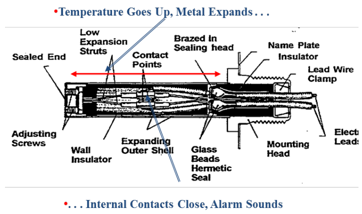


J. Rate-compensated detectors.

1. A rate-compensated detector operates when the ambient air temperature reaches a predetermined level, regardless of the rate at which it increases. The detector will operate at its design temperature during slow-building fire conditions, or will respond promptly during rapid fire build-up.

RATE COMPENSATED DETECTORS (cont'd)





Slide 2-63

2. A rate-compensated detector relies on the physical property that metals expand when heated. Rate-compensated detectors have typical temperature ratings between 133 and 220 F (56 and 104 C).

K. Smoke sensing detectors.

SELECTION CRITERIA

Refer to listing documents for application.

- Open area protection (OAP).
- Releasing service (RS).
- Combination (OAP/RS)
- Duct detector (sampling tube).
- Duct detector (internal).

Slide 2-64

1. Selection criteria.

   a. Open area protection (OAP).

   b. Releasing service (RS).

   c. Combination (OAP/RS).

   d. Duct detector (sampling tube).

   e. Duct detector (internal).

SPACING CONSIDERATIONS

- Ceiling shape and surface.
- Ceiling height.
- Room contents configuration.
- Contents' combustibility.
- Ventilation/Air flow.
- Ambient environment.

Slide 2-65

2. Spacing considerations.

   a. Ceiling shape and surface.

   b. Ceiling height.

   c. Room contents configuration.

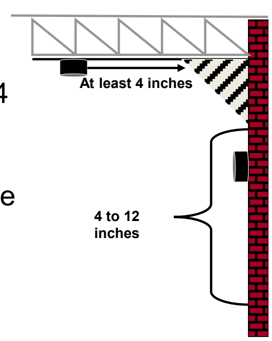
   d. Contents' combustibility.

   e. Ventilation/Air flow.

   f. Ambient environment.

DETECTOR PLACEMENT

- **Ceiling mounted:** as close to center of area as possible, or at least 4 inches from the wall or corner.
- **Wall mounted:** top edge of detector between 4 inches and 12 inches below ceiling line.



Slide 2-66

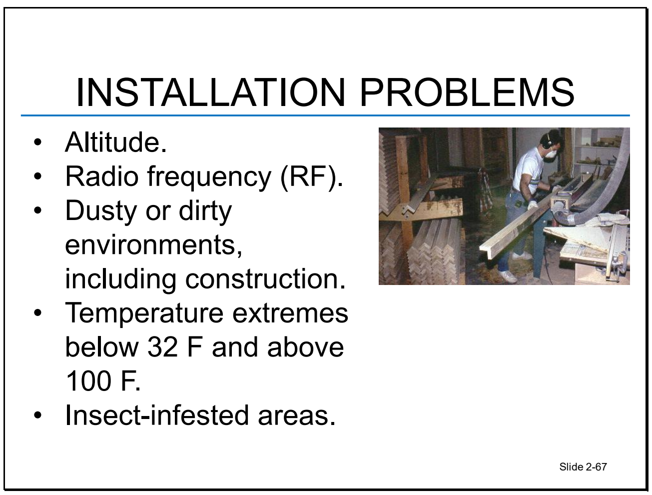
3. Detector placement.

VI. SMOKE SENSING DETECTORS

A. In the United States, studies and fire death statistics prove smoke and its toxic constituents are the leading killers in fires.

B. The advent of residential smoke detectors probably has been the single greatest factor leading to a reduction in fire deaths in America during the past 30 years. Simple devices that can alert occupants to life-threatening conditions and notify them to take appropriate life-saving action have reduced fire deaths and related injuries by more than 50% in less than a generation.

C. Smoke detection devices are identified by their operating principle. The two most common principles are ionization and photoelectric. Ionization detectors normally are spot-type, but photoelectric may be spot- or beam-type. There are detectors that employ both ionization and photoelectric principles. Two other, less common operating principles are the “cloud chamber” and the “air sampling” smoke detector assemblies. Some smoke detectors are manufactured with an integral heat detection element.



D. Installation problems.

SMOKE SENSORS: DETECTION PRINCIPLES

- Ionization.
- Photoelectric.
- Combined in some devices.

Slide 2-68

E. Smoke sensors: detection principles.

1. Ionization.
2. Photoelectric.
3. Combined in some devices.

SENSITIVITY

- Permanently marked.
- Adjustable.
  - Manually.
  - Computer software.

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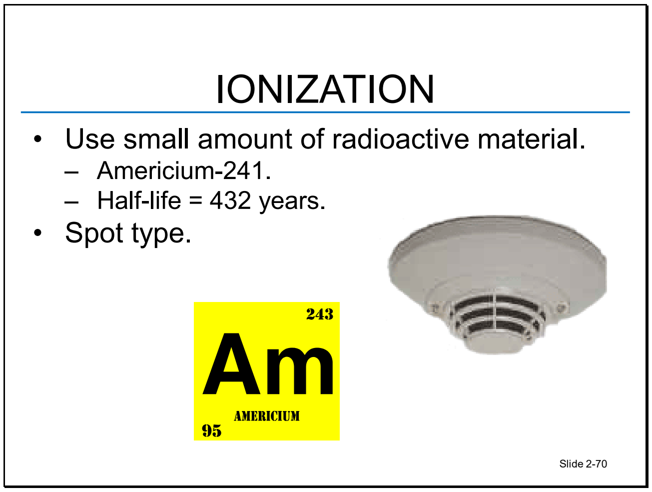
F. Sensitivity.

1. In order to receive listings in the Underwriters Laboratories (UL) fire protection equipment directory, smoke detectors must successfully pass the test criteria established in UL 268, *Smoke Detectors for Fire Alarm Systems*, for open area and releasing service detectors, and UL 268A, *Standard for Smoke Detectors for Duct Application*.

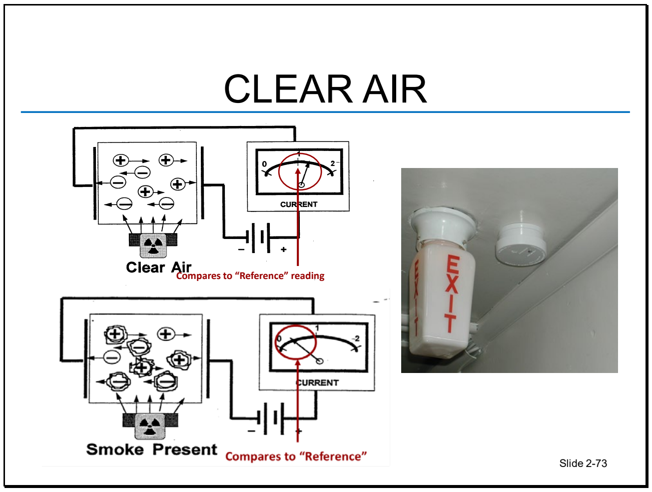
2. UL 268 requires that all smoke detectors be provided with a means of measuring detector sensitivity or a built-in sensitivity test feature. Smoke detectors must operate at a simulated smoke level of not more than 6% in ambient air. Most manufacturers exceed this standard by designing their equipment to operate between 0.5% and 3% in ambient air.



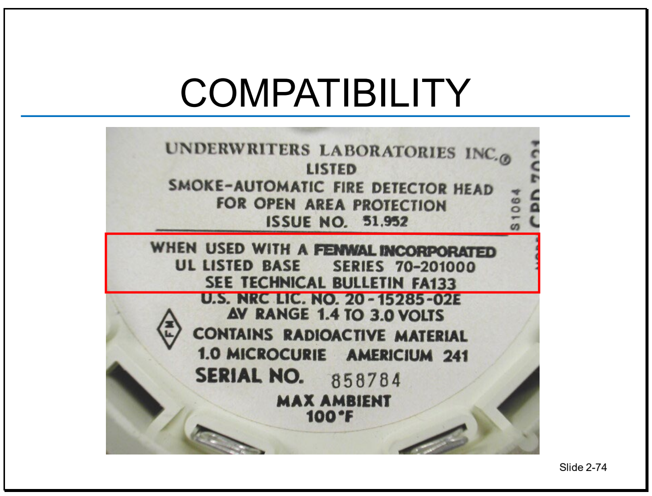
G. Ionization.

1. Ionization detectors are very sensitive to fast-burning fires or any condition where microscopic particles are in the air.

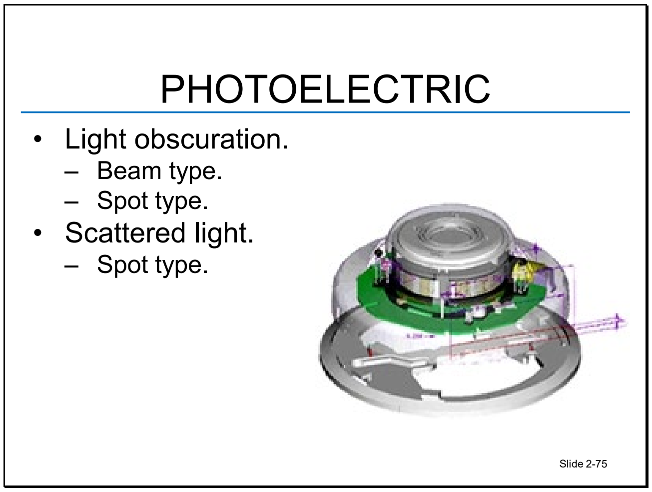
2. Ionization detectors have a small amount of a radioactive emitter in their smoke sensing chamber. The radioactive source ionizes the air in the sensing chamber, allowing the air to conduct electricity. This current flow is measured within specific limits. The detector also has a "reference" chamber where clear air is maintained for comparison.



3. Clear air.



4. Compatibility.



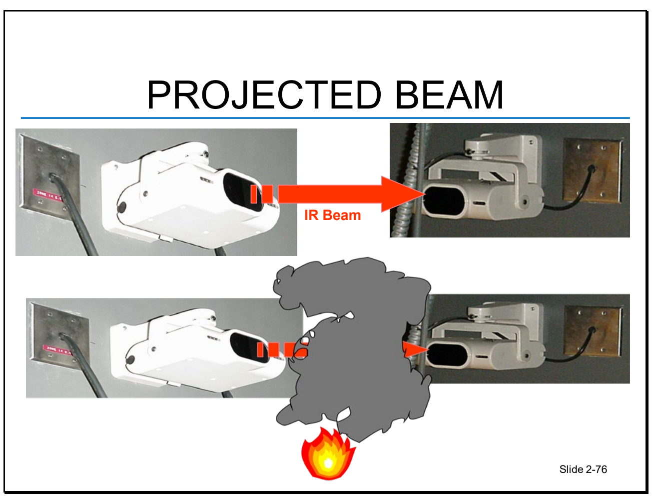
H. Photoelectric.

1. Smoke is an aerosol consisting of water vapor, gases and particulate matter. Normally — except in controlled, laboratory conditions — combustion is incomplete and the particulate concentration is easily visible to the naked eye.

2. Photoelectric principle smoke detectors take advantage of this visible spectrum by detecting fires in one of two ways:

   a. Light obscuration: where a beam of light is blocked by the density of the smoke.

   b. Light scattering: where the light beam is refracted or scattered onto a photosensitive device such as a photodiode or phototransistor.

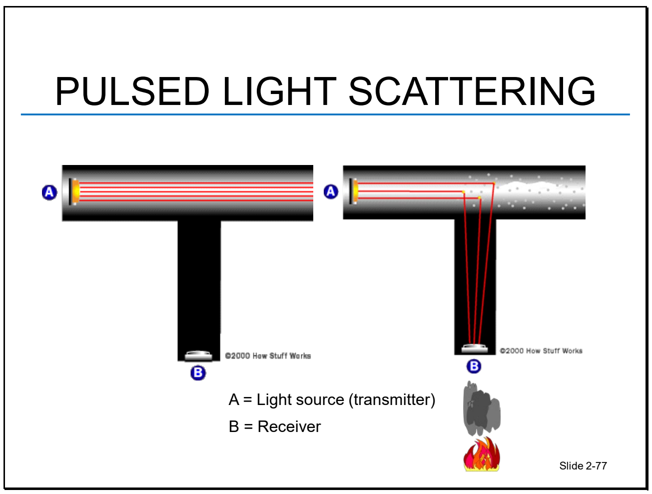


3. Projected beam.

a. Projected beam detectors operate on the light obscuration principle and use a sender and receiver. In some applications, mirrors may be installed to redirect the light beam where it is needed. If mirrors are used, the mirrored surface will absorb some light, so the range of the projected beam system may be reduced.

b. The manufacturer's literature will provide instructions for projector and receiver spacing so the length and width of the area to be protected is covered adequately. Beam detectors also require special testing techniques to ensure they are operating properly.

c. Open area projected beam detectors are calibrated so that if the beam is obscured entirely — such as by stored boxes or permanent decorations — the receiver will recognize and transmit a "trouble" condition, not a fire alarm. This response is based on the concept that, in the early stages of a fire, smoke is never truly opaque — like a permanent obstruction — but will begin with some amount of obscuration before it reaches total darkness.



4. Pulsed light scattering.

a. Light scattering principle smoke detectors project a pulsing beam of light on a reflective surface. The light source and light receiving sensor generally occur on the same side of the detection chamber.

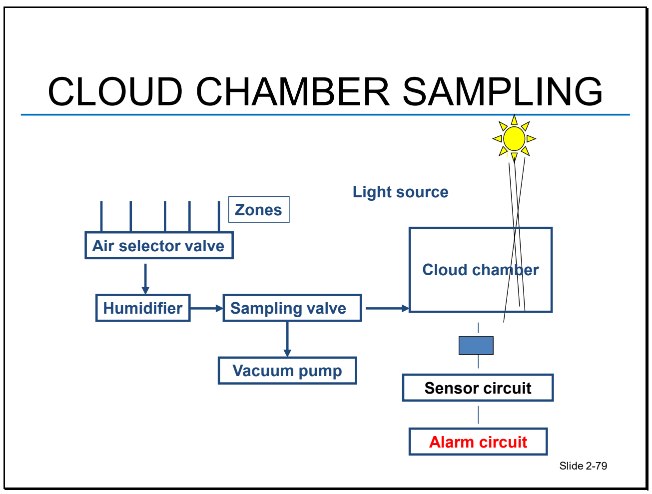
b. When smoke enters the chamber, the light from the source is reflected off the smoke particles and is sensed by the light target. The "connection" of light from the source to the target completes a circuit and the detector goes into alarm. When the smoke particles have cleared, the detector will reset.

AIR SAMPLING

- Used in areas of high air flow or high value.
- **Cloud Chamber.**
- **Aspirating-type air sampling** tubes connected to a control unit.
  - Uses a photoelectric detector in control unit.
- **V**ery **E**arly **S**moke **D**etection **A**ppliance (VESDA).
- Maximum air sample transport time = 120 seconds.

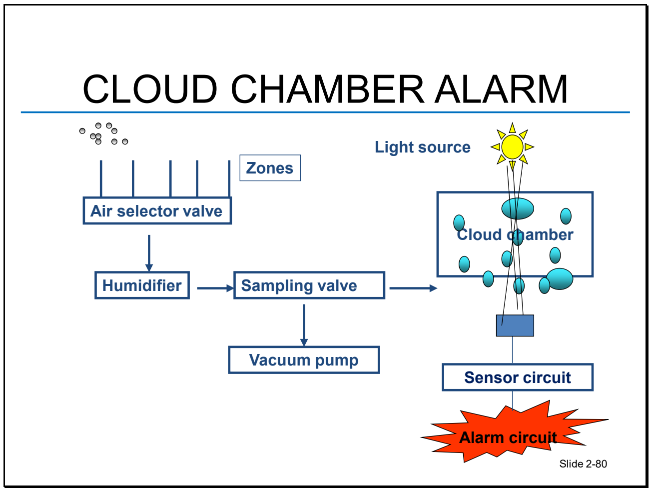
Slide 2-78

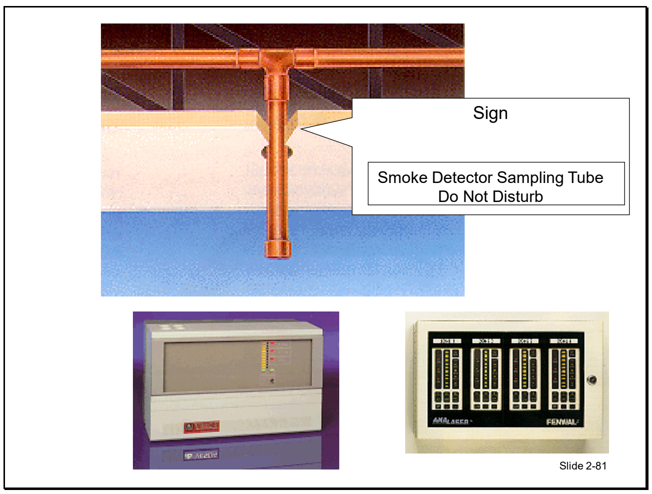
5. Air sampling.



a. Cloud chamber (sampling).

- A cloud chamber smoke detection apparatus is employed where early detection of changing conditions is critical. In a cloud chamber detector, the concentration of submicroscopic particles in the atmosphere is measured by the detection apparatus.





b. Cloud chamber (alarm).

- The air sample then passes through a chamber where the pressure is reduced with a vacuum pump, causing water condensation on the particles. The particles, once they adhere to the water vapor, quickly grow to a visible size. A light beam is passed through the droplets and measured on the other side of the chamber. As the smoke particles increase, more droplets are formed, causing the detector to actuate an alarm.

- For high-value properties, or where air velocities in open areas are a problem, optical air monitoring devices can be arranged to detect fires in their earliest stages.

- Marketed under the acronym **V**ery **E**arly **S**moke **D**etection **A**ppliance (VESDA), this equipment is similar to the cloud chamber detection principle:

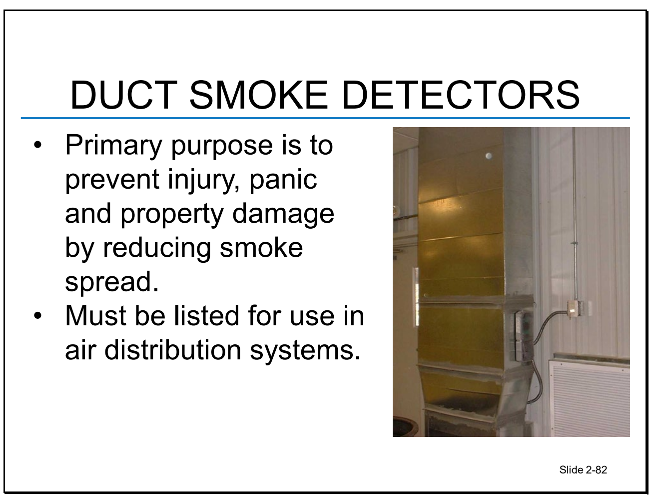
  -- Air from an enclosed space is drawn by an air-aspirating fan into a detection chamber.

  -- The air samples, and any particulates, are illuminated by a high-intensity strobe light which causes the light to reflect onto a highly sensitive solid-state photo-receiver.

  -- The photo-receiver generates an electronic signal that displays the amount of smoke obscuration sensitivity.

  -- If the sensitivity exceeds a predetermined, prescribed limit, an alarm is sounded.

- VESDA's advantages include the ability to establish the sensitivity settings for incipient fires, and the fact that the detection equipment can cover large areas ranging up to 20,000 square feet per detector by using sampling tubing installed in the protected area.



I. Duct smoke detectors.

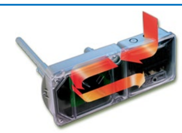
1. Smoke detection is installed in heating, ventilating, and air conditioning (HVAC) ducts to prevent smoke from migrating via a structure's air handling system. Generally, those air handling systems where the return air volume equals or exceeds 2,000 cubic feet per minute (cfm) require smoke detector shutdown, but the local mechanical code or NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*, should be checked for specific requirements.

2. NFPA 72 recommends the use of open area detectors for smoke control in buildings because of the chances of smoke in HVAC systems being diluted. However, if duct detection is chosen as an option, it must follow these guidelines.

3. Duct detection devices should not be substituted for OAP because smoke from open areas may not be drawn into the HVAC system when the air handling equipment is shut down for repair, maintenance, or if it is simply not being used. Detectors may be ionization type, photoelectric or both.

DUCT SMOKE DETECTORS (cont'd)

- In-duct pendant type.
  - Must be listed for application.
- Sampling tube type.
- All must be installed in accordance with manufacturer's listing.



Slide 2-83

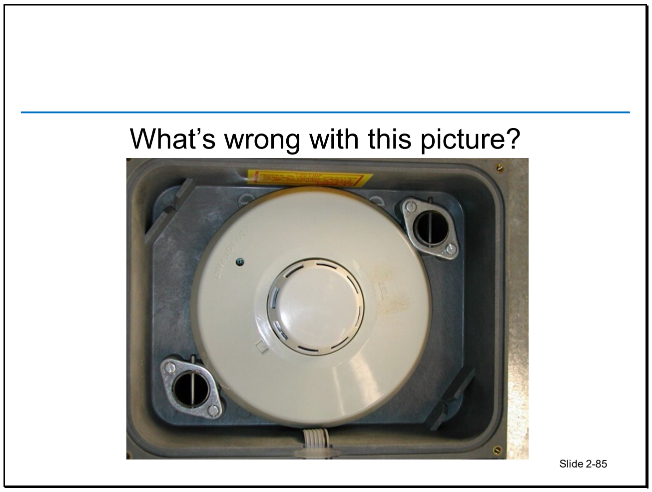
4. There are two primary methods of detector mounting: locating the detector inside the duct, or mounting the detector in a housing on the duct's exterior with its sensing element, sampling tubes or projected beam inserted into the air stream. In-duct installations must be accompanied by a service access panel so a technician can inspect, calibrate and repair the smoke detector.

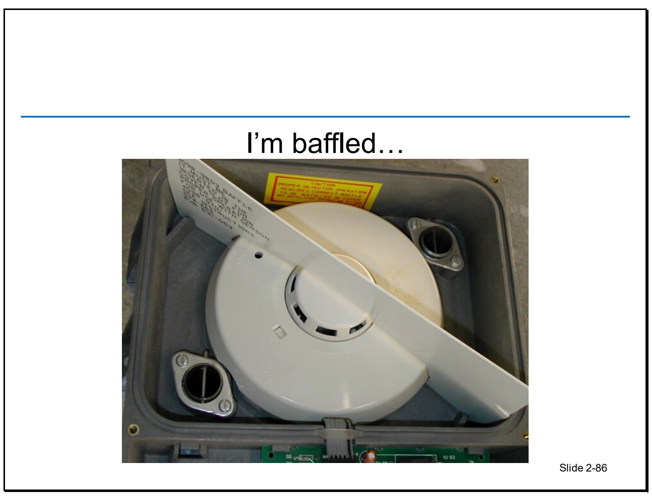
DUCT SMOKE DETECTOR STYLES

- Rigid mounted in the duct.
- Mounted to the wall of the duct with the sensing element protruding into the duct.
- Installed outside the duct with rigidly mounted sampling tubes protruding into the duct.
- Projected light beam in the duct.

Slide 2-84

5. Detectors must be listed specifically for use in air handling systems, and be compatible with the air velocity (in feet per minute) through the HVAC system. The range of acceptable velocities for a duct detector can be found on its manufacturer's specification sheet (catalog cut sheet) or in the UL fire protection equipment directory. In all cases, the manufacturer's installation and testing instructions must be followed.





DUCT SMOKE DETECTORS (cont'd)

- Sampling tube placement.
- Testing requirements.
  - Air flow.
  - Manometer.
- Remote indicator if in duct more than 10 feet above finished floor (AFF).

Slide 2-87

6. Air flow is measured with a manometer. The HVAC technician who installed the air handling system should have this device to "balance" the building's air delivery system. The fire alarm installer and HVAC contractor may have to coordinate their installations so the fire inspector can witness proper tests.

HEATING, VENTILATING, AND AIR CONDITIONING SHUTDOWN

- Check your locally adopted mechanical code.
- The International Mechanical Code (IMC) allows for elimination of duct detectors when unit cannot spread smoke to another compartment (i.e., rooftop unit in big-box store).
- Generally:
  - Two thousand cubic feet per minute (cfm) on supply.
  - More than 15,000 cfm on return.

Slide 2-88

J. HVAC shutdown.

FLAME DETECTORS

- UV flame detection.
- IR flame detection.

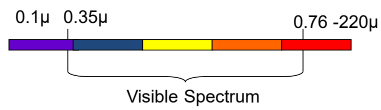


Photo Courtesy of Guilford, NC Technical Community College

Slide 2-89

K. Flame detectors.

1. Often, it is essential that automatic fire detectors be located outdoors where traditional smoke or heat detectors may be ineffective, or detection must occur before a fire erupts into flaming combustion. In those circumstances, flame detectors may be the best choice.

2. Flame detectors often are employed in explosion suppression systems, for operating water spray systems, or for detecting fires in and around bulk flammable liquid storage facilities.

Spectrum Wavelength Ranges

Range	Wavelength
Ultraviolet	0.1 to 0.35
Visible	0.36 to 0.75
Infrared	0.76 to 220

Note: 1.0 micron = 1000 nanometers (nM) = 10,000 Angstroms (Å)

SPACING CONSIDERATIONS

- Fire size to be detected.
- Fuel type.
- Detector sensitivity.
- Detector field of view.
- Distance from detector to hazard.

Slide 2-90

3. Spacing considerations.

   a. Fire size to be detected.

   b. Fuel type.

   c. Detector sensitivity.

   d. Detector field of view.

   e. Distance from detector to hazard.

SPACING CONSIDERATIONS (cont'd)

- Radiant energy absorption by atmosphere.
- Extraneous emission sources.
- Detection system purpose.
- Required response time.

Slide 2-91

   f. Radiant energy absorption by atmosphere.

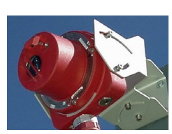
   g. Extraneous emission sources.

   h. Detection system purpose.

   i. Required response time.

RADIANT ENERGY

- Respond to flame or flicker.
- Filters minimize unwanted alarms from sunlight.
- IR will **not** detect alcohol, liquefied petroleum gas (LPG), hydrogen or magnesium type fires.
- Work best in low light areas.



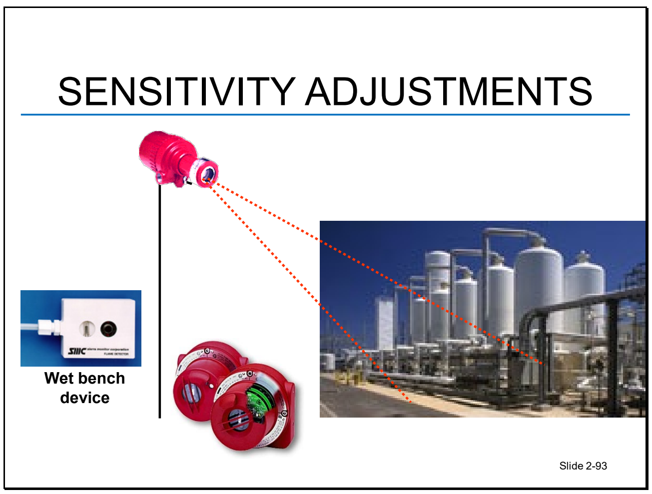
Slide 2-92

4. Radiant energy.

   a. Infrared (IR) flame detectors can respond to the total IR component of the flame or to a combination of IR energy and the flame flicker of a specific frequency.

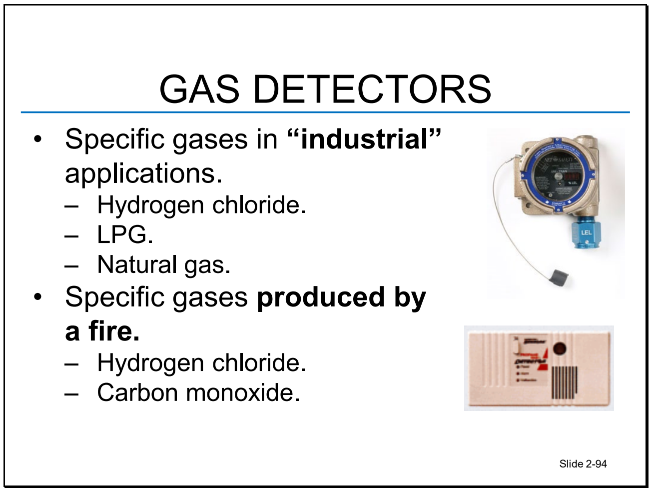
   b. Filtering systems and/or solar sensing circuits are used to minimize unwanted alarms from sunlight. IR detectors also are susceptible to false alarms from IR drying lamps, matches, cigarette lighters and other sources of IR radiation.

   c. IR detectors are limited in some of their applications because they will not detect fires involving alcohol, liquefied petroleum gas (LPG), hydrogen or magnesium.



5. Sensitivity adjustments.

   The IR detector's sensitivity varies depending upon the relationship of the energy source to the detector's viewing angle. At a 45-degree angle from the center line of the detector, the sensitivity drops to about 60% of its effectiveness. Likewise, as the distance increases, the effectiveness decreases.

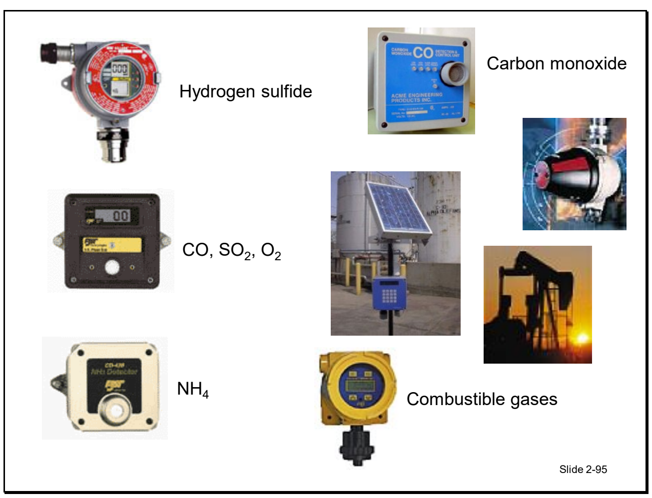


L. Gas detectors.

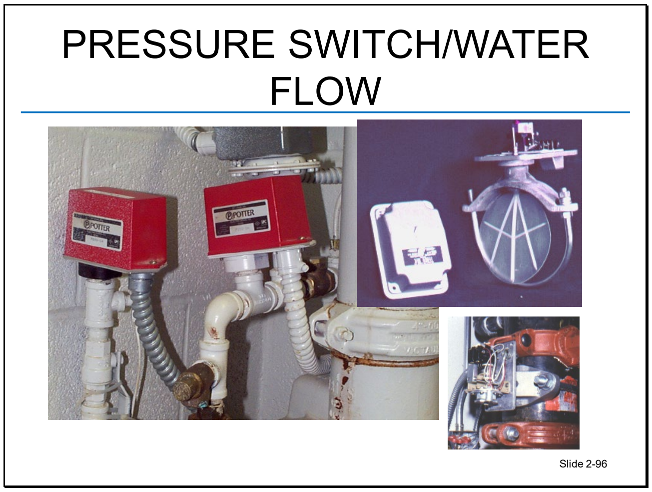
1. Gas detectors may be employed to detect either fire gases or so-called industrial or process gases.

2. During combustion, higher than normal levels of carbon monoxide, carbon dioxide (CO_2), hydrogen chloride, hydrogen fluoride, hydrogen sulfide and hydrogen cyanide may be produced. These gases may be sensed by special detectors designed and manufactured specifically for them.

3. Likewise, process gases (butane, propane, heptane, silane, chlorine, etc.) may be used in an industrial application where early detection of a leak is essential to life safety or property protection.

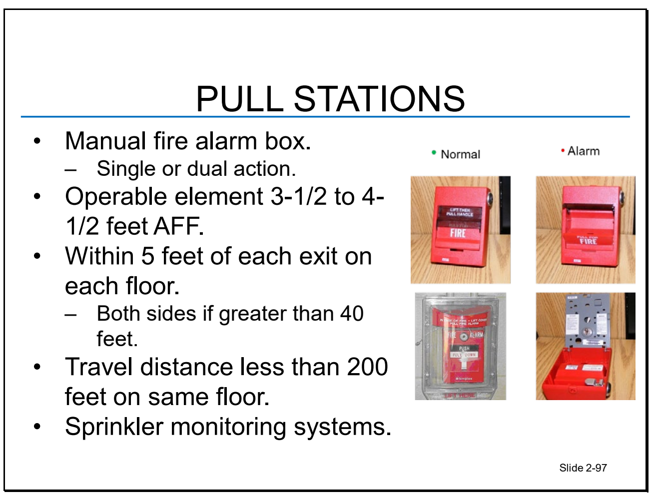


4. Examples of gas detectors.



M. Pressure switch/water flow.

Water flow and pressure switches are types of automatic fire detectors. When a fire sprinkler system operates, the water flow through the pipes, or the pressure increase on the water within the retard chamber, closes an electronic circuit that is connected to the FACU and is reported as an emergency.



N. Pull stations.

1. Although they are not automatic and require human intervention to operate them, manual fire alarm boxes (pull stations) may be considered a fire detection device.

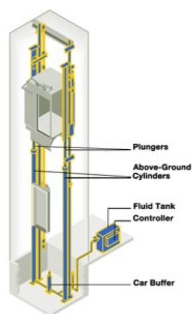
2. A single-action station requires only one motion to operate it. A dual action requires two motions, usually opening a door to access a lever or handle. The internal lever is pulled to operate the alarm.

3. Manual fire alarm boxes should be placed in normal paths of egress, adjacent to each exit door from each floor level. In large buildings, additional boxes should be provided so the maximum travel distance to the nearest fire alarm box is 200 feet.

4. Some fire codes allow the omission of manual fire alarm boxes when the building is outfitted with a complete automatic fire sprinkler system that is supervised off-premises. However, NFPA 72 requires that in any fire alarm system that employs automatic fire detectors or waterflow switches, there must be at least one manual pull station that can be used to operate the fire alarm system in case the other devices are out of service.

ELEVATOR RECALL

- Dedicated fire alarm control circuits are required for elevator recall.
  - They must be supervised and have primary as well as secondary power supplies.



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ELEVATOR RECALL (cont'd)

- Elevator recall must be initiated by smoke detection.
  - Lobby of each floor.
  - Elevator machine room.
  - Hoistway if sprinkler protected (may use heat detector because of nuisance alarms).
- Machine room and hoistway separate zone.

Slide 2-99

O. Elevator recall.

ADDITIONAL NOTES

- AHJ is permitted to require elevator recall by activation of the general fire alarm.
- Heat detectors are permitted in elevator lobbies when conditions are not suitable for smoke detectors.

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Additional notes.

DOOR HOLD-OPEN RELEASE

- Doors that are required to be normally closed can be held open with listed and approved automatic releasing means.
  - Fire doors.
    - -- Located in fire walls, exit enclosures, vertical openings, stair towers.
  - Smoke doors.
    - -- Located in smoke separations.

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P. Door hold-open release.

DOOR HOLD-OPEN RELEASE (cont'd)

- Smoke detection must be provided in the vicinity of the door(s).
- Although **not** required, it is recommended when smoke detectors are installed for door release purposes only, they connect to FACU and activate notification appliances.

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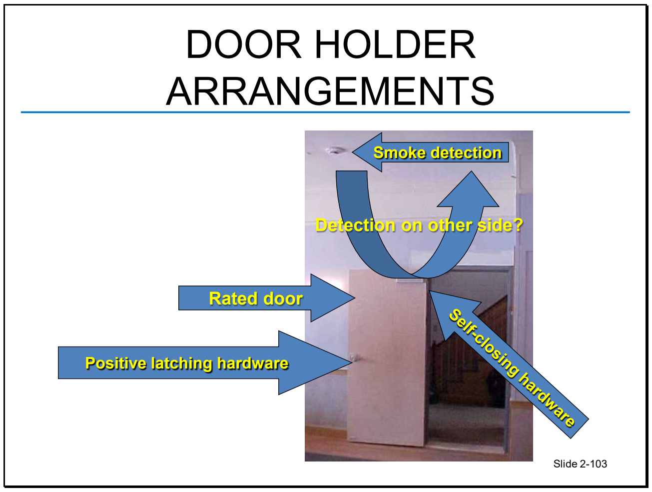
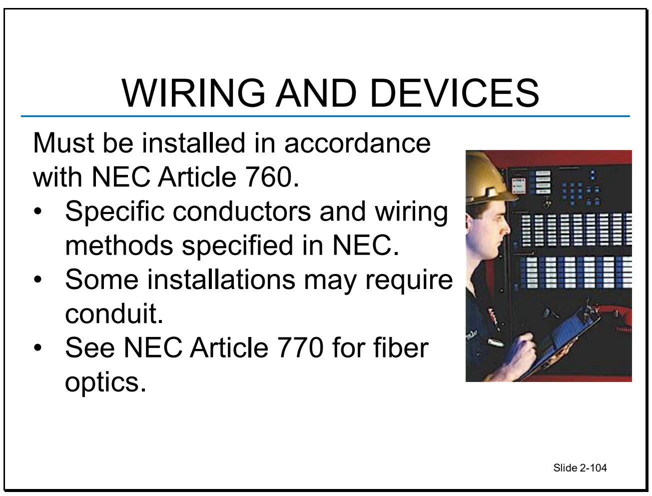
1. Proper use and installation.



2. Door holder arrangements.

VII. FIRE ALARM SYSTEM WIRING

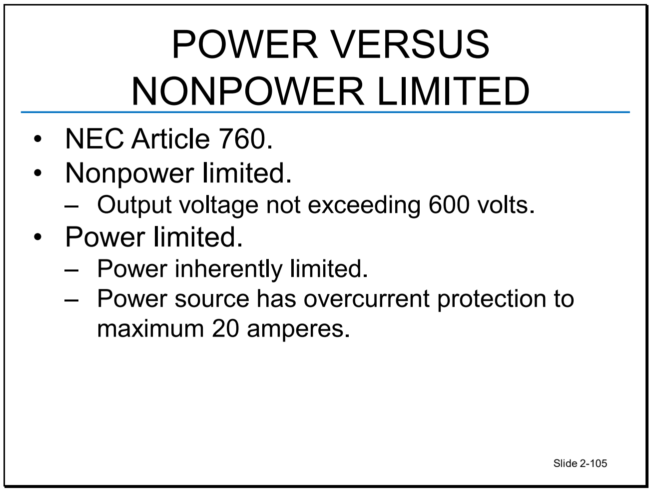


A. Wiring and devices.

1. While NFPA 72 establishes standards for the design, installation and maintenance of fire detection and alarm systems, it is NFPA 70 that prescribes the rules for fire protective signaling system point-to-point wiring. NEC Article 760 provides detailed requirements for wire types permitted in fire alarm systems.

2. NEC Article 760 applies to all the wiring between the “load side of the overcurrent device (circuit breaker) or the power-limited supply (battery) and the connected equipment” (2017).

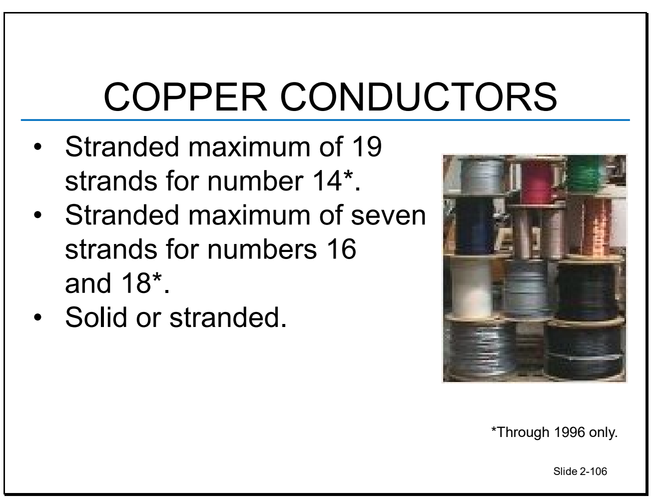
3. NEC Article 770 provides rules for optical fiber cables that may be used in fire alarm service.



B. Power versus non-power limited.

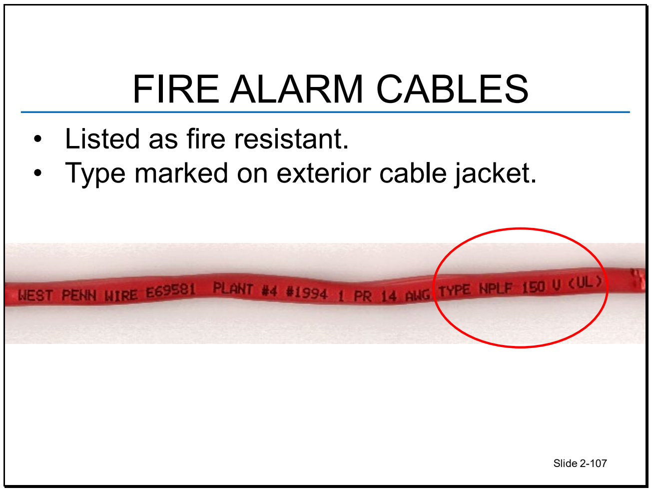
1. Non-power-limited fire alarm (NPLFA) circuits cannot operate at more than 600 volts, and there is no other power or current limitation for these systems. Usually these are used in 120-volt alternating current (AC) systems which generally have been rendered obsolete by the advent of low-voltage, direct current (DC) systems.

2. A power-limited fire alarm circuit (PLFA) is one that is inherently unable to exceed maximum voltages, or is equipped with a power-limiting source (transformer or battery) and a circuit breaker. Generally, these operate in the 24-volt DC range, although they may employ higher voltages.

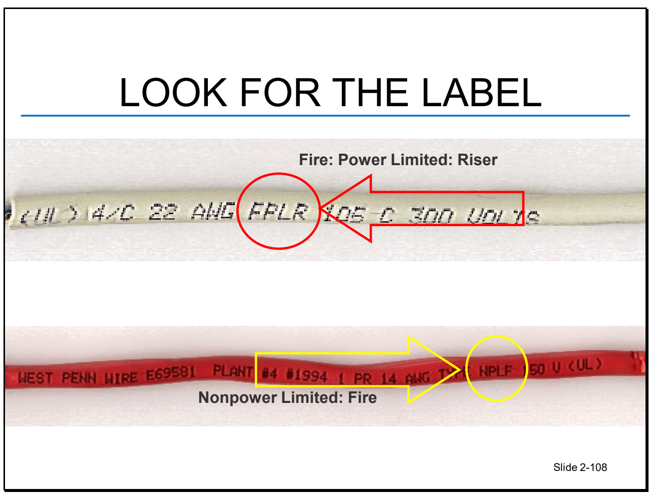


C. Copper conductors.

Only copper wires may be used as conductors on fire alarm circuits, unless they are approved photo-optical cables regulated under NEC Article 770. The wires must be solid or bunch-tinned (bonded) stranded copper, unless they comply with the table on the following page.

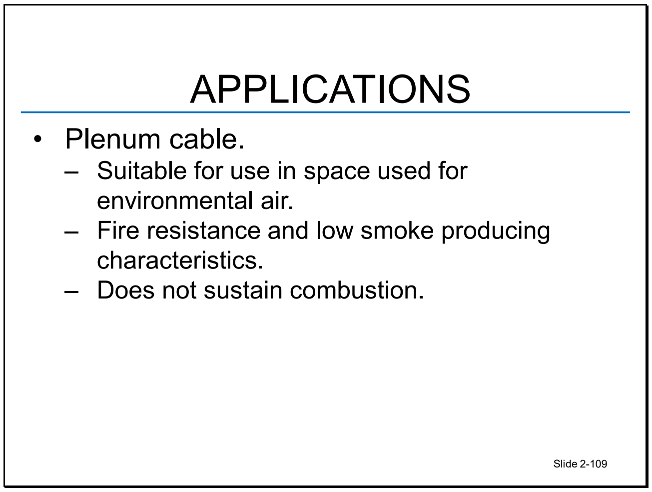


D. Fire alarm cables.



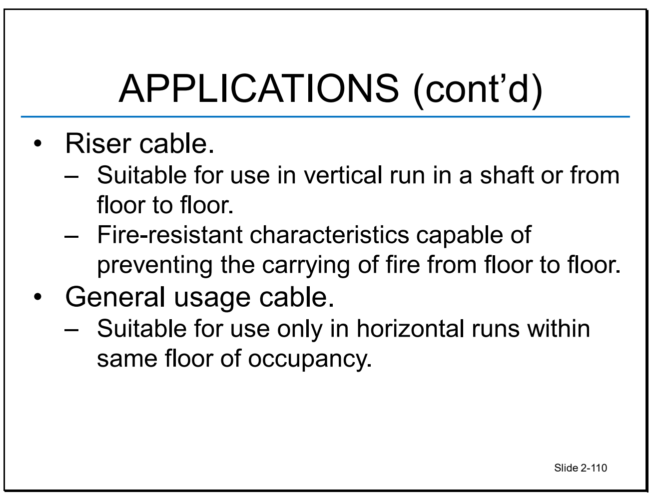
The outer jacket (sheathing) of a listed fire alarm cable must be labeled with one of the following marks:

Label	Type
NPLFP	Non-power-limited fire protective signaling circuit **plenum** cable
NPLFR	Non-power-limited fire protective signaling circuit **riser** cable
NPLF	Non-power-limited fire protective signaling circuit **(general usage)**
FPLP	Power-limited fire protective signaling circuit **plenum** cable
FPLR	Power-limited fire protective signaling circuit **riser** cable
FPL	Power-limited fire protective signaling circuit **(general usage)**



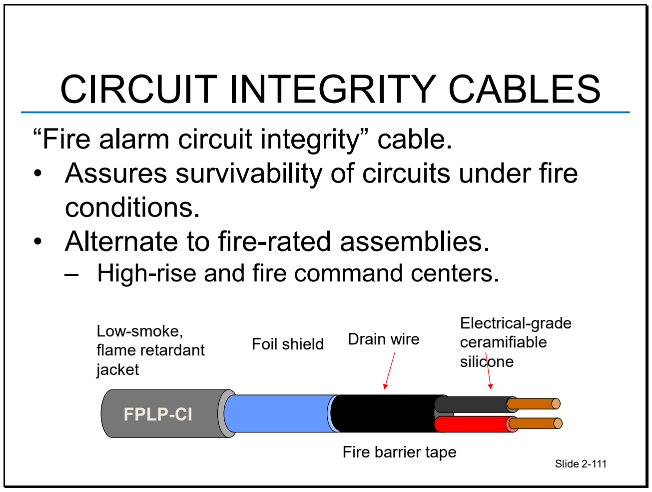
E. Applications.

1. **Plenum cable** is listed for use in above-ceiling spaces where the space acts as the environmental air-handling system and no HVAC ducts are used. The exterior sheathing of plenum cable, if ignited, does not sustain combustion nor give off substantial amounts of smoke.



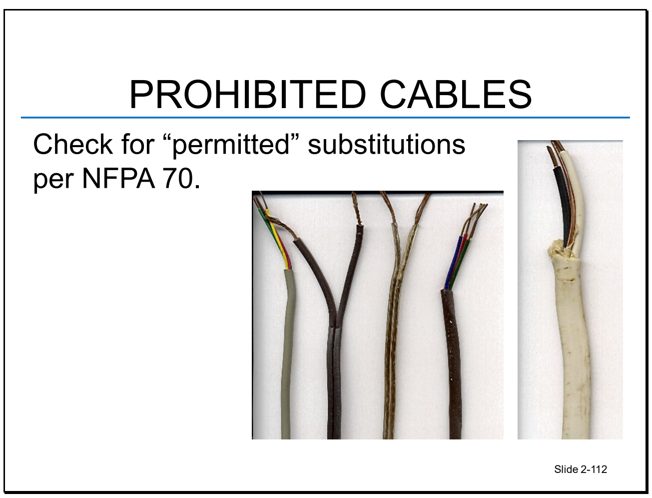
2. **Riser cable** is listed for use in vertical runs of wiring from floor to floor. The outer cover of riser cable, if ignited, does not allow flame to travel vertically.

3. General usage cable can be employed only in horizontal wire runs within the same floor level of an occupancy. The outer sheathing must be fire resistant.

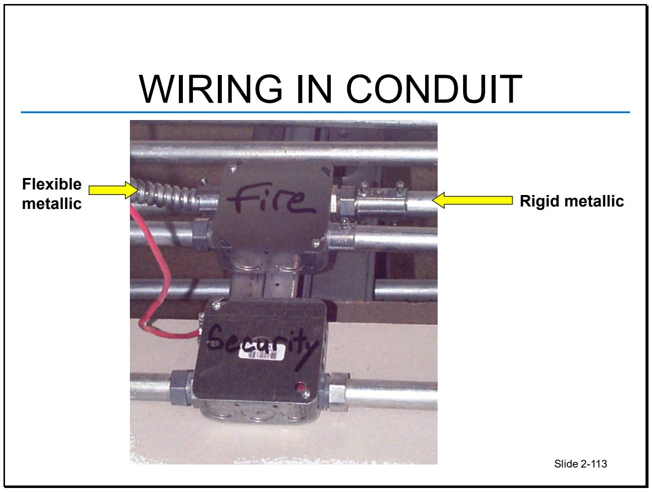


F. Circuit integrity cables.

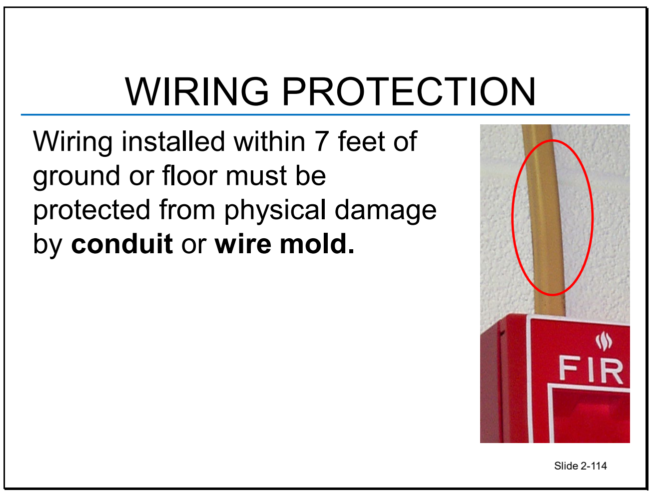
The 1999 edition of the NEC introduced another category for both non-power-limited and power-limited conductors: “fire alarm circuit integrity cable.” These cables are designed to ensure the survivability of critical circuits for a specified time under fire conditions, much like the fire resistance ratings of wall assemblies. Cables meeting this listing requirement include the letters CI at the end of the marking on their outer jackets, i.e., FPLP-CI.



1. Prohibited cables.



2. Wiring in conduit.

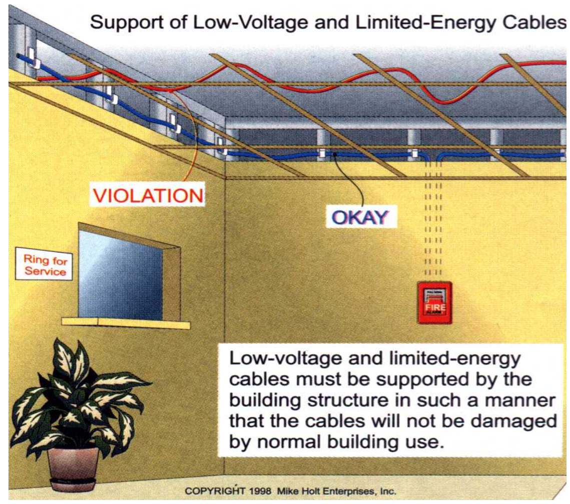


3. Wiring protection.

Fire alarm circuit wires must be installed in raceway (conduit), “fished” through the concealed spaces, or may be mounted exposed on ceilings or walls. Any portion of the fire alarm circuit wire within 7 feet of the floor must be protected from physical damage. Often this is accomplished by installing the wire in conduit or protecting it with wire molding. If the wire is installed in an elevator hoistway, it must be in conduit.

GENERAL NOTES

Wiring and/or conduit properly installed and supported.



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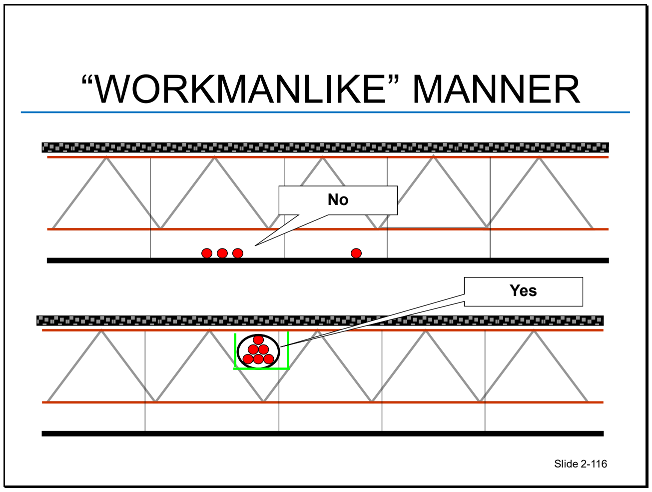
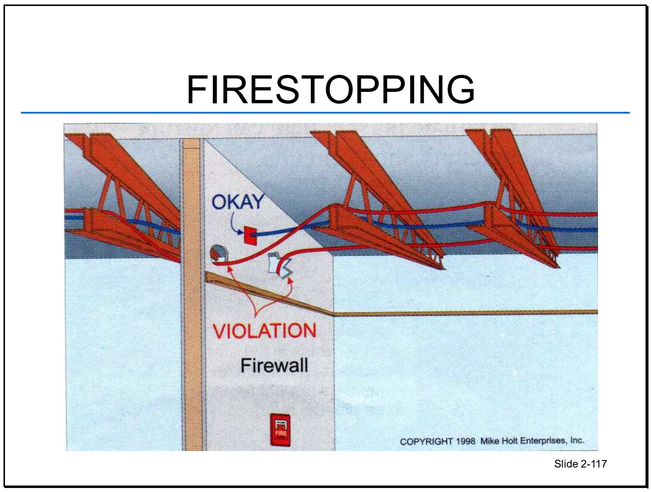
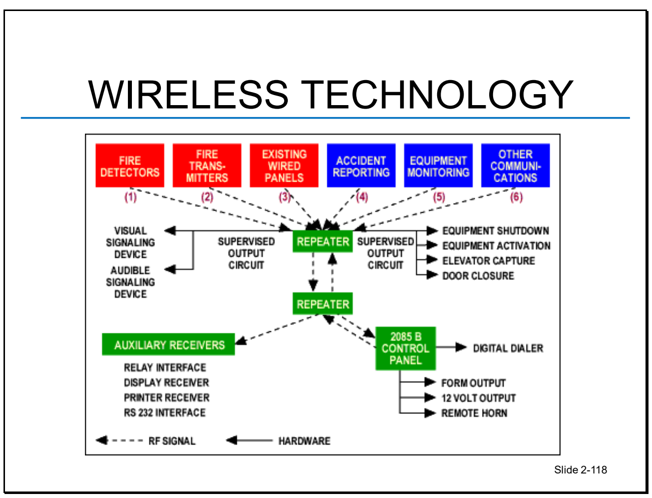
4. General notes.



5. "Workmanlike" manner.



6. Firestopping.



WIRELESS TECHNOLOGY (cont'd)

- Uses RF transmission.
- Listed for commercial or household use.
- Dry cell batteries in transmitters.
  - One-year life required.
  - Low-battery signal.
    - Seven-day warning.
    - Four-hour re-alarm.
- Trouble signals.
- Supervision.

Slide 2-119

G. Wireless technology.

VIII. NOTIFICATION APPLIANCES

INITIATING DEVICE CIRCUITS

Circuit(s) to which automatic or manual initiating devices are connected.

- Detectors.
- Manual pull stations.
- Water flow switches.
- Duct detectors.
- Supervisory devices.
- **Inputs.**

Slide 2-120

A. Initiating device circuits.

1. Initiating device circuits are those that carry alarm signals from automatic or manual devices that detect or report a fire. They are the circuits that carry system inputs. This includes smoke and heat detectors, flame detectors, manual pull stations, and sprinkler water flow. Alarm signals are transmitted only one way on initiating device circuits: from the device to the FACU.

2. Initiating device circuits also include supervisory circuits that report the conditions and status of various fire protection systems, including sprinkler system water supply valves, water level and temperature, air pressure, duct detectors, emergency power generators, and fire pump assemblies.

NOTIFICATION APPLIANCE CIRCUITS

Circuit(s) to which notification appliances are connected.

- Horns.
- Speakers.
- Bells.
- Strobes.
- **Outputs.**

Slide 2-121

B. Notification appliance circuits (NACs).

1. NACs carry system outputs in the form of alarms to notify occupants: horns, bells, chimes, buzzers, strobes, sirens, horn/strobe combinations, klaxons, or any device or devices intended to alert building occupants to an emergency.

NOTIFICATION APPLIANCE CIRCUITS (cont'd)

Circuit(s) for ancillary functions.

- Door release and lock release.
- Fuel shut-off.
- Elevator recall.
- Smoke management.
- Stairway pressurization.
- HVAC shutdown.

Slide 2-122

2. Alarm signals are transmitted only one way on notification device circuits, from the FACU to the A/V device.

SIGNALING LINE CIRCUITS

Circuit(s) that carries signals.

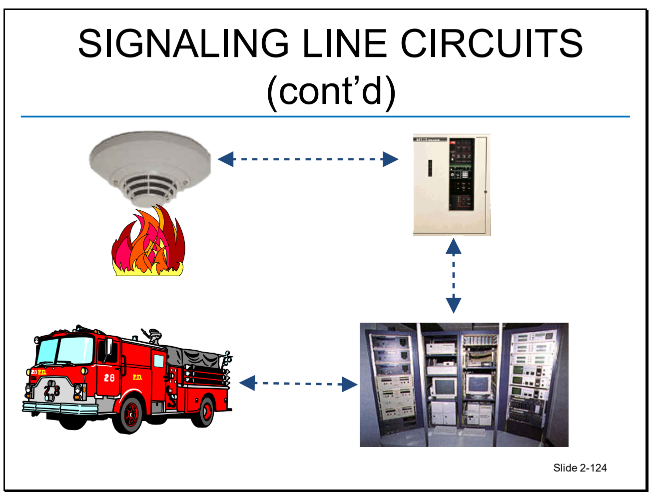
- More than one direction.
- More than one signal.
- Ancillary functions/off-premises reporting.

Slide 2-123

C. Signaling line circuits.

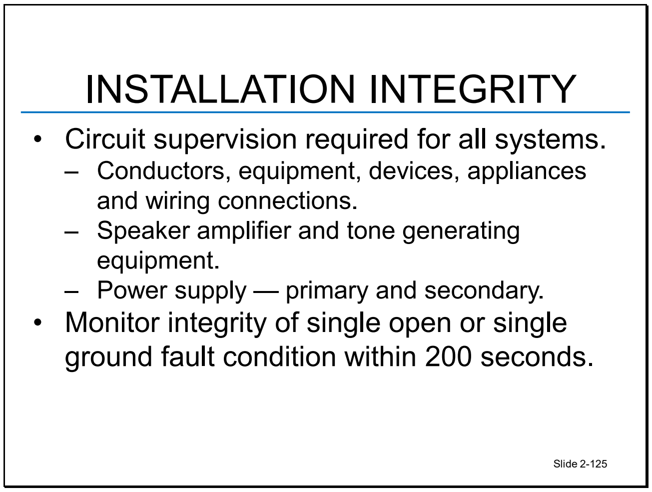
1. The largest category of fire alarm system circuits is signaling line circuits. Signaling line circuits may carry signals in more than one direction, and may carry more than one signal.

2. Signaling line circuits include those that transmit alarms to the ancillary fire control devices, such as HVAC shutdown, door release service, elevator recall, smoke control and stair tower pressurization.

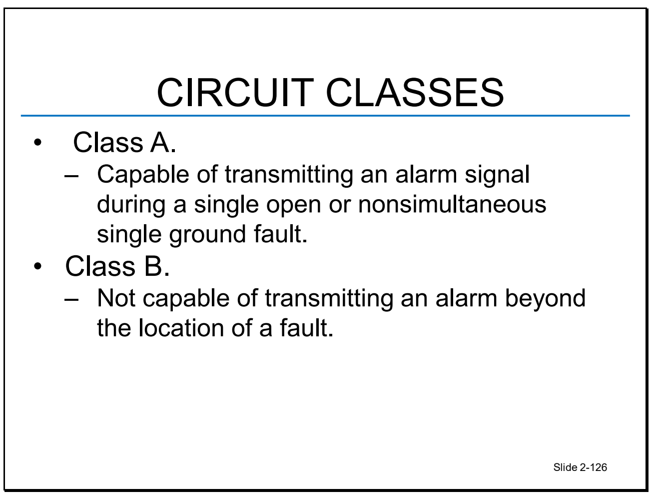


3. Signaling line circuits also transmit fire alarm signals to central, remote, auxiliary or proprietary supervisory services.

4. Signaling line circuits connect multiple FACUs, sub-panels and circuit interfaces, all of which are devices that allow expansion of basic fire alarm service in a building, throughout a facility, or even throughout an industrial or college campus, for example.



D. Installation integrity.



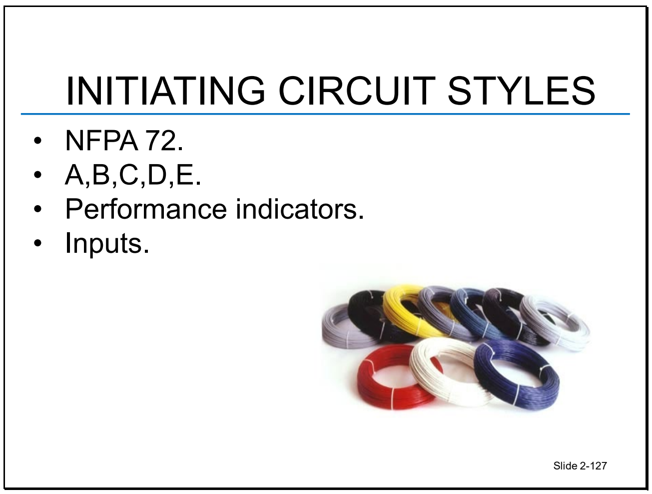
E. Circuit classes.

1. The ability to identify the different circuit designators becomes critical when understanding the importance of how they are intended to perform under normal and "failure" conditions.

2. Historically, fire alarm circuits were described as either Class A (four-wire) or Class B (two-wire). Now, while the class designations remain, NFPA 72 includes circuit "styles" that help the designer and fire inspector assess their performance.

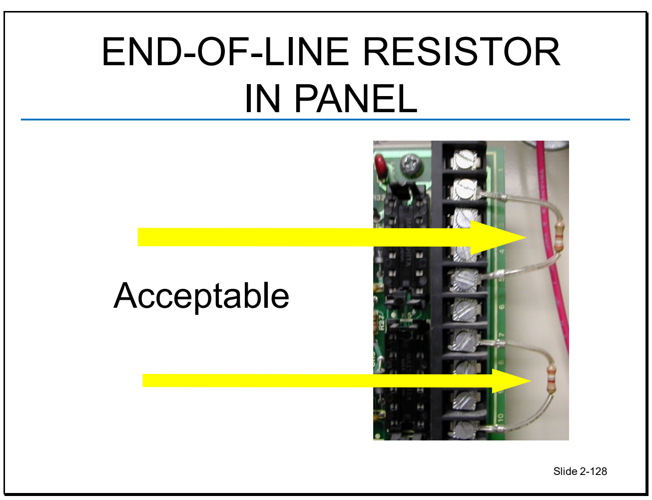
3. Class A circuits generally are considered to be more reliable than Class B because they employ four wires to carry current from the FACU, through the detecting devices, and back to the panel. If a wire is broken, or if there is a short circuit, the additional wires of the four-wire system prove an alternate path for the current flow. In a two-wire (Class B) system, if a circuit is opened, there is no current flow "downstream" of the break, and the remaining portion of the fire alarm system may be rendered inoperable.

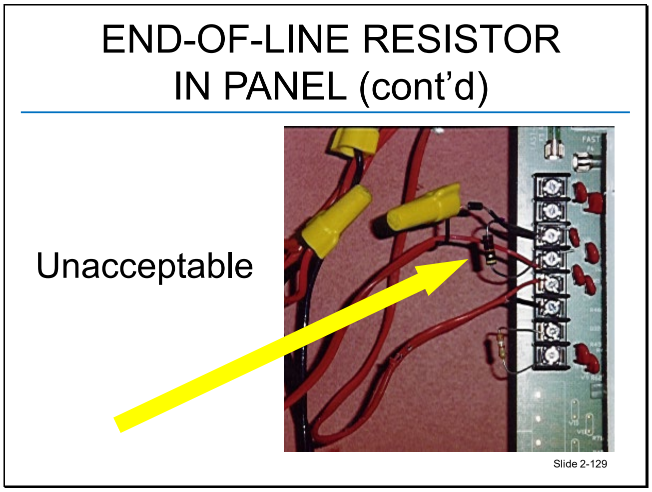
4. NFPA 72 does not require the owner to select one class over another, but does specify that if a Class A system is installed, its circuitry must be arranged to minimize the likelihood of all circuits being damaged simultaneously. This is accomplished by running circuits through different conduits or pathways. Because of their ease of installation and lower relative cost, Class B circuit systems are the most commonly installed.



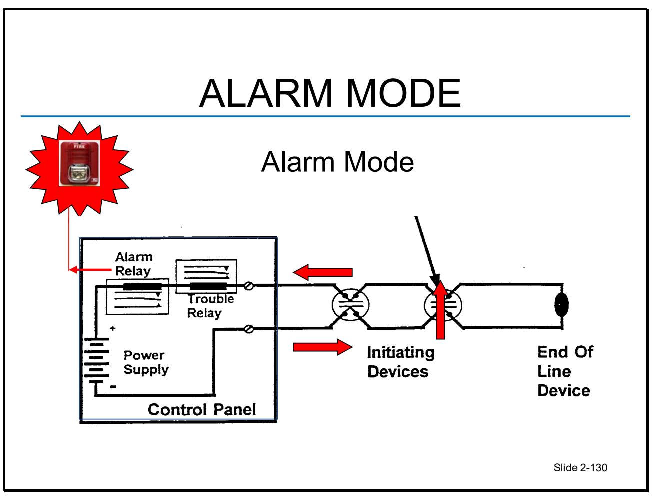
F. Initiating circuit styles.

1. Initiating device circuits are designated Style A, B, C, D or E depending upon their ability to perform during a single open (wire break), single ground fault, wire-to-wire short, or loss of carrier fault condition (high frequency energy).





2. When inspecting an FACU, the fire inspector always should verify there are no end-of-line devices installed on terminal posts that are connected to circuits. If all of the initiating device circuits have been routed back to the panel and the end-of-line resistors (EOLRs) installed there, the EOLRs should be connected only to the circuit wires and not the terminal posts.



3. Alarm mode.

NOTIFICATION APPLIANCE CIRCUITS (cont'd)

- Style W, X, Y and Z.
- **Outputs.**

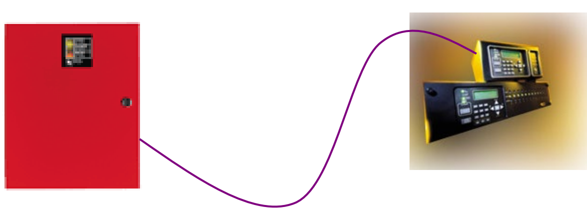
Slide 2-131

G. NACs.

1. NACs, to which horns, strobes, bells and other alarm devices are connected, also must meet performance criteria for single open, single ground or wire-to-wire shorts. They are designated Styles W, X, Y and Z depending upon their performance. All of these circuits are two-wire, except Style Z which is four-wire.

2. Unlike alarm initiating circuits, when an NAC suffers a fault, it will not sound an alarm, but is required to indicate a trouble signal at the protected premises.

SIGNALING CIRCUITS

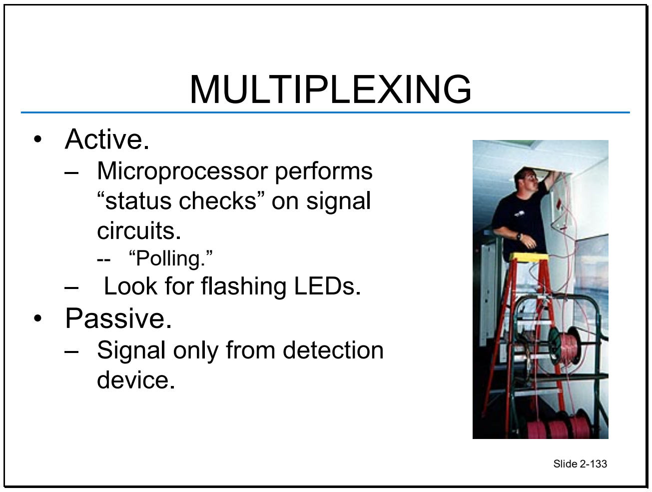


Slide 2-132

3. Signaling circuits.

   a. Signaling circuits are designated to carry a variety of fire alarm signals and may be multidirectional. Their performance criteria differ somewhat from an initiating device or NACs.

b. Depending upon the style, these circuits may be required to sound an on-premises trouble condition and transmit an alarm while suffering one or more faults.



4. Multiplexing.

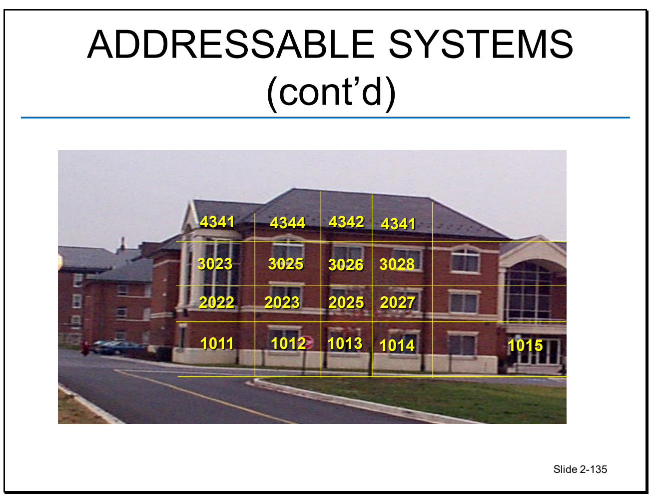
a. "Multiplexing" describes a fire alarm system that has "status check" signals that transmit simultaneously, sequentially or both along the signaling circuit paths. These systems may employ either "active" or "passive" multiplexing.

b. Active multiplexing systems use microprocessors (simple computers) to monitor the integrity of circuits and devices. Depending upon their design, they may send one or more signals from the microprocessor to the initiating devices or circuits to check their status, and receive that report back at the processor. If the microprocessor sends a status check signal along the circuit path and the initiating device (a smoke detector, for example) reports back that everything is in order, no problems are reported. If the smoke detector does not report back, the microprocessor initiates a trouble signal.

c. Passive multiplexed systems operate in a similar manner, but do not rely on a signal that is initiated from the fire alarm control or microprocessor. They are designed so that the signal transmission from the device to the microprocessor is one-way only.

5. Addressable systems.

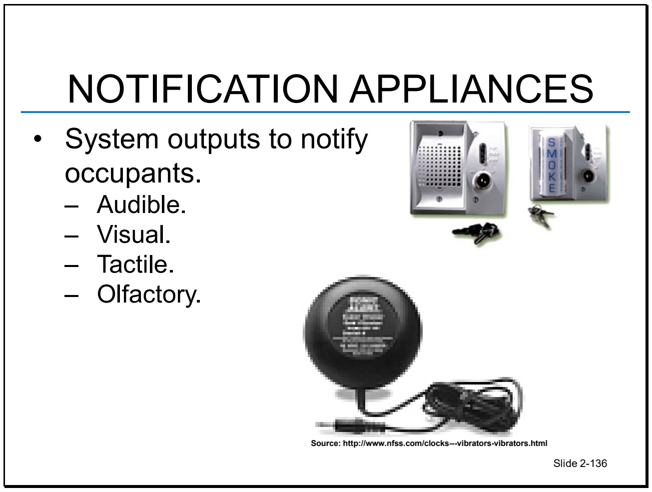
   a. Like multiplexed systems, addressable fire alarm systems initiate signals between the main controls and the remote devices. Addressable systems use FACUs, not microprocessors, that scan or "poll" the various detection and notification appliances on the circuits. Each device has a discrete digital "address" that the FACU can translate into a specific location.



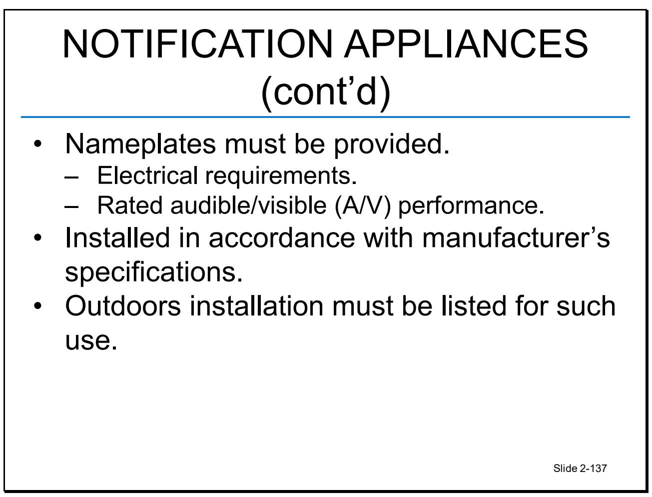
   b. When the FACU receives an alarm or trouble signal from detector 1011, it can immediately translate that into the alphanumeric characters "Zone 1, First Floor, Room 101" so responding personnel can identify the location of the alarm.

IX. SIGNALING THE ALARM

A. Once the fire alarm system has detected a hazardous condition, there must be a method to notify building occupants so they may take appropriate life-saving action: evacuation, relocation, refuge, or even fire investigation and attack.



B. NFPA 72 recognizes a number of methods of occupant notification, with the most common being audible (hearing) or visual (sight). Tactile (touch or vibration) or olfactory (smell) notification appliances also exist, but will not be covered in this unit.



C. All notification appliances must include a nameplate that specifies their electrical requirements (voltage and amperage) and rated A/V performance (measured in decibels (dB) and/or flash rates) as defined by the listing agency. Any appliance that is designed for special installation (outdoors, high humidity environments, dusty conditions or hazardous locations) must be listed for that use.

AUDIBLE SIGNAL REQUIREMENTS

- Alarm signal.
  - Must be distinctive in sound from other signals.
  - Not used for any other purpose.
- American National Standards Institute (ANSI) S3.41, *Audible Emergency Evacuation (E2) and Evacuation Signals with Relocation Instructions (ESRI)*, for systems after July 1996.
  - Three-pulse temporal pattern.
  - Synchronized within one notification zone.

Slide 2-138

D. Audible signal requirements.

1. In order for the audible fire alarm system to be effective, occupants must be able to hear it. The signal must be audible above the ambient noise levels found in the building or facility normally.

2. Sound is a function of vibrations in the air against a person's eardrum. The vibrations cause pressure increases in the air that can be described as sound pressure levels (SPLs). SPLs are measured in dB, and an increase in dB represents an increase in pressure. A person's ability to hear a noise begins at approximately 1 dB, and the recognized threshold for painful ear injuries is 130 dB. To prevent hearing damage, the total sound pressure output of all devices operating in a single area may not exceed 120 dB per NFPA 72.

TEMPORAL PATTERN

- Used only where **total evacuation** is required.
- Three successive **ON/OFF** cycles.
  - **ON** phase lasting one-half second +/- 10%.
  - **OFF** phase lasting one-half second +/- 10%.
- **OFF** period lasting one and a half seconds +/- 10%.
- Single stroke bell can be used.
  - **ON** phase one second.
  - **OFF** phase two seconds after three strokes.

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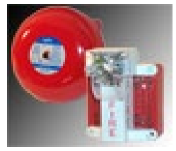
E. Temporal pattern.

AUDIBILITY



- Public mode: anywhere in a building, except mechanical rooms and those defined as private mode or sleeping area.
- Private mode: areas where trained staff work who are responsible to aid in the evacuation of occupants.
- Sleeping areas: rooms where people sleep.

Slide 2-140

F. Audibility.

PUBLIC MODE

- A sound level of at least 15 dB over average ambient sound or 5 dB above maximum level having duration of at least 60 seconds, whichever is greater, measured 5 feet (1.5 meters) above the floor.
- Requirements for audible signaling shall be permitted to be reduced or eliminated when visible signaling is provided.

Slide 2-141

1. Public mode.

   a. To ensure that audible public mode signals are clearly heard, unless otherwise permitted, they shall have a sound level at least 15 dB above the average ambient sound level or 5 dB above the maximum sound level having a duration of at least 60 seconds, whichever is greater, measured 5 feet (1.5 meters) above the floor in the area required to be served by the system using the A-weighted scale (dBA).

   b. Public mode is perhaps the most generic. It is defined as signaling to occupants or inhabitants of the area protected by the fire alarm system. This includes offices, conference rooms, classrooms, lobbies, hallways and other spaces where evacuation is necessary.

PRIVATE MODE

- Average sound level of at least 10 dB above average ambient, or 5 dB above maximum, sound level with a duration of at least 60 seconds, whichever is greater measured 5 feet (1.5 meters) above the floor.
- Requirements for audible signaling shall be permitted to be reduced or eliminated when visible signaling is provided.

Slide 2-142

2. Private mode.

   Private mode is those occupancies where the fire alarm signal is not immediately transmitted throughout to notify all occupants, such as switchboards, alarm supervising stations, nursing stations or guard stations. Private mode is intended to notify someone to take investigative and response action.

SLEEPING AREAS

- A sound level of at least 15 dB above average ambient, or 5 dB above maximum sound having duration of at least 60 seconds.
- Or a sound level of at least 75 dB, whichever is greater, measured at the pillow level of the room.

Slide 2-143

3. Sleeping areas.

   Sleeping areas are locations where people sleep and are expected to be awakened by the alarm. Hotels, motels and apartment rooms are good examples. Hospitals or institutional rooms would not meet this definition, since those occupants generally require someone to care for them and would be considered "private mode."

AUDIBLE LOCATIONS

- Wall-mounted appliances.
- Top of device not less than 90 inches AFF and not less than 6 inches below finished ceiling.
  - May be adjusted if equivalent sound pressure level (SPL) met.
  - Combination A/V devices mounted in accordance with visible appliance requirements.
  - Combination devices which are part of a smoke detector in accordance with smoke detectors.

Slide 2-144

G. Audible locations.

1. NFPA 72 requires that wall-mounted audible appliances be located so their tops are at least 90 inches above the floor, but at least 6 inches below the ceiling.

2. Audible alarms may be mounted on the ceiling or as recessed devices, especially if they are part of a combination A/V notification appliance. Combination appliances must meet the placement rules specified under visual devices.

EXIT MARKING AUDIBLE NOTIFICATION APPLIANCES

- Shall be installed in accordance with manufacturer's instructions.
- When used, must be installed at all building exits and areas of refuge.
- Signal must penetrate both ambient noise and fire alarm signal.

Slide 2-145

3. Exit marking audible notification appliances.

VOICE ALARM SIGNALING

- Preceded and followed by two cycles of audible tone.
- Signal transmitted in accordance with building evacuation plan.
- Live voice has precedence.

Slide 2-146

H. Voice alarm signaling.

1. Some occupancies, especially high-rise buildings, shopping malls and large places of assembly, will require automatic voice alarm signaling. Instead of an audible, coded or noncoded signal, a human voice will tell occupants precisely what actions they should take for self-preservation.

2. These voice commands must be automatic, from computer-generated or tape-recorded messages, and they may be supplemented by human intervention (building staff or fire response personnel) to deliver additional information.

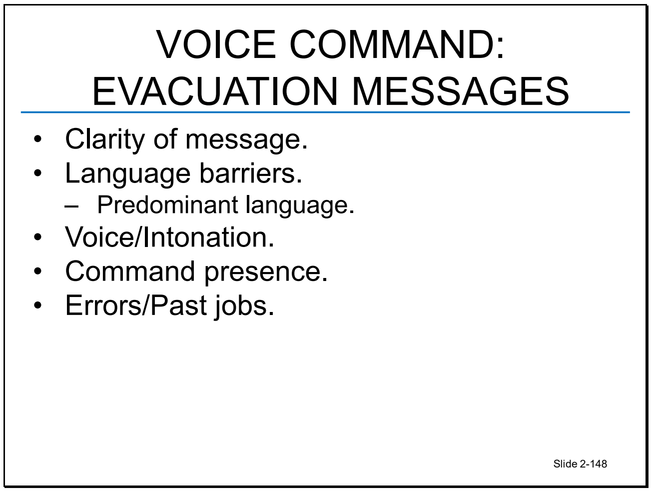
3. Voice alarm devices must sound an alert tone for a period of three to 10 seconds followed by the safety instructions. The instructions may tell occupants to move to another area of the building or facility, or direct them to evacuate by the nearest exit. The message must be repeated at least three times.

VOICE ALARM SIGNALING (cont'd)

- Loudspeakers.
  - At least two in each evacuation zone.
  - One in each elevator car.
  - Each enclosed stairway greater than two stories.
    - -- Separate paging zone.

Slide 2-147

4. NFPA 72 requires that loudspeakers used in conjunction with voice alarm systems meet all the listing requirements. Also, there must be at least two loudspeakers in each paging zone, one in each elevator car, and one in each stair enclosure exceeding two stories in height.



I. Voice command: evacuation messages.

Important points to remember with voice alarm systems:

1. **Clarity of message.** Try to ensure that all messages transmitted over the loudspeakers are simple and clear. Complicated instructions are confusing in an emergency.

2. **Language(s).** The diversity of populations in a building should be considered. If the occupancy routinely houses tenants or visitors who speak languages other than English, those languages should be included in the message.

3. **Voice/Intonation.** Select a voice or synthesized message that is clear and can be understood in an emergency environment.

4. **Command presence.** The voice message should be one to which occupants will respond and take appropriate action. An emergency is not the time to try to be mildly persuasive, but a time to make sure people understand the urgency of the circumstances.

5. **Unanticipated errors.** Occasionally, in the haste to finish a job, a contractor may inadvertently substitute a taped or synthesized voice alarm message from a previous fire alarm installation. The message must be suitable to the occupancy. There is no point in telling people to evacuate by the nearest stairs if the building has none.

VISUAL APPLIANCES

- Requirements of NFPA 72 — 1996 and later editions accepted as equivalent or superior to Americans with Disabilities Act (ADA).
- Two methods of visible signaling.
  - Direct viewing.
  - Illuminating the surrounding area.

Slide 2-149

J. Visual appliances.

1. **Direct viewing** describes those circumstances where occupants can see the visual device and its effects. In a small room, a single visual device may be all that is necessary for response.

2. **Illumination of the surrounding area** allows the designer to take advantage of the building or facility design to "bounce" light so occupants can see it. An office building with glass-wall hallways, for example, might have visual devices only in the hallway. When the fire alarm operates, the light reflecting off the walls can be seen in the offices.

LIGHT CHARACTERISTICS

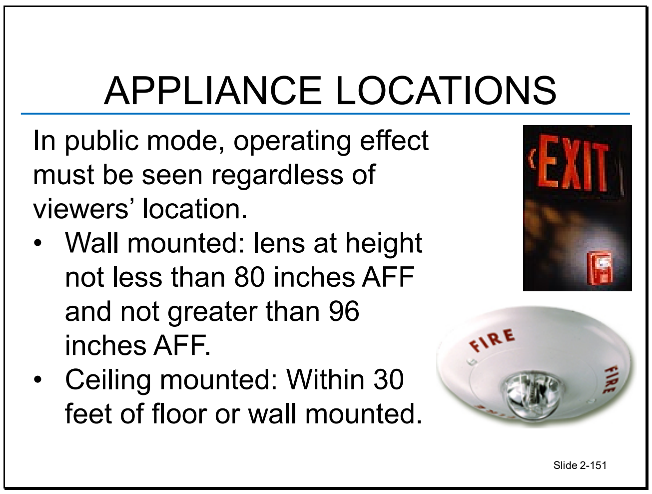
- Flash rate not exceeding two flashes per second, nor less than one flash per second.
- Not exceeding 1,000 candela, minimum 75 candela.

Slide 2-150

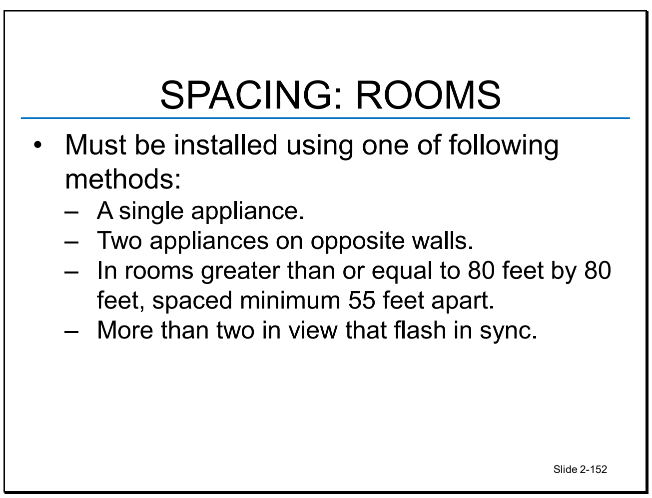
K. Light characteristics.

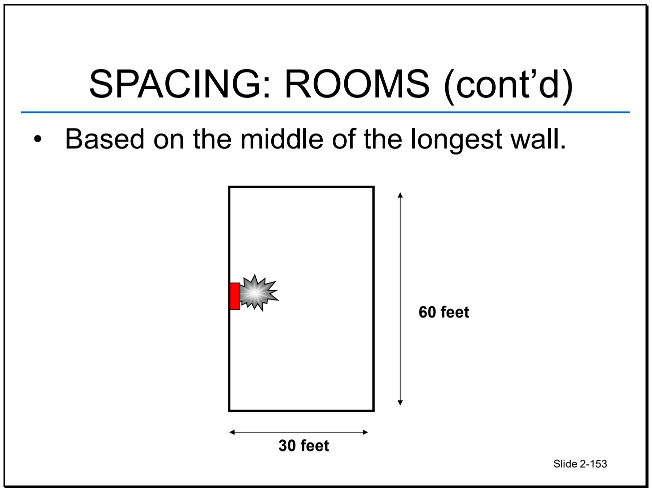
1. The visual devices themselves must be stroboscopic lights that have a flash rate of not more than two flashes per second (2 hertz (Hz)), nor less than one flash every second (1 Hz). The light source must be clear or white, and may not exceed 1,000 candela. A candela, formerly known as “candlepower,” is approximately equal to the amount of light emitted from a candle measured at a distance of one foot (a “foot-candle”). The flash rate and candela ratings of visual devices are found on their nameplates.

2. Other colors are permitted to signal occupants to seek information or instructions (non-fire event).



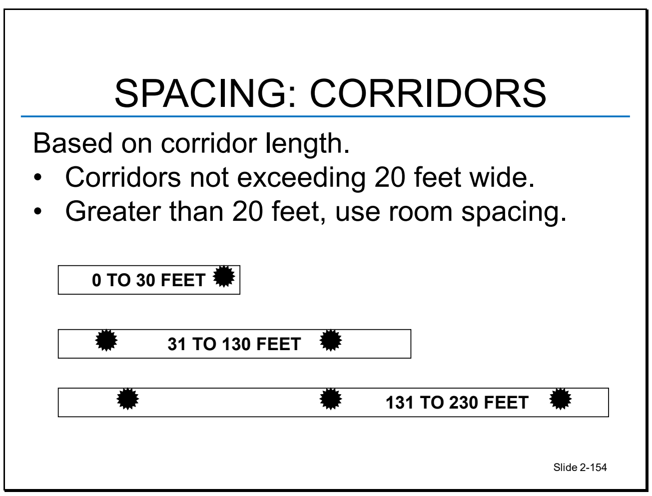
L. Appliance locations.





1. Spacing: rooms.

   In rooms measuring 80 feet by 80 feet or greater, where there are more than two appliances in any field of direct view, they must be spaced a minimum of 55 feet apart.



2. Spacing: corridors.

SLEEPING AREAS

- "For rooms with a linear dimension greater than 16 ft. (4.87 m), the visible notification appliance shall be located within 16 ft. (4.87 m) of the pillow" (NFPA 72, 2016, Section 18.5.5.7.3).
- Combination smoke detectors and visible notification appliances meet all requirements.

Slide 2-155

3. Spacing: sleeping areas.

   An important goal of visual devices in sleeping areas is to have adequate light output that they can awaken sleeping persons. For sleeping areas, NFPA 72 specifies the effective light intensity from the device to a person's pillow, and assumes a room size no bigger than 16 feet by 16 feet. If a sleeping room is larger, there must be a visual device within 16 feet of the pillow.

ALTERNATIVE APPROACH

NFPA 72 now permits a performance-based approach to the location of visual appliances.

Slide 2-156

4. Alternative approach.

X. SIGNAL TRANSMISSION

SYSTEM CATEGORIES

- Protected premises (local).
- Supervising station.
  - Central station.
  - Auxiliary.
  - Remote.
  - Proprietary.

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System categories.

PROTECTED PREMISES

- Provide occupant notification **only.**
- Used to:
  - Warn building occupants.
  - Activate building fire protection features.
- What types of problems can this system present?

Slide 2-158

A. Protected premises.

A protected premises fire alarm system (local alarm) provides fire detection and notification only within the building in which it is installed. Its primary functions are to notify occupants to evacuate or relocate, and to cause or report the activation of building fire protection features.

SUPERVISING STATION SERVICES

Those facilities that receive and "retransmit" alarms.

- Central station.
- Auxiliary.
- Remote.
- Proprietary.

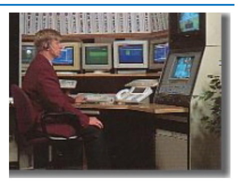
Slide 2-159

B. Supervising station services.

Supervising station fire alarm systems are described by the method in which they transmit alarm signals to a location where someone receives the alarm, interprets it, retransmits the information to the appropriate fire services, and, in some cases, responds to the protected premises for further investigation or service.

CENTRAL STATION SERVICE

- Ties to listed monitoring station.
- Service is controlled and operated by a person, firm or corporation whose business is the furnishing, maintaining or monitoring of supervised fire alarm systems.



Slide 2-160

C. Central station service.

1. Central station protective signaling systems are the most commonly used off-premises monitoring services. Central stations are in the business of receiving fire and supervisory alarms from one or more customers who may be located anywhere in the world. Unlike other receiving station services, central station services have specific performance and listing requirements to ensure system integrity and minimize the risks of false alarms.

CENTRAL STATION REQUIREMENTS

- System in building must be “certificated” or “placarded.”
  - Listing agency certifies installation.
  - Prime contractor placards installation.
- Maintenance, inspection and testing contract.

Slide 2-161

2. Central station requirements.

The protected premises fire alarm system must be “certificated” or “placarded.” This means the prime contractor for the fire alarm installation must confirm the installation meets all requirements of NFPA 72. If it is to be certificated, the agency that lists the central station issues a document stating that the installation complies with the code. This may be UL or another qualified person or agency that performs random quality control checks on fire alarm systems.

CERTIFICATION

- Building alarm system certificated by organization (Underwriters Laboratories (UL)) that lists the prime contractor.
  - Document on or near the FACU.
- Random follow-up inspections by listing agency.
- Listing organization keeps central repository of certificates.

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3. Certification.

PLACARDING

Building fire alarm receives central station service.

- 20 square inches or larger sign.
- Central station, prime contractor name and telephone number.

This property is protected by a listed central station fire alarm system:
APEX Fire Alarm Services
J.S. Fairfield, Prime Contractor
Telephone: 301-555-1212

Slide 2-163

4. Placarding.

   If the fire alarm system is placarded, it is provided with a sign at the FACU which indicates that the central station verifies the installation is in compliance with NFPA 72. In either case, the certificate or placard must be located at or near the FACU or system component (manual pull station, signaling device, etc.). Placards must be a minimum 20 square inches, and must identify the central station by name and telephone number.

CENTRAL STATION REQUIREMENTS (cont'd)

- Promptly retransmit alarm to public fire communication center "without unreasonable delay."
  - Generally interpreted as 90 seconds.
- Runner service within two hours.

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5. In this context, the term "immediately" is intended to mean "without unreasonable delay" and should take no longer than 90 seconds, but there is no hard-and-fast rule as to how long the retransmission should take.

6. Additionally, the central station must dispatch a runner or technician to the protected premises. The runner must arrive within two hours of the alarm when the FACU or other fire alarm equipment needs to be manually reset by the contractor. Out-of-state central stations may contract this service to a local alarm company.

CENTRAL STATION REQUIREMENTS (cont'd)

- If guard's tour service.
  - Failure to report within 15 minutes.
  - Notify premises.
  - Runner within 30 minutes.
- Supervisory or trouble signals.
  - Notify premises.
    - Four minute window.
  - Runner service.

Slide 2-165

7. If the protected premises has a guard or night watchman who is supposed to check in periodically via the protective signaling system, failure to report within 15 minutes of the expected time will result in the central station notifying the premises and sending a runner who must arrive within 30 minutes to perform a status check.

8. When a supervisory or trouble signal is received, a slightly different procedure is followed. Instead of immediately notifying the fire department if a sprinkler valve is being shut or a fire alarm system loses AC power, the central station notifies someone who is responsible for the premises. They must also dispatch a runner in the event of a supervisory alarm. NFPA 72 requires immediate retransmission of these signals, but recognizes they are not as critical as fire alarm signals and allows up to four minutes for notification.

REMOTE STATION SERVICE

- Ties directly into police, fire station or other public location approved by AHJ.
- What sort of challenges and liability does this provide/cause?

Slide 2-166

D. Remote station service.

In a remote station protective signaling system, the alarm is transmitted to a fire service communications center or to the government agency that has responsibility for taking action to ensure a response upon receipt of a fire alarm signal. If permitted by the AHJ, alternate locations may be used if they have personnel on duty who are trained to receive the alarm and transmit it to the fire department. This may include law enforcement dispatch centers, utility (water/sewer/electric) control centers or other municipal facility that has round-the-clock coverage.

PROPRIETARY SERVICE

- Ties to station owned by protected premises, usually on same property.
- Property does **not** have to be contiguous.

Slide 2-167

E. Proprietary service.

A **proprietary protective signaling system** is owned and operated by trained personnel who are responsible for receiving and retransmitting signals from property under common ownership. A college campus may send all of its buildings' fire alarm signals to a security office where operators handle the alarms. A major retailer may use its own signal receiving station to accept alarms from all its stores around the world. The protected property may be either a contiguous property or noncontiguous under one ownership.

XI. INSPECTION, TESTING AND MAINTENANCE

ACCEPTANCE INSPECTION AND TESTING

AHJ must be notified prior to installation or alteration of equipment or wiring.

- May request specifications, wiring diagrams, battery calculations, floor plans.
- May require written statement prior to final acceptance.
- Certificate of completion.

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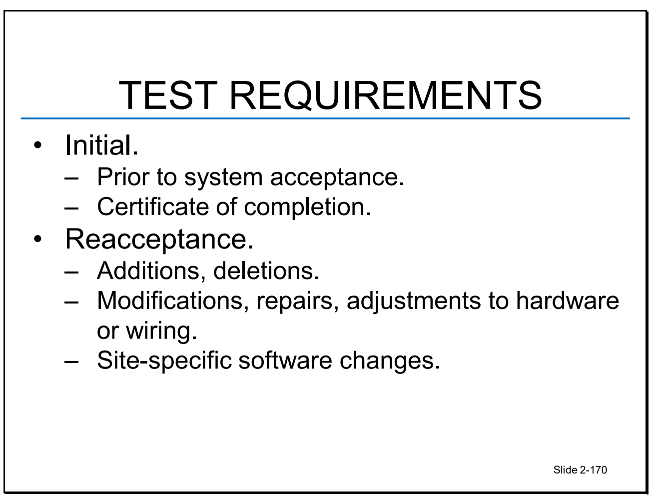
A. Acceptance inspection and testing.

Persons who install, test, maintain or service fire alarm systems should be qualified and experienced with the particular manufacturer's equipment and devices.

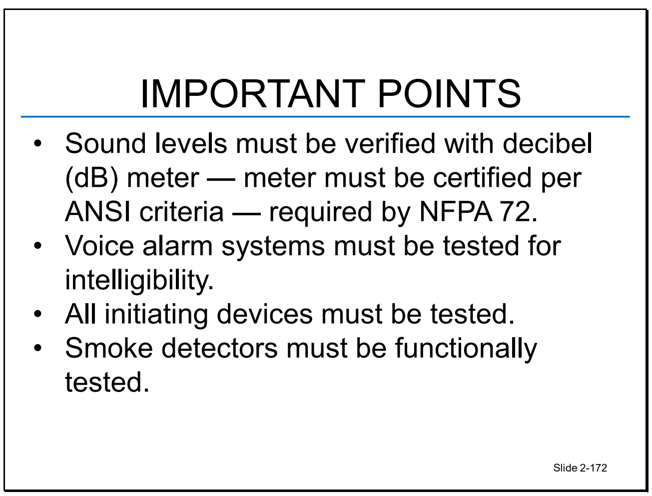
B. Qualifications.



C. Test requirements.

D. Preparing for the test.

All interested persons, from the AHJ to anyone who might be occupying a building, should be notified prior to testing so they may coordinate schedules, equipment and personnel. If the fire alarm system has off-premises monitoring, the fire alarm receiving station should be notified before and after testing.



E. Important points.

DOCUMENTATION AT ACCEPTANCE

- Owner's and manufacturer's manual.
- Record drawings (as-builts).
- Operating sequence.
- Special requirements.
  - Certification.
  - Placard.
- Owner must maintain for system life.

Slide 2-173

F. Documentation at acceptance.

1. The AHJ may require that the installer submit a written "record of completion" indicating that the system has been installed in accordance with the approved plans and has been tested in accordance with manufacturer's specifications and related NFPA standards. NFPA 72 contains a sample record of completion.

2. In addition, the installer must provide the owner with a copy of the "record drawings" which detail how the system was installed. Remember, because of field modifications, this may differ from the plans that were approved prior to installation.

3. The installer must give the owner an owner's manual and installation instructions for all equipment and devices.

ON-GOING INSPECTION, TESTING AND MAINTENANCE

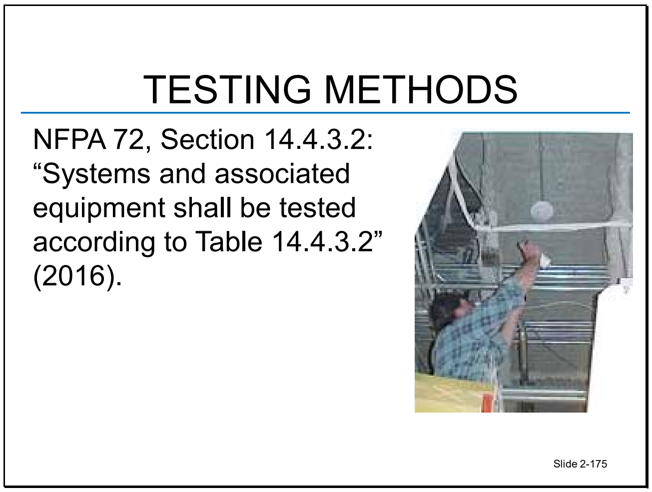
- Owner or owner's designated representative is responsible.
  - Delegation of responsibility must be in writing.
- Written contract.
- Service personnel must be qualified and experienced in field.

Slide 2-174

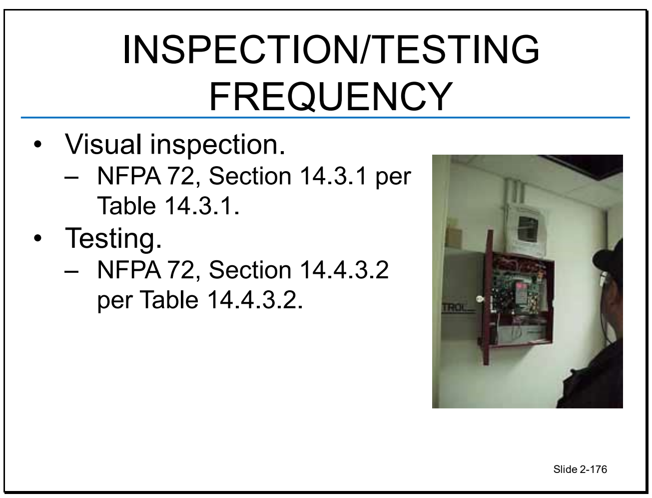
G. On-going inspection, testing and maintenance.

1. NFPA 72 requires monthly, quarterly, semi-annual and annual visual inspections of various components to confirm there have been no changes that can affect system performance. Building modifications, occupancy changes, environmental conditions, device locations, physical obstructions, damage, housekeeping and improper installation are just a few of the conditions that might change how the fire alarm system performs.

2. The owner or owner's designated representative is responsible for inspection, testing and maintenance of the fire alarm system. The owner may delegate that responsibility to someone else, but it must be in writing. A service agreement and contract is one way to transfer this responsibility.



H. Testing methods.



I. Inspection/Testing frequency.

SPECIAL NOTE

- Smoke detectors.
  - Within one year of installation and every other year after that.
  - If, after second test, calibration is within range, extend to five years.
- Restorable, fixed-temperature heat.
  - Two or more per circuit per year.
  - All tested within five years.
- Nonrestorable, fixed temperature.
  - After 15 years, replace all.
  - Lab test two detectors per 100.

Slide 2-177

1. Smoke detectors must be tested for sensitivity within one year of installation, and then every other year after that. These tests are intended to make certain the detector remains within its range of sensitivity, or to have it recalibrated if necessary.

2. If they are installed, at least two restorable fixed-temperature, spot-type heat detectors on each initiating circuit must be tested annually so that within five years every heat detector on the system has been tested.

3. Like any other electronic device, fire alarm systems should be subject to regular maintenance. The frequency and scope of maintenance shall be in compliance with the manufacturer's recommendations.

SINGLE- AND MULTIPLE-STATION SMOKE ALARMS

- When installed in other than one- and two-family dwellings.
- Subject to same sensitivity testing as system smoke detectors.
- Visual inspection upon installation and annually.
- Functional testing with "smoke" upon installation and annually.
- Monthly "button test."
- Not subject to 10-year replacement rule.

Slide 2-178

J. Single- and multiple-station smoke alarms.

Single- and multiple-station smoke alarms and connected appliances shall be inspected, tested and maintained in accordance with NFPA 72, Section 14.4.5 and the manufacturer's published instructions.

MAINTENANCE

System equipment shall be maintained in accordance with the manufacturer's published instructions.

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K. Maintenance.

RECORD KEEPING

- Inspection, testing and maintenance records retained until the next test and for one year thereafter.

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RECORD KEEPING (cont'd)

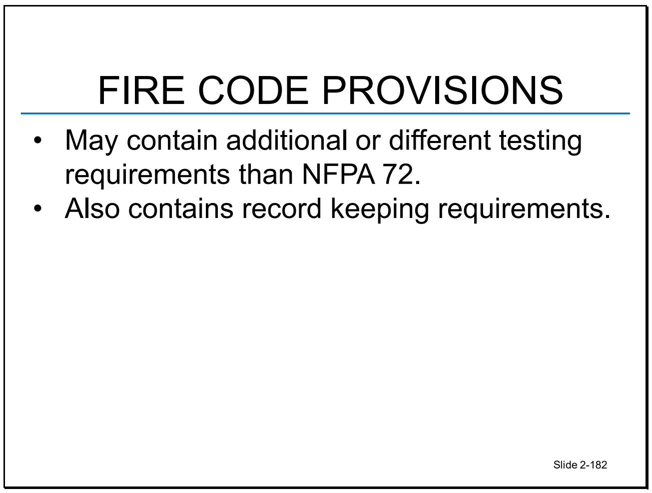
- Permanent record of:
  - Certificate of completion.
  - Approving agencies.
  - Test and inspection specifications.
  - Functional tests.
    - -- Detectors.
    - -- Operational sequence.
  - Signed approvals.

Slide 2-181

L. Record keeping.

1. After successful completion of acceptance tests approved by the AHJ, a set of reproducible as-built installation drawings, operation and maintenance manuals, and a written sequence of operation shall be provided to the building owner or the owner's designated representative.

2. The system owner shall be responsible for maintaining these records for the life of the system for examination by any AHJ. Paper or electronic media shall be permitted.



M. Fire code provisions.

ACTIVITY 2.1

Automatic Fire Alarm Systems

Purpose

Reinforce analytical skills required to review documentation and identify code violations.

Directions

1. Working in your table groups, review Handout 2-1: Automatic Fire Alarm Systems — General Information and Annual Inspection, Testing, and Maintenance Report, for years 2013, 2014 and 2015.

2. Identify any code violations in comparing each of the three inspections.

3. Identify any other items of concern such as incomplete or inaccurate information.

4. You will have 30 minutes to evaluate the documentation and apply the applicable code, NFPA 72, for each violation.

5. Be prepared to report on your findings including applicable code citations to the class.

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ACTIVITY 2.1 (cont'd)

Worksheet

Fire Alarm Reports

1. Code violation: ______________________________

   ____

   ____

   Applicable code: ______________________________

   ____

   ____

2. Code violation: ______________________________

   ____

   ____

   Applicable code: ______________________________

   ____

   ____

3. Code violation: ______________________________

   ____

   ____

   Applicable code: ______________________________

   ____

   ____

4. Code violation: ____

____

____

Applicable code: ____

____

____

5. Code violation: ____

____

____

Applicable code: ____

____

____

6. Code violation: ____

____

____

Applicable code: ____

____

____

Accuracy and completeness of the contractor's inspection:

1. ____

____

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2. ____

____

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3. ____

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4. ____

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5. ____

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6. ____

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7. ____

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XII. SUMMARY

FEMA

SUMMARY

U.S. Fire Administration

- Fire detection and alarm system functions.
- Fire alarm system fundamentals.
- Fire alarm signals.
- Fire alarm initiation devices.
- Smoke sensing detectors.
- Fire alarm system wiring.
- Notification appliances.

Slide 2-184

FEMA

SUMMARY (cont'd)

U.S. Fire Administration

- Signaling the alarm.
- Signal transmission.
- Inspection, testing and maintenance.

Slide 2-185

QUESTIONS?

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REFERENCES

NFPA. (2016). *National fire alarm and signaling code*. (Standard No. 72). Retrieved from www.nfpa.org

NFPA. (2017). *National electric code*. (Standard No. 70). Retrieved from www.nfpa.org

UNIT 3: SMOKE MANAGEMENT

TERMINAL OBJECTIVE

The students will be able to:

3.1 Analyze system components and established performance requirements for smoke management and control systems and equipment.

ENABLING OBJECTIVES

The students will be able to:

3.1 Identify the applicable standards for smoke management and control systems.

3.2 Explain the functions of smoke management and control systems and equipment.

3.3 Explain the in-service testing process for smoke management and control systems.

3.4 Explain the annual inspection and maintenance processes for smoke management and control systems.

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FEMA

U.S. Fire Administration

UNIT 3: SMOKE MANAGEMENT

Slide 3-1

TERMINAL OBJECTIVE

Analyze system components and established performance requirements for smoke management and control systems and equipment.

Slide 3-2

ENABLING OBJECTIVES

- Identify the applicable standards for smoke management and control systems.
- Explain the functions of smoke management and control systems and equipment.
- Explain the in-service testing process for smoke management and control systems.

Slide 3-3

ENABLING OBJECTIVES (cont'd)

- Explain the annual inspection and maintenance processes for smoke management and control systems.

Slide 3-4

I. OVERVIEW

SMOKE MANAGEMENT SYSTEMS

Protecting lives and maintaining tenable conditions.

Slide 3-5

DESIGN CRITERIA

- International Building Code (IBC) 2015 Edition, Section 909, *Smoke Control Systems*.
- National Fire Protection Association (NFPA) 92, *Standard for Smoke Control Systems* (first edition 2012). Combines NFPA 92A, *Standard for Smoke-Control Systems Utilizing Barriers and Pressure Differences,* and NFPA 92B, *Standard for Smoke Management Systems in Malls, Atria, and Large Spaces*.

Slide 3-6

A. Design criteria.

SMOKE CONTROL THEORY

- All fires produce smoke with potential to endanger life and damage property.
- A smoke control system should be designed to inhibit the flow of smoke into means of egress, exit passageways or other similar areas of a building.

Slide 3-7

B. Smoke control theory.

1. All fires produce smoke which, if not controlled, will spread throughout the building or portions of the building, endangering life and damaging property.

2. A smoke control system should be designed to inhibit the flow of smoke into means of egress, exit passageways or other similar areas of a building.

SMOKE CONTROL THEORY (cont'd)

- Limit fire size by providing early detection and suppression. Automatic sprinklers also provide effective and economical control of smoke in most occupancies.
- Provide tenable environment for occupants to escape or be defended in place (life safety).
- May be designed to specifically assist fire department.

Slide 3-8

3. Limiting fire size by providing automatic sprinklers or other means of automatic suppression generally will be necessary for effective and economical control of smoke in most occupancies.

4. Other techniques may be appropriate for specialized occupancies or existing facilities.

DESIGN FIRE

- "Design fire shall be based on a rational analysis performed by the registered design professional and approved by the fire code official" (IBC [F] 909.9, 2015).
- Engineering analysis shall include the characteristics of the fuel, fuel load heat release rate (HRR), effects included by the fire, and whether the fire is likely to be steady or unsteady.

Slide 3-9

DESIGN FIRE (cont'd)

- Minimum HRR is 5.3 megawatts (MW).
- Lower HRR is permitted to be used for design if it can be substantiated by engineering analysis and HRR is controlled by automatic sprinklers.
- Location of fire must also be justified.
- May involve more than one fire scenario (location and/or size).

Slide 3-10

C. Design fire.

Current editions of the International Building Code (IBC) and National Fire Protection Association (NFPA) 92, *Standard for Smoke Control Systems*, are now performance oriented and require an engineering analysis to justify the fire size.

TENABILITY CRITERIA

- "All portions of active or engineered smoke control systems shall be capable of continued operation after detection of the fire event for a period of not less than either 20 minutes or 1.5 times the calculated egress time, whichever is greater" (IBC [F] 909.4.6, 2015).

Slide 3-11

TENABILITY CRITERIA (cont'd)

- "The height of the lowest horizontal surface of the smoke layer interface shall be maintained not less than 6 feet (1829 mm) above a walking surface that forms a portion of a required egress system within the smoke zone" (IBC [F] 909.8.1, 2015).

Slide 3-12

TENABILITY CRITERIA (cont'd)

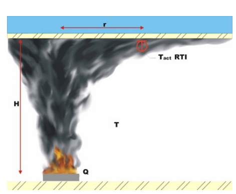
- NFPA 92, Section 4.5.1.1:
  - Tenability is "where the design of the smoke control system is based on the potential for occupants being exposed to smoke, the tenability conditions shall be assessed" (2012).
- The minimum design depth of the smoke layer for a smoke management system shall be either of the following:
  - Twenty percent of the floor-to-ceiling height.
  - Based on an engineering analysis.

Slide 3-13

D. Tenability criteria.

SMOKE MOVEMENT INFLUENCES

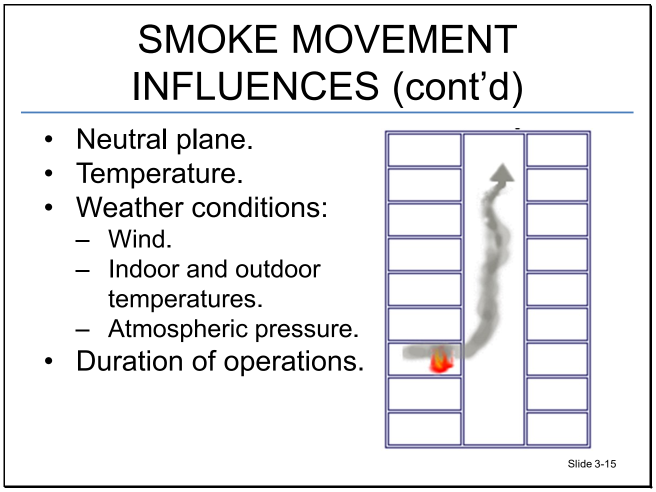
- Stack effect/buoyancy.
- Fire plume/ceiling jets.
- HRRs.
- Building design:
  - Openings/Shafts.
  - Mechanical air handling systems.
  - "Tightness."



Slide 3-14

E. Smoke movement influences.

1. Frequently smoke flow follows the overall air movement within a building. The following are principal factors that cause smoke to spread to areas outside a compartment.



2. Building design: Although a fire may be confined within a fire-resistive compartment, smoke can spread readily to adjacent areas through openings such as construction cracks, pipe penetrations, ducts and open doors.

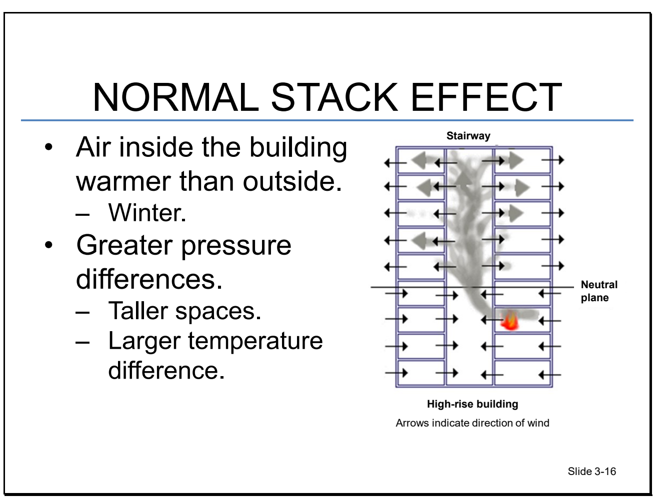
   a. The stack effect.

   b. Temperature effect of fire.

   c. Weather conditions, particularly wind and temperature.

   d. Mechanical air-handling systems.

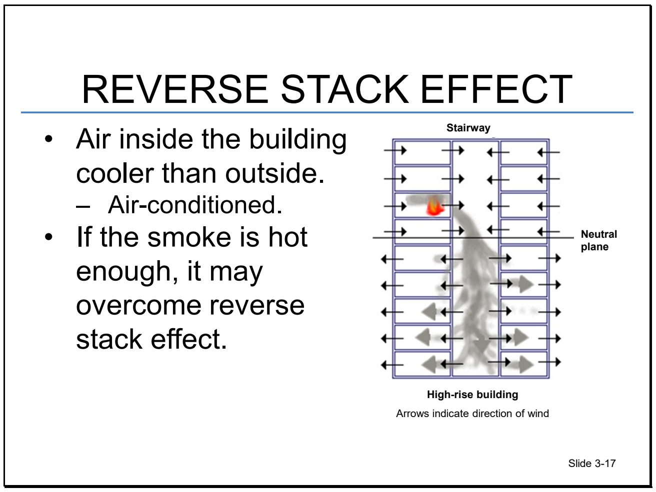
3. These factors cause pressure differences across partitions, walls and floors that can result in the spread of smoke.



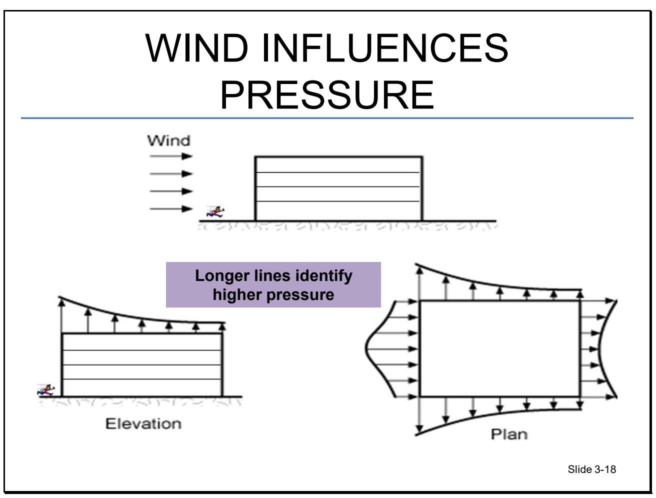
F. Normal stack effect.

1. Stack effect is the movement of smoke which can be controlled by altering pressure differences. Building components and equipment that can aid in the control and movement of smoke include the walls, floors, doors, dampers, smoke-proof stair towers, and the heating, ventilating, and air conditioning (HVAC) systems.

2. The proper overall building design and tight construction are essential to smoke control.



G. Reverse stack effect.

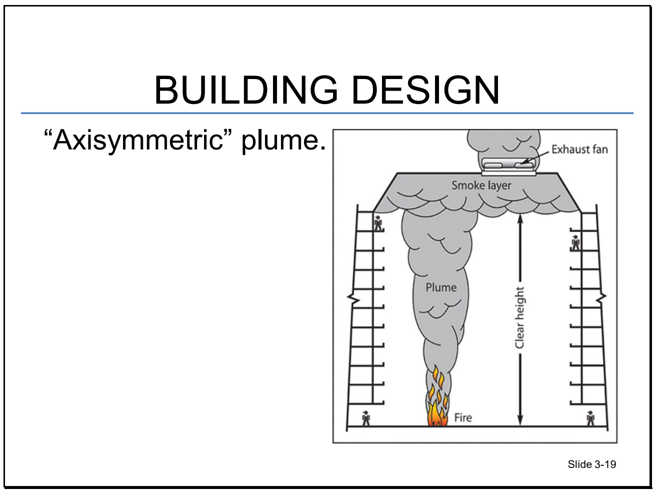


H. Wind influences pressure.

The dilution of smoke in the fire area of a compartmented building is not a means of achieving smoke control. Smoke control cannot be achieved simply by supplying air to and exhausting air from the compartment. Smoke control is based on two principles:

1. Air pressure differences of sufficient magnitude acting across barriers will control smoke movement.

2. Airflow by itself will control smoke movement if the average air velocity is of sufficient magnitude.



I. Building design.

1. The primary means of controlling smoke movement is by creating air pressure differences across partitions, floors and other building components.

2. The basic concept of building pressurization is to establish a higher pressure in adjacent spaces than in the smoke zone. This causes air to move into the smoke zone from adjacent areas, and smoke is inhibited from dispersing throughout the building.

3. Airflow can be used to stop movement through a space. This principle is most commonly used to control smoke movement through open doorways.

4. The flow of air through the opening into the smoke zone must be of sufficient velocity to prevent smoke from leaving that zone through such openings. Since the quantities of air required are large, airflow is not the most practical method of controlling smoke movement.

II. PASSIVE SMOKE CONTROL

PASSIVE SMOKE CONTROL

- Employs no mechanical functions.
- Relies on volumetric capacity of building to capture and hold smoke while simultaneous egress occurs.
  - Holding capacity must be calculated based on largest anticipated fire scenario and fire protection features.

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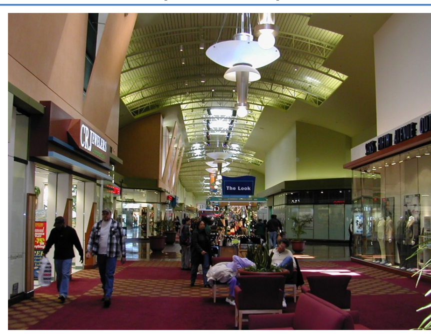
PASSIVE SMOKE CONTROL (cont'd)



Slide 3-21

A. Smoke management systems for large-volume spaces are intended to confine the smoke layer to the upper portion of the large-volume space or to limit the amount of smoke from spreading to areas outside the large-volume space.

B. The HVAC system serving the large-volume space and communicating spaces must be stopped if its operation would adversely affect the smoke management system.

C. Smoke should be removed in the large-volume space above the desired smoke layer interface, and sufficient makeup air should be provided to satisfy the exhaust.

D. It is essential that the makeup air supply inlet and the exhaust outlet be separated so that contaminated air is not drawn into the building.

PASSIVE SMOKE CONTROL (cont'd)

Slide 3-22

ADVANTAGES/DISADVANTAGES

- Advantages:
  - Low initial and ongoing cost.
  - No specific equipment or maintenance costs.
  - May actually perform better than active systems.

Slide 3-23

ADVANTAGES/DISADVANTAGES (cont'd)

- Disadvantages:
  - Content changes may affect performance.
  - Relies on natural conditions to manage smoke.
  - Buoyancy.
  - Stack effect.
  - Requires additional design features.
  - Fire suppression systems influences.

Slide 3-24

E. Advantages/Disadvantages.

III. MECHANICAL SMOKE CONTROL SYSTEMS

MECHANICAL SMOKE CONTROL SYSTEMS

- Variety of methods employed to achieve mechanical pressurization.
- Choice based on most suitable application.
  - Stair or shaft enclosure.
  - Open area/smoke zone.

Slide 3-25

SINGLE INJECTION (SHAFTS)

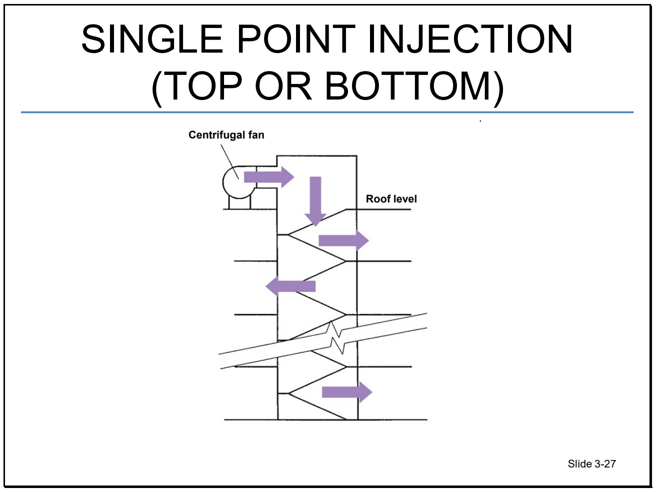
- Usually at top.
  - Often fail when multiple doors near top are open.
- Bottom installation especially prone to failure due to doors being open more often.
- Effective limiting height: 100 feet.

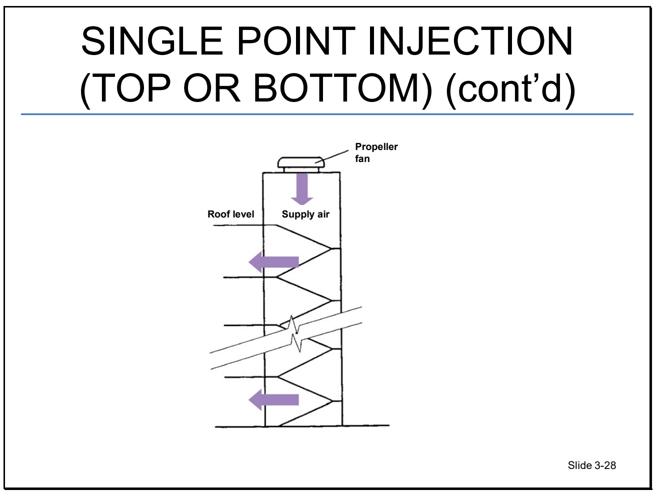
Slide 3-26

A. Single injection (shafts).

1. A single injection system can fail when a few doors are open near the air supply injection point. All of the pressurization air can be lost through these open doors, and the system then will fail to maintain positive pressures across doors farther from the injection point.

2. Because a ground-level stair tower door is likely to be in the open position much of the time, a single bottom injection system is especially prone to failure. Consideration of this specific situation as well as careful design analysis overall is required for all single bottom injection systems, and for all other single injection systems for stair towers in excess of 100 feet in height.





B. Single point injection (top or bottom).

1. Consideration for the design of these systems would be the ability to open or close doors that are a part of the enclosure due to the injection of higher pressures intended to control smoke movement.

2. Special testing may be necessary to verify that pressures introduced by the operation of the smoke control system do not prevent egress into the stair or maintenance of the shaft enclosure. This is particularly true where a single injection point is intended to introduce sufficient pressure to control smoke along the entire stairway.

MULTIPLE INJECTION (SHAFTS)

- Multiple entry points:
  - Top, bottom, all floors.
  - Generally do not exceed three floors apart.
- Balances airflow.

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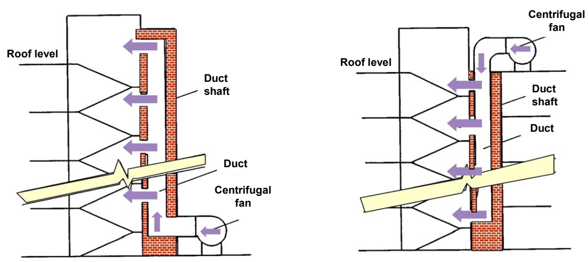
MULTIPLE INJECTION (SHAFTS) (cont'd)



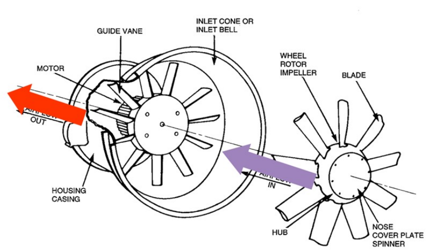
Slide 3-30

C. Multiple injection (shafts).

Multiple point injection systems can be used to overcome the limitations of single injection systems. The pressurization fans can be located at ground level, roof level or at any location in between.

NONCOMPENSATED

Single-speed fan.



Slide 3-31

D. Noncompensated systems.

Supply air is injected into the stair tower by actuating a single-speed fan, thus providing one pressure difference with all doors closed, another difference with one door open, and so on.

COMPENSATED

- Varying airflow or relieving excess pressure.
- Adjust to opening and closing doors.
- Static pressure sensors.

Slide 3-32

COMPENSATED (cont'd)

- Require overpressure relief:
  - Barometric dampers.
  - Pneumatic or electric motorized dampers.
  - Auto-opening stairwell door or vent.
  - Exhaust fan.

Slide 3-33

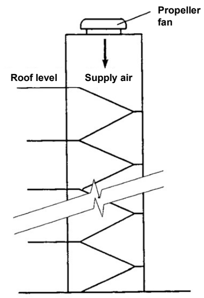
E. Compensated systems.

1. Compensated systems adjust to various combinations of open and closed doors while maintaining positive pressure differences across such openings.

2. Systems compensate for changing conditions by either modulating supply airflows or by relieving excess pressure from the stair tower.

DEDICATED SYSTEMS

- Intended **only** for smoke management.
- Rely on separate equipment and controls.



Slide 3-34

F. Dedicated systems are intended for the purpose of smoke control only. They are separate air-moving and distribution systems that do not function under normal building operating conditions. Upon activation, these systems operate specifically to perform the smoke control function.

ADVANTAGES/DISADVANTAGES (cont'd)

- Advantages:
  - System and control changes less likely to occur.
  - Operation and control are simpler.
  - Less likely to be affected by other system modifications.

Slide 3-35

1. Advantages.

ADVANTAGES/DISADVANTAGES (cont'd)

- Disadvantages:
  - May be more costly.
  - Component failures may go unnoticed.
  - Systems consume more building space.

Slide 3-36

2. Disadvantages.

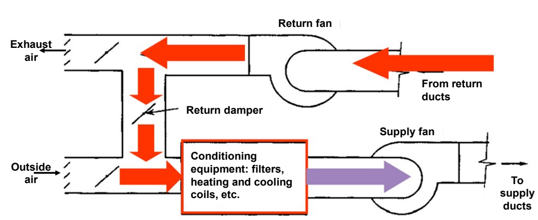
NONDEDICATED SYSTEMS

- Share components with existing heating, ventilating, and air conditioning (HVAC) systems.
- Activation changes mode from normal to emergency operations.

Slide 3-37

G. Nondedicated systems are those that share components with some other system(s), such as the building HVAC system. Activation causes the system to change its mode of operation to achieve the smoke control objectives.

NONDEDICATED SYSTEMS (cont'd)



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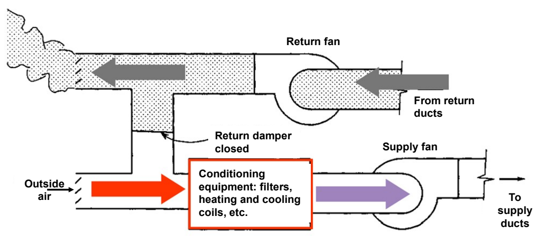
NONDEDICATED SYSTEMS (cont'd)



Slide 3-39

ADVANTAGES/DISADVANTAGES (cont'd)

- Advantages:
  - Component failures easily noticed and corrected.
  - Equipment costs are lower.
  - Less need for additional building space.

Slide 3-40

1. Advantages.

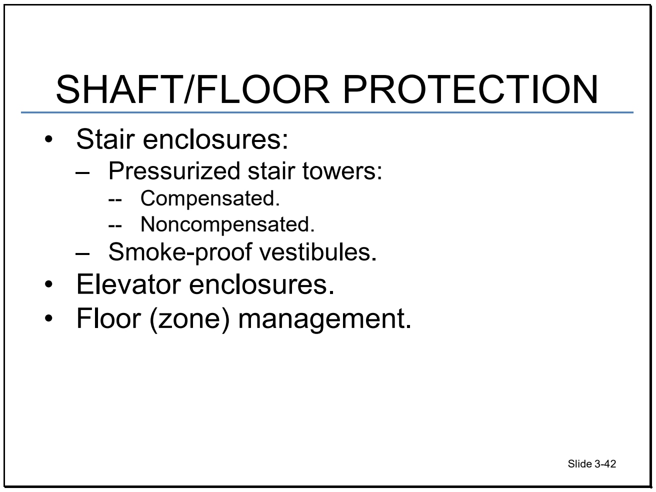
ADVANTAGES/DISADVANTAGES (cont'd)

- Disadvantages:
  - System controls may be elaborate.
  - Inadvertent alterations to other HVAC functions or controls may affect smoke management.

Slide 3-41

2. Disadvantages.

IV. SMOKE CONTROL IN BUILDINGS



A. Shaft/Floor protection.

1. Systems for controlling smoke movement in a building can generally be divided into two separate types:

   a. Stair enclosures:

      - Stair tower pressurization systems.

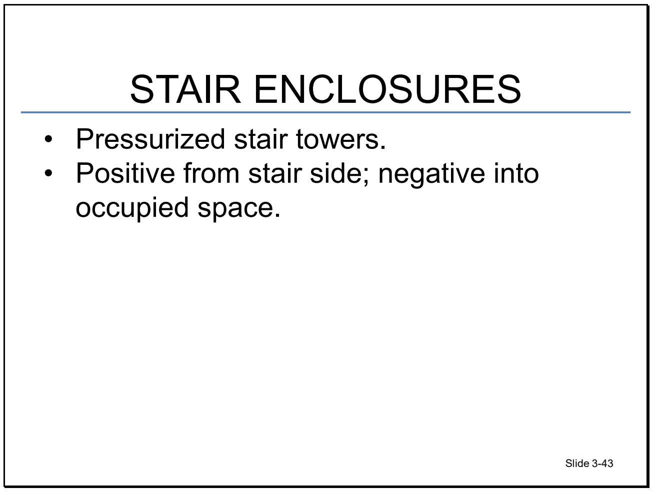
      - Elevator hoistway systems.

      - Smoke-proof vestibules.

   b. Elevator enclosures.

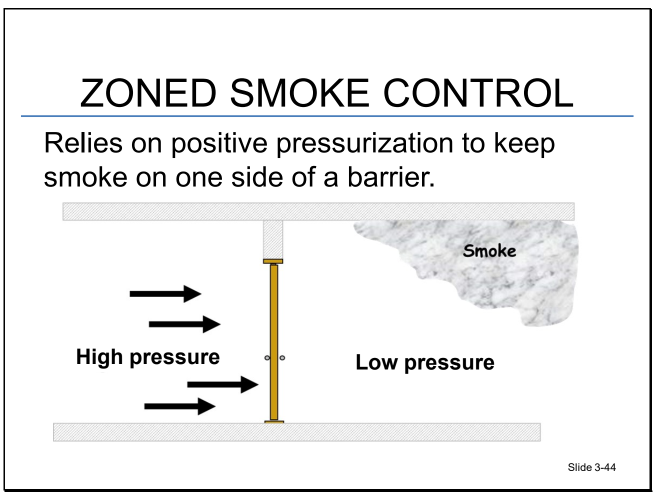
   c. Floor (zone) management.

2. Floor protection encompasses several variations of zoned smoke control. Use of a particular system or combination of systems is dependent on building and fire code requirements, as well as on the specific occupancy and life safety requirements of the situation being considered.



B. Stair enclosures.

The primary goal of pressurized stair towers is to provide a tenable environment within the stair tower in the event of a building fire. A secondary objective is to provide a staging area for firefighters. On the fire floor, a pressurized stair tower needs to maintain a pressure difference across a closed stair tower door so that smoke infiltration is limited.



C. Zoned smoke control.

1. Some buildings can be divided into a number of smoke control zones, with each zone separated from the others by partitions, floors and doors that can be closed to inhibit the movement of smoke. A smoke control zone can consist of one or more floors, or a floor can have more than one smoke control zone.

2. Smoke control zones should be kept as small as practicable so that their evacuation can be readily achieved and the quantity of air required to pressurize the surrounding spaces will be kept to a manageable level. However, they should be large enough so that heat buildup from the fire will become sufficiently diluted with surrounding air to prevent failure of major components of the smoke control system.

PRESSURE DIFFERENTIAL

- Preferred method described in building codes.
- Pressure "sandwich":
  - Vertical.
  - Horizontal.

Slide 3-45

D. Pressure differential.

PRESSURE DIFFERENTIAL (cont'd)

- Minimum nominal pressure needed across a smoke barrier:
  - 0.05-inch water column in sprinklered building.
  - Two times maximum calculated design fire pressure difference in nonsprinklered buildings.

Slide 3-46

PRESSURE DIFFERENTIAL (cont'd)

- Maximum pressure established by door opening and closing forces:
  - Interior doors without closers: 5 pounds.
  - Other side-swinging doors:
    - Latch release at 15 pounds.
    - Door in motion at 30 pounds.
    - Full open at 15 pounds.
  - Test with a door pressure gauge.

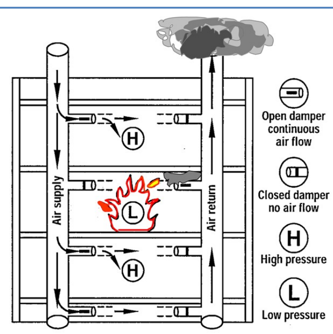
Slide 3-47

DOOR PRESSURE GAUGE

Slide 3-48

E. Door pressure gauge.

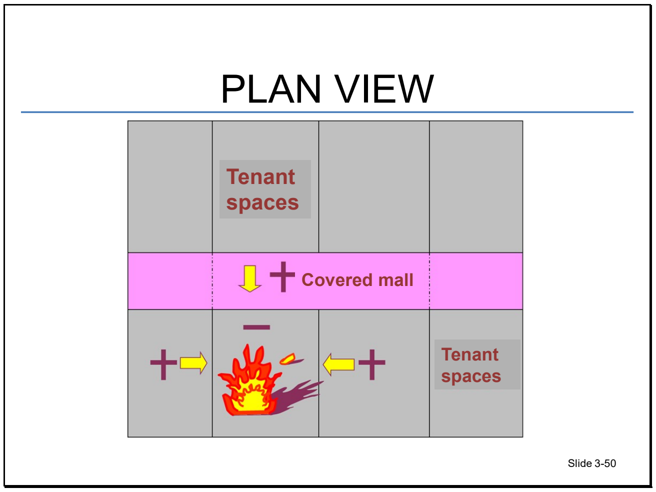
SECTION VIEW

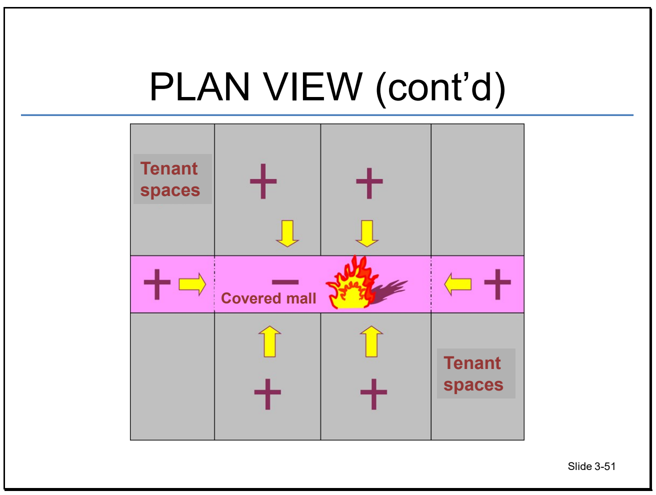


Slide 3-49

F. Section view.

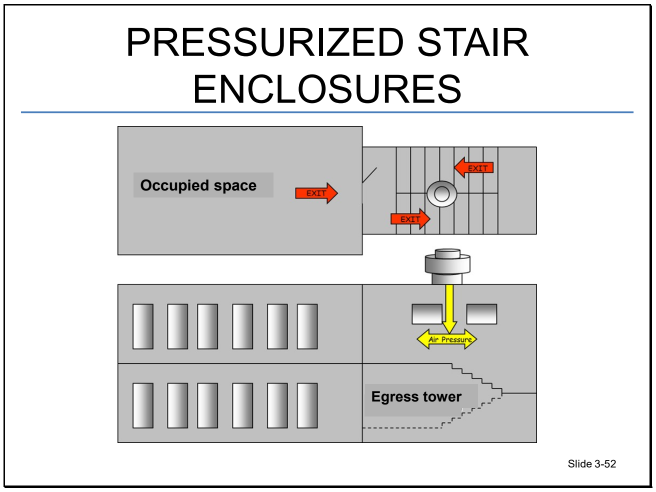
Smoke movement to an adjacent floor may be controlled by providing positive pressure above and below the fire floor.





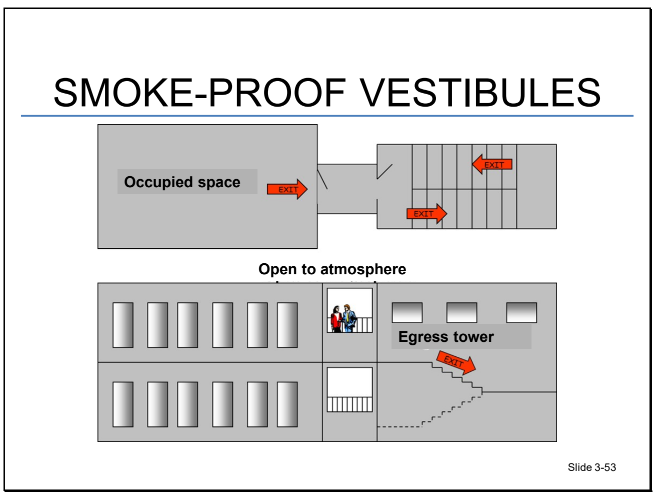
G. Plan view.

Smoke movement to adjacent spaces in a large structure may be controlled by providing positive pressure in designated spaces or all interior spaces adjacent to the fire area.



H. Pressurized stair enclosures.

Egress path is protected from smoke with the introduction of higher air pressure into the exit enclosure.



I. Smoke-proof vestibules provide a method to naturally ventilate smoke before it enters the exit enclosure.

SMOKE-PROOF ENCLOSURE

Slide 3-54

J. Smoke-proof enclosure.

ELEVATOR SHAFT CONTROL METHODS

- Fire floor exhaust.
- Pressurize enclosed elevator lobbies.
- Construct smoke-tight elevator lobbies.
- Pressurize hoistway.
- Close doors after Phase I recall.

Slide 3-55

K. Elevator shaft control methods.

Elevator shafts have proved to be a readily available conduit for movement of smoke throughout buildings in past fires. This is because the elevator doors have not been built with tight fittings, and elevator shafts have been provided with openings in their tops.

AIRFLOW METHOD

- Used primarily to control smoke flow through openings.
  - Calculated for egress from or access to smoke zone.
- Doors may not be open for long periods of time.
  - Must consider number of open doors.

Slide 3-56

AIRFLOW METHOD (cont'd)

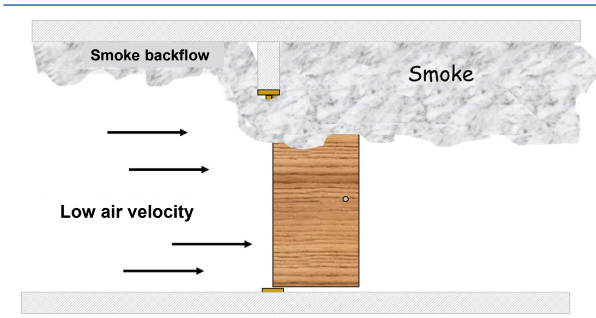
- Additional requirements for the design of smoke management systems are located in the following:
  - American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).
  - Society of Fire Protection Engineers (SFPE).

Slide 3-57

L. Airflow method.

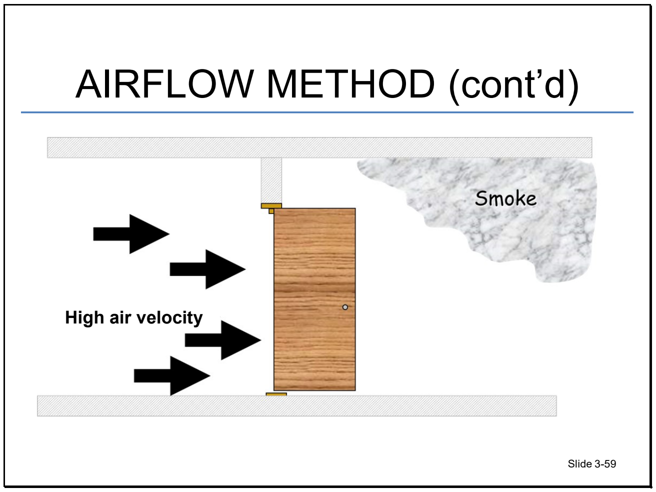
1. The airflow method is primarily used to control smoke flow through openings.

AIRFLOW METHOD (cont'd)

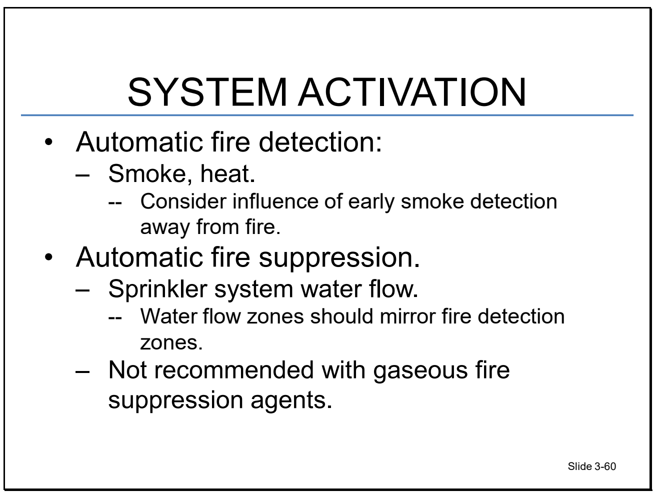


Slide 3-58

2. Normal airflows could allow the uncontrolled movement of smoke.

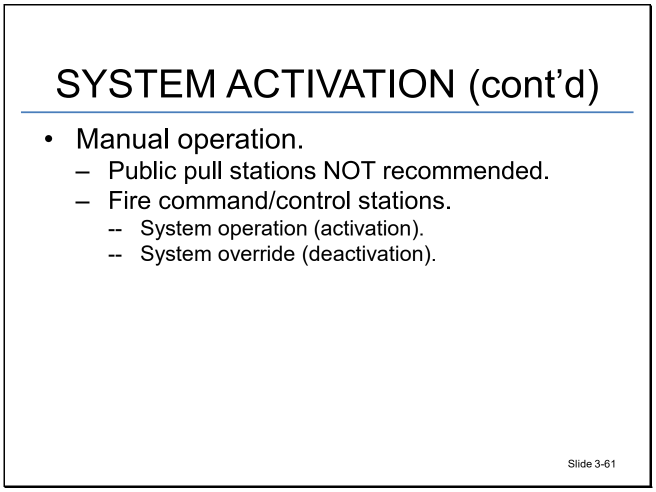


3. Increased air velocity controls the movement of smoke and confines it to a designated area.



M. System activation.

1. Automatic activation (or deactivation) includes all means whereby a specific fire detection device or combination of devices causes activation of one or more smoke control systems without manual intervention. For purposes of automatic activation, "fire detection devices" include automatic devices such as smoke detectors, water flow switches and heat detectors.



2. Manual activation (or deactivation) covers all means whereby an authorized person activates one or more smoke control systems by means of controls provided for the purpose. For purposes of manual activation, the location of the controls may be at a controlled device, at a local control panel, at the building's main control center, or at the firefighter's central control station.

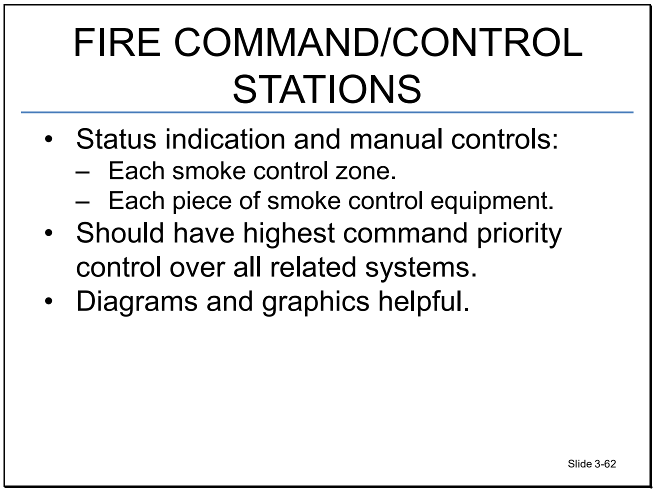
3. Manual fire alarm pull stations generally should not be used to activate smoke control systems, other than stair tower pressurization systems, because of the likelihood of a person signaling an alarm from a station outside the smoke zone of fire origin.

4. Smoke control system activation should be initiated immediately after receipt of an appropriate automatic or manual activation command. Smoke control systems should activate individual components (dampers, fans, etc.) in the sequence necessary to prevent physical damage to the fans, dampers, ducts and other equipment. The total response time for individual components to achieve their desired state or operational mode should not exceed the following:

   a. Fan operation at the desired state: 60 seconds.

   b. Completion of damper travel: 75 seconds.

V. FIRE COMMAND/CONTROL STATIONS



A. The Firefighter Smoke-Control Station (FSCS), when required, should provide full monitoring and manual control capability over all smoke control systems and equipment.

B. The FSCS should have the highest priority control over all smoke control systems and equipment. Where manual controls also are provided at other building locations for control of smoke control systems, the control mode selection from the FSCS should prevail.

C. The FSCS should contain a building diagram that indicates clearly the type and location of all smoke control equipment (fans, dampers, etc.), as well as the building areas affected by the equipment.

D. The actual status of the systems and equipment that are activated or are capable of activation for smoke control should be clearly indicated at the FSCS.

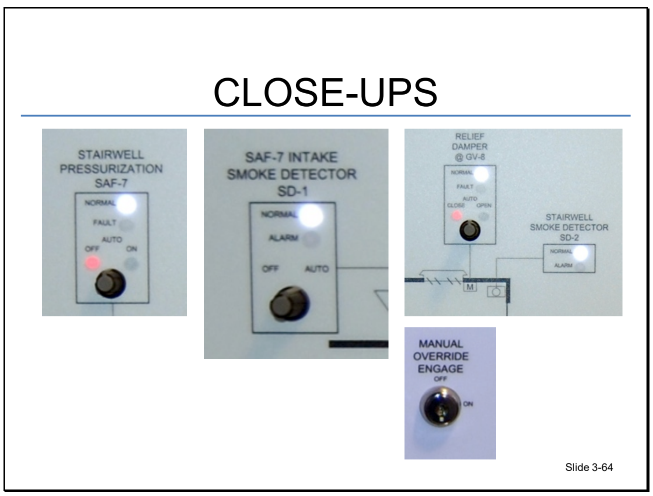
E. Automatic activation.

Operation of any zone of the building's protective signaling system should cause all stair pressurization fans to start. In limited instances, it may be desirable to pressurize only some stair towers due to particular building configurations and conditions. A smoke detector should be provided in the air supply to the pressurized stair tower. Upon detection of smoke, the supply fan(s) should be stopped.

F. Manual activation.

A manual override switch should be provided at the FSCS to restart the stair tower pressurization fan(s) after shutdown from the smoke detector, should it be determined that a lesser hazard exists from smoke entering the fan than from smoke migrating into the stair tower.

G. Manual activation or deactivation of zoned smoke control systems and equipment should have priority over automatic activation of smoke control systems and equipment, as well as over all other sources of automatic control within the building.



VI. REQUIRED INSPECTIONS, TESTS AND MAINTENANCE

REQUIRED INSPECTIONS, TESTS AND MAINTENANCE

- IBC requires that the contractor retain an independent third party to conduct the acceptance test.
- No consensus on test criteria or acceptable performance.
  - Stakeholders establish acceptable performance criteria.

Slide 3-65

REQUIRED INSPECTIONS, TESTS AND MAINTENANCE (cont'd)

- Agreed-upon acceptance criteria.
- Minimally:
  - Operational.
  - Acceptance.
  - Ongoing.

Slide 3-66

A. The intent of acceptance testing is to demonstrate that the final integrated system installation complies with the specified design and is functioning properly.

OPERATIONAL TESTING

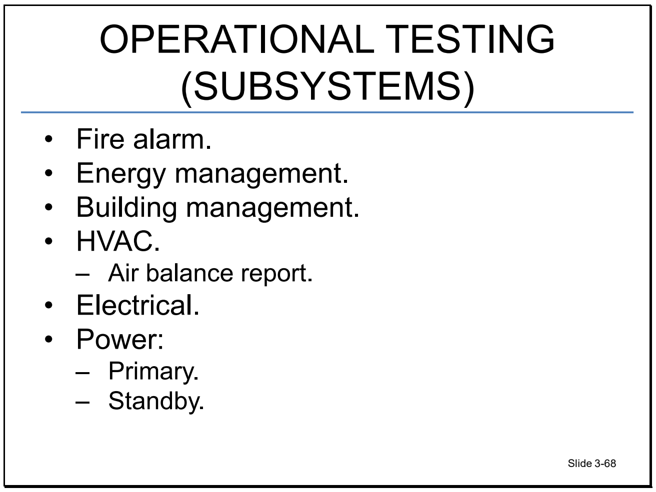
Verify construction completeness:

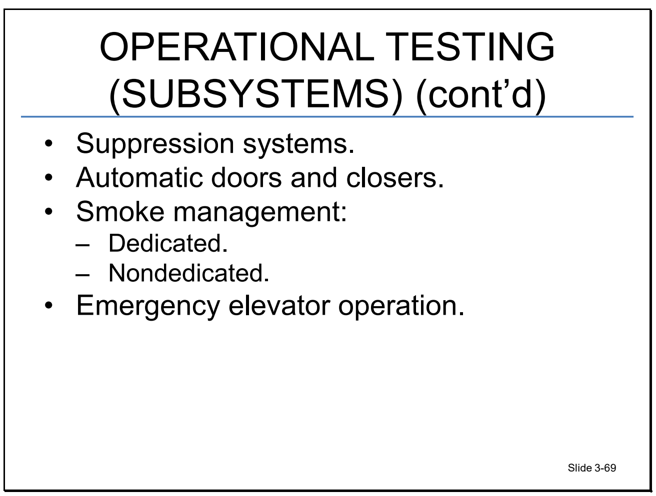
- Shaft integrity.
- Firestopping.
- Doors/Closers.
- Glazing.
- Partitions/Ceilings.

Slide 3-67

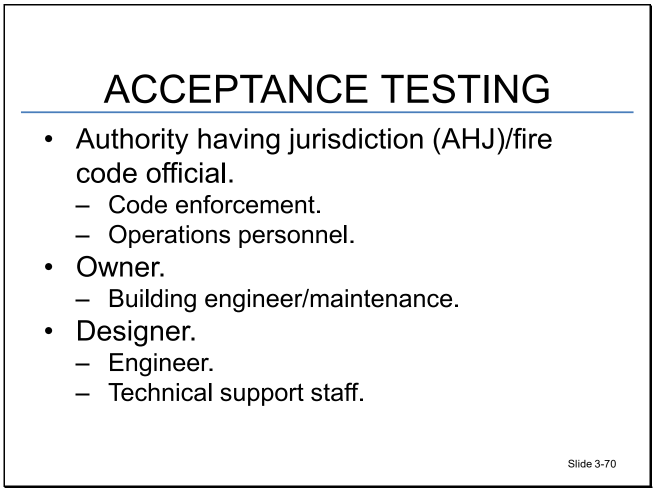
B. Operational testing.

1. Prior to beginning acceptance testing, all building equipment should be placed in the normal operating mode, including equipment that is not used to implement smoke control, such as toilet exhaust, elevator shaft vents, elevator machine room fans and similar systems.





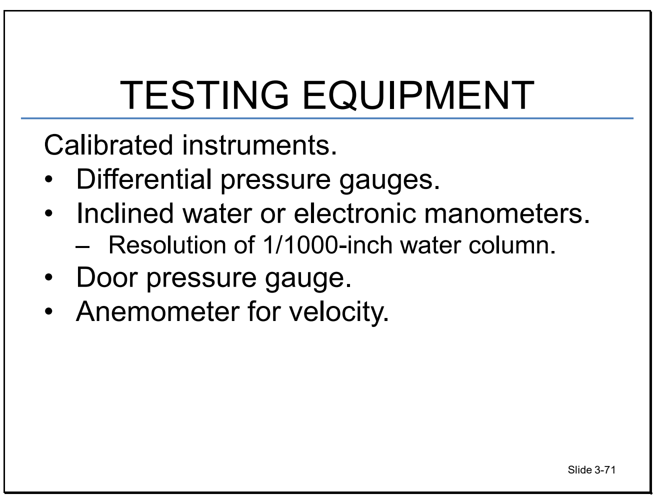
2. Operational testing (subsystems).



C. Acceptance testing.

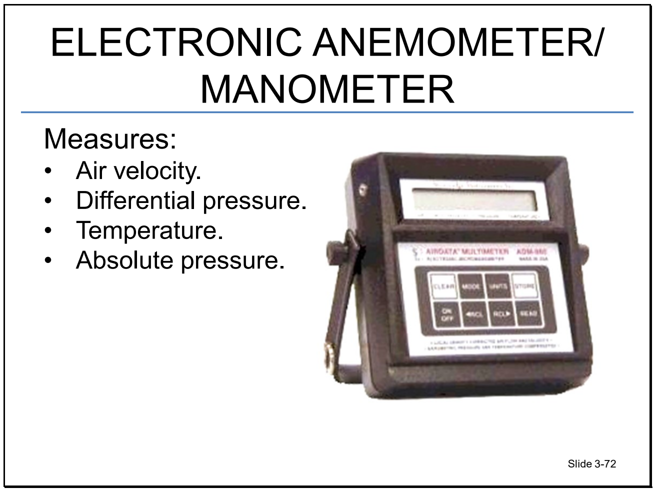
1. It is recommended that the building owner and building designer share their objective and design criteria for smoke control with the approving agency at the planning stage of the project. The design criteria should include a procedure for acceptance testing.

2. Contract documents should include operational procedures so that all parties, including fire code officials, owners, designers (including engineers and technical support) and installers, have a clear understanding of the system objectives and the testing procedure.



D. Testing equipment.

Calibrated instruments to read pressure difference: differential pressure gauges, inclined water manometers or electronic manometers.

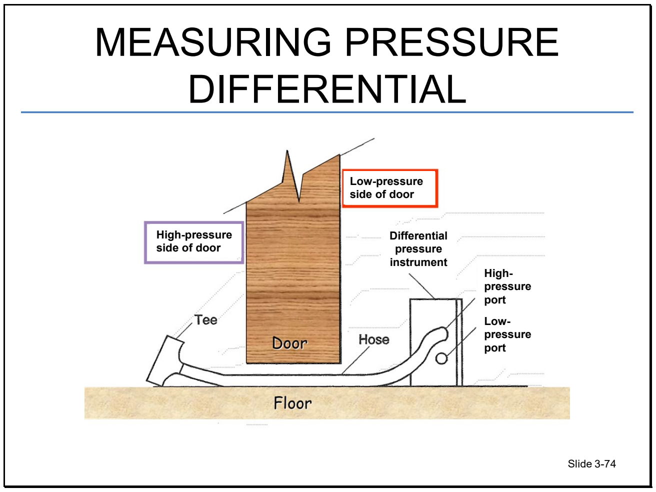


1. Electronic anemometer/manometer.

   a. **Anemometer:** measuring and indicating the force or speed and sometimes direction of wind.

   b. **Manometer:** an instrument (such as a pressure gauge) for measuring the pressure of gases and vapors.

2. Hand-held anemometers.



3. Measuring pressure differential.

Means of measuring pressure differential across a doorway.

TEST PROCEDURES

- All building equipment in normal operating mode:
  - Elevators.
  - Shaft vents.
  - Toilet vents.
  - Commercial cooking equipment.

Slide 3-75

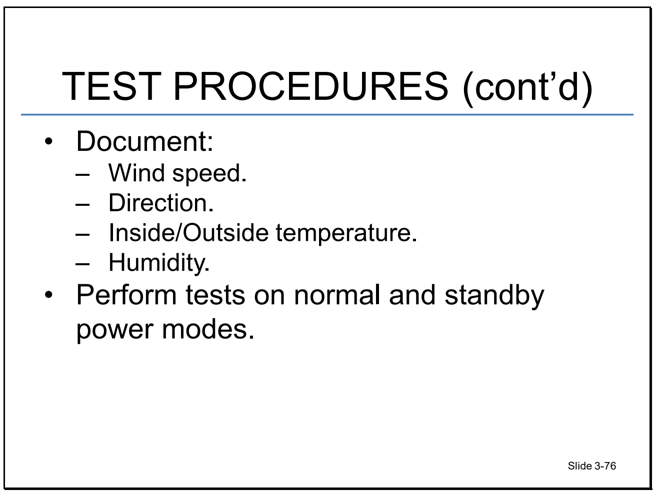
E. Test procedures.

1. The dynamics of the fire plume, buoyancy forces and stratification are all major critical elements in the design of the smoke management system. Therefore, to test the system properly, a real fire condition would be the most appropriate and meaningful test. But there are many valid reasons why such a fire is usually not practical in a completed building.

2. Open flame/actual fire testing may be dangerous and should not normally be attempted. Any other test is a compromise.

3. If a test of the smoke management system for building acceptance is mandated by the approving agency, such a test condition would become the basis of design and may not in any way simulate a real fire condition. More importantly, it could be a deception and provide a false sense of security that the smoke management system would perform adequately in a real fire emergency. Smoke bomb tests do not provide the heat, buoyancy and entrainment of a real fire and are not useful to evaluate the real performance of the system. A system designed and capable of providing the intended smoke management might not pass smoke bomb tests.

4. Conversely, it is possible for a system that is incapable of providing the intended smoke management to pass smoke bomb tests.



5. Wind speed, wind direction, outside temperature and humidity should be recorded on each test day.

6. If standby power has been provided for the operation of the smoke control system, the acceptance testing should be conducted on both normal and standby power. Disconnect the normal building power at the main service disconnect to simulate true operating conditions in this mode.

7. The system should be tested semiannually by persons who are thoroughly knowledgeable in the operation, testing and maintenance of the systems. The results of the tests should be documented in the operations and maintenance log and made available for inspection.

TEST PROCEDURES (cont'd)

- Verify operating sequence:
  - Normal mode.
  - Automatic mode on first alarm.
  - Manual override of normal and automatic modes.
  - Return to normal.

Slide 3-77

8. The smoke management system should be operated for each sequence in the current design criteria. The operation of the correct outputs for each given input should be observed. Tests also should be conducted under standby power, if applicable.

TEST PROCEDURES (STAIRS)

If stairwell pressurization is only means of smoke management:

- Normal HVAC operation and record pressure on both sides of doors.
- Measure force needed to open doors.
- Verify proper activation on alarm.
- Repeat pressure measurements while on smoke management mode.
  - Compare door-opening forces.

Slide 3-78

9. Test procedures:

   a. Stairs.

TEST PROCEDURES (ZONED)

- Verify location of each zone and perimeter door openings.
  - Measure and record all pressure differences across zones that divide floors while HVAC in normal mode and smoke barrier doors closed.
- Verify activation of all equipment (automatic and manual).

Slide 3-79

TEST PROCEDURES (ZONED) (cont'd)

- Conduct fire alarm system tests of all detection devices to verify equipment operation.
- Document pressure differential on both sides of all barriers while in operating mode.

Slide 3-80

b. Zoned.

TEST PROCEDURES (ELEVATORS)

If hoistway pressurization is only smoke control in building:

- Verify activation of all devices (automatic and manual).
- Measure and record pressures on both sides of doors with elevator doors closed.

Slide 3-81

c. Elevators.

PRIOR TO THE CERTIFICATE OF OCCUPANCY

IBC requires that prior to the issuance of the certificate of occupancy on any building that has smoke control, the fire department conduct familiarization tours.

Slide 3-82

F. Certificate of occupancy.

VII. DOCUMENTATION REVIEW

A. All aspects of the system design should be documented in a manner acceptable to the fire code official. It is important that sufficient justification is available to support the design parameters and effective results of the smoke management system.

B. The engineering standards, calculation methods and other forms of scientific information are important to address the particular application and methodologies used. The sources, methodologies and data used in system designs should be based on technical references that are widely accepted and used by the appropriate professions and professional groups.

C. This acceptance is often based on documents that are developed, reviewed and validated under standards developed under an open consensus process conducted by recognized professional societies, codes or standards organizations, or governmental bodies, such as NFPA 92, IBC Section 909, or other resource publications, such as “SFPE Handbook of Fire Protection Engineering,” which are widely recognized technical sources of information.

D. Proper documentation will also ensure that all parties involved understand the factors necessary for the implementation, maintenance and continuity of the system design parameters.

E. Details on required inspection, testing and maintenance performed on the system should all be a part of the permanent record for that system, and maintained by the property owner or designated representative in a location, and for a time period, which is acceptable to the fire code official.

F. The maintenance of complete documentation is also necessary for required reevaluation and reapproval in cases of remodeling, modification, renovation or change in use to the structure which might impact the original design parameters for the system.

VIII. CASE STUDY

VIDEO PRESENTATION

"NFA VIRTUAL SMOKE SIMULATION"

Slide 3-83

LACK'S WAREHOUSE

- Large rack storage facility.
- 380,000 square feet.
- Mechanical smoke control: large fans on roof — dedicated system.
- Acceptance testing was conducted using "hot smoke."
- Smoke generators used a gas-fired burner to heat the "smoke" from smoke bombs and generated 80,000 cubic feet per minute (cfm).

Slide 3-84

LACK'S WAREHOUSE (cont'd)

- Smoke temperature approximately 400 F.
- System was designed and intended to assist fire department in smoke removal.
- Not intended to be a life safety system for occupants.
- System was activated by water flow in sprinkler system.
- Controls provided for fire department to manually operate system.

Slide 3-85

Lack's Warehouse.

IX. SUMMARY

SUMMARY

- Overview.
- Passive smoke control.
- Mechanical smoke control systems.
- Smoke control in buildings.
- Fire command/control stations.
- Required inspections, tests and maintenance.
- Documentation review.
- Case study.

Slide 3-86

QUESTIONS?

Slide 3-87

REFERENCES

ICC. (2015). *International building code*. Washington, DC: Author.

ICC. (2015). *International fire code*. Washington, DC: Author.

NFPA. (2012). *Standard for smoke control systems*. (Standard No. 92). Retrieved from www.nfpa.org

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UNIT 4: AUTOMATIC FIRE SPRINKLERS

TERMINAL OBJECTIVE

The students will be able to:

4.1 Evaluate if automatic sprinkler systems and equipment are operational, adequate, maintained and tested.

ENABLING OBJECTIVES

The students will be able to:

4.1 Identify the applicable standards for automatic sprinkler systems.

4.2 Explain the functions of automatic sprinkler systems and equipment.

4.3 Explain the in-service testing process for automatic sprinkler systems.

4.4 Explain the annual inspection and maintenance processes for automatic sprinkler systems.

4.5 Analyze automatic sprinkler systems test documentation for accuracy, completeness and code compliance.

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FEMA

U.S. Fire Administration

UNIT 4: AUTOMATIC FIRE SPRINKLERS

Slide 4-1

TERMINAL OBJECTIVE

Evaluate if automatic sprinkler systems and equipment are operational, adequate, maintained and tested.

Slide 4-2

ENABLING OBJECTIVES

- Identify the applicable standards for automatic sprinkler systems.
- Explain the functions of automatic sprinkler systems and equipment.
- Explain the in-service testing process for automatic sprinkler systems.

Slide 4-3

ENABLING OBJECTIVES (cont'd)

- Explain the annual inspection and maintenance processes for automatic sprinkler systems.
- Analyze automatic sprinkler systems test documentation for accuracy, completeness and code compliance.

Slide 4-4

I. INTRODUCTION

A. The fire inspector plays an important part in enhancing the reliability of fire protection systems and equipment. While manufacturers, designers and engineers work together to create systems to protect a broad range of hazards, it is often up to the fire inspector to ensure that the finished product meets national standards and the designer's plan. Once the systems or equipment are installed, it is up to the fire inspector to ensure that they remain in an operable condition.

B. There are at least seven phases in a project where the fire inspector has the opportunity to influence the outcome.

1. The first occurs during the plans review or permit phase, where the inspector verifies that the system and equipment designs are in compliance with the nationally recognized standards (such as National Fire Protection Association (NFPA) 13, *Standard for the Installation of Sprinkler Systems*), the listing documents to make certain the product or system has been evaluated, or the manufacturer's requirements for design suitability.

2. The fire inspector must verify the work is being installed in accordance with the approved plans and specifications.

3. The fire inspector likely is involved in system commissioning or acceptance testing.

4. It may be up to the fire inspector to determine what an acceptable test is and what constitutes successful passage of that test.

5. Once the building or facility is occupied, the fire inspector conducts periodic inspections — visual checks that verify whether the systems and equipment are in place, appear to be operational and have been serviced as required.

6. All fire protection systems require periodic testing to verify their operational readiness. Testing is a task normally conducted by a third-party service, such as a fire protection systems contractor, that exercises the operational components of the fire protection systems to ensure that they are operational.

7. Any fire protection system is only as good as its regular maintenance. Just like manufacturers encourage us to change the oil and rotate the tires on our vehicles, fire protection systems need periodic tune-ups as well.

BASIC PHILOSOPHY

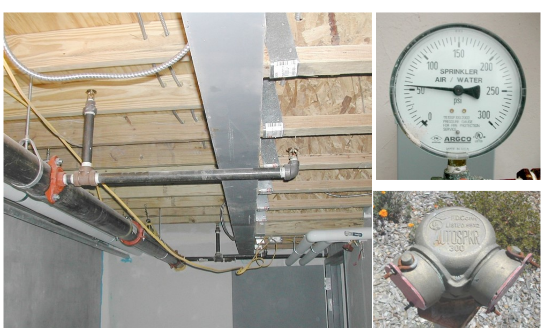
To understand how different types of sprinkler valves operate and therefore be able to properly identify individual components and their operational status.

Slide 4-5

C. Basic philosophy.

II. AUTOMATIC SPRINKLER SYSTEMS

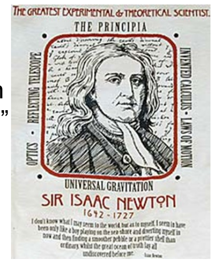
AUTOMATIC SPRINKLER SYSTEMS



Slide 4-6

NATURAL ORDER

- Newton's third law of motion.
  - "For every action, there is an equal and opposite reaction."
- The first law of codes and standards.
  - "For every rule, there's an exception."
- Training will emphasize the general rules and applications of fire sprinkler design.



Slide 4-7

SPRINKLER SYSTEM PURPOSE

- Sprinkler systems are designed to **control** or **contain** the fire to its room or area of origin, or accomplish fire **suppression** and **extinguishment.**
- The performance of the system is based on the design, such as an Early Suppression Fast Response (ESFR) system.

Slide 4-8

A. Sprinkler system purpose.

Sprinkler systems have two main purposes: to protect life and to protect property. They accomplish this by controlling or extinguishing unwanted fires. When connected to an approved fire alarm system, sprinkler systems provide the added benefit of acting as initiating devices to activate the fire alarm system.

NATIONAL FIRE PROTECTION ASSOCIATION 13

- Primarily property protection.
- Complete coverage.
- Water supply based on hazard classification.
  - System demand.
  - Hose streams.

Slide 4-9

B. Sprinkler system standards.

1. NFPA 13-designed systems are intended to protect property. A building protected by a system designed in accordance with NFPA 13 is presumed to have sprinklers in all spaces (with some special exceptions). This assumption allows the sprinkler system to be used as a "substitute" for certain fire-resistive construction features.

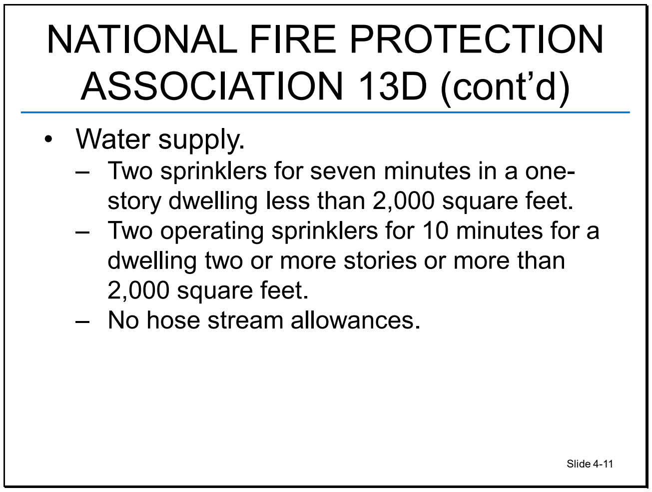
   The water supply for an NFPA 13-designed system is required to be adequate for operating the sprinkler system and to provide water for the fire suppression forces when they arrive.

NATIONAL FIRE PROTECTION ASSOCIATION 13D

- Life safety.
  - Omission from low-risk areas.
    - -- Bathrooms.
    - -- Unused attics.
    - -- Closets.
    - -- Open, attached balconies and porches.

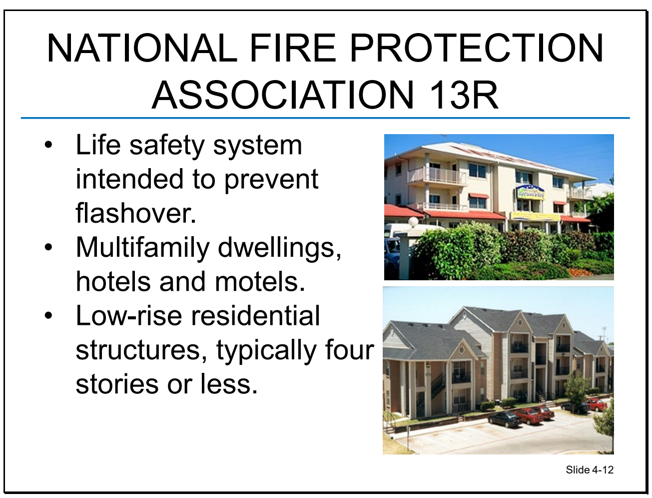
Slide 4-10

2. NFPA 13D, *Standard for the Installation of Sprinkler Systems in One-and Two-Family Dwellings and Manufactured Homes*, was developed to address life safety issues in these structures. In order to encourage homeowners to install systems at lower costs, NFPA 13D allows omissions from areas where the likelihood of fatal fires occurring is statistically insignificant. Thus, sprinklers may be omitted from unused attics, small closets, small bathrooms, garages and exterior balconies.



The water supply for an NFPA 13D system requires only enough to operate two sprinklers for seven minutes in a one-story dwelling less than 2,000 square feet and two operating sprinklers for 10 minutes for a dwelling two or more stories or more than 2,000 square feet — long enough to get occupants out of the structure. There is no requirement for fire suppression water supplies. Since NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies*, and NFPA 13D design systems are life safety systems only, their use is limited to dwelling occupancies.

3. NFPA 13R was produced in 1989 to address low-cost sprinkler applications for low-rise multifamily dwellings.



a. The NFPA 13R design goal has nothing to do with property protection. A system installed in accordance with this standard is intended to prevent flashover in the room where a fire begins, alert building occupants and give them adequate time to escape. It is designed solely as a life safety system.

b. Since property protection is not an issue, the standard requires sprinkler protection only in those areas where — according to national fire loss statistics — fatal dwelling fires are most likely to begin. Low-risk areas do not require sprinkler protection. This includes unused attics, small bathrooms and closets, garages, and exterior exit balconies.

NATIONAL FIRE PROTECTION ASSOCIATION 13R (cont'd)

- Water supply.
  - Four operating sprinklers for 30 minutes.
  - No hose stream allowances.

Slide 4-13

c. The water supply for an NFPA 13R design system only has to supply four operating sprinklers for 30 minutes. There is no requirement for a fire suppression water supply.

SPRINKLER SYSTEM STANDARDS

- National Fire Protection Association (NFPA) 13, *Standard for the Installation of Sprinkler Systems*, standards cover:
  - Planning.
  - Design.
  - Materials.
  - Components.
  - Installation practices used.

Slide 4-14

SPRINKLER SYSTEM STANDARDS (cont'd)

- Requirements may include:
  - Sprinkler head spacing.
  - Pipe sizing.
  - Pipe hanging methods.
  - Minimum design area.

Slide 4-15

III. SPRINKLER HAZARD CLASSES

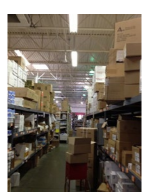
SPRINKLER HAZARD CLASSES

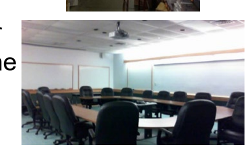
- NFPA 13 assigns fire risks to various hazard classes.
- Primarily content based.
- Based on:
  - Contents' rate of heat release.
  - Total heat of combustion.
  - Control or extinguishment challenge **in incipient stage.**

Slide 4-16

SPRINKLER HAZARD CLASSES (cont'd)

- Established on two primary factors.
  - Potential fire severity (heat release rate (HRR)).
  - Latent heat potential: total fuel available.
- Selected by the project design team and/or sprinkler designer and approved by the authority having jurisdiction (AHJ).





Slide 4-17

A. In addition to providing an approved sprinkler system complete with the required water supply source, it is important to assure that a sufficient quantity of water and duration is also available. The quantity and duration are based on the fire control challenges within the property.

B. The factors that influence water supply requirements include:

1. Quantity and combustibility of contents.

2. Expected heat release rates (HRRs).

3. Total potential for energy release.

4. Storage height and potential obstructions.

5. Presence of flammable and combustible liquids.

SPRINKLER HAZARD CLASSES (cont'd)

- Light hazard.
- Ordinary hazard (Group 1).
- Ordinary hazard (Group 2).
- Extra hazard (Group 1).
- Extra hazard (Group 2).

Slide 4-18

C. A building may have one or more occupancy hazard classifications within it. It is important for the inspector to realize that these categories are fairly subjective.

D. It is also important that the inspector realizes that the sample occupancies described in NFPA 13 for each hazard class are only representative and not absolute. For example, a museum is classified in NFPA 13 as light hazard, but what if the museum is storing and displaying highly combustible materials such as fabric wall hangings? The code official should help classify the occupancy based on realistic fire hazards rather than a broad category.

E. When conducting an inspection and evaluating the water supply of an existing sprinkler system, it is essential that the fire inspector verify that the occupancy hazard classification has not increased or conditions have changed that create additional fire hazards. These changes may require that the fire protection water supply be increased to compensate for the increased risk.

LIGHT HAZARD

- Low.
  - Amount of combustibles.
  - Low HRRs.
- Facilities such as:
  - Churches.
  - Offices.
  - Clubs.
  - Museums
  - Schools.
  - Residential.

Slide 4-19

1. Light hazard.

ORDINARY HAZARD GROUP 1

- Moderate.
  - HRRs.
  - Amount of combustibles.
  - Storage less than 8 feet high.
- Facilities such as:
  - Automobile parking and showrooms.
  - Bakeries.
  - Laundries.
  - Commercial kitchens.
  - Electronics plants.

Slide 4-20

2. Ordinary hazard (Group 1).

ORDINARY HAZARD GROUP 2

- Moderate.
  - HRRs.
  - Amount of combustibles.
  - Storage less than 12 feet high.
- Facilities such as:
  - Cold storage warehouses.
  - Mercantile.
  - Paper processing plants.
  - Repair garages.
  - Warehouses.

Slide 4-21

3. Ordinary hazard (Group 2).

EXTRA HAZARD GROUP 1

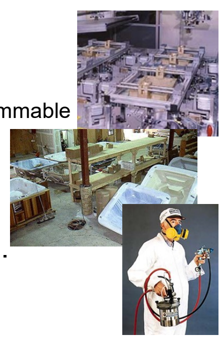
- High.
  - HRRs.
  - Amount of combustibles.
    - -- Little or no flammable or combustible liquids.
- Facilities such as:
  - Aircraft hangars.
  - Plywood plants.
  - Sawmills.
  - Textile.

Slide 4-22

4. Extra hazard (Group 1).

EXTRA HAZARD GROUP 2

- High.
  - HRRs.
  - Amount of combustibles.
    - -- Moderate to substantial flammable or combustible liquids.
    - -- Extensive combustible shielding.
- Facilities such as:
  - Flammable liquid spraying.
  - Flow coating.
  - Plastics processing.



Slide 4-23

5. Extra hazard (Group 2).

IV. COMMODITY CLASSIFICATIONS

COMMODITY CLASSIFICATIONS

- Commodity classification is governed by the types and amounts of materials (e.g., metal, paper, wood, plastics) that are a part of a product and its primary packaging.
- However, in a storage or warehousing situation, classification is also affected by such factors as the primary storage or shipping container material, the amount of air space, and the location.

Slide 4-24

CLASS I COMMODITY

- A noncombustible product that meets one of the following criteria:
  - Placed directly on wood pallets.
  - Placed in single-layer corrugated cartons, with or without single-thickness cardboard dividers, with or without pallets.
  - Shrink-wrapped or paper-wrapped as a unit load, with or without pallets.

Slide 4-25

CLASS I COMMODITY (cont'd)

- Examples:
  - Empty glass bottles or jars in a carton.
  - Canned foods in an ordinary carton.
  - Bags of cement.
  - Ice cream.
  - Cartoned metal cans of latex paint.
  - Metal filing cabinets in cardboard.
  - Major appliances, no carton.
  - Frozen fish in nonwaxed packaging.

Slide 4-26

A. Class I commodity.

CLASS II COMMODITY

- A noncombustible product that is in slatted wooden crates, solid wood boxes, multiple-layered corrugated cartons or equivalent combustible packaging material, with or without pallets.

Slide 4-27

CLASS II COMMODITY (cont'd)

- Examples:
  - Major appliances in corrugated carton.
  - Artificial stone sinks and countertops in cartons or crated.
  - Frozen baked goods in cartons.
  - Frozen fish in waxed paper containers in cartons.

Slide 4-28

B. Class II commodity.

CLASS III COMMODITY

- A product fashioned from wood, paper, natural fibers or Group C plastics, with or without cartons, boxes or crates, and with or without pallets. Class III commodities can contain a limited amount (5% by weight or volume or less) of Group A or Group B plastics.

Slide 4-29

CLASS III COMMODITY (cont'd)

- Examples:
  - Fresh baked goods in cartons.
  - Frozen fish in plastic trays, cartoned.
  - Cotton or linen diapers.
  - Medium or heavyweight rolled paper stored on the side or in racks.
  - Baled natural fiber rags.

Slide 4-30

C. Class III commodity.

CLASS IV COMMODITY

- A product, with or without pallets, that meets one of the following criteria:
  - Constructed partially or totally of Group B plastics.
  - Consists of free-flowing Group A plastic materials.
  - Contains within itself or its packaging an appreciable amount (5% to 15% by weight or 5% to 25% by volume) of Group A plastics.

Slide 4-31

CLASS IV COMMODITY (cont'd)

- Examples:
  - Disposable diapers containing plastics and nonwoven fabric (fluff) in cartons.
  - Baled synthetic fiber rags.
  - Lightweight rolled paper in racks.
  - Cartoned nail polish in 1- to 2-ounce glass bottles.
  - Vinyl floor tiles in cartons.

Slide 4-32

D. Class IV commodity.

PLASTICS, ELASTOMERS AND RUBBER

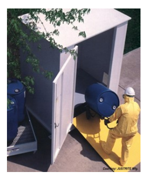
- Plastics, elastomers and rubber are classified as Group A, B or C plastics.
- Group A subcategories: expanded or unexpanded.
- Expanded Group A is the highest challenge.
- Group C is a similar hazard to wood or paper.

Slide 4-33

E. Plastics, elastomers and rubber.

PLASTIC FORMS

- Unexpanded plastics (solid, high density).
  - Polyethylene drums.
  - Polystyrene tote bins.
  - Polypropylene rope.
- Expanded plastics (injected with air to make "foam plastics").
  - Polystyrene cups.
  - Foam packing "peanuts."



Slide 4-34

Plastic forms.

SPECIAL HAZARDS

- Tire storage.
- High-piled or rack storage.
- Hyperbaric chambers.
- Piers, docks and wharves.
- Aerosol manufacture and storage.
- Racetracks and stables.
  - Other NFPA standards contain sprinkler system design criteria for fire control or suppression of specific hazards.

Slide 4-35

F. Special hazards.

INSPECTOR'S ROLE

- Verify that hazard classification has not increased.
  - Identify changes that may overwhelm sprinkler design.
- Verify that water supplies remain adequate for fire control or extinguishment.

Slide 4-36

G. Inspector's role.

V. FIRE DEPARTMENT CONNECTIONS

FIRE DEPARTMENT CONNECTION REQUIREMENTS

- Physical location is specified by the AHJ.
- Sized according to demand of system.
- Properly identified and connected.
- Compatible threads/ connection method.

Slide 4-37

FIRE DEPARTMENT CONNECTION REQUIREMENTS (cont'd)

- Caps must be provided and kept in place.
- Provided with check valve and ball drip.
- On all NFPA systems except:
  - Remote areas inaccessible to fire department.
  - Large capacity systems.
  - Single-story buildings not exceeding 2,000 square feet.

Slide 4-38

A fire department connection is not an automatic source as it clearly requires human action to initiate the flow. The fire department can flow water into the connection to provide both flow and pressure to the system. Fire department connections usually are a secondary water source.

VI. CLASSIFICATIONS OF SPRINKLER SYSTEMS

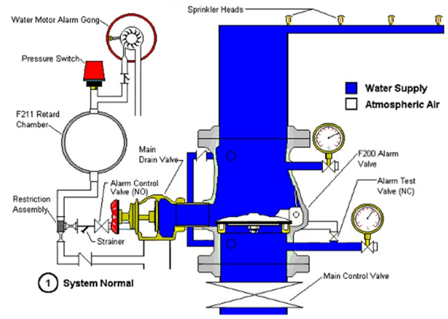
WET PIPE SPRINKLER SYSTEM

- Most common type.
- Above ground piping contains water under pressure.
- Closed sprinkler heads which operate individually.
- When head operates, water is discharged immediately.

Slide 4-39

A. Wet pipe systems use closed automatic sprinklers attached to a piping system containing water under pressure at all times. The wet pipe system is the most common type of sprinkler system and generally is used unless there is danger of the water in the pipes freezing or when other special conditions require one of the other types of systems.

WET PIPE SPRINKLER SYSTEM (cont'd)



F200 Alarm Valve

Slide 4-40

ALARM CHECK VALVE

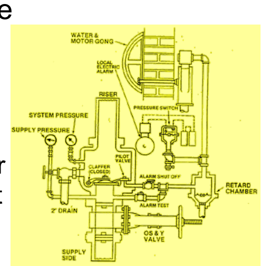
- Incoming water pressure lifts main clapper valve.
- Two gauges.
  - Upper shows system pressure.
  - Lower shows incoming water pressure.

Slide 4-41

1. Alarm check valve.

ALARM CHECK VALVE (cont'd)

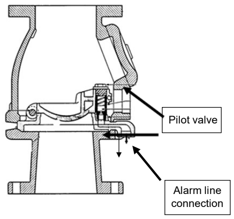
- When water flows in the system.
  - Clapper raises up off the seat.
  - Water flows from the supply into the sprinkler piping and out the "pilot valve" to the alarm line and water flow device.

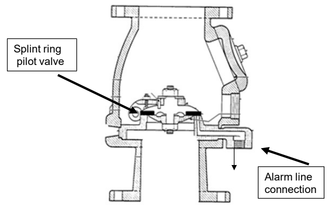


Slide 4-42

CLAPPER VALVE

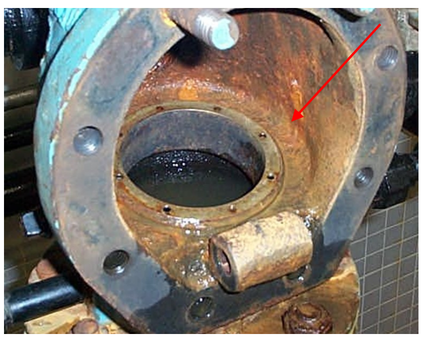
Traditional pilot valve | Split ring pilot valve





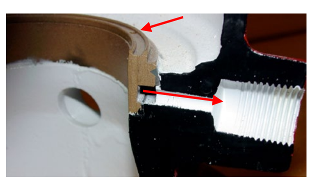
Slide 4-43

SPLIT RING TYPE PILOT VALVE



Slide 4-44

CLAPPER VALVE (cont'd)



Slide 4-45

The clapper valve could actually be called an alarm-initiating device. When the clapper rises up off the seat, water not only can flow into the overhead piping, but flow out of the alarm valve through a "pilot" valve and into the alarm line. Water flowing through the pilot valve goes to the alarm line connection. The alarm line is simply a 1/2-inch pipe that carries water from the pilot valve to the water motor gong or pressure switch.

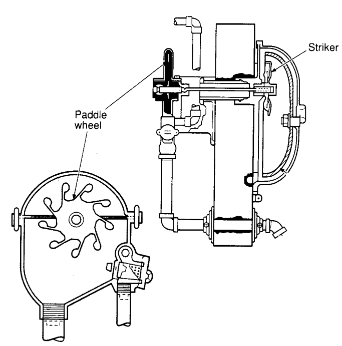
WATER FLOW DEVICES

- Water motor gong.
- Pressure switch.
- Flow switch.
- NFPA 13 requires local alarm on any system with 20 or more sprinklers.

Slide 4-46

2. Water flow devices.

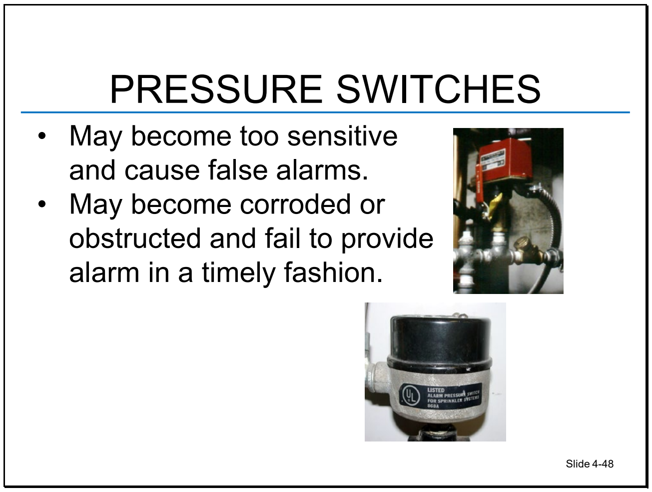
WATER MOTOR GONG



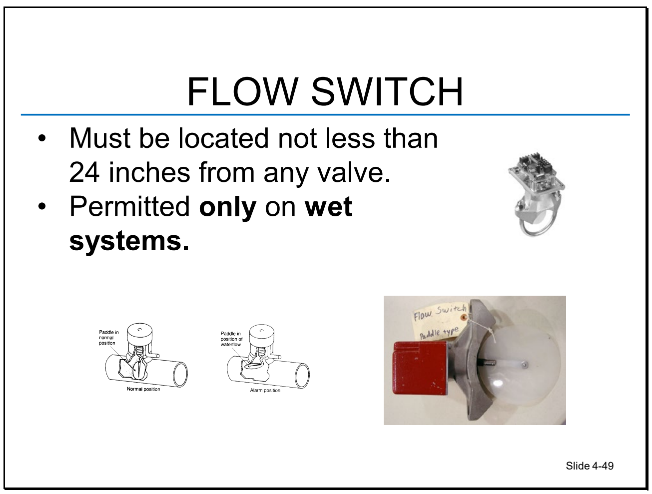
Slide 4-47

a. Water motor gong.

- Each sprinkler system must be provided with a water flow alarm or device. Historically, this device is a water motor gong that is simply a water-driven mechanical device. Some alarm lines may also be provided with a pressure switch to either activate an electric bell or provide a connection to the building's fire alarm system.



b. Pressure switches.



c. Flow switch.

- Flow switches are also known as vane or paddle switches. These types of devices are mounted directly to the sprinkler riser or piping. Water flow within the pipe causes a paddle or vane connected via a shaft to an electric switch. Water flow switches are designed so that the time between the beginning of the water flow and the closing of the switch and sounding of an alarm is adjustable. Flow switches can only be used on wet pipe systems.

CUTOUTS

- Washers, coupons, slugs.
- Hole cut with special drill.
- Installer must account for all cutouts.

Slide 4-50

3. Cutouts.

TIME FOR ALARM SIGNAL

- Time is the maximum permitted before the flow of one sprinkler causes an alarm signal.
- NFPA 13 permits a maximum of five minutes.
- NFPA 72, *National Fire Alarm and Signaling Code*®, requires alarm signal within 90 seconds.

Slide 4-51

4. Time for alarm signal.

NFPA 13 requires a local water flow alarm on any system with 20 or more sprinklers. Different requirements may be contained in the model building and fire codes. Under the provisions of NFPA 13, the maximum time for the sounding of the water flow alarm is five minutes. This is the time permitted before the flow of one sprinkler causes an alarm signal. If a fire alarm system is present, whether it is a required system or not, the maximum time permitted under the provisions of NFPA 72, *National Fire Alarm and Signaling Code*®, is 90 seconds.

ALARM SHUT-OFF

- Located in the alarm line.
- Used to silence the alarm during maintenance or fire conditions.
- Shut-off is normally open and is required to be supervised.

Slide 4-52

5. Alarm shut-off.

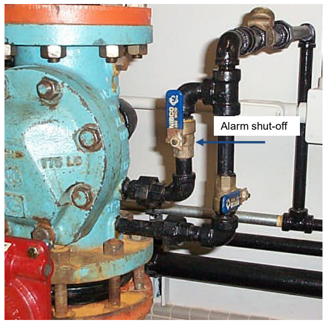
   a. The alarm shut-off is simply a valve in the alarm line piping that, when closed, prevents water from reaching the alarm device. The alarm shut-off would be used to silence the alarm device during fire conditions or to prevent sounding an alarm during testing or maintenance procedures.

SUPERVISION OF ALARM SHUT-OFF

- If not properly supervised, the closing of the valve may prevent an alarm from being initiated under fire conditions.
- NFPA 13 permits locking, sealing or tamper switch.
- NFPA 72 permits only tamper switch.

Slide 4-53

ALARM SHUT-OFF (cont'd)

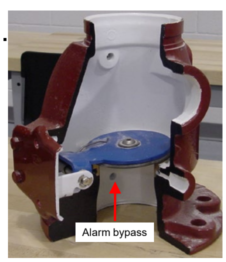


Slide 4-54

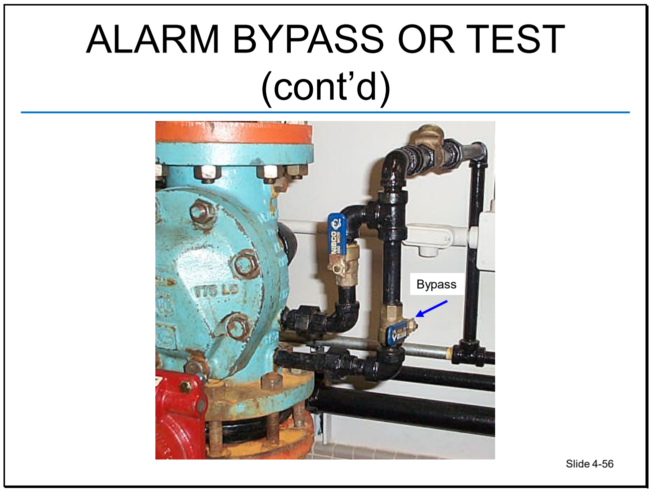
b. Because the alarm shut-off can prevent water from reaching the alarm device, the provisions of both NFPA 13 and NFPA 72 require that this valve be supervised. Under the provisions of NFPA 13, this supervision may be accomplished by either locking or sealing the valve in an open position. If a fire alarm system is present, whether it is a required system or not, supervision of this valve must be a tamper switch.

ALARM BYPASS OR TEST

- Used to test functional status of water flow device.
- Takes water from supply side of clapper.
- Bypass valve is normally closed and is not required to be supervised.

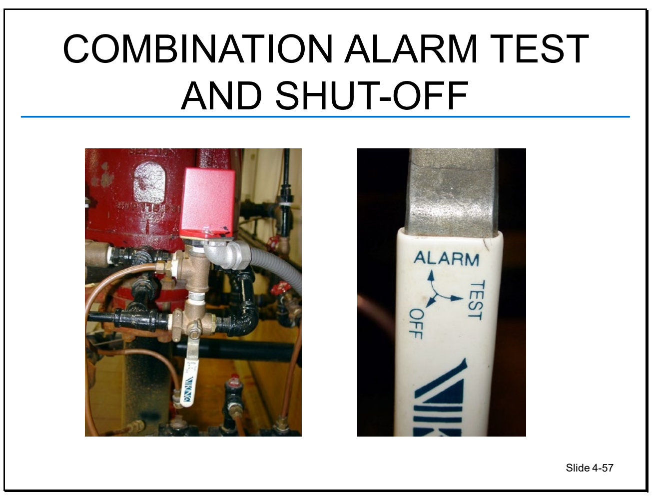


Slide 4-55



6. Alarm bypass or test.

In order to test the water flow device, an alarm test or bypass must be provided. The alarm bypass or test valve is connected to the sprinkler piping or riser on the supply side of the sprinkler valve. Opening this valve allows water from the supply to flow into the alarm line piping, thus testing the functional status of the alarm. This valve is not required to be supervised.



7. Combination alarm test and shut-off.

RETARD DEVICES

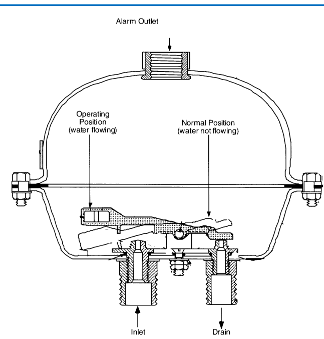
- When systems are connected to a water supply which is subject to pressure surges, retarding devices must be installed to reduce false alarms from surges.
- **Retard chambers are found on wet systems only.**
- Adjustable time delay in flow switches.

Slide 4-58

8. Retard devices.

NFPA 13 requires that any system that is subject to false alarms from water pressure surges be equipped with a retarding device. With the traditional wet pipe valve, the retarding device was a retard chamber. The retard chamber is simply a chamber placed in the alarm line such that it must first fill with water before the water flow alarm is sounded. Retard chambers are found only on wet pipe systems.

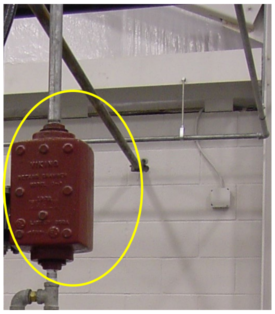
RETARD CHAMBER

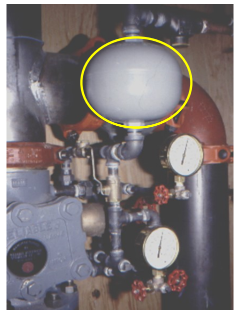


Slide 4-59

a. Retard chamber.

RETARD CHAMBER (cont'd)





Slide 4-60

PRESSURE SWITCH WITH RETARD

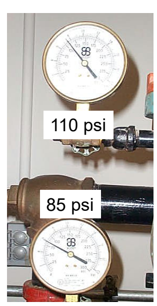
Eliminates need for retard chamber on wet system.

Slide 4-61

b. Pressure switch with retard.

PRESSURE GAUGES ON WET SYSTEM

- Two pressure gauges.
  - One above the clapper on the system side and one on the supply side.
- Normal for top gauge to read higher than bottom gauge.
- Residual pressure from surges trapped above clapper.



Slide 4-62

9. Pressure gauges.

When an alarm valve or riser check valve is present, two pressure gauges are required. One of these gauges is above the clapper on the system side, and the other is below the clapper on the supply side. Because the clapper is free, any pressure surges on the system will cause the clapper to rise up, allowing the surge pressure into the overhead piping system. When the surge condition is no longer present, the clapper will again drop back down into the closed position; however, some of the surge pressure will become trapped on the system side. Because of this, it is quite normal for the top pressure gauge to read higher than the lower gauge.

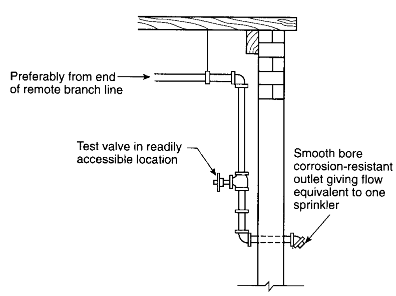
LOCATION OF ALARM/ INSPECTOR'S TEST

- Alarm test is located at the riser (only required when a wet alarm valve is used).
- NFPA 13 requires an additional inspector's test, but does not specify where the valve is to be located.
- Location can be determined by AHJ.
- Should be located in remote area.
- Remote location recognized by NFPA 13, Annex A.
- How to cheat the test: Leave out the orifice.

Slide 4-63

10. Location of alarm/inspector's test.

INSPECTOR TEST CONNECTION



Slide 4-64

INSPECTOR TEST CONNECTION (cont'd)

Slide 4-65

SHOTGUN RISER

- NFPA 13 issued formal interpretation in 1983 which allows use of flow switch in lieu of alarm valve.
- Has all components necessary for a wet riser.

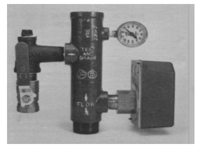
Slide 4-66

11. Shotgun riser.

Wet pipe risers can be installed without the use of the traditional wet pipe alarm valve. These risers use a flow switch as the water flow device. In addition to the flow switch, the riser will be equipped with a control valve, main drain, and pressure gauge and alarm/inspector's test.

RISER MANIFOLD

- Preassembled.
- Sizes up to four inches.
- Metal and chlorinated polyvinyl chloride (CPVC).



Slide 4-67

12. Riser manifold.

Some manufacturer's market "manifolds" which are used to install shotgun risers. These manifolds are metal and chlorinated polyvinyl chloride (CPVC) pipe assemblies with connection for the flow switch, drain and test connection. In most cases, the assembly comes with the flow switch, drain valve and test valve attached.

ACTIVITY 4.1

Sprinkler System Documentation

Purpose

Reinforce analytical skills required to review documentation and identify code violations.

Directions

1. Work in your table groups to review Handout 4-1: Automatic Sprinkler Systems — General Information and Annual Inspection, Testing, and Maintenance Report (Includes Wet Systems) for years 2013, 2014 and 2015.

2. Identify any code violations in comparing each of the three inspections.

3. Using NFPA 13 and NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, you will have 30 minutes to evaluate the documentation and research the applicable codes.

4. Be prepared to report on your findings, including applicable code citations, to the class.

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ACTIVITY 4.1 (cont'd)

Worksheet

Suggested responses:

1. Code violation: ______________________________

____

____

Applicable code: ______________________________

____

____

2. Code violation: ______________________________

____

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Applicable code: ______________________________

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3. Code violation: ______________________________

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Applicable code: ______________________________

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4. Code violation: ______________________________

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Applicable code: ______________________________

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5. Code violation: ______________________________

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Applicable code: ______________________________

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6. Code violation: ______________________________

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Applicable code: ______________________________

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7. Code violation: ______________________________

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Applicable code: ______________________________

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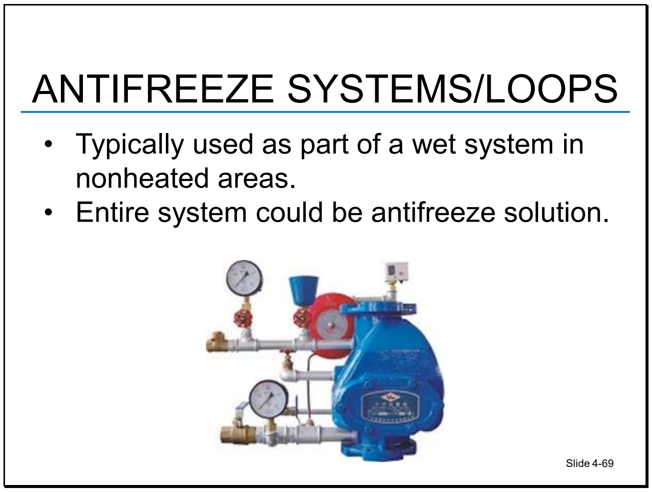
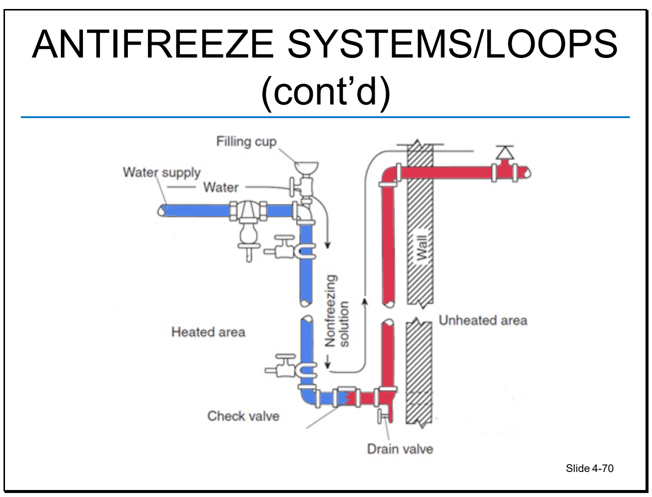
VI. CLASSIFICATIONS OF SPRINKLER SYSTEMS (cont'd)



B. Antifreeze systems/loops.

An antifreeze sprinkler system is a wet pipe sprinkler system that has automatic sprinklers attached to a piping system that contains an antifreeze solution and is connected to a water supply. Antifreeze solution is discharged, followed by water, immediately upon operation of sprinklers opened by the heat of a fire.



NEGLECTED SYSTEM

Slide 4-71

1. Neglected system.

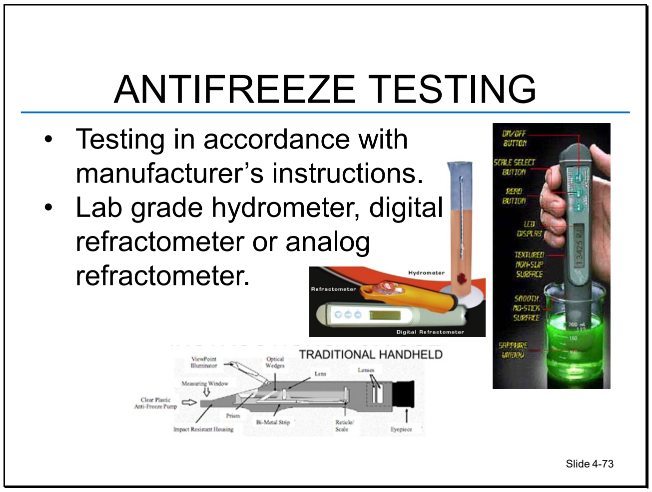
ANTIFREEZE TYPES

- Glycerin-based for use in all types of piping including CPVC.
- Propylene glycol (PG) for use in all types of piping except CPVC.

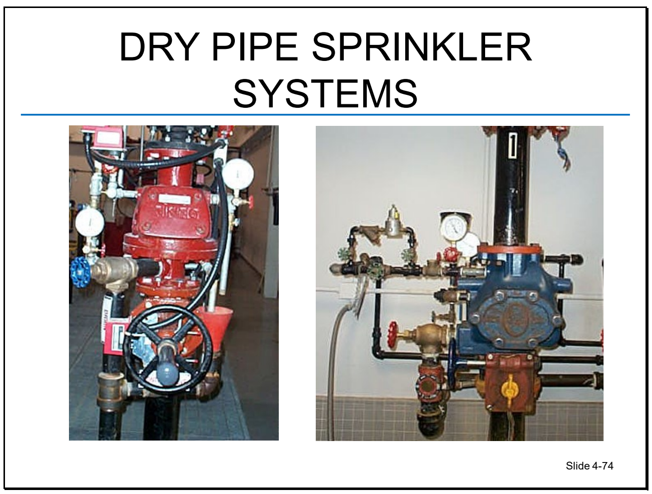
Slide 4-72

2. Antifreeze types.

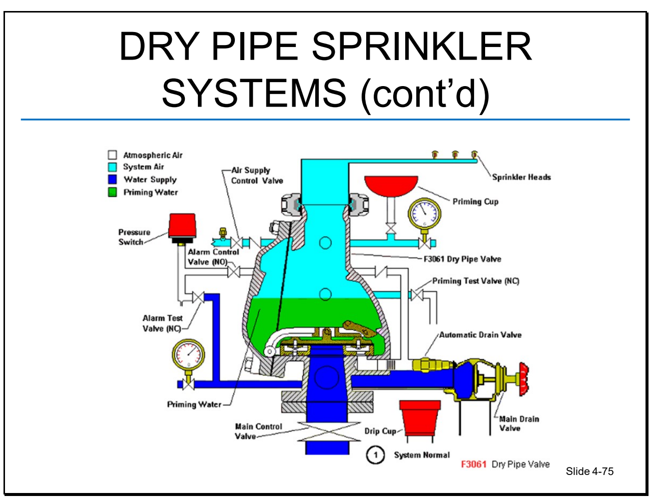
The percentages of antifreeze solutions needed for various temperatures are set forth in NFPA 13. The solution must be prepared with a freezing point below the expected minimum temperature for the locality.



3. Antifreeze testing.



C. Dry pipe sprinkler systems.



1. Dry pipe system components.

DRY PIPE SPRINKLER SYSTEMS (cont'd)

- Second most common type of system.
- Used where building is unheated or ambient temperature is kept below 40 F.
- Not to be used where building or space is normally heated.
- Overhead piping contains air under pressure.
- Connection to water supply source is kept open.

Slide 4-76

a. The second most common type of sprinkler system is the dry pipe. Dry pipe systems use closed sprinkler heads attached to a piping system containing air or nitrogen under pressure.

DRY PIPE SPRINKLER SYSTEMS (cont'd)

- The air pressure is reduced through fused sprinkler, and sprinkler valve opens allowing water to flow into the overhead piping and be discharged onto the fire.
- Because of the inherent delay in water application, dry pipe systems are not as efficient as wet systems.
- Valve room must be heated to minimum of 40 F — supervision required by NFPA 72.

Slide 4-77

b. The operation of a sprinkler head by the heat of a fire results in the release of the air pressure in the piping, thus allowing the water pressure to open up the dry pipe valve. Water then flows into the overhead piping and is discharged from the open sprinkler head(s). Because of the inherent delay in water application, dry pipe systems do not have the same degree of efficiency as wet pipe systems.

COMPONENTS

- Control valve, outside stem and yoke (OS&Y), butterfly.
- Dry pipe valve.
  - Purpose is to activate an alarm signal upon water flow and separate water supply source from air in overhead piping.

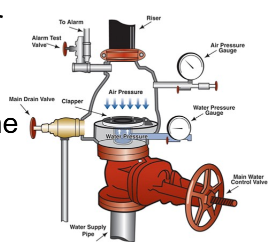
Slide 4-78

2. Individual components.

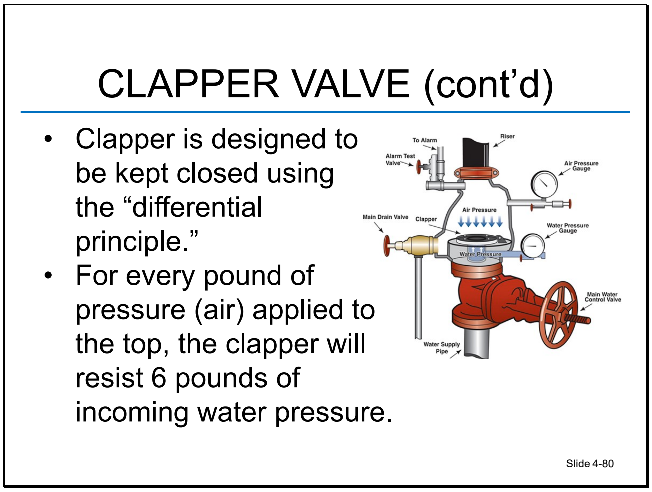
When the system has been activated and water begins flowing from the supply into the overhead piping, the clapper raises up mechanically and locks in an open position. When the clapper rises up off the seat, water not only can flow into the overhead piping but also can flow out of the alarm valve through an intermediate chamber. Water flowing through this chamber goes to the alarm line connection. The alarm line is simply a 1/2-inch pipe that carries water from the pilot valve to the water motor gong or pressure switch. On a dry pipe system, the alarm line will be equipped with an automatic ball drip to allow water to drain from the intermediate chamber.

CLAPPER VALVE (cont'd)

- Held closed by the air pressure.
- A limited quantity of water is kept inside the valve on top of the clapper; this is known as "priming water."
- Some new dry pipe valves do not require priming water.

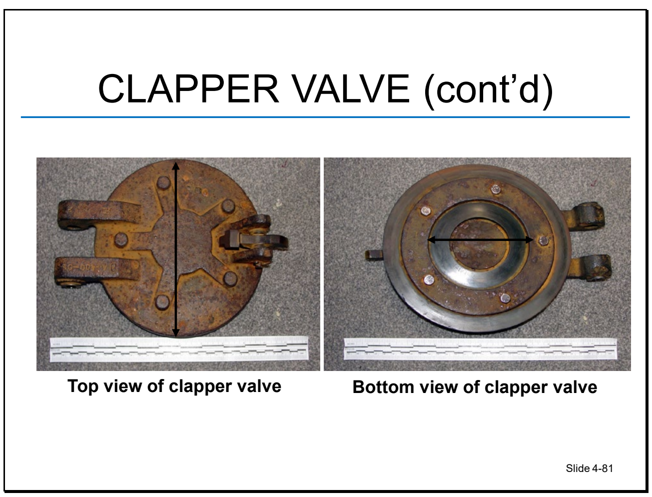


Slide 4-79



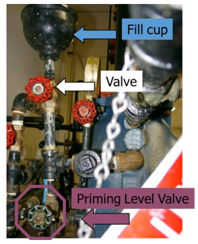
a. Clapper valve.

- The clapper is held closed by the "differential principle." The clapper and the dry pipe valve are designed so that for every pound of air pressure placed on the top of the clapper, it will hold back 6 pounds of incoming water supply pressure. This 1 to 6 ratio is known as the differential. Some older valves employed a differential of 1:1.1 or 1:2.



PRIMING WATER

- Rule of thumb — 1 gallon of water for every inch of the valve.
- Primary purpose is to assist in achieving a good gasket seal.
- Weight of water is also an issue.
- Too much water can prevent valve from opening even if all air pressure is lost.
- Excessive water is known as "water columning."



Slide 4-82

PRIMING/FILL CUP PLUMBING

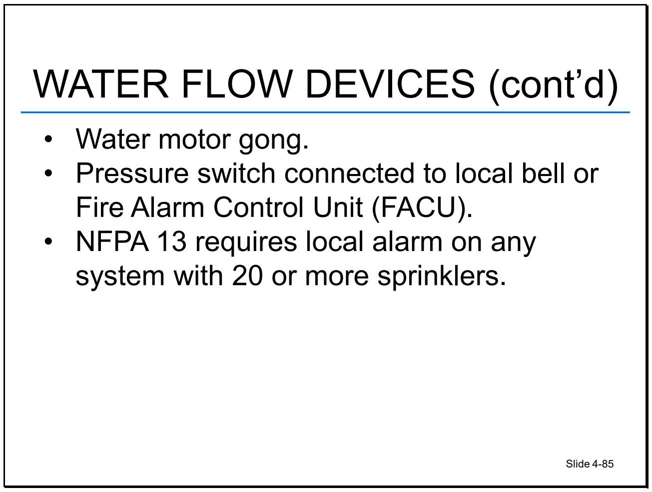
Slide 4-83

PRIMING WATER (cont'd)

- There are some models that do not require priming water.
- Examples:
  - Viking Model F.
  - Tyco Model DPV-1.
  - Reliable LDX.

Slide 4-84

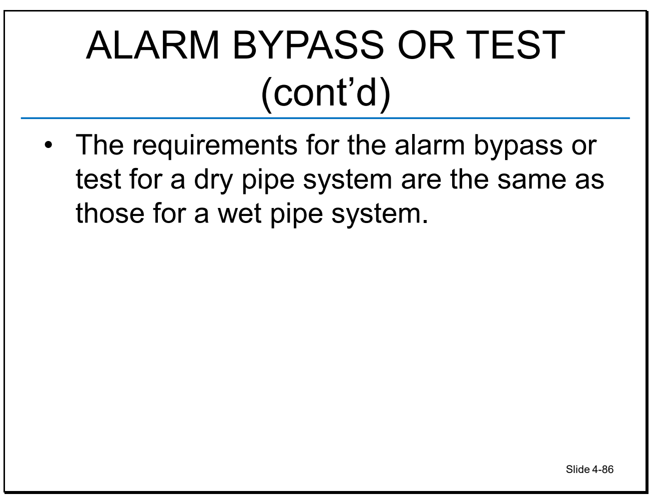
b. Priming water.



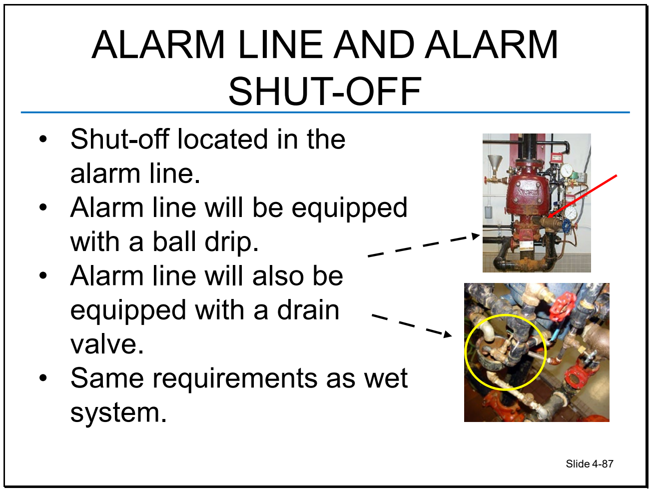
c. Water flow devices.

- Each sprinkler system must be provided with a water flow alarm or device. On dry pipe systems, this will be a water motor gong or a pressure switch.

- The requirements for the water flow alarm for a dry pipe system are the same as those for a wet pipe system.

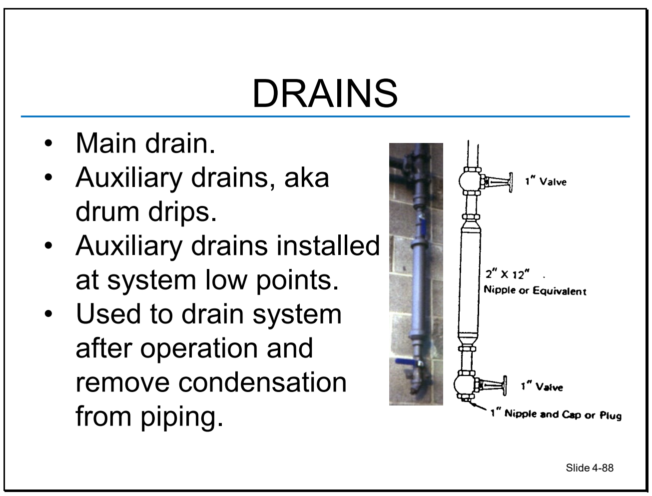


d. Alarm bypass or test.



e. Alarm line and alarm shut-off.

- The requirements for the alarm shut-off for a dry pipe system are the same as those for a wet pipe system.



f. Drains.

- The requirements for a main drain on a dry riser are the same as those for a wet riser. On a dry riser, the main drain will be connected below the clapper. In addition to the main drain located at the riser, all dry pipe systems must be equipped with auxiliary drains to assist in removing the water from all portions of the system.

PRESSURE GAUGES

- One above the clapper on the system side and one on the supply side.
- The top gauge is the air gauge; the lower is the water gauge.

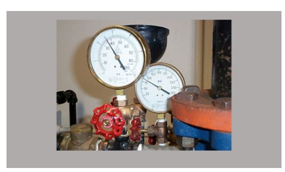
Slide 4-89

g. Pressure gauges.

- A dry pipe riser must be provided with two pressure gauges. One of these gauges is above the clapper on the system side, and the other is below the clapper on the supply side. The gauge above the clapper is the air gauge, and the one below the clapper is the water or supply gauge.

PRESSURE GAUGES (cont'd)

- When the system is set and ready to operate, the air pressure will always be lower than the water pressure.
- If the air and water gauges read the same, the system has tripped or operated.



Slide 4-90

PRESSURE GAUGES (cont'd)

System has been tripped.

Slide 4-91

- Because of the differential principle, the air pressure will always be lower than the water pressure when a dry pipe system is in the set and ready to operate mode. If the air pressure and the water pressure read the same or close to the same, it is a positive indication that the system has been tripped or operated. When reading these gauges, it is important to pay attention to the gradation, as air and water gauges often have different scales.

AIR SUPPLY

- Most common air supply is an air compressor.
- Other recognized sources are compressed air or dry nitrogen cylinders.

Slide 4-92

h. Air supply.

- The most common air supply for dry pipe systems is an air compressor. Other recognized sources are compressed air or dry nitrogen cylinders. There are several requirements or conditions for this air supply.

-- The air supply must be readily available. This means the supply is permanently installed and connected to the sprinkler system.

-- The air supply must be capable of reaching the operating pressure of the system in not more than 30 minutes.

-- The air supply does not have to be automatic. A main line air valve separates the air supply from the sprinkler system. This valve is required to be kept in the closed position except when the system is being placed in service.

DETERMINING PROPER AIR PRESSURE

- Manufacturer's installation/technical manual.
- Calculated mathematically.

Slide 4-93

i. Determining proper air pressure.

- The amount of air pressure to be carried on a dry pipe system can be determined in one of two ways. First, this information will be contained in the manufacturer's installation manual. If the manual is not available, then the correct amount of air can be easily calculated. With the calculation method, the calculated trip pressure must be determined first. This is done by dividing the static water pressure by the differential (6). In order to provide a cushion to help avoid flash trips of the system from water surges, an additional 20 pounds per square inch (psi) is added to the calculated trip pressure. This additional pressure is necessary to help avoid false activation of the system from surges in the water supply system.

CALCULATION METHOD

- Determine the calculated trip pressure.
  - Static water pressure divided by six.
- Operating pressure is calculated trip pressure plus 20 pounds per square inch (psi).
- Example:
  - Static water pressure of 100 psi.
  - 100/6 = 17 calculated trip pressure.
  - 17 + 20 = 37 the amount of air to be carried on the system.

Slide 4-94

j. Calculation method.

AIR MAINTENANCE COMPRESSOR

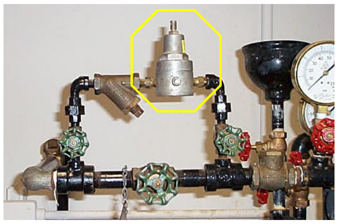
- Mounted directly on riser.
- May be sole or only air supply for a small dry pipe system.
- Capacity of air compressor will be marked on the listing tag.

Slide 4-95

k. Air maintenance compressor.

- The air supply can be made automatic by the use of an air maintenance device. This may be a device placed between the air source and the sprinkler piping or a small, tankless air compressor attached directly to the sprinkler piping.

AIR MAINTENANCE COMPRESSOR (cont'd)



Main air line

Air maintenance device

Slide 4-96

SUPERVISION OF AIR PRESSURE

- Monitoring of the air pressure is required by NFPA 72.
- Monitoring is plus or minus 10 psi.

Slide 4-97

l. Supervision of air pressure.

- Monitoring of the air pressure is required by NFPA 72 if a fire alarm system is present. The pressure is monitored at plus or minus 10 psi from the normal operating pressure.

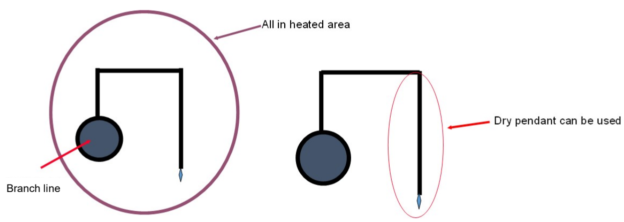
ORIENTATION OF SPRINKLER HEADS

- Upright position.
- Pendant sprinklers and sidewall sprinklers installed on return bends.
- The sprinklers, return bend and branch line piping are in an area maintained at or above 40 F.

Slide 4-98

3. Orientation of sprinkler heads.

RETURN BEND



Slide 4-99

a. Return bend.

DRY PENDANT, SIDEWALL, UPRIGHT

Typically used on wet systems in isolated, unheated areas.

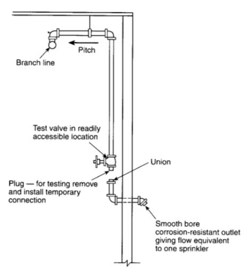
Slide 4-100

b. Sprinkler heads.

- In some instances, it is desirable to use dry sprinklers attached to wet pipe sprinkler systems. One common example is the protection of a walk-in freezer in an otherwise heated area. Dry sprinklers have mechanisms that keep a tight seal in place which prevents water from the wet pipe system flowing into the dry sprinklers. The dry sprinklers typically have extended pipe lengths that are dry (without water) and which extend into the unheated area. When the sprinkler fuses, the seal linkage drops out, allowing water to flow into the previously dry sprinkler.

LOCATION OF INSPECTOR'S TEST

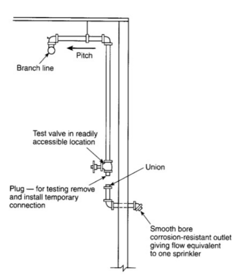
- Must be located at the most remote point within the system.
- Discharge pipe is 1 inch and terminates in a test orifice equal to the sprinkler orifice in the system.



Slide 4-101

LOCATION OF INSPECTOR'S TEST (cont'd)

- From the time this valve is fully opened to the time a solid stream of water is discharged cannot be more than 60 seconds.
- How to cheat the test: Leave out the orifice and/or slowly open the test valve.



Slide 4-102

4. Location of inspector's test.

An inspector's test connection is not less than 1 inch in diameter and terminates in a smooth bore corrosion-resistant orifice equivalent to the smallest sprinkler orifice on the system. This inspector's test connection is used to test the water flow alarm of the system. The inspector's test connection is required to be located at the highest, most remote point in the system. Water delivery time will be tested with the inspector's test valve. The time for water delivery is measured from the time the test valve is fully opened until a solid, continuous stream of water is discharged.

WATER DELIVERY TIME

- System size limited to not more than 750 gallons unless water can be delivered to the inspector's test connection in not more than 60 seconds.
- Calculations for dry pipe system water delivery must be based on the hazard.
- System size not limited if calculated water delivery time does not exceed values set forth in NFPA 13, Section 7.2.3.6.1.
- Calculations must be by a listed program.

Slide 4-103

5. Water delivery time.

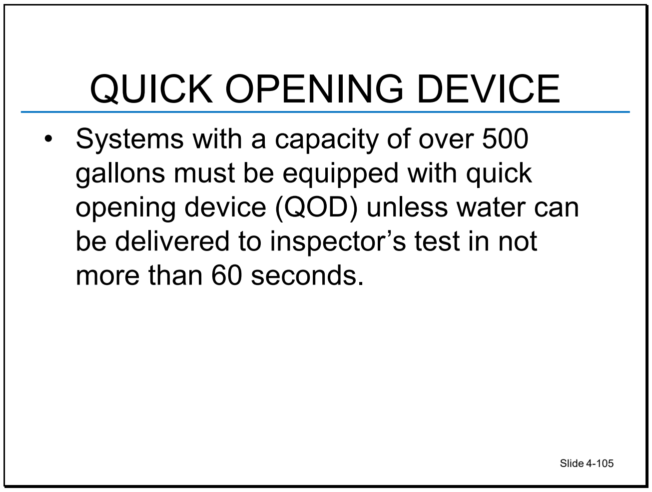
   a. NFPA 13 limits the size of a single dry pipe system to no more than 750 gallons unless the water can be delivered to the inspector's test connection within not more than 60 seconds. Systems with capacities of over 500 gallons are required to be equipped with a quick opening device (QOD) unless water can be delivered to the inspector's test connection in not more than 60 seconds.

DRY PIPE SYSTEM WATER DELIVERY TABLE

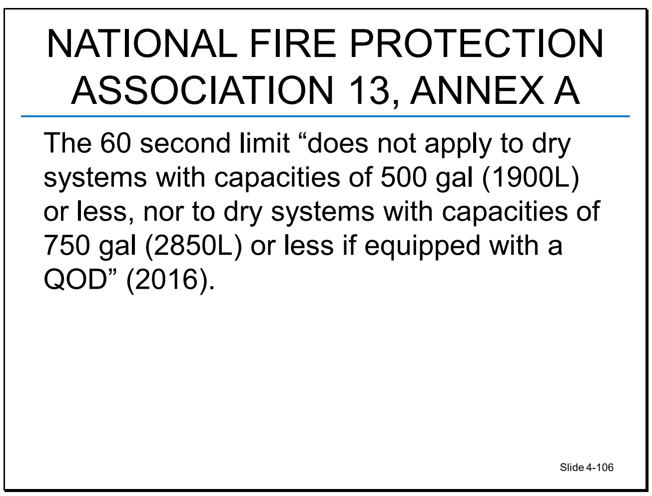
HAZARD CLASSIFICATION	# OF MOST REMOTE SPRINKLERS INITIALLY OPEN	MAXIMUM WATER DELIVERY TIME
Residential	1	15 seconds
Light	1	60 seconds
Ordinary I	2	50 seconds
Ordinary II	2	50 seconds
Extra hazard I	4	45 seconds
Extra hazard II	4	45 seconds
High piled storage	4	40 seconds

Slide 4-104

b. Dry pipe system water delivery.



6. QOD required.



a. NFPA 13, Annex A.

- In Annex A.7.2.3.1 of NFPA 13, it states that the 60 second requirement "does not apply to dry systems with capacities of 500 gal (1900L) or less, nor to dry systems with capacities of 750 gal (2850L) or less if equipped with a quick-opening device" (2016).

NATIONAL FIRE PROTECTION ASSOCIATION 13, AUTOMATIC SPRINKLER SYSTEMS HANDBOOK

Commentary:
- No 60 second requirement where the 750 gallons volume limitation is not exceeded.
- Some dry pipe systems with capacities less than 750 gallons may take up to three minutes to deliver water at the inspector's test connection, but this is considered acceptable.

Slide 4-107

b. NFPA 13, Automatic Sprinkler Systems Handbook.

- Information in the handbook indicates that there is no 60 second requirement for systems where the 750 gallon capacity is not exceeded, and with such systems it can take up to three minutes to deliver water to the inspector's test connection. This is considered acceptable.

NATIONAL FIRE PROTECTION ASSOCIATION 13 (cont'd)

- Does not fix problem, actually makes it worse (Reference NFPA 13, Section 7.2.3).
- Designer has option to use any **one** of the following approaches:
  - Deliver water in not more than 60 seconds.
  - Limit system to not more than 500 gallons without a QOD and no time limit.

Slide 4-108

NATIONAL FIRE PROTECTION ASSOCIATION 13 (cont'd)

- Limit system to not more than 750 gallons with QOD and no time limit.
- System designed with computer calculations (time 15 to 60 seconds depending upon hazard class).

• NFPA Research Foundation has a current research project underway regarding this issue.

Slide 4-109

c. NFPA 13.

QUICK OPENING DEVICE (cont'd)

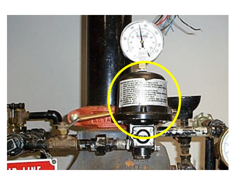
• There are two types of QODs that can be found on dry pipe sprinkler systems.
  - Accelerator.
  - Exhauster.

Slide 4-110

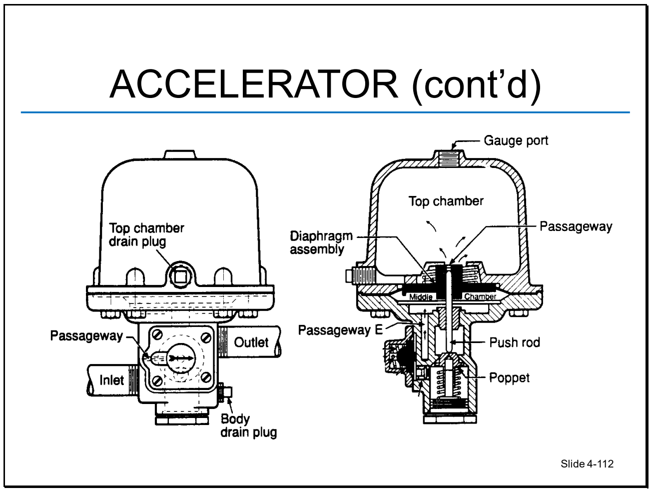
7. QODs.

ACCELERATOR

• Takes air from the system and injects it into the intermediate chamber under the clapper.
• When set and ready to go, air pressure gauge on top of device will read the same as the system air pressure gauge.

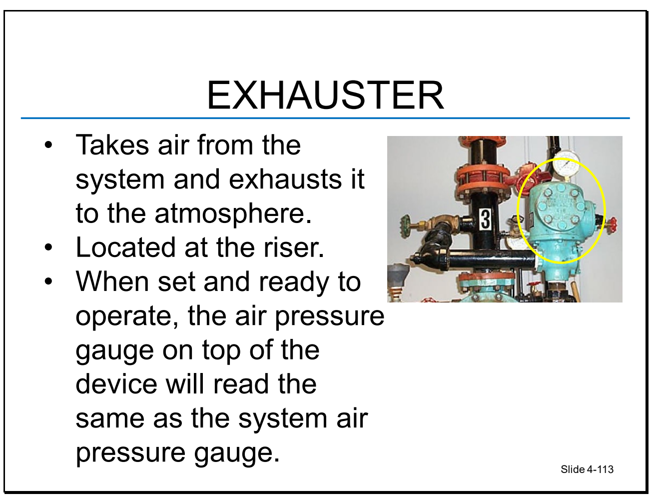


Slide 4-111

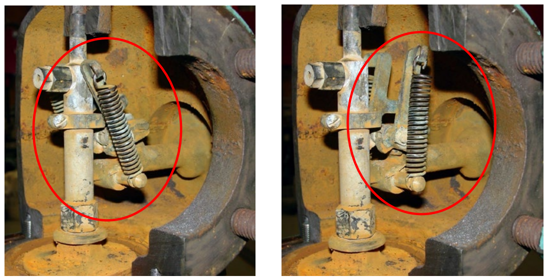


a. Accelerator.

- An accelerator takes air from the overhead piping and injects it into the intermediate chamber under the clapper. When a sprinkler(s) is opened from the heat of a fire, the air pressure begins to drop within the overhead piping and a portion of the accelerator. This reduction in air pressure allows a valve inside the accelerator to open, and air from the overhead piping flows into the intermediate chamber, causing the clapper to open more quickly. When the device is set and ready to operate, the air pressure gauge on the top of the device should read the same as the air gauge on the system riser.



THE SECRET LEVER



Slide 4-114

b. Exhauster.

- The exhauster is designed to actually exhaust air from the system in order to speed up the opening of the dry pipe valve. When a sprinkler(s) is opened from the heat of a fire, the air pressure begins to drop within the overhead piping and within a portion of the exhauster. This reduction in air pressure allows the exhauster to open and air from the overhead piping is vented or exhausted to the atmosphere. In order to prevent the open exhauster from discharging water once the dry pipe valve has tripped, a connection is made between the exhauster and the airline piping. When water pressure enters the alarm line it causes the exhauster valve to reclose, thus preventing water from being discharged through the device.

RESETTING PROCEDURES

- Shut down water supply.
- Shut down air supply (air maintenance device).
- Drain system.
- Replace sprinkler head.
- Remove face plate.
- Loosen all bolts first and knock faceplate loose.
- Clean interior of valve.
- Inspect clapper and seat for damage.

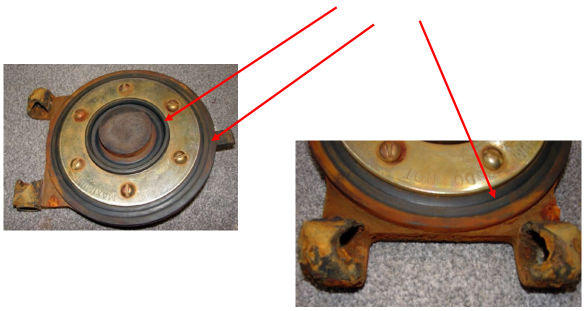
Slide 4-115

8. Resetting procedures.

a. Whenever a dry pipe valve has been tripped, it is necessary to mechanically reset the valve. Resetting of the valve must be done by a qualified person.

b. If the system had been tripped due to fire, any open or damaged sprinkler heads would be replaced first.

INSPECT CLAPPER AND SEAT FOR DAMAGE



Slide 4-116

RESETTING PROCEDURES (cont'd)

- Reset clapper in a closed position.
- Replace faceplate.
- No torque specs — just snug up bolts.
- Restore priming water.
- Restore air pressure and shut off main line air valve.
- Put air maintenance device in service (if present).
- Turn on main control valve in water supply.
- Check water flow alarm.

Slide 4-117

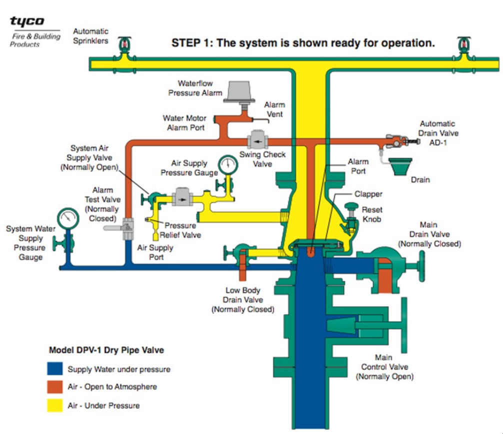
EXTERNAL RESETTABLE VALVES

- Various manufacturers have available dry pipe valves that can be reset from exterior without removing the faceplate.
- Some are modified deluge/preaction type valves.
- NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, now requires internal inspection of all dry pipe valves on an annual basis.

Slide 4-118

9. External resettable valves.

   a. Recently, several manufacturers have introduced modified deluge/ preaction valves for use as dry pipe valves. These types of valves are designed so that the clapper can be reset without removal of the faceplate.



Slide 4-119

   b. System ready for operation.

ACTIVITY 4.2

Dry Pipe Sprinkler System

Purpose

Reinforce analytical skills required to review documentation and identify code violations.

Directions

1. Work in your table groups to review Handout 4-2: Automatic Sprinkler Systems — Dry Pipe Sprinkler System Annual Inspection, Testing, and Maintenance Report for years 2013, 2014 and 2015.

2. Identify any code violations in comparing each of the three inspections.

3. You will have 30 minutes to evaluate the documentation and research the applicable codes using NFPA 25 for each violation.

4. Be prepared to report on their findings, including applicable code citations, to the class.

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ACTIVITY 4.2 (cont'd)

Worksheet

Suggested responses:

1. Code violation: ____

   ____

   ____

   Applicable code: ____

   ____

   ____

2. Code violation: ____

   ____

   ____

   Applicable code: ____

   ____

   ____

3. Code violation: ____

   ____

   ____

   Applicable code: ____

   ____

   ____

4. Code violation: ____

   ____

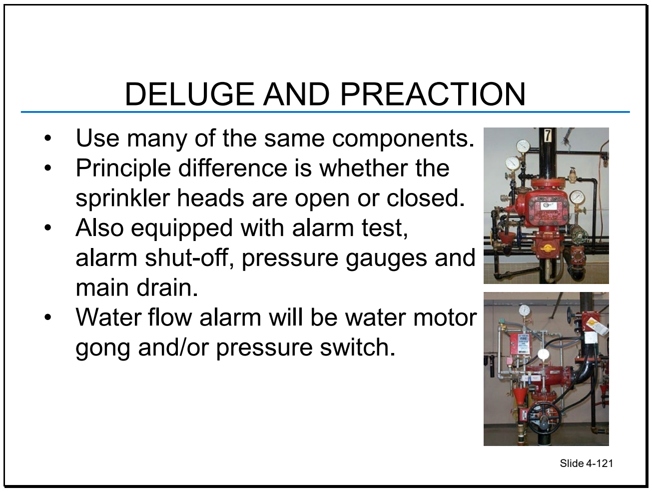
   ____

Applicable code: ____

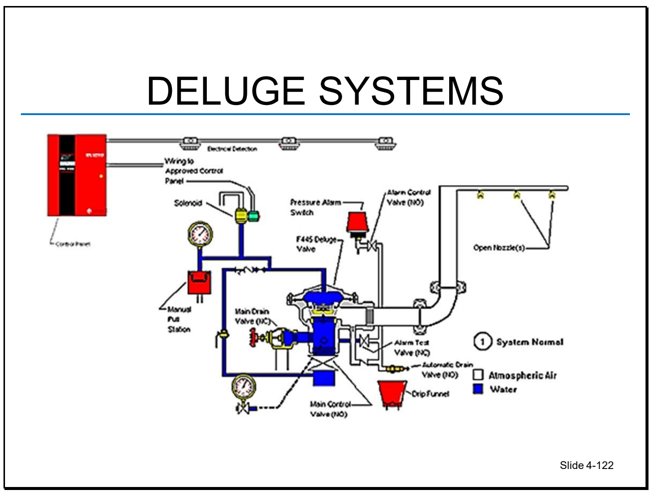
____

____

VI. CLASSIFICATIONS OF SPRINKLER SYSTEMS (cont'd)

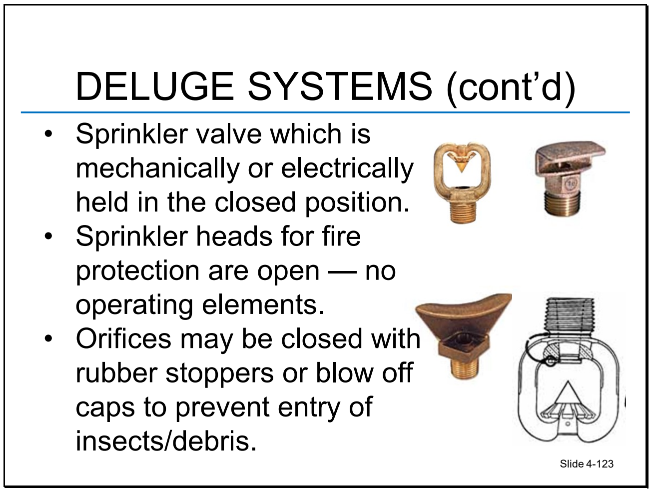


D. Deluge and preaction sprinkler system.



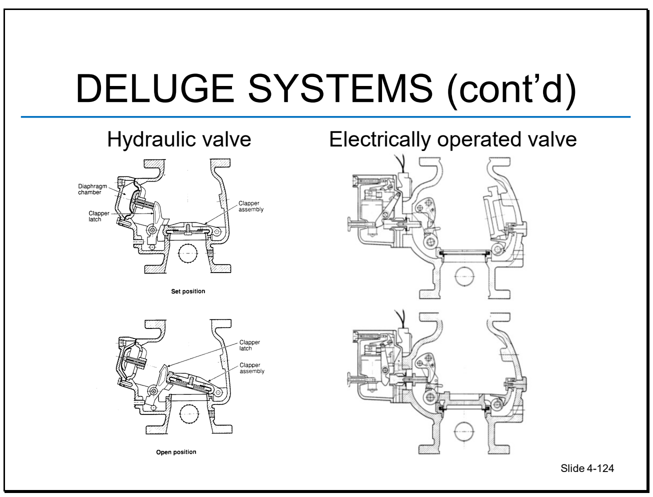
1. Deluge system.

a. Deluge systems use open sprinkler heads attached to a piping system that is connected to a water supply through a valve that is opened by the operation of a detection system of some type. The detection system is located in the same areas as the sprinkler protection. When the valve opens, water flows into the piping system and is immediately discharged from all sprinkler heads. While the individual sprinkler heads do not have fusible elements, they may be provided with covered or orifice plugs to prevent insects and debris from entering the piping via the open sprinkler orifices.



b. The clapper valve inside a deluge valve may be held closed mechanically or electrically.

c. Mechanically operated valves use water pressure against a diaphragm to cause a locking pin to hold the clapper valve in the closed position. When the water pressure is reduced, the clapper is pushed into the open position by the incoming water pressure.



DELUGE SYSTEMS (cont'd)

Slide 4-125

DELUGE SYSTEMS (cont'd)

- A detection system is used to detect the presence of a hostile fire condition which in turn allows the sprinkler valve to open.
- Once the sprinkler valve opens, water flows up into the overhead piping and is discharged throughout the entire protected area.
- Systems are used in very high hazard areas.

Slide 4-126

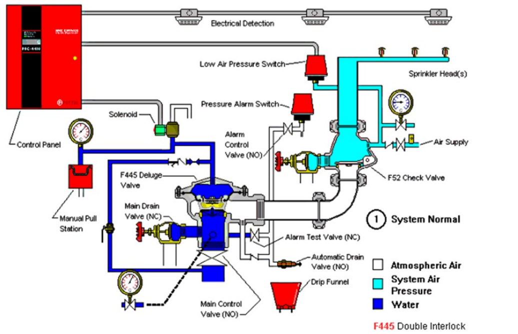
PREACTION SYSTEMS

- Sprinkler valve which is mechanically or electrically held in the closed position.
- Sprinkler heads for fire protection are closed.
- Type and operating temperatures are determined by the specific hazards being protected.

Slide 4-127

2. Preaction system.

PREACTION SYSTEMS (cont'd)



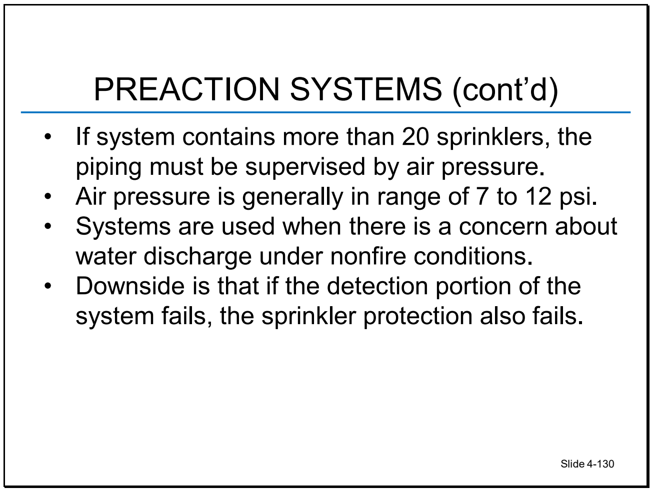
Slide 4-128

PREACTION SYSTEMS (cont'd)

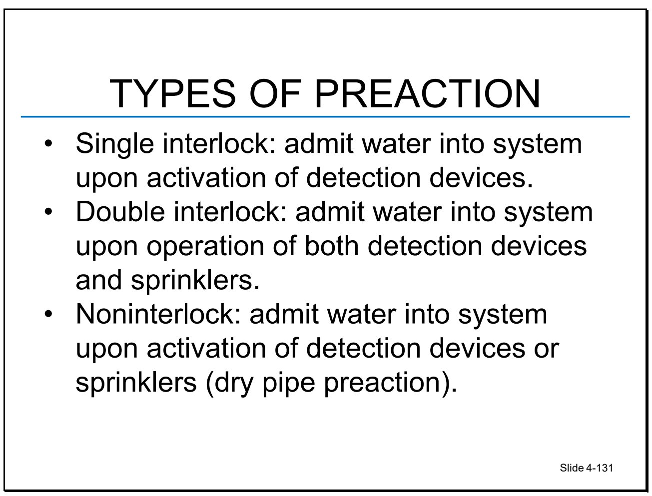
- A detection system is used to detect the presence of a hostile fire condition which in turn allows the sprinkler valve to open.
- Once the sprinkler valve opens, water flows up into the overhead piping charging the piping with water.
- No water is discharged until a sprinkler head(s) is opened by the heat of the fire.

Slide 4-129

a. Preaction systems use many of the same components as deluge systems. Preaction systems use closed sprinkler heads attached to a piping system that is connected to a water supply through a valve that is opened by the operation of a detection system of some type. The detection system is located in the same areas as the sprinkler protection. When the valve opens, water flows into the piping system and will be discharged from any sprinklers that are opened by the heat from a fire.



b. When a preaction system contains more than 20 sprinkler heads, the integrity of the sprinkler piping and sprinkler heads must be supervised. This supervision is provided by placing and maintaining 7 to 10 psi of air pressure in the sprinkler piping. If this supervisory air pressure is lost, it would indicate that the piping or sprinkler head has been damaged.

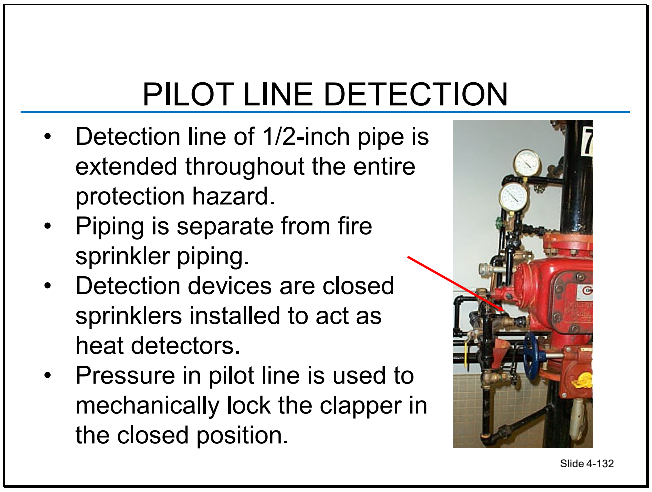


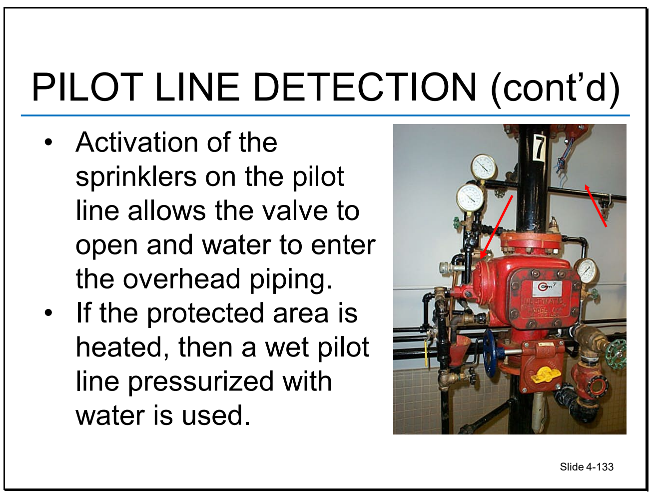
c. Types of preaction systems.

- Single- and double-interlocked-type systems are used where there is a concern about accidental water discharge under nonfire conditions. One of the most common uses for these systems is the protection of computer rooms.

- The downside to the use of single- and double- interlocked-type systems is that if the detection system should fail, then the automatic sprinkler protection capability also is lost.

- In double-interlocked systems, this air pressure is also used for alarm conditions. The loss of the air pressure signals the Fire Alarm Control Unit (FACU) that a sprinkler has been activated.





d. Pilot line detection.

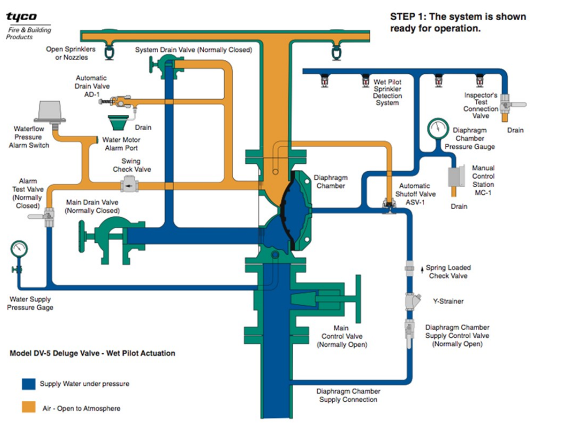
- In some systems, a pilot line consisting of 1/2-inch piping is extended throughout the same areas as the sprinkler protection. This pilot line is connected to the diaphragm on the preaction valve, and closed sprinklers are installed on the pilot line. These closed sprinklers are used as heat activated devices or the detection system.

PILOT LINE DETECTION (cont'd)

- If the protected area is unheated, then the pilot line is converted to a dry pilot line with a dry pilot actuator and the pilot line around the hazard is pressurized with air.

Slide 4-134

- When one or more of the closed sprinklers on the pilot line is activated by the heat of a fire, the water pressure in the pilot line is reduced and the clapper inside the preaction valve opens. This arrangement is known as a wet pilot line.



Slide 4-135

- If the area to be protected is unheated, then a dry pilot line must be used. The clapper inside the deluge valve is still held by water pressure against a diaphragm; however, the portion of the pilot line in the unheated area contains air pressure.

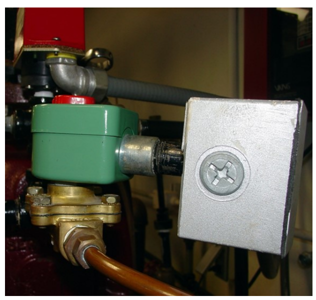
AUTOMATIC FIRE ALARM AND DETECTION

- Uses standard initiating devices (smoke, heat, flame) connected to an FACU.
- Solenoid valve with a pilot line connection.
- Actuating valve is placed on the pilot line connection in valve room.
- Solenoid is activated by FACU.
- Opening solenoid releases pressure on pilot line connection.

Slide 4-136

AUTOMATIC FIRE ALARM AND DETECTION (cont'd)

Solenoid for air release.



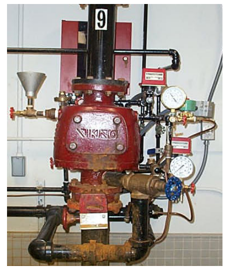
Slide 4-137

e. Automatic fire alarm and detection.

- Attached to the end of this short section of pilot line is an electrically operated solenoid valve. This valve also is connected to the FACU. The detection system will incorporate smoke, heat or another type of initiating device connected to the FACU. When the fire alarm system is activated, the FACU causes the solenoid to open releasing the water pressure from the pilot line connection. This reduction in water pressure allows the deluge valve to open.

DRY PIPE/PREACTION SYSTEM

- Dry pipe valve held closed by air pressure.
- Same basic components as normal dry pipe system.
- FACU and automatic detection system.
- Activation of detection system causes air pressure to be released from system causing valve to trip open.



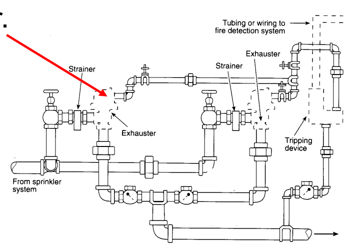
Slide 4-138

E. Dry pipe/preaction system.

1. Dry pipe/preaction systems are by definition a noninterlocked system as defined by NFPA 13. A dry pipe/preaction system employs closed automatic sprinklers attached to a piping system containing air under pressure with a supplemental detection system installed in the same areas as the sprinklers. Operation of the detection system releases the air from the system, allowing the dry pipe valve to trip open and charge the piping with water.

DRY PIPE/PREACTION SYSTEM (cont'd)

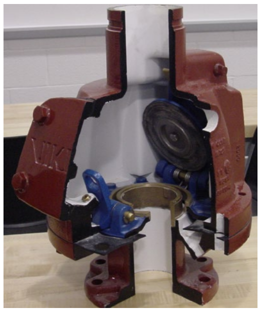
- Exhauster.
- Located at end of system to assist in removal of air.

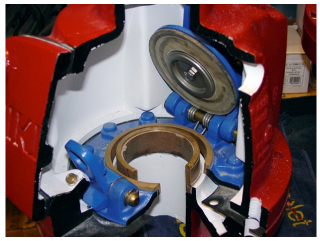


Slide 4-139

2. In order to help ensure that the piping can be quickly and fully charged with water, an exhauster is required to be located on the end of the feed main. This QOD functions the same as an exhauster on a standard dry pipe system.

DRY PIPE/PREACTION SYSTEM (cont'd)





Slide 4-140

FIRECYCLE® SYSTEM

- Made by Viking.
- Detection system allows water to be both turned on and off to the entire system.
- Restorable-type heat detectors are placed in the protection area.
- Activation of heat detectors allows sprinkler valve to open.

Slide 4-141

F. Firecycle® System.

1. The Firecycle® System is a specialized automatic sprinkler system manufactured by Viking Sprinkler Corporation. This type of sprinkler system is designed and installed so that the water supply to the sprinkler piping can be automatically turned on and off. The system uses a hydraulically operated valve and an automatic detection system.

2. The automatic detection system used restorable-type heat detectors connected to a specially designed FACU. Activation of an initiating device causes the sprinkler valve to open, allowing water to flow into the sprinkler piping.

FIRECYCLE® SYSTEM (cont'd)

- When sprinkler head(s) opens from heat of fire, water is discharged.
- When temperature decreases, heat detector resets and water system is shut off.
- Can be installed as single interlock, double interlock, wet pipe and deluge.
- Installation must follow manufacturer's criteria!

Slide 4-142

3. When water is discharged onto the fire, the temperature is reduced, allowing the initiating device to cool and reset. When the initiating device resets, the fire alarm panel causes the sprinkler valve to close, shutting off the water supply to the sprinkler piping. If the temperature in the protected area should again rise, reactivating an initiating device, the sprinkler valve would reopen, allowing additional water to be discharged.

4. Because the integrity of the fire alarm system is critical to the ability of the system to cycle on and off, very specific installation requirements are set forth in the manufacturer's installation manual and listing criteria. Only specified initiating devices and wiring can be used.

VII. DETERMINING AVAILABLE FLOW FROM MAIN DRAIN TEST RESULTS

MAIN DRAIN TEST

- Required on all systems regardless of type.
- Conducted as part of acceptance test.
- Required by NFPA 25 to be conducted on an annual (or quarterly) basis.
- Drain must be located so it will take full flow!

Slide 4-143

A. Main drain test.

IMPORTANCE OF TEST

- Creates benchmark by which the water supply will be compared throughout the life of the system.
- Critical that the pressure readings be validated.
- If not validated, everyone is assuming that pressure readings reflect an adequate water supply.

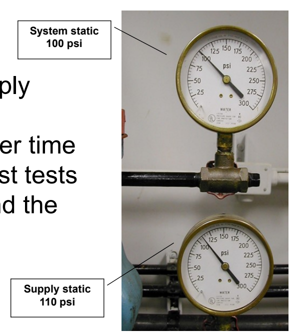
Slide 4-144

B. Importance of test.

The main drain test is required to be conducted during the original acceptance test and annually thereafter. The main drain test creates a benchmark which is used for the life of the system to evaluate the adequacy of the water supply. Traditionally, only the static and residual pressures are recorded with no verification process. If the actual flow rate at the base of the riser is not verified, then all parties are assuming that the static and residual pressure reflect an adequate water supply for the system.

MAIN DRAIN TEST STEPS

- Record static water pressure.
  - Evaluates water supply conditions.
  - Results observed over time by comparison of past tests to the current test and the original test.



Slide 4-145

MAIN DRAIN TEST STEPS (cont'd)

- Open main drain valve fully and allow water to run until clear and pressure stabilizes.

Slide 4-146

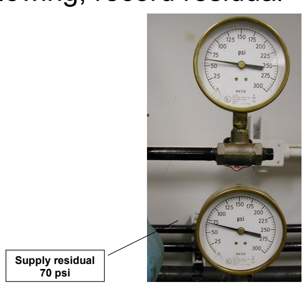
MAIN DRAIN TEST STEPS (cont'd)

- Two-minute run until clear.

Slide 4-147

MAIN DRAIN TEST STEPS (cont'd)

- While water is flowing, record residual pressure.



Slide 4-148

C. Main drain test steps.

The first step in conducting the main drain test is to record the static pressure on the water gauge on the riser. Once the static pressure has been recorded, the main drain valve must be fully opened. Proper testing cannot be conducted if the drain is not fully opened! The water is permitted to run until clear and the pressure on the gauge stabilizes. Once this occurs, a second pressure reading is taken from the gauge. This is the residual pressure. If the second method is being used, a pitot reading will be taken while the water is being discharged from the drain. The main drain is then closed down.

VERIFICATION STEPS

- Use the main drain chart or take pitot readings from the flowing main drain.
- Plot the results on an "n" chart.
- Compare the flow curve with the demand of the system.

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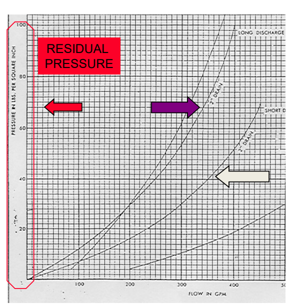
D. Verification steps.

MAIN DRAIN CHART

- Chart is used to convert **residual** pressure to an available flow.
- Two 2-inch curves — long and short.
- Short less than 20 feet.
- Long 20 to 30 feet.
- Length is actual distance from outlet of valve to discharge opening.



Slide 4-150

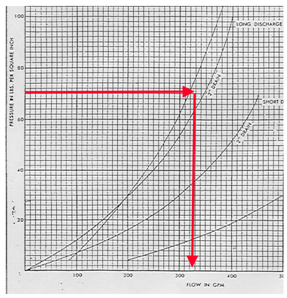
E. Main drain chart.

1. There are two ways to determine the amount of water available at the base of a sprinkler riser. The first and easiest is the use of the main drain chart. This chart is used only for 2-inch drains and converts the residual pressure during the test to a flow rate. The 1 1/2-inch and 1 3/4-inch nozzle curves on this chart are not be used for main drain testing. The main drain chart

must be used as it is written, the values (pressures and gallons per minute (gpm)) cannot be modified. Two 2-inch main drain curves are depicted on the main drain chart. The short drain line is used for drain lines 20 feet or less in length. If the length of the line is over 20 feet and up to 30 feet in length, the long line curve is used. The length of the drain line is a straight-line measurement from the discharge opening of the drain valve to the discharge opening of the drain piping.

MAIN DRAIN CHART EXAMPLE

- Residual pressure during test was 70 psi.
- Assume the drain line is a long line.
- Read across at the 70 psi line until the intersection with the long drain line curve.
- Read down to the gallons per minute (gpm) line and determine the volume available.



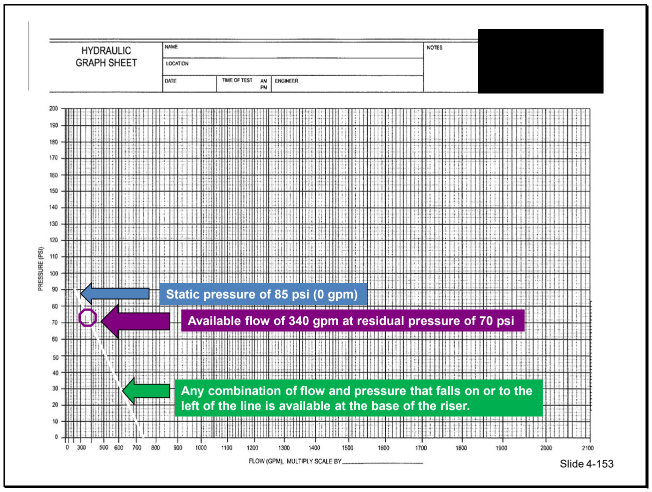
Slide 4-151

2. Example.

INFORMATION NOW AVAILABLE

- Static pressure of 85 psi.
- Residual pressure of 70 psi.
- Flow of 340 gpm.
- Now plot this information on an “n” chart.

Slide 4-152



3. Information now available.

VIII. HYDRAULIC ENGINEERING DESIGN

HYDRAULIC ENGINEERING DESIGN

- Hydraulic data plate.
- Pipe schedule tables.

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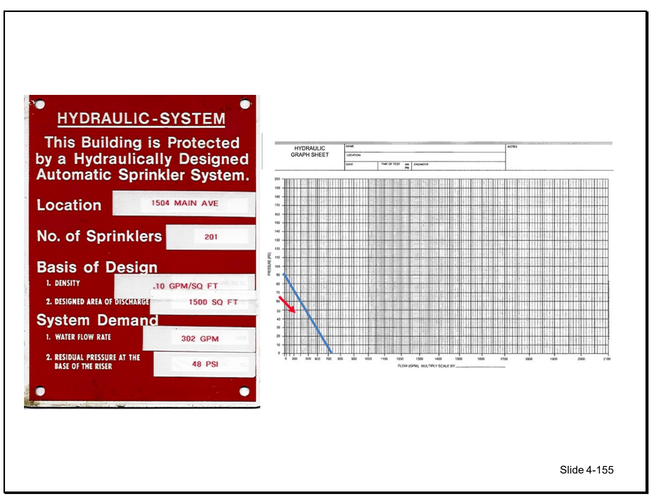
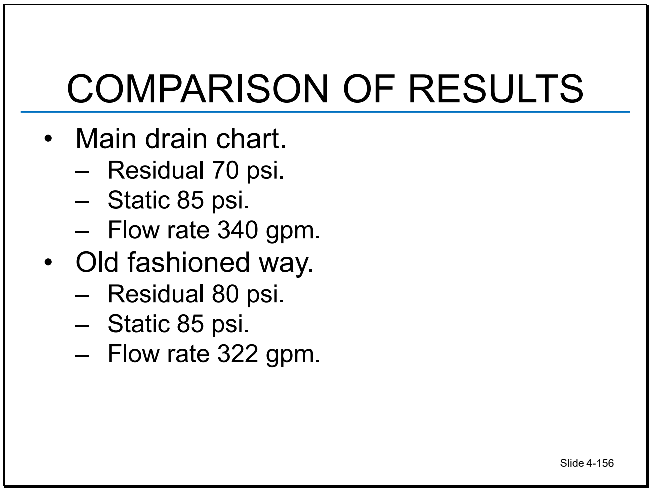
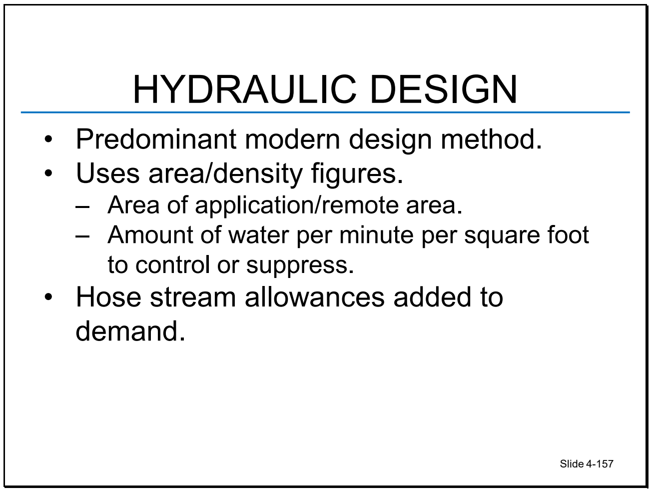


A. Automatic sprinkler systems may be hydraulically or pipe schedule designed. A hydraulically designed system is one in which the pipe sizes are selected on a pressure loss basis to provide a prescribed water density, in gpm per square foot, or a prescribed minimum discharge pressure or flow per sprinkler, uniformly distributed over a specified design area. These types of systems are site specific; that is, the system was designed to fit the available water supply. For hydraulically designed systems, the flow rate and minimum residual pressure will be shown on the data plate which is required to be attached to the base of the riser.



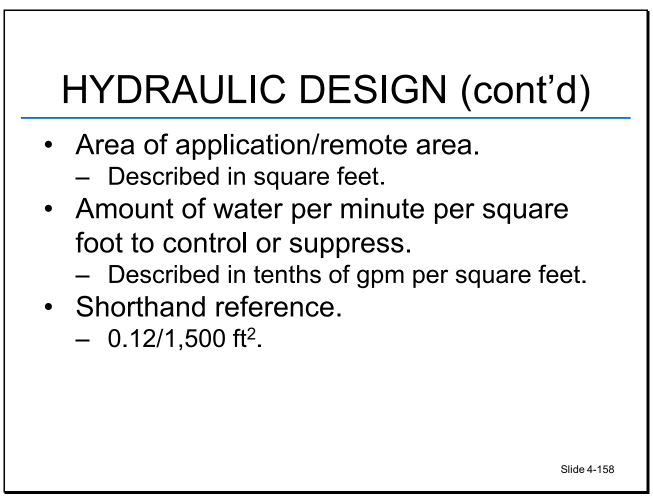
B. Today's automatic sprinkler systems are designed using a hydraulic calculation method, which involves the use of a computer. The designer can rapidly enter the general pipe layout and sizes, along with some additional data requirements, and the program will determine the pressure drop through the pipe network. This provides the minimum pressure and flow requirement for the system, which then can be compared to water supply data to determine if the required flow and pressure are available. If excess pressure is available, the system designer can reduce pipe sizes to provide a cost savings.

C. The design of such systems usually is based on a required area/density formula. The area portion of the formula is known as the area of application, remote area, design area or hydraulically remote area. The size of this area varies depending upon the hazard classification; light hazard occupancies may have a small remote area, while extra hazard occupancies have a larger one.



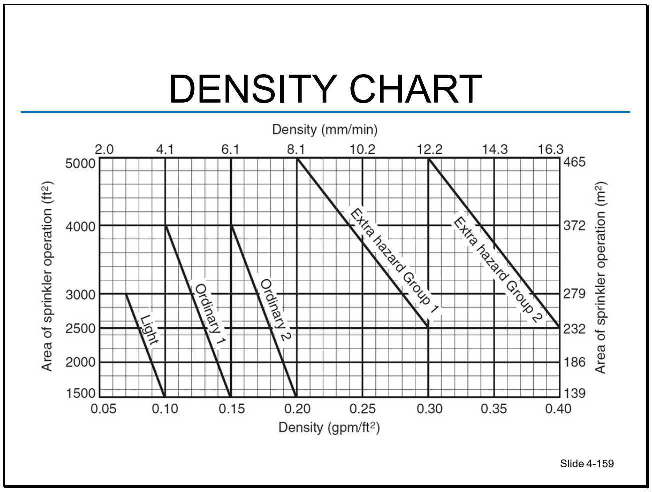
D. Hydraulic design.

1. Density is the amount of water required to control or extinguish an incipient fire in the remote area. It is referenced in tenths or hundredths of gpm per square foot. For example, a density of 0.12 means the sprinkler system will deliver 12 hundredths of a gallon of water per minute over each square foot of the remote area.

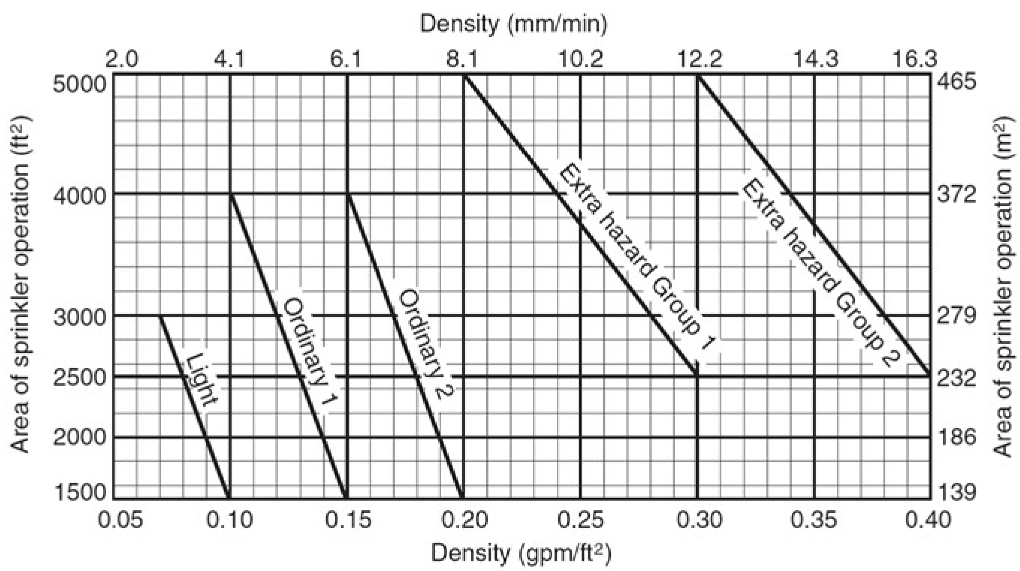


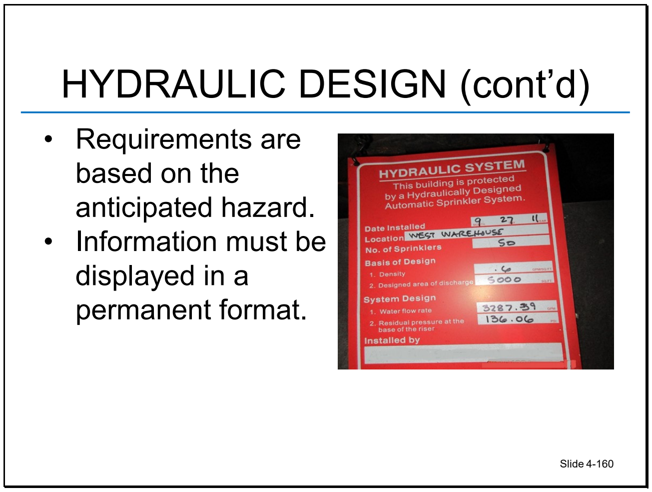
2. To get an approximate idea of how much water is needed to supply the sprinkler system, multiply the density by the size of the remote area. This will tell you how much water is required for protecting the remote area of application. For example, 0.12 times 1,500 equals 180 gpm. There will be some additional volume included in the calculations to account for filling the pipe network between the riser and the remote area.

3. The area density curves are used to determine the required water supply for the sprinkler system.

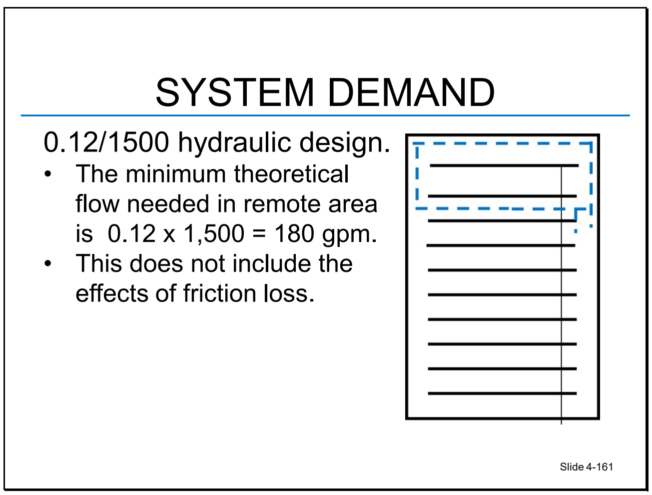


E. Density chart.





NFPA 13 requires that a nameplate be attached permanently to the base of risers of hydraulically designed systems. The nameplate indicates the location of the system and the basis of the design, including discharge densities and design area size, as well as the gpm flow and the residual pressure demand at the base of the riser.



F. System demand.

HOSE STREAM ALLOWANCES

- Hose stream allowances for each hazard classification are:
  - Light = 100 gpm.
  - Ordinary = 250 gpm.
  - Extra = 500 gpm.
- The hose stream allowance is water supply set aside for suppression forces.

Slide 4-162

G. Hose stream allowances.

When a hydraulically engineered sprinkler system is designed, the water supply calculations must include an allotment for hose stream allowances. This is the volume added to the sprinkler system demand to ensure that there is an adequate water supply for manual firefighting when the fire suppression forces arrive.

DEMAND EXAMPLE

Given:

- Light hazard occupancy.
- Design = 0.12/1,500.
- Hose streams = 100 gpm.

- Design demand = (0.12 x 1,500) + 100.
- Design demand = 180 + 100.
- Theoretical water demand > 280 gpm.

Slide 4-163

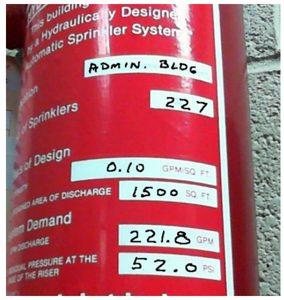
H. Demand example.

In the previous example, we established a sprinkler system demand of 180 gpm based on a 0.12/1,500 design. In a light hazard occupancy, 100 gpm would be added to this to establish the total water flow requirement: 180 + 100 = 280 gpm.

HYDRAULIC DESIGN (cont'd)

Is this information questionable on the hydraulic design plate?

- Design demand = (0.12 x 1,500) + 100.
- Design demand = 180 + 100.
- Theoretical water demand > 280 gpm.



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INSPECTOR'S ROLE (cont'd)

- Verify that hazard classification has not increased.
  - Identify changes that may overwhelm sprinkler design.
- Verify that water supplies remain adequate for fire control or extinguishment.

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IX. PIPE SCHEDULE DESIGN

PIPE SCHEDULE DESIGN

- Limited modern use.
  - Prevalent in pre-1980s systems.
- Water supplies.
  - Light hazard.
  - 15 psi residual at highest sprinkler.
- Ordinary hazard.
  - 20 psi residual at highest sprinkler.

Slide 4-166

A. Before the advent of readily available computer programs and cost-effective computer hardware, sprinkler systems typically were designed using the pipe schedule method. This is a simple approach but often more costly to install. This approach uses the concept of the maximum number of heads that may be supplied by a given pipe diameter. The designer then selects pipe sizes, starting at the location most remote from the water supply, until all pipe sizes are determined. The pipe schedules also are based on the classification of the protected hazard.

PIPE SCHEDULE DESIGN (cont'd)

- Uses a recipe describing how many sprinklers could be fed by each pipe size.
- The recipe is based on the hazard classification.
  - Light hazard, see NFPA 13, Table 23.7.2.2.1.
  - Ordinary hazard, see NFPA 13, Table 23.7.3.4.
- Extra hazard occupancies and deluge systems cannot be pipe schedule.

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B. The use of pipe schedule design is now limited to new systems of 5,000 square feet or less or for the modification of existing pipe schedule systems. An exception does exist which permits the use of new pipe schedule systems over 5,000 square feet if the minimum flow rates specified in the table are available at a minimum residual pressure of 50 psi at the top-most elevation of the system.

PIPE SCHEDULE DEMAND

- NFPA 13, Table 11.2.2.1 displays demand based upon hazard classification of system.
- Lower flow permitted with noncombustible or compartmented construction.
- Lower duration for off-site monitoring.
- Pipe schedule system can be converted to hydraulically calculated system.

Occupancy Classification	Minimum residual psi	Base of Riser Flow in gpm	Duration
Light	15	500-750	30-60
Ordinary	20	850-1,500	60-90

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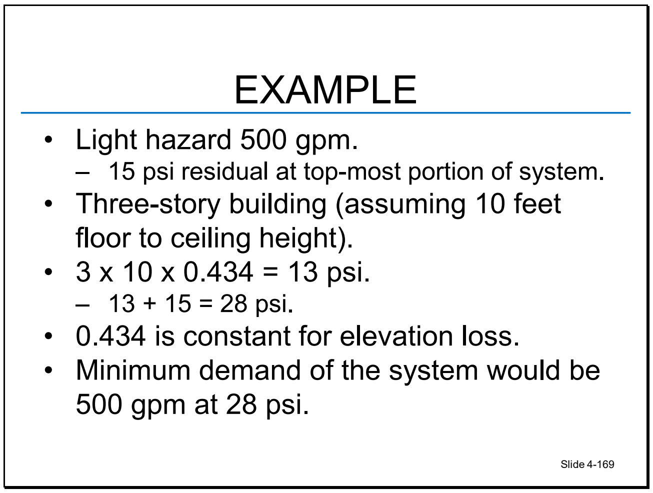
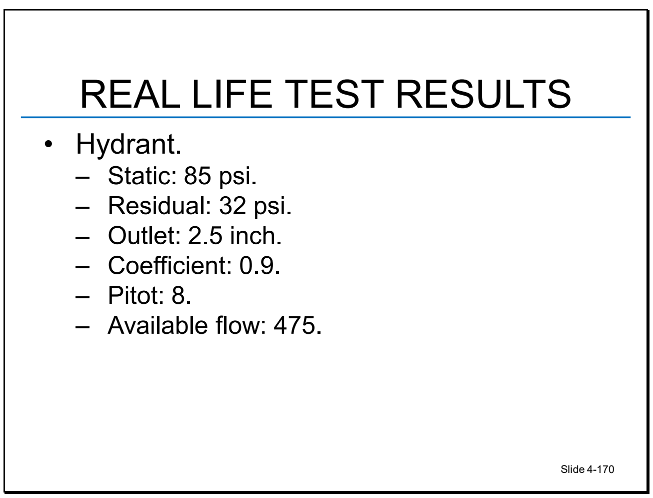
C. Pipe schedule demands.

The water supply or demand of a pipe schedule sprinkler system is determined by NFPA 13, Table 11.2.2.1. The minimum pressure specified in the table is the pressure at the highest elevation of the sprinkler system, not the most remote. For light hazard systems, the minimum residual pressure at the top-most elevation is 15 psi and the flow ranges from 500 to 750 gpm. For ordinary hazard systems, the minimum residual pressure at the top-most elevation is 20 psi and the ranges from 850-1,500 gpm.





REAL LIFE TEST RESULTS (cont'd)

- Main Drain.
  - Static: 85 psi.
  - Residual: 32 psi.
  - Short drain line.
  - Available flow: 230.

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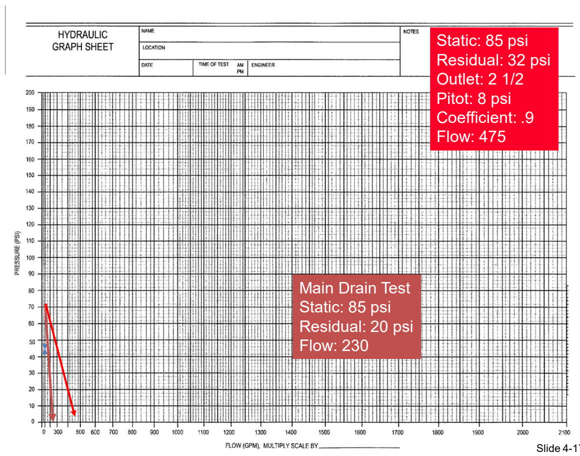

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D. From outside to inside.

ACCEPTANCE TESTING

- Hydrostatic test at 200 psi or 50 psi over the maximum operating pressure, whichever is greater, for two hours with no leakage and no more than plus or minus 5 psi.
- Alarm and supervisory functions.
- Main drain.
- Trip test on all dry pipe and preaction systems.

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E. Acceptance testing.

PNEUMATIC TESTING

- Air test for dry pipe systems at 40 psi for 24 hours with no more than 1.5 psi loss.
- Formula for pressure loss or gain due to temperature change.

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F. Pneumatic testing.

AIR PRESSURE CHANGES DUE TO TEMPERATURE CHANGES

- Not specifically addressed in NFPA 13.
- Simple formula provided to calculate pressure loss or gain due to temperature change during test.

Slide 4-175

G. Air pressure changes.

X. RESIDENTIAL SPRINKLERS

VIDEO: "NEW VERSUS OLD ROOM FIRE"

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NATIONAL FIRE PROTECTION ASSOCIATION 13D (cont'd)

- NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*.
- Protection of fire hazards only in one- and two-family dwellings and manufactured homes.
- NFPA 101, *Life Safety Code®*, permits use of 13D systems in small residential board and care facilities.

Slide 4-177

A. NFPA 13D.

INTERNATIONAL RESIDENTIAL CODE DESIGN CRITERIA

- Does not rely upon NFPA 13D.
- Complete design criteria is set forth in the 2018 International Residential Code (IRC), Section P2904.

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B. International Residential Code (IRC) design criteria.

How is building height determined?

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NATIONAL FIRE PROTECTION ASSOCIATION 13R (cont'd)

- NFPA 13R, *Standard for the Installation of Sprinkler Systems in Low-Rise Residential Occupancies.*
- Apartment buildings, lodging and rooming houses, board and care facilities, hotels, motels, and dormitories.
- If height is five stories or more, system must be in accordance with NFPA 13.

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C. NFPA 13R.

NATIONAL FIRE PROTECTION ASSOCIATION 13R DESIGN

- System capacity but no hose stream allowance.
- Duration: 30 minutes.
- Level of protection: anticipates only partial coverage.
  - Bathrooms.
  - Unused attics.
  - Clothes closets.
  - Open, attached balconies and porches.

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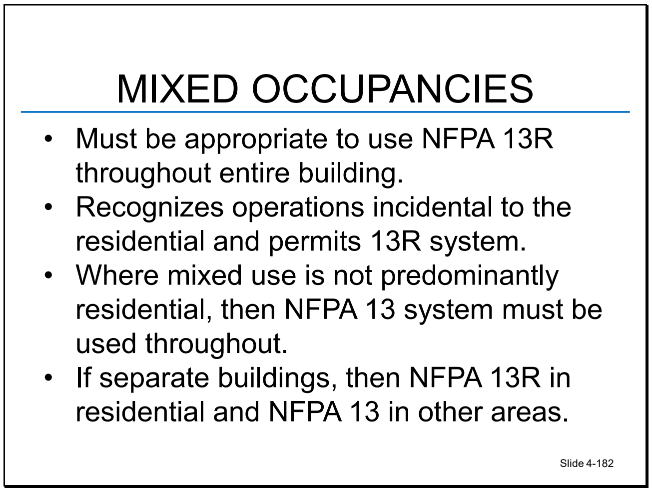
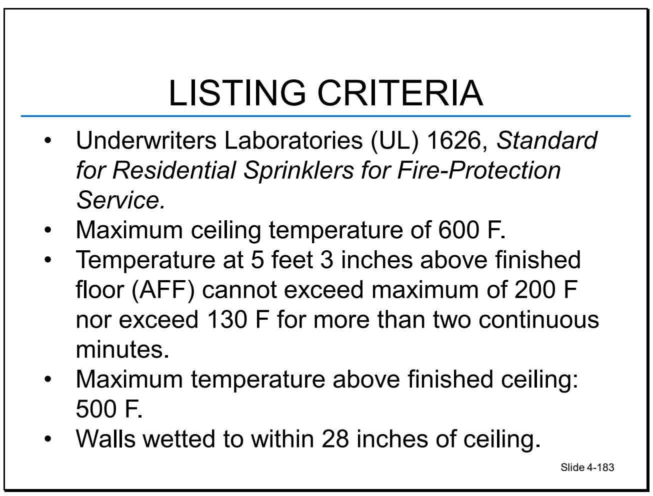
D. NFPA 13R design.



E. Mixed occupancies.



F. Listing criteria.

1. Underwriters Laboratory (UL) 1626, *Standard for Residential Sprinklers for Fire-Protection Service*, 2018 Edition.

2. Factory Mutual (FM) 2000, *Automatic Sprinklers for Fire Protection*, 2018 Edition.

DRY SYSTEMS NOW PERMITTED

- Check listing of heads very carefully.
- Basic listing is based on use on **wet** systems only.
- TYCO has listed heads and dry pipe valve.

Slide 4-184

G. Residential dry pipe systems.

ACTIVITY 4.3

Fire Protection System Impairments

Purpose

Identify obvious impairments to water-based fire protection systems, and identify how those impairments may have potential effects on system performance.

Directions

1. As a class, you will review a series of slides for any impairments to fire protection systems.

2. Identify obvious impairments to water-based fire protection systems and identify how those impairments may affect system performance.

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XI. SUMMARY

SUMMARY

- Automatic sprinkler systems.
- Sprinkler hazard classes.
- Commodity classifications.
- Fire department connections.
- Classifications of sprinkler systems.

Slide 4-201

SUMMARY (cont'd)

- Determining available flow from main drain test results.
- Hydraulic engineering design.
- Pipe schedule design.
- Residential sprinklers.

Slide 4-202

QUESTIONS?

Slide 4-203

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REFERENCES

NFPA. (2016). *Standard for the installation of sprinkler systems*. (Standard No. 13). Retrieved from www.nfpa.org

NFPA. (2017). *Standard for the inspection, testing, and maintenance of water-based fire protection systems*. (Standard No. 25). Retrieved from www.nfpa.org

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UNIT 5: WATER MIST SYSTEMS

TERMINAL OBJECTIVE

The students will be able to:

5.1 Analyze system components and established performance requirements for water mist fire protection systems and equipment.

ENABLING OBJECTIVES

The students will be able to:

5.1 Identify the applicable standards for water mist fire protection systems.

5.2 Explain the functions of water mist fire protection systems and equipment.

5.3 Explain the in-service testing process for water mist fire protection systems.

5.4 Explain the annual inspection and maintenance processes for water mist fire protection systems.

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UNIT 5: WATER MIST SYSTEMS

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TERMINAL OBJECTIVE

Analyze system components and established performance requirements for water mist fire protection systems and equipment.

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ENABLING OBJECTIVES

- Identify the applicable standards for water mist fire protection systems.
- Explain the functions of water mist fire protection systems and equipment.
- Explain the in-service testing process for water mist fire protection systems.

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ENABLING OBJECTIVES (cont'd)

- Explain the annual inspection and maintenance processes for water mist fire protection systems.

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I. WATER MIST SYSTEMS

WATER MIST SYSTEMS

- Research was done as far back as the 1940s and was reported in "The Mechanism of Extinguishment of Fire by Finely Divided Water."
- National Fire Protection Association (NFPA) 750, *Standard on Water Mist Fire Protection Systems*.

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WATER MIST SYSTEMS (cont'd)

- Automatic water mist is addressed by International Building Code (IBC) [F], 904.11: "Automatic water mist systems. Automatic water mist systems shall be permitted in applications that are consistent with the applicable listing or approvals and shall comply with Sections 904.11.1 through 904.11.3" (2015).

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A. One of the emerging technologies in the field of fire protection is that of water mist. This type of water-based fire protection system uses mist that absorbs heat, displaces oxygen or blocks radiant heat to control, suppress or extinguish fires. Water mist systems are designed, installed and maintained in accordance with National Fire Protection Association (NFPA) 750, *Standard on Water Mist Fire Protection Systems*. While this standard contains the minimum requirements for the design, installation and maintenance of such systems, it does not provide definitive fire performance criteria nor does it offer specific guidance on how to design a system to control, suppress or extinguish a fire. Substantial reliance is placed upon the information contained within manufacturer's listing and installation manuals.

B. Water mist systems are used to protect gas jet fires, flammable and combustible liquids, and hazardous solids, such as plastic foam, Class A combustibles, electrical hazards and electronic equipment. These systems cannot be used for any materials that react with water, such as reactive metals, carbides, halides, sulfides and cyanates.

WATER MIST SYSTEMS (cont'd)

- Distribution system connected to a water supply or a water supply and an atomizing media supply.
- One or more nozzles.
- Intended to control, suppress or extinguish fires.

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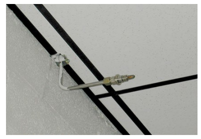
C. Water mist systems consist of a distribution system connected to a water supply or a water supply and an atomizing media supply. The atomizing media is compressed air or other gases that produce water mist by mechanical mixing with water. The system will also contain one or more nozzles. The intended performance of the system can be fire control, fire suppression or fire extinguishment.

DISCHARGE NOZZLES



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FIRE CONTROL

Limitation of growth of fire by pre-wetting adjacent combustibles and controlling ceiling gas temperatures to prevent structure damage.

Slide 5-9

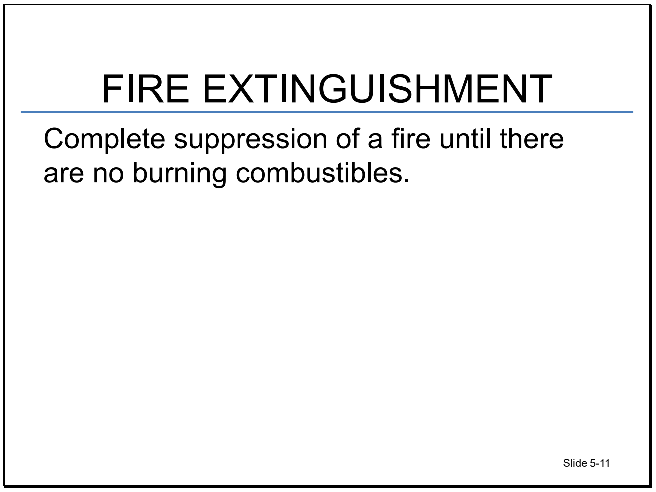
D. Fire control is the limitation of the growth of fire by pre-wetting adjacent combustibles and controlling ceiling gas temperatures to prevent structural damages.

FIRE SUPPRESSION

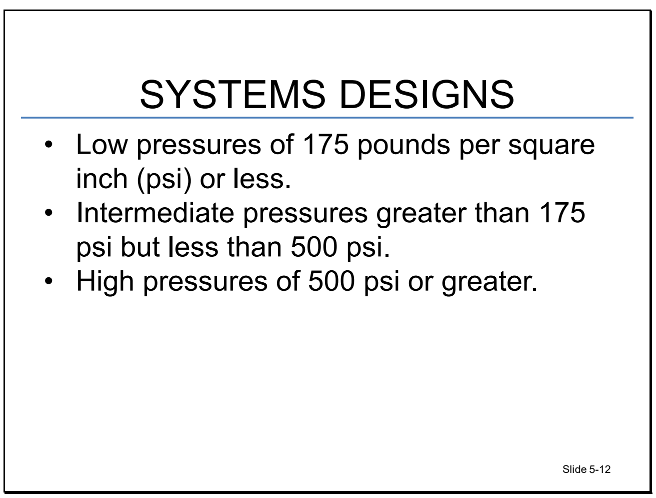
- Oxygen displacement at molecular level.
- Sharp reduction of the rate of heat release of a fire and the prevention of regrowth.

Slide 5-10

E. Fire suppression is the sharp reduction of the rate of heat release of a fire and the prevention of regrowth.



F. Fire extinguishment is the complete suppression of a fire until there are no burning combustibles.



G. System designs.

Water mist systems can be designed to operate at low, intermediate and high pressures within the distribution piping system. Low-pressure systems operate at 175 pounds per square inch (psi) or less. Intermediate-pressure systems operate at pressures greater than 175 psi but less than 500 psi. High-pressure systems operate at 500 psi or greater.

LOW-PRESSURE SYSTEM

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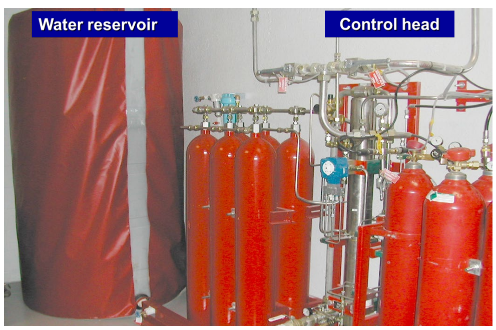
1. Low-pressure system.

HIGH-PRESSURE CYLINDERS



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2. High-pressure system.

ATOMIZING MEDIA

- Compressed air or other gases that produce water mist by mechanical mixing with water.
- Some systems use pumps to create the necessary pressure.

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H. Atomizing media.

DESIGN CONCEPTS

- Engineered: systems designed by individual (site specific) calculation and design.
- Pre-engineered: systems having predetermined flow rates, nozzle pressures and water quantities.

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I. Design concepts.

Systems can be either engineered or pre-engineered. Engineered systems are designed by individual (site specific) calculation and design. Pre-engineered systems have predetermined flow rates, nozzle pressures and water quantities. Regardless of the type of system, plans and specifications are required to be submitted to the authority having jurisdiction (AHJ) for review and approval prior to the commencement of any installation work.

APPLICATION TYPES

- Local: designed to discharge directly on an object or hazard in an enclosed, unenclosed or open outdoor condition.
- Zoned: designed to protect hazards in a predetermined portion of an enclosure.
- Total compartment: designed to protect all hazards within an enclosure.

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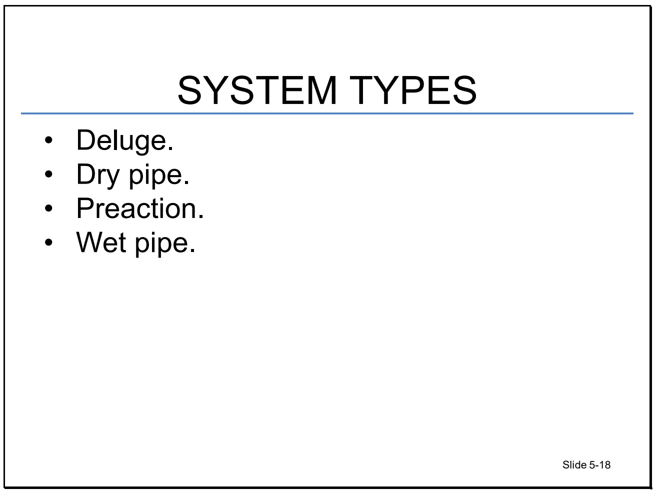
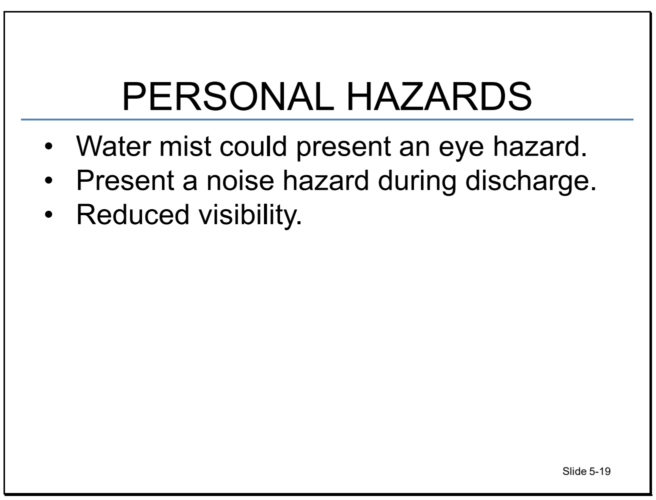
J. Application.

Application can be local, zoned or total compartment. Local systems are designed to discharge directly onto an object or hazard in an enclosed, unenclosed or open outdoor condition. Zoned systems are intended to protect hazards in a predetermined portion of an enclosure. Total compartment protection systems protect all hazards within an enclosure. For the purposes of water mist systems, an enclosure is the case, housing, partition or walls that substantially contain water mist in the vicinity of the hazard for a sufficient time to achieve the fire protection objectives.



K. System types.

Systems can be configured for operation as deluge, dry pipe, preaction and wet pipe.



OPERATING PRESSURES

- In standby mode, wet systems pressurized to 200 psi, dry to 400 psi.
- In operation, pressure rises to approximately 2,200 psi.

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L. Personal hazards.

1. Water mist systems are unlikely to present any significant hazards to personnel; however, both the designer and AHJ should consider this potential. Given the operating pressure of the systems, direct impingement of water mist could present an eye hazard. Additionally, intermediate- and high-pressure systems can present a noise hazard during discharge. Finally, all systems can result in reduced visibility, thereby increasing the difficulty and time necessary for egress of the protected compartment.

2. These hazards can generally be mitigated by providing a means for prompt evacuation/rescue of personnel, prevention of entry into the hazardous atmosphere, training, warning signs, discharge alarms, self-contained breathing apparatus (SCBA), evacuation plans and drills.

ACCEPTANCE TESTS

- Authority having jurisdiction (AHJ) must be notified.
- Test to manufacturer's requirements.

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M. Acceptance test.

1. Prior to conducting any acceptance testing, notice must be given to the AHJ. Acceptance testing is based primarily on the manufacturer's requirements and will include a review of mechanical and electrical components, as well as functional tests. A full discharge test is required.

2. The underground water supply must also be flushed thoroughly in accordance with the provisions of NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*.

COMPONENT TESTS

- Hydrostatic pipe tests.
  - Low-pressure systems.
    - Two hours: 200 psi or 50 psi over operating pressure.
  - Intermediate and high.
    - Two hours: 150% of operating pressure.
- Pneumatic tests.
  - Dry and preaction.
    - 24 hours: 40 psi with no more than 1.5 psi loss.

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N. Component tests.

Once the system has been installed, all piping and associated components must be subjected to a two-hour hydrostatic test. Low-pressure systems must be tested at a minimum of 200 psi or 50 psi over the operating pressure, whichever is greater. Intermediate- and high-pressure systems must be tested at 150% of the normal operating pressure. No leakage or loss is permitted. Dry and preaction systems must also be subjected to an air test at 40 psi for 24 hours with no more than 1.5 psi loss.

MAINTENANCE

- Per NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*.
- Inspections.
  - Weekly.
    - Water level, air supply, compressors on unsupervised systems.
  - Monthly.
    - Water level, air supply, compressors.

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O. Maintenance.

The responsibility for properly maintaining a water mist fire protection system is the obligation of the property owner. The owner is also responsible for notifying the AHJ prior to shutting down the system. Specific inspection and testing requirements are set forth in NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*.

II. BURN TEST

A. Marriott hotel test.

VIDEO PRESENTATION

"PLUMIS LTD: INNOATIVE TECHNOLOGY FOR RESIDENTIAL FIRE SUPPRESSION"

https://www.youtube.com/watch?v=NNPs6pdxrso

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B. Automist test.

III. CASE STUDY

CASE STUDY

Tom's Creek Methodist Church
Use of Water Mist Protection

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BACKGROUND

- Located just outside the town of Emmitsburg.
- Erected in 1904.
- 1,800 square feet in existing building (wood-frame construction).
- Addition of fellowship hall with footprint of approximately 6,900 square feet (wood frame).
- Addition is two stories with usable attic space (storage).
- Addition is not separated from existing.

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A. Background.

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FIRE PROTECTION ISSUES

- Due to size of addition, applicable code required installation of automatic fire sprinklers.
- No public water supply available.
- Electrical utility service in area limited to single phase.
- Need for on-site tank of 10,000 gallons — loss of basement space.
- Estimated cost for pump, tank and utility upgrade: $180,000.

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B. Fire protection issues.

WATER MIST ALTERNATIVE

- General contractor became aware of availability of water mist protection.
- Local county fire officials familiar with water mist due to one of their stations being protected in 2004.
- Marioff Hi-Fog® system designed as alternative.

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C. Water mist alternative.

SYSTEM DESIGN

- Designed for fire suppression.
- Wet system in occupied areas of addition.
- Dry system in attic of addition.
- Dry system in attic and occupied spaces of existing building.
- Uses gas-driven pump unit.
- Total water supply: 1,000 gallons.

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D. System design.

HIGH-PRESSURE CYLINDERS (cont'd)

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IV. SUMMARY

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SUMMARY

- Water mist systems.
- Burn test.
- Case study.

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QUESTIONS?

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REFERENCES

ICC. (2015). *International Building Code*. Washington, DC: Author.

ICC. (2015). *International Fire Code*. Washington, DC: Author.

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UNIT 6: STANDPIPE SYSTEMS

TERMINAL OBJECTIVE

The students will be able to:

6.1 *Analyze system components and established performance requirements for standpipe fire suppression systems and equipment.*

ENABLING OBJECTIVES

The students will be able to:

6.1 *Identify the applicable standards for standpipe fire suppression systems.*

6.2 *Explain the functions of standpipe fire suppression systems and equipment.*

6.3 *Explain the in-service testing process for standpipe fire suppression systems.*

6.4 *Explain the annual inspection and maintenance processes for standpipe fire suppression systems.*

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UNIT 6: STANDPIPE SYSTEMS

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TERMINAL OBJECTIVE

Analyze system components and established performance requirements for standpipe fire suppression systems and equipment.

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ENABLING OBJECTIVES

- Identify the applicable standards for standpipe fire suppression systems.
- Explain the functions of standpipe fire suppression systems and equipment.
- Explain the in-service testing process for standpipe fire suppression systems.

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ENABLING OBJECTIVES (cont'd)

- Explain the annual inspection and maintenance processes for standpipe fire suppression systems.

Slide 6-4

I. INTRODUCTION

GOVERNING STANDARD

National Fire Protection Association (NFPA) 14, *Standard for the Installation of Standpipe and Hose Systems*, 2016 edition.

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PURPOSES OF STANDPIPES

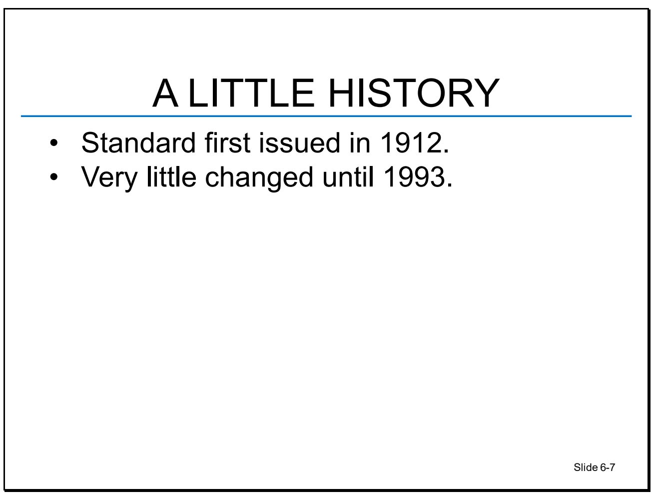
- Aid in manual fire suppression.
  - Lessen hose carries.
  - Deliver large water volumes.
- For use by building occupants and fire department personnel.
  - First-aid fire equipment.
  - Post-incident mop up.

Slide 6-6

A. Purpose of standpipes.

1. Standpipe systems are installed in buildings to facilitate manual suppression by occupants or fire service personnel. Standpipe systems are an arrangement of piping, valves, hose connections and related equipment installed in a building in a fixed manner. The systems may or may not have hoses permanently attached. Water supplies may or may not be continually provided to standpipe systems. These features of a standpipe system are dictated by the class and type of system. The primary use of standpipe systems is by fire department personnel who are trained in manual fire suppression methods.

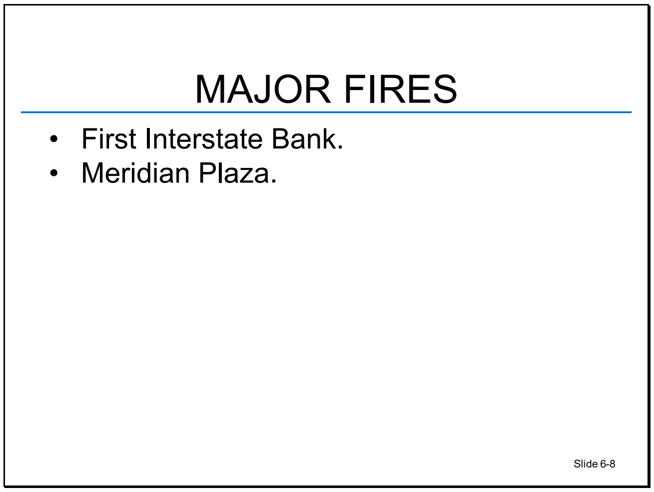
2. Many standpipe systems no longer have occupant hoselines (small diameter 1 1/2-inch). The fixed piping of a standpipe system in a building allows the fire service to connect its hoselines into a pressurized water source near the fire floor. The fire service is consequently relieved of the burden of extending hoses into the building from grade level to the location (floor) of the fire. In mid- to high-rise buildings, standpipe systems are extremely important for the prompt manual extinguishment of fires.



B. A little history.

1. As a standard, the National Fire Protection Association (NFPA) dates back to 1912 when an initial report was made by the Committee on Standpipe and Hose Systems. Over the years the standard underwent numerous revisions and changes.

2. In 1993, significant changes to the document were made as a result of actual fire experiences with standpipe systems under fire conditions.



C. Major fires.

Two of the primary fire events which effected these changes were the First Interstate Bank fire in Los Angeles, California, and the Meridian Plaza fire in Philadelphia, Pennsylvania. Both of these fires occurred in high-rise buildings and involved serious failures of standpipe systems.

1. First Interstate Bank.

    a. The fire at the First Interstate Bank in Los Angeles, California, demonstrated the problems that can be generated by high pressures within a standpipe system at lower-level floors. The standpipe system in this building was a single wet standpipe riser that extended from grade to the top of the 62nd floor. This type of design, referred to as a single standpipe zone, was permitted by local codes. To attain the necessary pressure and flow for firefighting purposes at the top floor with this design requires extreme pressures at the lower floors to compensate for the pressure loss due to elevation.

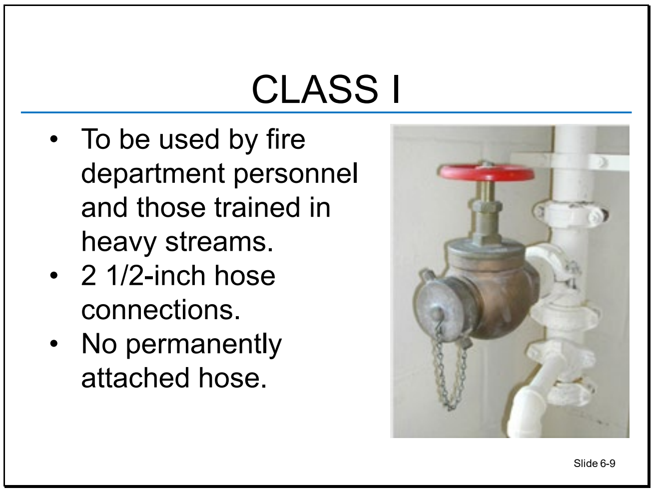
    b. In the early stages of the fire, the only water available from the standpipe system was that which was above the fire floors. Once the building's fire pump was turned on (some 45 minutes into the incident), an adequate standpipe water supply was provided.

2. Meridian Bank building.

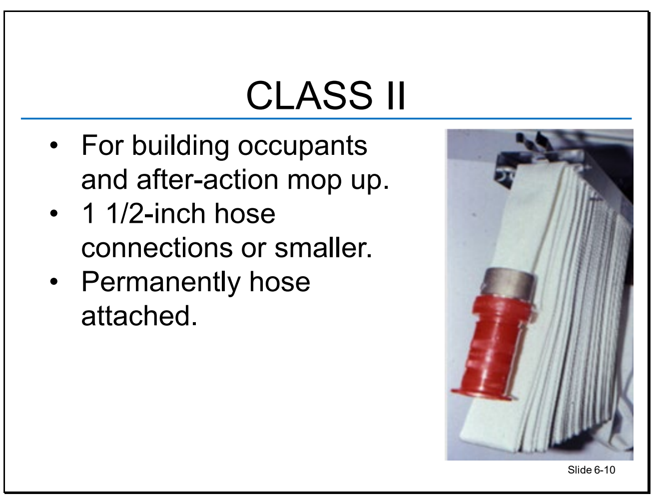
    a. The fire dramatically demonstrated what can occur when pressure regulating devices (PRDs) fail. In this fire, the standpipe system was equipped with pressure reducing valves (PRVs). These devices were not properly installed, tested or maintained, and the result was fire flows that were so restricted as to be unusable. The failure of these devices made it necessary for the fire department to stretch large-diameter hose up nearly 30 stories.

b. While standpipe systems are fairly simple in comparison to other fire protection systems, failure to comply with applicable design, installation and maintenance requirements can result in a system being nonfunctional under actual fire conditions. Designers, installers, fire departments and authority having jurisdictions (AHJs) must remember that standpipes are more than just simple pipes and valves.

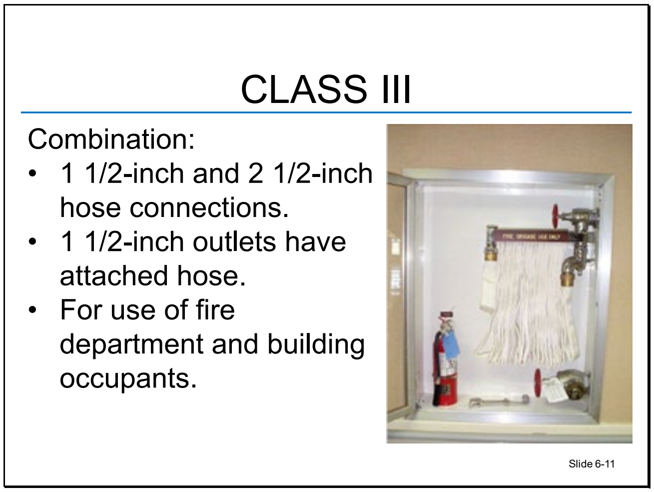
II. CLASSES OF SYSTEMS AND WATER SUPPLY



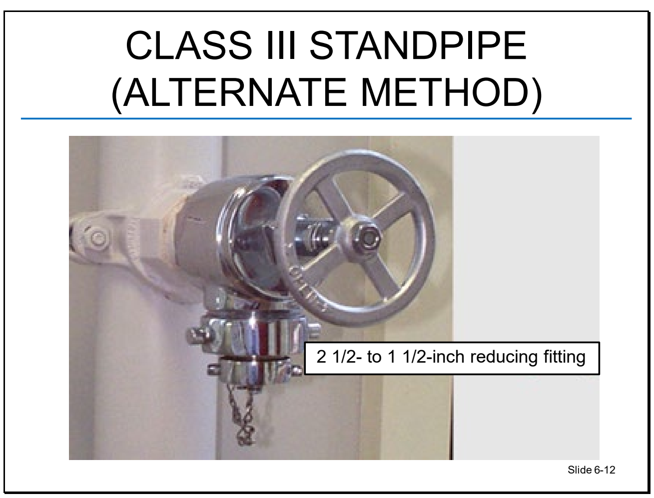
A. Class I systems have 2 1/2-inch hose connections on the system piping. This size of hose produces what is considered a heavy fire stream and is intended primarily for the fire service, which supplies its own hoses for firefighting.



B. Class II systems have 1 1/2-inch hose connections and are used by the building occupants or by the fire department during overhaul operations. In light hazard occupancies, the installation of 1-inch hose is permitted when approved by the AHJ. In recent years, many concerns have arisen about Class II standpipes. These concerns have included the use of a hose stream by untrained persons, delayed alarms, personal injuries, maintenance, misuse, vandalism and training requirements. Because of these concerns, many AHJs have permitted the removal of, or prohibited the installation of, Class II standpipes.



C. Class III systems have both 2 1/2- and 1 1/2-inch outlets and are intended to be used by the fire department, those trained in heavy hose streams and the building occupants. These systems may be designed with 2 1/2-inch valves with 1 1/2-inch adapters or with separate 2 1/2- and 1 1/2-inch hose valves. In either case, there will be a permanently attached 1 1/2-inch hose.



D. Class III (alternate method).

E. Water supply.

The volume and pressure required for standpipe operation varies depending upon its classification.

WATER SUPPLY FOR
2 1/2-INCH OUTLETS

- 500 gallons per minute (gpm) at 100 pounds per square inch (psi) residual, at top-most outlet of remote riser.
- Additional 250 gpm for each additional riser.
- Maximum demand of 1,250 gpm.

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1. Water supply for 2 1/2-inch outlets.

   a. Class I and Class III systems require a minimum flow rate for the hydraulically most remote outlet of 500 gallons per minute (gpm) at a residual pressure of 100 pounds per square inch (psi). For each additional standpipe riser the demand is increased by 250 gpm up to a maximum of 1,250 gpm for buildings that do not exceed 80,000 square feet and are not sprinklered throughout, in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*.

   b. For buildings that exceed 80,000 square feet (7,432 square meters) per floor, the minimum flow rate for additional standpipes shall be 500 gpm for the second standpipe and 250 gpm for the third standpipe if the additional flow is required for an unsprinklered building.

   c. The AHJ can require a higher minimum residual pressure for system operation. The AHJ should conduct an analysis of their operations and equipment to determine what minimum pressure is necessary for proper system operation. Many of the automatic nozzles in use require a minimum of 100 psi at the nozzle.

OLDER SYSTEMS MAY HAVE LESS SUPPLY

- 500 gpm at 65 psi residual.
- Need to coordinate with suppression.
- Higher pressures can be required by authority having jurisdiction (AHJ).

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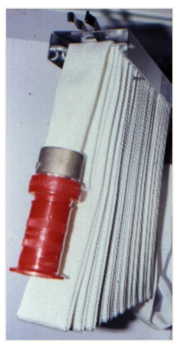
2. Older systems.

MINIMUM FLOW FOR 1 1/2-INCH OUTLETS

100 gpm at 65 psi.



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3. Minimum flow for 1 1/2-inch outlets.

   Class II systems require a minimum flow rate of 100 gpm at a residual pressure of 65 psi. Additional flow is not required where more than one standpipe is provided.

COMBINATION SYSTEMS

Combine both standpipe and sprinkler system piping.

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COMBINED SYSTEM

Hose stations attached to sprinkler system.

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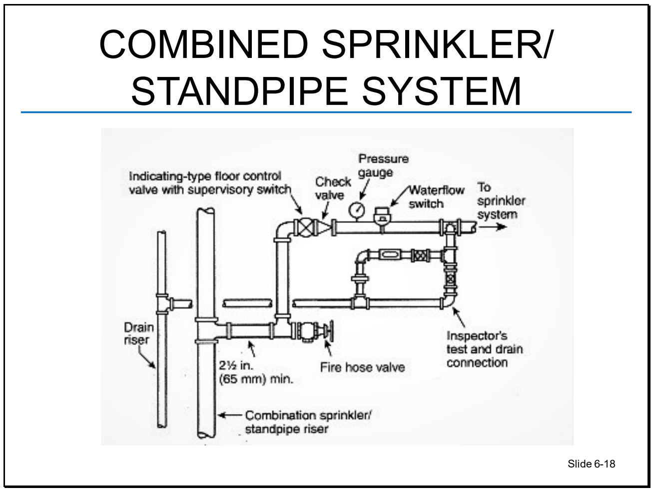
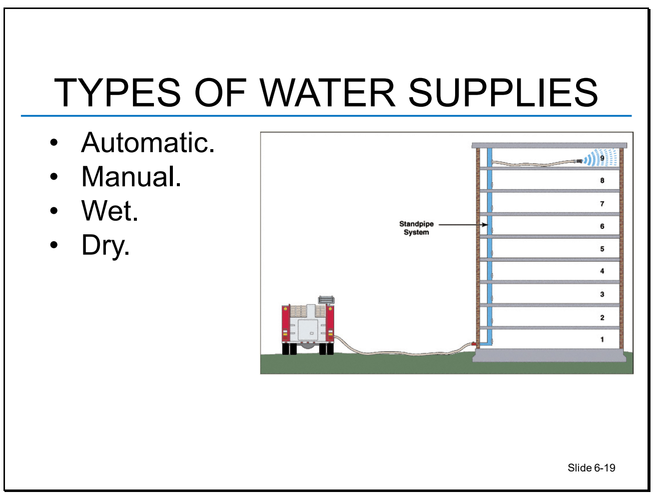
F. Combination systems.

For combined systems (sprinklers and standpipes), the demand is dependent upon several factors. For fully sprinklered buildings, the standpipe demand is permitted to serve the sprinkler system demand. Where the sprinkler demand exceeds the standpipe demand, the larger of the two rates must be provided. For partially sprinklered buildings, the demand rate for the standpipe system must be increased by the hydraulically calculated sprinkler demand or 150 gpm for light hazard occupancies or 500 gpm for ordinary hazard occupancies, whichever is less.

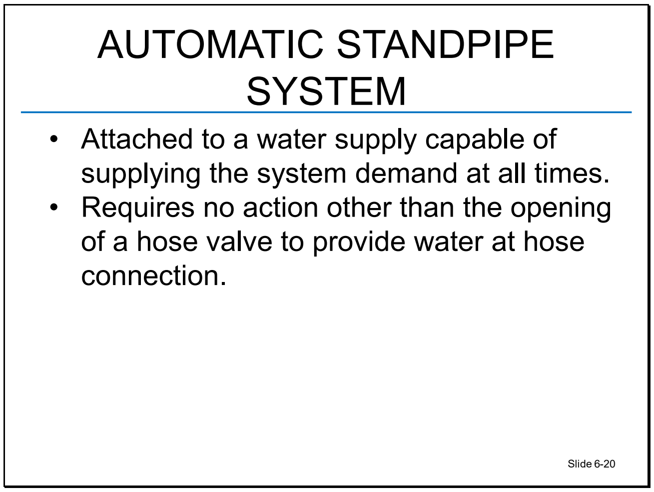


G. Combined sprinkler/standpipe system.

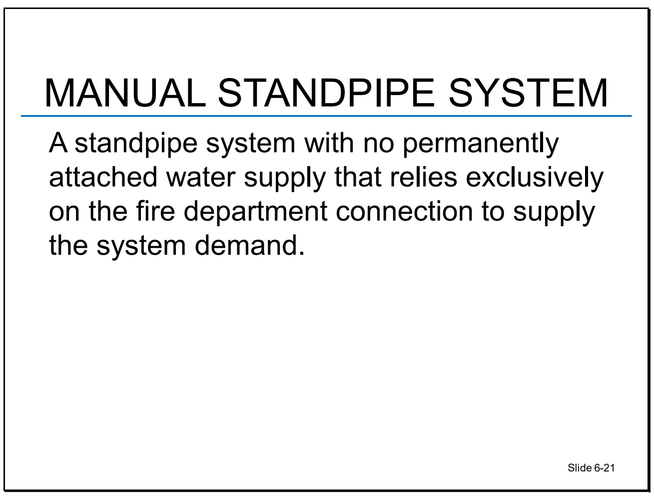
III. TYPES OF STANDPIPES AND WATER SUPPLIES



A. Standpipe operation is classified as either “automatic” or “manual” as follows:



1. Automatic standpipe systems.



2. Manual standpipe systems.

B. In addition to the system operation, the type of water supply is further classified as "wet" or "dry." Wet standpipes have piping containing water at all times, while dry standpipes are designed to contain water only when the system is being used. These systems are further defined as follows.

AUTOMATIC WET STANDPIPE SYSTEM

A standpipe system containing water at all times that is attached to a water supply capable of supplying the system demand at all times and that requires no action other than opening a hose valve to provide water at hose connections.

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1. Automatic wet systems.

MANUAL WET SYSTEMS

- Connected to a water supply for the purpose of maintaining water within the system (primed) but does not have a water system capable of delivering the system demand.
- Manual wet systems need water from a fire department pumper in order to supply the system demand.

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2. Manual wet systems.

MANUAL DRY SYSTEMS

- Systems have no permanent water supply system attached to the standpipe system.
- Systems need water from a fire department pumper in order to supply the system demand.
- Normally filled with air and using a dry pipe valve (automatic dry).

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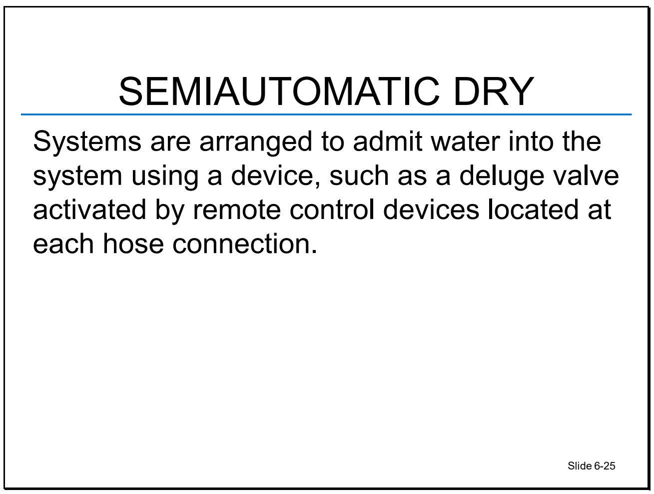
3. Manual dry systems.

   a. Manual dry pipe systems are not permitted to be used in high-rise buildings, Class II or Class III systems. Each hose connection for manual standpipes shall be provided with a conspicuous sign that reads "MANUAL STANDPIPE FOR FIRE DEPARTMENT USE ONLY."

   b. Dry standpipes are to be used only where the piping is subject to freezing. However, the provisions of NFPA 88A, *Standard for Parking Structures*, and some of the building and fire codes permit the use of dry standpipes in parking garages/structures. Dry standpipes are not permitted to be used in Class II and III systems.



4. Semiautomatic dry.

IV. REQUIRED TYPES OF STANDPIPES, LOCATION AND SPACING

A. Required types of standpipes.

CLASS I STANDPIPES

- "Class I standpipe systems shall be permitted to be automatic dry, automatic wet, semiautomatic dry, manual dry or manual wet in buildings **not classified** as high-rise buildings."
- "Class I standpipe systems in buildings classified **as high-rise** buildings shall be automatic or semiautomatic" (NFPA 14, 2016).

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1. Class I standpipes.

CLASS II AND III STANDPIPES

"Class II and Class III standpipe systems with 1 1/2-in. (40 mm) hose stations shall be automatic wet systems unless located in a facility where piping is subject to freezing and where a fire brigade is trained to operate the system without fire department intervention, in which case an automatic dry or semiautomatic dry system shall be permitted" (NFPA 14, 2016).

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2. Class II and III standpipes.

B. Location and spacing.

CLASS I LOCATION AND SPACING

- "Hose connections shall be provided at each main floor landing of required exit stairs" (NFPA 14, 2016).
- Travel distance shall be 200 feet for sprinklered buildings and 130 feet for nonsprinklered buildings.
- Additional outlets so travel distance does not exceed 150 feet for nonsprinklered buildings and 200 feet for sprinklered buildings.
- "Hose connections shall be provided on each side of the wall adjacent to the exit openings of horizontal exits" (NFPA 14, 2016).

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CLASS I LOCATION AND SPACING (cont'd)

- "Hose connections shall be provided in covered mall buildings, at the entrance to each exit passageway or exit corridor, and at the interior side of public entrances from the exterior to the mall."
- "Hose connections shall be provided at the highest landing of stairways with stairway access to a roof."
- "In stairways that do not access the roof, a hose connection shall be provided on the roof" (NFPA 14, 2016).

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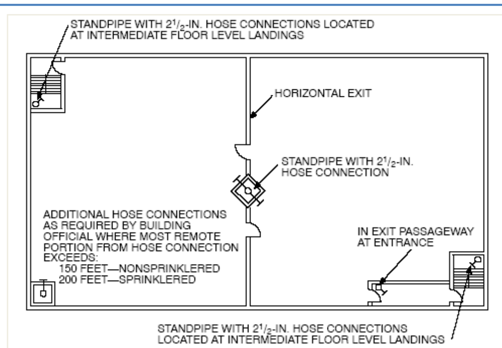
1. Class I system.

ADDITIONAL HOSE CONNECTIONS



Slide 6-30

Additional hose connections.

CLASS II AND III LOCATION AND SPACING

- "**Class II systems** shall be provided with 1 1/2-in. (40 mm) hose stations so that all portions of each floor level of the building are within 130 ft (39.7 m) of a hose connection provided with a 1 1/2-in. (40 mm) hose or within 120 ft (36.6 m) of a hose connection provided with a less than 1 1/2-in. (40 mm) hose."
- "**Class III systems** shall be provided with hose connections as required for both Class I and Class II systems" (NFPA 14, 2016).

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2. Class II and III systems.

STANDPIPE SYSTEM ZONE

"A vertical subdivision of a standpipe system limited or determined by the pressure limitations of the system components" (NFPA 14, 2016).

- Prior to 1993, limit was 275 feet, with exception for 400 feet.
- Current requirement is that the maximum pressure at any point in a system cannot exceed 350 psi.

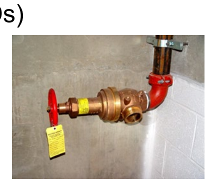
Slide 6-32

3. Standpipe system zone.

V. PRESSURE REGULATING DEVICES

PRESSURE REGULATING DEVICES

- Pressure regulating devices (PRDs) are designed for the purpose of reducing, regulating, controlling or restricting water pressure.
- If these devices are not properly installed, tested and maintained, the operational ability of the standpipe system can be seriously impaired.
- Some of these devices are field adjustable, while others are factory set during the manufacturing process.



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PRESSURE REGULATING DEVICES (cont'd)

- Pressure control valves are a pilot-operated pressure reducing valve (PRV) designed for the purpose of reducing the downstream water pressure to a specific value under both flow (residual) and no flow (static) conditions.
- Examples include PRVs, pressure control valves and pressure restricting devices.

Slide 6-34

A. PRDs.

DEVICES FOUND AT HOSE CONNECTIONS

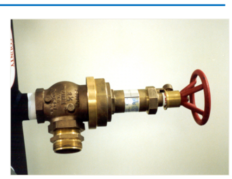
- PRV.
- Pressure restricting device.

Slide 6-35

B. Devices found at hose connections.

PRESSURE REDUCING VALVE

- PRVs are designed for the purpose of reducing the downstream water pressure under both flow (residual) and no flow (static) conditions.
- These valves work very similarly to the pressure regulating arrangement on fire department pumpers.

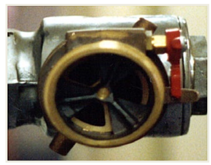


Slide 6-36

C. PRV.

PRESSURE RESTRICTING DEVICE

- Pressure restricting devices are designed for the purpose of reducing the downstream water pressure under flow (residual) conditions only.
- These devices generally work as a restricting orifice.



Slide 6-37

D. Pressure restricting device.

Pressure restricting devices must be installed as follows:

1. At 1 1/2-inch hose valves when the residual pressure exceeds 100 psi and limit the residual pressure to not more than 100 psi.

2. At 1 1/2-inch valves where the static pressure exceeds 175 psi and limit the static and residual pressure to not more than 100 psi.

3. At 2 1/2-inch valves where the static pressure exceeds 175 psi and limit the static and residual pressure to not more than 175 psi.

E. Testing and inspection.

ACCEPTANCE TESTING

NFPA 14 requires:

- All new and modified standpipe systems shall be tested hydrostatically at not less than 200 psi or 50 psi over the maximum operating pressure, whichever is higher, for a period of two hours with no leakage.
- The hydrostatic test pressure is measured at the low elevation point of the individual system or zone being tested.

Slide 6-38

ACCEPTANCE TESTING (cont'd)

- Each PRD shall be tested to verify that the installation is correct, that the device is operating, and that the inlet and outlet pressures and flow devices are in accordance with the design.
- Static and residual inlet pressure and static and residual outlet pressure and flow shall be recorded on the contractor's test certificate.

Slide 6-39

1. Acceptance testing.

CONTRACTOR'S MATERIALS AND TEST CERTIFICATE

- All tests are required to be conducted by the contractor in the presence of the AHJ or the representative of the owner.
- It is important to remember that the AHJ is not the owner's representative.
- Upon completion of all tests, the contractor must complete and file with the AHJ the "Contractors Material and Test Certificate for Above Ground Piping."

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2. Contractor's materials and test certificate.

PERIODIC TESTING

Per NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 2017 edition, a flow test shall be conducted every five years on all automatic standpipe systems to verify the required flow.

Slide 6-41

3. Periodic testing.

VI. SUMMARY

SUMMARY

- Classes of systems and water supply.
- Types of standpipes and water supplies.
- Required types of standpipes, location and spacing.
- PRDs.

Slide 6-42

QUESTIONS?

Slide 6-43

REFERENCE

NFPA. (2016). *Standard for the installation of standpipe and hose systems*. (Standard No. 14). Retrieved from www.nfpa.org

UNIT 7: FIRE PUMPS

TERMINAL OBJECTIVE

The students will be able to:

7.1 Evaluate if fire pump systems and equipment are operational, adequate, maintained and tested.

ENABLING OBJECTIVES

The students will be able to:

7.1 Identify the applicable standards for fire pump systems.

7.2 Explain the functions of fire pump systems and equipment.

7.3 Explain the in-service testing process for fire pump systems.

7.4 Explain the annual inspection and maintenance processes for fire pump systems.

7.5 Analyze fire pump systems test documentation for accuracy, completeness and code compliance.

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UNIT 7: FIRE PUMPS

Slide 7-1

TERMINAL OBJECTIVE

Evaluate if fire pump systems and equipment are operational, adequate, maintained and tested.

Slide 7-2

ENABLING OBJECTIVES

- Identify the applicable standards for fire pump systems.
- Explain the functions of fire pump systems and equipment.
- Explain the in-service testing process for fire pump systems.

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ENABLING OBJECTIVES (cont'd)

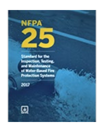
- Explain the annual inspection and maintenance processes for fire pump systems.
- Analyze fire pump systems test documentation for accuracy, completeness and code compliance.

Slide 7-4

I. INTRODUCTION

GOVERNING STANDARDS

- National Fire Protection Association (NFPA) 20, *Standard for the Installation of Stationary Pumps for Fire Protection*.
- NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*.



Slide 7-5

A. Fire pumps, when installed as part of a water-based fire protection system, play a critical role in the installation reliability. Fire pumps are used to provide or enhance the water supply available from public water systems, gravity tanks, reservoirs, lakes, ponds or other reliable sources.

B. The standard for fire pumps is National Fire Protection Association (NFPA) 20, *Standard for the Installation of Stationary Pumps for Fire Protection*.

C. NFPA 20 deals with the selection and installation of pumps supplying water for private fire protection. Items considered include:

1. Criteria for water supply.

2. Suction.

3. Discharge.

4. Auxiliary equipment.

5. Power supplies.

6. Electric drive and control.

7. Internal combustion engine drive and control.

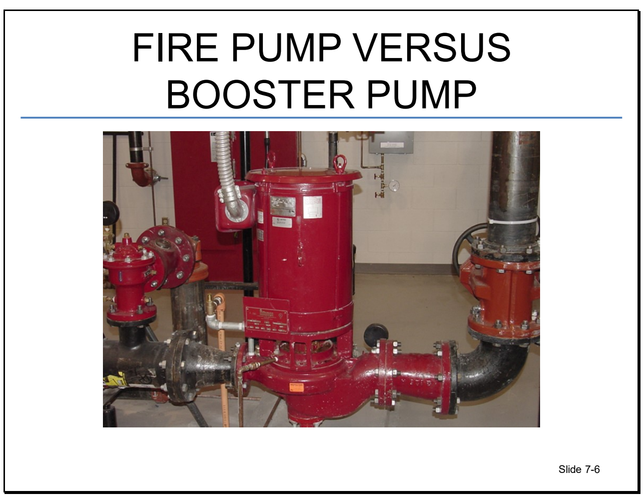
8. Steam turbine drive and control.

9. Acceptance tests and operation.

D. NFPA 20 **does not** cover water supply capacity and pressure requirements; requirements for periodic inspection, testing and maintenance; and wiring of fire pump units.

E. A fire pump unit is an assembled unit consisting of a fire pump, driver, controller and accessories.

II. PUMPS



A. Pump selection.

1. Fire pumps can be of the centrifugal, vertical shaft turbine or positive displacement types.

a. Vertical shaft turbine pumps draw from static water sources.

b. Horizontal and vertical split case pumps supplement water main pressure and may be called booster pumps.

2. Centrifugal pumps are those in which the pressure is developed principally by the action of centrifugal force. A vertical shaft turbine pump is a vertical shaft centrifugal pump with a rotating impeller or impellers and with discharge from the pumping element coaxial (wrapped around) with the shaft.

3. The selection of a fire pump must be based upon the conditions under which it will be installed and used. The rated capacity and pressure can be determined by using the standard fire pump curve for a typical manufacturer's pump characteristic curve. Examples of how this is achieved can be found in "Fire Protection Handbook" or "Stationary Fire Pumps and Standpipe Systems Handbook," published by the NFPA.

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 of the fire pump" (2016).

Slide 7-7

B. Water supply.

1. It is important to remember that a fire pump can only produce pressure — it cannot make water. Of utmost importance is the adequacy and dependability of the water supply.

2. An acceptable water supply is any source that is adequate in quality, quantity and pressure.

3. Allowances for reliability in the future must also be considered. Where the supply from a public main is not adequate in quality, quantity or pressure, an alternative supply must be provided. The water supply must be "determined and evaluated prior to the specification and installation of the fire pump" (NFPA 20, 2016).

4. Service personnel shall be qualified and experienced in the inspection, testing and maintenance of fire protection systems.

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 pounds per square inch (psi).

Slide 7-8

C. Residual pressure.

1. When the water supply is taken from a public main, the pump operation must not reduce the suction intake head (residual) below the minimum pressure permitted by the local regulatory authority (water purveyor or health department).

2. In most instances, a minimum residual pressure of 20 pounds per square inch (psi) (138 kilopascal (kPa)) must be maintained in the municipal-type water supply system. When used in conjunction with a public water system, fire pumps are often referred to as booster pumps.

WHEN BACKFLOW PREVENTION DEVICE IS INSTALLED

Final arrangement must provide effective pump performance with a minimum suction pressure of 0 psi at 150% of rated capacity.

Slide 7-9

D. Backflow prevention.

1. When backflow prevention devices are installed, care must be taken to ensure that devices are listed for fire protection service.

2. Additionally, such devices must allow effective pump performance with a minimum suction pressure of 0 psi at the gauge at 150% of rated capacity.

LOCATION OF FIRE PUMP

- Protected against possible interruption of service. Some examples are:
  - Explosion, fire, flood, earthquake, rodents, insects, windstorm, freezing, vandalism, vehicle impact (if outside), etc.
- Must be sprinklered if protecting a fully sprinklered building.

Slide 7-10

E. Fire pump location.

1. The fire pump, driver and controller are required to be protected against possible interruption of service through damage caused by explosion, fire, flood, earthquake, rodents, insects, windstorm, freezing, vandalism and other adverse conditions. Rain and the intense heat of the sun are considered adverse conditions for equipment not installed in protective enclosures. At a minimum, equipment should be shielded by a roof or deck.

2. If the fire pump is supplying a sprinkler system for a completely sprinklered building, the fire pump location is considered a part of the building and must be fully sprinklered.

FIRE-RATED SEPARATION

- Not less than two hours in high-rise.
- Not less than two hours if complete automatic sprinkler protection is not provided.
- Not less than one hour with complete automatic sprinkler protection.
- Applies only to new construction or installation.

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F. Fire-rated separation.

Indoor fire pump units must be separated from all other areas of the building by not less than two-hour fire-rated construction. This separation may be reduced to one hour when the building is protected throughout by automatic sprinkler protection in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems*.

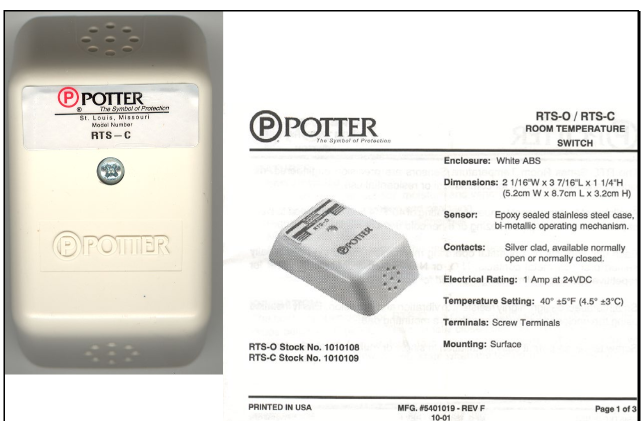
HEATING

- Fixed heating equipment.
- Capable of maintaining minimum temperature of 40 F.
- Higher temperature may be required for internal combustion engine installation.
- If heating is necessary and if fire alarm system present, temperature must be supervised.

Slide 7-12

G. Heating.

The fire pump room must be provided with fixed heating equipment capable of maintaining a minimum temperature of 40 F (4.4 C). If an internal combustion engine driver is present, a higher temperature may be required if required by the engine manufacturer. (This will be discussed later in this section.) If the pump is required to be monitored and a fire alarm system is present, the pump room temperature must be monitored. A room temperature supervisory device shall indicate a decrease in room temperature below 40 F (4.4 C).



Slide 7-13

VENTILATION

- Ventilation to reduce excessive ambient temperatures and humidity.
- Care must be taken to ensure ventilation and heating system do not counteract one another.
- Additional ventilation for internal engine drivers.

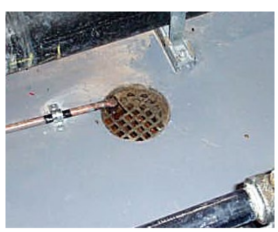
Slide 7-14

H. Ventilation.

The pump room must also be provided with proper ventilation, although NFPA 20 does not prescribe how. Care must be taken to ensure that the ventilation system and heating system do not counteract one another. The additional ventilation requirements for internal combustion engine locations will be discussed later in this section.

FLOORS

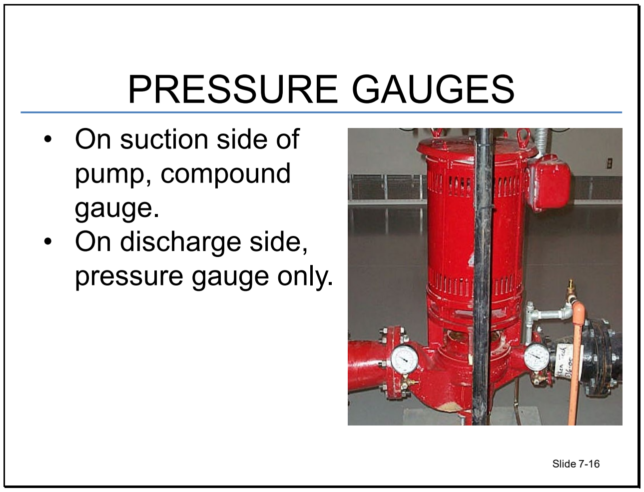
- Pitched to allow for adequate draining of water away from critical equipment.
- Floor drain must discharge to a frost-free location.



Slide 7-15

I. Floors.

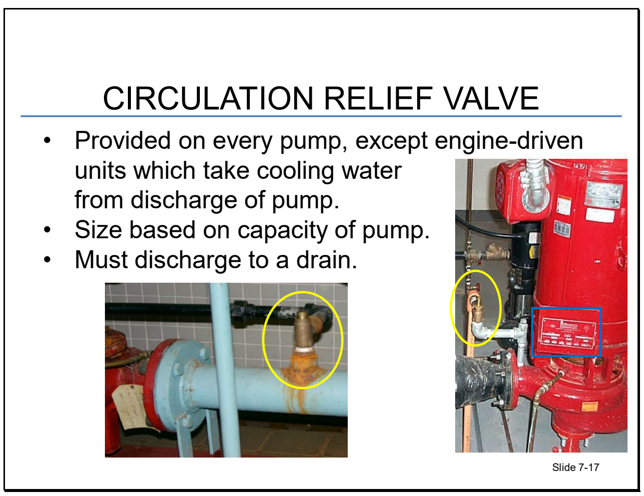
Floors of the pump room are required to be pitched to allow for the adequate draining of escaping water away from critical equipment such as the pump, driver and controller. A floor drain discharging to a frost-free location must be provided.



J. Pressure gauges.

1. Compound gauge (able to read below 0 psi) on suction side.

2. Pressure gauge on discharge side.



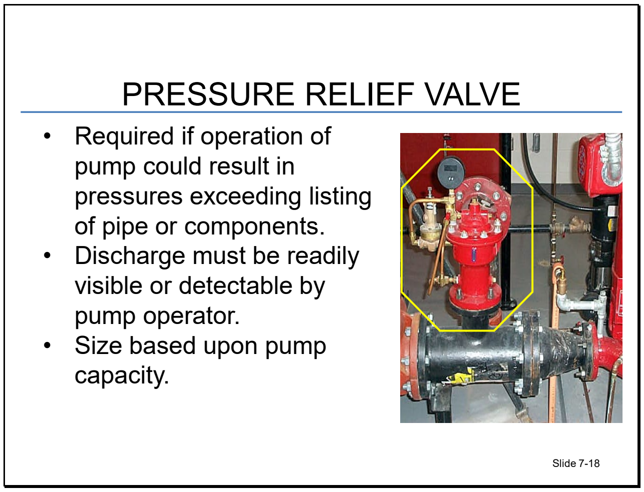
3. Circulation relief valve.

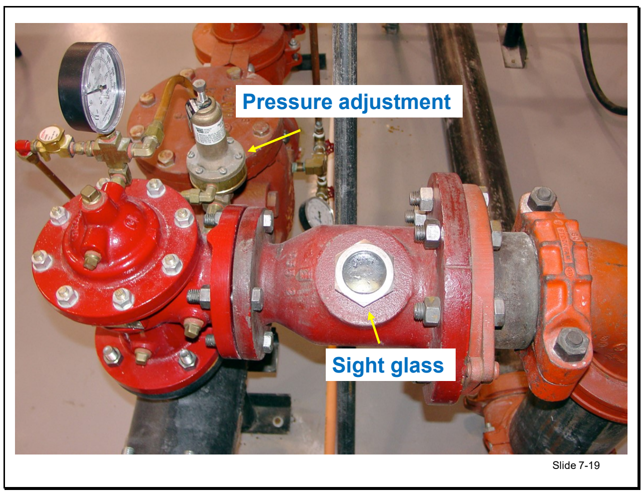
a. Each fire pump must be provided with an automatic circulation relief valve. This valve must provide a flow sufficient to prevent the pump from overheating when operating with no fire protection water discharging.

- Three-fourths inch to 2,500 gallons per minute (gpm).

- One inch to 3,000-5,000 gpm.

b. The relief valve must discharge to a drain. This rule does not apply to engine-driven pumps that take the engine cooling water from the pump discharge.





4. Pressure relief valve. (Used only where NFPA 20 allows.)

a. Where operation of the pump can result in pressures greater than the working pressure for the piping and components, a pressure relief valve must be installed.

b. The relief valve must discharge to an open pipe. Discharge must be readily visible or detectable by the pump operator. The size of the relief valve and discharge piping is determined by the size of the fire pump.

RELIEF VALVE DISCHARGE

- NFPA 20 prohibits the piping of the relief valve discharge to the suction or supply connection.
- Outside discharge concerns.

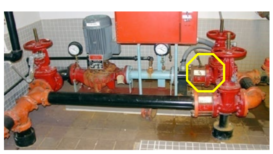
Slide 7-20

5. Relief valve discharge.

It is not permissible to pipe the relief valve discharge to the pump suction or supply connection. The size of the relief valve and discharge piping is determined by the size of the fire pump.

CHECK VALVE

- Installed on the discharge side of the pump.
- On the pump side of the control valve.



Slide 7-21

6. Check valve.

DISCHARGE CONTROL VALVE

- Listed, indicating type valve.
- Supervision required.

Slide 7-22

7. Discharge control valve.

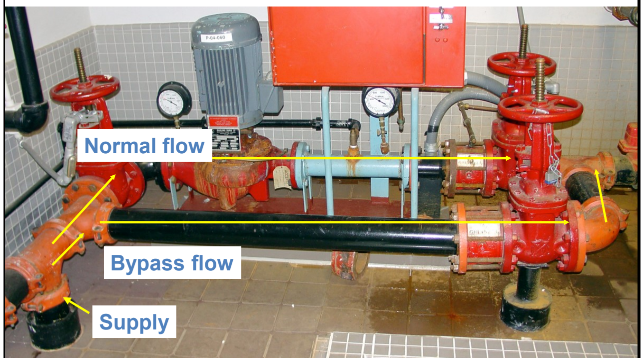
BYPASS LINE

- Required when suction supply is of "sufficient pressure to be of material value without the pump" (NFPA 20, 2016).
- Serves two functions: maintenance and emergency.
- At least as large as discharge piping and equipped with a control valve and check valve.
- Valve must remain open and be supervised.

Slide 7-23

K. Bypass line.

1. Where the suction supply for the fire pump is of "sufficient pressure to be of material value (not defined in NFPA 20) without the pump," a bypass line must be installed (NFPA 20, 2016). When the water supply is a public water system or elevated tank, some amount of water and pressure likely will be available even without fire pump operation.



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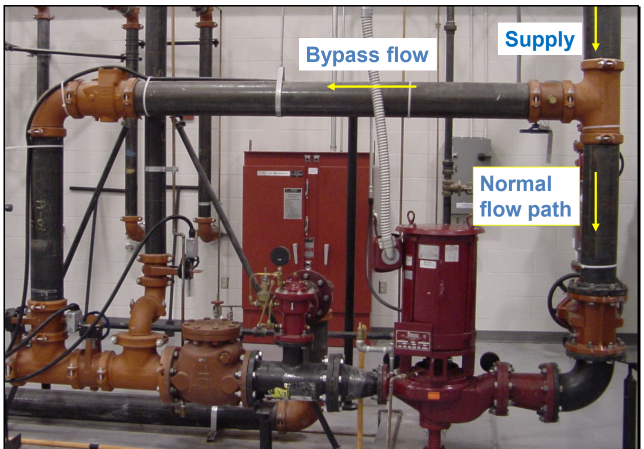

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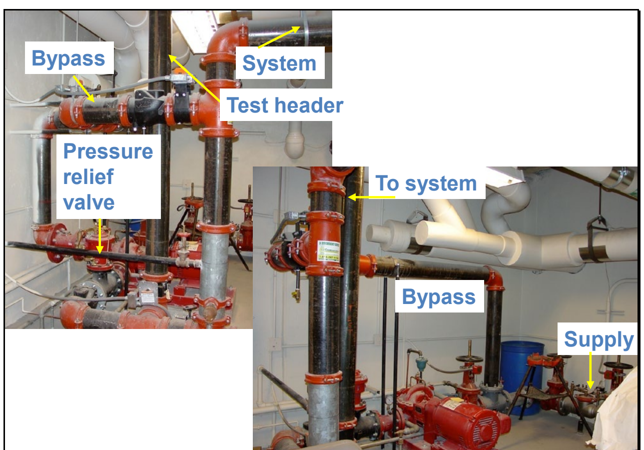


Slide 7-26

2. The bypass line serves two functions: maintenance and pump failure. In the case of maintenance, the pump can literally be removed from the installation and a limited water supply can still be maintained in the fire protection system. If the pump should fail to start or fail during operation, without a bypass line, the only way water would have to enter the system would be to pass through a stationary pump impeller.

3. The presence of the bypass line provides an automatic path for the water to take into the system without the added friction loss brought on by the stationary pump impeller. The size of the bypass line must be at least as large as the discharge piping. A check valve and control valve must be installed in the bypass line. The bypass control valve must remain open at all times and supervised.

WATERFLOW TEST DEVICE

- Provides the ability to test the pump and water supply at the maximum flow available.
- Required on all fire pump installations.
- Test header unless other adequate pump testing facilities are provided.
- Number of valves and size of piping based upon size of pump.

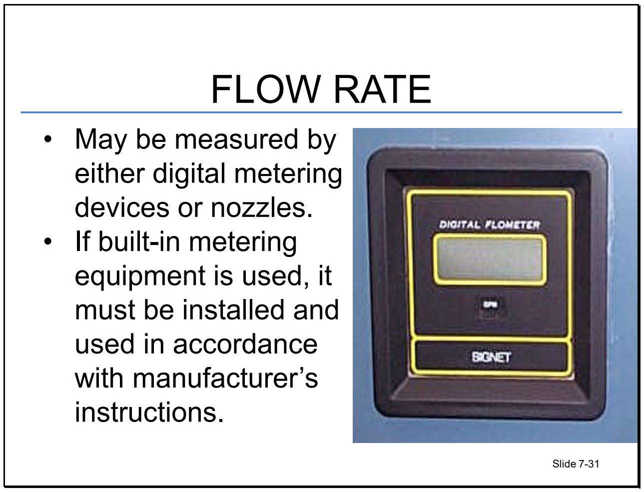
Slide 7-27

L. Waterflow test device.

1. All fire pump installations must have the ability to test the pump and the suction supply at the maximum flow available from the fire pump. Configurations/Equipment must be provided to allow for the actual discharge of water and measurement of the flow rate.

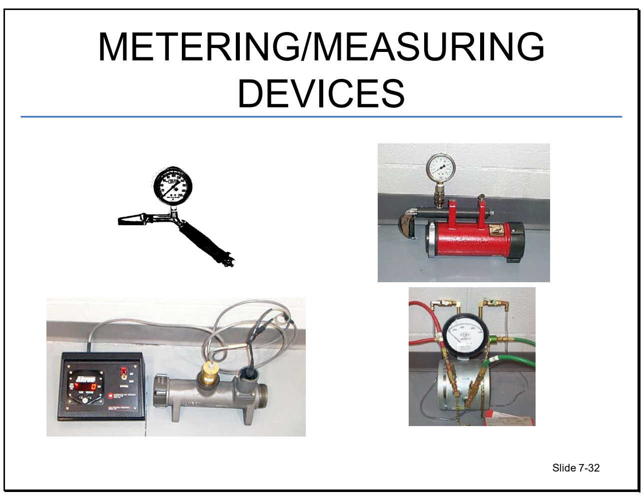
2. Every fire pump must be provided with hose valves (test header) for flow testing, unless there are other adequate pump testing facilities. The number of hose valves and the size of the hose header piping are based upon the size of the pump. Typically, one 2 1/2-inch outlet for each 250 gpm of pump-rated capacity.

3. The hose valve should be attached to a test header or manifold and connected to suitable piping to the pump discharge. Hose valves should be located to avoid any possible water damage to the pump driver or controller, and they should be outside the pump room or pump house.

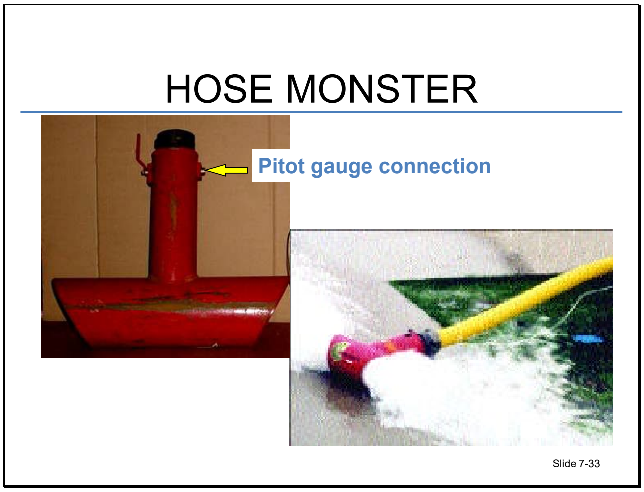


a. Flow rate.

- The flow rate may be measured by either built-in metering devices or fixed nozzles. Either method must be capable of flowing not less than 175% of the rated pump capacity. If built-in metering equipment is used, it must be installed and used in accordance with the manufacturer's instructions.



b. Metering/Measuring devices.



c. Hose Monster®. Registered trademark for a water test diffuser.

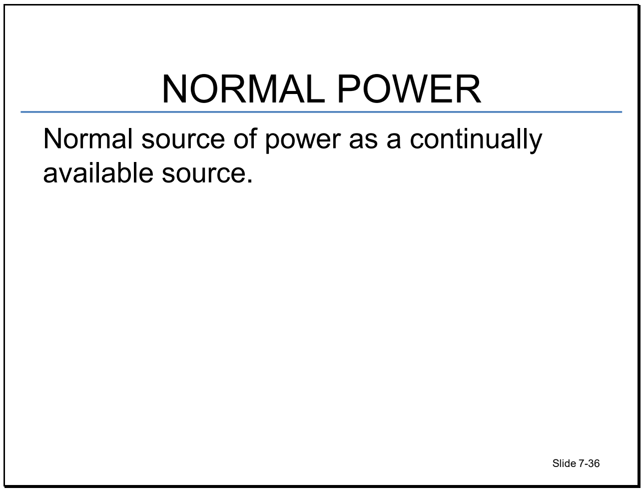
III. ELECTRICAL SUPPLY

ELECTRICAL SUPPLY

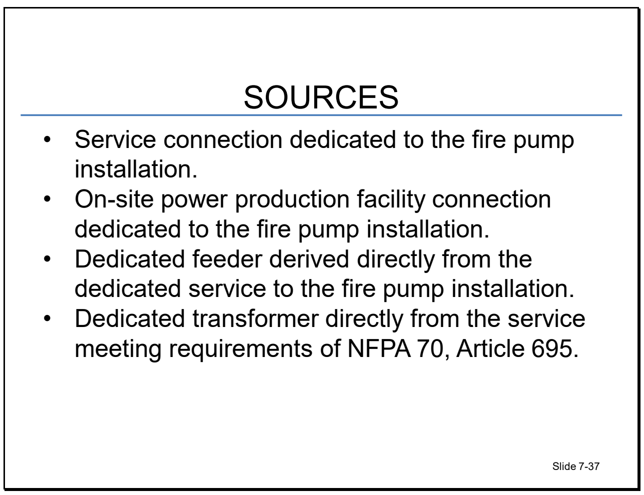
- Requirements contained in both NFPA 20 and NFPA 70, *National Electrical Code*® (NEC), Article 695.
- Supply must be either service or on-site generation.

Slide 7-34

A. Reliability.



B. Normal.



C. Sources.

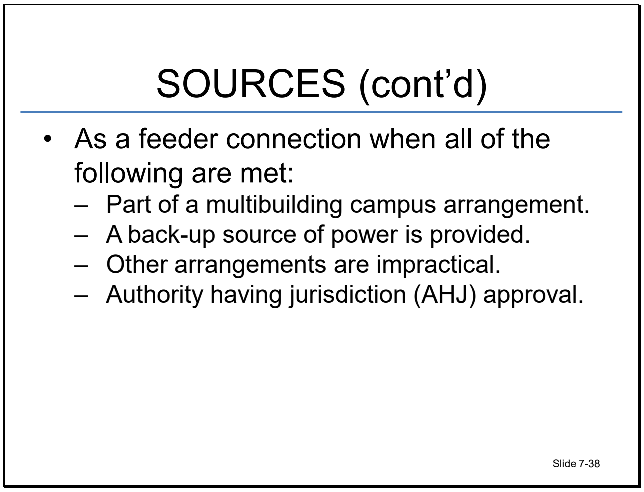
The normal source of power required, and its routing, must be arranged in accordance with one of the following:

1. Service connection dedicated to the fire pump installation.

2. On-site power production facility connection dedicated to the fire pump installation.

3. Dedicated feeder connection derived directly from the dedicated service to the fire pump installation.

4. Dedicated transformer connection directly from the service meeting the requirements of Article 695 of NFPA 70.



5. As a feeder connection when all the following are met:

   a. Facility is part of a multibuilding campus.

   b. Backup power supply is provided.

   c. Typical power feed methods are impractical.

   d. Overcurrent protection among all equipment is coordinated.

   e. Code official approves it.

D. Feeder connection.

1. In multibuilding campus-style complexes, an approved combination of feeders constituting two or more power sources.

2. In multibuilding campus-style complexes, a combination of one or more feeders and an on-site generator.

ALTERNATE POWER

- When height of structure is beyond pumping capacity of fire department.
- When normal power is not reliable.

Slide 7-39

E. Alternate power.

1. At least one alternative source of power must be provided for high-rise buildings or where the height of the structure is beyond the pumping capacity of the fire department apparatus.

2. Other sources.

   At least one alternate source of power shall be provided where the normal source is not reliable.

3. Reliable.

   Code official has to make the decision.

What do you define as “reliable power”?

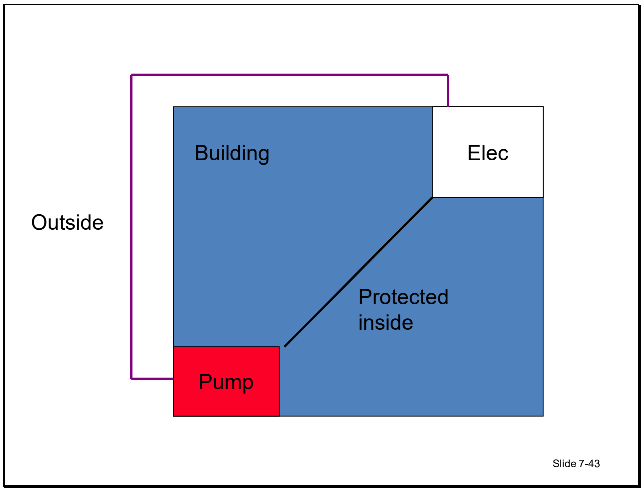
Slide 7-40

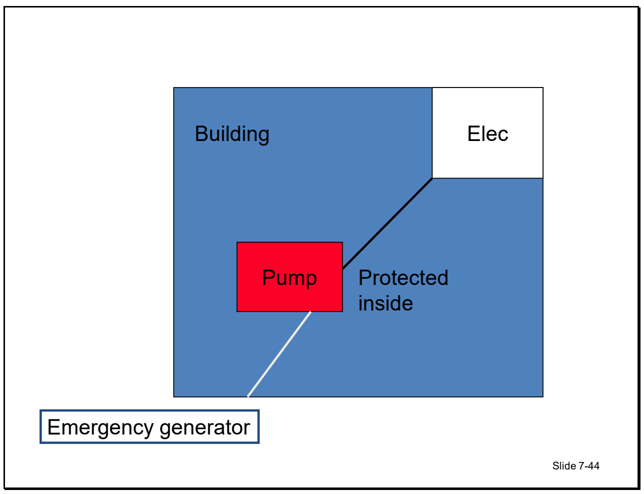
F. Arrangement of power supply.

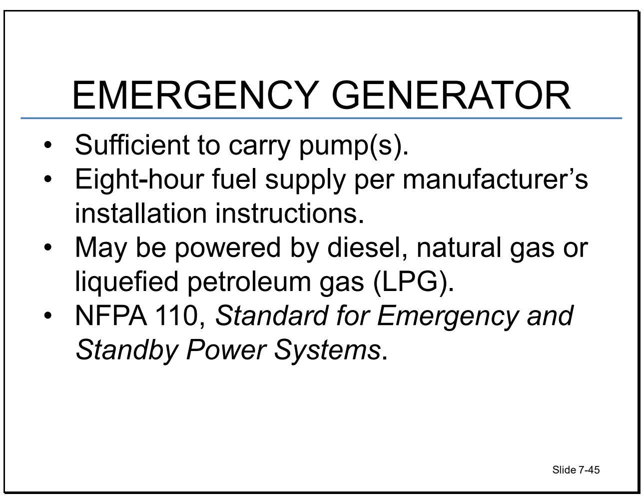
1. Regardless of the power supply source, the power supply for the fire pump must be arranged so it is not disconnected when the building power is disconnected.

2. Since a common action taken by fire suppression personnel under emergency conditions is to have the electrical service disconnected by the public utility, code enforcement personnel should make sure that the suppression forces are aware of the power supply arrangement to prevent the inadvertent disconnection of the fire pump power supply.

G. Electrical conductor routing.







H. Emergency generator for electrical backup.

The generator fuel supply must be sufficient to allow for eight hours of fire pump operation at 100% of the rated pump capacity in addition to the supply required for other demands. Generators powered by diesel, liquefied petroleum gas (LPG) or natural gas drivers are permitted to provide electrical power for a fire pump installation. All generators must be installed in accordance with NFPA 110, *Standard for Emergency and Standby Power Systems.*

DIESEL ENGINE DRIVERS

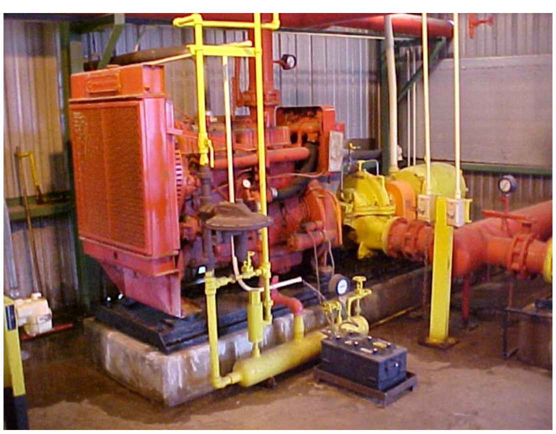
- Compression engine proven to be most dependable.
- Since 1974, spark-ignited engines (gasoline) prohibited.
- Gas turbine engines.
- Listed for fire pump service.

Slide 7-46

I. Diesel engine drivers.

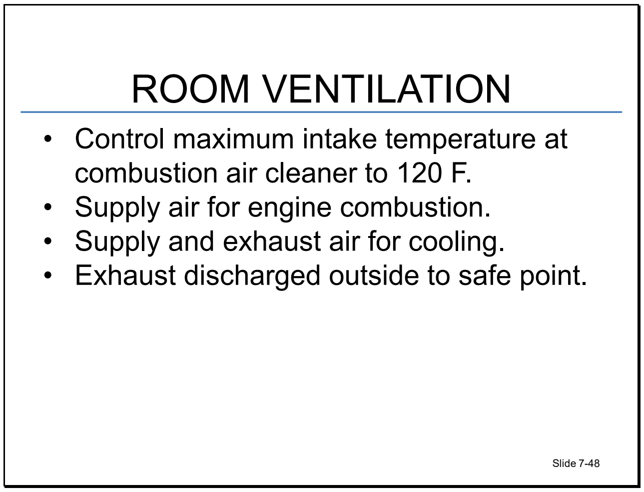
1. The compression ignition diesel has proven to be the most dependable of the internal combustion engines for driving fire pumps.

2. Except for installations made prior to the adoption of the 1974 edition of NFPA 20, spark-ignited internal combustion engines may not be used. This restriction will not be interpreted to exclude gas turbine engines as future pump drivers.



Slide 7-47

3. All engines must be listed for fire pump service and be provided with a governor capable of regulating the engine speed within a range of 10% between shut off and maximum load condition of the pump.

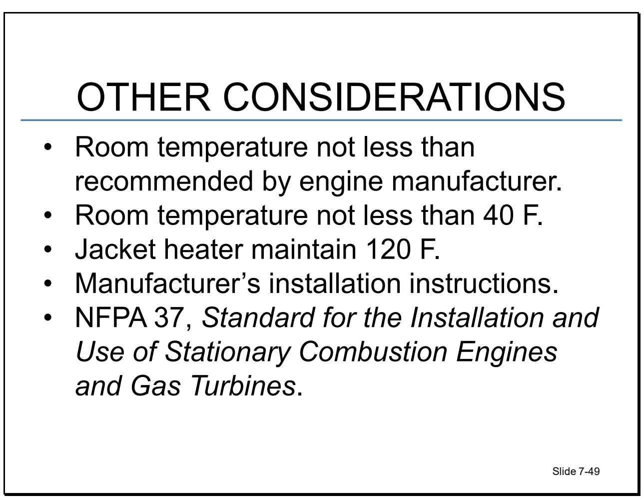


J. Room ventilation.

Effective Ventilation For Combustion Engines

Maximum Hp	Area (in^2)	Diameter (in)	Cfm
40	50	8	120
120	150	14	360
400	500	25	1200
680	850	33	2040

Extracted from Global Asset Protection Services Bulletin, GAP. 14.2.2.2.



K. Other considerations.

1. The temperature of the pump room, pump house or area must never be less than the minimum recommended by the engine manufacturer. An engine jacket heater must be provided to maintain 120 F.

2. Details concerning the installation of the internal combustion engine are contained in the manufacturer's installation instructions and NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*.

FUEL SUPPLY

- Fuel supply tank must have capacity of at least 1 gallon per horsepower, plus 5% volume for expansion and 5% volume for sump.
- Tank(s) must be aboveground.
- Supply must be dedicated solely to a pump.
- Each pump must be provided with separate supply.
- Eight-hour fuel supply.

Slide 7-50

L. Fuel supply.

Fuel supply tanks must have a capacity of at least 1 gallon per horsepower plus a 5% volume for expansion and a 5% volume for sump. The fuel supply tank must be located aboveground and be reserved exclusively for the fire pump diesel engine. If multiple diesel-driven pumps are installed, it is not permissible for them to share a common stored fuel supply.

CONTROLLERS

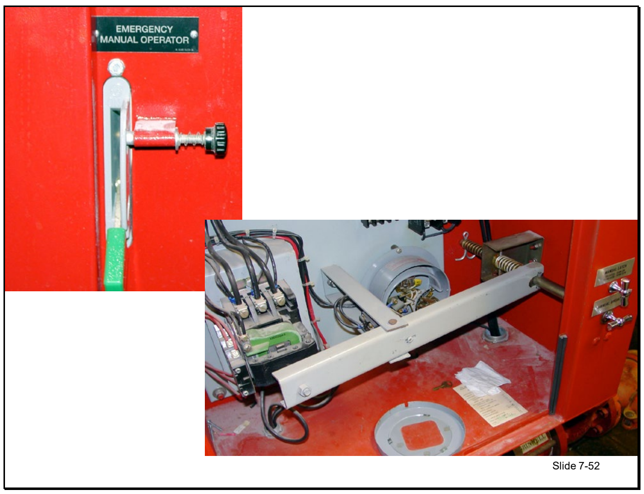
- Every fire pump must be provided with a controller listed for fire service.
- If water supply is required to be automatic, then pump must be automatic.
- Automatic controllers must also be operable as manual controllers.
- Electrical controllers have emergency run mechanical control.
- Diesels have manual override on solenoids.

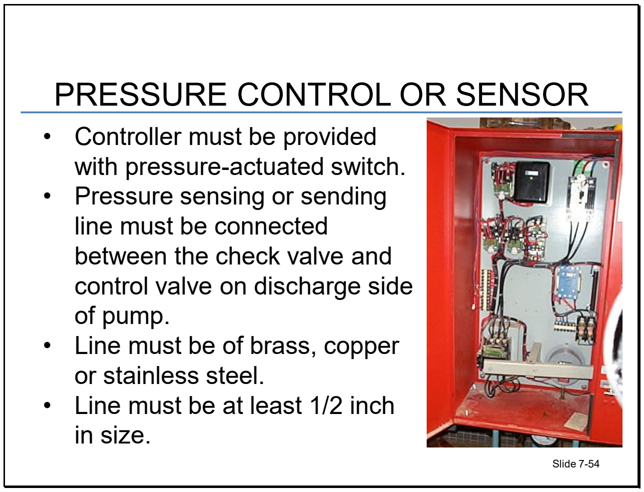
Slide 7-51

M. Controllers.

1. Every fire pump, whether driven by an electric motor or diesel engine, must be provided with a controller listed for fire service. If the water supply for the water-based fire protection system is required to be automatic, then the fire pump controller must provide for this service. Additionally, an automatic controller must be operable as a nonautomatic (manual) controller.

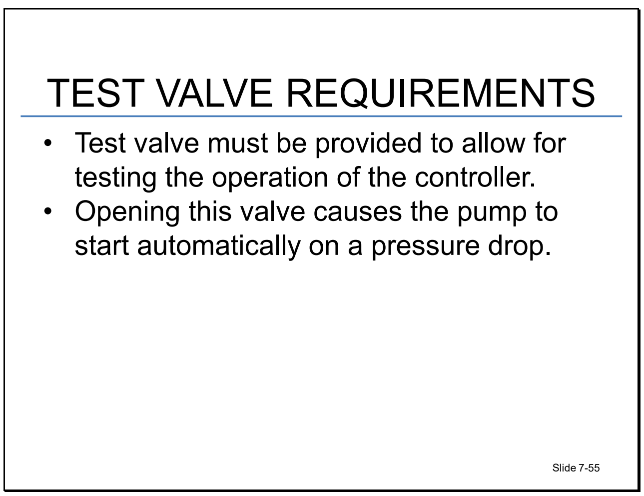
2. Electrical controllers must also be provided with an emergency run mechanical control. This is a handle or lever that operates to mechanically close the motor switching mechanism and start the pump.





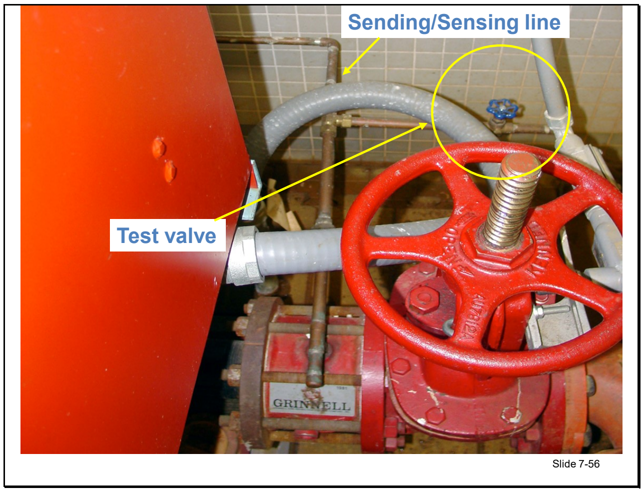
N. Pressure control or sensor.

The controller must be provided with a pressure-actuated switch having independent high and low calibrated adjustments. The pressure sensing or sending line must be connected between the check valve and control valve on the discharge side of the pump. The line must be of brass, copper or stainless steel and be at least 1/2-inch nominal size.

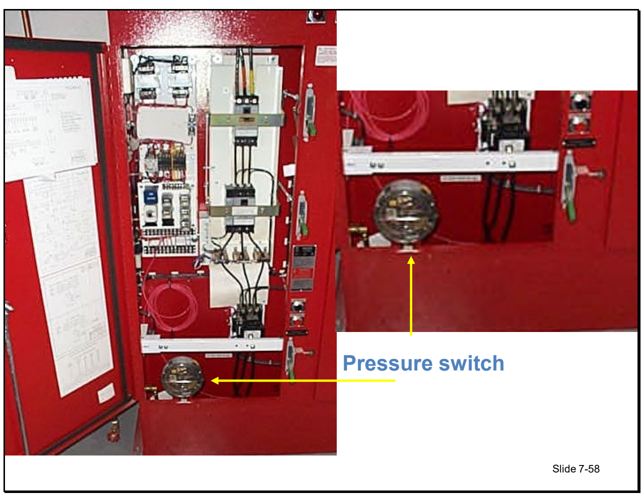


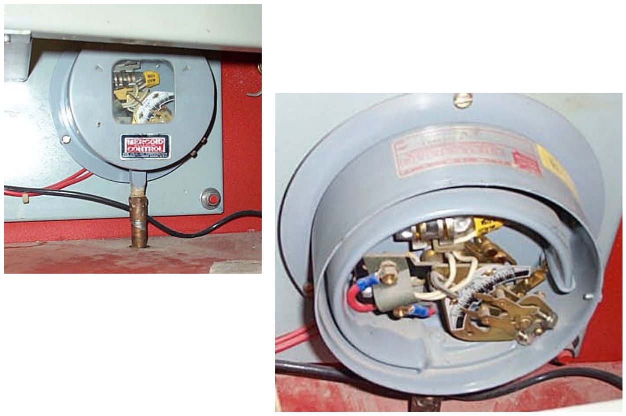
O. Test valve requirements.

No shut-off valve is permitted in the pressure sensing line. A test valve must be provided to allow for testing of the operation of the controller that is causing the pump to start automatically on a pressure drop.

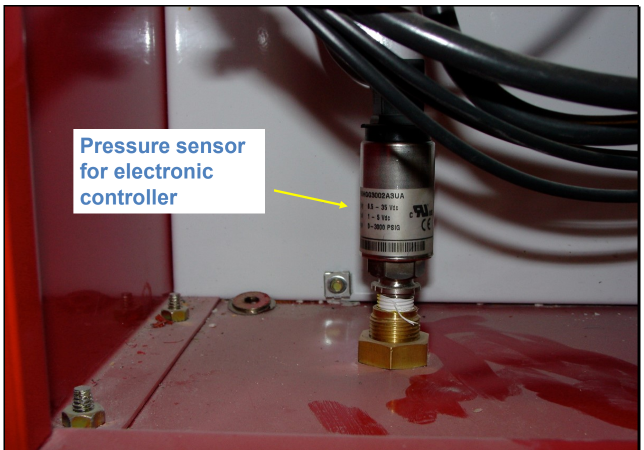

Sending/Sensing line
Test valve
GRINNELL
Slide 7-56


Sending/Sensing line
Slide 7-57


Pressure switch
Slide 7-58



Slide 7-59



Slide 7-60

PRESSURE RECORDING DEVICE

- Must be provided in every controller.
- Required since the 1990 edition of NFPA 20.
- Must be capable of operation for seven days without setting or rewinding.

Slide 7-61

P. Pressure recording device.

Every controller must be provided with a pressure recording device that is capable of operating at least seven days without setting or rewinding. Charts produced by the recorder must be kept as part of the maintenance records. Pressure recording devices were first required by the 1990 edition of NFPA 20. Controllers manufactured prior to this date may have been equipped with the device as an option. This requirement is not retroactive.

Slide 7-62

SHUTDOWN CONTROLS

- Controls may provide for either manual or automatic shutdown.
- If pump is sole supply for fire sprinkler or standpipe system, automatic shutdown prohibited.

Slide 7-63

Q. Shutdown controls.

Controllers provide for either manual or automatic shutdown of the fire pump. If the pump constitutes the sole supply of a fire sprinkler or standpipe system or if required by the authority having jurisdiction (AHJ), automatic shutdown is prohibited. If automatic shutdown is provided on a diesel-driven pump, the minimum run time must be 30 minutes.

JOCKEY PUMPS

- Pressure-maintenance pump.
- Sized to make up allowable leakage within 10 minutes or 1 gallon per minute (gpm), whichever is greater.
- Domestic pump may serve this purpose.
- Must be provided with separate check valve, control valve and pressure-sensing line.

Slide 7-64

R. Jockey pumps.

1. Pressure-maintenance pumps, also known as jockey or make-up pumps, should be used when it is desirable to maintain a uniform or relatively high pressure on the fire protection system.

2. A jockey pump is installed parallel to the main pump and should be sized to make up the allowable leakage rate within 10 minutes or 1 gpm, whichever is larger.

3. The primary or standby fire pump is not permitted to be used as a pressure-maintenance pump. The jockey pump line must be provided with a separate check valve, control valve and pressure-sensing line.

IV. TESTING

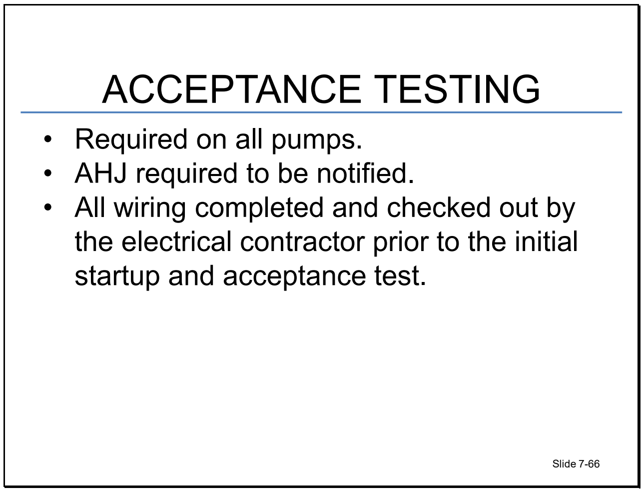
HYDROSTATIC TESTING

- Like any other aboveground water-based fire protection system, piping must be hydrostatically tested.
- Test pressure is a minimum of 200 psi, or 50 psi over the maximum operating pressure, whichever is greater.
- Test pressure maintained for two hours with no leakage.

Slide 7-65

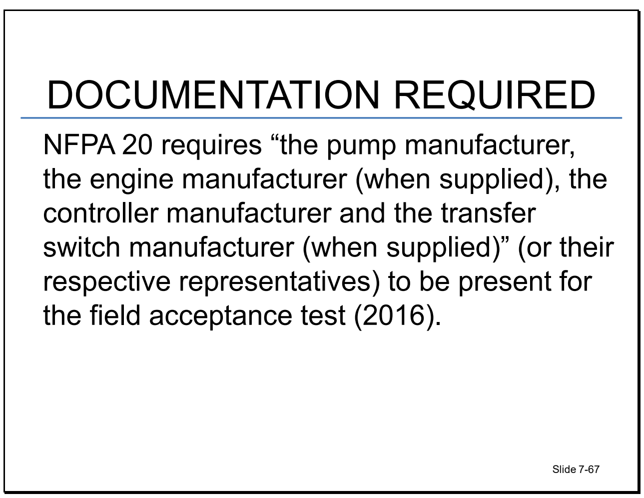
A. Hydrostatic testing.

Like any other aboveground water-based fire protection system, the piping associated with a fire pump must be at not less than 200 psi, or at a pressure 50 psi greater than the maximum operating pressure, whichever is greater. The test pressure must be maintained for two hours with no leakage permitted.



B. Acceptance testing.

All fire pumps must be subjected to an acceptance test. Prior to conducting any tests, it is required that the AHJ be notified. Additionally, all electrical wiring associated with the fire pump installation must be completed and checked out by the electrical contractor prior to the initial startup and acceptance test.



C. Documentation.

NFPA 20 requires "the pump manufacturer, the engine manufacturer (when supplied), the controller manufacturer and the transfer switch manufacturer (when supplied)" (or their respective representatives) to be present for the field acceptance test (2016).

MANUFACTURER’S CERTIFIED PUMP TEST CHARACTERISTICS CURVE

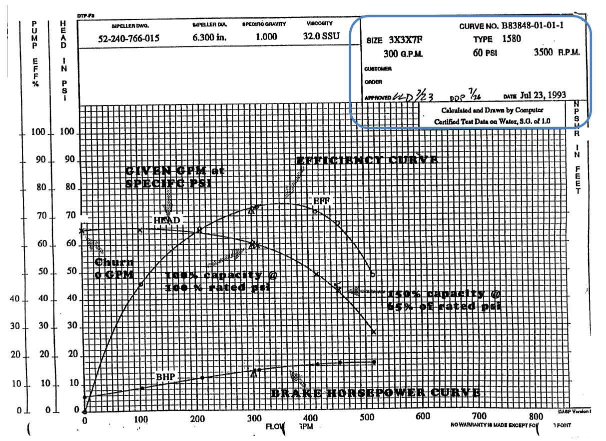
- Paperwork now required to be submitted to the AHJ is the manufacturer’s certified pump test characteristic curve.
- AHJ should confirm the test curve matches the pump that was specified and installed.

Slide 7-68

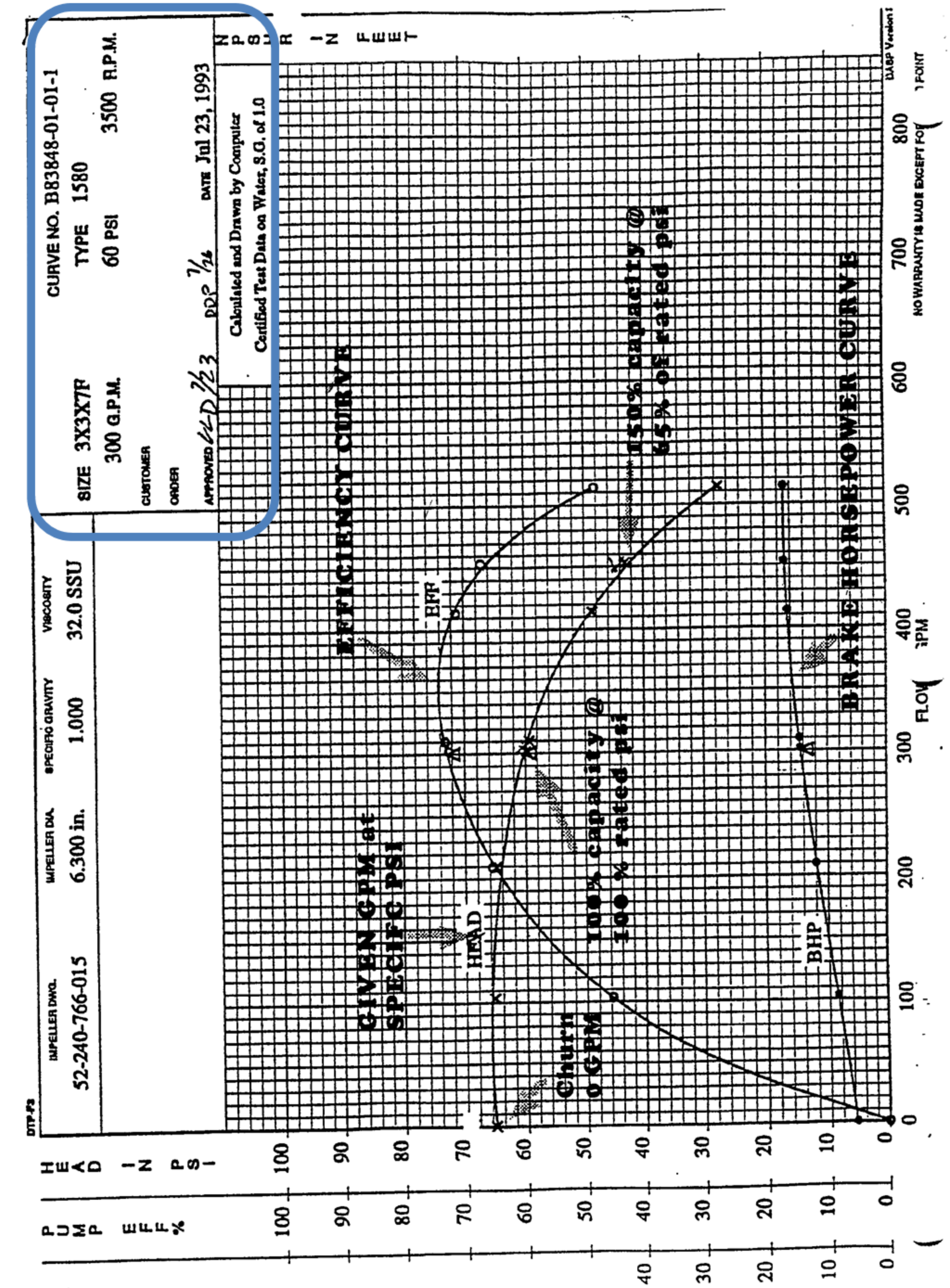
D. Certified pump test.

1. Paperwork now required to be submitted to the AHJ is the manufacturer’s certified pump test characteristic curve.

2. The AHJ should confirm that the test curve matches the pump that was specified and installed.



Slide 7-69


CURVE NO. B83848-01-01-1
TYPE 1580
60 PSI
3500 R.P.M.
SIZE 3X3X7R
300 G.P.M.
CUSTOMER
ORDER
APPROVED
DATE Jul 23, 1993
Calculated and Drawn by Computer
Certified Test Data on Water, S.G. of 1.0
IMPELLER DWG.
52-240-766-015
IMPELLER DIA.
6.300 in.
SPECIFIC GRAVITY
1.000
VISCOSITY
32.0 SSU
EFFICIENCY CURVE
EFF
HEAD
BHP
BRAKE HORSEPOWER CURVE
GIVEN GPM at SPECIFC PSI
Churn 0 GPM
100% capacity @ 100 % rated psi
150% capacity @ 65% of rated psi
FLOW GPM
NO WARRANTY IS MADE EXCEPT FOR POINT
HEAD IN PSI
PUMP EFF %
NPSHR IN FEET

3. The Brake horsepower curve (BHP) is determined by mathematical calculations during the test. The next curve is the efficiency curve (EFF). Like the BHP curve, this curve is based upon mathematical calculations.

4. The most important curve is the head curve. This curve depicts volume (gpm) and pressure (psi). It is important to remember that the volumes and pressures depicted on the manufacturer's curve are based upon the pump operating at draft. If the pump is supplied by a municipal-type water system, the pressure will be modified during on-site performance testing to reflect the water system pressure at the suction intake of the pump.

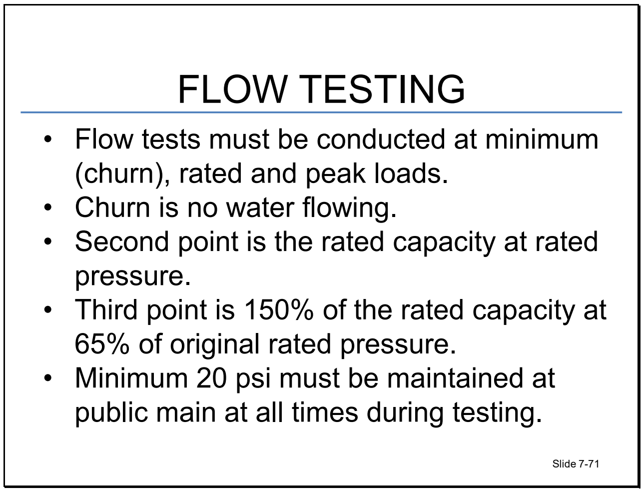
TEST EQUIPMENT

- Net pump pressure, rate of flow through pump, volts and amperes for electric motors, and speed.
- Provided by the AHJ, installing contractor or pump manufacturer.
- Suggested that AHJ not provide any of the equipment.

Slide 7-70

E. Test equipment.

Test equipment must be provided to determine the net pump pressure, rate of flow through the pump, volts and amperes for electric motor-driven pumps, and speed. NFPA 20 provides that the test equipment should be furnished by the AHJ, the installing contractor or the pump manufacturer, depending upon the prevailing arrangement made between the above-mentioned parties. In order to limit liability, it would be beneficial for the AHJ to not provide any of the necessary equipment. This equipment can cause errors of 15% to 30% in readings. The use of uncalibrated test equipment may lead to inaccurate reported test results.



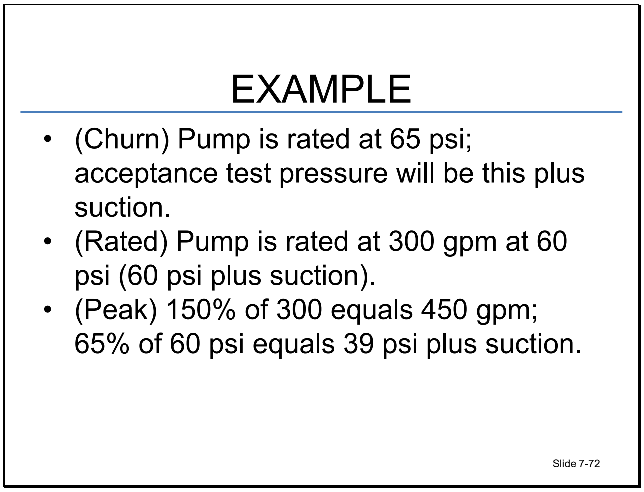
F. Flow testing.

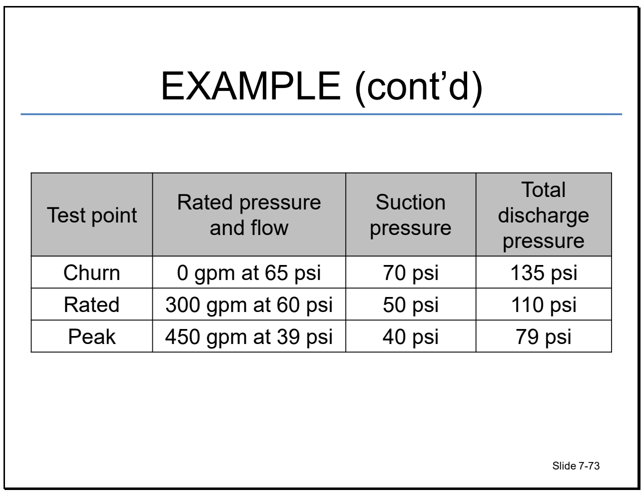
1. For centrifugal pumps, flow tests must be conducted at minimum, rated and peak loads. For positive displacement pumps, flow testing is only required to be conducted at a single performance point. As previously stated, the performance of the pump during the acceptance test will be compared to the certified pump test characteristic curve.

2. Minimum is also known as churn. At this point, no water is being discharged from the test header. The only water discharge during churn will be from the circulation relief valve. The discharge pressure generated would be that shown on the manufacturer's curve (65 psi in our example) plus the suction pressure.

3. The next test point is at 100% of the rated capacity and pressure of the pump. For the test curve example, this is 300 gpm and 60 psi. The actual discharge pressure would be 60 psi plus the suction pressure.

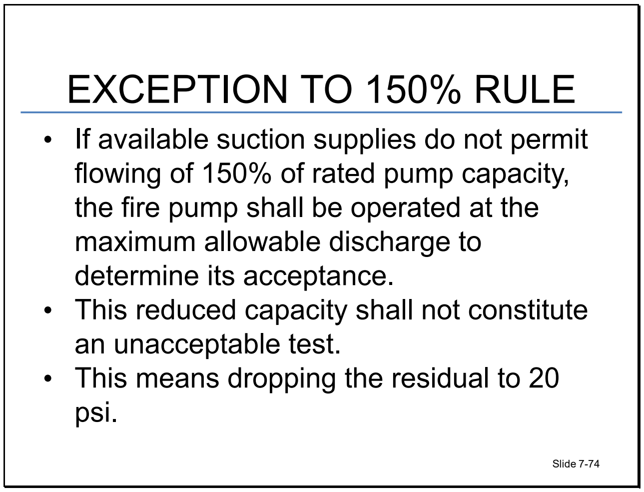
4. The last test point is peak. Peak represents 150% capacity of the pump at 65% of the original rated pressure.





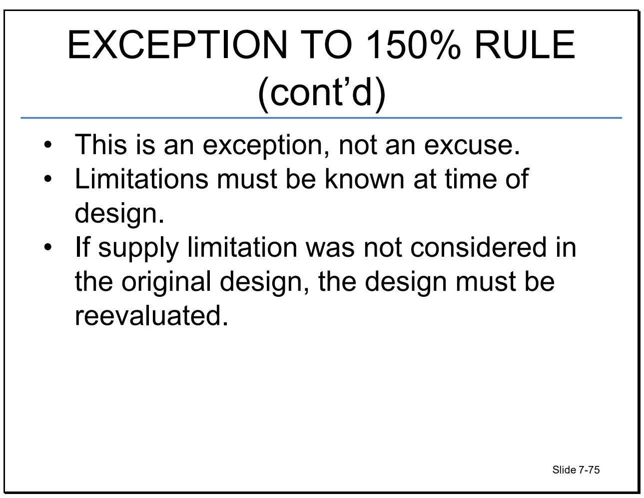
a. Example.

Test point	Rated pressure and flow	Suction pressure	Total discharge pressure
Churn	0 gpm at 65 psi	70 psi	135 psi
Rated	300 gpm at 60 psi	50 psi	110 psi
Peak	450 gpm at 39 psi	40 psi	79 psi



b. Exception to the 150% rule.

- An exception is provided concerning the 150% peak capacity. NFPA 20 allows that if available suction supplies do not permit flowing of 150% of rated pump capacity, the fire pump will be operated at the maximum allowable discharge to determine its acceptance. This reduced capacity will not constitute an unacceptable test. This means that the pump would be operated at the minimum residual pressure (20 psi) and the flow determined.



- It is important to remember that this is an exception, not an excuse. In order to permit the exception to be used, the limitations of the water supply must have been known at the time of original design. If the supply limitations were not considered in the original design, then the design must be reevaluated.

CONTROLLER TEST

- Tested in accordance with manufacturer's recommended procedures.
- At minimum, pump must be started not less than six times manually and six times automatically.
- After each start, pump must run at least five minutes at full speed.

Slide 7-76

c. Controller test.

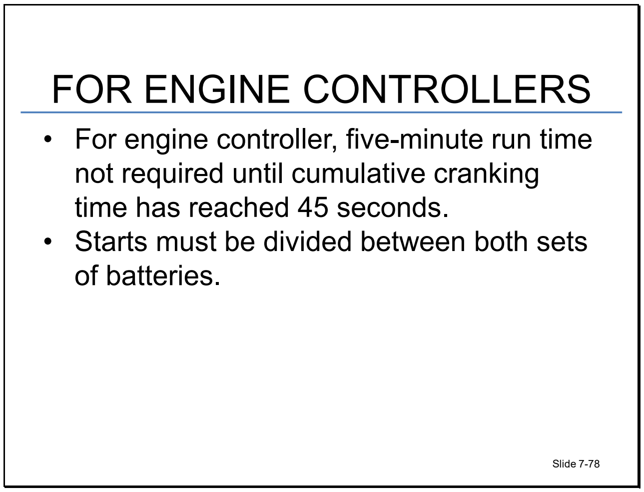
- Once the flow tests have been concluded, additional testing must be conducted on the controller. All fire pump controllers must be tested in accordance with the manufacturer's recommended test procedure.

- At a minimum, the pump shall be started not less than six times manually and six times automatically (pressure drop in pressure sensing line). Each time the pump is started, it must run at full speed for not less than five minutes.

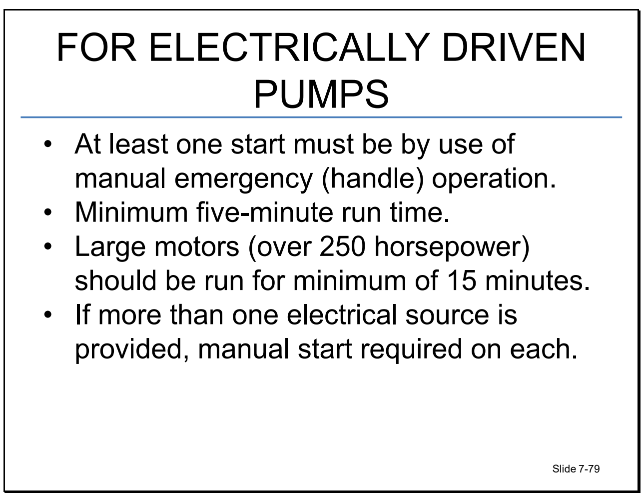
PURPOSE OF FIVE-MINUTE RUN TIME

- Cool-down period.
- Time necessary to dissipate the heat generated in the starting components (batteries, cables, starter).
- Cool-down period comes from NFPA 37.

Slide 7-77



- An engine driver will not be required to run for five minutes at full speed between the successive starts until the cumulative cranking time of successive starts has reached 45 seconds. Tests of engine drive controllers must also be divided between both sets of batteries.



d. Electrically driven pumps.

- For electrically driven pumps, at least one start must be by use of the manual emergency (handle) operation. A minimum of five minutes of run time is required with this starting method. If more than one source of electrical power is supplied, a manual start is required for each.

EMERGENCY POWER

- Loss of power must be simulated and transfer must occur while pump is operating under peak load (150%).
- At least one-half of manual and automatic starts must be performed with pump connected to alternative source.

Slide 7-80

e. Emergency power.

- When emergency power is provided, the loss of primary power must be simulated and transfer must occur while the pump is operating under peak (150%) load. At least one-half of the manual and automatic controller starts must be performed with the pump connected to the alternate source. The emergency generator must also be tested in accordance with NFPA 110.

OTHER TESTS

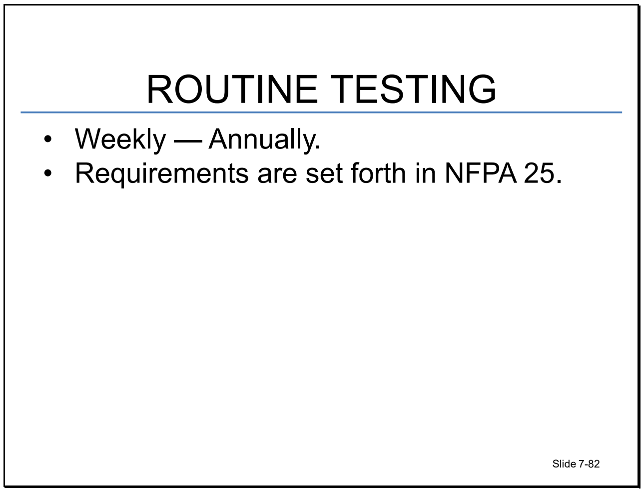
- For electric motors, phase reversal in both normal and emergency supply.
- All alarm and supervisory signals.

Slide 7-81

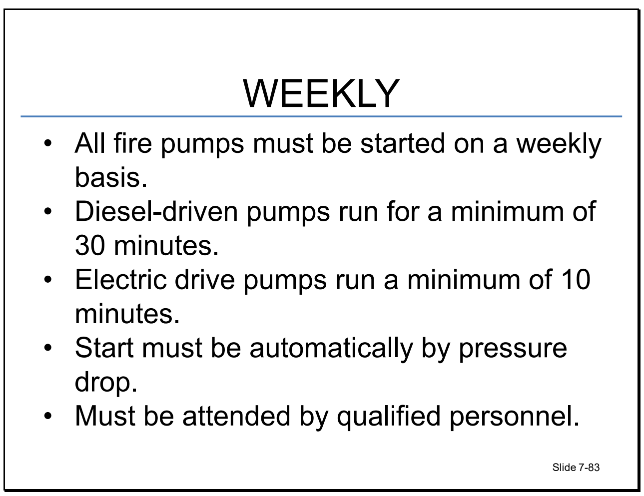
f. Other tests.

- For electric motors, a test must be performed to ensure that there is not a phase reversal condition in either the normal power supply configuration or from the alternative power supply.

- Finally, all alarm and supervisory signals must be tested. Where a fire alarm system is present, testing must be in accordance with NFPA 72, *National Fire Alarm and Signaling Code*®.



G. Routine testing.



1. Weekly.

NFPA 25 requires that all fire pumps be tested on a weekly basis. Electrically driven pumps must be run for not less than 10 minutes and diesel-driven pumps not less than 30 minutes. The pump must be started automatically by a pressure drop in the pressure-sensing line. If a timer is installed, the timer will cause such a pressure drop. All weekly tests must be attended by qualified operating personnel.

OBSERVATIONS

- Set forth in NFPA 25, Section 8.1.1.2 and Table A8.1.1.2.
- Table A8.1.1.2, under the heading of Visual Inspection, sets out 30 different visual items to be inspected.

Slide 7-84

2. Observations.

ANNUAL TESTING

- Every pump must be tested on an annual basis under minimum, rated and peak loads.
- Maximum deficiency of not more than 5% for peak load permitted.
- Three test methods are set forth in standard.

Slide 7-85

H. Annual testing.

1. NFPA 25 also requires that every fire pump be tested on an annual basis under minimum, rated and peak flows. As with the weekly testing, qualified personnel must be present during the test.

2. Three test methods are set forth for the annual test.

FIRST METHOD

- The old fashioned way.
- Water is discharged on the ground via hoselines and nozzle(s).
- Volume is measured with pitot tube.

Slide 7-86

a. First method.

SECOND METHOD

- Same as first method, except volume is measured by built-in/portable flow meter.
- Water may be discharged back into storage tank.
- Metering equipment must be operated in accordance with manufacturer's instructions.

Slide 7-87

b. Second method.

THIRD METHOD

- Closed loop metering.
- Water is recirculated from the pump discharge to pump suction.
- Flow rate is measured by a built-in flow meter.
- If this method is used, every three years the pump must be tested by using one of the first two methods.

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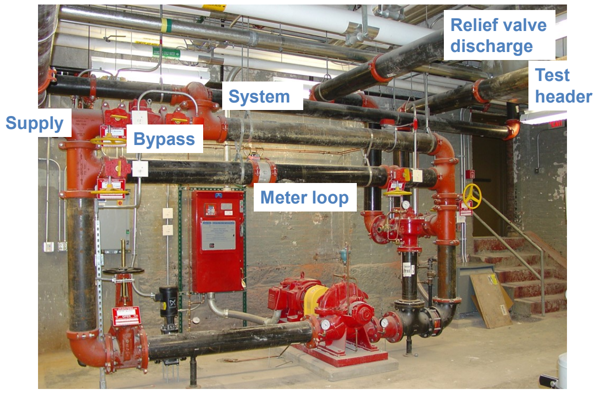
c. Third method.



Slide 7-89

- The third method is what is known as closed loop metering. With this method, water is recirculated from the pump discharge to pump suction with the flow rate being measured by a built-in flow meter. If the closed loop metering method is used, every three years the pump must be tested by either discharging water onto the ground or back into a reservoir.

ANNUAL TEST PROCEDURE

- Check circulation relief valve for operation at churn.
- Check pressure relief valve (if present).
- Run pump for at least one half hour.
- Test at 100% and 150%.
- Record electric motor speed.
- Record pump speed.

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ANNUAL TEST PROCEDURE (cont'd)

- Record suction and discharge pressures.
- Check all alarm and supervisory functions.
- Transfer switch, if present, must be tested at peak flow.
- Emergency generator tested per NFPA 110.
- Flow control valves must be tested.

Slide 7-91

I. Annual test procedure.

ACTIVITY 7.1

Fire Pump Documentation

Purpose

Reinforce analytical skills required to review documentation, and identify code violations.

Directions

1. Working in your table groups, review Handout 7-1: Fire Pump — Annual Fire Pump Test, for years 2013, 2014 and 2015.

2. Identify any code violations in comparing each of the three inspections.

3. You will have 30 minutes to evaluate the documentation and apply the applicable code, NFPA 25, for each violation.

4. Be prepared to report on your findings, including applicable code citations, to the class.

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ACTIVITY 7.1

Worksheet

Suggested responses:

1. Code violation: ______________________________

   ____

   ____

   Applicable code: ______________________________

   ____

   ____

2. Code violation: ______________________________

   ____

   ____

   Applicable code: ______________________________

   ____

   ____

3. Code violation: ______________________________

   ____

   ____

   Applicable code: ______________________________

   ____

   ____

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V. SUMMARY

SUMMARY

- Pumps.
- Electrical supply.
- Testing.

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QUESTIONS?

Slide 7-94

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REFERENCES

NFPA. (2016). *Standard for the installation of stationary pumps for fire protection*. (Standard No. 20). Retrieved from www.nfpa.org

NFPA. (2017). *Standard for the inspection, testing, and maintenance of water-based fire protection systems.* (Standard No. 25). Retrieved from www.nfpa.org

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UNIT 8: COMMERCIAL COOKING: VENTILATION AND FIRE PROTECTION

TERMINAL OBJECTIVES

The students will be able to:

8.1 Analyze system components and established performance requirements for commercial cooking ventilation and fire protection components.

ENABLING OBJECTIVES

The students will be able to:

8.1 Identify the applicable standards for commercial cooking ventilation and fire protection systems.

8.2 Explain the functions of commercial cooking ventilation and fire protection systems and equipment.

8.3 Explain the in-service testing process for commercial cooking ventilation and fire protection systems.

8.4 Explain the annual inspection and maintenance processes for commercial cooking ventilation and fire protection systems.

8.5 Analyze commercial cooking ventilation and fire protection system requirements outlined in NFPA 96, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.

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FEMA

U.S. Fire Administration

UNIT 8: COMMERICAL COOKING: VENTILATION AND FIRE PROTECTION

Slide 8-1

TERMINAL OBJECTIVE

Analyze system components and established performance requirements for commercial cooking ventilation and fire protection components.

Slide 8-2

ENABLING OBJECTIVES

- Identify the applicable standards for commercial cooking ventilation and fire protection systems.
- Explain the functions of commercial cooking ventilation and fire protection systems and equipment.
- Explain the in-service testing process for commercial cooking ventilation and fire protection systems.

Slide 8-3

ENABLING OBJECTIVES (cont'd)

- Explain the annual inspection and maintenance processes for commercial cooking ventilation and fire protection systems.
- Analyze commercial cooking ventilation and fire protection system requirements outlined in NFPA 96, *Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations*.

Slide 8-4

I. INTRODUCTION

A. National Fire Protection Association (NFPA) 96, *Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations*, establishes the necessary provisions to provide a reasonable level of protection from loss of life and property from fire and explosion associated with commercial operations. NFPA 96 provides the minimum fire safety requirements, both preventative and operative, related to the design, installation, operation, inspection and maintenance of all public and private cooking operations except for single-family usage. Requirements are established for cooking equipment, exhaust hoods, grease removal devices, exhaust ductwork, exhaust fans, dampers, fire extinguishing equipment, and auxiliary components or systems that are involved in the capture, containment and control of grease-laden cooking equipment.

B. The main problem with cooking equipment is the circulation of grease in the duct, hood and fan housing, both in residential and commercial systems. If a fire should start in the system, burning grease can reach temperatures of 2,000 F.

C. The entire system should be arranged so that cleaning is readily possible. Grease filters must be removed and cleaned or replaced at intervals to prevent grease buildup, which in time will allow grease vapors to accumulate in the duct. The system should be cleaned inside to prevent grease accumulation. The frequency will depend on what type of cooking equipment is used and how often it is used.

D. The entire system should be treated as a chimney. The system should not be interconnected with air conditioning systems or any other venting or exhaust systems in the building. Where ducts pass through combustible walls, floors, attics and roof framing, they should be provided with a clearance of 18 inches. Ducts should not pass through fire walls or fire-rated partitions.

II. COOKING OPERATIONS

COMMERCIAL COOKING OPERATIONS

- National Fire Protection Association (NFPA) 96.
- Not specifically referenced by International Fire Code (IFC) and International Mechanical Code (IMC).

Slide 8-5

REQUIREMENTS

IFC/IMC:

- Require that equipment be tested and listed.
- Underwriters Laboratories (UL) testing and listing is based on compliance with NFPA 96.

Slide 8-6

A. Requirements.

SCOPE

NFPA 96 provides:

- The **minimum** fire safety requirements (preventative and operative) related to:
  - Design.
  - Installation.
  - Operation.
  - Inspection.
  - Maintenance.
- Of all public and private cooking operations except for single-family residential usage.

Slide 8-7

B. Scope.

SCOPE (cont'd)

- To provide the minimum fire and safety requirements related to cooking operations.
- Includes but not limited to all components or systems involved in the capture and control of grease-laden cooking vapors.

Slide 8-8

SCOPE (cont'd)

- Per NFPA 96, it does not apply when:
  - Only residential equipment is used.
  - Fire extinguishers are provided.
  - It is not an assembly occupancy.
  - Specifically approved by the authority having jurisdiction (AHJ).

Slide 8-9

MOBILE AND TEMPORARY COOKING OPERATIONS

- NFPA 96 contains an annex, written in mandatory language, specific to "food trucks" designed to be adopted for enforcement.
- Application of both mobile and temporary cooking installations/activity.
- Other "cooking equipment used in fixed, mobile or temporary concessions, such as trucks, buses, trailers, pavilions, tents, or any form of roofed enclosure, shall comply with this standard" (2017).

Slide 8-10

C. Mobile and temporary cooking operations.

Annex B is not part of the requirement of the NFPA 96 document unless specifically adopted by the jurisdiction and at the discretion of the adopting jurisdiction. Additional information in the annex is intended to be incorporated on a voluntary basis. The annex is written in mandatory language, but is not to be enforced or applied unless specifically adopted by the jurisdiction or it is applied on a voluntary basis.

REDUCED EMISSION EQUIPMENT

- Listed to American National Standards Institute (ANSI)/UL 197, *Standard for Commercial Electric Cooking Appliances.*
- Not required to have an exhaust system.
- Listing demonstrates that grease discharge at the test hood does not exceed 5 milligrams per cubic meter when operated with total airflow of 500 cubic feet per minute (cfm).

Slide 8-11

D. Reduced emission equipment.

AUTHORITY HAVING JURISDICTION

- Shall determine compliance with the standard.
- Can authorize equivalent deviations.
- Take into account the type of cooking being performed, items being cooked and frequency.
- Documentation is critical.

Slide 8-12

E. Authority having jurisdiction (AHJ).

EXAMPLES

- Day care center warming bottles and lunches.
- Therapy cooking facilities in health care.
- Churches and meeting operations that are not cooking meals that produce grease-laden vapors.
- Employee break rooms where food is warmed.
- Temporary activities.

Slide 8-13

PURPOSE OF REQUIREMENTS

NFPA 96, Section 1.2: "Reduce the potential fire hazard of cooking operations, irrespective of the type of cooking equipment used and whether it is used in public or private facilities" (2017).

Slide 8-14

F. Purpose of requirements.

GENERAL REQUIREMENTS

- Cooking equipment producing smoke or grease-laden vapors equipped with exhaust system.
- All equipment is maintained in good working condition.
- Air flows are maintained.
- Fire protection equipment is provided.
- All interior surfaces of exhaust system are accessible for inspection and cleaning.

Slide 8-15

G. General requirements.

RESPONSIBILITY

Inspection, testing, maintenance and cleanliness shall ultimately be responsibility of owner of system, provided that the responsibility has not been transferred **in writing** to a management company, tenant or other party.

Slide 8-16

H. Responsibility.

III. EXHAUST SYSTEM INSTALLATION

EXHAUST SYSTEM INSTALLATION

Hood clearance.

- A drawing(s) of the exhaust system installation along with a copy of operating instructions for subassemblies and components used in the exhaust system.
- Including electrical schematics.
  - Shall be available on the premises.

Slide 8-17

A copy of the permit drawings and all the cut sheets for the fans and dampers shall be given to the owner.

HOOD CONSTRUCTION

- Eighteen gauge constructed and supported.
- Twenty gauge if stainless steel.
- Listed hoods permitted to be constructed of materials required by their listing.

Wood blocks

Gas line

Slide 8-18

A. Hood construction.

1. Hoods shall be constructed and supported by steel of at least 18 gauge, or 20 gauge if it is stainless steel. Slide 8-18 shows a hood that was supported by chains and held off the wall by two-by-four wood spacers. Are the ceiling tiles 18 inches away? They need to be noncombustible to be closer than 18 inches.

HOOD CONSTRUCTION (cont'd)

- Seams, joints and penetrations.
  - Those that direct and capture grease-laden vapors and exhaust gases shall have a continuous external weld to the hood's lower, outermost perimeter.
  - Internal weld if smooth so as not to trap grease and is cleanable.
  - Penetrations sealed by listed devices.
  - Listed hoods permitted to be assembled in accordance with listing requirements.

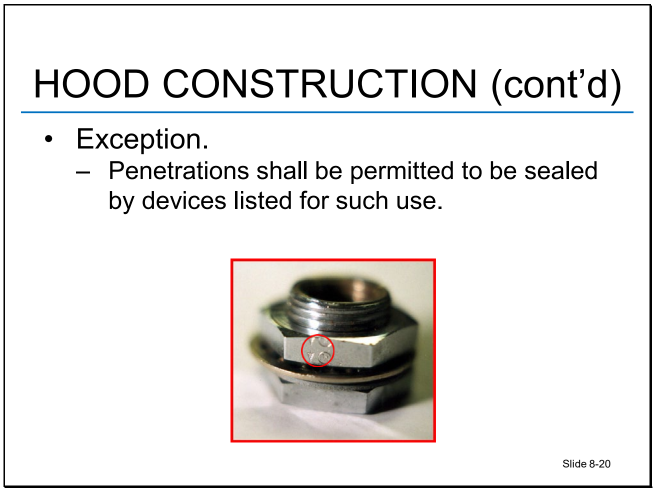
Not welded or capped

Slide 8-19

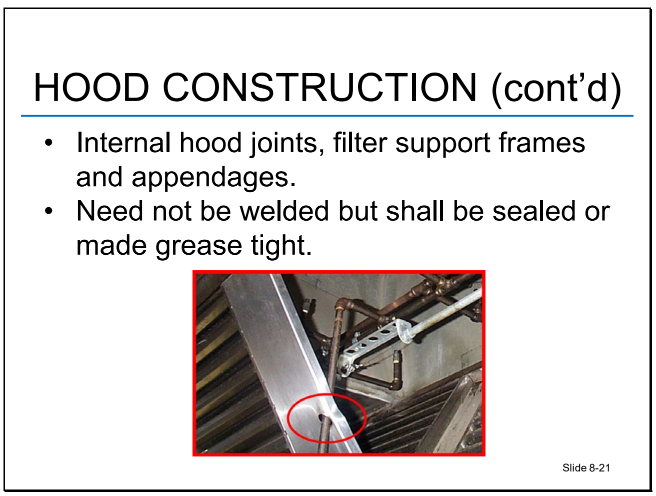
2. Seams, joints and penetrations.

   a. Two hoods end to end must be welded as this is a seam. Both hoods make one hazard area. Some hoods are listed hoods and have been tested by Underwriters Laboratories (UL) with just a cap. Make sure that the cap is on the seam, and it must stay on forever.

   b. Some hood manufacturers like Captive-Aire and Larkin have a UL listing, but there **has** to be a cap on the edge where the hoods come together for the listing.



c. All seams, joints and penetrations shall have a liquid-tight weld. Listed sealing devices may be used. All pipes that enter the hood must be sealed; also, each hanger bracket and fuse link bracket must either be welded or a listed device must be used.



d. These can be caulked, but they have to use the correct caulk. It has to be high-temperature caulk that is Food and Drug Administration (FDA) approved. As seen in Slide 8-21, the hole in the filter spacer where the pipe passes through to the appliances needs to be caulked also. Grease can run back down the pipe.

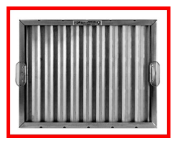
GREASE REMOVAL DEVICES

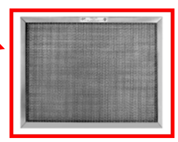
- Listed grease filters, baffles or other approved grease removal devices shall be provided.
- Listed filters shall be tested in accordance with UL 1046, *Standard for Grease Filters for Exhaust Ducts.*
- Mesh filters shall not be used.
- Mesh filter is "a filter constructed of a net made of intersecting strands with a space between each strand."

Slide 8-22

GREASE REMOVAL DEVICES (cont'd)

- Filters (UL 1046).
  - Baffle.
  - Waterwash.
  - Mesh filters **shall not** be used.

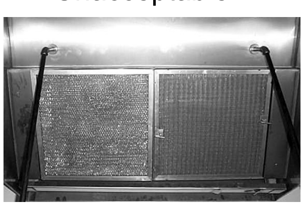




Slide 8-23

GREASE REMOVAL DEVICES (cont'd)

Unacceptable



Acceptable

Slide 8-24

B. Grease removal devices.

Mesh filters shall not be used unless evaluated as an integral part of a listed exhaust hood or listed in conjunction with a primary filter in accordance with American National Standards Institute (ANSI)/UL 1046, *Standard for Grease Filters for Exhaust Ducts*, revised 2012.

GREASE REMOVAL DEVICES (cont'd)

- Separation distance.
  - Between grease removal device and cooking surface; as great as possible but not less than 18 inches.
  - With charbroilers, not less than 4 feet from lower edge of grease removal device and cooking surface.
  - Equipment with no exposed flame and flue gases bypassing grease removal, distance reduced to 6 inches.
  - In accordance with listing.

Slide 8-25

1. Separation distance.

GREASE REMOVAL DEVICES (cont'd)

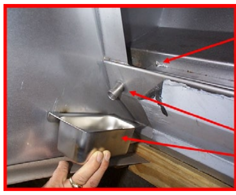
- Filters.
  - **Shall** be **listed** and constructed of steel or **listed** equivalent material.
  - **Shall** be of rigid construction that will not distort or crush under normal operation.
  - Filters **shall** be tight fitting and firmly held in place.

Slide 8-26

2. Filters.

   a. The filters must be listed for use in commercial hoods. They shall withstand their intended use and be tight fitting. During inspections, broken or missing filters need to be replaced. They will not work to remove the grease and will allow grease in the ductwork and on the roof.

GREASE REMOVAL DEVICES (cont'd)

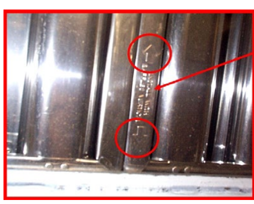


- **Shall** be equipped with a drip tray beneath their lower edges.
- The tray **shall** be kept to the minimum size needed to collect grease and **shall** be pitched to drain into an enclosed metal container having a capacity not exceeding 1 gallon.

Slide 8-27

b. Filters must have a drip tray to transport the collected grease to the grease collection cup. The cup or container shall not be larger than 1 gallon in capacity and should be emptied on a regular basis. Sometimes a hose is hooked to the drain tube running down to a 5-gallon pail. This violates the code. A 1-gallon container is the maximum allowed.

GREASE REMOVAL DEVICES (cont'd)

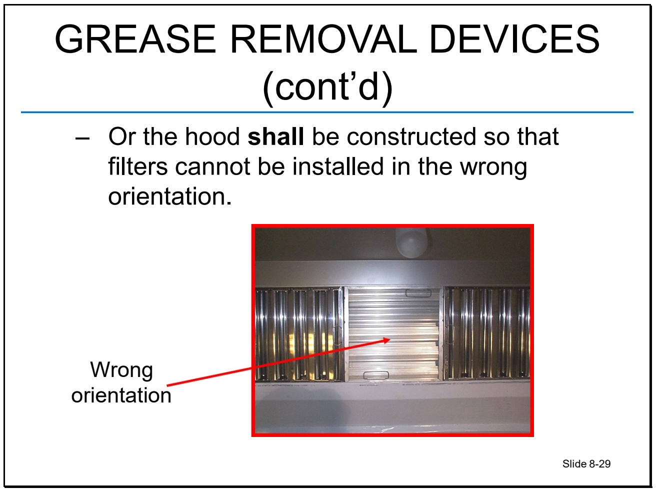


Directional arrows on filters

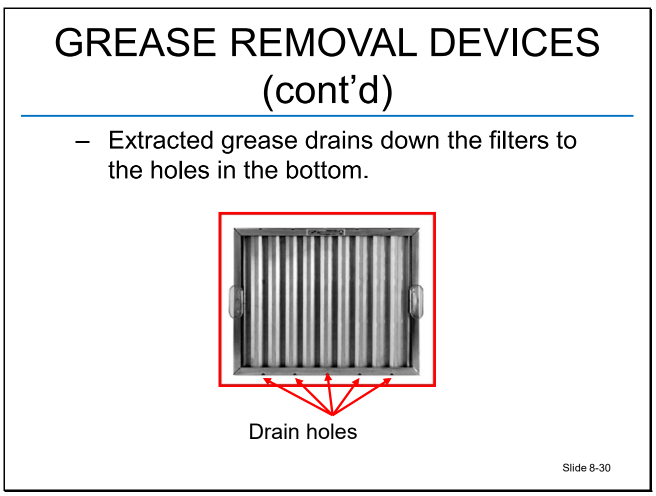
- Grease filters that require a specific orientation to drain grease **shall** be clearly so designated.

Slide 8-28

c. The filters must be installed correctly. The baffles must be orientated up and down. If they are installed incorrectly, they will not drain the grease to the grease tray. Some filters have arrows pointing up, but all have holes in the bottom for the grease to run out. The baffles need to be running up and down.



d. The filters must designate which way to install them or the hood must be designed so that they cannot be installed incorrectly. Installed like the one in Slide 8-29, the filter does nothing but collect grease and hold it.



e. As the grease-laden fumes pass through the filters, they extract some of the grease and it drains down the filters to the holes in the bottom.

GREASE REMOVAL DEVICES (cont'd)

– Missing filters allow grease to enter the duct and plenum.

Slide 8-31

f. Missing or misaligned filters will allow grease buildup in the duct and plenum.

IV. DUCT SYSTEMS

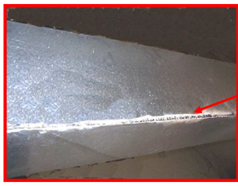
DUCT SYSTEMS

General.

- Ducts **shall not** pass through fire walls or fire partitions.
- All ducts shall lead as directly as is practicable to the exterior of the building, so as not to unduly increase any fire hazard.
- Duct systems shall not be interconnected with any other building ventilation or exhaust system.

Slide 8-32

DUCT SYSTEMS (cont'd)



- All ducts **shall** be installed without forming dips or traps that might collect residues.

Slide 8-33

A. General.

DUCT CONSTRUCTION/ INSTALLATION

- Duct construction.
  - Ducts **shall** be constructed of and supported by carbon steel not less than 16 gauge.
    - Eighteen gauge stainless steel.

Slide 8-34

DUCT CONSTRUCTION/ INSTALLATION (cont'd)

- Duct installation.
  - All seams, joints, penetrations and hood to duct collar connections.
    - **Shall** have a liquid-tight continuous external weld.

Slide 8-35

B. Duct construction/installation.

1. The minimum thickness of the material that can be used:

    a. Carbon steel: 16 gauge.

    b. Stainless steel: 18 gauge.

DUCT CONSTRUCTION/ INSTALLATION (cont'd)

- Duct clearances.
  - Ducts shall have a clearance of at least:
    - -- Eighteen inches to combustible material.
    - -- Three inches to limited-combustible material.
    - -- Zero inches noncombustible.

Slide 8-36

2. All hoods and duct assemblies must maintain specific clearances from limited-combustible and combustible materials. An enclosure that is noncombustible that separates the duct from the combustible materials may be installed.

INTERIOR DUCT INSTALLATION

- Penetrations of vertical fire barriers protected by continuous rated enclosure.
- Shaft extends from lowest fire-rated ceiling or floor above the hood, through any concealed spaces, to or through roof.
- Maintain integrity of fire separations.
- Listed systems.

Slide 8-37

C. Interior duct installation.

SHAFT REQUIREMENTS

- In multistory buildings and single story with rated roof/ceiling assembly.
- Less than four stories: one hour.
- Four or more stories: two hours.
- Normal clearances.
- Listed assemblies.

Slide 8-38

Shaft requirements.

IMPROPER CLEARANCES

Slide 8-39

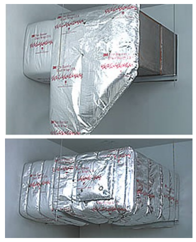
D. Improper clearance.

IMPROPER INSTALLATIONS

Slide 8-40

DUCT WRAP

- One- to two-hour rated.
- Follow proprietary instructions.



Slide 8-41

E. Duct wrap.

Zero clearance to limited-combustible materials shall be permitted where other noncombustible materials or assembly of noncombustible materials that are listed for the purpose of reducing clearance and/or other materials and products that **are listed** for the purpose of reducing clearance.

EXTERIOR DUCT INSTALLATIONS

- Vertical as possible.
- Fasteners may not penetrate duct walls.
- Clearances.
- Weather-protective coating.

Slide 8-42

F. Exterior duct installation.

OPENINGS/CLEANOUTS

- Cleanouts.
  - Openings **shall** be provided at the sides or at the top of the duct, whichever is more accessible, and at changes of direction.
  - Openings **shall** be protected by approved access panels.

Slide 8-43

OPENINGS/CLEANOUTS (cont'd)

- A sign **shall** be placed on all access panels stating the following:

ACCESS PANEL
DO NOT
OBSTRUCT

Slide 8-44

OPENINGS/CLEANOUTS (cont'd)

- Exception: **Listed** grease duct access door assemblies (access panels) **shall** be installed in accordance with the terms of the **listing** and the manufacturer's instructions.

Slide 8-45

OPENINGS/CLEANOUTS (cont'd)

- Access panels.
  - Access panels shall be of the same material and thickness as the duct.
  - Access panels shall have a gasket or sealant that is rated for 1,500 F and shall be grease tight.

Slide 8-46

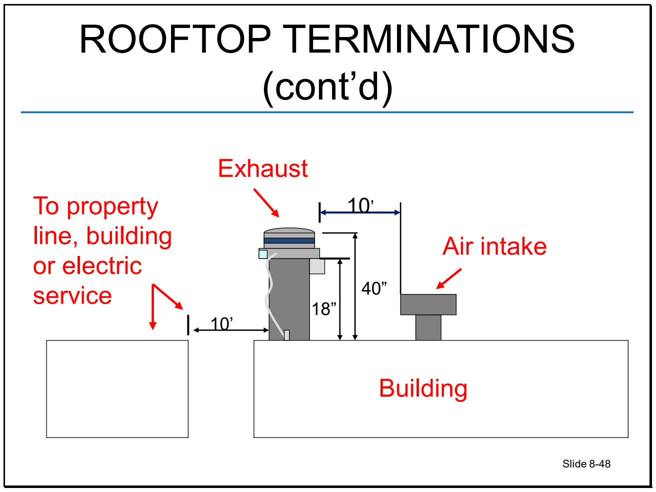
G. Openings/Cleanouts.

A thinner gauge metal than the duct cannot be used. There must also be either a gasket or sealant to keep the warm grease from leaking out of the duct. The gasket works better for cleaning as it has to be removed from the duct each time the duct work is cleaned.

ROOFTOP TERMINATIONS

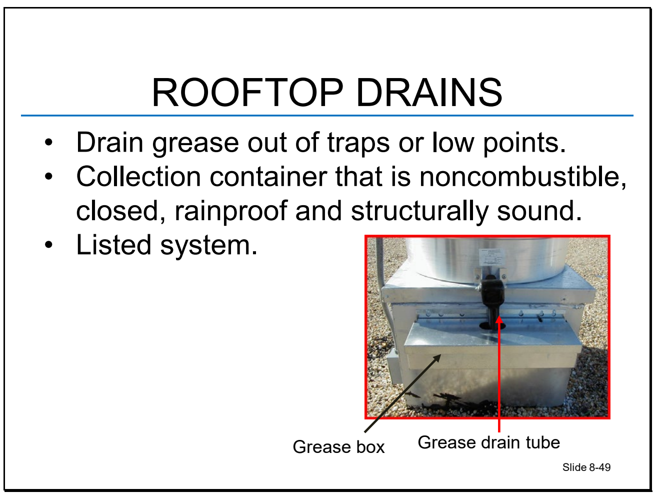
- Minimum of 10 feet horizontal clearance from the outlet to adjacent buildings, property lines and air intakes.
- Minimum of 5 feet horizontal clearance from the outlet (fan housing) to any combustible structure.
- Vertical separation of 3 feet below any exhaust outlets for air intakes within 10 feet of exhaust outlet.

Slide 8-47



H. Termination of exhaust systems.

1. Rooftop terminations.



2. Rooftop drains.

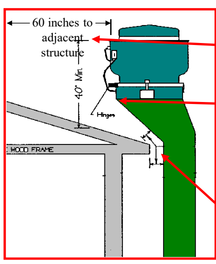
Grease boxes collect the grease brought up by the fan. This grease collects at the base of the fan and drains through a tube into the grease box.

UPBLAST FAN

- Listed for use.
- Flexible electrical connection.
- Hinged for access and servicing, with hold-open device.
- Ductwork is minimum of 18 inches above the roof surface.
- Fan discharge a minimum of 40 inches above roof surface.

Slide 8-50

UPBLAST FAN (cont'd)



- Installation.
  - Upblast fan discharge is 40 inches above roof.
  - Duct termination at least 18 inches above roof.
  - Ten feet from adjacent buildings, property lines, air intakes.
  - Duct must maintain clearance from combustibles.

Slide 8-51

UPBLAST FAN (cont'd)

- Improper termination.
- Placement.
  - Exhaust blows onto a window.
  - Curb sits on wooden base.
  - No cleaning provisions.

Slide 8-52

3. Upblast fan.

WALL TERMINATIONS

- Ten feet to adjacent buildings, property lines, grade level, combustible construction, electrical equipment/lines and closest point of any air intake or window at or below the plane of exhaust termination.
- Three feet clearance from air intakes, doors or windows.
- Flow outward or upward.
- Ductwork pitched to drain back into the hood, a container or remote grease trap.

Slide 8-53

4. Wall terminations.

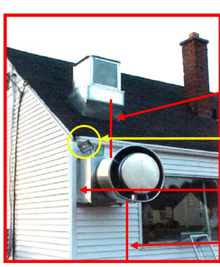
COMBUSTIBLE OR LIMITED-COMBUSTIBLE WALLS

- Must be provided with proper clearances.
- Openings must be sealed with weather-protected vented opening.

Slide 8-54

a. Combustible or limited-combustible walls.

IMPROPER INSTALLATION



Multiple installation problems.

- Exhaust and makeup air fan not 10 feet apart.
- Lights next to fan curb.
- Fan curb attached directly to vinyl siding.
- Fan not 10 feet above grade.

Slide 8-55

b. Improper installation.

IMPROPER TERMINATION

Clearance to combustibles.

Slide 8-56

c. Improper termination.

AIR VELOCITY AND VOLUME

- Air velocity through any duct shall not be less than 500 feet per minute.
- Exhaust air volumes shall be of a sufficient level for capture and removal of grease-laden cooking vapors.
- Hood overhang over edge of appliances not required by NFPA 96.

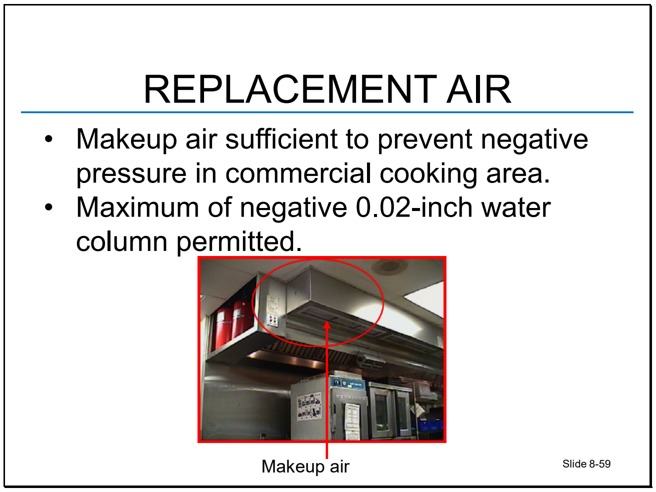
Slide 8-57

AIR VELOCITY AND VOLUME (cont'd)

- Fan must operate during cooking.
- Fan must continue to operate after extinguishing system operation (exception).
- Lower exhaust air volumes shall be permitted during no-load cooking conditions, provided they are sufficient to capture and remove flue gases and residual vapors from cooking equipment.

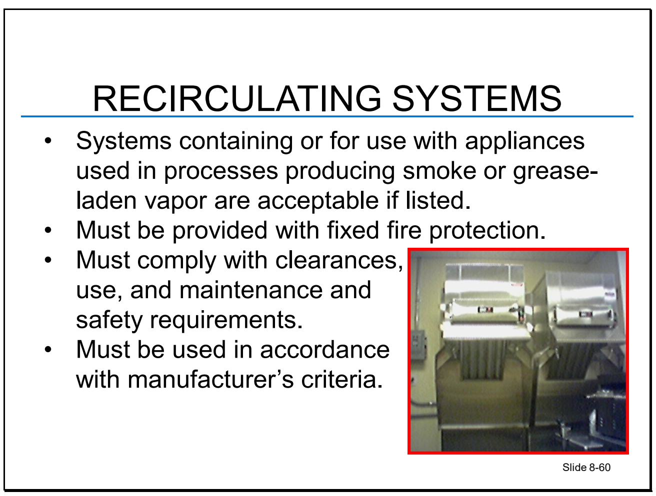
Slide 8-58

5. Air velocity and volume.

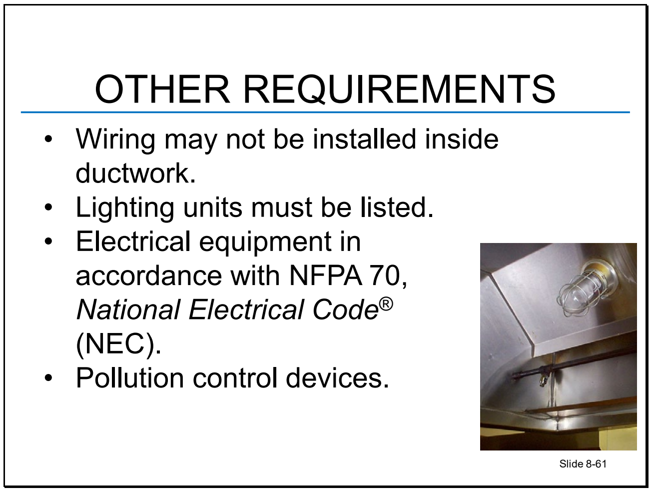


6. Replacement air.

Makeup air internally supplied to the hood shall be shut off upon system actuation. **But** air coming into the kitchen not on the hood does not get shut down.



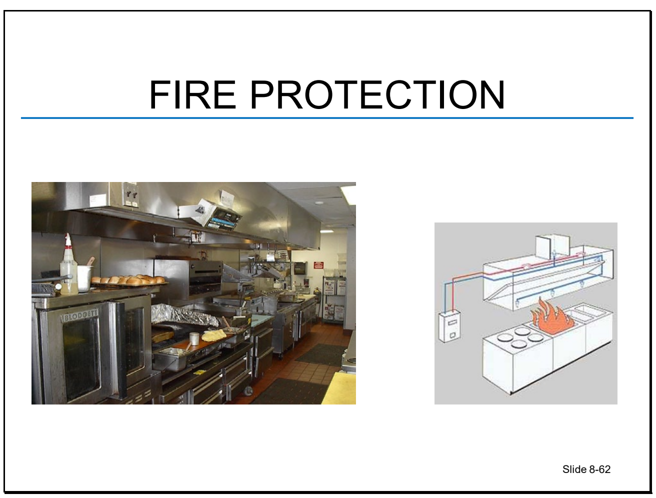
7. Recirculating systems.



8. Other requirements.

Motors, lights or any other electrical devices **shall not** be installed in the ducts or hoods or located in the exhaust air path. Lighting units shall be listed for use over cooking appliances and installed per their listing. They must be installed according to NFPA 70, *National Electrical Code*® (NEC). A cord running out of the fixture is not to code.

V. FIRE PROTECTION



FIXED FIRE PROTECTION

- Fire extinguishing equipment.
- For the protection of:
  - Grease removal devices.
  - Hood exhaust plenums.
  - Exhaust duct systems shall be provided.

Slide 8-63

FIXED FIRE PROTECTION (cont'd)

- Cooking equipment.
  - Producing grease-laden vapors such as, but not limited to:
    - Deep fat fryers, ranges, griddles, broilers, woks, tilting skillets and braising pans.
  - **Shall** be protected by fire extinguishing equipment.

Slide 8-64

A. Fixed fire protection.

Fire systems shall be provided for the protection of the hood, plenum, duct and grease removal devices. Upon activation of the system either manually or automatically, the whole system discharges at the same time in all areas simultaneously. If a grease hood is required, it shall be protected by an approved fire suppression system.

PROTECTION METHODS

- Must be listed for the hazard.
- Installed in accordance with manufacturer's instructions.
  - Pre-engineered.
  - Engineered.

Slide 8-65

B. Protection methods.

FIRE PROTECTION STANDARDS

Automatic fire extinguishing systems shall be installed in accordance with the terms of their listing, the manufacturer's instructions and the following standards where applicable:

- NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems.*
- NFPA 13, *Standard for the Installation of Sprinkler Systems.*

Slide 8-66

C. Fire protection standards.

1. NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems.*
2. NFPA 13, *Standard for the Installation of Sprinkler Systems.*

FIRE PROTECTION STANDARDS (cont'd)

- NFPA 17, *Standard for Dry Chemical Extinguishing Systems.*
- NFPA 17A, *Standard for Wet Chemical Extinguishing Systems.*
- NFPA 750, *Standard on Water Mist Fire Protection Systems.*

Slide 8-67

3. NFPA 17, *Standard for Dry Chemical Extinguishing Systems.*

4. NFPA 17A, *Standard for Wet Chemical Extinguishing Systems.*

5. NFPA 750, *Standard on Water Mist Fire Protection Systems.*

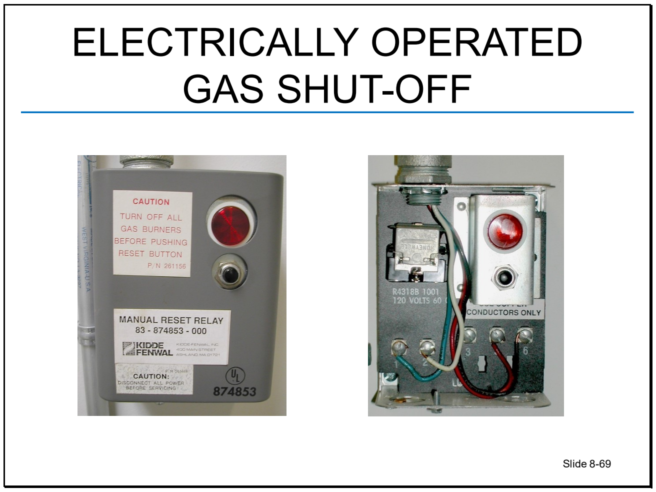
AUTOMATIC SHUT-OFF

- All fuel and power sources **that produce heat** under the hood must shut off on system operation.
- All gas appliances not requiring protection but under the same ventilation hood must shut off.
- Exceptions.
  - Steam supplied from an external source.
  - Solid fuel appliances.

Slide 8-68

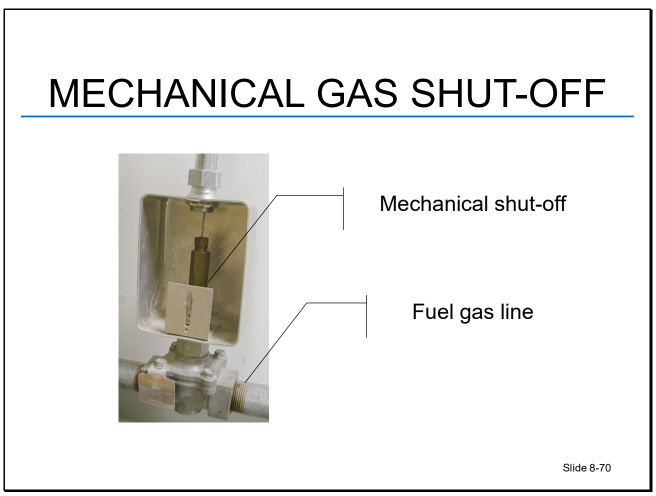
D. Automatic fuel shut-off.

All systems shall have both automatic and manual methods of actuation. At least one manual actuation device shall be located in a means of egress or at a location acceptable to the AHJ. Steam is not considered a hazard and solid fuel is self-supporting. Solid fuel cooking operations shall not be required to be shut down.



1. Electrically operated gas shut-off.

   The gas and electric must be shut down under the hood. If the gas is left on and the pilot lights are extinguished, the gas may leak into the kitchen and produce a dangerous situation.



2. Mechanical gas shut-off.

AUTOMATIC SPRINKLERS

Refer to NFPA 13 for specific sprinkler placement rules.

Slide 8-71

E. Automatic sprinklers.

UNDERWRITERS LABORATORIES 300

- UL 300, *Standard for Fire Testing of Fire Extinguishing Systems for Protection of Commercial Cooking Equipment*.
- Applies to all new self-contained (pre-engineered) systems.
- Testing criteria more stringent.
- Addresses concerns of vegetable oil/ animal fats.
- Insulated appliances.

Slide 8-72

UNDERWRITERS LABORATORIES 300 (cont'd)

- What about existing systems?
  - All manufacturers have **ceased** support for existing dry chemical systems.
  - NFPA 96 set final date for removal as January 2014.
  - Committee-approved changes to NFPA 96 require removal of any and all non-UL 300 systems.

Slide 8-73

F. UL 300, *Standard for Fire Testing of Fire Extinguishing Systems for Protection of Commercial Cooking Equipment*.

PORTABLE FIRE EXTINGUISHERS

- Installed per NFPA 10, *Standard for Portable Fire Extinguishers*.
- Extinguishers for protection of cooking appliances using vegetable or animal oils and fats must be listed and labeled for Class K fires.
- Class B gas-type extinguishers **not** permitted in kitchen cooking areas.
- Class K extinguishers shall be selected from either a wet or dry chemical type.

Slide 8-74

PORTABLE FIRE EXTINGUISHERS (cont'd)

- Agents such as sodium bicarbonate and potassium bicarbonate dry chemical and potassium carbonate wet chemical may be used.
- Dry chemical extinguishers installed prior to June 30, 1998, could only remain in service until due six-year maintenance or hydrostatic test (2004).
- Rating of Class B extinguishers does not take into consideration the special nature of heated grease fires.

Slide 8-75

PORTABLE FIRE EXTINGUISHERS (cont'd)

- Maximum travel distance to an extinguisher cannot exceed 30 feet from the hazard.
- Placard must be conspicuously placed near the extinguisher that states that the fixed system shall be activated prior to using the fire extinguisher.

Slide 8-76

G. Portable fire extinguishers.

NFPA 10, *Standard for Portable Fire Extinguishers.*

ACCEPTANCE TESTING

- In accordance with the manufacturer's manual.
- Agent piping, detection devices and piping, fuel shut-offs.
- No "dump" testing.
- Puff testing of piping.
- Verification of air velocities.
- Operation of shutdowns (fuel and fan).

Slide 8-77

H. Acceptance testing.

VI. SOLID FUEL COOKING

SOLID FUEL COOKING

- Requirements for venting, locations of appliances, hoods, exhaust systems, air movement and fire extinguishing equipment.
- Also addresses inspection, cleaning, maintenance, fuel storage and ash removal.

Slide 8-78

RESTRICTIONS

- No solid fuel device is permitted to be used for deep fat frying.
- No solid fuel device may be within 3 feet of any deep fat frying unit.

Slide 8-79

A. Restrictions.

SOLID FUEL STORAGE

- Supply may not exceed one-day supply in same room as appliance, fuel loading or clean-out doors.
- Fuel separated from all flammable liquids, all ignition sources, all chemicals and food supplies.
- All inside fuel storage areas must be protected with automatic sprinklers, unless exempted by AHJ.

Slide 8-80

B. Solid fuel storage.

ASH REMOVAL

- Removed at regular intervals.
- Heavy metal container or cart with cover not exceeding 20-gallon capacity.

Slide 8-81

C. Ash removal.

FIRE PROTECTION

- Must be listed.
- AHJ may exempt masonry installation.
- Portable 2A extinguisher or Class K in immediate vicinity of cooking equipment.
- Fireboxes over 5 cubic feet require hoseline with minimum of 5 gallons per minute (gpm) flow at 40 pounds per square inch (psi).

Slide 8-82

D. Fire protection.

SOLID FUEL FOR FLAVORING

- Limits on amount of solid fuel that can be used.
- Must be used with a listed appliance.
- Must be placed under the burner.
- Does not require a separate ventilation system.

Slide 8-83

E. Solid fuel for flavoring.

VII. INSPECTIONS

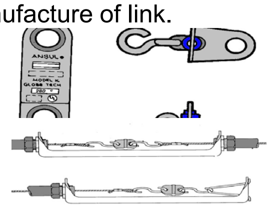
INSPECTIONS

- Maintenance of the fire extinguishing systems shall be made by properly trained, qualified and certified person(s) acceptable to the AHJ at least every six months.
- All actuation and control components shall be tested for proper operation during the inspection in accordance with the manufacturer's procedures.

Slide 8-84

FUSIBLE LINKS

- (NFPA 96) **Inspected and replaced at least every six months.**
- (IFC) **Inspected every six months, replaced at least annually.**
- Date on link is date of manufacture of link.
- Date of manufacture and replacement marked on inspection tag.
- Removed links shall be destroyed when removed.



Slide 8-85

A. Fusible links.

GLASS BULB SPRINKLERS

- Kept free of grease and other buildup.
- Inspection every six months.
- Fusible links of the metal alloy type and automatic sprinklers of the metal alloy type shall be replaced at least semiannually.

Slide 8-86

B. Glass bulbs.

MANUFACTURER VERSUS CODE/STANDARD

- Manufacturer of extinguishing system sets out inspection schedule and procedures that must be followed.
- Manufacturer's criteria may be more stringent than the standard.

Slide 8-87

C. Manufacturer versus code/standard.

INTERNATIONAL KITCHEN EXHAUST CLEANING ASSOCIATION

- International Kitchen Exhaust Cleaning Association (IKECA).
- Grease comb.
- Certification program.
- www.ikeca.org.
- Now in IFC, as of 2015 version.

Slide 8-88

D. International Kitchen Exhaust Cleaning Association (IKECA).

REQUIRED HOOD/DUCT INSPECTIONS

Schedule of Inspection for Grease Buildup

Type or volume of cooking	Inspection frequency
Systems serving solid fuel cooking operations.	Monthly
Systems serving high-volume cooking operations include 24-hour cooking, charbroiling and wok cooking.	Quarterly
Systems serving moderate-volume cooking operations.	Semiannually
Systems serving low-volume cooking operations include churches, day camps, seasonal businesses and senior centers.	Annually

Source: NFPA 96, 2017 edition.

Slide 8-89

E. Required hood/duct inspections.

IMPROPER CLEANING

Slide 8-90

F. Improper cleaning.

ACTIVITY 8.1

National Fire Protection Association 96 Code Research

Purpose

Identify the use of NFPA 96.

Directions

1. Using your tablet or laptop, log onto the NFPA.org website and use the Free Access for your research.

2. Using NFPA 96, answer each of the 10 questions with the correct answer and site the proper code references.

3. Your group should be prepared to justify your answers.

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ACTIVITY 8.1 (cont'd)

Cooking Equipment/Hood Systems

1. What type of joints and seams are required for grease-laden commercial hood and duct systems?

2. In Type I hoods, what is the required thickness of the hood material?

3. Grease filters shall be installed at what angle from the horizontal?

4. What is the minimum requirement for horizontal clearance for exhaust outlets to an adjacent building?

5. Exhaust outlets serving Type II hoods shall terminate not less than how many feet above grade and from property lines or buildings?

6. Exhaust equipment serving a Type I hood shall have a clearance to combustible construction of not less than how many inches?

7. Access panels shall have a gasket or sealant that is rated for what temperature and shall be grease tight?

8. Should fuel shut-off devices require a manual reset?

9. What should listed hood assemblies be tested in accordance with?

10. What are the minimum opening dimensions/size of cleanout doors on horizontal ducts?

VIII. SUMMARY

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REFERENCES

ICC. (2015). *International fire code*. Washington, DC: Author.

ICC. (2015). *International mechanical code*. Washington, DC: Author.

NFPA. (2017). *Standard for the ventilation control and fire protection of commercial cooking operations.* (Standard No. 96). Retrieved from www.nfpa.org.

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UNIT 9: SPECIAL AGENT SYSTEMS

TERMINAL OBJECTIVE

The students will be able to:

9.1 Analyze system components and established performance requirements for special agent systems and equipment.

ENABLING OBJECTIVES

The students will be able to:

9.1 Identify the applicable standards for special agent systems.

9.2 Explain the functions of special agent systems and equipment.

9.3 Explain the in-service testing process for special agent systems.

9.4 Explain the annual inspection and maintenance processes for special agent systems.

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FEMA

U.S. Fire Administration

UNIT 9:
SPECIAL AGENT SYSTEMS

Slide 9-1

TERMINAL OBJECTIVE

Analyze system components and established performance requirements for special agent systems and equipment.

Slide 9-2

ENABLING OBJECTIVES

- Identify the applicable standards for special agent systems.
- Explain the functions of special agent systems and equipment.
- Explain the in-service testing process for special agent systems.

Slide 9-3

ENABLING OBJECTIVES (cont'd)

- Explain the annual inspection and maintenance processes for special agent systems.

Slide 9-4

I. CARBON DIOXIDE

CARBON DIOXIDE

- National Fire Protection Association (NFPA) 12, *Standard on Carbon Dioxide Extinguishing Systems*.
- Design, installation and maintenance.

Slide 9-5

A. Fixed carbon dioxide (CO_2) systems are designed, installed and maintained in accordance with National Fire Protection Association (NFPA) 12, *Standard on Carbon Dioxide Extinguishing Systems*. Only individuals with proper training and experience are permitted to design, install, inspect and maintain this equipment.

B. The agent is colorless, odorless, electrically nonconductive and 1.5 times heavier than air. The agent extinguishes fire by reducing the oxygen concentration, the vapor phase of fuel (cooling) or both. CO_2 is best for surface-type fire and least effective for deep-seated fires.

C. CO_2 systems are not effective on chemicals containing their own oxygen supply, reactive metals and metal hydrides.

TOTAL FLOODING

- System consisting of a supply of carbon dioxide (CO_2) arranged to discharge into, and fill to the proper concentration, an enclosed space or enclosure about the hazard.
- Electrical switchgear rooms, flammable liquid rooms, printing presses, computer rooms, telecommunications rooms.
- Integrity of enclosure is critical.

Slide 9-6

1. Total flooding.

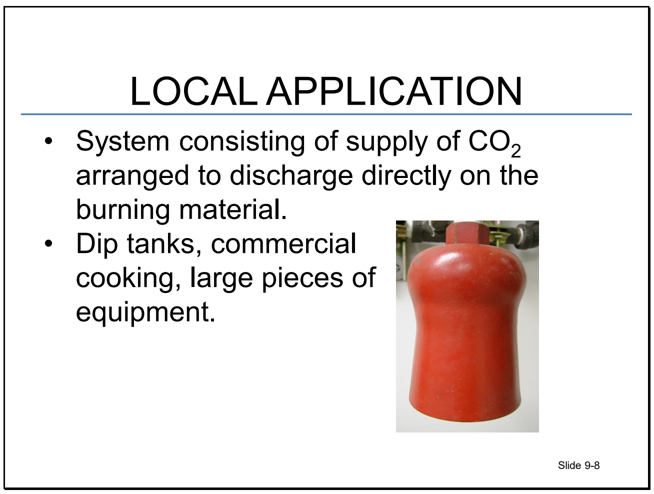
   a. Total flooding systems consist of a CO_2 supply arranged to discharge into an enclosed space or enclosure around a hazard and fill the space with a specific concentration of agent. Total flooding systems are often used in electrical switchgear rooms, flammable and combustible liquid rooms, printing presses, computer rooms, and telecommunications rooms.

CONCENTRATION AND DISCHARGE TIMES FOR TOTAL FLOODING

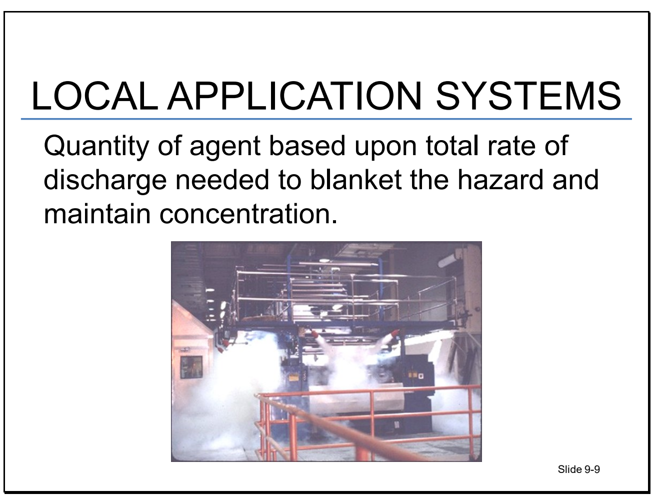
- Very hazard specific.
- Flammable liquid protection ranges from 34% to 75% and must be achieved within one minute.
- Combustible material protection ranges from 50% to 70% and must be achieved within seven minutes with 30% of concentration reached within first two minutes. Concentration must be held for not less than 20 minutes.

Slide 9-7

b. Concentration and discharge: The concentration of the agent, and discharge and hold times are very hazard specific. For a total flooding system designed for surface fires (flammable and combustible liquids and gases), the concentrations range from 34% to 75%, and this concentration must be achieved within one minute. For a total flooding system protecting deep-seating fires (combustible materials), the concentration ranges from 50% to 70%. This concentration must be reached within seven minutes and must also develop a concentration of 30% within the first two minutes. For rotating electrical equipment, a minimum concentration of 30% must be maintained for the deceleration period, but not less than 20 minutes.



2. Local application.



a. For local application systems, the quantity of agent is based upon the total rate of discharge needed to blanket the area of volume protected and the time that the discharge must be maintained to assure complete extinguishment.

EXAMPLE

- Test fire with gasoline.
- Gasoline requires a 34% concentration.
- Room volume of 2,737 cubic feet.
- To reach a 34% concentration (931 cubic feet) would require approximately 104 pounds of agent (1 pound agent = 9 cubic feet).
- 25 pound supply = 8.2%.

Slide 9-10

b. Example.

SYSTEM OPERATION

- Automatic.
- Normal manual.
- Emergency manual.
- Abort switches are NOT permitted.

Slide 9-11

3. System operation.

a. CO_2 system operation can be automatic, normal manual and emergency manual. Automatic operation does not require any human action. Normal manual operation requires human action and the operation of a device that is easily accessible at all times. Manual operation requires the operation of only one device. Emergency manual operation also requires human action and uses a device that is fully mechanical in nature and is located at or near the device being controlled. Emergency manual operation is used only when the automatic and normal manual operation methods have failed.

b. Total flooding and local application systems are required to be designed and installed for automatic detection and activation, unless the authority having jurisdiction (AHJ) specifically approves manual operation. The approval of manual operation is limited to those situations where automatic release could result in an increased risk.

c. All controls or devices necessary for operation must be located, installed or suitably protected so that they are not subject to mechanical, chemical or other damage that would render them inoperative. The controls must also be located for easy accessibility at all times. The controls must be of distinct appearance and clearly recognizable as to their function or purpose. **Abort switches are not permitted to be used on CO_2 systems.**

d. All detection systems must comply with the provisions of NFPA 72, *National Fire Alarm and Signaling Code*®.

SIGNAGE REQUIRED

Slide 9-12

e. With any CO_2 system, consideration must be given to the possibility that personnel could be trapped in or enter into an atmosphere made hazardous by the presence of the agent. Suitable provisions must be made to ensure prompt evacuation, to prevent entry into such atmospheres, and to provide means for prompt rescue of any trapped personnel. Personnel training must be provided. Appropriate signage must be installed. Examples of various signs are included in NFPA 12.

SHUTDOWNS

Any equipment, fuel supplies, ventilation or processes that could contribute to fire or interfere with effectiveness of system must be shut down/off automatically.

Slide 9-13

4. Shutdowns.

   Any equipment, fuel supplies, ventilation equipment or processes that could contribute to sustaining the fire or interfere with the effectiveness of the system must be shut down/off automatically. This shutdown must occur prior to or at the time of system discharge.

ACCEPTANCE TESTING

- Complete system must be inspected and tested by qualified personnel and meet the approval of the authority having jurisdiction (AHJ).
- Only listed or approved equipment and devices shall be used in the system.
- Thorough visual inspection of piping, discharge nozzles, alarms, manual releases, hazard configuration and integrity of enclosure.

Slide 9-14

5. Acceptance testing.

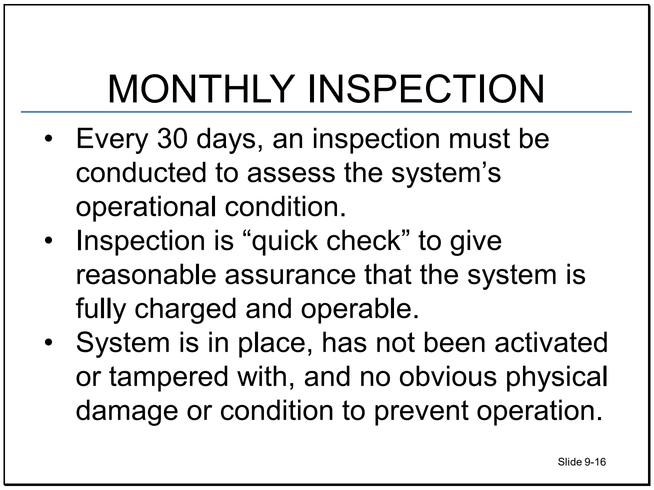
   a. Once the system installation has been completed, it must be inspected and tested by qualified personnel and meet the approval of the AHJ. Prior to any acceptance testing, notification must be given to the AHJ. Acceptance testing includes a thorough visual inspection of the piping, discharge nozzles, alarms, manual releases, hazard configuration and enclosure integrity. The visual inspection is to ensure only listed or approved equipment or devices are used.

ACCEPTANCE TESTING (cont'd)

- Nondestructive operational testing on all devices necessary for functioning of the system.
- Fire alarm components according to NFPA 72, *National Fire Alarm and Signaling Code®*.
- Full discharge test.
- Follow manufacturer's manual.

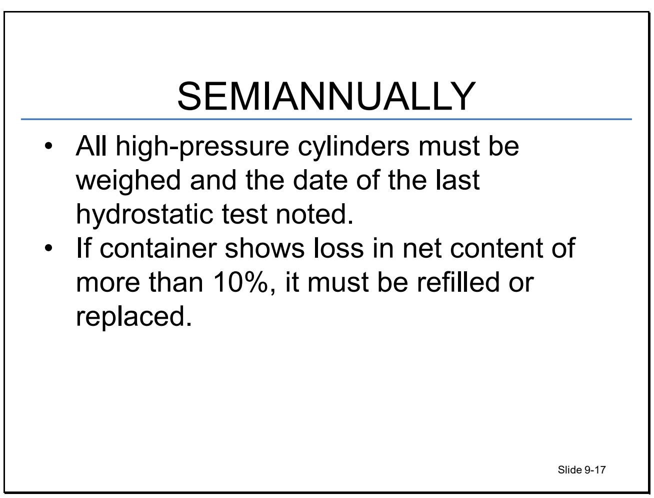
Slide 9-15

b. Nondestructive testing is required on all devices necessary for system functioning, as well as a full discharge test with the agent. All fire alarm components must comply with the requirements of NFPA 72. All provisions of the manufacturer's manual must be met.



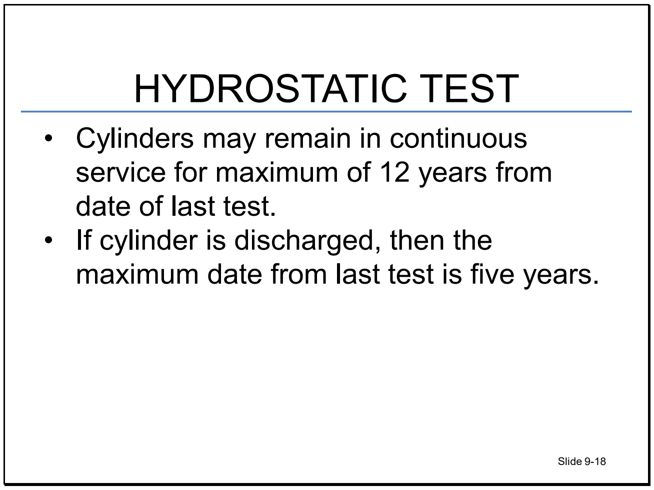
6. Monthly inspection.

Every 30 days, an inspection must be conducted of the entire system to assess its operational status. This inspection is a "quick check" intended to give reasonable assurance that the system is fully charged and operable. This quick check verifies that the system is in place, has not been activated or tampered with, and has no obvious physical damage or other condition which would prevent proper operation. This inspection is often performed in-house.



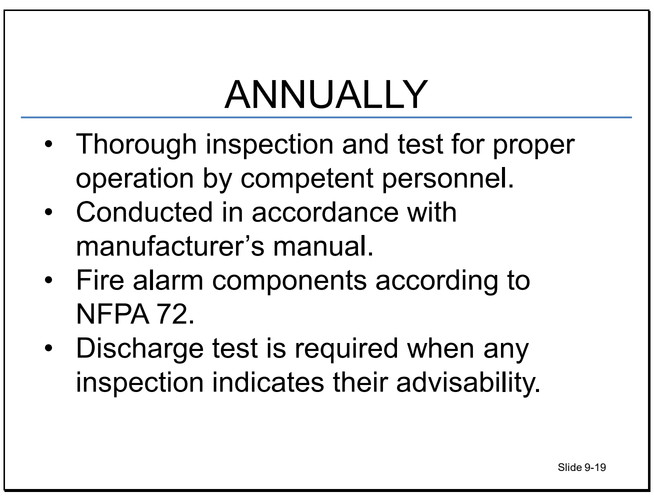
7. Semiannually.

On a semiannual basis, all high-pressure cylinders must be weighed and the date of the last hydrostatic test noted. If the container shows a loss of more than 10%, it must be refilled or replaced.



8. Hydrostatic test.

High-pressure cylinders may remain in continuous service for a maximum of 12 years between hydrostatic tests. However, if a cylinder is discharged, it must be retested if it has been more than five years since the last hydrostatic test.



9. Annually.

On an annual basis, a thorough inspection and test of the system must be conducted by competent personnel. All testing must be conducted in accordance with the manufacturer's manual. All fire alarm components must be tested in accordance with NFPA 72. No additional discharge testing is required unless an inspection indicates their advisability.

II. HALON 1301

A. There is no prohibition against installing a new Halon 1301 system, nor is there any requirement that existing systems be taken out of service. However, since the cost of the agent is high, the installation of any new systems or recharging of existing systems is not very common.

B. These types of systems were used in enclosed areas, such as electrical and electronic hazards, telecommunications, flammable and combustible liquids, and high value assets. The agent is not permitted to be used on chemicals that are capable of rapid oxidation in the absence of air. The integrity of the protected enclosure is critical to proper system operation.

HALON 1301 (cont'd)

- Existing agent may be stockpiled or "banked."
- Only one direct replacement agent is available (Dupont FE-25/ECARO 25).

Slide 9-22

C. Halon 1301 (bromotrifluoromethane or $CBrF_3$) is a colorless, odorless, electrically nonconductive gas used for fire extinguishment in a total flooding environment. Halon 1301 is one of many products that are subject to the provisions of the Montreal Protocol on Substances that Deplete the Ozone Layer that was signed on September 16, 1987. This international treaty permits the continued use of this agent but restricts the actual production of the product. Any country that signed the treaty was required to cease production of the product by 1992. Additionally, any country that signed the treaty is prohibited from importing the product from any other country where it may still be produced. Existing agent is permitted to be "banked" or stored for further use. This banking also includes agent that is part of an extinguishing system.

D. Testing.

SEMIANNUALLY (cont'd)

- Thorough inspection and test for proper operation by competent personnel.
- Fire alarm components according to NFPA 72.
- Thorough inspection of enclosure.

Slide 9-23

1. Semiannually.

   a. Semiannually, the system must be thoroughly tested and inspected for proper operation by competent personnel. All fire alarm components must be tested in accordance with NFPA 72. A thorough inspection of the enclosure is also required.

SEMIANNUALLY (cont'd)

- All high-pressure cylinders must be inspected and the date of the last hydrostatic test noted.
- If container shows loss of more than 5% by net weight or 10% by pressure, then cylinder must be refilled or replaced.

Slide 9-24

b. All high-pressure cylinders must be inspected on a semiannual basis and the date of the last hydrostatic test noted. If the cylinder is equipped with a pressure gauge, it may not show a loss of more than 10%. Cylinders without pressure gauges must be weighed, and the maximum loss cannot exceed 5%. Any cylinder that has excessive losses must be refilled or replaced. Cylinders may remain in continuous service for a maximum of five years from the date of the last hydrostatic test.

HYDROSTATIC TESTING

- Cylinders may be refilled if more than five years since last retest and inspection.
- Retest is complete visual inspection per Code of Federal Regulations (CFR) 49, Parts 100-185.
- Cylinders in continuous service without discharge must have a complete external inspection every five years.
- If external inspection indicates damage, additional strength testing required.

Slide 9-25

2. Hydrostatic testing.

III. CLEAN AGENTS

CLEAN AGENTS

- NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*.
- Covers agents introduced in response to Montreal Protocol.
- Does not cover CO_2, Halon 1301, Halon 1211, Halon 2402 or water.
- Requires compliance with manufacturer's installation requirements.

Slide 9-26

A. The term "clean agent" is defined in NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, as an "electrically nonconducting, volatile, or gaseous fire extinguishant that does not leave a residue upon evaporation" (2015).

B. Clean agent benefits:

1. Fast — clean agent systems reach extinguishing levels in 10 seconds or less!

2. Effective — clean agents are designed to control and extinguish a fire in its incipient stage before it has a chance to spread. Clean agents are electrically nonconductive and noncorrosive, and there will be no damage to electronics and delicate mechanical devices.

3. Safe — clean agents are designed to provide a wide margin of human safety; they are safe to use where people are present.

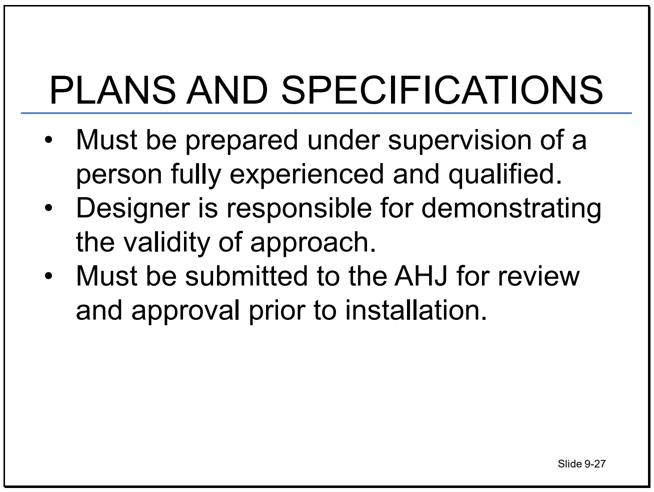
4. Clean — clean agents rapidly vaporize to gas during discharge and evaporate cleanly, leaving no residue behind, which means no costly cleanup.

5. Earth-friendly — clean agents are non-ozone depleting and have a short atmospheric lifetime.

C. Clean agents are the result of the effects of the Montreal Protocol on the production of Halon 1301. The basic requirements of the design, installation and testing of clean agent systems are contained in NFPA 2001. This standard does not address CO_2, Halon 1301, Halon 1211, Halon 2902 or water as the primary extinguishing method as they are covered by other NFPA documents.

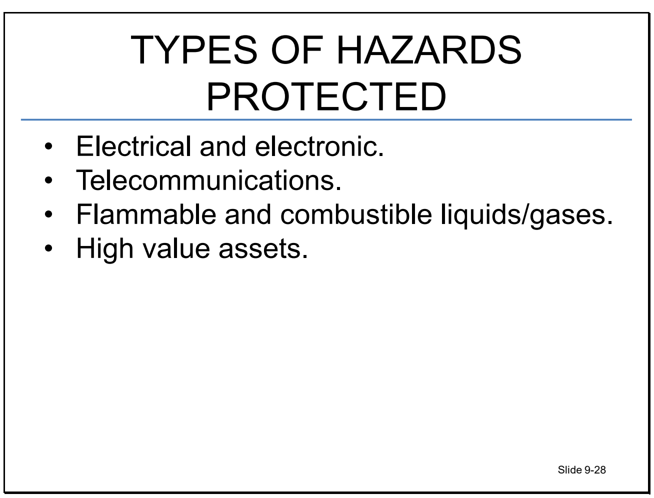
D. NFPA 2001 does not provide all the necessary criteria for the implementation of a total flooding clean agent system and is not a design handbook. The provisions of the standard do not eliminate the need for the engineer or for competent engineering judgment. This standard relies heavily on the criteria provided in the manufacturer's manuals.

E. No standard can be promulgated that will provide all the necessary criteria for the implementation of a total flooding clean agent fire extinguishing system. Technology in this area is under constant development.



F. Plans and specifications.

All plans and specifications must be prepared under the supervision of a person fully experienced and qualified. The designer bears the burden of demonstrating the validity of the approach. Plans and specifications are required to be submitted to the AHJ for review and approval prior to installation.



G. Types of hazards protected.

Clean agents are used to protect various hazards, such as electrical and electronic, telecommunications, flammable and combustible liquids, and high value assets. Clean agents cannot be used to protect materials that are capable of rapid oxidation in the absence of air, reactive metals, metal hydrides and chemicals that are capable of undergoing automatic thermal decomposition, such as organic peroxides.

TWO TYPES OF AGENTS

- Halocarbon.
- Inert gas.
- Agents are electrically nonconductive and leave no residue upon evaporation.

Slide 9-29

H. Types of agents.

1. Clean agents fall into one of two categories: halocarbon or inert gas. Halocarbon agents contain, as primary compounds, one or more organic compounds containing one or more of the elements of fluorine, chlorine, bromine or iodine. Inert agents contain, as their primary component, one or more of the gases helium, neon, argon or nitrogen. These blends may also contain CO_2 as a secondary component.

2. Clean agents, by definition, are electrically nonconductive, volatile or gaseous agents that leave no residue upon evaporation. Clean agents include FC-2-1-8, FC-3-1-10, HCFC Blend A, HCFC-124, HFC-125, HFC-227a, HFC-23, HFC-236fa, FIC-1311, IG-O1, IG-100, IG-541 and IG-55. Commonly known/marketed agents by brand name include Inergen and Factory Mutual (FM)-200.

HAZARDS TO PERSONNEL

- Agents used in normally occupied areas must first be evaluated by U.S. Environmental Protection Agency (EPA).
- Safeguards must be provided to ensure prompt evacuation from and to prevent entry into, hazardous atmospheres and to provide means of prompt rescue for any trapped personnel.

Slide 9-30

I. Hazards to personnel.

1. Any agent used under NFPA 2001 must first be evaluated in a manner that is equivalent to the process used by the U.S. Environmental Protection Agency's (EPA's) Significant New Alternatives Policy (SNAP) Program. The manufacturer's manual will contain information about the agents' Lowest Observable Adverse Effect Level (LOAEL) and No Observed Adverse Effect Level (NOAEL).

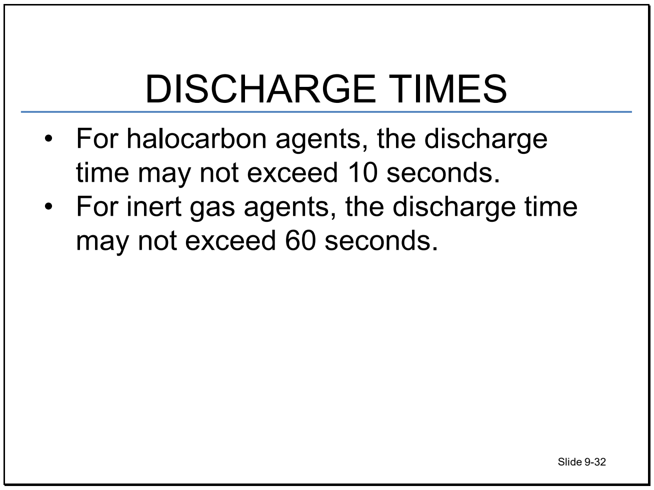
2. LOAEL is the lowest concentration at which an adverse physiological or toxicological effect has been observed. NOAEL is the highest concentration at which no adverse toxicological or physiological effect has been observed.

HAZARDS TO PERSONNEL (cont'd)

- Safety items, such as personnel training, warning signs, discharge alarms, self-contained breathing apparatus (SCBA), evacuation plans and fire drills, shall be considered.
- Consideration must be given to the possibility of agent migrating to adjacent areas outside of protected space.

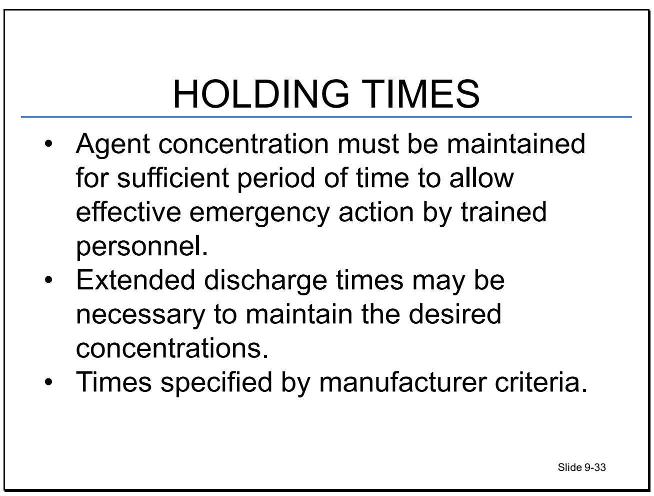
Slide 9-31

3. Safeguards must be provided to ensure prompt evacuation from, and prevention of entry into, hazardous atmospheres and prompt rescue for any trapped personnel. Safety items include personnel training, warning signs, discharge alarms, self-contained breathing apparatus (SCBA), evacuation plans and fire drills. Consideration must also be given to the possibility of the agent migrating to adjacent areas outside of the protected space.



J. Discharge times.

For halocarbon agents, the discharge time to reach the required concentration cannot exceed 10 seconds. For inert agents, the maximum discharge time may not exceed 60 seconds.



K. Holding times.

Agent concentration must be maintained for a sufficient time to allow effective emergency action by trained personnel. It may be necessary to extend the discharging time to maintain desired concentration levels. All discharge times will be based upon manufacturer's information.

ACCEPTANCE TESTING

- Completed system must be reviewed and tested by qualified personnel to meet approval of AHJ.
- Mechanical components — visual inspection (piping, nozzles, supports, storage containers).
- Discharge test not generally recommended.
- Quantity of agent.

Slide 9-34

L. Acceptance testing.

1. The complete system must be reviewed and tested by qualified personnel to meet the approval of the AHJ. Acceptance testing must be in accordance with the manufacturer's manual and will include a visual inspection of all mechanical components and the integrity of the enclosure. The quantity of agent must also be verified. The system must be functionally tested, but discharge testing is generally not recommended.

ACCEPTANCE TESTING (cont'd)

- Pressure test for 10 minutes at 40 pounds per square inch (psi), with no more than 20% drop.
- Flow test with dry nitrogen or inert gas to verify piping is continuous and unobstructed.
- Enclosure integrity.
- Fire alarm components per NFPA 72.
- Functional testing.

Slide 9-35

2. All piping must be pressure tested for 10 minutes at 40 pounds per square inch (psi) with no more than a 20% drop (8 psi). A flow test of all piping must be conducted using dry nitrogen or other inert gas to verify that the piping is continuous and unobstructed.

SEMIANNUALLY (cont'd)

- Thorough inspection and test for proper operation by competent personnel.
- Fire alarm components according to NFPA 72.
- All high-pressure cylinders must be inspected and the date of the last hydrostatic test noted.

Slide 9-36

M. Semiannually.

A thorough inspection and test for proper system operation must be conducted on a semiannual basis by competent personnel. All fire alarm components must be tested and inspected in accordance with NFPA 72. All high-pressure cylinders must be inspected and the date of last hydrostatic test noted.

SEMIANNUALLY (cont'd)

- For halocarbon agents, if the container shows loss of more than 5% by net weight or 10% by pressure, then the cylinder must be refilled or replaced.
- For inert gas agents that are not liquefied, if the container shows loss of more than 5% by pressure, then the cylinder must be refilled or replaced.

Slide 9-37

HYDROSTATIC TESTING (cont'd)

Cylinders may remain in continuous service for maximum of five years from date of last test.

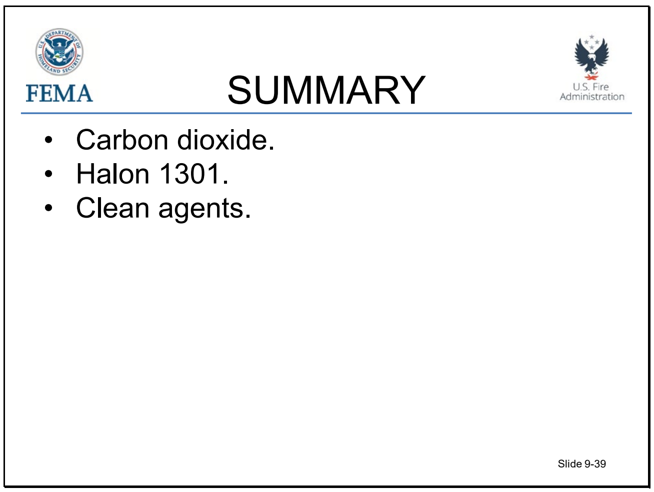
Slide 9-38

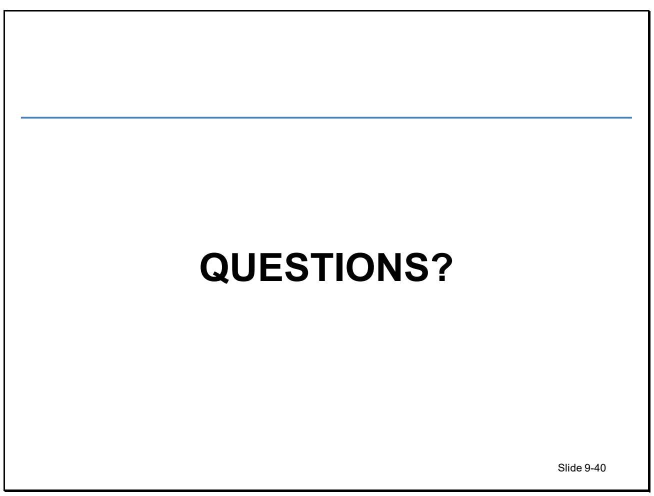
N. Hydrostatic testing.

1. Cylinders may remain in continuous service for a maximum of five years from the date of the last hydrostatic test.

2. All hoses shall be tested every five years at a pressure 1.5 times the normal operating pressure. At least every 12 months, the integrity of the enclosure must be verified.

IV. SUMMARY





REFERENCE

NFPA. (2015). *Standard on clean agent fire extinguishing systems*. (Standard No. 2001). Retrieved from www.nfpa.org

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ACRONYMS

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ACRONYMS

Å	Angstrom
A/V	audible/visible
AC	alternating current
ADA	Americans with Disabilities Act
AFF	above finished floor
AHJ	authority having jurisdiction
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
AWWA	American Water Works Association
BHP	brake horsepower curve
cfm	cubic feet per minute
CPVC	chlorinated polyvinyl chloride
CO_2	carbon dioxide
dB	decibel
dBA	A-weighted decibel
DC	direct current
DCVA	double check valve assembly
EFF	efficiency curve
EOLR	end-of-line resistor
EPA	Environmental Protection Agency
ESFR	Early Suppression Fast Response
FACP	Fire Alarm Control Panel

FACU	Fire Alarm Control Unit
FDA	Food and Drug Administration
FIP 2: ISS	Fire Inspection Principles 2: Inspection of Structures and Systems
FM	Factory Mutual
fps	feet per second
FSCS	Firefighter Smoke-Control Station
gpm	gallons per minute
HRR	heat release rate
HVAC	heating, ventilating, and air conditioning
Hz	hertz
IBC	International Building Code
IDLH	immediately dangerous to life or health
IG	Instructor Guide
IFC	International Fire Code
IKECA	International Kitchen Exhaust Cleaning Association
IMC	International Mechanical Code
IMSA	International Municipal Signal Association
IR	infrared
IRC	International Residential Code
kPa	kilopascal
LED	light-emitting diode
LOAEL	Lowest Observable Adverse Effect Level
LPG	liquefied petroleum gas

MW	megawatt
NAC	notification appliance circuit
NEC	National Electrical Code®
NETC	National Emergency Training Center
NFA	National Fire Academy
NFPA	National Fire Protection Association
NFSA	National Fire Sprinkler Association
NICET	National Institute for Certification in Engineering Technologies
NIST	National Institute of Standards and Technology
nM	nanometer
NOAEL	No Observed Adverse Effect Level
NPLFA	non-power-limited fire alarm
OAP	open area protection
OS&Y	outside stem and yoke
PG	propylene glycol
PIV	post indicator valves
PLFA	power-limited fire alarm
PRD	pressure regulating device
PRV	pressure reducing valve
psi	pounds per square inch
PVC	polyvinyl chloride
QOD	quick opening device
RF	radio frequency

rpm	revolutions per minute
RPZ	reduced pressure zone device
RS	releasing service
SCBA	self-contained breathing apparatus
SFPE	Society of Fire Protection Engineers
SM	Student Manual
SNAP	Significant New Alternatives Policy
SPL	sound pressure level
UL	Underwriters Laboratories
UPS	uninterruptible power supply
USFA	U.S. Fire Administration
UV	ultraviolet
VESDA	**V**ery **E**arly **S**moke **D**etection **A**ppliance
WIV	wall indicator valve