

**American Society of Safety Engineers**  
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**Session No. 101E**

# **Fire Protection**

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# Fundamentals of SH&E



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# Agenda

## Introduction

- Science of Fire
- Fire Controls
- Fire Protection
  - Detection / Suppression
- Testing - Maintenance
- Warehousing / Storage
- Questions

# What is Fire ?



# Classic Definition

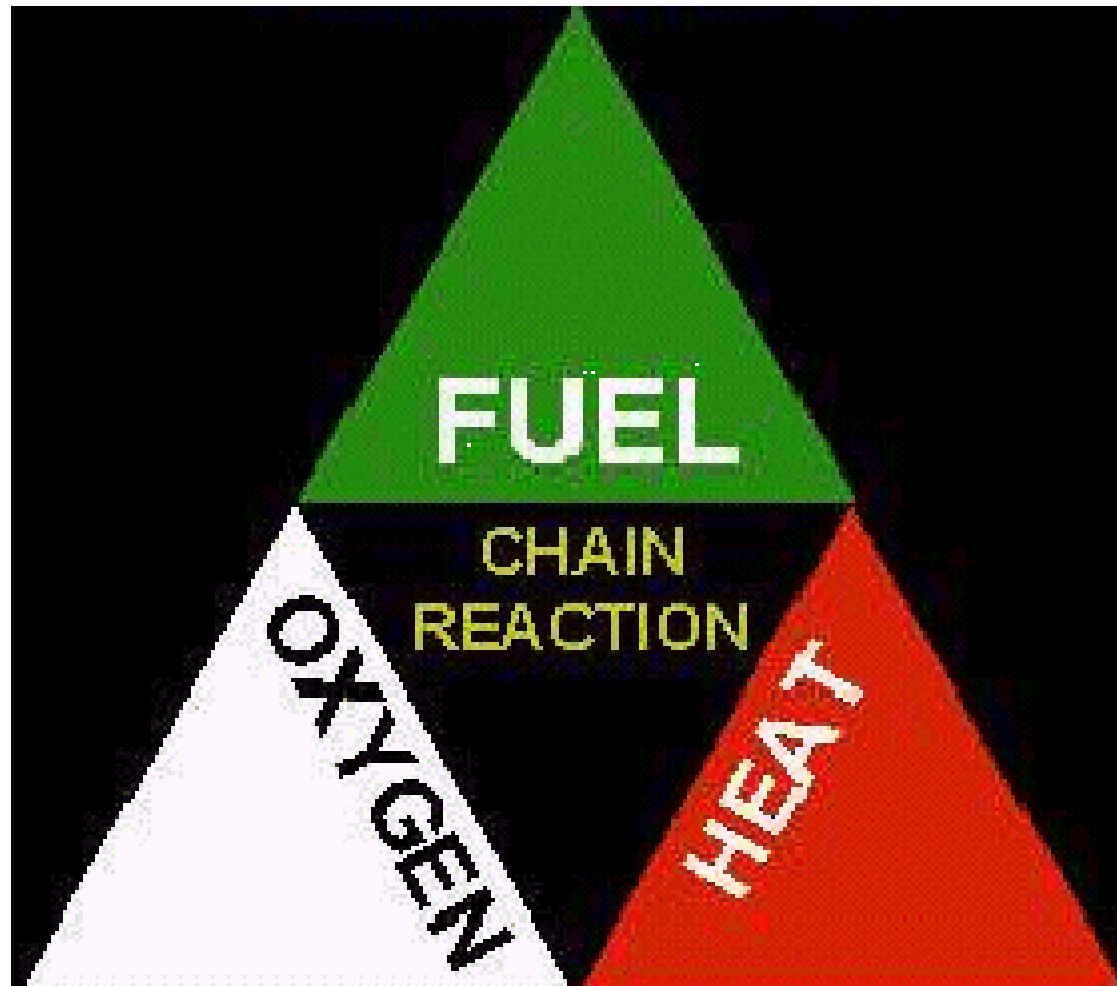
Fire is rapid oxidation with the evolution of heat and light



# The Fire Triangle



# Triangle? Not a Tetrahedron?



# What's Burning?



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# Pyrolysis

- Some of the heat is lost (convective)
- Some of the heat goes back into the system (conductive)
- Heat produces vapors
- Vapors ignite and propagate



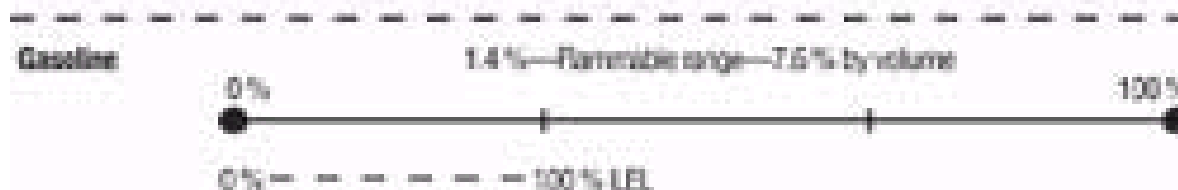
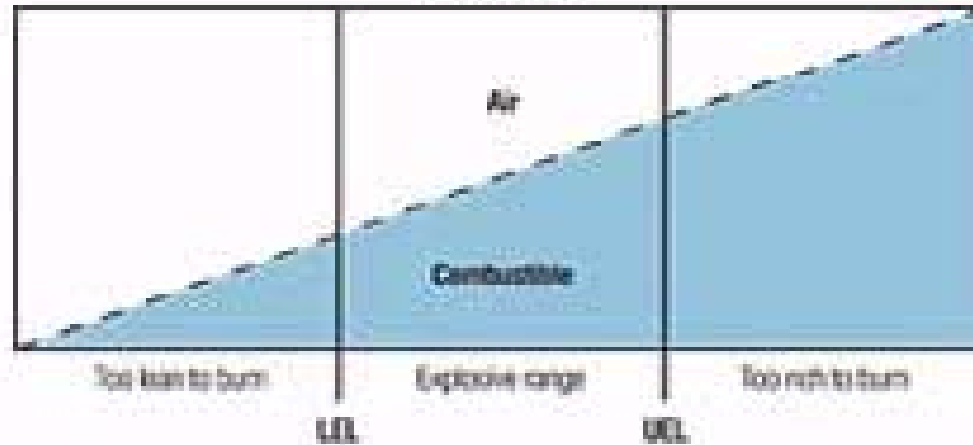
# Vapors

## Flammable Range LFL - UFL, LEL - UEL

- Lean
- Rich

EXPLOSIVE RANGE OF GASOLINE

LEL vs. UEL



# So Far



- **Defined Fire**
- **Know what is burning**
- **Concept of Flammability Range**

# Control

- Remove one or more legs of the triangle
- Omit the Fuel
- Inert the Atmosphere
- Cool the Reaction
- Interfere with the combustion process



# Applied Controls -- Fuel

- Segregate fuel from processes
- Minimize the amount of fuel
- Use less combustible materials
- Housekeeping - Dusts

# Applied Controls -- Oxygen



- Can the process operate rich?
- Can the process operate lean?
- Inert the operation –  $N_2$ ,  $CO_2$

# Applied Controls -- Heat

- Exothermic processes
- Frictional heat
- Chemical heat
- Sparks - Electrical



# Applied Controls -- Heat

- Sparks - Welding, Hot Work
- Grinding
- Open Flames
- Lightning
- Smoking







# Applied Controls -- Chain Reaction

- **Less Hazardous Materials**
  - **Water Soluble vs. Oil Based**
    - **Paints, Cutting Oils, Lubricants, Inks Etc.**
- **Fire Resistive Materials**
  - **Phenols, PVC's vs. Polyethylene, Styrene**
  - **Inerting Fillers for Plastic**
  - **Intumescent**

# Applied Controls -- Management



## Written Procedures

- Air Sampling
- Hot Work
- Self Inspections
- Outside Contractors

FOR ALL CUTTING/WELDING OPERATIONS

SPECIAL INSTRUCTIONS

**Cutting/Welding Permit**  
Applies Only to Area Specified Below

SEE INSTRUCTIONS ON REVERSE SIDE

**SECTION A**

LOCATION	JOB OR WVA NUMBER
----------	-------------------

**INSTRUCTIONS**

1. Supervisor completes section to be used and then fills in Sections A & C.
2. Supervisor retains the top copy of the form and issues the permit card (Sections B & C) to the worker.
3. Worker completes Section C, marks Section B in the work area, and returns Section C to the supervisor.
4. Section B remains at the work area until it is picked up one hour after work is completed, and is then returned to the Supervisor.

**IS THERE A SAFER WAY?**

# So Far



- Principles of Extinguishment
- Know what is burning
- Concept of Flammability Range
- Applied Controls

# System Controls -- Devices

- Fire Detection
- Fire Suppression



# System Controls -- Devices

## Fire Detection

- **Smoke**
  - Ionization, Photoelectric
- **Heat**
  - Restorable, Rate of Rise
- **Beam**
  - Obscuration
- **Flame**
- **IR**



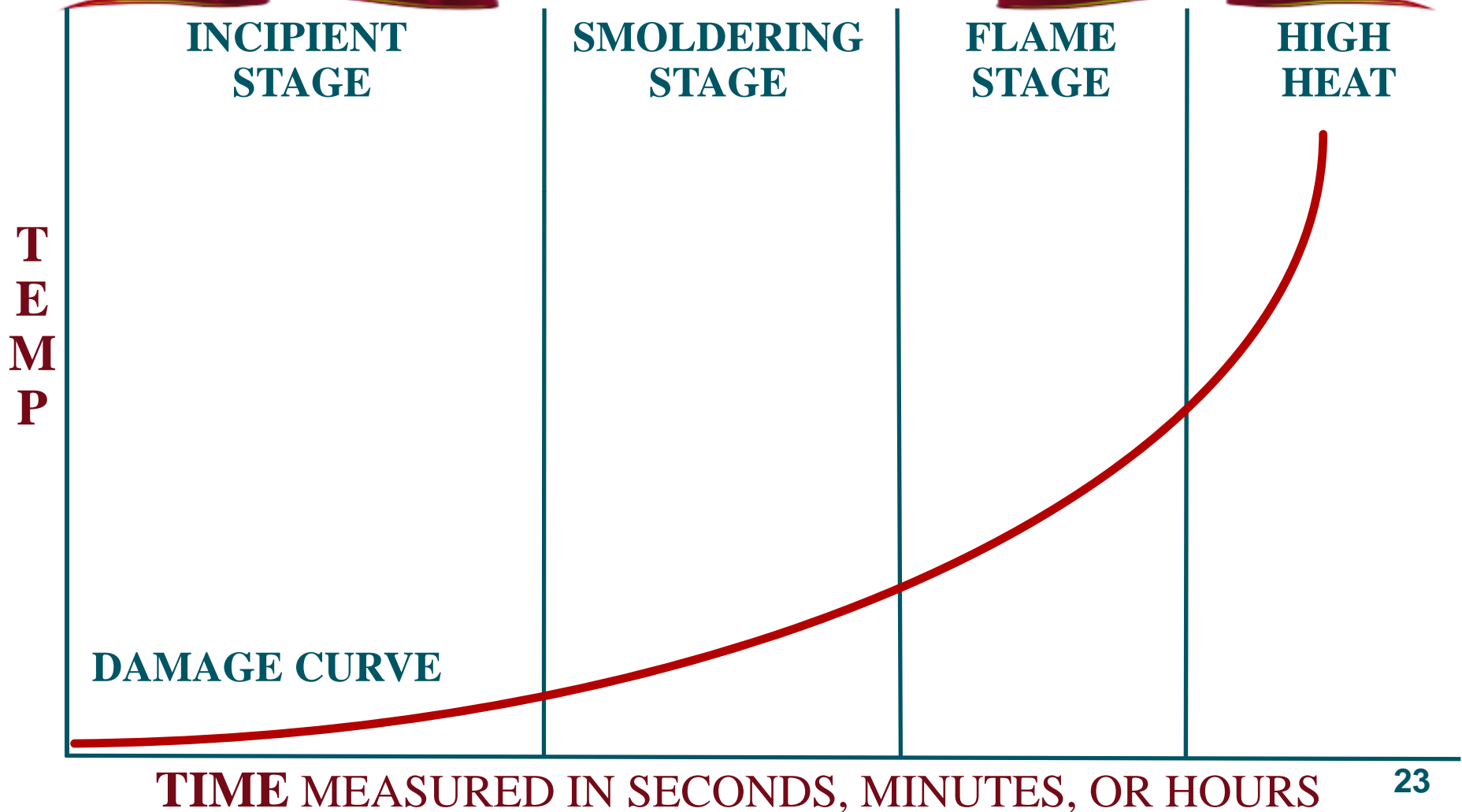
# System Controls -- Devices

## Four Stages of a Fire

- **Incipient**
  - Microseconds to days
- **Smoldering**
  - Microseconds
- **Flaming**
- **High Heat**



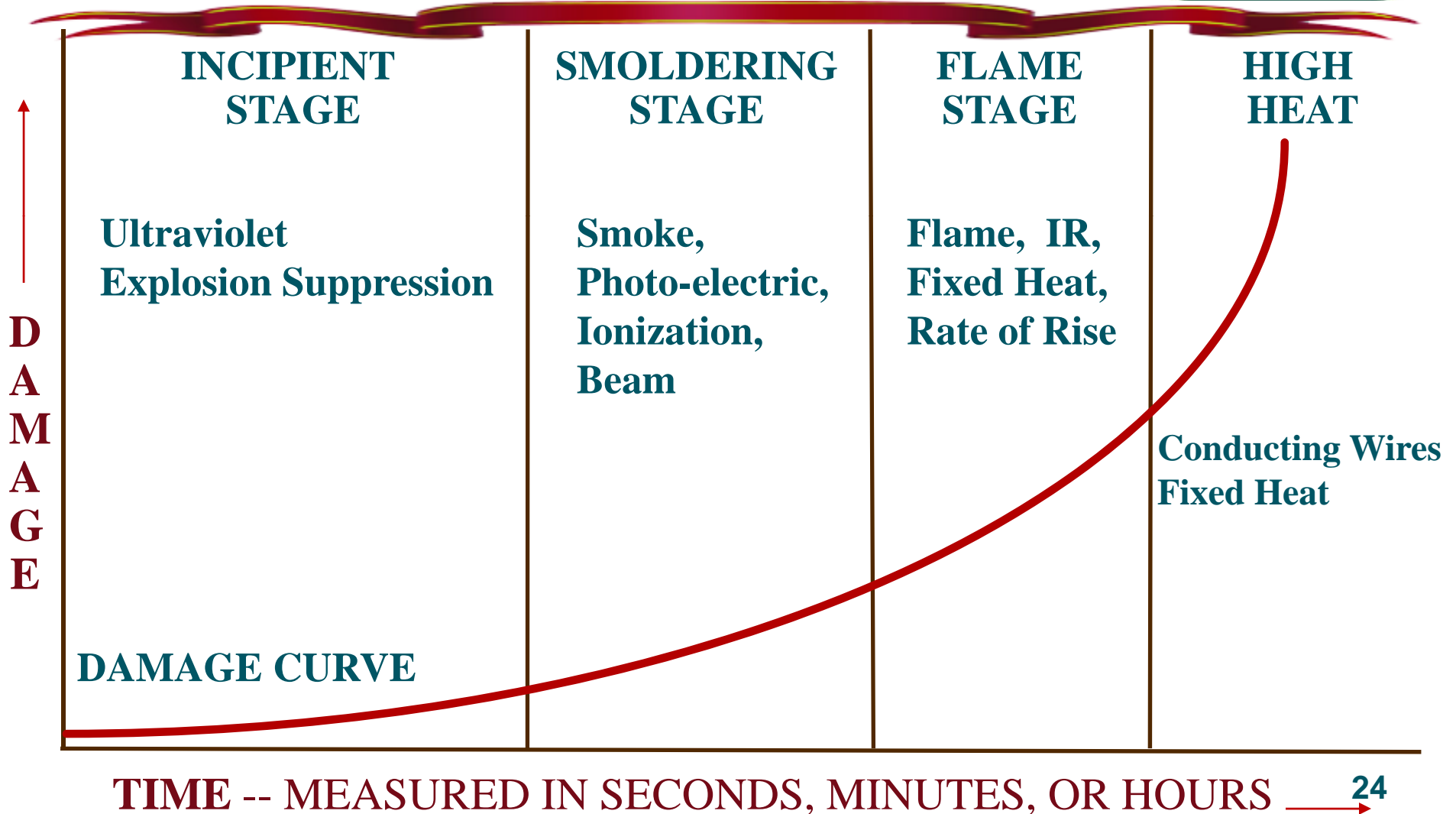
# Time -Temperature Curve





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# Time -Temperature Curve





# So Far

- Principles of Extinguishment
- Know what is burning
- Concept of Flammability Range
- Applied Controls
- Stages of a Fire
- Fire Detection

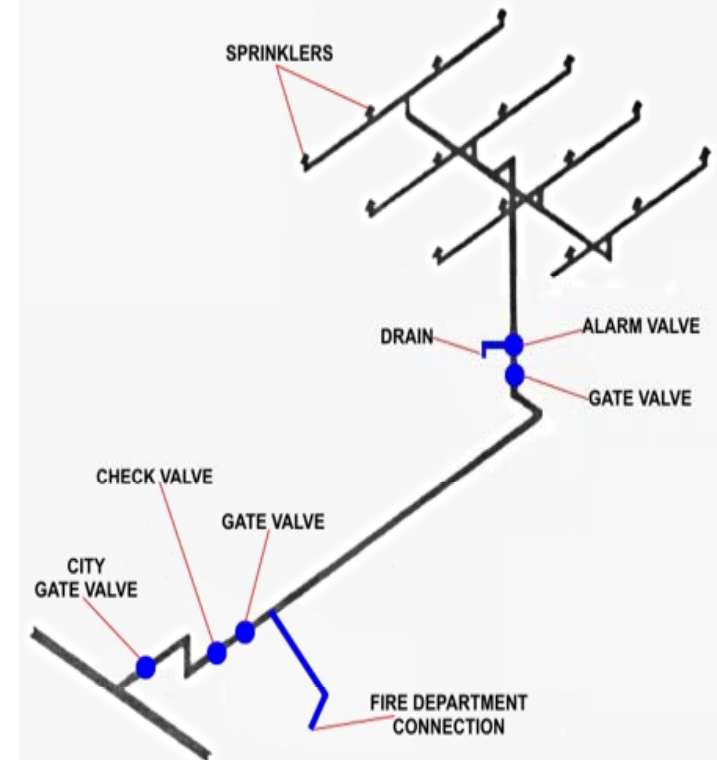
# System Controls - Fixed Suppression



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## Sprinkler Systems

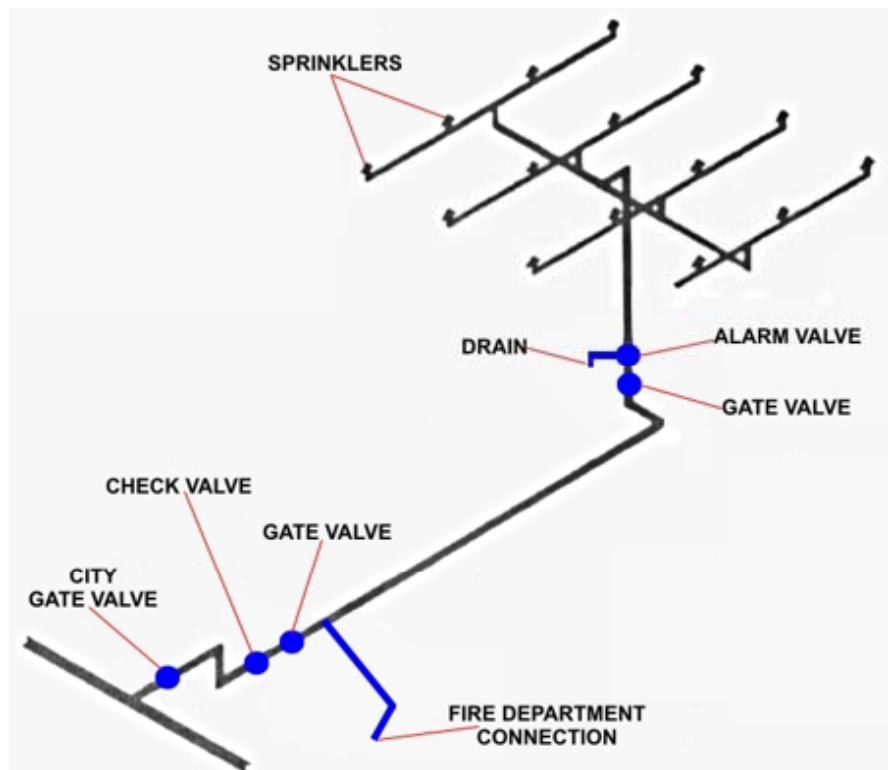
- Wet
- Dry
- Anti-freeze
- Deluge
- Pre-action
- Combined Dry / Pre-action
- Cycling On-Off
- Ref: NFPA 13



# System Controls - Fixed Suppression

## Sprinkler Systems

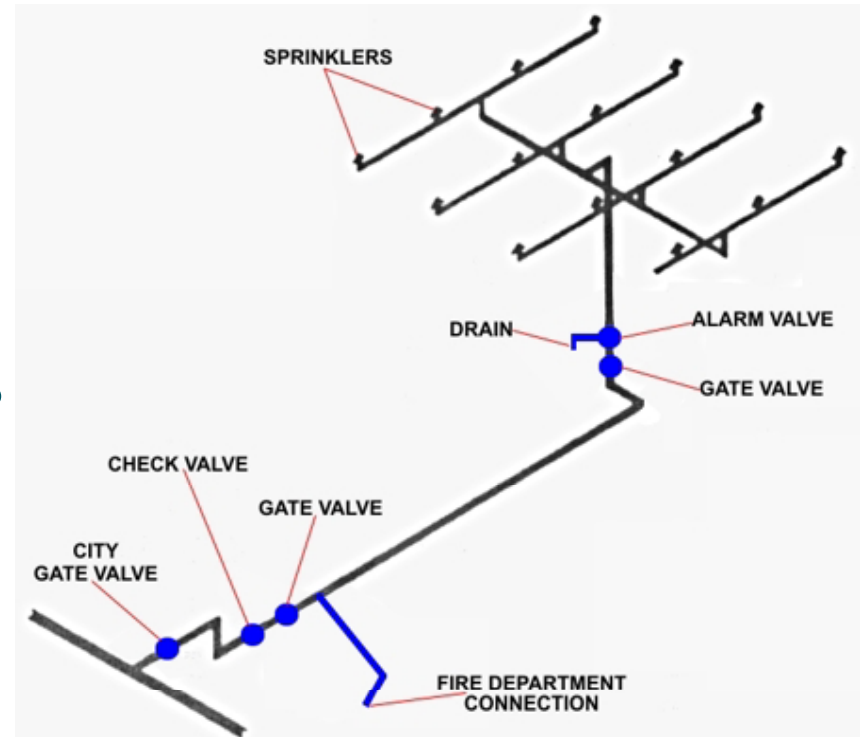
- **Wet**
  - **Most Common**
  - **Water in the pipes**
  - **Very efficient**
  - **Requires Heat**



# System Controls - Fixed Suppression

## Sprinkler Systems

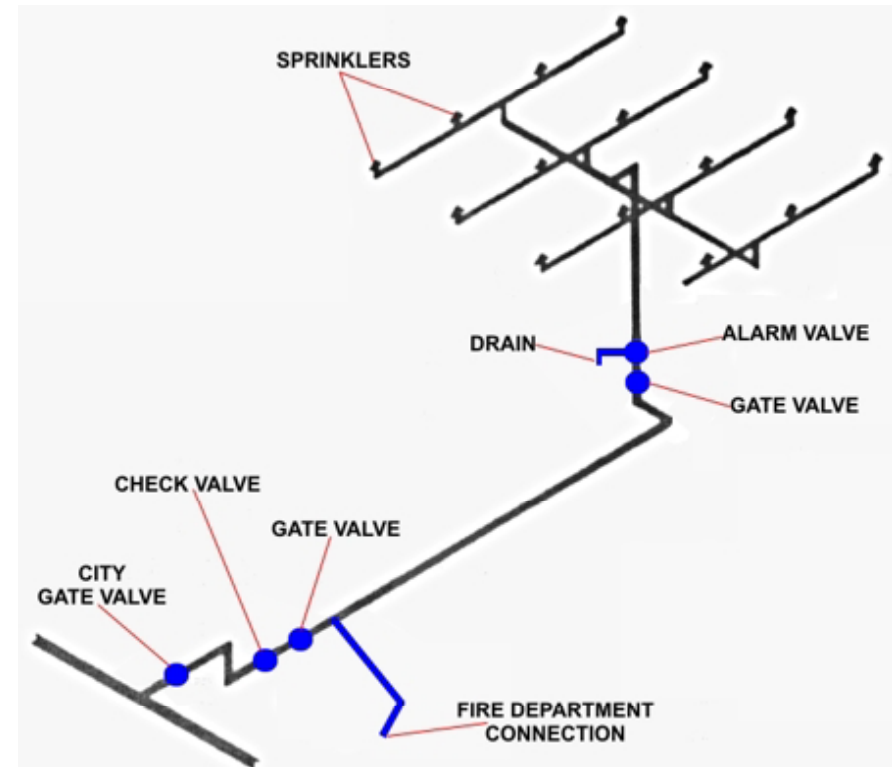
- **Dry**
  - Compressed air in pipes
  - Needs more devices
  - Used in areas subject to freezing
  - Limited in size



# System Controls - Fixed Suppression

## Sprinkler Systems

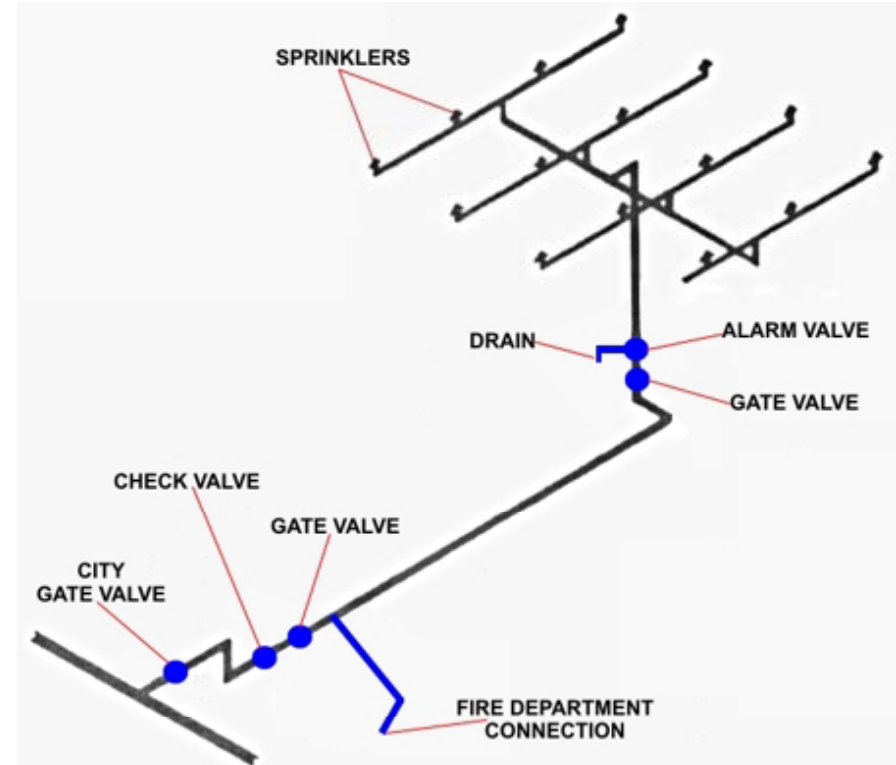
- **Anti-Freeze**
  - Filled with a glycol solution
  - Limited in size
  - Some applications to storage occupancies



# System Controls - Fixed Suppression

## Sprinkler Systems

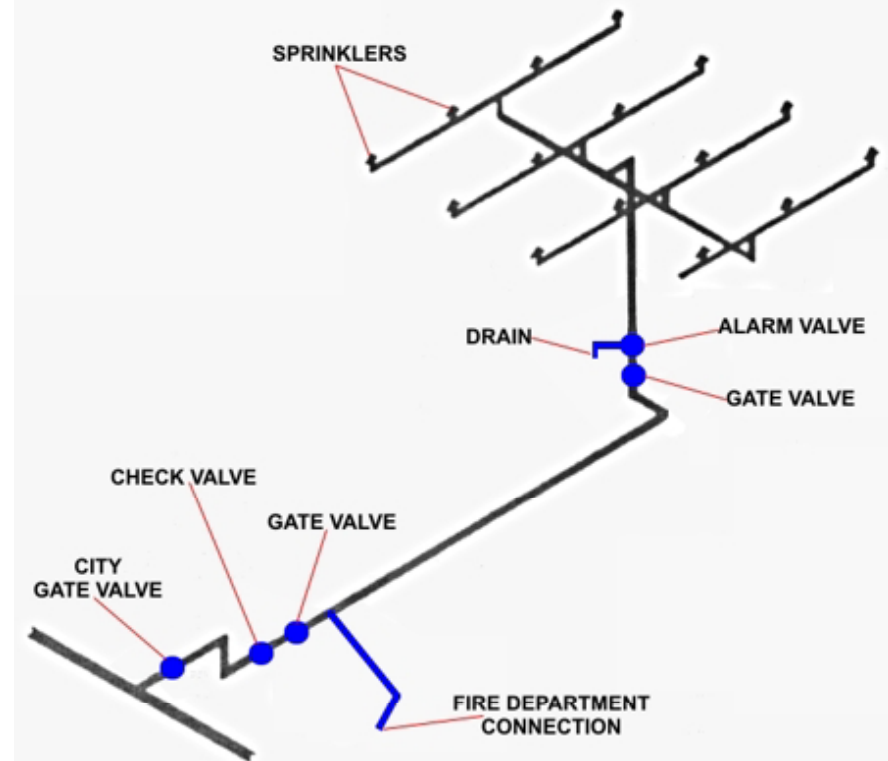
- Deluge
  - Nothing in pipes
  - Sprinklers are open
  - Used in High Hazard areas / processes
- Requires an actuation system



# System Controls - Fixed Suppression

## Sprinkler Systems

- **Pre-Action**
  - Pipes filled with a compressed air
  - Requires an actuation system
  - Minimizes water damage



# System Controls - Fixed Suppression



## Terminology

- **Pipe Schedule System**
  - Pre – 1972
  - Pipes Sized per a schedule
  - Pipes Sized based on Occupancy
    - Light, Ordinary Hazard, Extra Hazard
- **Hydraulically Calculated Systems**
  - Pipes sized on friction loss
  - Loops and Grids **MUST** be Calculated
  - Risers Clearly Placarded with Design Info



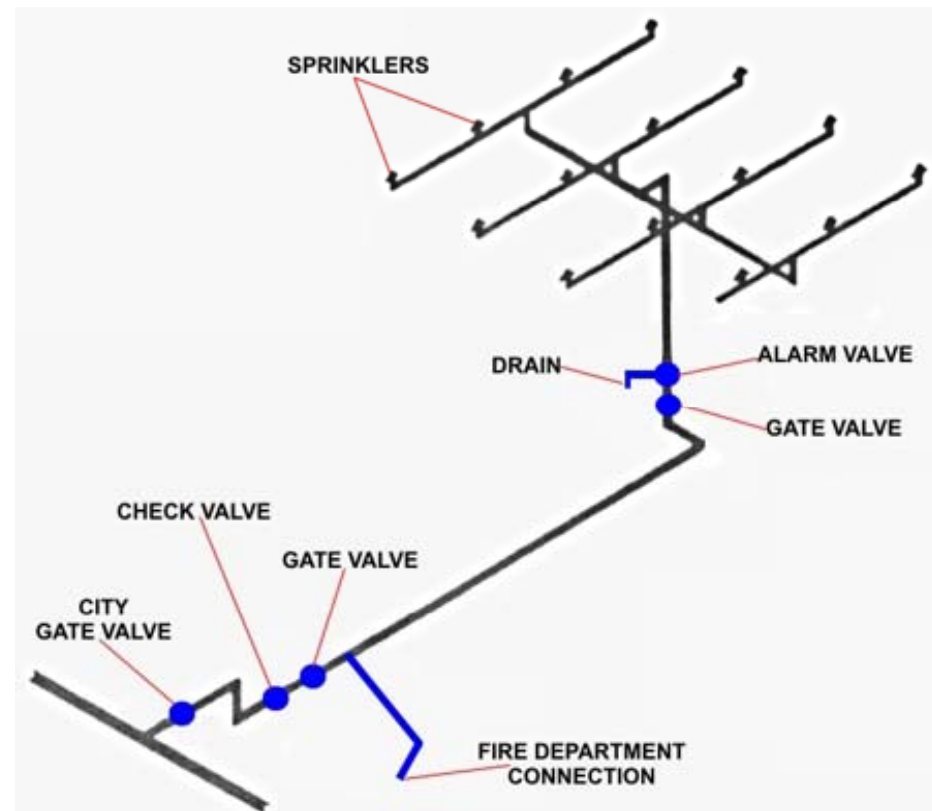
# System Controls - Fixed Suppression



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## Terminology

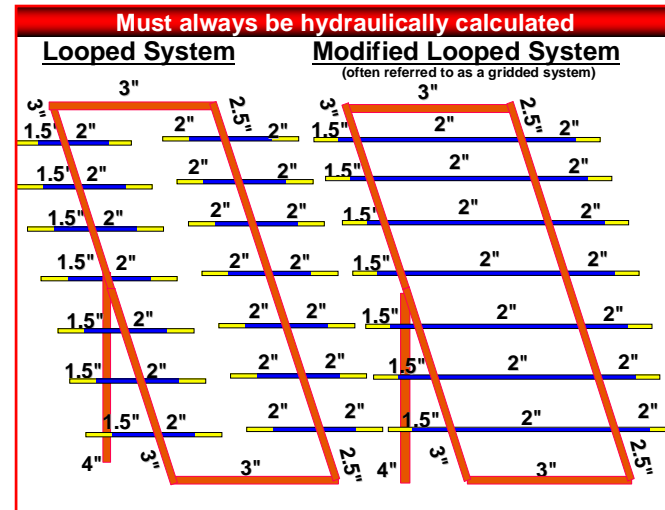
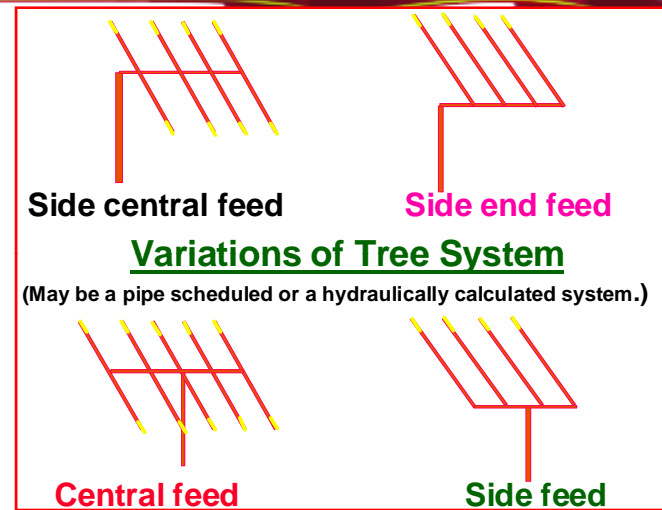
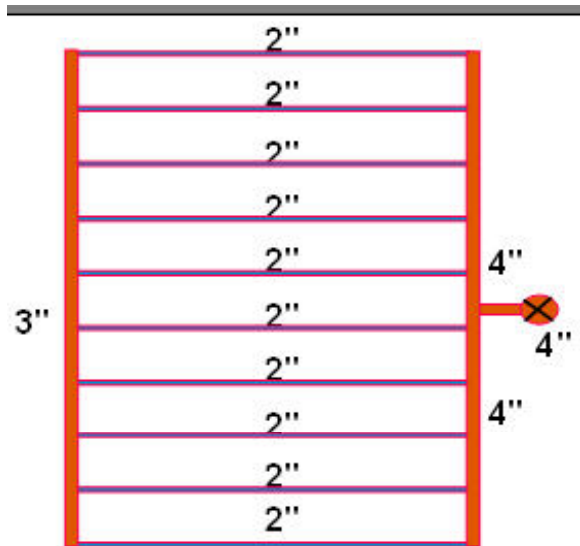
- Branch lines
- Crossmains
- Feedmains
- Risers
- Sprinklers



# System Controls - Fixed Suppression

## Sprinkler Systems

- Tree Systems
- Looped Systems
- Gridded Systems



# So Far

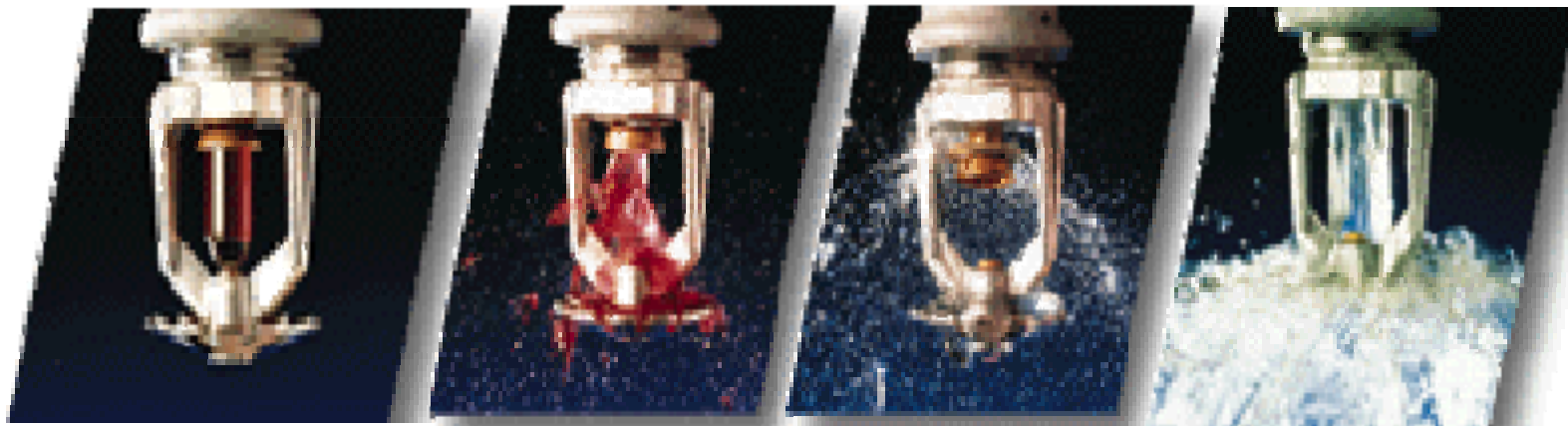
- Principles of Extinguishment
- Know what is burning
- Concept of Flammability Range
- Applied Controls
- Stages of a Fire
- Fire Detection
- Sprinkler Systems

# System Controls - Fixed Suppression



## Sprinklers

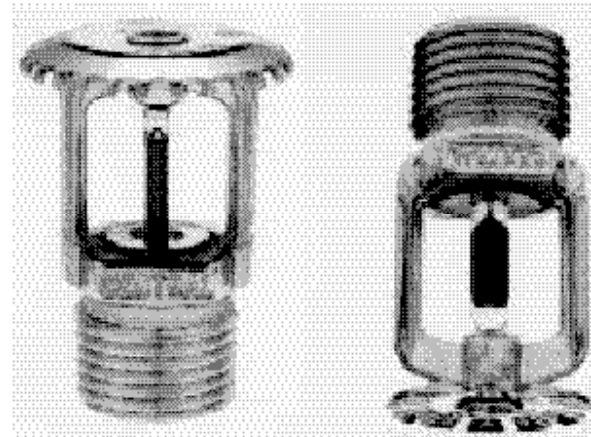
- Upright
- Pendant
- Special Application



# System Controls - Fixed Suppression

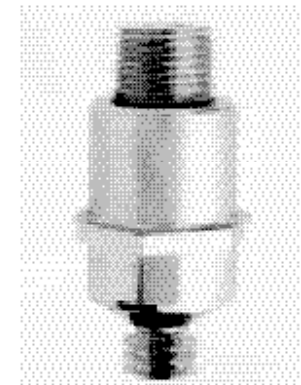
## Sprinklers

- Upright
- Pendant
- Quick Response
- Fast Response
- Nozzles
- Storage
- Special Application

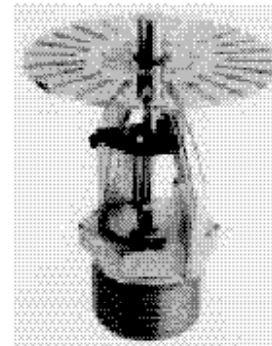


Fast response  
3-mm bulb

Standard response  
5-mm bulb



Fast response element



Fast response link

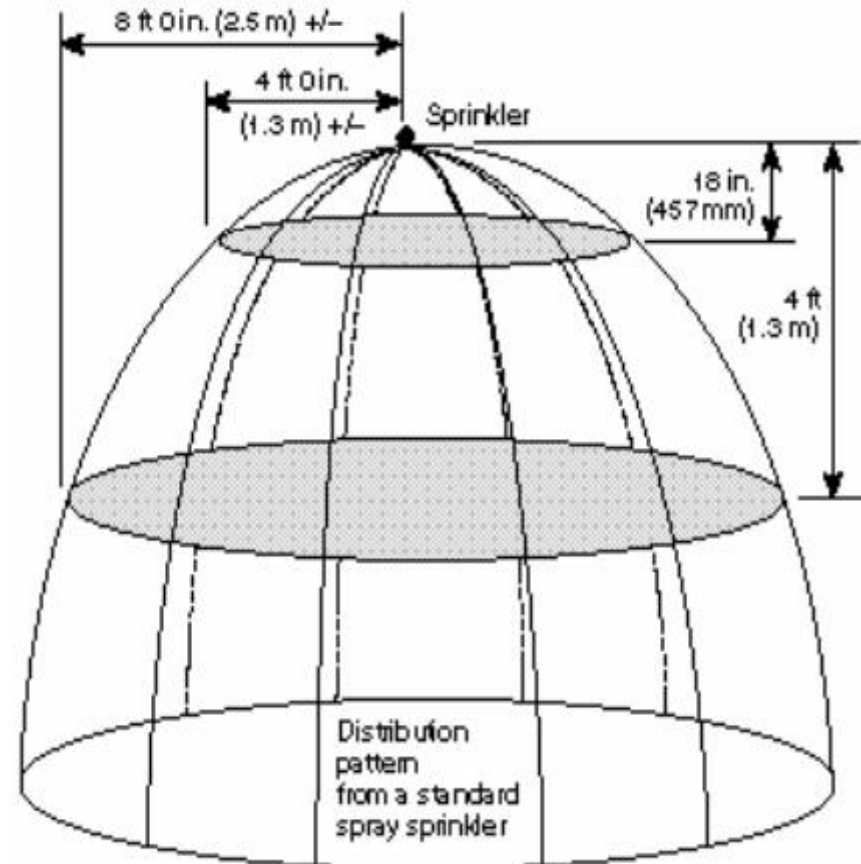


Standard response  
solder link sprinkler

# System Controls - Fixed Suppression

## Sprinklers

- **Good for 50 years**
  - Must be tested
- **Orientation**
  - Replace like kind
- **Obstructions**
  - Adequate Clearance



# So Far

- Principles of Extinguishment
- Know what is burning
- Concept of Flammability Range
- Applied Controls
- Stages of a Fire
- Fire Detection
- Sprinkler Systems

# System Controls - Fixed Suppression

## Other Systems

- CO2
- Halon 1301 1211
- Clean Agents
  - FM 200
  - Inergen
  - Sapphire
- Dry Chemical
- Liquid Salts
- Explosion Suppression





# System Controls - Fixed Suppression



## Other Systems

- Used Where water damage is an issue
- Can be used in inhabited areas
- Preferred for Specific Hazards
- Special Maintenance Needs



# So Far

- Principles of Extinguishment
- Know what is burning
- Concept of Flammability Range
- Applied Controls
- Stages of a Fire
- Fire Detection
- Sprinkler Systems
- Special Extinguishing Systems

# System Controls - First Attack

- **Hand Held Extinguishers**

- Water
- Dry Chemical
- CO<sub>2</sub>
- Metal Powders
- Liquid Salts

- **Class Of Fire**

- “A”            Paper, Cloth, Wood
- “B”            Oils, Grease
- “C”            Electrical
- “D”            Metal
- “K”            Kitchens



# System Controls - First Attack



## • Hand Held Extinguishers

- Placement
- Size
- Correct Extinguisher for Class of Fire
- Employee Training
- Maintenance
- Obsolete Extinguishers



# Maintenance

- **Maintenance for Suppression Systems**
  - Prescribed by NFPA 25
- **Maintenance for Detection Systems**
  - Prescribed by NFPA 72
- **Fire Extinguishers**
  - Prescribed by NFPA 10
- **Document the Work / Tests**

# So Far

- Principles of Extinguishment
- Know what is burning
- Concept of Flammability Range
- Applied Controls
- Stages of a Fire
- Fire Detection
- Sprinkler Systems
- Special Extinguishing Systems
- Hand Held Extinguishers

**WHEW !!**



# Storage and Warehousing

## NFPA Commodity Classifications

- **Class I**  
Noncombustible product on pallet or in carton
- **Class II**  
Noncombustible product in wood or multi-layered carton
- **Class III**  
Combustible product, with or without cartons, pallets and not > 5% Class A plastic

# Storage and Warehousing

## NFPA Commodity Classifications

- **Class IV**

**Product with 25% (vol.) 15% (wt.) Grp. A Plastic**

- **Plastics**

Group "A" POLY – anything, Styrene

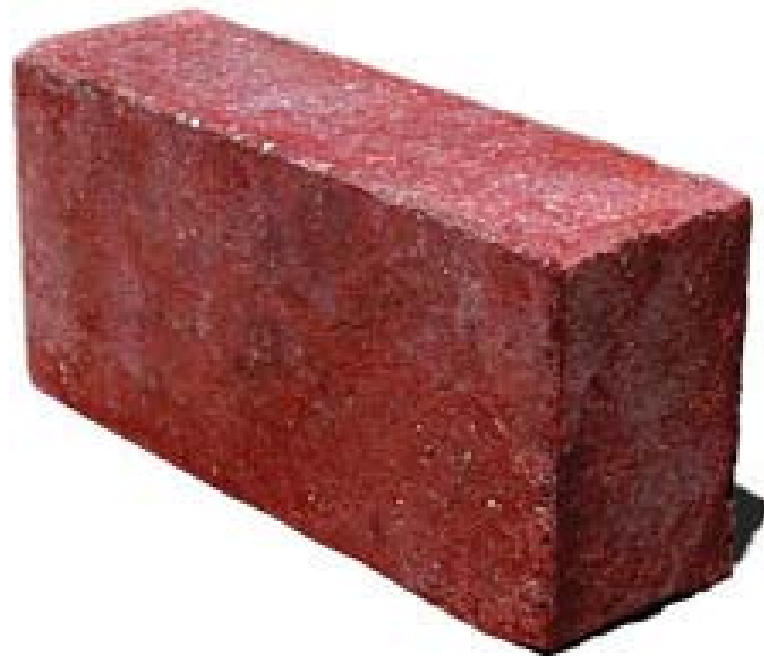
Group "B" Nylon, Rubber

Group "C" Phenols, CPVC

- **Idle Pallets**



# Storage and Warehousing



**Remember -- *The Brick***

# Storage and Warehousing

## Protection Based On:

- What is being Stored?
  - Commodity Class (Worst Class)
- How is it being Stored?
  - Stock pile. Racks, Shelves, Multi-row Racks
- How High is it being Stored?
  - Measured from floor to top of storage
- How High is the ceiling?



# Changes in Storage and Warehousing



- Metal vs. Plastic
- Stock Pile vs. Rack
- Rack vs. Multi-Row Racks
- 12', 20', 22', 25' Storage?



In general change is *Not* good

# Whew !! – Were Finished

- Principles of Extinguishment
- Know what is burning
- Concept of Flammability Range
- Applied Controls
- Stages of a Fire
- Fire Detection
- Sprinkler Systems
- Special Extinguishing Systems
- Hand Held Extinguishers
- Storage

# Questions

