From Paper to Flames: The Real Fire Behind Hazard Class

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Ben Brooks, M.Eng., P.E., CFPE, CHRS, CPD

SAN ANTONIO, TX

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The authority on fire, electrical, and building safety

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Christopher M. Campion Jr.

P.E., SET, CFPS

Chris began working in fire protection in 1996. His experience includes inspection, testing, service, installation, design, commissioning, engineering, and code enforcement.

He is a licensed fire protection engineer, fire protection contractor, fire official, and fire sub-code official. He is a principal of Trace Everett Associates, LLC and a partner in Eastern Fire & Safety, LLC.

He holds the NFPA CFPS credential, NICET Level IV in Fire Alarm and Special Hazards, and NICET Level II in Inspection and Testing of Water-Based Systems.

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Ben Brooks

M.Eng., P.E., CFPE, CHRS, CPD

Ben is a licensed Professional Fire Protection Engineer with 15 years of experience specializing in fire protection design. He has expertise in water-based, chemical and gaseous fire protection systems, smoke management & control systems for higher educational facilities, laboratories, government & healthcare facilities, office buildings, kitchens, and commercial buildings.

He established Brooks Fire Protection Engineering, LLC in 2024 after developing and growing a fire protection team at his previous employer. He supports fire departments in St. Louis, MO with training on the growing trends in fire protection.

Ben@BrooksFireProtection.com | Brooks Fire Protection Engineering, LLC

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Objectives

- Explain how occupancy and fuel affect fire size.
- Describe flow rate as a measure of water available to absorb heat.
- Identify why the correct hazard classification matters.
- Explain how system design connects the expected fire to the water being delivered.
- Describe the risks created by changes in use, storage, or layout.
- Explain why spacing and obstruction rules matter in the field and on the drawings.

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Why Are We Here?

- Understanding fire is an important part of working on fire protection systems.
- Most people know the "how," but do not always understand the "why."
- The "why" explains what the system is intended to accomplish.

Ever walk into a room and forget why you went there? That is what happens when we know the how, but forget the why.

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Why Are We Here?

- Smart people can design systems without fully understanding the fire problem.
  - Electrical engineers understand electronics and power systems.
  - Mechanical engineers and plumbing designers understand hydraulics and thermodynamics.

  They know how their systems work.
- They may not have the same understanding of what happens when a fire grows in a room.
  - Fire protection engineering connects the rules to what happens during a fire.

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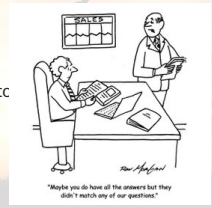
Why Are We Here?

- Skilled people can install a system without understanding why every rule matters.
  - They know what the book says.
  - They know the rules.
- The same problem can affect inspecto and owners.



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What Is Fire?

- Definition:
  - "A rapid oxidation process, which is a chemical reaction resulting in the evolution of light and heat in varying intensities." (NFPA 921)
  - A fire is an exothermic chemical reaction that gives off heat and light. (Webster's Dictionary)

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What Does That Mean?

- Oxidation:
  - "To combine with oxygen."
- Rapid:
  - "Marked by a fast rate of motion, activity, succession, or occurrence."
- Evolution:
  - "The action or an instance of forming and giving something off."
- Exothermic:
  - "Accompanied by the release of heat."

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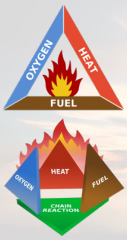
Fundamentals



- Fire exists when four elements come together.
- The simplest illustrations are the fire triangle and fire tetrahedron.
  - The components must be present in the right balance to support combustion.
  - Changing any one component can change the fire.

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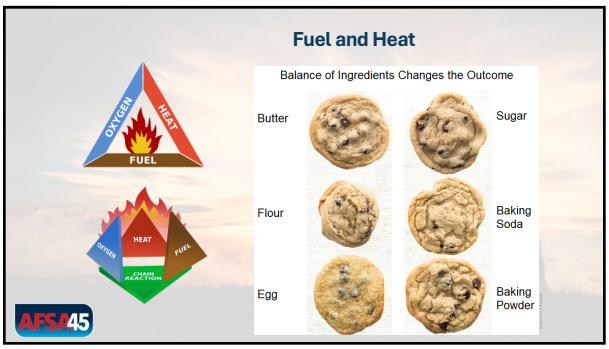

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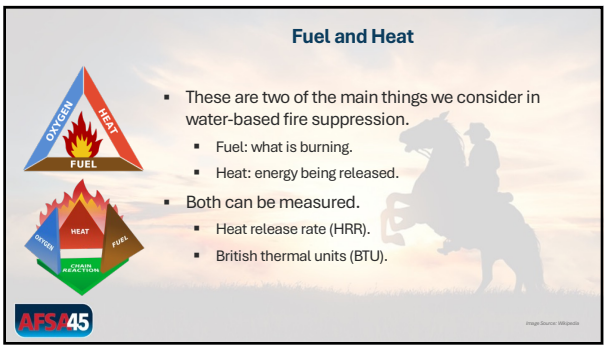

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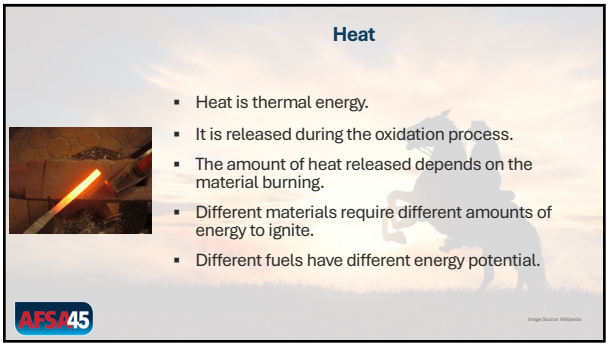

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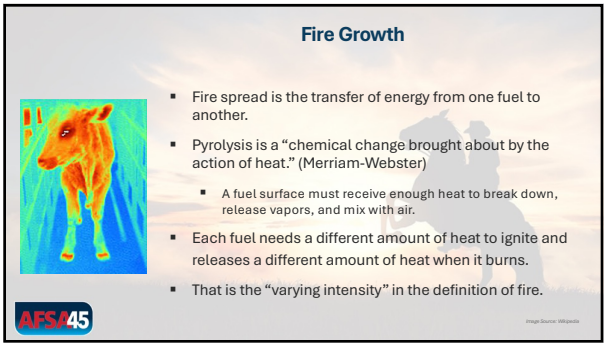

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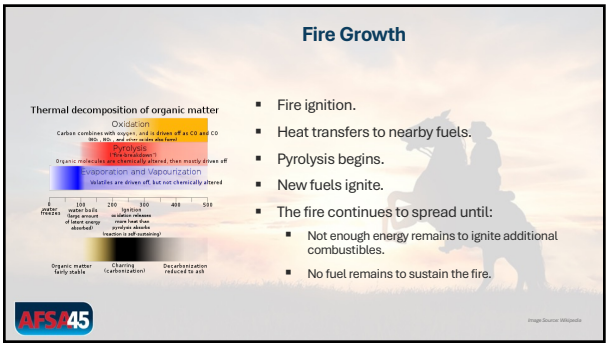

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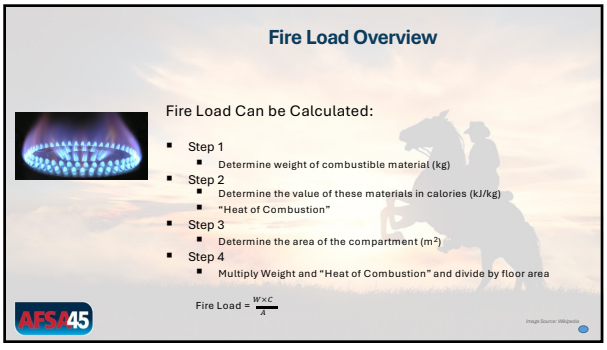

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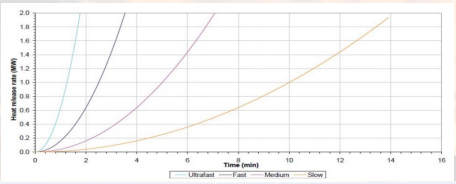
Heat Release Rate



Fire Growth Coefficient	Time to reach 1 MW (s)	Coefficient α	Fire Scenario
Slow	600	0.00293	Densely packed paper
Medium	300	0.01172	Traditional mattress or armchair
Fast	150	0.0469	PU mattress or PE pallets
Ultra Fast	75	0.1876	High pile storage rack

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Heat Release Rate

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Control, Extinguishment, Suppression

- Fire control in NFPA 13 means limiting the size of a fire by distribution of water so as to decrease the heat release rate and pre-wet adjacent combustibles, while controlling ceiling gas temperatures to avoid structural damage.
- Fire extinguishment in NFPA 750 means the complete suppression of a fire until there are no burning combustibles.
- Fire suppression in NFPA 13 means sharply reducing the heat release rate of a fire and preventing its regrowth by means of direct and sufficient application of water through the fire plume to the burning fuel surface

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Heat Release Rate

- No Effect

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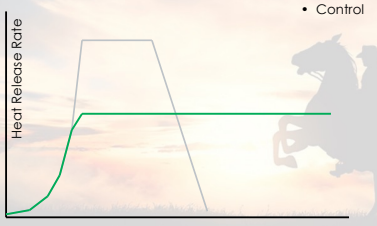
Heat Release Rate

- No Effect
- Control



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Heat Release Rate

- No Effect
- Control
- Control with Decay

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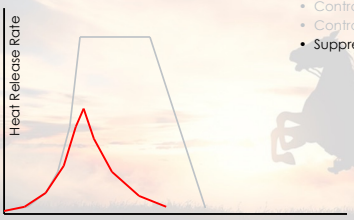
Heat Release Rate

- No Effect
- Control
- Control with Decay
- Suppression



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What Does It Mean?

- A fire starts and spreads based on the fuel and the compartment.
  - Type, amount, and arrangement all matter.
- Changes in the room can change how the fire burns.
- Changes in the material can change how the fire burns.
- Changes in the arrangement can change how the fire burns.

What is burning changes how we protect it.

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What Does It Mean?

- This is the basis for occupancy classifications and storage rules.
- What is burning and how it burns affect how it must be protected.
  - How much water is needed.
  - How the water is delivered.
  - Where the water is delivered.

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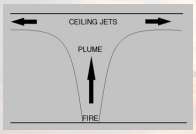
Basics of Fire Spread



- Burning fuel releases heat.
- Heat rises toward the ceiling.
- At the upper boundary, it spreads horizontally.
- When it reaches a vertical boundary, it banks down.
- The upper layer radiates heat back into the room.
- The cycle continues until the fuel or oxygen is removed.

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How Sprinklers Suppress Fire

- A fire releases energy as heat.
- Heat rises into the upper layer.
- Hot gases spread across the ceiling.
- The sprinkler's thermal element responds to the heat.
- Water is discharged as droplets.
  - The water absorbs energy and cools the fire.
  - One BTU is the energy needed to raise one pound of water one degree Fahrenheit. A gallon of water weighs about 8.33 pounds.

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Flow Rate

- Gallons per minute represent the theoretical heat-absorbing potential of the water.
  - Example: 250 gpm can absorb 2,082.5 BTU per minute for each 1°F rise in the water temperature. (250 × 8.33)
  - When one pound of water turns to steam at 212°F, it absorbs about 970 BTU.
  - That energy must be returned before the steam can condense back into water.

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Balancing Act

- The fuel is burning and releasing heat.
- The heat must reach the sprinkler.
- The sprinkler must respond soon enough.
- Water must discharge into the space.
- Enough water must reach the fire in a way that absorbs the released energy.

Image Source: Wikipedia

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Building Features

- Building features can block or delay heat from reaching a sprinkler.
  - Physical barriers create obstructions.
  - Wide spacing can allow heat to dissipate before a sprinkler operates.
  - Building features can also block water from reaching the fire.
- A severe fire can release heat faster than the sprinkler system can absorb it.

Image Source: Wikipedia

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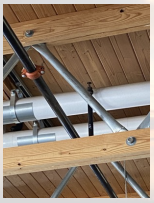
Obstructions



- Obstructions change how heat and smoke move.
- They can delay heat from reaching a sprinkler.
- They can block the water pattern and reduce effective water delivery.
- The fire can grow beyond the sprinkler system's capability before the system operates.

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Prescriptive Standards

- They are written to cover common conditions.
- They are often conservative: one size fits most.
  - They are based largely on what has worked in the past.
- They are updated as the industry learns from fires, tests, and field experience.

Image Source: Wikipedia

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Hazard Classification

- Buildings with similar uses often have similar contents, but not always.
  - A small change can create a large change in the fire challenge.
  - Hotels may have similar guest rooms, but what about ballrooms, kitchens, and storage rooms?
- An office building may have different hazards depending on who uses the space and what is stored there.

Image Source: Wikipedia

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Use Group Is Not Hazard Class

- Construction codes classify how a space is used.
- Sprinkler hazard classifications address the fire challenge inside that space.
- Example: a hotel with banquet areas.
  - The guest rooms may be Residential Group R-1 under the construction code.
    - The banquet hall may be Assembly Group A-2.
      - The sprinkler design could include Light Hazard guest rooms, Ordinary Hazard Group 1 service areas, and Ordinary Hazard Group 2 banquet areas.

Image Source: Wikipedia

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Use Groups

- Use groups are assigned by the construction code based on how a building or space will operate.
- They help identify the general construction and life-safety features needed for that use.
- Similar businesses are often grouped together.
  - A use group does not tell you exactly what materials, products, or storage will be inside.

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Hazard Classifications

- Hazard classifications consider the contents and the fire potential.
  - Fuel load.
  - Required flow rate.
- They provide design guidance based on protection that has worked in the past.
- They may need to change when the contents change.
- A general classification can be wrong for a specific hazard.
  - Storage means real storage, not just a room labeled "storage."

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Hazard Classifications

The requirements can be general or specific.

Before a change in use, occupancy, renovation, or modification, the fire challenge must be reviewed.

When the new fire load exceeds the original design basis, the sprinkler protection may need to change.

The change may affect one area, not necessarily the entire building.

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Different Classes

- Hazard classifications relate to the expected fire load.
- Each classification has a required flow rate over a design area.
- The flow is intended to address a potential fire within that area.
- The relationship is based on the expected energy release.
- It can be estimated with math, but the field condition still has to match the assumptions.

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Different Classes

	NFPA Design Densities				
	LH	OH1	OH2	EH1	EH2
	0.1 gpm/ft²	**0.15 gpm/ft²**	**0.2 gpm/ft²**	**0.25 gpm/ft²**	**0.3 gpm/ft²**
Inlet Water Temp:	60 °F	60 °F	60 °F	60 °F	60 °F
	1 ft²	1 ft²	1 ft²	1 ft²	1 ft²
	0.833 lbs/min/ft²	1.2495 lbs/min/ft²	1.666 lbs/min/ft²	2.0825 lbs/min/ft²	2.499 lbs/min/ft²
	0.833 lbs/min	1.2495 lbs/min	1.666 lbs/min	2.0825 lbs/min	2.499 lbs/min
	0.01388333 lbs/s	0.02083 lbs/s	0.02777 lbs/s	0.03471 lbs/s	0.04165 lbs/s
	152 ΔT	152 ΔT	152 ΔT	152 ΔT	152 ΔT
Btu Input ΔT (212°F)	2.11026667 BTU/s	3.1654 BTU/s	4.22053 BTU/s	5.27567 BTU/s	6.3308 BTU/s
Steam Conversion	13.4709983 BTU/s	20.2065 BTU/s	26.942 BTU/s	33.6775 BTU/s	40.413 BTU/s
Total Btu/s	15.581265 BTU/s	23.3719 BTU/s	31.1625 BTU/s	38.9532 BTU/s	46.7438 BTU/s
Fire Size:	**15.58** BTU/s/ft²	**23.37** BTU/s/ft²	**31.16** BTU/s/ft²	**38.95** BTU/s/ft²	**46.74** BTU/s/ft²
	0.27 KW/ft²	**0.41** KW/ft²	**0.55** KW/ft²	**0.68** KW/ft²	**0.82** KW/ft²
	2.95 kW/m²	**4.42** kW/m²	**5.90** kW/m²	**7.37** kW/m²	**8.85** kW/m²

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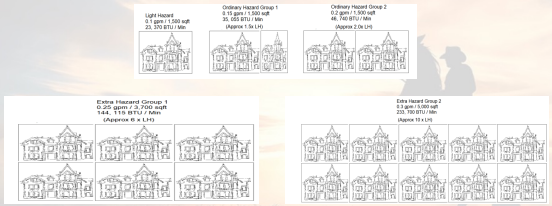
Different Classes



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Example Peak HRR

- A Coffee Maker: 19 BTU/s
- A wooden dresser: Peak HRR around 1,600 BTU/s
- Wooden Pallets Stacked 6 feet high: 4,800 BTU/s
- A polyurethane Chair: 2,000 BTU/s
- a Christmas tree 5,000 BTU/s
- a School bus: 35,000 BTU/s
- A Subway Car: 35,000 BTU/s
- A Television: 200 BTU/s

Image Source: Wikipedia

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Example Peak HRR

- **Single passenger cars**
  - 284,345 BTU, 5 MW average
- How many cars are in the parking garage?
  - Avg. space: 8' x 17' = 136 ft²
  - Design area: 1,500 ft², OH2
- How many cars are in the remote area?
- Can water get there before peak heat?
- Can that flow rate control or suppress?
- What about fuel changes, like lithium-ion?

Image Source: Wikipedia

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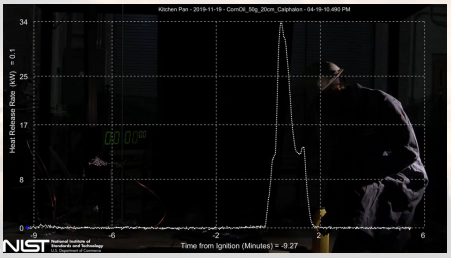

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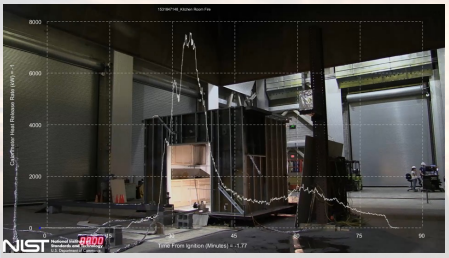

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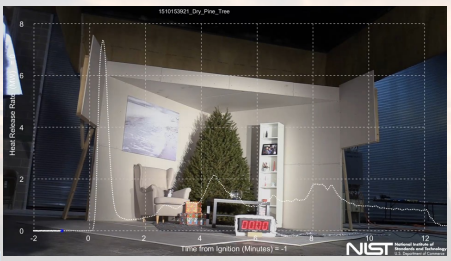

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Who Needs to Know?

- Enforcers:
  - Know how the building and each space are actually being used.
  - During inspections, confirm that the use and storage have not changed.
- Designers:
  - Recognize room labels or field conditions that do not match the design criteria.
  - Flow is not just a number needed to pass the calculation.
    - Do not fudge it.

Image Source: Wikipedia

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Who Needs to Know?

- Owners:
  - Understand how changes in use affect the sprinkler system.
  - Understand how changes in storage affect the sprinkler system.
  - Do not change walls, ceilings, finishes, equipment, or storage without considering sprinkler protection.
- Inspectors:
  - Look at the space from the standpoint of what will happen during a fire.

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Image Source: Wikipedia

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Who Needs to Know?

- Insurers:
  - Confirm that the use has not changed.
  - Confirm that the storage classification has not changed.
  - Changes in use, hazard classification, or building features can make an otherwise sound system ineffective.

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Image Source: Wikipedia

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Summary

- Occupancy describes how a space is used. Hazard classification addresses the fire potential inside it.
- Combustibles release heat at different rates and intensities. The sprinkler system must deliver enough water to control that energy.
- The selected classification must match the materials, arrangement, and expected fire challenge.
- Changes in use or storage can change the amount of water needed.
- Obstructions can delay sprinkler operation and block water from reaching the fire.

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Summary

- Everyone involved in the design, installation, inspection, use, and maintenance of the building has a reason to identify changes and question conditions that do not make sense.
- A sprinkler system can only work as intended when enough water reaches the fire soon enough to overcome the energy being released.

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REQUIRED

FOR CEU CREDIT:

- ✓ Badge scanned at start of seminar
- ✓ Attend full seminar
- ✓ Complete survey 1 of 2 ways:
  - ✓ Survey link is emailed to attendees with scanned badges
  - ✓ Event app by EventsAir
    - Login to app
    - Navigate to seminar survey
  - ✓ Surveys close 10/31/26

Thank you!

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Scan QR code to submit questions for **Ask the Experts!**

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2027 Training Schedule

WEBINARS

1/6	Updates to NFPA 20
1/20	Calculating Pressure Reducing Hose Valves
2/3	Consumer Alert: Nitrogen in Sprinkler Systems
2/17	Reviewing Hydraulic Calculations
3/3	Updates to NFPA 13, 2028 Ed.
3/17	Updates to NFPA 13R & 13D, 2028 Eds.
4/7	Topic Coming Soon
4/21	NFPA 25: Roles & Responsibilities
5/5	Standpipe Flow Test Procedures
5/19	Storage 101
6/2	NFPA Technical Meeting - Voting Guide
6/16	Topic Coming Soon
6/30	Topic Coming Soon
7/7	Updates to NFPA 14, 2027 Edition
7/21	Adjacent Hazards & Design Methods
8/4	Acceptance Testing
8/18	Modifications to Existing Systems
9/22	Topic Coming Soon
10/6	Seismic 101
10/20	Proposed Updates to NFPA 25, 2029 Ed.
11/3	Evaluating Fire Pump Flow Tests
11/17	Top 10 Tech Reviews
12/1	Designing Water Storage Tanks
12/15	Pump Room Layout

PROGRAMS

Feb 9 - Mar 5 Apr 20 - May 14 Aug 3 - Aug 27** Oct 26 - Nov 19	Beginning Design School*
Apr 26 - May 7 Nov 1 - 12	Intermediate Design School*
Feb 8 - 10** Apr 12 - 14 Jul 12 - 14 Oct 11 - 13	Sprinkler Hydraulics Calculations Workshop
Apr 19 - 21 Oct 18 - 20	Advanced Hydraulics Calculations Workshop
Feb 11** Apr 30 Jul 23 Sep 24	Introduction to the Fire Sprinkler Industry
Mar 1 - 3 May 17 - 19 Aug 16 - 18 Oct 18 - 20**	NFPA 25 Essentials Workshop
Jun 7 - 10 Sep 20 - 23	Experienced Inspector Skills Lab
Mar 4 - 5 May 20 - 21 Aug 19 - 20 Oct 21 - 22**	NFPA 25 Fire Pump Workshop
Spring Summer Fall	ITM Inspector Development Program* *This program is 20 months.*

** Hybrid course **At General Air Products Lab, Exton, PA*

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September 8-11	Manchester Grand Hyatt San Diego, CA

For More Details Visit:
firesprinkler.org

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Dates subject to change. Programs subject to minimum registrations.

rev 9/14/2026

Virtual Instruction Path (VIP)

for Sprinkler Fitting Apprentices

Level 1 - Begins January 2027

Level 2 - Begins February 2027

Level 3 - Begins January 2027

Level 4 - Begins March 2027

www.firesprinkler.org/VIP

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HANDS-ON WORKSHOPS FOR 2027

FEATURING AFSA'S TRAINING LAB

NFPA 25 Essentials Workshop

Mar | May | Aug | Oct

Description: Understand roles, responsibilities, and NFPA 25 ITM procedures through hands-on testing of wet systems, dry systems, and fire pumps.

NFPA 25 Fire Pump Workshop

Mar | May | Aug | Oct

Description: Develop practical NFPA 25 fire pump ITM skills, including no-flow and full-flow testing, water supply graphing, and performance evaluation.

Introduction to the Fire Sprinkler Industry

Feb | Apr | Jul | Sep

Description: This course is designed for those new to the industry. An introductory, wide-ranging 8-hour course that provides a broad overview of core fire sprinkler industry concepts for those new to the field.

Experienced Inspector Skills Lab NEW

Mar | Sep

Description: Take your ITM expertise beyond the basics. Designed for experienced technicians, this course combines focused classroom instruction with hands-on system lab training to strengthen your application of current NFPA 25 inspection, testing, and maintenance requirements. Refine fire sprinkler testing practices, improve documentation, deliver more consistent service, and help reduce liability while reinforcing knowledge commonly covered on certification exams.

Learn more about AFSA's fire sprinkler lab featuring functional risers, a spray room, fire pumps, and an interactive classroom.

firesprinkler.org/lab