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**Fundamentals of SH&E:  
Fire Protection 101C**

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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**

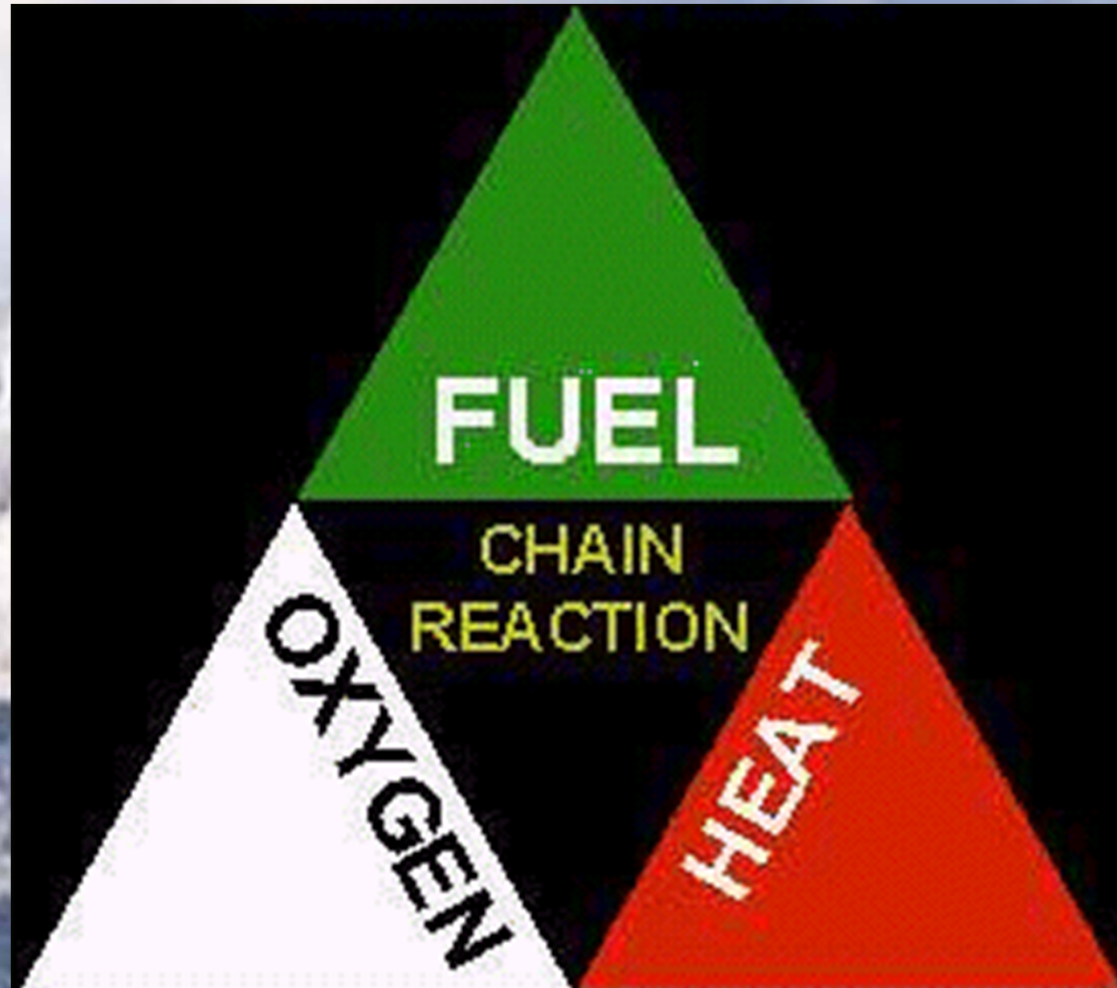


# The Fire Triangle





# Triangle? Not a Tetrahedron?





# What's Burning?







# Pyrolysis

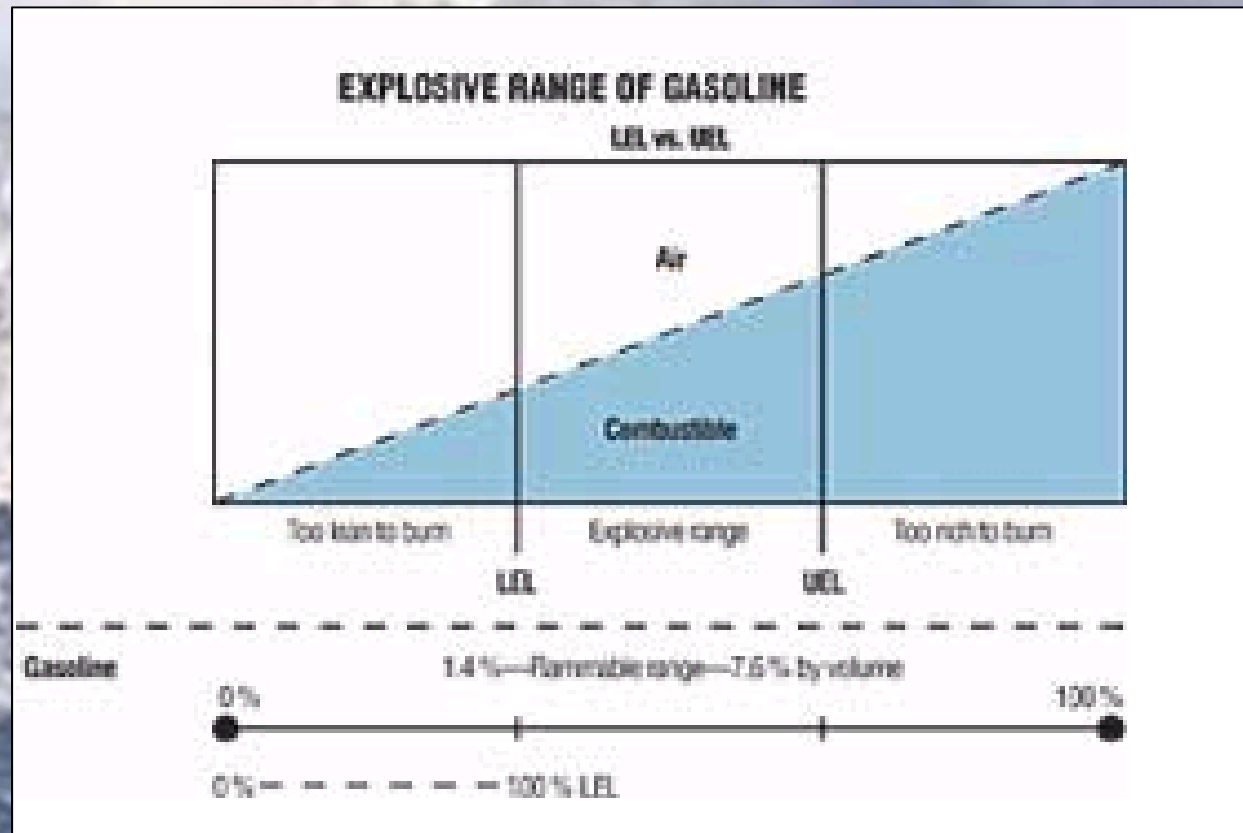
- Some of the heat is lost (convective)
- Some of the heat goes back into the system (conductive)
- Heat produces vapors
- Vapors ignite and propagate



# Vapors

## Flammable Range LFL - UFL, LEL - UEL

- Lean
- Rich







# 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



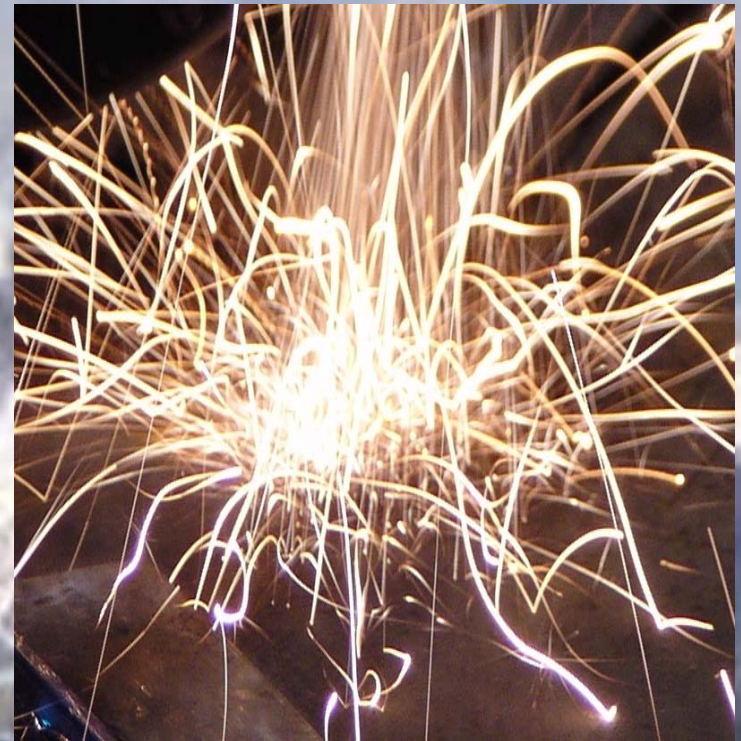
- Can the process operate rich?
- Can the process operate lean?
- Inert the operation –  $N_2$ ,  $CO_2$



# 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 Spotted Below

SEE INSTRUCTIONS ON REVERSE SIDE

**SECTION A**

LOCATION	JOB OR AREA NUMBER

**INSTRUCTIONS**

1. Supervisor completes section to be 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 B, then Section B in the work area, and returns Section C to the supervisor.
4. Section B remains in 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

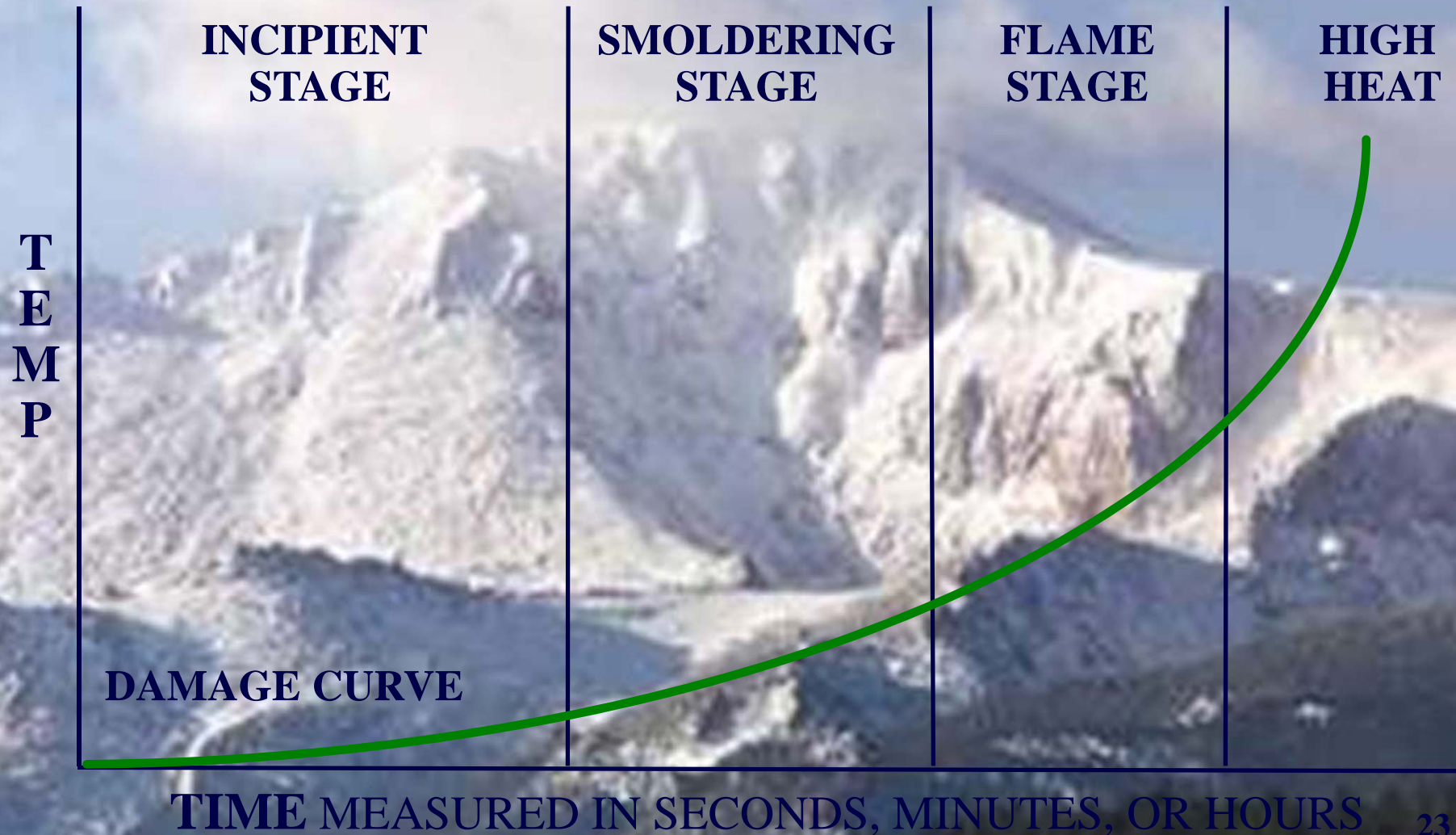
- Incipient
  - Microseconds to days
- Smoldering
  - Microseconds to hours
- Flaming
- High Heat





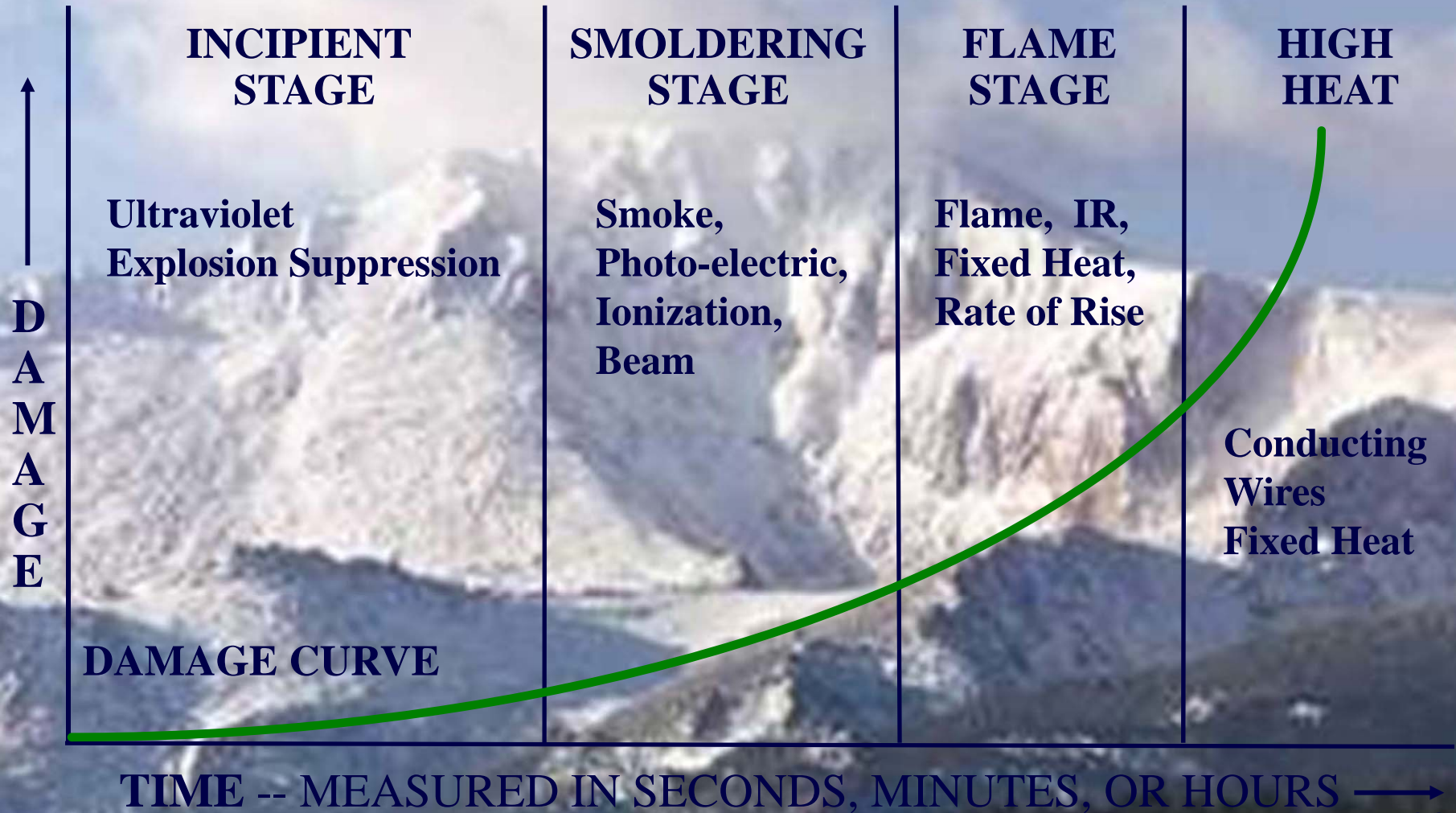


# Time –Temperature Curve





# Time –Temperature Curve







# So Far

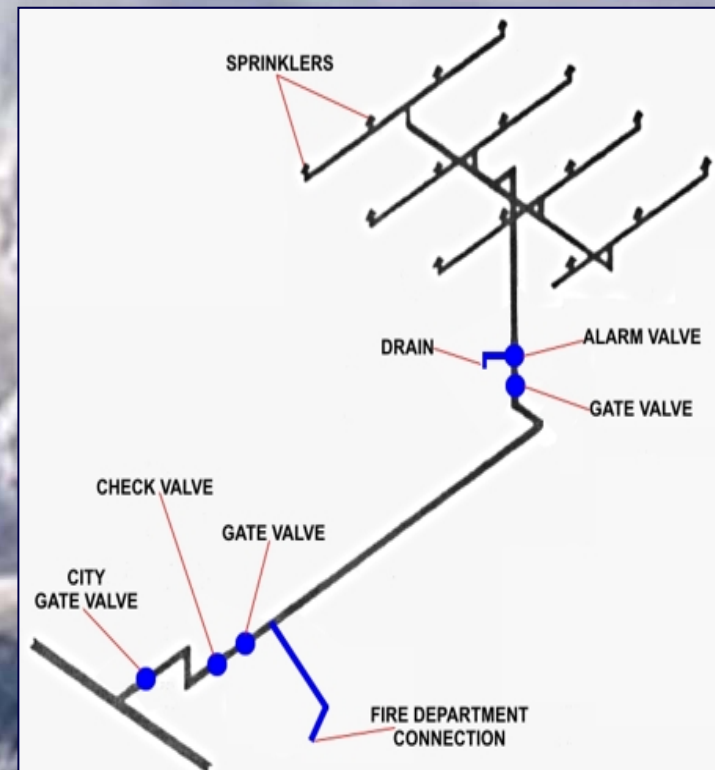
- Principles of Extinguishment
- Know what is burning
- Concept of Flammability Range
- Applied Controls
- Stages of a Fire
- Fire Detection



# System Controls – Fixed Suppression

## Sprinkler Systems

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



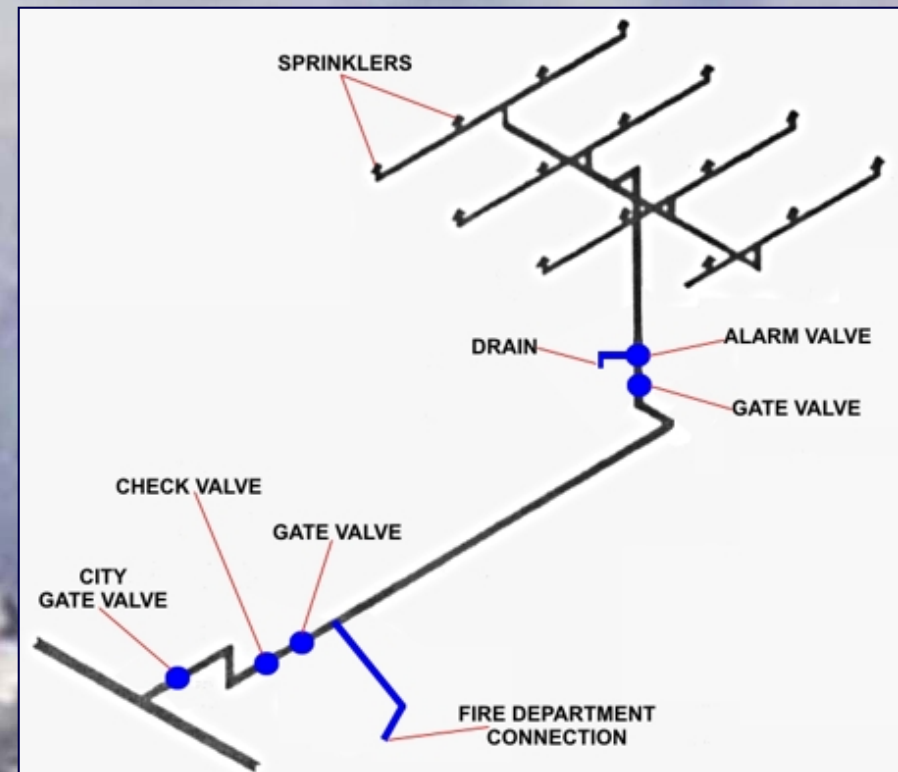




# System Controls – Fixed Suppression

## Sprinkler Systems

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

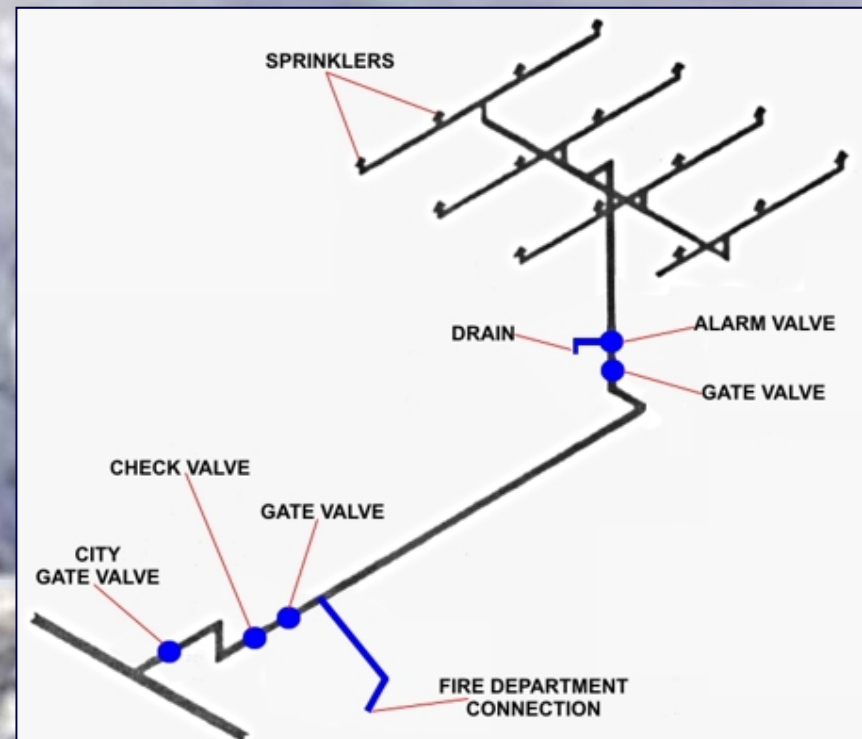




# System Controls – Fixed Suppression

## Sprinkler Systems

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



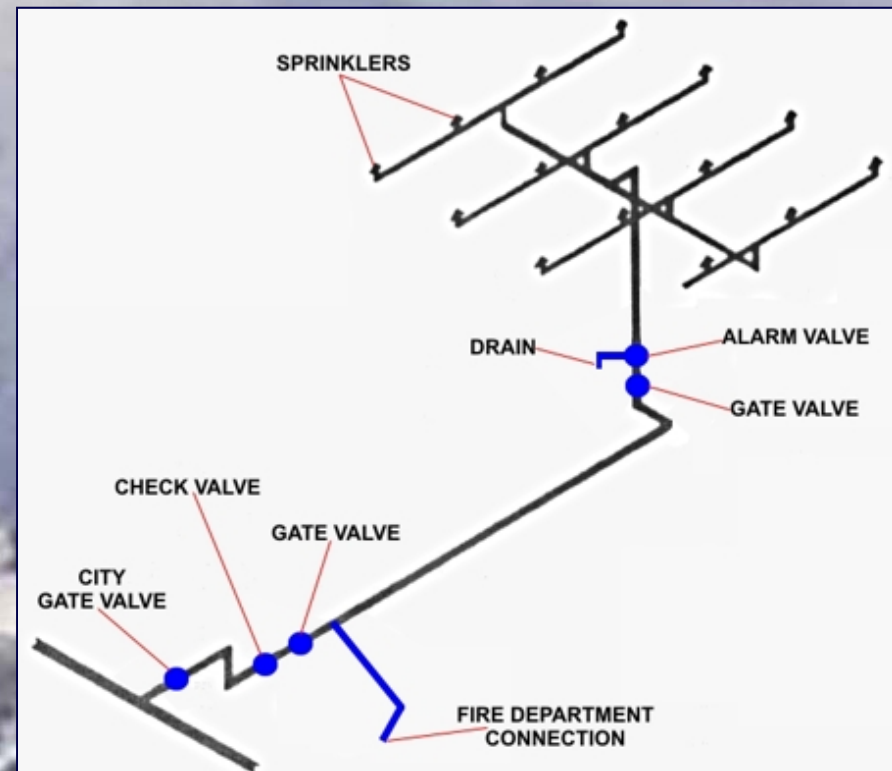




# System Controls – Fixed Suppression

## Sprinkler Systems

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

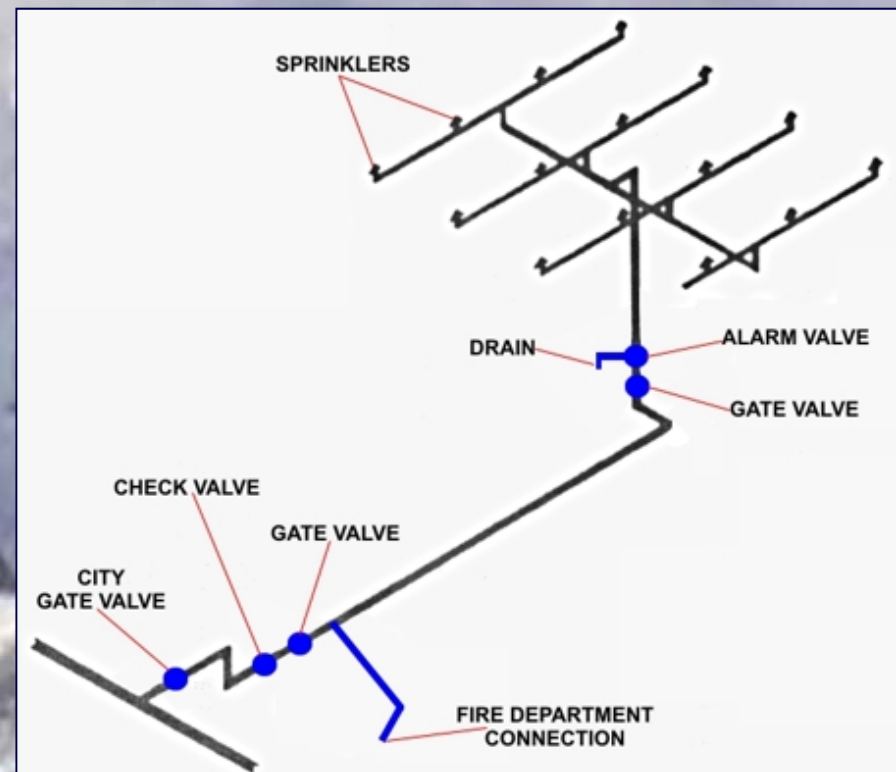




# System Controls – Fixed Suppression

## Sprinkler Systems

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



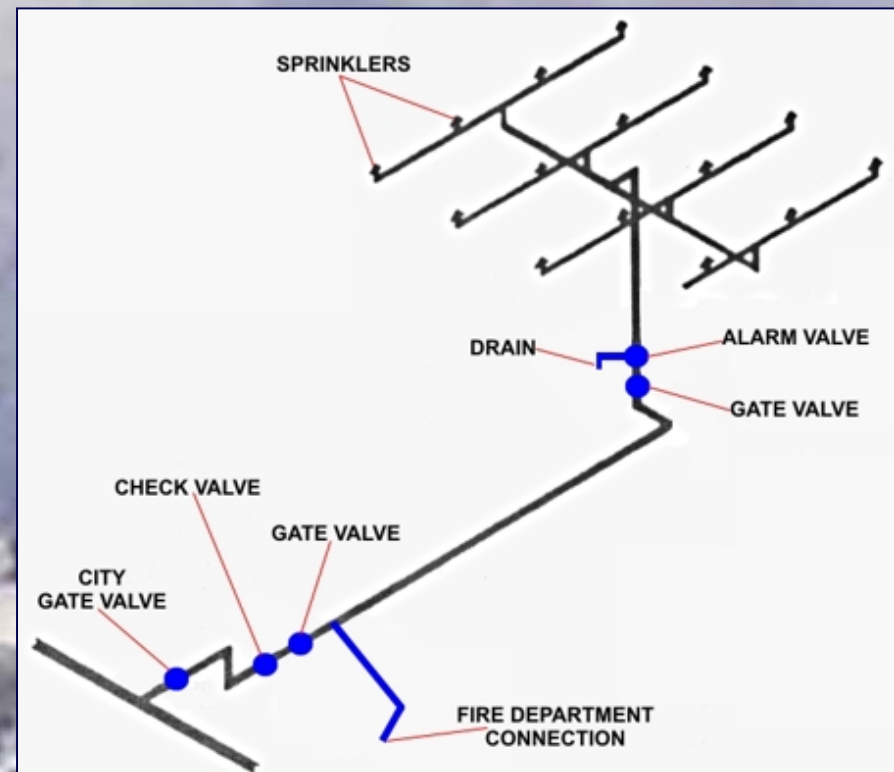




# System Controls – Fixed Suppression

## 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

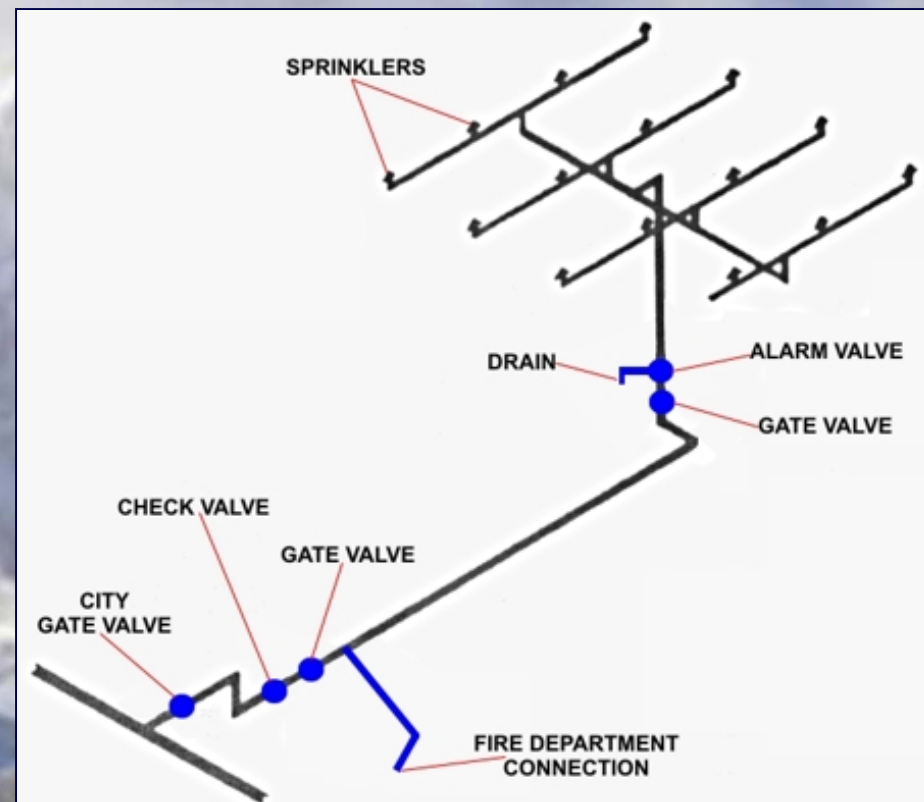




# System Controls – Fixed Suppression

## Terminology

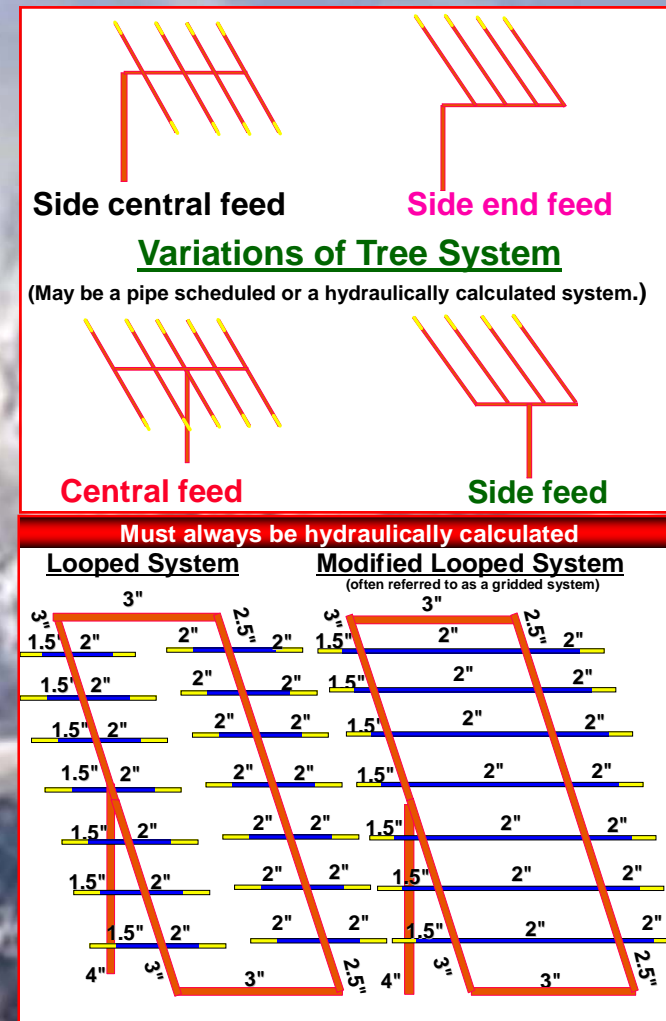
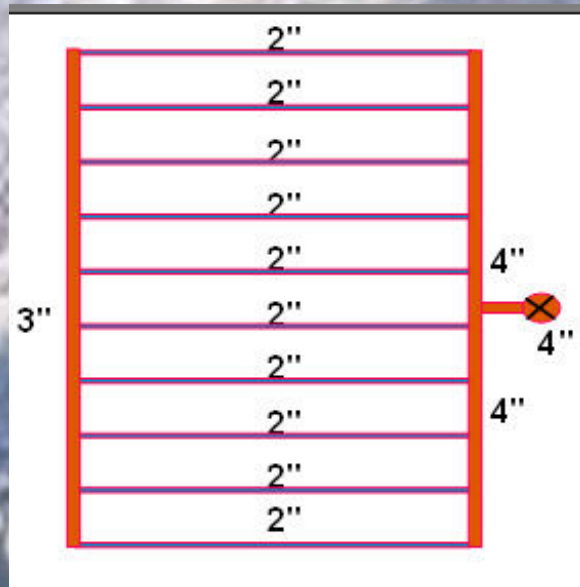
- Branch lines
- Crossmains
- Feedmains
- Risers
- Sprinklers



# 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

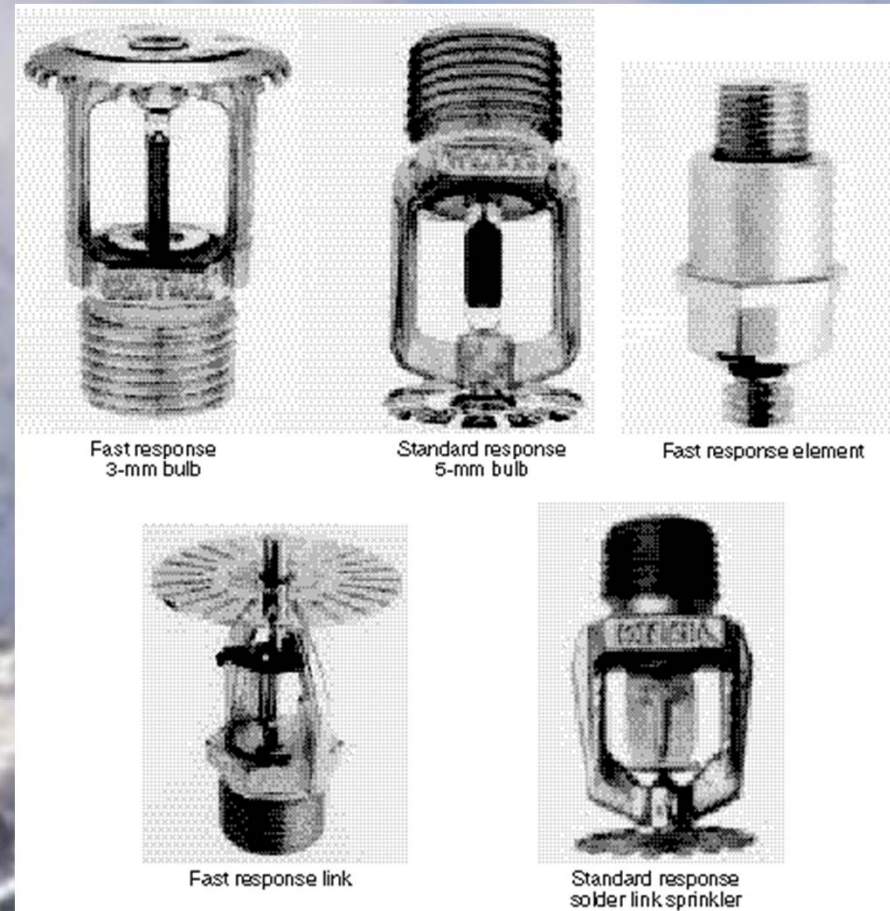




# System Controls – Fixed Suppression

## Sprinklers

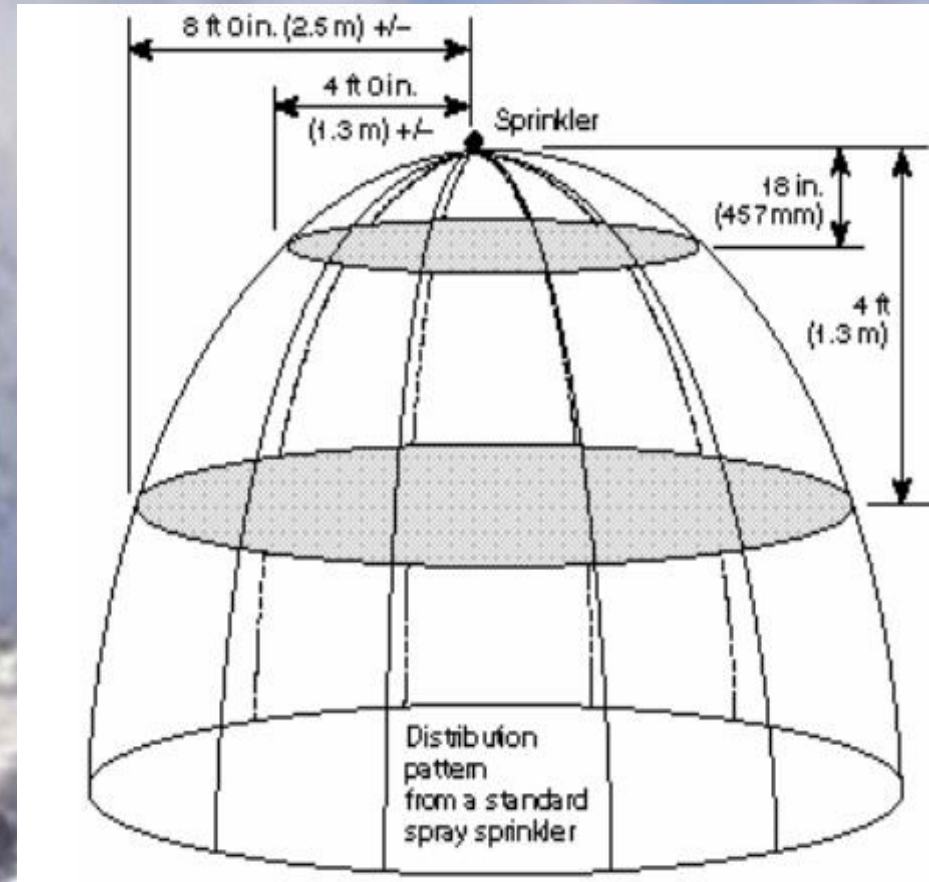
- Upright
- Pendant
- Quick Response
- Fast Response
- Nozzles
- Storage
- Special Application



# 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.) Group A Plastic**

- **Plastics**

**Group "A" POLY – anything, Styrene**

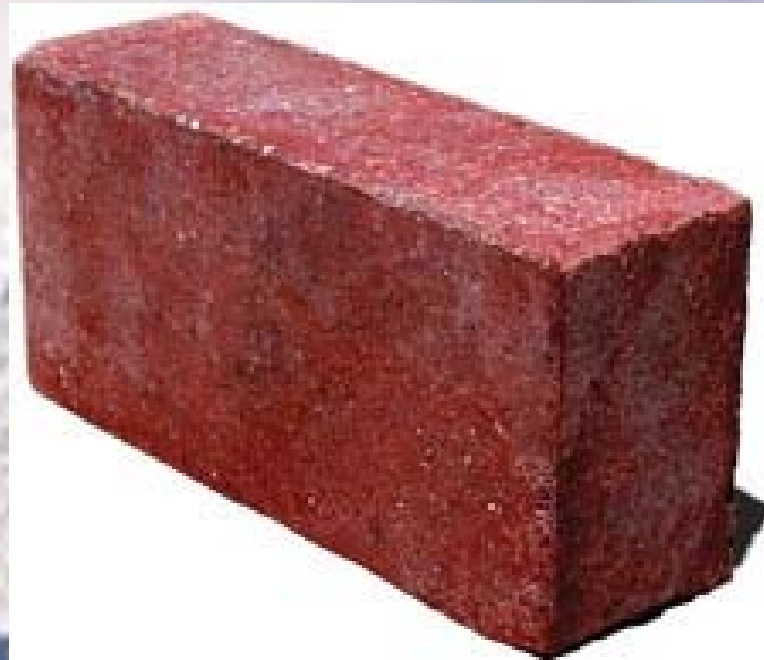
**Group "B" Nylon, Rubber**

**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

