FIRE | EMERGENCY RESPONSE | SECURITY | VOILANCE

FUNDAMENTALS OF FIRE SAFETY, EMERGENCY PREPAREDNESS , EMERGENCY RESPONSE, DISASTER MANAGEMENT, SECURITY, Fleet Safety, VIOLANCE PREVENTION, BUSINESS CONTINUITY

Domain 4 CSP / Domain 4,5 ASP

CSP® | Emergency Management

ASP® | Fire Prevention and Protection
Emergency Preparedness and Response

Domain Marks Distribution

- CSP : 9 % (Approx 18 Questions)
- ASP : 12 + 10 = 32 % (Approx 64 Questions)

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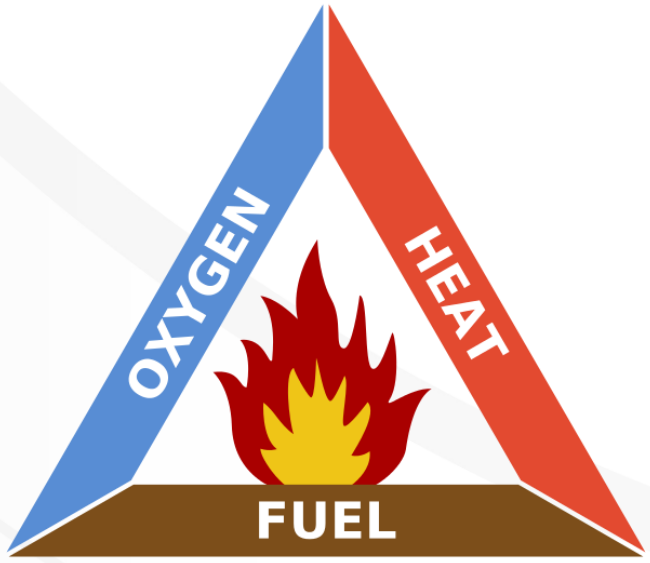
Fire or Combustion:

Fire or Combustion is a chemical reaction that occurs between a fuel and an oxidizing agent that produces energy, usually in the form of heat and light. When a fuel is burned, the carbon reacts with the oxygen and can form either carbon monoxide (CO) or carbon dioxide (CO_2), Hydrogen present in Hydrocarbon fuel will be transformed to water vapors.

Fire Triangle:

The fire triangle or combustion triangle is a simple model for understanding the necessary ingredients for most fires. The triangle illustrates the three elements a fire needs to ignite: heat, fuel, and an oxidizing agent.

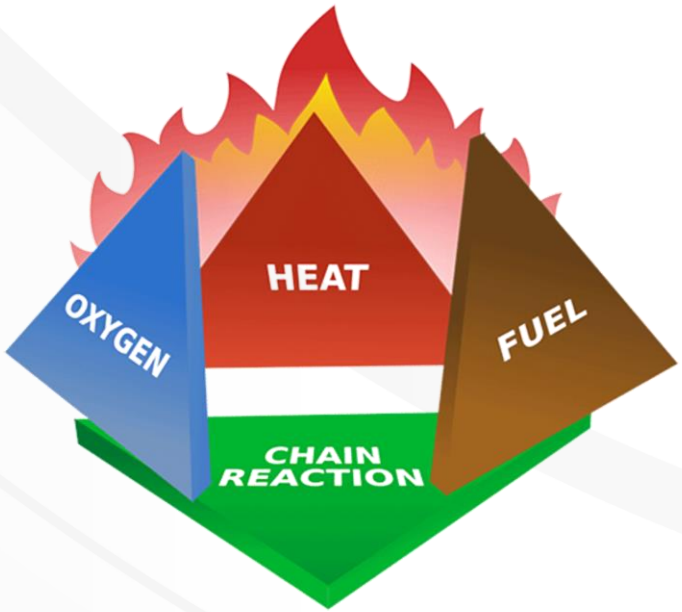
Fire Tetrahedron = Fuel + Oxygen + Heat



Fire Tetrahedron:

There are four components that are necessary to sustain combustion. Without the presence of all four components, fires will not exist. The four components include fuel, oxygen, heat, and a chain reaction.

Fire Tetrahedron = Fuel + Oxygen + Heat + Chemical Chain Reaction



Fire Extinguishing Techniques:

Cooling: Removal of heat from fire

Smothering: Removing the oxygen from Fire

Starving: Removing the fuel

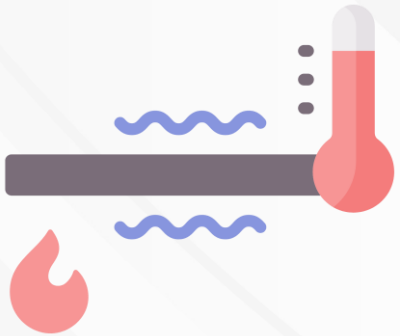
Interrupting CCR: Interrupting Chemical Chain Reaction

Methods Of Heat Transfer

Conduction: Heat moves through solid objects (needs contact).

Convection: Heat moves by bulk movement of air or liquids (needs a medium).

Radiation: Heat travels as energy waves even through vacuum (no medium needed).



Ignition of Combustables

Two Ways to Ignite Combustibles

Direct Flame Ignition:
A combustible ignites when exposed to an open flame, spark, or another burning source.

Auto-Ignition:
A combustible ignites when heat alone raises it to its auto-ignition temperature without a flame.

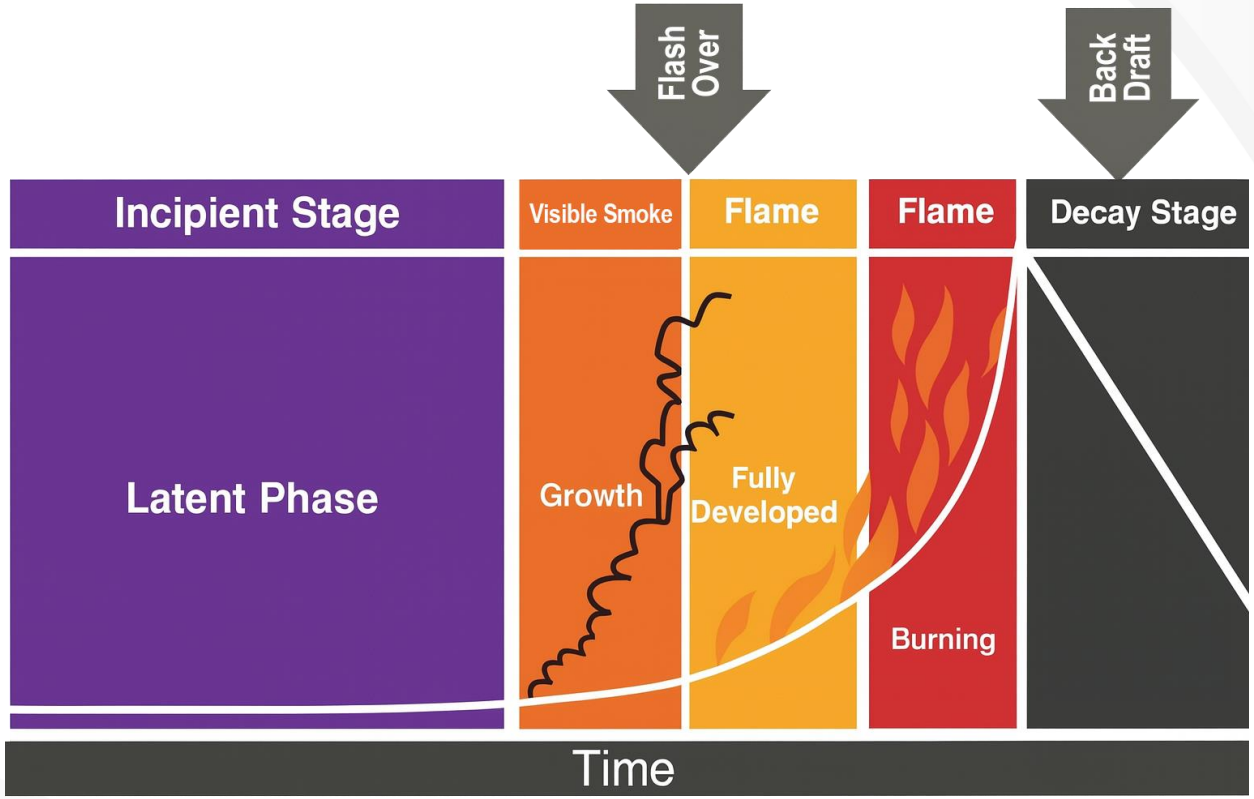
Stages Of Fire (Solid Fuels)

3 Specific Stages of a Fire
(5 when including Flashover and Backdraft)

1. Incipient Stage (Beginning Stage)
- The fire just starts, with heat, fuel, and oxygen available.
- Usually small and localized (like a match igniting paper).
- Can often be controlled quickly with a fire extinguisher.

2. Free Burning Stage (Visible Smoke & Flame)
- Fire increases in size as fuel and oxygen are consumed.
- Smoke becomes visible, and flames spread.
- Heat rises and spreads through convection and radiation.
- All available fuel is burning.
- Requires professional firefighting operations to control.

Flashover (Danger Point)
A sudden event where all combustible items in a room reach Auto ignition temperature at once. Causes the entire area to erupt in flames almost instantly. Extremely dangerous and life-threatening.



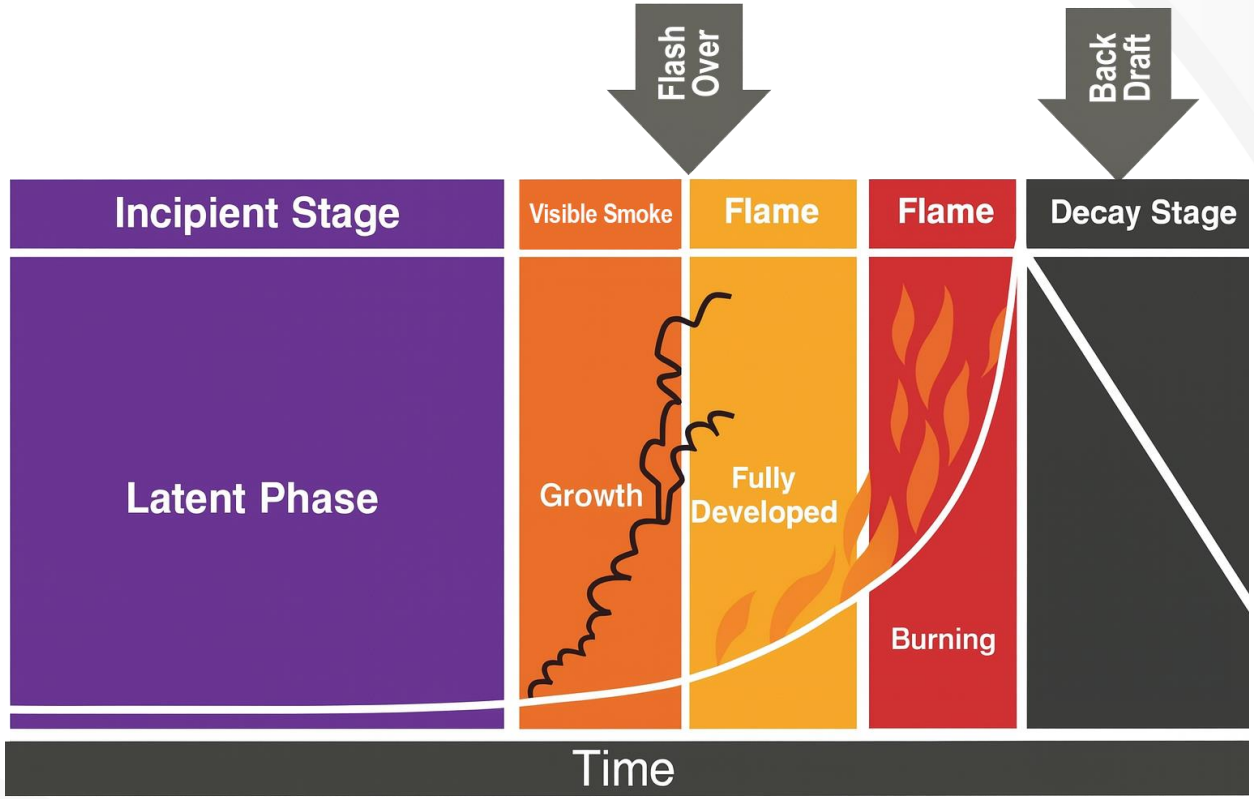
Stages Of Fire (Solid Fuels)

3 Specific Stages of a Fire
(5 when including Flashover and Backdraft)

3. Smoldering Stage (Intense Burning)

- Fire starts to weaken because fuel or oxygen is running out.
- Smoldering can occur, producing a lot of toxic smoke.

Backdraft risk:
if oxygen is suddenly re-introduced (like opening a door/window), explosive combustion can occur.



Classification of Fire NFPA-10

Class A : Solid Combustibles

Class B : Liquids and gases

Class C : Electrical fire

Class D : Metal Fires

Class K : Cooking oil and fats

Classification of Fire NFPA-10

Class	Fuel Type	Typical Extinguishing Agent
Class A	Solid combustibles (wood, paper)	Water, foam
Class B	Flammable liquids/gases	Foam, CO_2, Dry Chemical
Class C	Electrical fires	CO_2, Dry Chemical
Class D	Combustible metals (Mg, Na)	Dry Powder
Class K	Cooking oils/fats (kitchen)	Wet chemical

Types Of Fire Extinguishers:

Extinguisher Type	Suitable Fire Class	How It Works	Notes / Examples
Water	Class A (wood, paper, cloth)	Cooling	Not for electrical or flammable liquid fires
Foam	Class A & B (solids + flammable liquids)	Smothers flames + Cooling	Used in fuel or chemical storage areas
Dry Chemical	Class A, B, C	Interrupts chemical chain reaction	**Ordinary:** Sodium/Potassium Bicarbonates B, C **Multipurpose:** Mono-Ammonium Phosphate A,B,C
Dry Powder	Class D (metal fires)	Smothers + Interrupts	Special powders (sand, talc, graphite) for specific metals
CO_2 (Carbon Dioxide)	Class C (electrical)	Smothers oxygen + Cooling	Safe for electrical equipment; leaves no residue
Wet Chemical	Class K (cooking oils/fats)	Interrupts chemical reaction	Potassium acetate forms soapy layer to prevent re-ignition
Clean Agents	Class A, B, C	Interrupt CCR + Cooling	Examples: FM-200, HFC-227ea, NOVEC 1230; safe for electronics, eco-friendly

Flash Point, Fire Point & Auto-Ignition Temperature

Flash Point:
The lowest temperature at which a liquid fuel gives off enough vapors in the mixture of air that ignite momentarily in the presence of an ignition source.

Fire Point:
The lowest temperature at which a liquid fuel gives off enough vapors in the mixture of air that sustain continuous combustion once ignited.

Auto-Ignition Temperature:
The Lowest temperature at which a substance will ignite spontaneously without any external ignition source (no spark or flame needed). At this temperature, the vapors and oxygen in air react due to heat energy alone.

Auto-Ignition Temperature > Fire Point > Flash Point

NFPA 30: Classification

Flammable and Combustible Liquids

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Flammable Liquids (Class I) Flash Point < 100°F (37.8°C)

Class	Flash Point (°F)	Boiling Point (°F)	Examples
IA	< 73°F	< 100°F	Ethyl ether
IB	< 73°F	≥ 100°F	Acetone, Gasoline
IC	≥ 73°F and < 100°F	Any	Xylene, Toluene

Combustible Liquids (Class II & III) Flash Point ≥ 100°F (37.8°C)

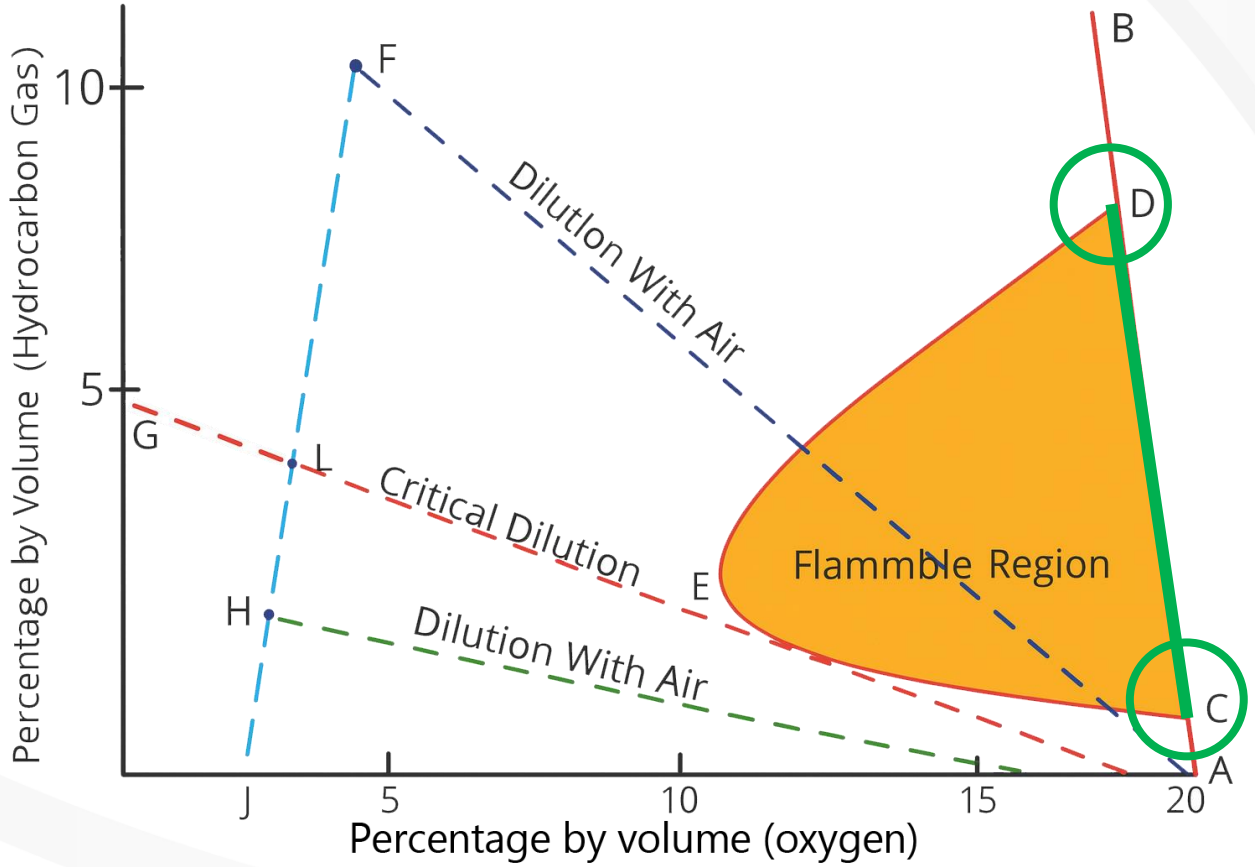
Class	Flash Point (°F)	Examples
Class II	≥ 100°F and < 140°F	Diesel fuel
Class IIIA	≥ 140°F and < 200°F	Kerosene
Class IIIB	≥ 200°F	Vegetable oil, Motor oil

Limits Of Flammability

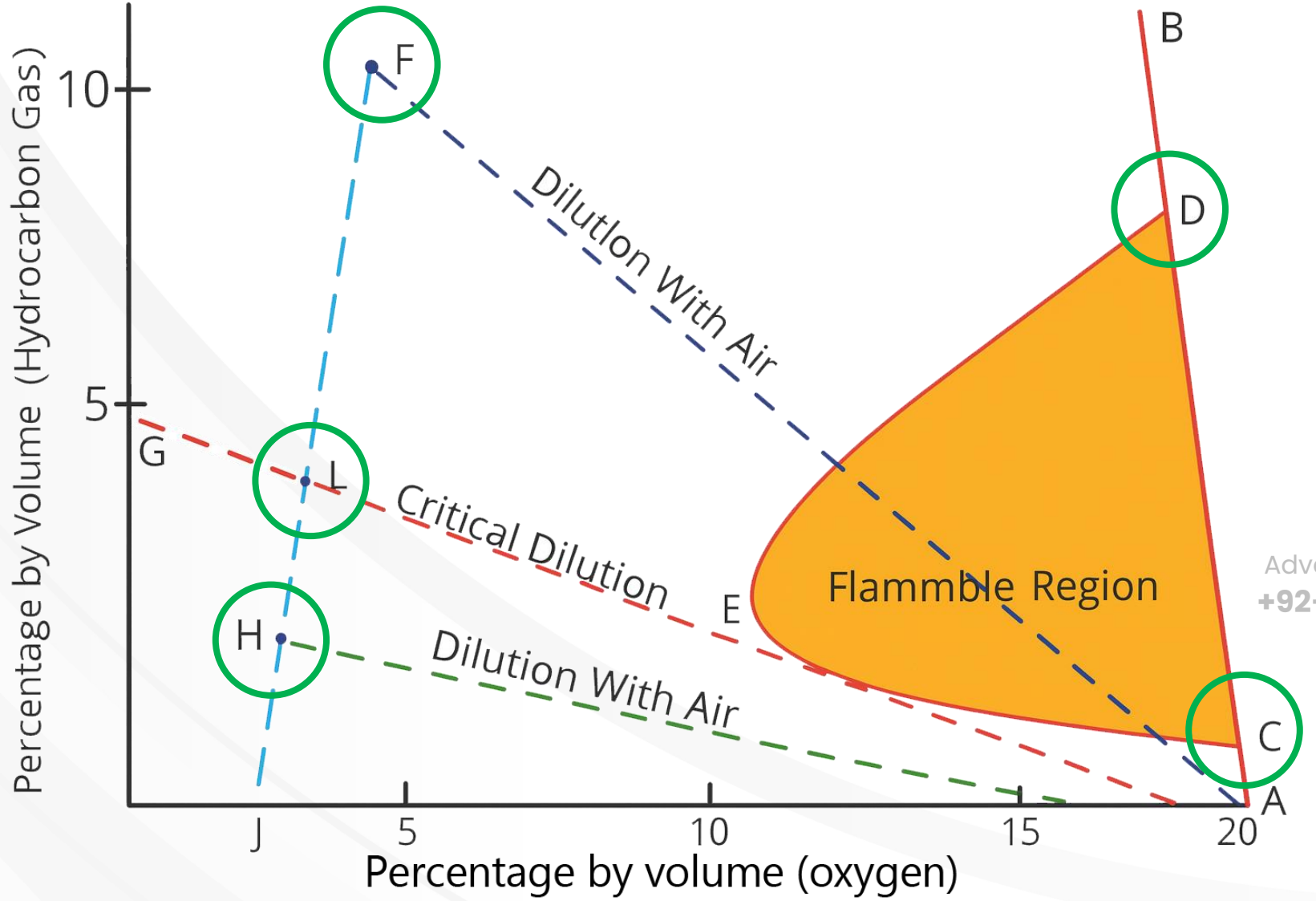
LEL (Lower Explosive Limit):
The lowest concentration (%) of gas or vapor in air capable of producing a flash of fire in presence of an ignition source.

UEL (Upper Explosive Limit):
The highest concentration (%) of gas or vapor in air capable of producing a flash of fire in presence of an ignition source.

Flammability Range:
The range of concentrations between the LEL and UEL where the mixture can burn.



Flammability Diagram



Gas Testing

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Oxygen first → Ensures safe breathing levels and accurate sensor readings.
Flammable gases second → Prevents explosion risk (checked against LEL).
Toxic gases last → Confirms exposure hazards after other conditions are stable.

Why Oxygen is Tested First?

Life Safety: Oxygen concentration directly affects whether the atmosphere is safe to breathe. Too little oxygen (<19.5%) is dangerous for workers.

Sensor Accuracy: Flammable gas sensors (LEL detectors) require normal oxygen levels to work correctly; low oxygen can give false readings.

Sensor for LEL (Flammable gases)?

Uses Catalytic bead sensors or Semiconductor sensors, often based on the Wheatstone bridge principle.

Sensor for Toxic Gases?

Usually **electrochemical sensors** (for CO, H_2S, SO_2, etc.) or **infrared sensors** (for gases like CO_2).

Gas Density Behavior?

If a gas is heavier than air, it will sink and accumulate in low areas (e.g., CO_2, H_2S).
If a gas is lighter than air, it will rise and collect in high areas (e.g., H_2, CH_4).

Sprinkler System

- Dry Pipe
- Wet Pipe
- Deluge System
- Pre- Action System

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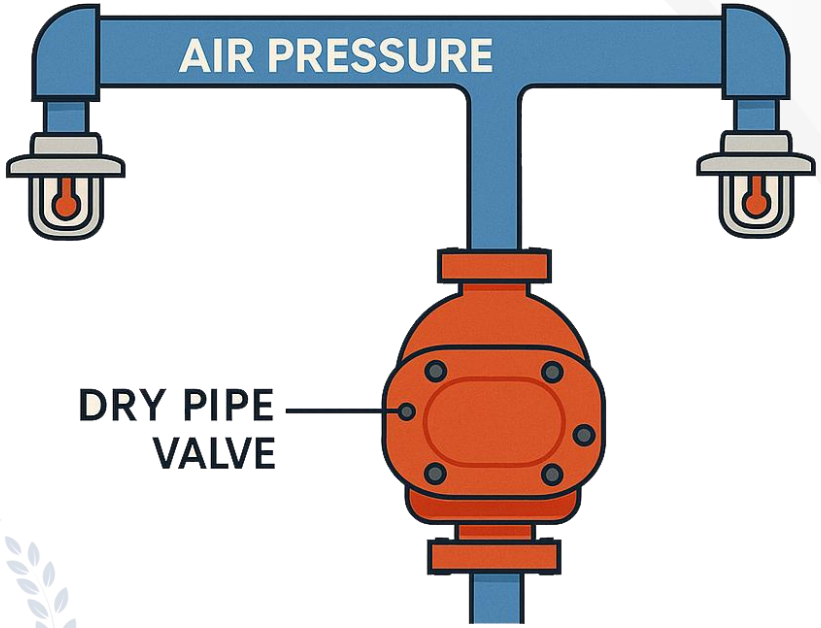
Sprinkler System

Dry Pipe System

- Pipes are filled with pressurized air / nitrogen, not water.
- When a sprinkler head activates, air pressure drops, valve opens, and water flows in to discharge.
- Advantage: Suitable for freezing areas, can be used as a standby system.
- Disadvantage: Delay in water discharge.

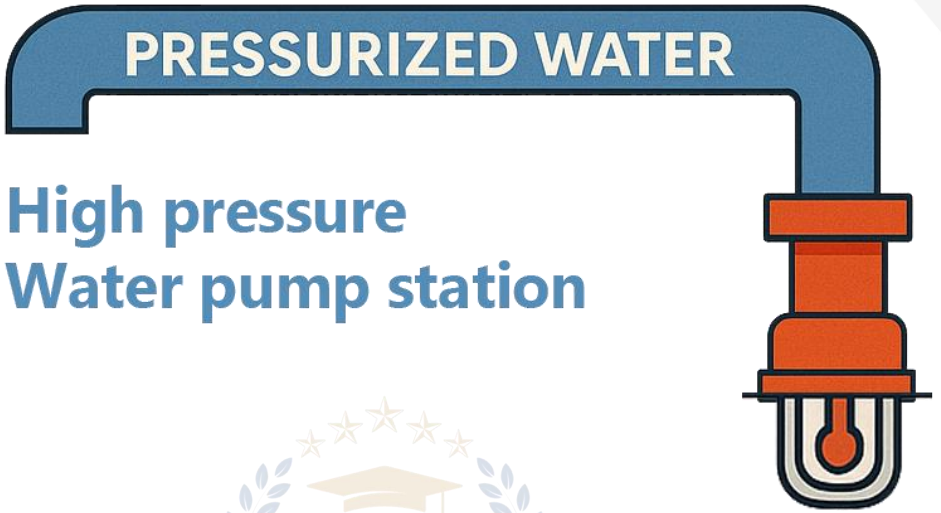


High pressure
Water pump station

Sprinkler System

Wet Pipe System

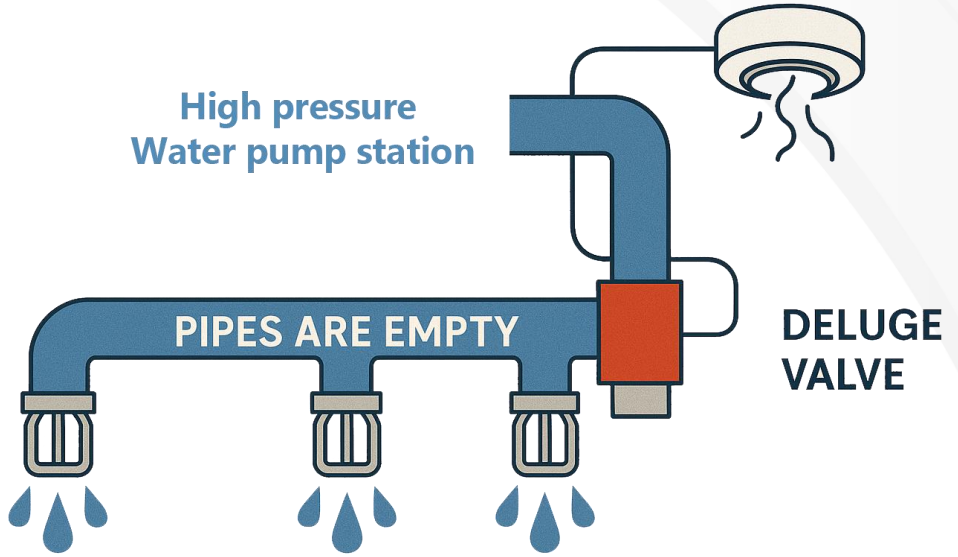
- Pipes are always filled with pressurized water.
- Sprinkler heads activate immediately when heat melts the fusible link.
- Advantage: Fastest response time.
- Disadvantage: freezing water, risk of corrosion, leakage, and water stagnation.



Sprinkler System

Deluge System

- Pipes are empty until a detection system (Fire Sencer) activates the deluge valve.
- All sprinkler heads are open, so water discharges over the entire area at once.
- Advantage: Provides rapid, full-area coverage (ideal for high-hazard zones like aircraft hangars, chemical plants).
- Disadvantage: Can cause significant water damage.



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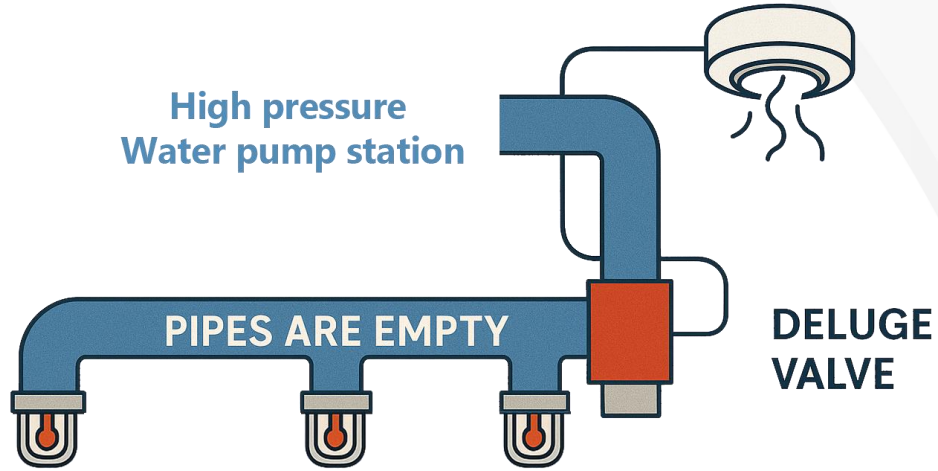
Sprinkler System

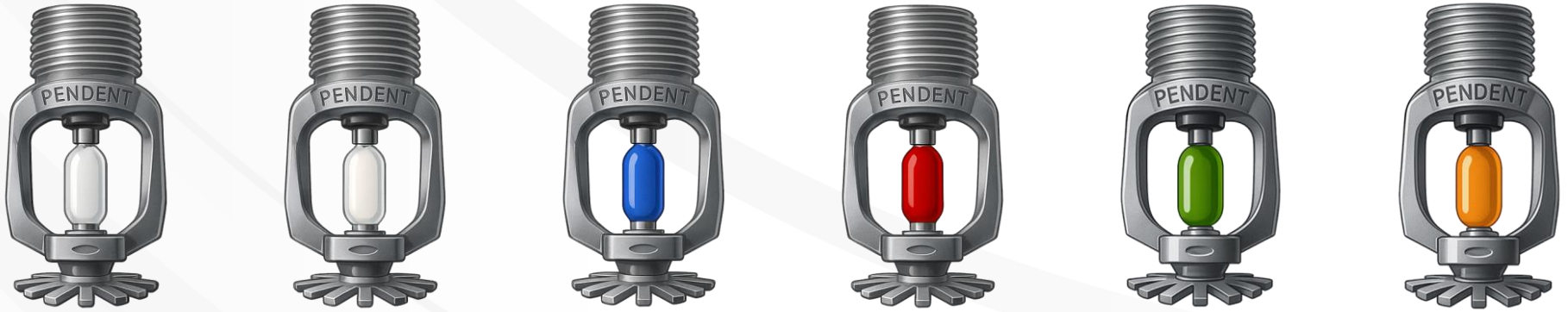
Pre-Action System

- Combination of dry pipe + Deluge system.
- Requires two steps: detection system activation + sprinkler head opening.
- Advantage: Prevents accidental discharge; ideal for data centers, museums, libraries.
- Disadvantage: Slight delay compared to wet systems.



Sprinkler Head Color Codes (°F Only – NFPA 13)

Max Ceiling Temp (°F)	Temperature Rating (°F)	Classification	Glass Bulb Color	Frame Color Code
100	135–170	Ordinary	Orange or Red	Uncolored / Black
150	175–225	Intermediate	Yellow or Green	White
225	250–300	High	Blue	Blue
300	325–375	Extra High	Purple	Red
375	400–475	Very Extra High	Black	Green
475	500–575	Ultra High	Black	Orange
625	650	Ultra High	Black	Orange



Sprinkler Head Terms

Maximum Ceiling Temperature (°F)
The highest normal ceiling temperature (not during a fire) that a sprinkler can safely be exposed to without accidentally activating.
Example: If a ceiling can reach 150°F due to machinery/heat, you need a sprinkler rated above this.

Temperature Rating (°F)
The temperature at which the sprinkler is designed to activate (the glass bulb or fusible link breaks).
Example: A sprinkler with a 175–225°F rating will release water once that range is reached.

Temperature Classification
NFPA categories (Ordinary, Intermediate, High, Extra High, Very Extra High, Ultra High) that group sprinklers by their temperature rating ranges.

Ordinary = 135–170°F
High = 250–300°F
Ultra High = 500–575°F

Fire Detectors (Heat, Smoke, Radiation)

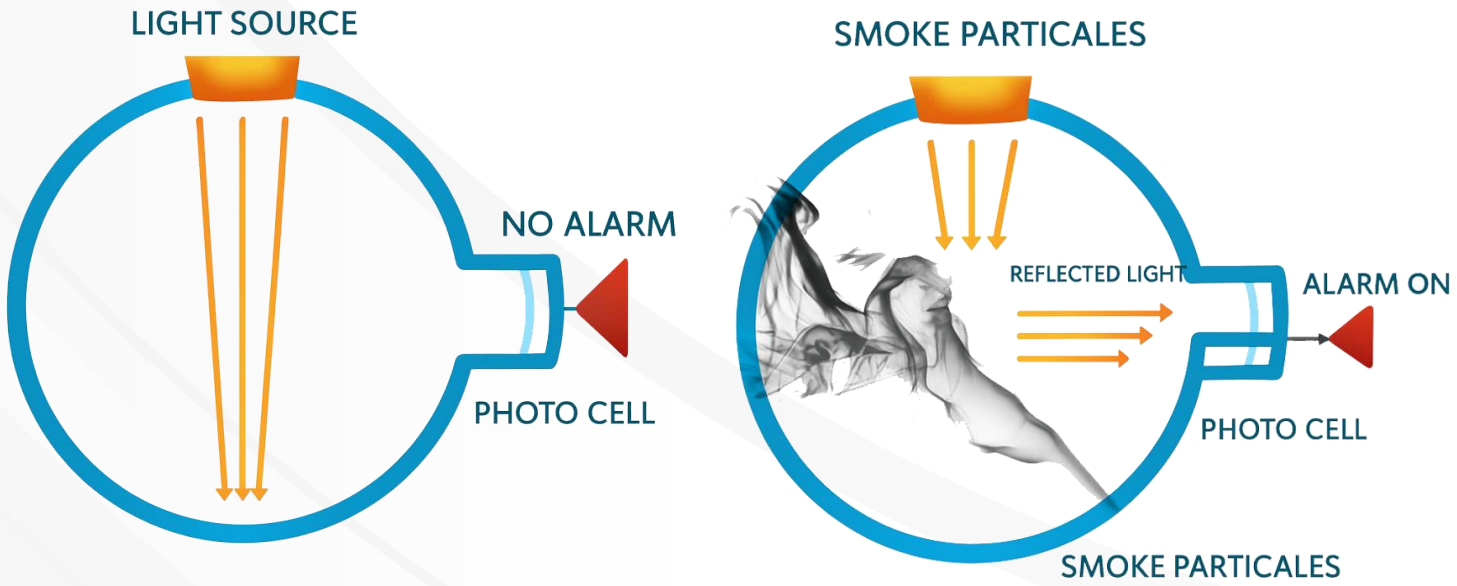
Following are the commonly used fire detectors:

- **Smoke Detectors**
  - Optical Detectors
  - Ionization Detectors
- **Flame Detectors**
  - Infra red flame detector
  - Ultra-violet (UV) Flame detector
- **Heat Detectors**
  - Fixed temperature heat detector
  - Rate of rise heat detector
  - Rate-of-Compensation Detector

Smoke Detectors

Optical Smoke Detectors

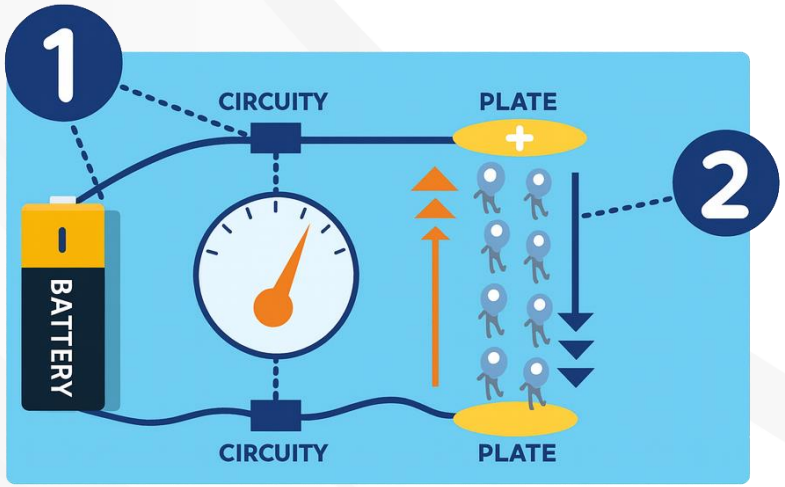
- Work by using a light beam inside a sensing chamber.
- When smoke particles enter, they scatter the light, reflected light hit the photocell and triggering the alarm.

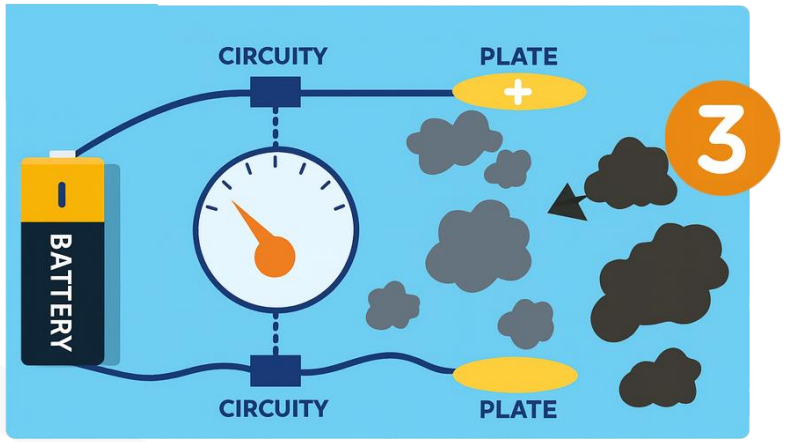


Smoke Detectors

Ionization Smoke Detectors

- Use a small radioactive source (Americium-241) to ionize air inside chamber.
- A steady electric current flows through ionized air. Smoke disrupts this current, activating the alarm.





Flame Detectors

Infra red flame detector

- Detect flames by sensing infrared (IR) radiation emitted during combustion.
- Provide fast response to open flames, even without visible smoke.
- Effective for hydrocarbon fires (e.g., oil, gas, fuel fires).

Ultraviolet (UV) Flame Detectors

- Detect ultraviolet radiation from flames within the 180–260 nm range.
- Respond extremely fast to explosions or open flames.
- Effective in areas with hydrogen fires, which emit strong UV but little IR.
- Can trigger false alarms from UV sources (arc welding, lightning).

Heat Detectors

Fixed Temperature Detector

- Activates when a preset temperature is reached (typically 57°C to 100°C).
- Simple, reliable, but slower to respond.

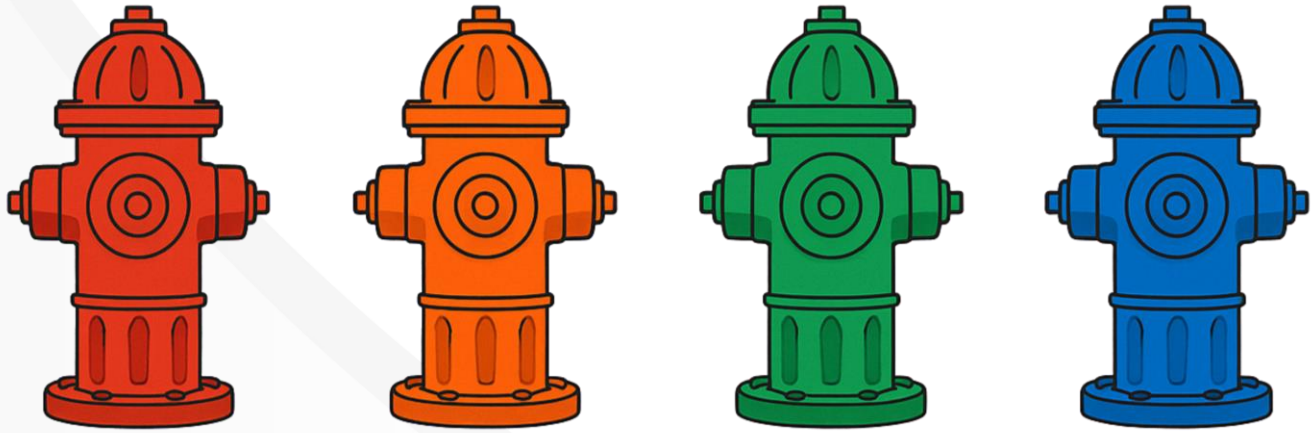
Rate-of-Rise Detector

- Activates when temperature rises rapidly (about 12–15°F per minute).
- Detects sudden fire growth quickly.

Rate-of-Compensation Detector

- Programmable; adjusts to normal ambient fluctuations and climatic changes.
- Reduces false alarms compared to simple rate-of-rise detectors.
- A specialized type of rate-of-rise detector.

Fire Hydrants Flow



Red	Orange	Green	Blue
< 500 GPM	500 – 999 GPM	1000 – 1499 GPM	1500 GPM or more

Hazardous Location Classification (NFPA 497)

Class 1: Flammable/Combustible Gases or Vapors

Division 1 (High Risk):

- Zone 0: Gas/vapor present all the time (continuous hazard).
- Zone 1: Gas/vapor present during normal operations.

Division 2 (Low Risk):

- 2: Gas/vapor present only in abnormal conditions (e.g., leaks).

Class 2: Combustible Dust

Division 1 (High Risk):

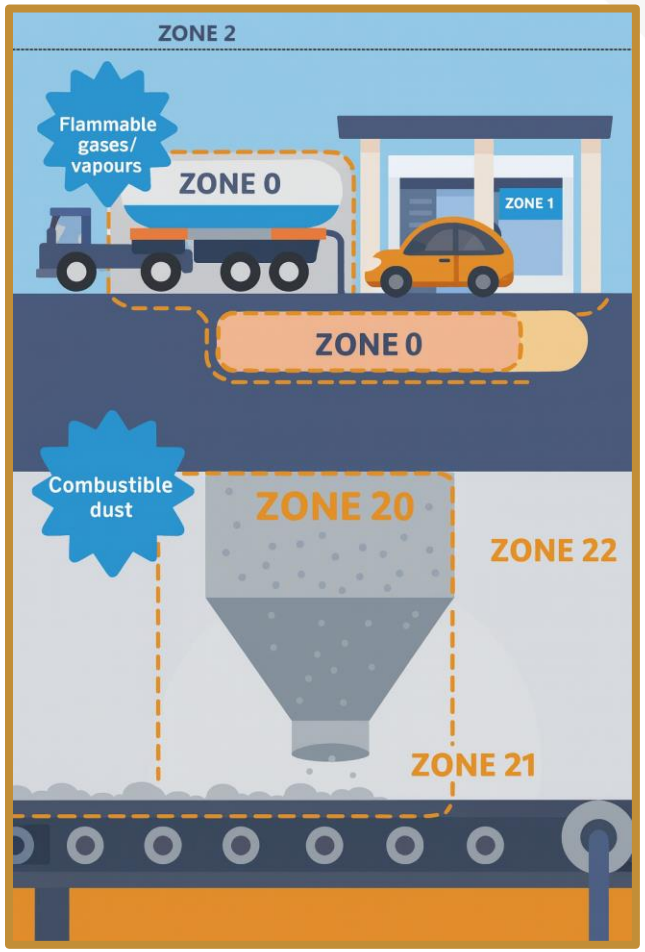
- Zone 20: Combustible dust present continuously.
- Zone 21: Dust present during normal operations.

Division 2 (Low Risk):

- Zone 22: Dust present only in abnormal conditions.

Class 3: Ignitable Fibers

- Covers areas with easily ignitable fibers or flying (e.g., textile mills, woodworking plants). Fibers do not typically remain airborne in high concentrations like dust, but can still create fire hazards.



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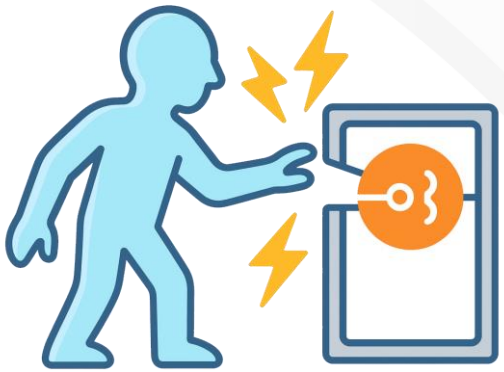
Static Electricity, Bonding & Grounding



What is Static Electricity?

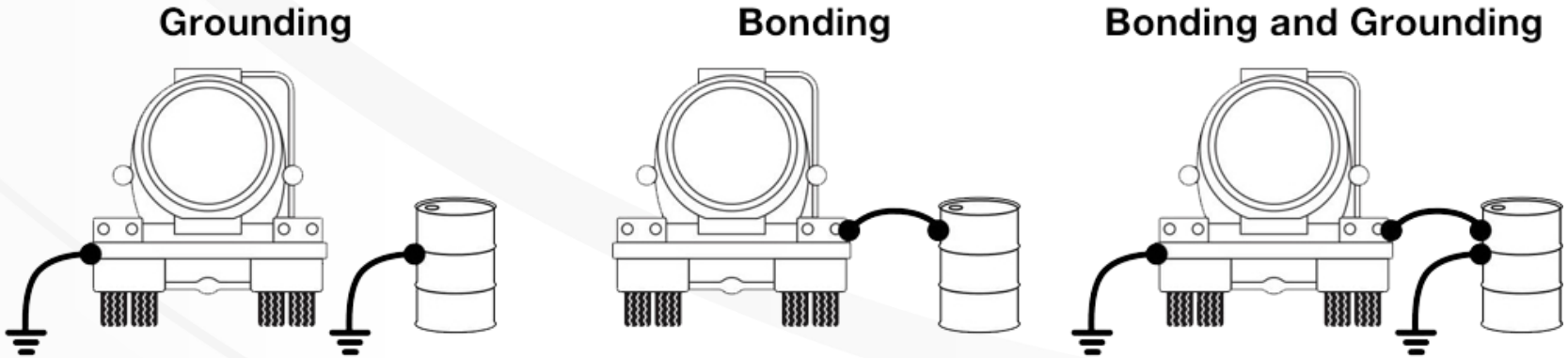
- Static electricity is an electric charge at rest, typically formed by friction between two dissimilar materials (e.g., plastic and rubber, metal and fabric).
- Common in operations involving, Flow of liquids (especially flammable), Powder transfer, Conveyor systems.

Grounding:

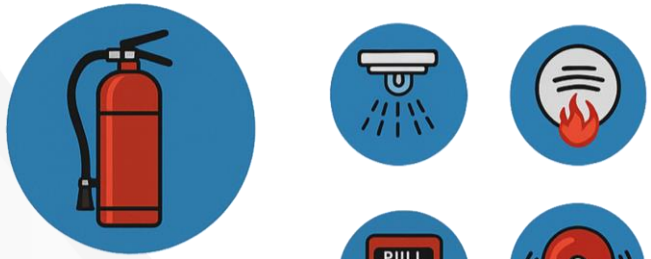
- Connects object to the ground with a conductor
- Dissipates static charge to the earth (zero potential)
- Protect from Electrocutions and static discharge

Bonding:

- Equalizes electrical potential between objects
- Connects two objects with a conductor
- Bonding will not eliminate static charge



Active Fire Protection | Passive Fire Protection



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Aspect	Active Fire Protection (AFP)	Passive Fire Protection (PFP)
Definition	Detects & actively fights fire	Contains & slows fire spread
Activation	Manual or automatic activation is required	Always in place, no activation is required
Main Role	Suppression & evacuation aid	Structural protection & safe escape
Examples	Sprinklers, alarms, extinguishers, hose reels	Fire doors, fire-rated walls, coatings, compartmentation
Strength	Immediate response	Long-term containment
Limitation	Needs activation & maintenance	Can not extinguish fire alone

Fire Load And Fireproofing

Fire Load

Definition: Maximum calorific value released when all combustible materials in an area are completely burnt.

Purpose: Assess the severity of a fire. Determine firefighting requirements. Evaluate how long a structure can withstand fire exposure.

Fireproofing

Definition: Insulation or protective measures to withstand fire.

Example: Fire door

Materials used in fire doors: Fibre board, Rock wool, Mineral wool, Fire-resistant glazing, Intumescent strips, Cold smoke seals

Dust Explosion, Dust Pentagon

1. Combustible Dust
2. Ignition source
3. Oxygen
4. Confinement
5. Dispersion

Dust Explosion, Dust Pentagon

1. Combustible Dust
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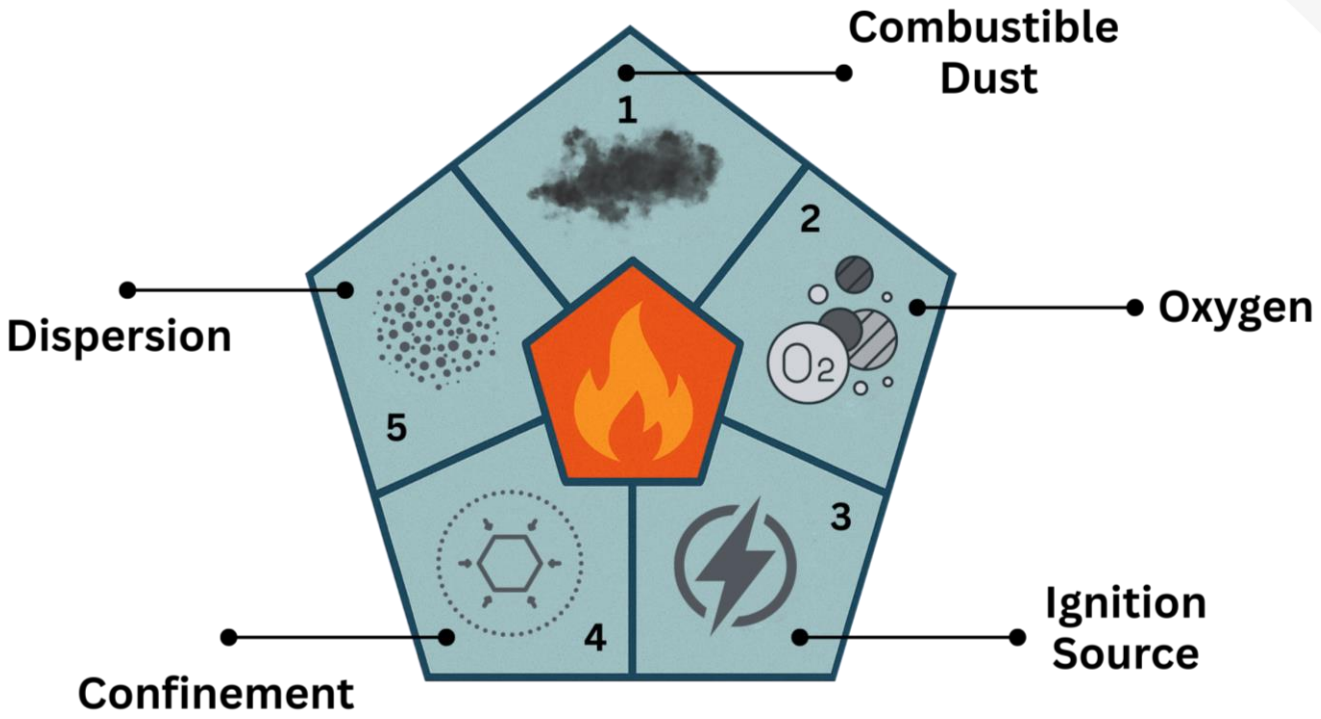
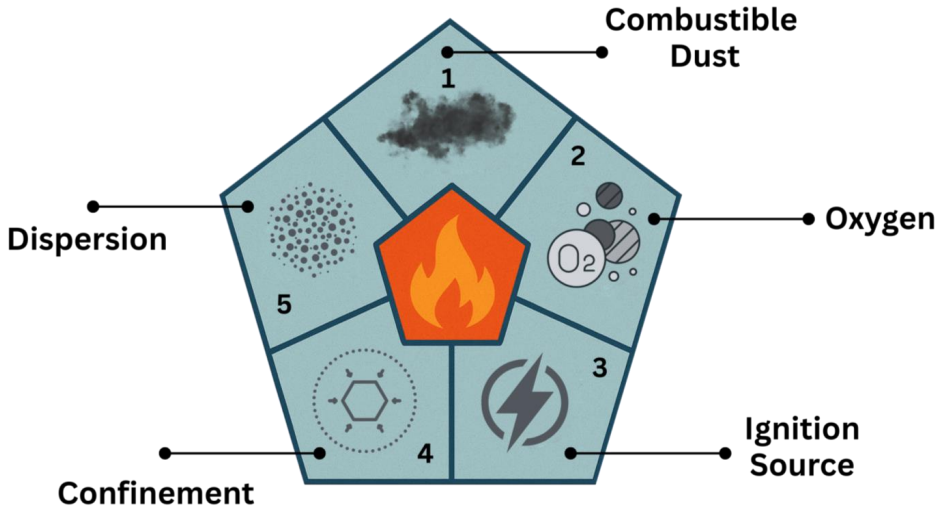


Dust Explosion, Dust Pentagon

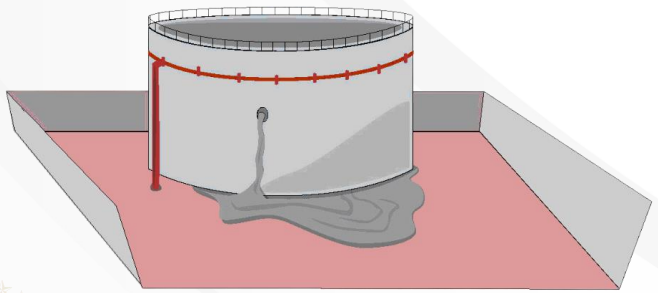
Primary Dust Explosion:
The first ignition of a dust cloud in a confined space (e.g., silo, duct, or equipment).

Secondary Dust Explosion:
A larger, more destructive blast caused when the primary explosion disturbs settled dust, creating new clouds that ignite.

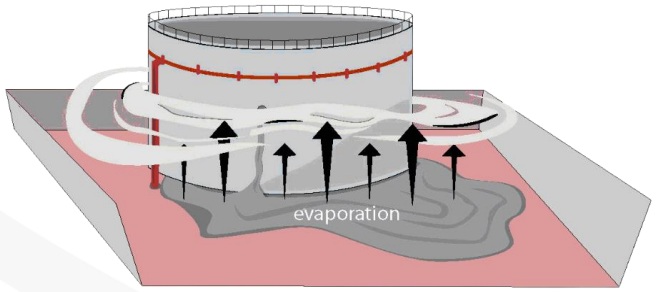


Unconfined Vapor Cloud Explosion (UVCE)

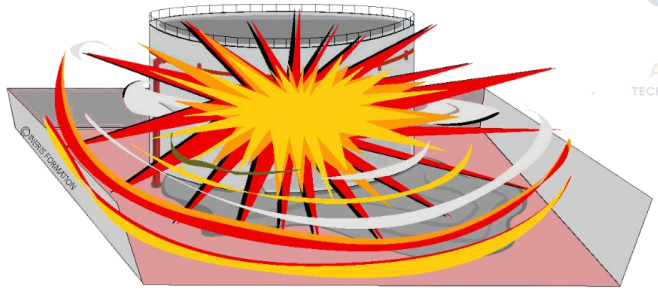
- Occurs when flammable gas or vapor leaks into the open environment and mixes with air, forming a flammable fuel air mixture.
- When this mixture encounters an ignition source, it can lead to a powerful explosion.
- Consequences: Formation of a fireball. Severe damage by heat radiation. Potential to trigger secondary fires/explosions at a distance.



Release of flammable Substance



Flammable substances evaporate and mix with air



Lead to explosion upon reaching ignition source

Confined Vapor Cloud Explosion (CVCE)

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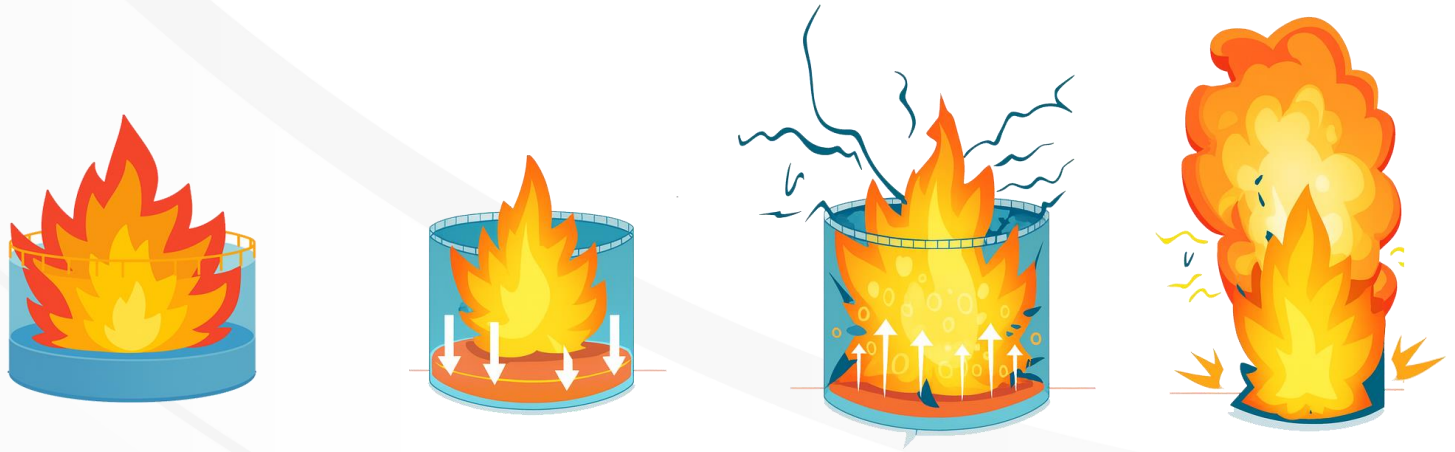
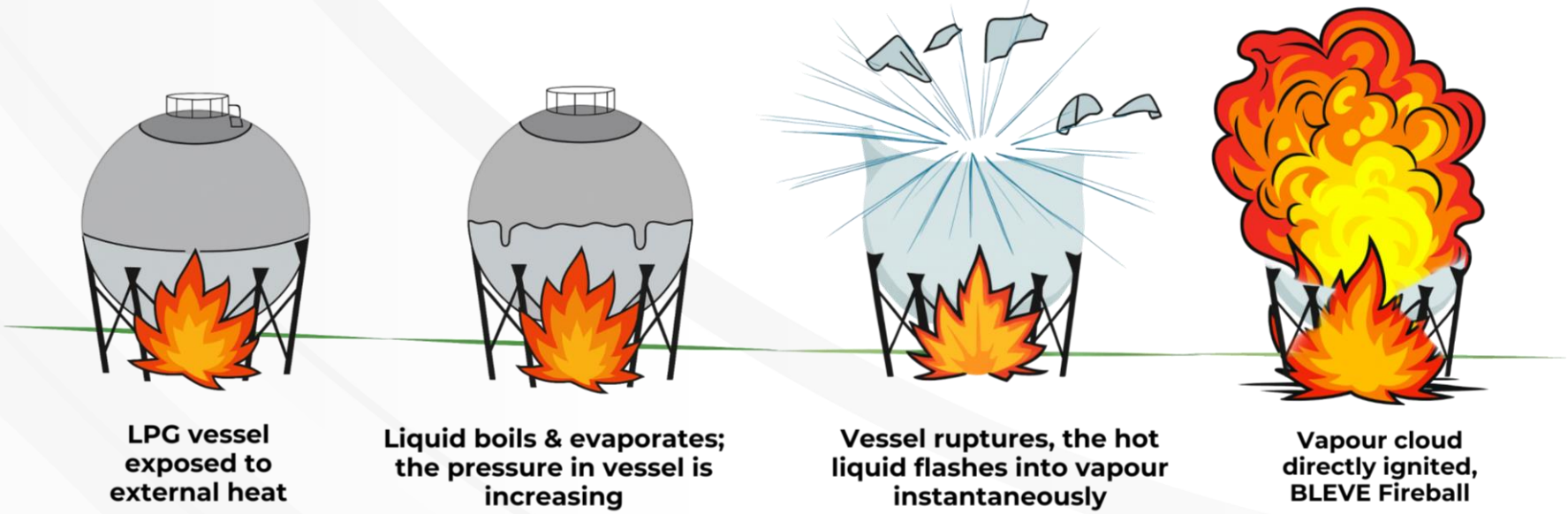
- Occurs when a flammable vapor cloud is trapped/contained inside a vessel, tank, building, or enclosed process unit.
- The vapor mixes with air and, upon ignition, creates rapid combustion within the confined space.
- Pressure builds up inside the enclosure until the walls rupture, producing Shrapnel and debris, Intense fire and flame jets, A destructive blast pressure wave.
- CVCE events are extremely hazardous because damage comes from both fire and blast overpressure.
- Exp: Explosions inside storage tanks, silos, enclosed process vessels, or poorly ventilated rooms.



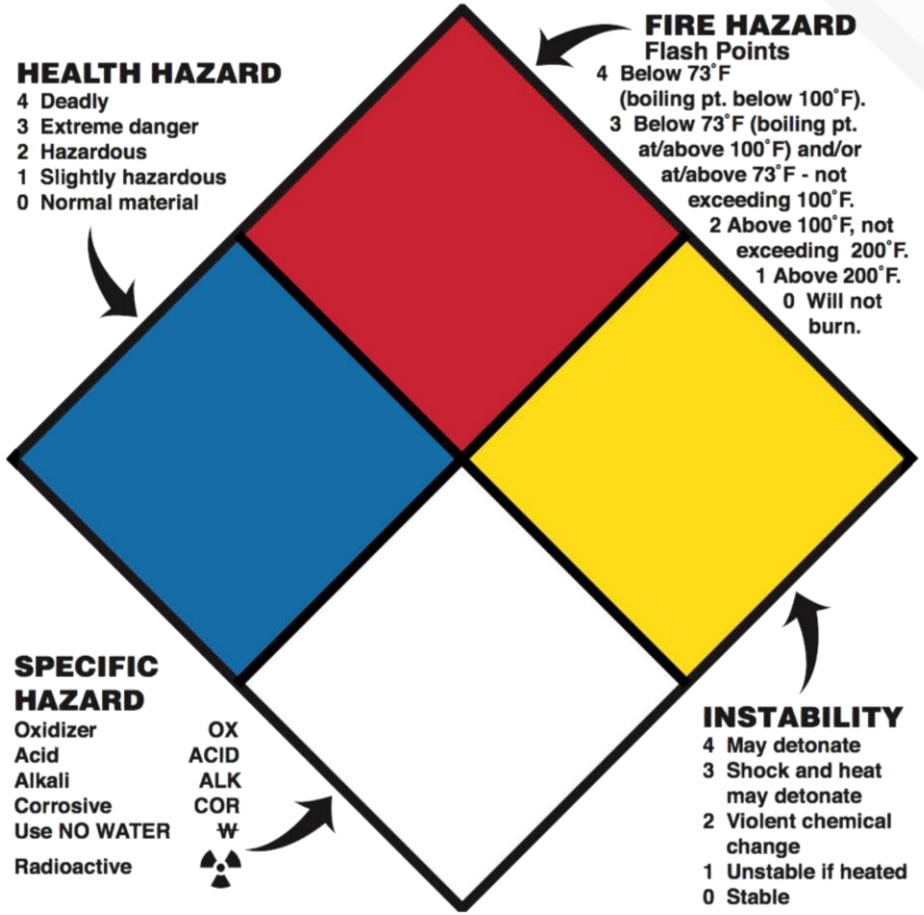
Boiling Liquid Expanding Vapor Explosion, Bleve

- BLEVE is an explosion caused by rupture of a pressurized vessel containing liquid (e.g., LPG).
- External fire or heat raises the temperature of the vessel and its contents.
- Vapor pressure of the liquid rises above its normal boiling point.
- Relief valve cannot release pressure fast enough compared to vapor generation.
- Vessel walls weaken due to continuous heating.
- Vessel structure fails, releasing liquid and vapor instantly.
- Sudden release causes explosion, fireball, and flying fragments.



NFPA 704 Diamond

NFPA Diomande is developed by the National Fire Protection Association, is a standard system for identifying the hazards of materials for emergency response. It is commonly known as the Fire Diamond, and it provides a visual indication of health, flammability, reactivity, and specific hazards associated with a material.



Fire Safety Management Program (NFPA 550)

Fire Safety Management Program

- Comprehensive framework to prevent and protect against workplace fires
- Based on NFPA 550 Fire Safety Concepts Tree

Fire Safety Objectives

- Life Safety: protect people from injury or death
- Property Conservation: minimize damage to assets and equipment
- Business Continuity: ensure rapid recovery of operations

Prevent Fire Ignition

- Control Fuel: manage storage and housekeeping
- Control Ignition Sources: maintain electrical systems, permits
- Control Heat Transfer: insulation, ventilation, separation

Manage Fire Impact

- Control Fuel: use fire-resistant materials, compartmentalize hazards
- Control Environment: smoke/ventilation management
- Suppress Fire: automatic systems (sprinklers) or manual response
- Construction Controls: fire-rated walls, doors, and passive protection

Workplace Emergencies

- **Fires:** Rapid spread of flames and heat.
- **Toxic Gas Releases:** Dangerous airborne chemicals.
- **Floods:** Sudden water overflow and damage.
- **Hurricanes:** Strong winds and heavy rain.
- **Tornadoes:** Fast, destructive rotating storm.
- **Violence:** Harm from aggression or attacks.

What is an Emergency Response Plan?

- Outlines steps employees must follow to stay safe during an emergency.
- A well-prepared plan reduces injuries and limits damage to people and property.
- A poor plan creates confusion, delays, and greater risk.

Contents of an Emergency Response Plan

ERP Should Include

- Emergencies requiring evacuation procedures
- Primary and secondary escape routes
- Accessible pathways maintained at all times
- Assigned emergency wardens
- Communication system details

During Emergency Situations

- Step-by-step procedures, maps, and directions
- Regular emergency drills
- Updated employee lists and contact details
- Designated assembly areas
- Shelter-in-place guidelines

OSHA Evacuation Planning Matrix

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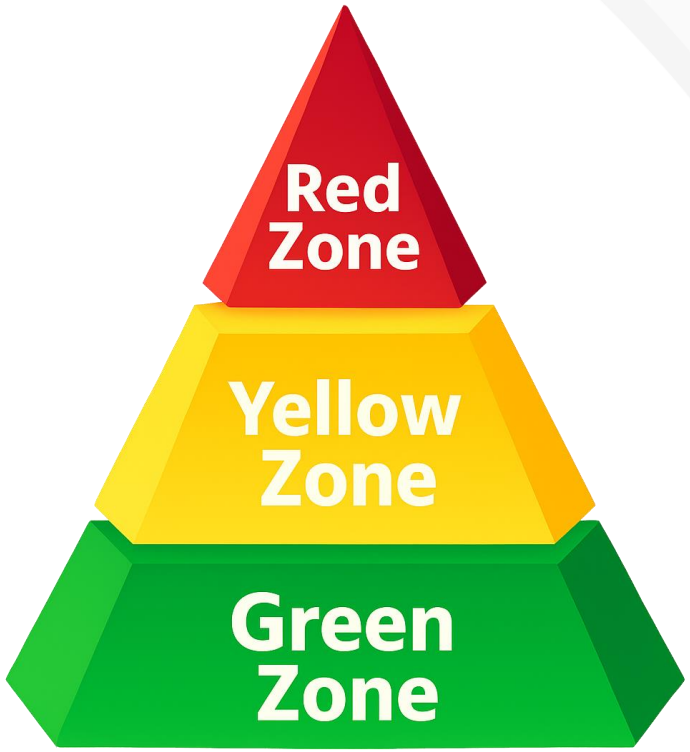
Purpose of this Matrix

Classify locations into risk zones (Green, Yellow, Red) based on three semi-quantitative criteria

- Vulnerability: How attractive the site is to a potential Threats
- Likelihood: Estimation of the presence of a threat group
- Significant Impact: Severity of consequence if an incident occurs



Green Zone

Low vulnerability, low threat, and low consequence

- Minimal potential for terrorist targeting
- Examples: Remote warehouses, low-occupancy admin offices
- Usually requires standard evacuation planning only

Yellow Zone

Moderate risk, High vulnerability or high threat or significant impact
But only one of these is high

- Examples: Urban offices, industrial plants with moderate hazardous material
- May require enhanced shelter-in-place planning or limited lockdown procedures

Red Zone

High risk (2 or more of the following): High vulnerability, High threat, Catastrophic impact

- Examples: Chemical plants, power stations, federal buildings, schools during threat levels
- Requires detailed emergency planning: Shelter-in-place, Full-scale evacuation
- Possible internal response roles (e.g., trained fire or security teams)

Incident Command Systems (ICS)

5 Components of the ICS Organization

- **Command:** Provides overall leadership and sets incident objectives.
- **Operations:** Directs tactical actions to achieve response goals.
- **Planning:** Develops action plans and tracks incident status.
- **Logistics:** Supplies resources, equipment, and support services.
- **Finance:** Manages costs, contracts, and documentation.

Key Team Members

- **Incident Commander:** Has overall responsibility for managing the incident.
- **Operations Section Chief:** Leads on-scene tactical operations and coordinates field activities.
- **Directors:** Oversee specific functional areas such as safety, communications, or public information.
- **Supervisors**: Manage individual teams and ensure tasks are completed safely and efficiently.
- **Leaders:** Provide guidance to specialized groups and support their operational needs.

Incident Command Systems (ICS)

Incident Commander Role

- Responsible for managing the entire incident
- Must be fully briefed and have a written authority to act
- Can assign team members and give them the needed authority
- This is the one role that is always filled in every incident

Public Information Officer (PIO)

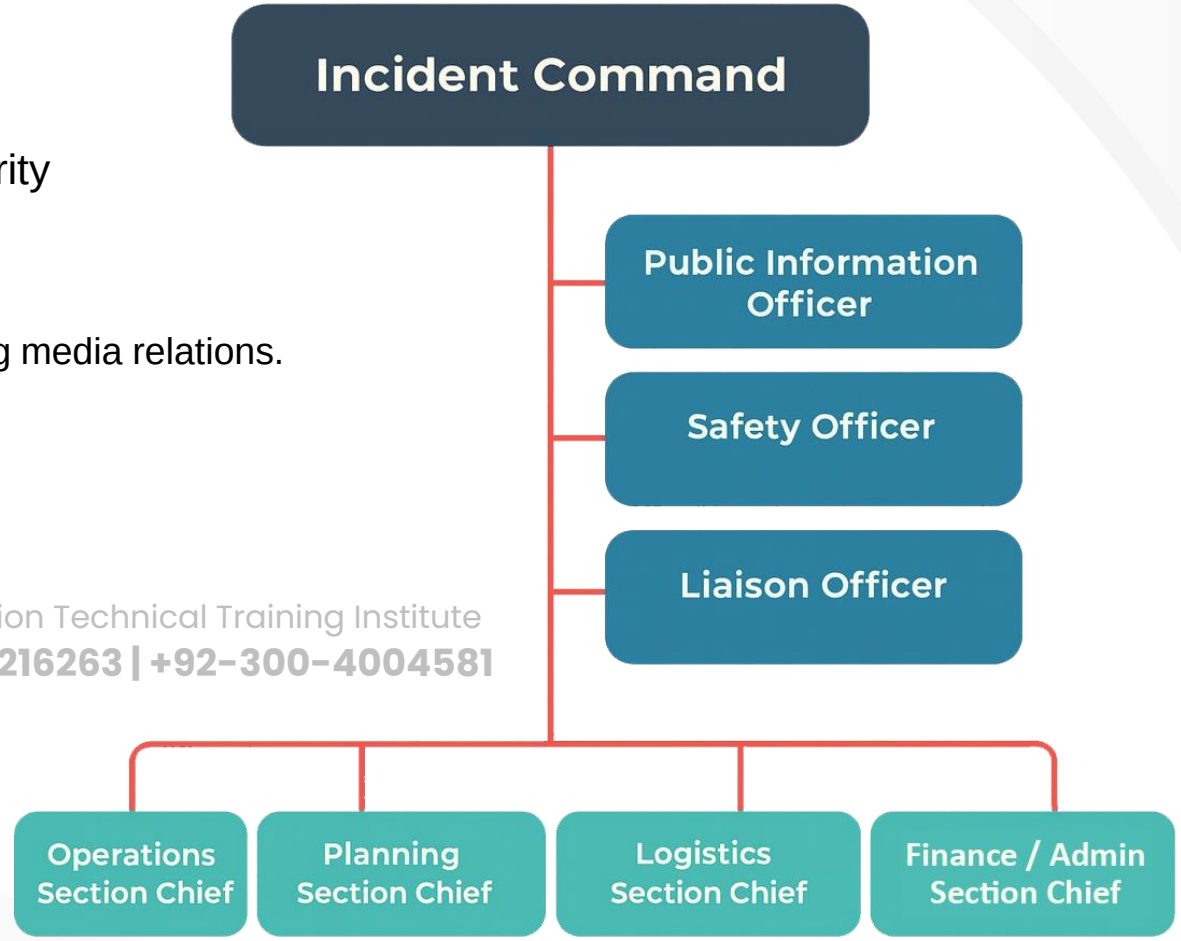
- Advise the Incident Commander on sharing information and managing media relations.
- Act as the main contact for anyone seeking official updates.
- Communicate with both internal teams and the public.
- Gather details from the Planning Section to keep messages accurate.

Safety Officer (SO)

- Protects responders during the incident.
- Advises Incident Command on safety concerns.
- Works to reduce risks for all personnel.

Liaison Officer Responsibilities

- Collects key information from all support agencies.
- Coordinates with outside agencies not in the command structure.
- Provides regular briefings and responds to questions.



Incident Command Systems (ICS)

Liaison Officer Coordinate with agencies:

- **Government departments:** fire service, police, public health, environmental protection.
- **Utility companies:** electricity, gas, water, telecom providers.
- **Private contractors:** hazardous-materials cleanup, heavy equipment, medical transport.
- **Non-governmental organizations (NGOs):** Red Cross, volunteer rescue teams.
- **Neighboring jurisdictions or mutual-aid partners:** nearby cities or counties offering personnel or equipment.

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Shelter-in-Place

- Shelter in plant is the safest option when hazardous gases / contaminants released on plant.
- The emergency plan must include a fast, reliable employee alert system.
- All employees should receive training on their shelter-in-place roles and steps.
- Regular practice drills help everyone respond quickly and correctly.

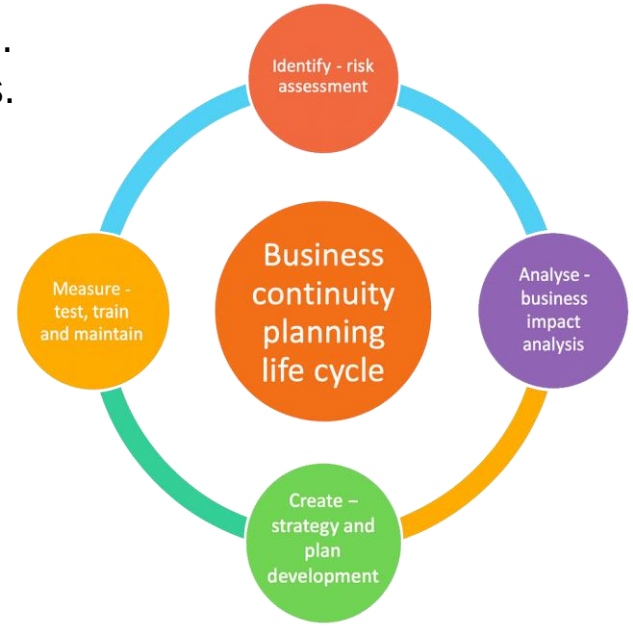
Business Continuity Planning

Key Components

- **Purpose:** Reduce downtime and revenue loss after an emergency by identifying critical risks and ways to keep operations running.
- **Impact Assessment:** Determines vulnerable operations and guides strategies to reduce exposure.

Business Continuity Planning Life Cycle

- **Reduce Identify:** Risk Assessment: Recognize potential hazards and critical processes.
- **Analyze: Business Impact Analysis:** Evaluate consequences of disruptions on operations.
- **Create: Strategy & Plan Development:** Design practical recovery and continuity strategies.
- **Measure:** Test, Train & Maintain: Conduct drills, train staff, and update plans regularly.



Continuity of Operations Plan (COOP)

- Outlines steps to move critical operations to an alternate location when needed.
- Activated if an emergency makes the primary facility unsafe or unusable.
- Aims to restore essential functions quickly to minimize downtime.
- Includes an Emergency Notification Phone Tree for rapid communication.
- Specifies the designated backup site or reporting location for employees.

Essential Steps in Emergency Planning

- **Identification:** Detect hazards and evaluate potential vulnerabilities.
- **Assessment:** Analyze the most likely and most severe emergencies and create response plans.
- **Control:** Ensure the organization has the resources and ability to implement the emergency plan effectively.

End of Session

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