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CSP EXAMINATION PREPARATION

DOMAIN 4

Emergency Management

Supplementary Learning Notes

Exam Weight: 9% of Total Score

Covering 5 Core Knowledge Areas

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DOMAIN 4 — EMERGENCY MANAGEMENT

CSP V11.0 Examination Preparation • Exam Weight: 9% • Blueprint Objectives 1–5

1. Create, employ, and maintain an Emergency Response Plan

1.1. Regulatory Framework

OSHA 29 CFR 1910.38 (Emergency Action Plan): Required for facilities with 10 or more employees. The written EAP must be accessible to all employees and reviewed with each new employee and after each exercise. Key required elements:

- Preferred method for reporting fires and other emergencies
- Evacuation procedures and route assignments (floor plans, workplace maps, refuge areas)
- Names and contact info of personnel responsible for EAP duties
- Procedures for employees operating critical systems during evacuation
- Rescue and medical duties for designated employees

1.2. ERP Explanation

An **Emergency Response Plan (ERP)** is a documented system that defines how an organization will prepare for, respond to, and recover from emergencies that could threaten people, property, the environment, or business operations.

The process involves three key stages:

1. Create the Emergency Response Plan

Develop a structured plan based on a risk assessment and hazard identification process.

Key elements include:

- Identification of potential emergencies
- Roles and responsibilities of emergency personnel
- Emergency communication procedures
- Evacuation and shelter-in-place procedures
- Emergency equipment and resources
- Coordination with external agencies (fire brigade, police, hospitals, civil defense)
- Business continuity and recovery procedures

Example:

A chemical manufacturing plant identifies risks such as toxic gas releases, fires, explosions, and chemical spills. The ERP specifies evacuation routes, assembly points, spill response teams, and emergency contact numbers.

2. Employ (Implement) the Emergency Response Plan

The plan must be effectively communicated and practiced.

Methods include:

- Employee training and awareness
- Emergency drills and exercises
- Mock scenarios
- Testing communication systems
- Coordination with emergency responders

Example:

A company conducts quarterly fire evacuation drills to ensure employees know how to safely exit the building and report to assembly points.

3. Maintain the Emergency Response Plan

An ERP must remain current and effective.

Maintenance activities include:

- Annual reviews
- Updating contact lists
- Revising procedures after incidents
- Incorporating lessons learned from drills
- Updating plans following organizational or facility changes

Example:

After a severe storm causes power outages, the organization updates its ERP to include backup generators and alternative communication methods.

1.3. Examples of Emergency Response Plans

1. Fire Emergency

Scenario

Electrical short circuit causes a warehouse fire.

Response Actions

- Activate fire alarm.
- Notify emergency services.
- Evacuate personnel via designated routes.
- Account for all employees at assembly points.
- Trained personnel use fire extinguishers if safe.

Example

A warehouse employee discovers smoke from an electrical panel and activates the alarm. Employees evacuate while the emergency team isolates power and contacts the fire department.

2. Severe Weather

Scenario

Hurricane, cyclone, tornado, thunderstorm, or extreme flooding.

Response Actions

- Monitor weather alerts.
- Suspend outdoor work.
- Move personnel to safe shelters.
- Secure equipment and hazardous materials.
- Implement business continuity measures.

Example

An oil and gas facility receives a cyclone warning and shuts down operations while relocating workers to reinforced shelters.

3. Nuclear Incident

Scenario

Radiological release from a nearby nuclear facility.

Response Actions

- Shelter-in-place.
- Close ventilation systems.
- Monitor radiation levels.
- Distribute protective equipment if required.
- Follow government emergency directives.

Example

Employees remain indoors with sealed windows while emergency authorities assess radiation exposure risks.

4. Natural Disasters

Earthquake Example

Response Actions

- Drop, Cover, and Hold On.
- Evacuate after shaking stops.
- Inspect for structural damage.
- Account for personnel.

Flood Example

Response Actions

- Move personnel to higher ground.
- Shut down electrical systems.
- Protect critical equipment.

Example

Following an earthquake, employees evacuate to open areas while emergency teams inspect buildings for structural integrity.

5. Terrorist Attack or Active Threat

Scenario

Bomb threat or active shooter incident.

Response Actions

- Notify law enforcement.
- Implement lockdown procedures.
- Evacuate or shelter depending on threat.
- Establish communication channels.
- Provide post-incident counseling.

Example

After receiving a bomb threat, security personnel coordinate with police and evacuate the building until it is declared safe.

6. Chemical Spill or Hazardous Material Release

Scenario

Sulfuric acid tank rupture in a processing plant.

Response Actions

- Isolate the affected area.
- Notify HazMat team.
- Use appropriate PPE.
- Contain and neutralize the spill.
- Monitor environmental impacts.

Example

A forklift damages a chemical drum, releasing acid. The spill response team deploys absorbent materials and neutralizing agents while evacuating nearby workers.

7. Utility System Failure

Scenario

Loss of electricity, water, gas, compressed air, or communication systems.

Response Actions

- Activate backup systems.
- Assess operational impact.
- Shut down critical equipment safely.
- Communicate status to stakeholders.

Example

A data center experiences a power outage and automatically transfers operations to backup generators and UPS systems.

8. Cyber Security Incident

Scenario

Ransomware attack on company servers.

Response Actions

- Isolate affected systems.
- Activate incident response team.
- Preserve evidence.
- Restore data from backups.
- Notify regulatory authorities if required.

Example

A phishing email compromises company computers. IT personnel disconnect affected systems and restore operations from secure backups.

1.4. Emergency Action Plan (EAP) Components

Emergency Types Covered (OSHA / FEMA)

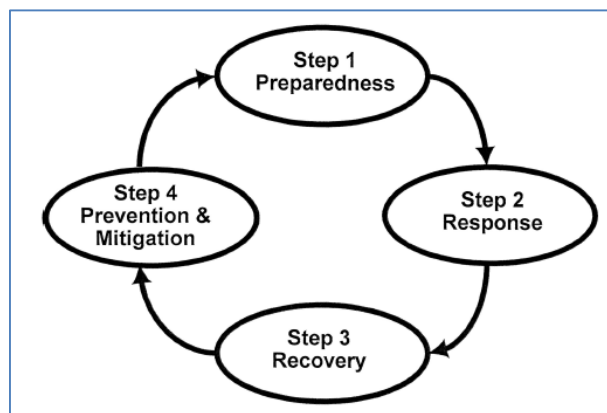
- Natural: Floods, hurricanes, tornadoes, earthquakes, severe weather
- Technological: Chemical spills, toxic gas releases, radiological accidents, explosions
- Human-induced: Terrorist attacks, civil disturbances, workplace violence, cyber attacks

Emergency Action Plan (EAP) must include:

- A preferred method for reporting fires and other emergencies;
- An evacuation policy and procedure;
- Emergency escape procedures and route assignments, such as floor plans, workplace maps, and safe or refuge areas;
- Names, titles, departments, and telephone numbers of individuals both within and outside your company to contact for additional
- information or explanation of duties and responsibilities under the emergency plan;
- Procedures for employees who remain to perform or shut down
- critical plant operations, operate fire extinguishers, or perform other essential services that cannot be shut down for every emergency alarm before evacuating; and

Rescue and medical duties for any workers designated to perform them.

EAP Development Steps



Step	Action	Key Element
1 - Preparedness	Risk assessment, hazard identification, vulnerability analysis	Hazard mapping (FEMA approach)
2 - Response	Notification, evacuation/shelter-in-place, ICS activation	Chain of command; Warden role
3 - Recovery	Damage assessment, BCP activation, continuity of operations	RTO / RPO targets
4 - Mitigation	Engineering controls, training, after-action review	Lessons learned loop

Step 1: Preparedness

- **Objective:** Plan and train before an emergency occurs.
- **Activities Include:**
 - Emergency drills and simulations
 - Developing emergency response plans
 - Public awareness campaigns
 - Training personnel and first responders

Step 2: Response

- **Objective:** Act immediately after a disaster strikes.
- **Activities Include:**
 - Activating emergency operations
 - Providing medical aid and rescue services
 - Ensuring communication and coordination
 - Evacuations and sheltering

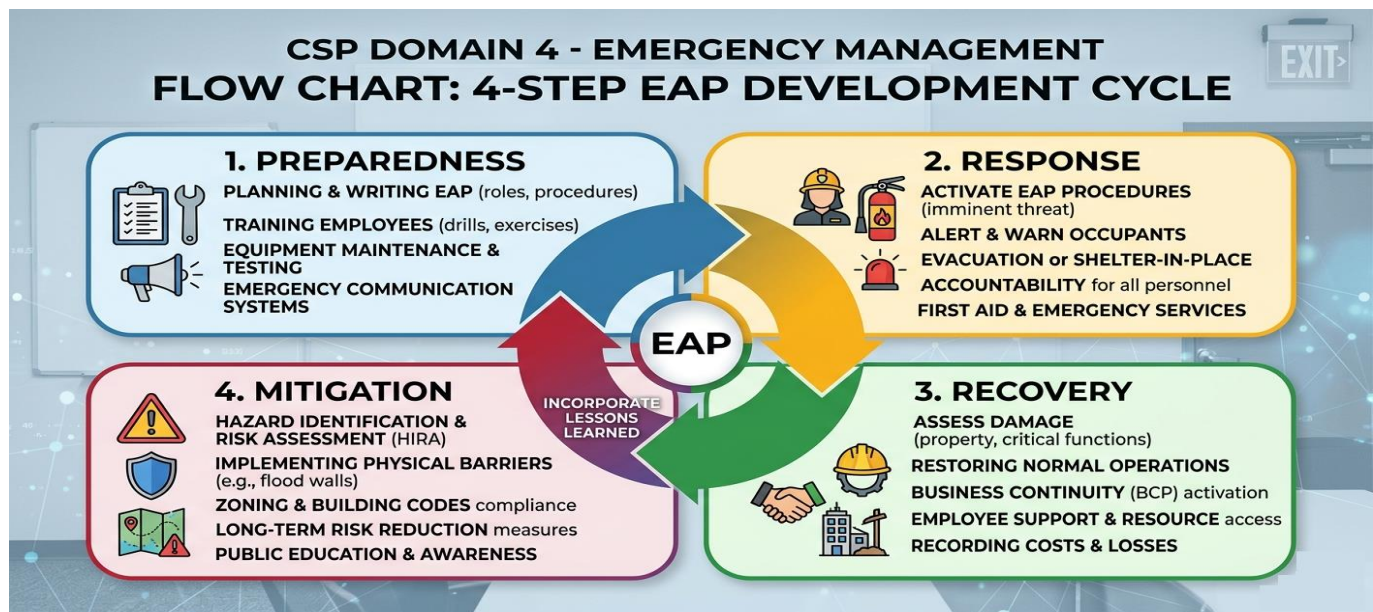
Step 3: Recovery

- **Objective:** Restore normal operations and repair damages.
- **Activities Include:**
 - Business Continuity
 - Rebuilding infrastructure
 - Restoring services (electricity, water, etc.)

- Providing psychological and financial support
- Evaluating response effectiveness

Step 4: Prevention & Mitigation

- **Objective:** Reduce or eliminate risks to life and property.
- **Activities Include:**
 - Incident Investigation
 - Risk assessments and hazard mapping
 - Enforcing building codes and land use planning
 - Retrofitting vulnerable structures
 - Implementing long-term safety measures



Alarm and Notification Systems (NFPA 72)

- Make sure alarms are distinctive and recognized by all employees as a signal to evacuate the work area or perform actions identified in your plan;
- Make available an emergency communications system such as a public address system, portable radio unit, or other means to notify employees of the emergency and to contact local law enforcement, the fire department, and others; and
- Alarms must be audible, visual (strobes for hearing-impaired), and tactile where needed

- Auxiliary power supply required to maintain alarm operation during a power outage
- Although it is not specifically required by OSHA, you also may want to consider the following:
 - Using tactile devices to alert employees who would not otherwise be able to recognize an audible or visual alarm; and
 - Providing an updated list of key personnel such as the plant manager or physician, in order of priority, to notify in the event of an emergency during off-duty hours.
- NFPA 72 Temporal-Three Signal: Standard fire evacuation signal — 3 short pulses (0.5 s on / 0.5 s off), 1.5-second pause, repeated
- Temporal-Four Signal: Used specifically for carbon monoxide (CO) alarms

Roger Brauer Reference — Ch. 36, 37

Brauer emphasizes that EAP effectiveness depends on realistic hazard-scenario planning rather than on generic checklists.

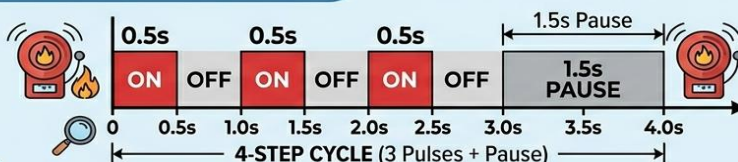
Emergency planning must integrate with engineering controls — detection, suppression, and egress systems form an integrated safety architecture.

Business continuity requires alignment of safety, operations, and IT resilience plans (Ch. 36).

NFPA 72 TEMPORAL SIGNAL PATTERNS: EXAM RECALL GUIDE

1. PREPAREDNESS

TEMPORAL-3 (FIRE) PATTERN



KEY CHARACTERISTICS

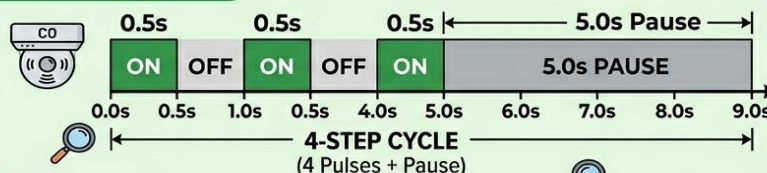
- Fire alarm resonator (bells) on pulses
- Pulses off pulses/meaning
- Emergency communit fire alarm

APPLICATIONS

Evacuations, avoid on practice, and all significant places

3. RECOVERY

TEMPORAL-4 (CO) PATTERN



KEY CHARACTERISTICS

- Damaged detector
- Protecting CO and demicity
- Restoring normal connotations

APPLICATIONS

Evacuation, and rancotucharnter, tearing nominents or critical elocions

MEMORIZE THIS: PULSE SEQUENCE & PAUSE DURATION

1.5. Evacuation Planning

Evacuation Considerations

- Conditions under which an evacuation would be necessary;
- A clear chain of command and designation of the person in your business authorized to order an evacuation or shutdown. You may want to designate an “**evacuation warden**” to assist others in an evacuation and to account for personnel;
- Specific evacuation procedures, including routes and exits. Post these procedures where they are easily accessible to all employees;
- Procedures for assisting people with disabilities or who do not speak English;
- Designation of what, if any, employees will continue or shut down critical operations during an evacuation. These people must be capable of recognizing when to abandon the operation and evacuate themselves; and
- A system for accounting for personnel following an evacuation. Consider employees’ transportation needs for community-wide evacuations.

Evacuation Warden & Coordinator(s) Responsibilities (OSHA 1910.38)

- Assessing whether the situation warrants emergency plan activation
- Supervising and directing personnel evacuation
- Coordinating with outside emergency services (fire, EMS)
- Directing shutdown of critical plant operations when required

Evacuation Route Requirements

- Clearly marked and well-lit; posted throughout the facility
- Wide enough to accommodate all evacuating personnel simultaneously
- Unobstructed and clear of debris at all times
- Routes that avoid exposing evacuees to additional hazards

Personnel Accountability/Head Count After Evacuation

- Designated assembly areas; head count immediately after evacuation
- Names and last known locations of unaccounted persons reported to the incident commander
- Procedure for accounting for non-employees (visitors, contractors, suppliers)
- Provisions for further evacuation if the incident expands (e.g., transportation to off-site location)

Special Needs Provisions

- Elevator use: Elevators cannot serve as a means of egress except for firefighter service elevators
- Signage options: Non-illuminated, internally illuminated, and LEDs (most visible for visually impaired)
- Evacuation chairs and personal assistance for mobility-impaired employees
- Tactile devices for employees who cannot perceive audible or visual alarms

Rescue Operations Considerations

- It takes more than just willing hands to save lives. Untrained
- individuals may endanger themselves and those they are trying to rescue.
- For this reason, it is generally wise to leave rescue work to those who are trained, equipped, and certified to conduct rescues.
- If you have operations that take place in permit-required confined spaces, you may want your emergency action plan to include rescue procedures that specifically address entry into each confined space.

What Training shall address?

- Individual roles and responsibilities;
- Threats, hazards, and protective actions;
- Notification, warning, and communications procedures;
- Means for locating family members in an emergency;
- Emergency response procedures;
- Evacuation, shelter, and accountability procedures;
- Location and use of common emergency equipment; and
- Emergency shutdown procedures.

Relevant Organizations

- Federal Emergency Management Agency (FEMA)
- Chemical Transportation Emergency Center, CHEMTREC
- American Chemistry Council, Center for Chemical Process Safety of the American Institute of Chemical Engineers (AIChE)
- Department of Homeland Security (DHS)
- OSHA
- NFPA

1.6. Business Continuity & Recovery Planning

Key Recovery Metrics

Term	Definition	Example
RTO (Recovery Time Objective)	Maximum acceptable downtime before operations must resume	IT systems back online within 4 hours
RPO (Recovery Point Objective)	Maximum acceptable data loss measured in time	Data is backed up every 1 hour
MTD (Maximum Tolerable Downtime)	Total time a function can be out before critical damage occurs	Payroll: 7 days

Yates Reference — Ch. 22, 23

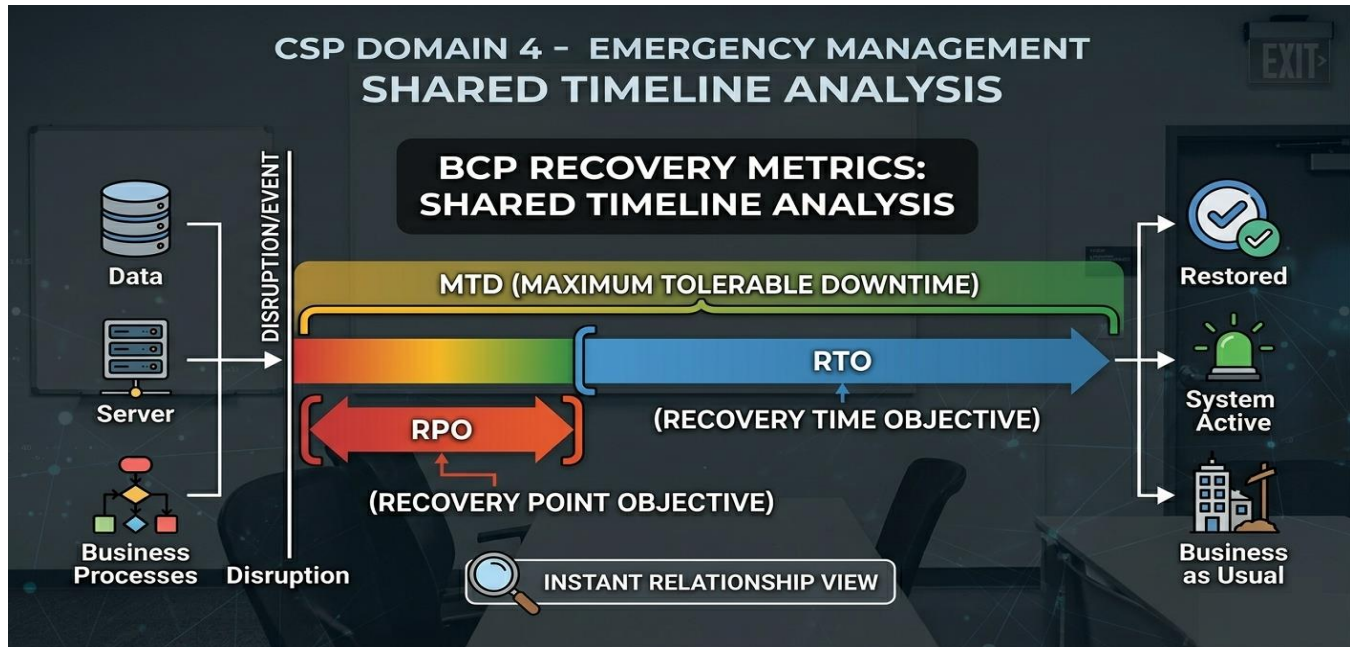
Yates identifies BCP as a core component of organizational resilience. Critical functions must be identified and ranked before disaster strikes.

Recovery strategies include alternate site operations, cloud backups, cross-training of personnel, and supply chain redundancy.

Communication plans must address both internal stakeholders and external parties, including regulators and media (Ch. 23).

EXAM TIP

OSHA 1910.38: Written EAP required when 10+ employees. Oral EAP only allowed for facilities with fewer than 10 employees. Warden = ERT indicator.



2. Disaster Response, Recovery & Incident Command

2.1. Incident Command System (ICS)

ICS is a standardized, on-scene, all-hazards incident management approach. It is the operational structure for NIMS (National Incident Management System). ICS provides a common language and organizational structure for managing emergencies, ensuring coordination among diverse response teams. The system is designed to be flexible and adaptable to incidents of any size and complexity.

ICS Structure

- Incident Commander (IC): Overall authority and responsibility for incident management
- Operations Section: Directs tactical operations to reduce hazard
- Planning Section: Collects and analyses information; maintains situation status
- Logistics Section: Provides resources, services, and support to incident operations
- Finance/Administration Section: Tracks costs; administers procurement contracts

Incident Commander (IC):

Responsibilities: Overall authority and responsibility for managing the incident, making strategic decisions, and ensuring safety.

Qualifications: Leadership skills, situational awareness, and the ability to make quick, informed decisions.

Operations Section:

Function: Directs all tactical operations, including deploying resources, managing teams, and executing response strategies.

Sub-Units: May include fire suppression, medical response, search and rescue, and law enforcement units.

Planning Section:

Function: Collects and analyzes information, develops the Incident Action Plan (IAP), and forecasts future needs.

Tasks: Situation reporting, resource tracking, and documenting incident progress.

Logistics Section:

Function: Provides support, resources, and services required for the response, such as equipment, facilities, and transportation.

Sub-Units: Includes supply management, communications, and medical support.

Finance/Administration Section:

Function: Tracks costs, manages procurement, and handles financial and administrative tasks related to the incident.

Responsibilities: Timekeeping, reimbursement processing, and cost analysis.

ICS Principles

- **Span of Control:** Optimal = 1 supervisor to 5 subordinates (range: 1:3 to 1:7). Maintains manageable supervision ratios, typically limiting the number of direct reports to five to ensure effective oversight.
- **Unity of Command:** Each person reports to only one supervisor. When multiple agencies or jurisdictions are involved, a unified command structure ensures coordinated decision-making and resource allocation.
- **Common Terminology:** Standardized titles, facilities, and resource designations
- **Unified Command:** Used in multi-agency or multi-jurisdiction incidents
- **Management by Objectives:** Establish incident objectives and communicate to all

Managing Active Incidents**1. Initial Response:**

- **Rapid Assessment:** Quickly evaluate the situation to determine the nature and severity of the incident.
- **Scene Safety:** Ensure the area is safe for responders and civilians, implementing necessary protective measures.
- **Activation of Response Plan:** Initiate the relevant emergency response protocols based on the incident type.

2. Command and Control:

- **Establishing an Incident Command Post (ICP):** A centralized location for coordinating response efforts, communication, and decision-making.
- **Resource Allocation:** Deploy personnel, equipment, and supplies efficiently to address the incident's demands.
- **Coordination with Agencies:** Collaborate with local, state, and federal agencies to leverage additional resources and expertise.

3. Communication Management:

- **Internal Communication:** Ensure clear and consistent communication among response teams and within the organization.
- **External Communication:** Provide timely updates to stakeholders, including employees, customers, media, and the public.
- **Use of Communication Tools:** Utilize radios, satellite phones, emergency notification systems, and digital platforms to maintain connectivity.

4. Resource Management:

- **Personnel Deployment:** Assign roles and responsibilities based on skills and availability, ensuring optimal use of human resources.
- **Equipment Utilization:** Monitor the use and status of equipment, ensuring critical tools are available and functioning.
- **Supply Chain Management:** Maintain a steady flow of necessary supplies, such as medical kits, food, water, and protective gear.

5. Public Information and Media Relations:

- **Designated Spokesperson:** Appoint a person responsible for communicating with the media to ensure consistent and accurate information dissemination.
- **Information Accuracy:** Provide factual updates to prevent misinformation and panic.
- **Public Guidance:** Offer clear instructions to the public on safety measures, evacuation routes, and emergency contacts.

6. After-Action Review and Continuous Improvement:

- **Debriefing Sessions:** Conduct meetings post-incident to discuss what worked well and identify areas for improvement.
- **Documentation:** Record lessons learned and update emergency plans accordingly.
- **Training Enhancements:** Incorporate insights from the review into future training programs to enhance preparedness.

Advanced Incident Management Techniques

1. Multi-Agency Coordination:

- **Joint Operations Centers (JOCs):** Establish centers where multiple agencies can coordinate their efforts in real-time.
- **Interoperable Communication Systems:** Ensure different agencies can communicate seamlessly, using compatible technologies and protocols.

2. Technology Integration:

- **Geographic Information Systems (GIS):** Utilize GIS for real-time mapping, situational awareness, and resource tracking.
- **Drones and Robotics:** Deploy drones for aerial reconnaissance and robots for hazardous environment assessments, reducing risk to human responders.
- **Incident Management Software:** Implement software solutions that facilitate planning, resource management, and communication during incidents.

3. Psychological First Aid:

- **Mental Health Support:** Provide immediate psychological support to victims and responders to address trauma and stress.
- **Resilience Building:** Implement programs that enhance the mental resilience of employees and response teams.

4. Sustainability and Environmental Considerations:

- **Eco-Friendly Practices:** Incorporate sustainable practices in response efforts, such as using environmentally safe materials and minimizing waste.
- **Environmental Impact Assessments:** Evaluate and mitigate the environmental consequences of response actions to prevent further harm.

D. Case Studies

1. Hurricane Katrina (2005):

- **Lessons Learned:** Importance of coordinated multi-agency response, robust evacuation plans, and effective communication systems.
- **Improvements Implemented:** Enhanced disaster preparedness plans, improved infrastructure resilience, and better training for emergency responders.

2. September 11 Attacks (2001):

- **Incident Command Insights:** Necessitated the integration of multiple federal agencies under a unified command structure.
- **Response Enhancements:** Development of specialized protocols for terrorism-related incidents and improved inter-agency communication frameworks.

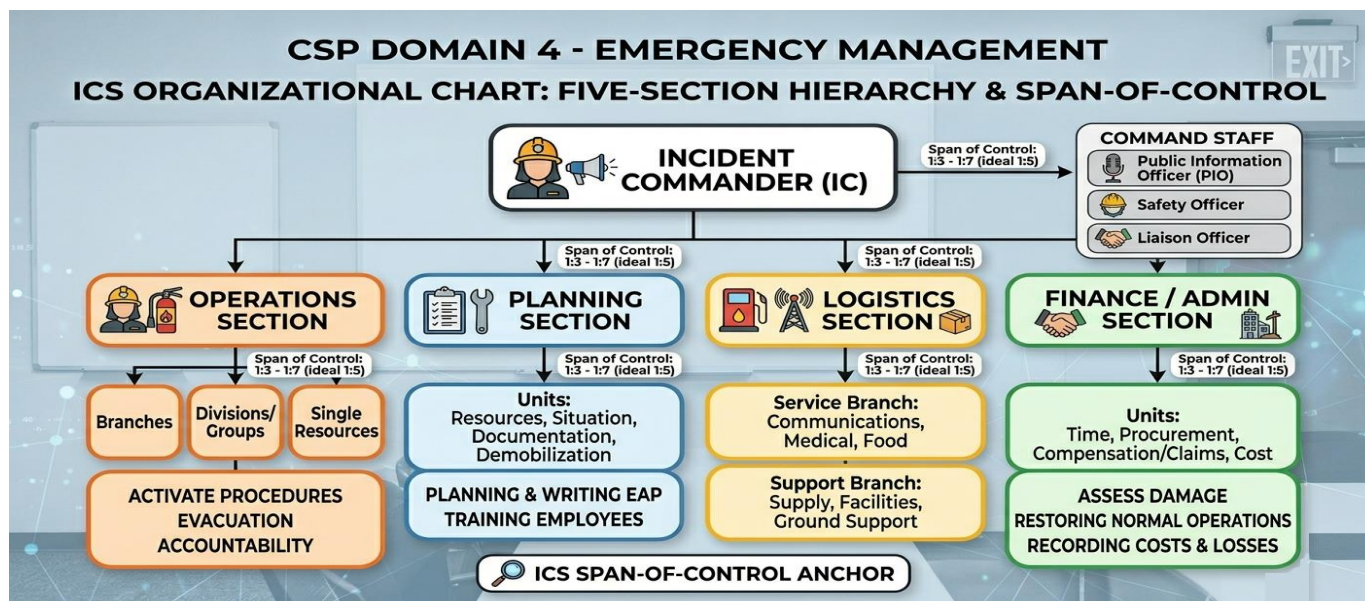
3. COVID-19 Pandemic (2020-Present):

- **Crisis Management Strategies:** Highlighted the need for flexible business continuity plans, remote work capabilities, and health and safety protocols.
- **Innovations:** Accelerated adoption of digital communication tools, telehealth services, and data-driven decision-making processes.

4. Wildfires in California:

- **Emergency Response Techniques:** Utilized advanced GIS mapping for fire tracking, deployed aerial firefighting resources, and implemented community evacuation plans.
- **Preventative Measures:** Enhanced vegetation management, improved building codes for fire resistance, and increased public awareness campaigns.

ICS Level	Description
Type 5 — Single Resource	Routine incident — 1-2 resources; managed by single officer
Type 4 — Initial Attack	Small incident; requires agency notification; under 24 hours
Type 3 — Extended Attack	Multi-operational periods; some ICS positions activated; written IAP
Type 2 — Regional	Most ICS activated; incident extends into multiple operational periods
Type 1 — National	Highest complexity; all command and general staff activated; national resources



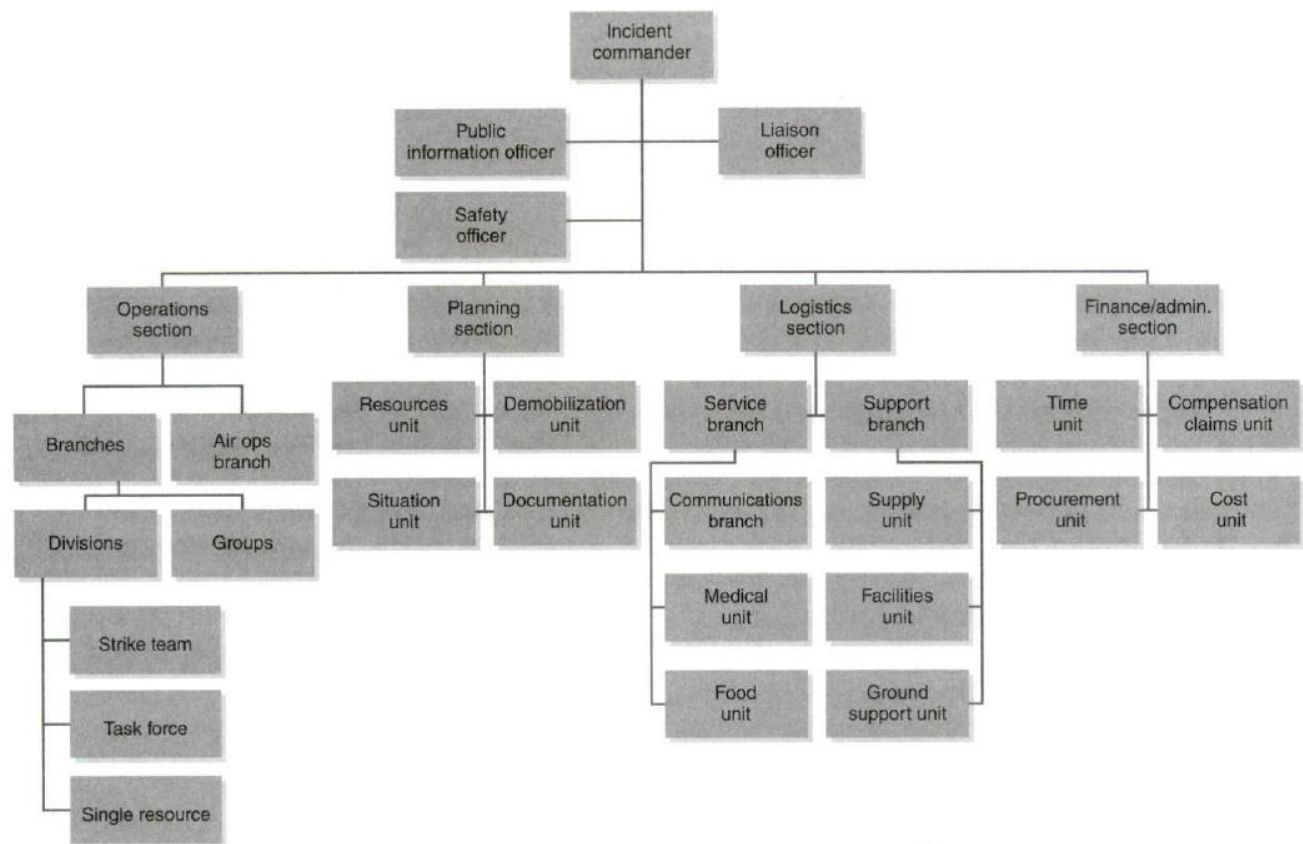
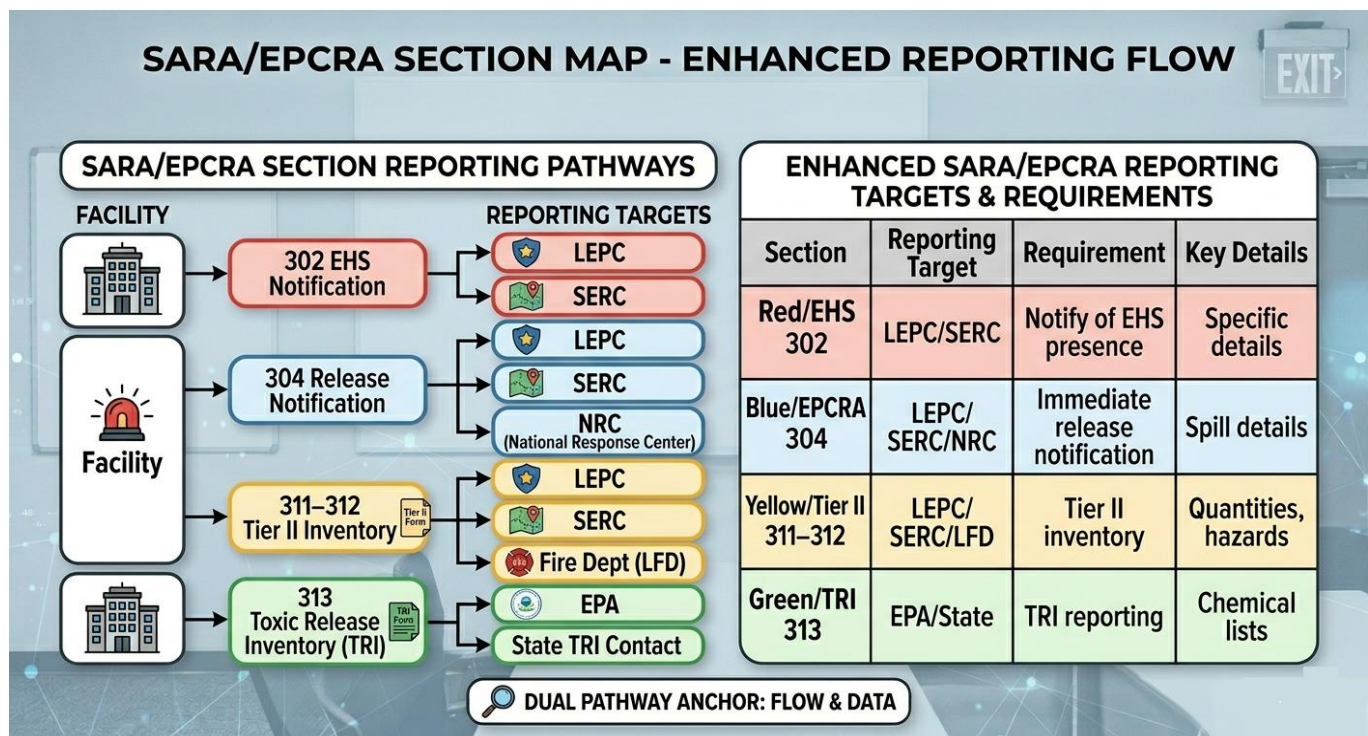


Figure 22 ICS Organizational Chart Example

2.2. EPCRA / SARA Title III

Emergency Planning and Community Right-to-Know Act (EPCRA), enacted as Title III of SARA (Superfund Amendments and Reauthorization Act), was enacted following the 1984 Bhopal, India disaster. It requires:

SARA Section	Requirement	To Whom
Section 302	Facilities with Extremely Hazardous Substances (EHS) above Threshold Planning Quantity (TPQ) must notify LEPC and SERC	LEPC, SERC
Section 304	Immediate notification when EHS or CERCLA hazardous substance released in Reportable Quantity (RQ)	LEPC, SERC, NRC
Sections 311-312	Facilities must submit SDS and Tier I/II inventory reports for chemicals above the threshold	LEPC, SERC, Fire Dept
Section 313	Annual Toxics Release Inventory (TRI) reporting of listed toxic chemicals released or transferred	EPA, State



2.3. Emergency Priorities

Priority	Focus
1st	Safety of people (life safety above all)
2nd	Protection of property
3rd	Cleanup and salvage operations
4th	Restoring normal operations

Roger Brauer Reference — Ch. 37

Brauer notes that disaster recovery success depends on pre-established mutual aid agreements and memoranda of understanding (MOUs) with neighbouring facilities and local authorities.

The incident command structure must be practiced regularly — tabletop exercises and full-scale drills test ICS integration across agencies.

CERCLA Reportable Quantities (RQ): Immediate release notifications to National Response Center (NRC) required when threshold quantities are exceeded.

EXAM TIP

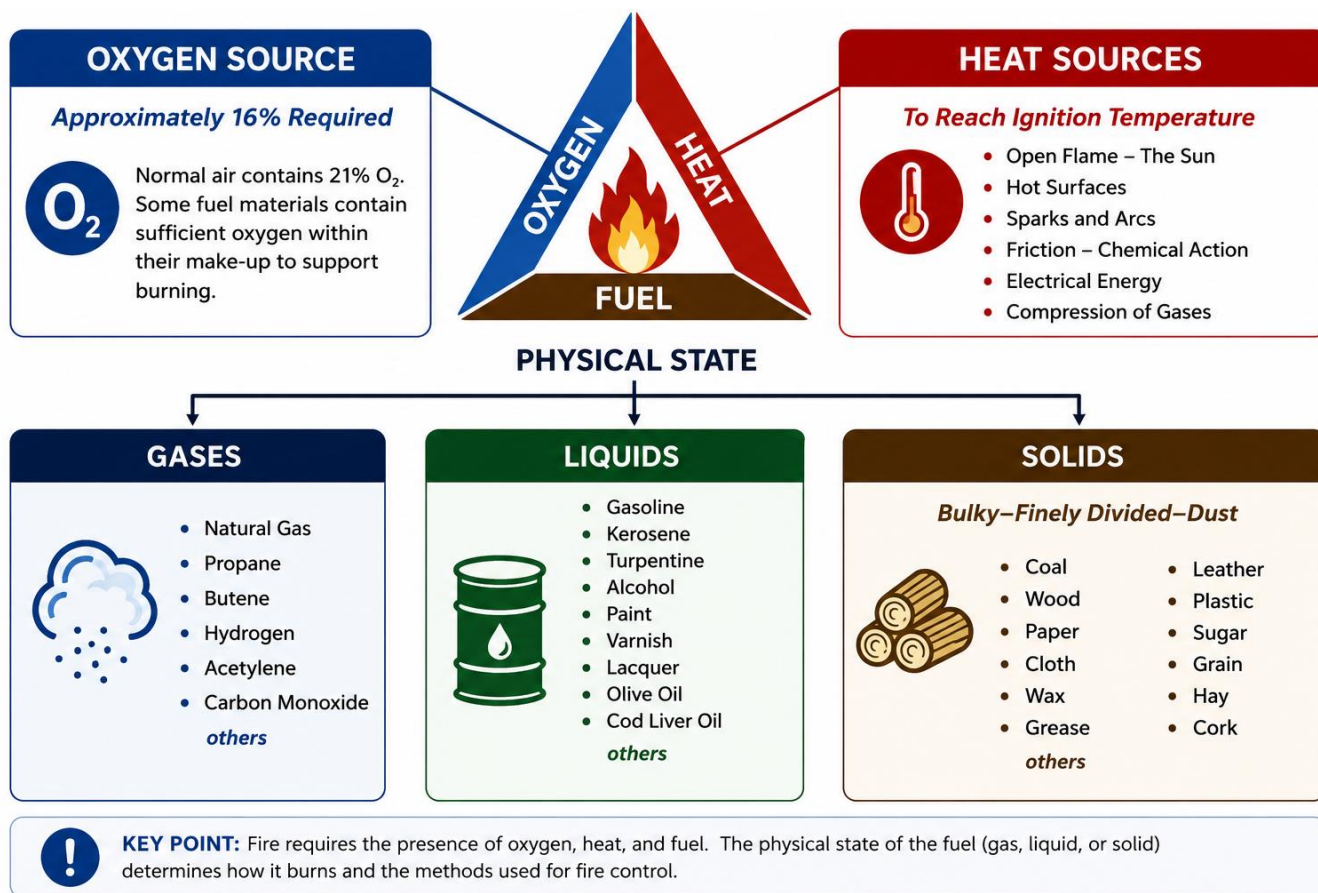
SARA Title III = EPCRA. Remember Bhopal 1984 as the triggering event. LEPC = Local Emergency Planning Committee. SERC = State Emergency Response Commission. Span of control optimal = 1:5.

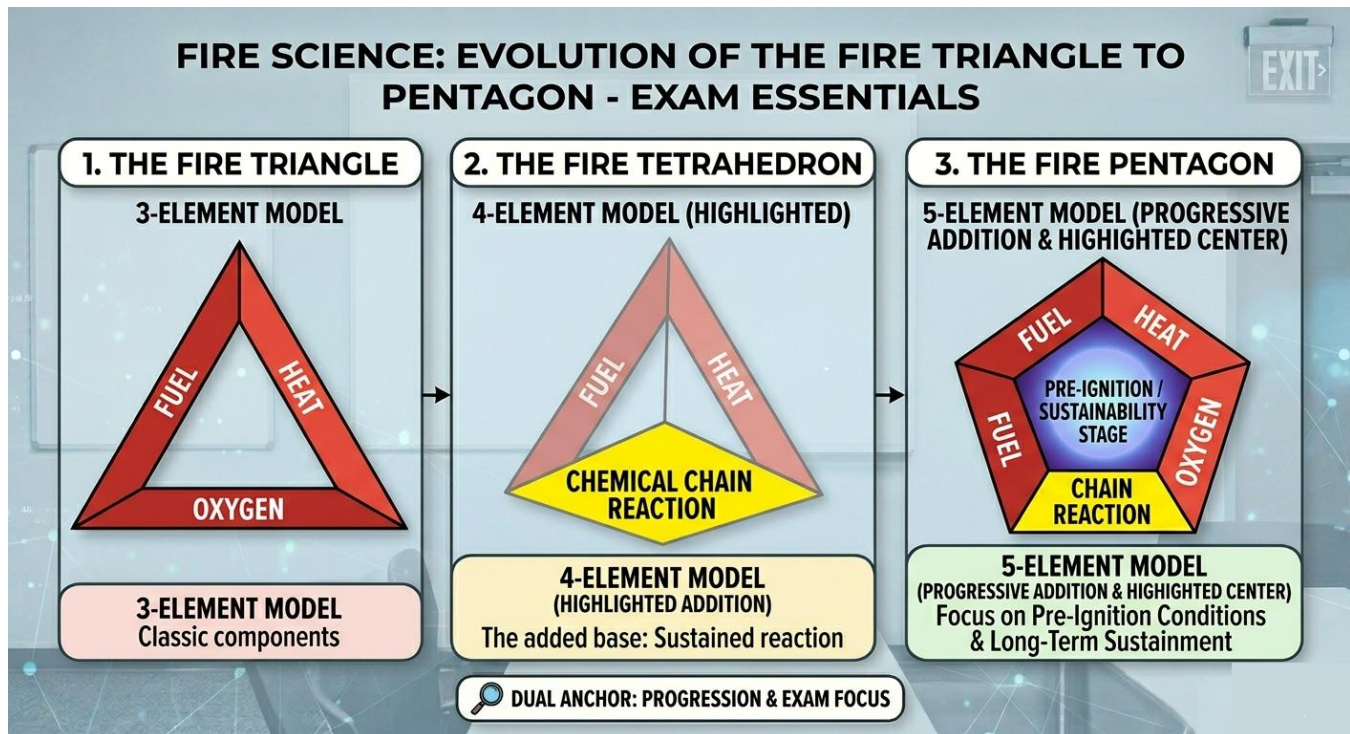
3. Fire Prevention, Protection & Suppression

3.1. Fire Science Fundamentals

The Fire Triangle, Tetrahedron, and Pentagon

- Fire Triangle: Fuel + Oxygen + Heat (all three required for combustion)
- Fire Tetrahedron (adds): Uninhibited chemical chain reaction as the 4th element
- Fire Pentagon: Adds Dispersion (dust/vapor must be dispersed at ignitable concentration)





1. Fire Pentagon

The Fire Pentagon is used to explain the conditions required for a dust explosion. It includes five elements:

1. Fuel (Combustible Dust): Finely divided solid material (like flour, sugar, or metal dust) that can burn when suspended in air.
2. Oxygen: Usually from air, it supports the combustion process.
3. Ignition Source: A heat source such as sparks, hot surfaces, or static electricity.
4. Dispersion of Dust: The dust must be suspended in air as a cloud.
5. Confinement: The dust cloud must be in an enclosed or semi-enclosed space, allowing pressure to build and cause an explosion.

All five elements must be present for a dust explosion to occur.

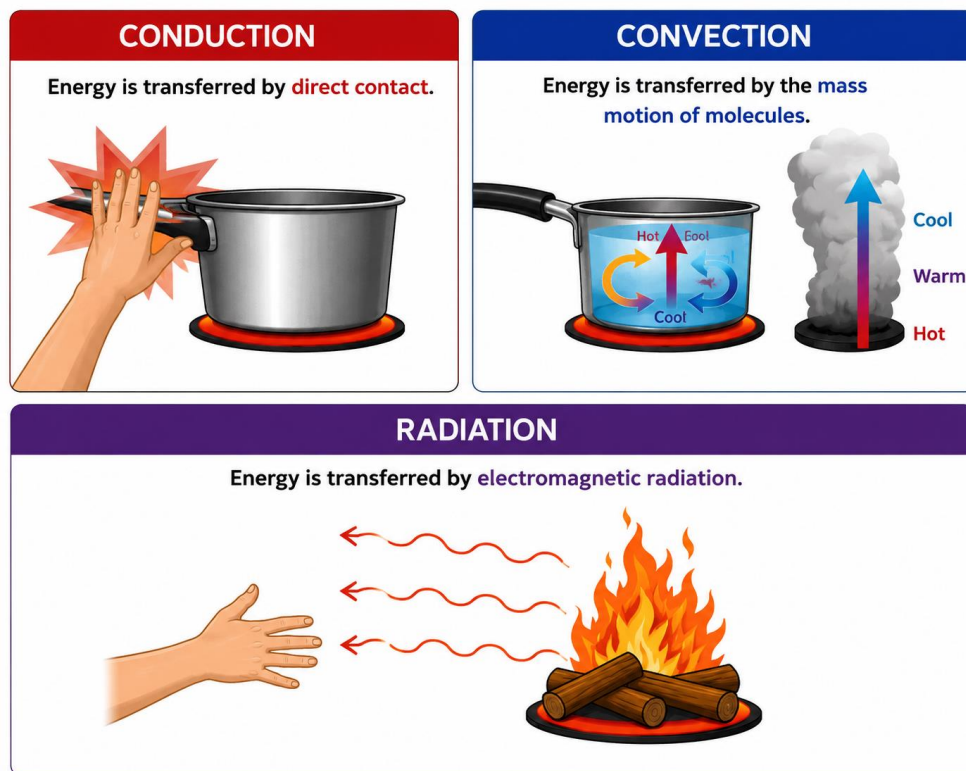
2. Fire Tetrahedron

The Fire Tetrahedron expands on the traditional fire triangle by including a fourth element. It is used to describe the conditions necessary for a sustained fire:

1. Fuel: Any material that can burn (solid, liquid, or gas).
2. Oxygen: Usually from the air (about 21% oxygen), it enables combustion.
3. Heat: Raises the temperature of the fuel to its ignition point.
4. Chemical Chain Reaction: A self-sustaining reaction that keeps the fire going after ignition.

Removing any one of these four elements will extinguish the fire.

Method of Fire Spread



1. Conduction

- **Definition:** Transfer of heat through direct contact.
- **Example:** A hand touching a hot pot. Heat flows from the pot (hotter) to the hand (cooler) through direct contact.
- **How It Works:** Molecules in the hot object vibrate and transfer energy to adjacent cooler molecules.

2. Convection

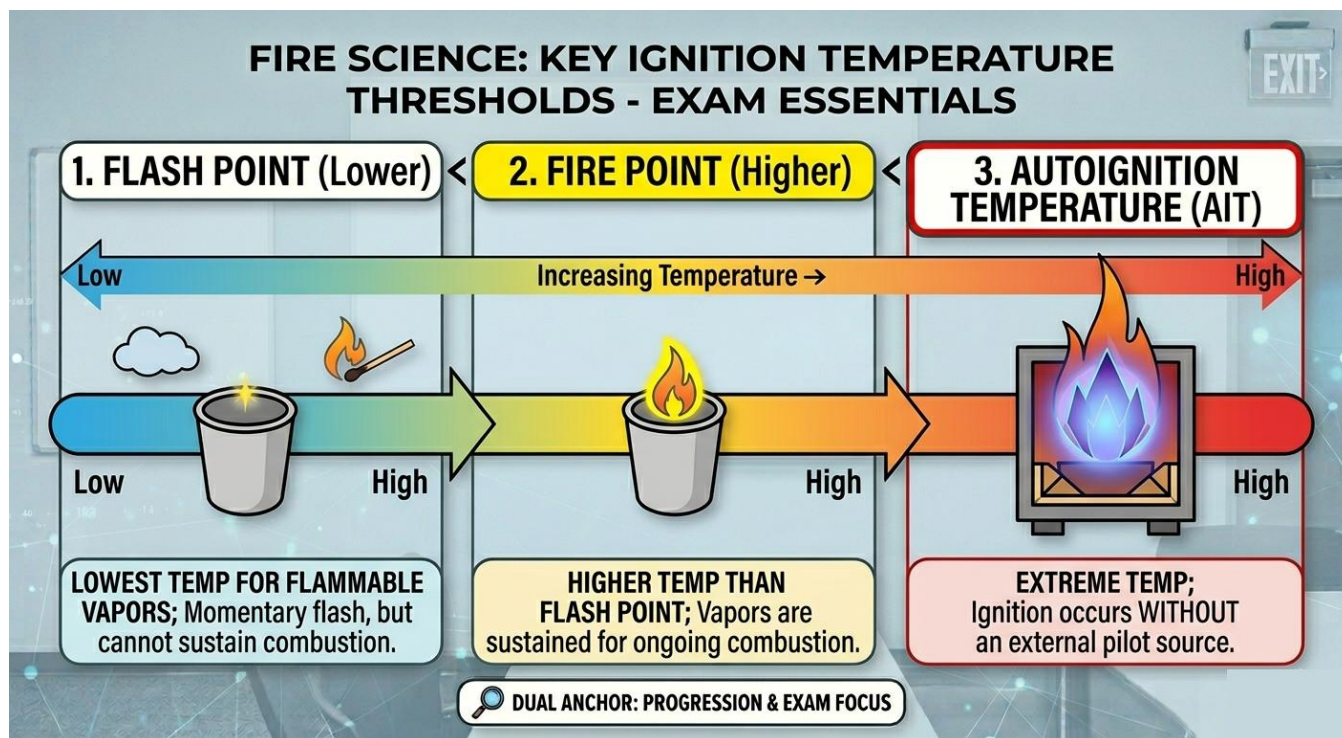
- **Definition:** Transfer of heat by the **movement of fluids** (liquids or gases).
- **Example:** Heat moving through water in a pot or through air beside the pot.
- **How It Works:** Warm fluid rises because it is less dense, and cool fluid sinks, creating a convection current that transfers heat.

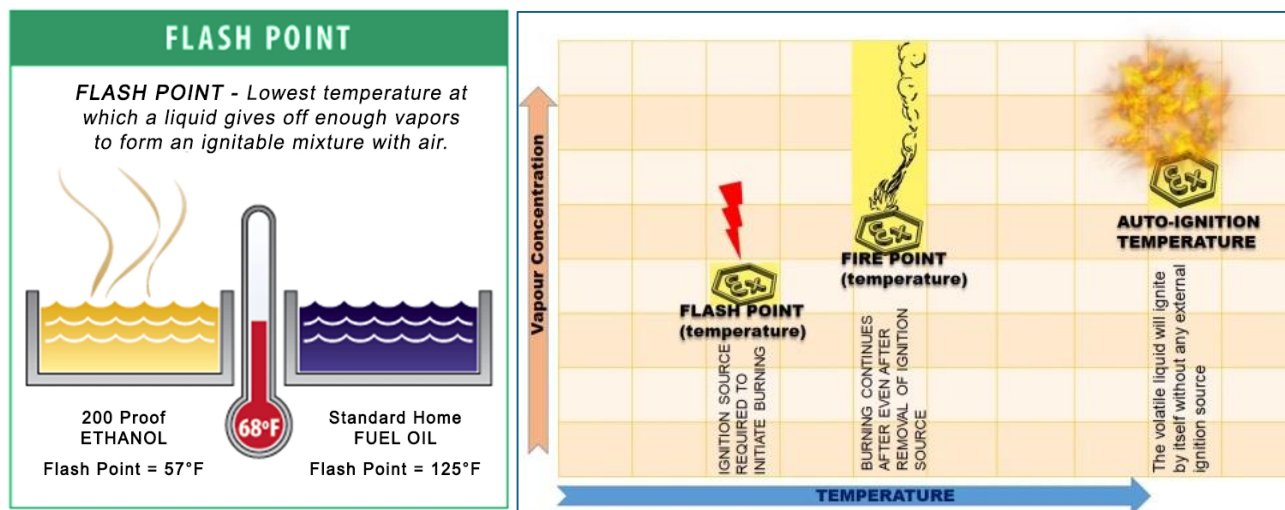
3. Radiation

- **Definition:** Transfer of energy through **electromagnetic waves** (no medium needed).
- **Example:** Feeling heat from a fire without touching it.
- **How It Works:** Infrared radiation emitted from the fire travels through the air and warms objects or people in its path.

Critical Temperature Definitions

Term	Definition	Significance
Flash Point	Lowest temperature at which a liquid produces sufficient vapor to ignite momentarily (with an ignition source)	Classifies flammability; NFPA Class designations
Fire Point	Lowest temperature at which vapor ignites and SUSTAINS combustion for at least 5 seconds	Higher than flash point
Auto-Ignition Temperature (AIT)	The temperature at which a substance ignites WITHOUT an external ignition source	Critical for storage/process design
Explosive / Flammable Limits	LEL = lowest and UEL = highest fuel-air concentration for ignition	LEL-UEL range = flammable envelope





Relationship Summary:

- As temperature increases, vapor concentration increases.
- Flash Point < Fire Point < Auto-Ignition Temperature.
- These values are critical in fire safety, chemical storage, and process safety management.

Upper and Lower Explosive Limits (UEL and LEL)

These limits define the concentration range of a flammable gas or vapor in air within which combustion can occur:

- LEL (Lower Explosive Limit): The lowest concentration of a gas or vapor in air that can ignite. Below this limit, the mixture is too lean to burn.
- UEL (Upper Explosive Limit): The highest concentration of a gas or vapor in air that can ignite. Above this limit, the mixture is too rich to burn.

A substance is flammable/explosive only when its concentration in air is between the LEL and UEL.

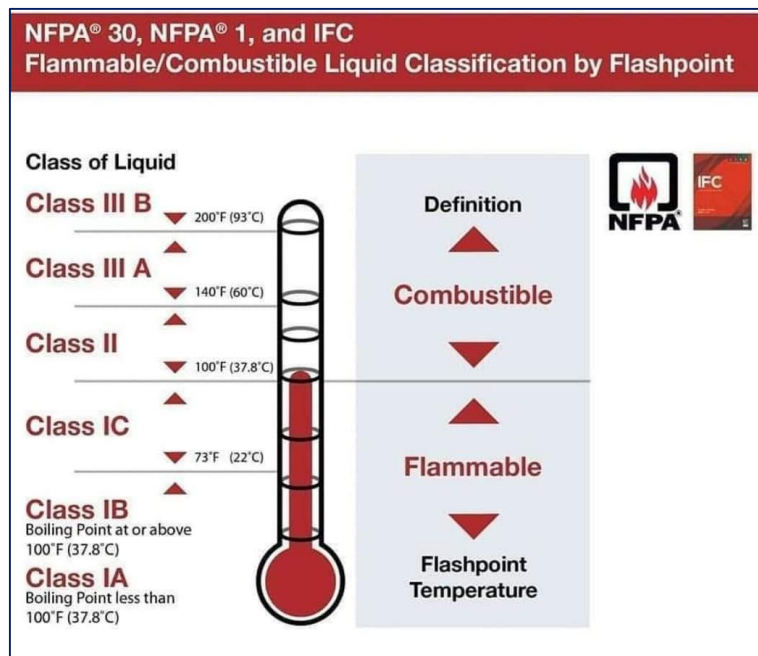
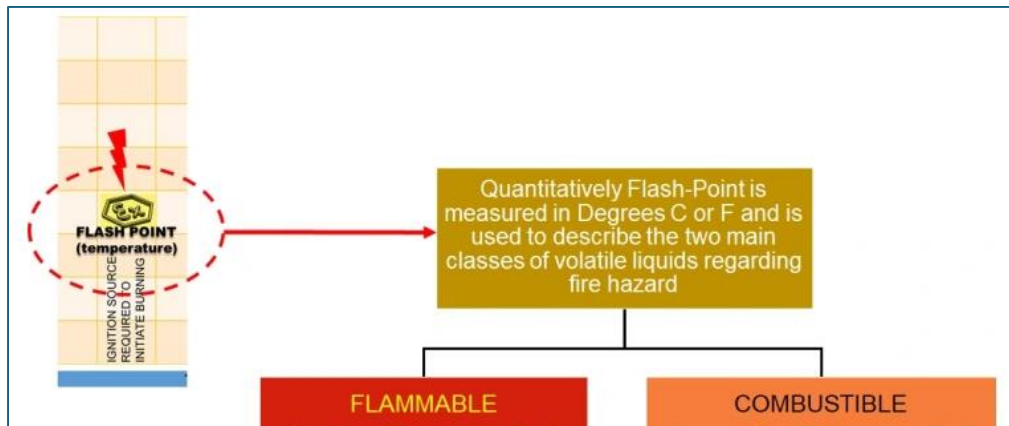
LOWER AND UPPER FLAMMABILITY / EXPLOSIVE LIMITS FOR COMMON CHEMICALS

CHEMICAL	LFL/LEL (Vol%)	UFL/UEL (Vol%)
Acetaldehyde	4	60
Acetone	2.6	12.8
Acetylene	2.5	81
Ammonia	15	28
Arsine	5.1	78
Benzene	1.35	6.65
n-Butane	1.86	8.41
iso-Butane	1.80	8.44
iso-Butene	1.8	9.0
Butylene	1.98	9.65
Carbon disulfide	1.3	50
Carbon monoxide	12	75
Cyclohexane	1.3	8
Cyclopropane	2.4	10.4
Diethyl ether	1.9	36
Ethane	3	12.4
Ethylene	2.75	28.6
Ethyl alcohol	3.3	19
Ethyl chloride	3.8	15.4
Fuel oil no. 1	0.7	5
Hydrogen	4	75
Isobutane	1.8	9.6
Isopropyl alcohol	2	12
Gasoline	1.4	7.6
Kerosene	0.7	5
Methane	5	15
Methyl alcohol	6.7	36
Methyl chloride	10.7	17.4
Methyl ethyl ketone	1.8	10
Naphthalene	0.9	5.9
n-Heptane	1.0	6.0
n-Hexane	1.25	7.0
n-Pentane	1.65	7.7
Neohexane	1.19	7.58
Neopentane	1.38	7.22
n-Octane	0.95	3.20
iso-Octane	0.79	5.94
n-Pentane	1.4	7.8
iso-Pentane	1.32	9.16
Propane	2.1	10.1
Propylene	2.0	11.1
Silane	1.5	98
Styrene	1.1	6.1
Toluene	1.27	6.75
Triptane	1.08	0.69
p-Xylene	1.0	6.0



Note: Limits are for gas and air at 20°C and atmospheric pressure.

Flammable and Combustible Liquids Classification NFPA 30



CLASSIFICATION OF FLAMMABLE LIQUIDS

NFPA 30 classifies flammable liquids based on flash point and boiling point.



Class	Flash Point	Boiling Point
Class IA	Below 73°F (22.8°C)	Below 100°F (37.8°C)
Class IB	Below 73°F (22.8°C)	100°F (37.8°C) and above
Class IC	73°F (22.8°C) and above, but below 100°F (37.8°C)	—



Flash point is the lowest temperature at which a liquid can produce enough vapor to form an ignitable mixture in air near the surface of the liquid.

FIRE HAZARD SEVERITY OF FLAMMABLE LIQUIDS

NFPA 30 assigns fire hazard severity based on the maximum flash point of each class.

Class of Liquid

- Class IA, IB** → < 73°F (22.8°C)
- Class IC** → < 100°F (37.8°C) and ≥ 73°F (22.8°C)
- Class III B** → ≥ 100°F (37.8°C)



Temperatures are maximum flash points.

Fire Hazard Severity

Extreme
(Most Hazardous)

▼

Considerable

▼

Moderate

▼

Slight
(Least Hazardous)



FLAMMABLE LIQUID



COMBUSTIBLE LIQUID

CLASSIFICATION OF COMBUSTIBLE LIQUIDS

NFPA 30 classifies combustible liquids based on flash point.



Class	Flash Point
Class II	100°F (37.8°C) and above, but below 140°F (60°C)
Class IIIA	140°F (60°C) and above, but below 200°F (93°C)
Class IIIB	200°F (93°C) and above



KEY POINTS:

- Flash point determines how easily a liquid can produce flammable vapors.
- Lower flash points mean greater fire hazard.

FIRE HAZARD SEVERITY OF COMBUSTIBLE LIQUIDS

NFPA 30 assigns fire hazard severity based on the minimum flash point of each class.

Class of Liquid

- Class II** → ≥ 100°F (37.8°C) and < 140°F (60°C)
- Class IIIA** → ≥ 140°F (60°C) and < 200°F (93°C)
- Class IIIB** → ≥ 200°F (93°C)



Temperatures are minimum flash points.

Fire Hazard Severity

Extreme
(Most Hazardous)

▼

Considerable

▼

Moderate

▼

Slight
(Least Hazardous)



FLAMMABLE LIQUID



COMBUSTIBLE LIQUID

- NFPA 30 classification is used for storage, handling, and protection requirements.
- Always refer to the latest edition of NFPA 30 for complete details.

Above explains the classification of flammable and combustible liquids based on flash point and boiling point, as defined by NFPA 30, NFPA 1, and IFC (International Fire Code) standards. Understanding these classifications is crucial for safe storage, handling, and fire protection.

EXAM TIP

Remember the Class and corresponding Flashpoint ranges for the direct or scenario-based questions in the exam,

Storage Requirements Flammable and Combustible Liquids

STORAGE REQUIREMENTS FOR
FLAMMABLE AND COMBUSTIBLE LIQUIDS

GENERAL

These tables show the maximum allowable size of containers for flammable and combustible liquids, respectively.



INSIDE STORAGE ROOMS

When flammable or combustible liquids are stored in inside rooms, the storage room shall be equipped with either a gravity or a mechanical exhaust ventilation system. This system shall be designed to provide a complete change of air within the room at least six times per hour.

In addition, in each inside storage room, there shall be maintained one clear aisle at least 3 ft wide. Containers over 30-gal capacity will not be stacked one upon the other.

The table below illustrates the maximum storage capacity for any inside storage room.



MAXIMUM ALLOWABLE SIZE OF CONTAINERS FOR FLAMMABLE LIQUIDS (OSHA)

Container Type	Flammable Liquids		
	Class IA	Class IB	Class IC
Glass or approved plastic	1 pt	1 qt	1 gal
Metal (other than DOT drums)	1 gal	5 gal	5 gal
Safety cans	2 gal	5 gal	5 gal
Metal drums (DOT specifications)	60 gal	60 gal	60 gal
Approved portable tanks	660 gal	660 gal	660 gal



MAXIMUM ALLOWABLE SIZE OF CONTAINERS FOR COMBUSTIBLE LIQUIDS (OSHA)

Container Type	Combustible Liquids	
	Class II	Class III
Glass or approved plastic	1 gal	1 gal
Metal (other than DOT drums)	5 gal	5 gal
Safety cans	5 gal	5 gal
Metal drums (DOT specifications)	60 gal	60 gal
Approved portable tanks	660 gal	660 gal



INSIDE STORAGE ROOM MAXIMUM QUANTITIES PER SQUARE FOOT (OSHA)

Fire Protection Provided ^a	Fire Resistance (h)	Maximum Size (ft ²)	Total Allowable Quantities (gal/ft ²)
Yes	2	500	10
No	2	500	5
Yes	1	150	4
No	1	150	2



Note: Limits are for gas and air at 20°C and atmospheric pressure.

3.2. Common Electrical Fire Causes

- Static electricity
- Surge
- Arc flash
- Ground fault circuit interrupter
- Grounding and bonding

What is Static Electricity?

Static electricity is the accumulation of electrical charges on the surface of materials due to friction, separation, or movement of materials. When the accumulated charge is suddenly released, it can cause electrostatic discharge (ESD), resulting in equipment damage, product defects, fires, explosions, or personnel injury.

Industry	Process	Example of static electricity related issue
Semiconductor and electronic parts	SMT line	Chip component suction / mounting problem
	Assembly / Inspection	Circuit and device destruction
Automobile	Painting	Dust adhesion
Paper and pulp	Printing	Paper sticking together
	Processing	Adhesion of foreign particle, electric shock, pinhole formation
	Coating	Ignition
Other	Chemical	Ignition, explosion
	Textile	Stripping and cutting of thread
	Food	Contamination with foreign particles

Method	Example	Principle
Conductive method	Conductive mat, painted floor, etc.	Redirect static electricity to the ground
	Wrist strap etc.	
	Electrostatic shoes, electrostatic work clothing etc.	
	Conductivity (Antistatic spray etc.)	
Static eliminator (Ionizer)	Corona discharge type	Neutralize static electricity
	Soft X-ray type	
Humidity control	Humidification	Prevent the generation of static electricity

Table 2. Anti-static measures (example)

1. Industrial Impacts of Static Electricity

The upper table illustrates how static electricity affects different industries and processes.

Industry	Process	Potential Static Electricity Problem
Semiconductor & Electronics	SMT Line	Components may stick to pick-and-place nozzles, causing mounting errors.
Semiconductor & Electronics	Assembly / Inspection	Electrostatic discharge can destroy sensitive circuits and electronic devices.
Automobile	Painting	Charged surfaces attract dust particles, resulting in paint defects and poor finish quality.
Paper & Pulp	Printing	Sheets may stick together, causing feeding and printing problems.
Paper & Pulp	Processing	Dust attraction, electric shocks, and pinhole defects may occur.
Paper & Pulp	Coating	Static discharge can ignite flammable coating materials.
Chemical Industry	Chemical Processing	Electrostatic sparks may ignite flammable vapors leading to fires or explosions.
Textile Industry	Textile Manufacturing	Static charges cause thread breakage, stripping, and production interruptions.
Food Industry	Food Processing	Dust and foreign particles are attracted to products, causing contamination.

Example

During solvent transfer in a chemical plant, static charge accumulates on the transfer hose. If not grounded, a spark can occur and ignite flammable vapors, resulting in a fire or explosion.

2. Anti-Static (ESD Control) Measures

The lower table presents common methods used to prevent or control static electricity.

A. Conductive Grounding Method

Principle:

Provide a path for accumulated electrical charges to safely flow to earth (ground).

Examples:**Conductive Mats and Floors**

- Installed in electronic assembly areas.
- Prevent charge buildup on personnel and equipment.

Wrist Straps

- Worn by workers handling sensitive electronic components.
- Continuously discharge static electricity to ground.

Electrostatic Shoes and Clothing

- Used in electronics, pharmaceutical, and explosive environments.
- Prevent charge accumulation on workers.

Antistatic Sprays and Conductive Coatings

- Increase surface conductivity.
- Allow charges to dissipate safely.

Example:

Workers assembling microchips wear wrist straps connected to grounding systems to prevent ESD damage to electronic components.

B. Static Eliminators (Ionizers)**Principle:**

Neutralize positive and negative electrical charges in the air.

Types:**Corona Discharge Ionizers**

- Produce positive and negative ions.
- Neutralize charged surfaces.

Soft X-ray Ionizers

- Generate ions using low-energy X-rays.
- Used where grounding alone is insufficient.

Example:

In semiconductor manufacturing, ionizers are installed above conveyor belts to eliminate static charges on electronic parts.

C. Humidity Control

Principle:

Increasing humidity reduces static charge generation by making air and surfaces more conductive.

Method:

- Humidifiers maintain relative humidity, typically between 40% and 60%.

Example:

Printing facilities maintain humidity levels to prevent paper sheets from sticking together due to static electricity.

Hazards of Static Electricity

- Fire and explosion
- Damage to electronic equipment
- Product contamination
- Process interruptions
- Personnel electric shock
- Reduced product quality

Control Hierarchy for Static Electricity

1. Grounding and Bonding
2. Conductive Flooring and Equipment
3. Antistatic Clothing and PPE
4. Ionization Systems
5. Humidity Control
6. Inspection and Maintenance
7. Employee Training

Key Point

Static electricity becomes a significant occupational safety hazard when an electrostatic discharge occurs in the presence of sensitive electronics, combustible dusts, flammable liquids, gases, or vapors. Effective control is achieved through grounding, bonding, ionization, humidity control, and the use of conductive materials.

Relevant Standards

- NFPA 77 – Recommended Practice on Static Electricity
- NFPA 652 – Standard on Combustible Dust
- IEC 61340 Series – Electrostatics
- OSHA 29 CFR 1910.106 (Flammable Liquids)
- OSHA 29 CFR 1910.307 (Hazardous Locations)

These standards provide guidance for controlling static electricity and preventing fires, explosions, and equipment damage in the workplace.

Surge/ Inrush Current?

Inrush current is the very high, short-duration surge of current that occurs when electrical equipment is first energized. It is typically much higher than the normal operating current and lasts only for a few milliseconds to seconds before settling to the steady-state value.

The left-side graph illustrates this phenomenon:

- Peak Current: The highest current reached immediately after startup.
- Inrush Current Magnitude: Difference between the peak current and the normal operating current.
- Pulse Width: Duration of the inrush current event.
- Steady-State Current: Normal operating current after the equipment stabilizes.

Example:

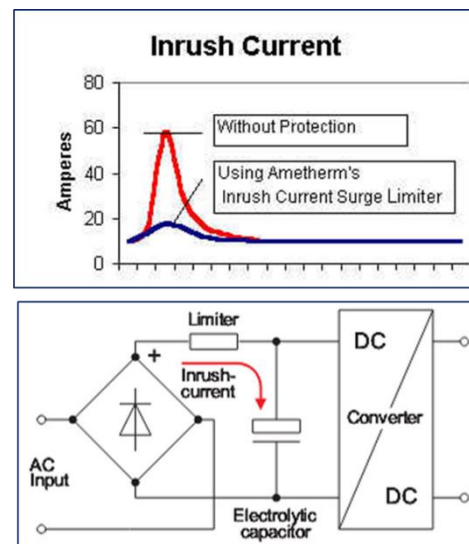
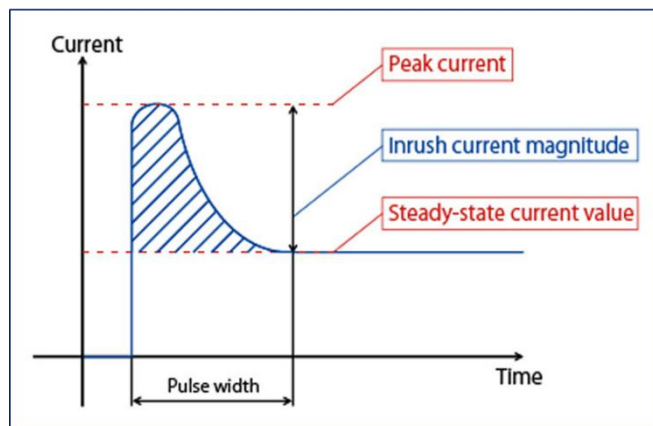
A motor normally operating at 10 A may draw 50–70 A during startup. Similarly, a power supply with large capacitors may draw several times its rated current when switched on.

Why Does Inrush Current Occur?

Inrush current is caused by components that initially behave like a short circuit when power is applied.

Common sources include:

- Capacitors: Large capacitors in power supplies are initially discharged and draw a large charging current.
- Transformers: Magnetic cores can saturate during energization, causing high magnetizing current.
- Electric Motors: Motors require high starting torque, resulting in high startup current.
- LED Drivers and SMPS: Switch-mode power supplies contain large DC bus capacitors that create charging surges.



Hazards Associated with Excessive Inrush Current

Electrical Hazards

- Tripping of breakers
- Fuse failure
- Voltage dips

Equipment Damage

- Overheating of cables
- Contact welding in switches and relays
- Transformer stress
- Capacitor degradation

Operational Problems

- Unexpected shutdowns

- Reduced equipment lifespan
- Production interruptions

Hazard Recognition

A safety professional should recognize that excessive inrush current can:

- Create overheating hazards
- Damage electrical equipment
- Cause power quality issues
- Increase fire risk
- Lead to unexpected process shutdowns

Control Measures

- Proper equipment sizing
- Inrush current limiters
- Soft starters and VFDs
- Correct fuse and breaker selection
- Preventive maintenance
- Thermal monitoring

Key Note

Inrush current is a temporary startup current surge that can be several times higher than normal operating current. Although short in duration, it can cause overheating, equipment damage, nuisance tripping, and electrical fires. Effective controls include NTC thermistors, soft starters, VFDs, pre-charge circuits, and properly designed protective devices.

Relevant Standards

- NFPA 70 (National Electrical Code – NEC)
- NFPA 70E – Electrical Safety in the Workplace
- IEEE 3004 Series – Electrical System Design
- IEC 60947 – Low Voltage Switchgear and Controlgear
- OSHA 29 CFR 1910 Subpart S – Electrical Safety

Arc Flash

An Arc Flash is the sudden release of thermal energy caused by an electric arc between conductors or between a conductor and ground. Arc temperatures can exceed 19,000°C (35,000°F), which is hotter than the surface of the sun.

Arc flashes can produce:

- Extreme heat
- Intense light
- Molten metal splatter
- Pressure waves (arc blast)
- Toxic fumes
- Serious burns and fatalities

Common Causes of Arc Flash

- Accidental contact with energized conductors
- Dropped tools
- Equipment failure
- Dust, moisture, or corrosion
- Improper maintenance
- Insulation breakdown

Incident Energy

Incident Energy is the amount of thermal energy reaching a worker's body at a specific distance from the arc source.

- Measured in calories/cm² (cal/cm²)
- Used to determine PPE requirements
- Higher incident energy = greater burn severity

Example:

An electrical panel may have:

- Incident Energy = 4.8 cal/cm² at 18 inches

Personnel working on that equipment must wear arc-rated PPE exceeding 4.8 cal/cm².

Flash Protection Boundary

The Arc Flash Boundary is the distance from an arc source where a person may receive a second-degree burn if not protected by arc-rated PPE. The value of incident energy at this point is quantified as 1.2 cal/cm² or 5J/cm² as per NFPA 70E.

Only qualified and properly protected persons should enter this boundary.

Arc Flash Dependence

Arc flash severity depends primarily on:

1. Fault Current

Fault current is the amount of electrical current flowing during a fault condition.

Higher fault current produces:

- Larger arc energy
- Greater heat release
- More severe burns

Control Measures

- Current-limiting fuses
- Current-limiting circuit breakers
- High-resistance grounding
- Proper system design

Example:

Replacing a standard fuse with a current-limiting fuse can significantly reduce available arc energy.

2. Arcing Time

Arcing time is the duration that the arc exists before the protective device clears the fault.

Arc Flash Energy $\propto$ Arcing Time

The longer the fault remains active, the greater the energy released.

Control Measures

- Maintenance switches
- Arc flash relays
- Zone selective interlocking

- Faster protective devices

Example:

A breaker clearing a fault in 0.05 seconds produces much less incident energy than one clearing it in 0.5 seconds.

3. Distance

Incident energy decreases rapidly as distance from the arc source increases.

Control Measures

- Remote racking systems
- Remote switching devices
- Automated operation
- Robotic maintenance systems

Example:

An operator standing 10 meters away using remote breaker racking is exposed to significantly less arc flash energy than someone standing directly in front of the switchgear.

Arc Flash PPE Categories (NFPA 70E Article 130)

PPE Category	Minimum Arc Rating of Clothing System	Typical PPE Requirements
Category 1	4 cal/cm ²	Arc-rated shirt and pants or coverall, arc-rated face shield, hard hat, safety glasses, hearing protection, leather gloves, leather footwear
Category 2	8 cal/cm ²	Arc-rated clothing system, arc-rated face shield with balaclava, hard hat, safety glasses, hearing protection, leather gloves
Category 3	25 cal/cm ²	Arc-rated flash suit hood, arc-rated clothing system, hard hat, safety glasses, hearing protection, voltage-rated gloves with leather protectors
Category 4	40 cal/cm ²	Arc-rated flash suit hood, multilayer arc-rated clothing system, hard hat, hearing protection, voltage-rated gloves with leather protectors, leather footwear

NFPA 70E Article 130 Key Boundaries

Boundary	Purpose
Limited Approach Boundary	Protection against electric shock
Restricted Approach Boundary	Increased shock hazard; only qualified persons allowed
Arc Flash Boundary	Distance at which incident energy equals 1.2 cal/cm ² (threshold for second-degree burn)

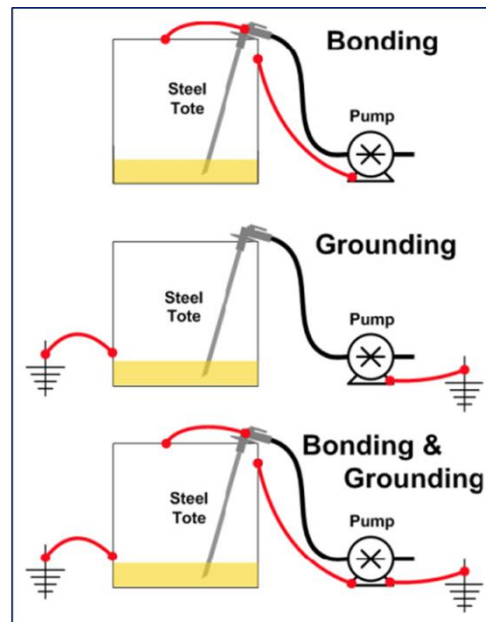
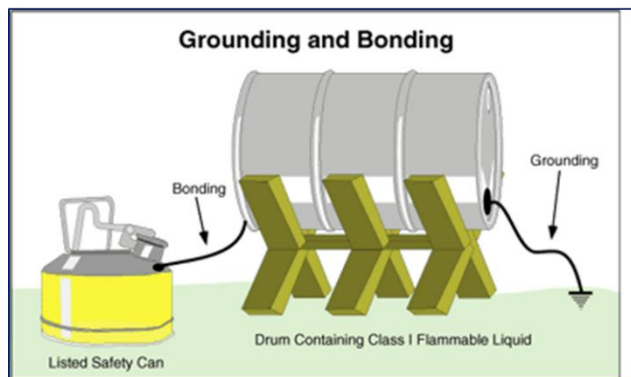
Key Points**Methods to Reduce Arc Flash Risk**

1. Eliminate energized work whenever possible.
2. Establish an Electrically Safe Work Condition (LOTO).
3. Reduce available fault current.
4. Reduce fault clearing time.
5. Increase working distance.
6. Use remote operation technologies.
7. Wear properly rated Arc Flash PPE.
8. Conduct Arc Flash Risk Assessments as required by NFPA 70E.

Relevant Standards

- NFPA 70E – Standard for Electrical Safety in the Workplace
- NFPA 70 (NEC)
- IEEE 1584 – Guide for Arc Flash Hazard Calculations
- OSHA 29 CFR 1910 Subpart S
- CSA Z462 – Workplace Electrical Safety

Grounding and Bonding



1. Grounding

Definition:

Grounding is the process of connecting electrical systems or equipment to the earth to establish a reference voltage level (zero volts) and safely dissipate electrical faults or lightning.

Purpose:

- Provides a path to the earth for fault currents such as lightning or insulation failure
- Maintains voltage stability in electrical systems
- Protects equipment and people by ensuring exposed metal parts do not reach dangerous voltages

Types of Grounding:

- System grounding: Connecting one point of the system (typically the neutral) to ground
- Equipment grounding: Connecting non-current-carrying metal parts of equipment to ground

Applications:

- Electrical substations and transformers
- Power distribution systems
- Building electrical installations
- Lightning protection systems

2. Bonding

Definition:

Bonding is the intentional connection of all metallic parts and conductive components together to maintain a common electrical potential, especially during fault conditions.

Purpose:

- Prevents voltage differences between conductive parts
- Ensures all metal parts remain at the same potential to reduce shock hazards
- Complements grounding by connecting all grounded parts

Applications:

- Bonding of metal enclosures, piping systems, and structural steel
- Electrical panels and junction boxes
- Fueling systems to prevent static discharge
- Aircraft and fuel trucks during refueling operations

Key Differences between Grounding and Bonding

Feature	Grounding	Bonding
Purpose	Connects to earth (ground)	Connects metal parts to each other
Path	Provides path to ground for fault current	Provides path between conductive parts
Components	Uses earth, ground rods, electrodes	Uses conductors, clamps, and bonding straps
Focus	Fault current dissipation	Equal potential between metal parts
Example	Neutral of panel connected to ground rod	Water pipe connected to electrical panel

Why Both Are Important:

Grounding helps remove dangerous voltages by directing fault current to earth. Bonding ensures that no dangerous voltage difference exists between conductive surfaces that people may touch. Together, grounding and bonding are essential for electrical safety, minimizing electric shock hazards and protecting equipment in compliance with standards like NFPA 70E and OSHA.

3.3. Hot Work (Welding, Cutting, and Brazing)

Hot Work refers to any operation that produces heat, sparks, flames, or molten metal capable of igniting combustible or flammable materials. Common examples include welding, cutting, brazing, grinding, and soldering.

Hazards of Welding Operations

1. Fire Hazards

Sparks and molten metal can ignite nearby combustible materials.

Control: Remove combustibles, use fire blankets, and keep fire extinguishers available.

2. Metal Splatter

Molten metal droplets can cause burns and eye injuries.

Control: Wear welding gloves, leather aprons, and safety boots.

3. Electric Shock

Contact with energized welding equipment can cause serious injury or death.

Control: Proper grounding, equipment inspection, and dry working conditions.

4. Explosion Hazards

Welding near flammable gases, vapors, or tanks may cause explosions.

Control: Gas testing, isolation, purging, and hot work permits.

5. Released Gases and Fumes

Welding fumes may contain toxic metals and harmful gases.

Control: Ventilation, fume extraction, and respiratory protection.

6. Radiant Energy

UV and infrared radiation from the welding arc can damage eyes and skin.

Control: Welding helmet, face shield, welding curtains, and FR clothing.

Hot Work Hazards at Oil & Gas Sites

Hot work hazards are commonly found at:

- Wellheads
- Storage tanks
- Pipelines
- Separator units
- Compressor stations
- Drilling rigs
- Refineries and processing plants

Due to the presence of **flammable hydrocarbons**, hot work can easily lead to fires or explosions if proper controls are not implemented.

Essential Hot Work Controls

- Hot Work Permit
- Gas Testing
- Isolation/LOTO
- Fire Watch
- Fire Extinguishers
- Adequate Ventilation
- Appropriate PPE

Required PPE

- Welding Helmet
- Safety Glasses
- Welding Gloves
- Flame-Resistant (FR) Clothing
- Leather Apron/Jacket
- Safety Boots
- Respiratory Protection (when required)

Exam Note

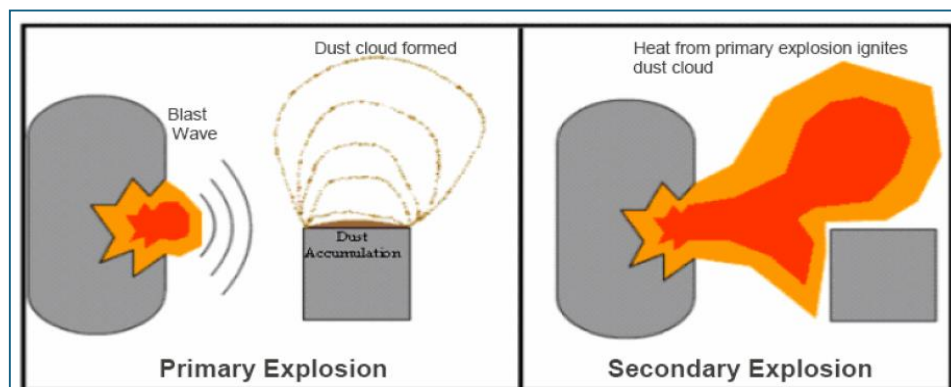
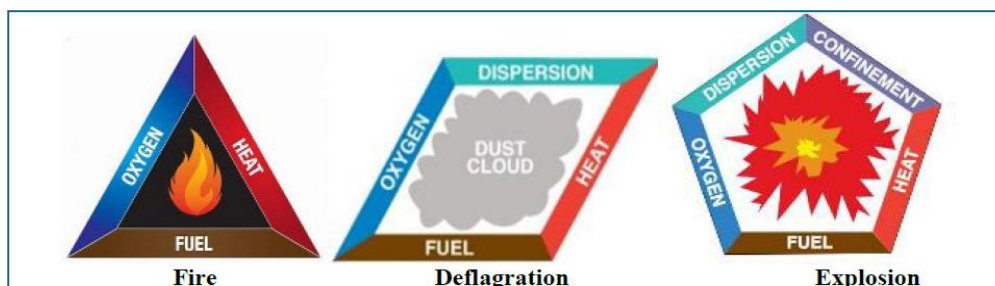
Hot work is any activity that generates heat, sparks, or flames and can cause fires, explosions, burns, electric shock, toxic fume exposure, and radiation injuries. Effective controls include permits, gas testing, fire watch, isolation, ventilation, and proper PPE.

References: OSHA 29 CFR 1910 Subpart Q, NFPA 51B, ANSI Z49.1, API RP 2009.

3.4. Combustible Dust

Table 1: Common categories of combustible dusts (with examples).³

Foods	Flours, starches, sugars, powdered milk, corn meal, cocoa powder, whey, cereal, spices, and gluten.
Agriculture and Grains	Wheat, corn, barley, oats, and soybeans.
Metals	Aluminum, iron, magnesium, nickel, niobium, tantalum, titanium, zinc, and zirconium dusts.
Wood	Sawdust and cellulosic dusts, including dusts from paper, cardboard, paper towels, facial tissue, and other paper products.
Plastics	Resins (e.g., melamine, epoxy, phenolic), polymers (e.g., polyethylene, polyvinylchloride, polyacrylamide, polyacrylonitrile), and copolymers.
Chemicals	Adipic acid, anthraquinone, dextrin, lactose, paraformaldehyde, sodium stearate, and sulfur.
Coal and other Carbonaceous Materials	Bituminous, subbituminous, lignite, charcoal, petroleum coke, and carbon black.
Other	Textiles, biosolids, soap, and pet food.



This image illustrates the two-stage process of a dust explosion—a highly hazardous event in industries handling combustible dust (e.g., food processing, pharmaceuticals, metalworking).

Primary Explosion

- What happens: A small initial explosion occurs inside a confined piece of equipment (e.g., a silo, duct, or hopper).
- Cause: Accumulated combustible dust in the air ignites due to heat, spark, friction, or another ignition source.
- Effect: This causes a blast wave and dislodges settled dust in the surrounding area.
- Result: The disturbance forms a dust cloud (suspended particles in air), setting the stage for the next phase.

Secondary Explosion

- What happens: The heat and flame from the primary explosion ignite the newly formed dust cloud.
- Cause: The dust cloud is now in an ignitable concentration, and the primary explosion provides sufficient heat to ignite it.
- Effect: A much larger and more dangerous secondary explosion occurs, often outside the equipment and in open workspace.
- Result: This explosion is often far more destructive—causing fatalities, injuries, and extensive damage to facilities.

Key Takeaways

- Dust accumulation is a critical hazard if not regularly cleaned.
- The secondary explosion is typically the deadliest and most damaging.
- Proper housekeeping, ventilation, dust collection, and explosion mitigation systems are vital to prevent such events.

Ignition sources in equipment

- Impact sparks,
- Mechanical heating (friction),
- Material self-heating,
- Open flames,
- Hot work,
- Incompatible chemical reactions,

- Electrical equipment, and
- Electrostatic discharge.

3.5. Fire Detection Systems

Detector Type	Mechanism	Best Application
Ionization Smoke	Radioactive source ionizes the air; smoke disrupts the current	Fast-flaming fires; open areas
Photoelectric Smoke	Light beam scattered by smoke particles	Slow-smouldering fires are better for residences
Heat Detector — Fixed Temperature	Triggers at set temperature (e.g., 135°F/57°C)	Dusty/dirty environments where smoke detectors falsely alarm
Heat Detector — Rate-of-Rise	Triggers if the temperature rises >12°-15°F per minute	Rapid-fire growth scenarios
Flame Detector (UV/IR)	Detects UV or IR radiation emitted by flames	High-value areas: flammable liquids storage
Sprinkler Waterflow	The flow switch activates the alarm when the sprinkler opens	All suppressed areas

1. Heat Detectors

Heat detectors respond to elevated temperatures and are commonly used in areas where smoke detectors may trigger false alarms (e.g., kitchens, boiler rooms). They are slower to react than smoke detectors but are effective in detecting fires in harsh environments.

a. Rate-of-Rise Heat Detectors

These detectors activate when the temperature increases rapidly—typically 12 to 15°F per minute or more. They are ideal for detecting fast-growing fires and can respond more quickly than fixed temperature detectors. However, they may not activate during slow, smoldering fires.

b. Rate Compensation/Fixed Temperature Heat Detectors

These detectors respond when a preset temperature is reached, regardless of whether the temperature rise is rapid or gradual. They are designed to avoid false alarms due to normal temperature fluctuations while still reacting to actual fire conditions.

2. Smoke Detectors

Smoke detectors sense airborne particles produced by combustion. They are early warning devices that are more sensitive than heat detectors. There are two main types: ionization and photoelectric.

a. Ionization Smoke Detectors

Ionization detectors use a small amount of radioactive material to ionize air between two electrodes. When smoke enters the chamber, it disrupts the ion flow, triggering the alarm. They are more responsive to fast-flaming fires with little visible smoke.

b. Photoelectric Smoke Detectors

Photoelectric detectors use a light beam and a sensor. When smoke particles scatter the light beam, it hits the sensor and triggers the alarm. These detectors are more sensitive to smoldering fires that produce more smoke and less flame.

3.6. Automatic Sprinkler Systems

System Type	Description	Use Case
Wet Pipe	Pipes are always filled with pressurized water; the fastest response	Most commercial/industrial occupancies
Dry Pipe	Pipes filled with pressurized air/nitrogen; water enters on activation	Freezing environments (loading docks, parking garages)
Pre-Action	Requires two triggers: detector activation THEN sprinkler opens	Data centers, museums — accidental discharge prevention
Deluge	All heads open simultaneously when the system activates; no fusible link	Aircraft hangars, high-hazard processes
ESFR (Early Suppression Fast Response)	High-flow heads for rapid suppression	High-pile storage warehouses

Each of these sprinkler systems has a unique functionality and working principle tailored to specific environmental and fire safety needs:

1. Wet Sprinkler System

- **Functionality:** Wet sprinkler systems are the most common and are ideal for locations not prone to freezing, such as office buildings, schools, and residential areas. These systems constantly hold water within the pipes.
- **Working Principle:** The system consists of a series of sprinkler heads connected to pipes filled with water. When a fire activates a sprinkler head (through heat melting a fusible link or releasing a glass bulb filled with liquid), water immediately flows out to control or extinguish the fire. Because water is readily available in the pipes, the system provides a quick response to heat in the area.

2. Dry Sprinkler System

- **Functionality:** Dry sprinkler systems are designed for environments where the pipes are at risk of freezing, such as unheated warehouses, loading docks, and outdoor canopies. Instead of water, the pipes are filled with pressurized air or nitrogen.
- **Working Principle:** In this system, the sprinkler pipes contain pressurized air or nitrogen, keeping a valve closed that prevents water from entering the pipes. When a sprinkler head is activated by heat, the pressure drops, causing the valve to open and allowing water to flow into the pipes and then out of the open sprinkler heads. This design prevents the risk of frozen pipes and bursting in cold temperatures.

3. Pre-Action Sprinkler System

- **Functionality:** Pre-action systems are used in areas where accidental water discharge could cause significant property damage, such as data centers, museums, and libraries. These systems are often used in high-value asset protection.
- **Working Principle:** Pre-action systems require two triggers before water is released, reducing the chance of accidental discharge. First, a separate fire detection system (like a smoke detector) detects a fire and opens the pre-action valve, allowing water to enter the pipes. However, water won't discharge until the sprinkler head activates from heat exposure, providing an added layer of control. This dual-action requirement minimizes the risk of unintended water release.

4. Deluge Sprinkler System

- **Functionality:** Deluge systems are intended for high-hazard areas where rapid and wide-spread application of water is required, such as chemical processing plants, aircraft hangars, and power plants. They are designed for situations with highly flammable materials and a high risk of rapid fire spread.
- **Working Principle:** In a deluge system, all sprinkler heads are open, and the pipes are dry until the system is activated. When a fire detection system (such as heat or smoke detectors) identifies a fire, it opens the deluge valve, and water flows into the pipes and out through all sprinkler heads simultaneously. This setup allows for large volumes of water to be quickly dispersed, saturating the area and controlling or suppressing the fire.

5. ESFR Sprinkler System

- **Functionality:** ESFR sprinklers are specially designed fire sprinkler heads that provide rapid fire suppression in high-challenge storage occupancies. Unlike conventional sprinklers that primarily control a fire until firefighters arrive, ESFR sprinklers are intended to suppress the fire at its early stage, minimizing fire growth and property damage.

Typical Applications:

- High-piled storage warehouses
 - Distribution centers
 - Logistics facilities
 - Rack storage areas
- **Working Principle:**
 1. Fire Initiation
 - A fire starts and generates heat beneath the ceiling.

2. Fast Thermal Activation

- The ESFR sprinkler's heat-sensitive element (glass bulb or fusible link) activates quickly due to its high responsiveness.

3. High Water Discharge

- Once activated, the sprinkler releases a large volume of water at high pressure and flow rate.

4. Fire Suppression

- Large water droplets penetrate the fire plume and reach the burning fuel.
- The water cools the fuel surface, absorbs heat, and reduces oxygen around the fire.

5. Rapid Control and Extinguishment

- The fire is suppressed before it can spread extensively through storage racks or to adjacent commodities.

NFPA HAZARD CLASSIFICATIONS

 In accordance with NFPA, areas are typically classified as being **light (low)** hazard, **ordinary (moderate)** hazard, or **extra (high)** hazard.

1. LIGHT (LOW) HAZARD



LOW FIRE LOAD

- Light (low) hazard areas are locations where the quantity and combustibility of Class A combustibles and Class B flammables is low.
- In these areas, expected fires have relatively low rates of heat release.
- Light hazard areas may include offices, classrooms, meeting rooms etc.

2. ORDINARY (MODERATE) HAZARD



MODERATE FIRE LOAD

- Ordinary (moderate) hazard areas are locations where the quantity and combustibility of Class A combustible materials and Class B flammables is moderate.
- Fires with moderate rates of heat release are expected in these areas.
- Ordinary hazard locations could be offices, malls, light manufacturing or research operations, parking garages, workshops, or maintenance/service areas.

3. EXTRA (HIGH) HAZARD



HIGH FIRE LOAD

- Extra (high) hazard areas are locations where the quantity and combustibility of Class A combustible material is high or where high amounts of Class B flammables are present.
- Quickly developing fires with high rates of heat release are expected.
- These locations could be sites for cars repair, aircraft and boat servicing, painting, dipping, and coating, storage areas (tanks, containers etc).

 **KEY POINT:** Correct hazard classification is critical for proper sprinkler system design, including water supply, system demand spacing requirements.

 **REFERENCE:**
NFPA 13 – Standard for the Installation of Sprinkler Systems (2022 Edition)

NFPA 13 (2022) – PROTECTION AREAS AND MAXIMUM SPACING

STANDARD SPRAY UPRIGHT / STANDARD SPRAY PENDENT

LIGHT HAZARD Standard Spray Upright / Standard Spray Pendent

Construction Type	System Type	Protection Area (Maximum)		Spacing (Maximum)	
		ft ²	m ²	ft	m
Noncombustible, unobstructed, or combustible, unobstructed, or combustible, unobstructed with members less than 3 ft (0.9 m) on center	Pipe Schedule	200	18.6	15	4.6
	Hydraulically Calculated	225	20.9	15	4.6
Combustible, obstructed, with members less than 3 ft (0.9 m) on center	All	168	15.6	15	4.6
Combustible, with members less than 3 ft (0.9 m) on center	All	130	12.1	15	4.6
Combustible concealed space under a pitched roof having combustible wood joist or wood truss construction with members less than 3 ft (0.9 m) on center with slopes having a pitch of 4 in 12 or greater	All	120	11.1	15 parallel to slope 10 perpendicular to slope	4.6 parallel to slope 3.05 perpendicular to slope

ORDINARY HAZARD Standard Spray Upright / Standard Spray Pendent

Construction Type	System Type	Protection Area (Maximum)		Spacing (Maximum)	
		ft ²	m ²	ft	m
All	All	130	12.1	15	4.6

EXTRA HAZARD Standard Spray Upright / Standard Spray Pendent

Construction Type	System Type	Protection Area (Maximum)		Spacing (Maximum)	
		ft ²	m ²	ft	m
All	Pipe Schedule	90	8.4	12 (In buildings with storage bays 25 ft (7.6 m) wide, 12 ft 6 in. (3.8 m) shall be permitted)	3.7 (In buildings with storage bays 25 ft (7.6 m) wide, 12 ft 6 in. (3.8 m) shall be permitted)
All	Hydraulically Calculated with density ≥ 0.25	100	9.3	12 (In buildings with storage bays 25 ft (7.6 m) wide, 12 ft 6 in. (3.8 m) shall be permitted)	3.7 (In buildings with storage bays 25 ft (7.6 m) wide, 12 ft 6 in. (3.8 m) shall be permitted)
All	Hydraulically Calculated with density < 0.25	130	12.1	15	4.6

KEY NOTES

- Areas are maximum permitted coverage per sprinkler.
- Spacing is the maximum distance between sprinklers.
- Values are per NFPA 13 (2022 Edition), Chapter 16.
- All dimensions are horizontal projections on the ceiling.
- Hydraulically calculated systems are permitted to use larger areas where listed.

LEGEND

ft² = Square feet
m² = Square meters
ft = Feet
m = Meters



IMPORTANT: These are maximum limits. Actual design shall be based on hydraulic calculations, occupancy, water supply, and other requirements of NFPA 13.



REFERENCE:
NFPA 13: 2022 Edition
Standard for the Installation
of Sprinkler Systems

DEFINITIONS:

Light Hazard: Low combustible content and fire load.
Ordinary Hazard: Moderate fire load.
Extra Hazard: High fire load, high value, or high hazard contents.

SPRINKLER HEAD COLOR CODES – SUMMARY OF NFPA 13

MAXIMUM CEILING TEMPERATURE		
°C	°F	COLOR CODE
38	100	Uncolored
66	150	White
107	225	Blue
150	300	Red
190	375	Green
218	425	Orange
246	475	Orange



KEY POINTS

- ✓ Select sprinkler heads with a temperature rating that is equal to or higher than the maximum ambient ceiling temperature.
- ✓ Do not install sprinkler heads with a lower temperature rating than the actual ceiling temperature.
- ✓ Refer to NFPA 13 for complete requirements and allowances.
- ✓ Regular inspection ensures sprinkler heads are not painted, corroded, or obstructed.

WHAT DO THE COLORS MEAN?

The color of the sprinkler head (or its temperature-sensitive element) indicates the maximum ambient ceiling temperature at which the sprinkler is designed to operate. When the ceiling temperature reaches the rated temperature, the element activates and the sprinkler opens.



Uncolored 100°F (38°C)	White 150°F (66°C)	Blue 225°F (107°C)	Red 300°F (150°C)	Green 375°F (190°C)	Orange 425°F (218°C)	Orange 475°F (246°C)
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IMPORTANT: Always verify the ceiling temperature of the protected area and select sprinkler heads accordingly to ensure proper operation.

3.7. Fire Extinguisher Classifications

Class	Fuel Type	Agent
A	Ordinary combustibles (wood, paper, cloth)	Water, foam, dry chemical
B	Flammable liquids and gases	CO2, dry chemical, foam, halon alternatives
C	Energized electrical equipment	CO2, dry chemical (non-conductive)
D	Combustible metals (magnesium, titanium, sodium)	Dry powder (specialized)
K	Cooking oils and fats (commercial kitchens)	Wet chemical agent



Roger Brauer Reference — Ch. 19

Brauer covers fire protection engineering, including detection reliability, sprinkler system hydraulics, and NFPA standard integration.

NFPA 13 governs sprinkler system installation; NFPA 72 governs fire alarm and notification systems.

Passive fire protection (compartmentalization, fire-resistant construction) works alongside active systems to limit fire spread.

PORTABLE FIRE EXTINGUISHERS – CSP NOTES

1. INTRODUCTION

It is important to understand the classification of fires when selecting the appropriate type of fire extinguisher. For example, water should not be used to put out a Class C (electrical) fire, since it presents a shock hazard.

Fire extinguishers are labeled in such a manner as to clearly identify the class of fires that they can extinguish.

The new labeling system uses pictures to indicate what types of fires extinguishers can be used on and red diagonal lines through the types of fires they should not be used on.

In addition, fire extinguishers also come with number ratings to indicate how large a fire they can contain.

- For Class A fires: numeric rating (e.g., 1A) indicates the amount of water equivalent in gallons.
- For Class B or C fires: rating indicates the number of square feet of coverage.
- Example: 5BC indicates a coverage area of 5 ft² for Class B and C fires.
- A multipurpose extinguisher rated (example) 2A-10BC means it will cover up to 3000 ft² for Class A fires and 10 ft² for B/C fires.

2. FIRE EXTINGUISHER LABELING SYSTEM

Fire Class Symbols		
		Class A – Ordinary combustibles (wood, paper, cloth, rubber, many plastics)
		Class B – Flammable liquids (gasoline, oil, grease, paint, solvents)
		Class C – Energized electrical equipment
		Class D – Combustible metals (magnesium, sodium, titanium, etc.)
		Class K – Cooking oils and fats (commercial cooking equipment)

How to Read the Label

-  Green symbol without a line = can be used on that fire class.
-  Red diagonal line through the symbol = should **not** be used on that fire class.

3. PORTABLE FIRE EXTINGUISHERS AND TRAVEL DISTANCES BY HAZARD (NFPA 10)

Hazard Level	Minimum Fire Extinguisher Rating	Maximum Travel Distance to a Fire Extinguisher	Maximum Square Footage (per unit of A rating)
Light hazard	2A10B:C	75 ft	3000 ft ² (2A can cover 6000 ft ²)
Ordinary hazard with moderate amounts of Class A combustibles and only minimal amounts of flammable/combustible liquids and gases	2A10B:C	75 ft	1500 ft ² (2A can cover 3000 ft ²)
Ordinary hazard with moderate amounts of flammable/combustible liquids and gases	Option 1 2A10B:C	30 ft	1500 ft ² (2A can cover 3000 ft ²)
	Option 2 2A20B:C	50 ft	1500 ft ² (2A can cover 3000 ft ²)
Extra hazard—all types	Option 1 4A40B:C	30 ft	1000 ft ² (4A can cover 4000 ft ²)
	Option 2 4A80B:C	50 ft	1000 ft ² (4A can cover 4000 ft ²)
Commercial kitchens	2A1B:C:K	30 ft	1000 ft ² (2A can cover 2000 ft ²)

4. HYDROSTATIC TESTING (PORTABLE FIRE EXTINGUISHERS)

OSHA requires portable fire extinguishers to undergo hydrostatic testing at the intervals listed in Table 12.2 (except under the following circumstances):

- When the unit has been repaired by soldering, welding, brazing, or the use of patching compounds.
- When the cylinder or shell threads are damaged.
- When there is corrosion that has caused pitting, including corrosion under removable name plate assemblies.
- When the extinguisher has been burnt in a fire.
- When a calcium chloride extinguishant agent has been used in a stainless-steel shell.

5. OSHA'S HYDROSTATIC TEST INTERVALS (OSHA 29 CFR 1910.157(f)(3))

Type of Extinguisher	Test Interval (years)
Soda acid (soldered brass shells) (until Jan 1, 1982) *	—
Soda acid (stainless steel shell)	5
Cartridge operated water and/or antifreeze	5
Stored pressure water and/or antifreeze	5
Wetting agent	5
Foam (soldered brass shells) (until Jan 1, 1982) *	—
Foam (stainless steel shell)	5
Aqueous film forming foam (AFFF)	5
Loaded stream	5
Dry chemical with stainless steel	5
Carbon dioxide	5
Dry chemical, stored pressure, with mild steel, brazed brass, or aluminum shells	12
Dry chemical, cartridge or cylinder operated, with mild steel shells	12
Halon 1211	12
Halon 1301	12
Dry powder, cartridge, or cylinder operated with mild steel shells	12

* Extinguishers having shells constructed of copper or brass joined by soft solder or rivets shall not be hydrostatically tested and shall be removed from services by January 1, 1982.

6. FIRE EXTINGUISHER INSPECTIONS AND SERVICE REQUIREMENTS

An employer is responsible for ensuring that the inspection, maintenance, and testing of all portable fire extinguishers are conducted.



Monthly Visual Inspection

All portable fire extinguishers shall be visually inspected **monthly** for:

- Proper location and accessibility
- Pressure gauge in operable range
- No physical damage or corrosion
- Seals and tamper indicators intact
- Instruction label readable



Annual Service and Testing

Each portable fire extinguisher shall be serviced **annually** and tested in accordance with the intervals listed in Section 5 (Table 12.2).

KEY POINTS FOR CSP EXAM

- ✓ Select the correct extinguisher based on fire class.
- ✓ Understand ratings (A = gallons of water; B/C = ft² coverage).
- ✓ Follow maximum travel distances and coverage requirements.
- ✓ Ensure hydrostatic testing at required intervals (OSHA).
- ✓ Conduct monthly inspections and annual servicing.
- ✓ Maintain, test, and keep extinguishers fully operational.

Automatic Fire Suppression Systems

- Gaseous Suppression Systems: Use inert gases or chemical agents (e.g., FM-200, Novec 1230) to extinguish fires without water damage.
- Dry Chemical Systems: Release powdered agents to interrupt the chemical reaction of a fire.
- Specialized Systems: Such as kitchen hood suppression systems for commercial kitchens.

3.8. Fire Hydrants

A fire hydrant is a fixed fire protection device connected to a municipal water supply system, private water main, or dedicated fire water network. It provides firefighters with immediate access to a reliable water source for firefighting operations and emergency response activities.

Fire hydrants are strategically installed along roads, around industrial facilities, warehouses, commercial buildings, and residential areas to ensure rapid access to water during a fire emergency. The available water flow and pressure from a hydrant are critical factors in determining its firefighting capability.

To assist firefighters, hydrants are often color-coded in accordance with NFPA 291, with the top (bonnet) color indicating the hydrant's available flow capacity. This allows emergency responders to quickly identify hydrants capable of supplying sufficient water for fire suppression operations.

Key Functions of Fire Hydrants

- Provide a readily available source of water for firefighting.
- Support fire department hose and pumping operations.
- Supply water to sprinkler and standpipe systems during emergencies.
- Improve emergency response effectiveness and fire control capabilities.
- Reduce property damage and fire spread through rapid water application.

Typical Components of a Fire Hydrant

- Operating Nut
- Bonnet (Top Section)
- Hose Nozzles/Outlets
- Barrel (Body)
- Main Valve
- Base and Underground Connection

Reference: NFPA 291 – Recommended Practice for Fire Flow Testing and Marking of Hydrants.

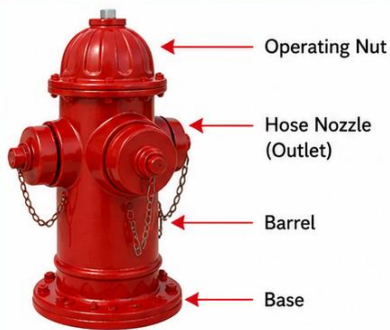
FIRE HYDRANT COLOR CODE SYSTEM (SUMMARY FROM NFPA 291)

FIRE HYDRANT TOP COLOR	FLOW RATE (GPM, gallons per minute)
Red	500
Orange	500 – 999
Green	1000 – 1499
Blue	1500 or more



NOTE: The flow rate indicates the available water supply that the hydrant can deliver at a 20 psi residual pressure.

TYPICAL FIRE HYDRANT PARTS



FIRE HYDRANT TOP COLOR EXAMPLES



KEY POINTS



Hydrant top colors indicate available flow rate.



Higher flow rates improve fire suppression capability.



Always refer to NFPA 291 for installation and testing requirements.

3.9. Fire Alarms

Types of Fire Alarms (NFPA 72)

1. Manual Fire Alarm

A manual fire alarm system relies on human intervention to initiate an alarm. When a person discovers a fire or smoke condition, they activate a pull station or break-glass unit to alert building occupants. Manual systems are simple and reliable but depend on someone noticing the fire before the alarm can be raised.

Example: Pull stations installed near exits in schools, offices, and commercial buildings.

2. Automatic Fire Alarm

An automatic fire alarm system detects fire conditions without requiring human action. Smoke detectors, heat detectors, flame detectors, or gas detectors continuously monitor the environment and automatically initiate an alarm when abnormal conditions are detected. These systems provide early warning and are the most common type used in modern facilities.

Example: Smoke detectors in offices, hospitals, and residential buildings.

3. Local Fire Alarm System

A local fire alarm system provides notification only within the protected building or premises. When activated, horns, bells, sirens, or strobe lights warn occupants to evacuate, but the signal is not automatically transmitted to an external monitoring station or fire department.

Example: Small warehouses or standalone commercial buildings.

4. Central Station Fire Alarm System

A central station fire alarm system transmits alarm signals to an off-site monitoring center staffed 24 hours a day. Upon receiving an alarm, the monitoring center verifies the signal and notifies emergency responders. This type of system provides a higher level of protection and supervision.

Example: Shopping malls, industrial facilities, and large commercial buildings.

5. Proprietary Supervising Station System

A proprietary system is used by organizations that operate their own monitoring station. Multiple buildings within the same organization are connected to a central control room that supervises fire alarm signals and coordinates emergency response.

Example: Airports, universities, military bases, and large industrial complexes.

6. Remote Supervising Station System

In a remote supervising station system, fire alarm signals are transmitted to a remote location, such as a fire department communication center or monitoring facility. This ensures that emergency responders are notified even when the building is unoccupied.

Example: Government facilities and public buildings.

7. Emergency Voice/Alarm Communication System (EVACS)

An Emergency Voice/Alarm Communication System combines traditional alarm signals with voice messages. Instead of relying solely on horns or bells, the system provides clear instructions to occupants regarding evacuation routes, shelter-in-place procedures, or other emergency actions. These systems are particularly useful in large or complex buildings.

Example: High-rise buildings, airports, stadiums, and hospitals.

Fire Alarm Signal Types (NFPA 72)

Alarm Signal

An alarm signal indicates the presence of a fire or emergency condition requiring immediate action and evacuation.

Supervisory Signal

A supervisory signal indicates that a fire protection system has changed from its normal operating condition and requires attention, but does not necessarily indicate a fire.

Example: A sprinkler control valve is partially closed.

Trouble Signal

A trouble signal indicates a fault within the fire alarm system that may impair its ability to function properly.

Example: Detector failure, wiring fault, or loss of power.

Examination Note

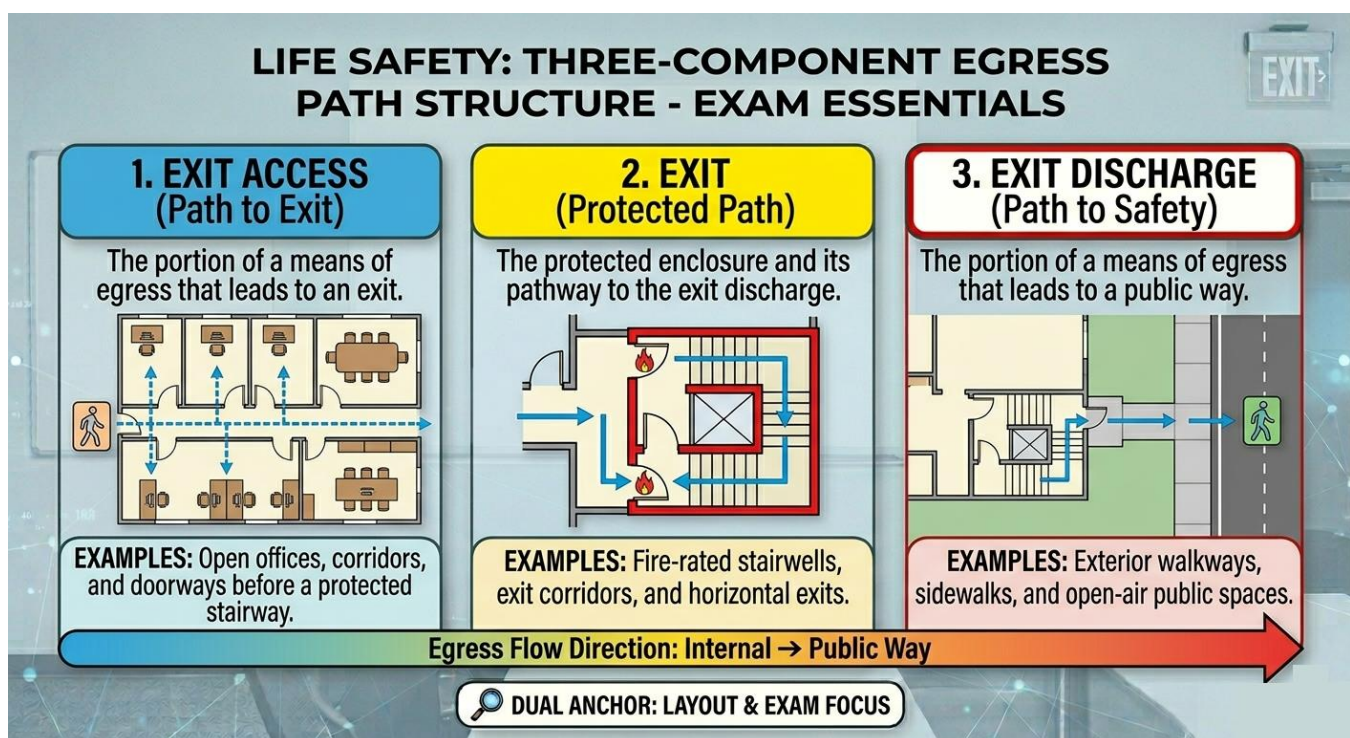
NFPA 72 fire alarm systems may be manual, automatic, local, central station, proprietary, remote supervising, or emergency voice communication systems. Their primary purpose is to provide early warning, facilitate occupant evacuation, and ensure prompt emergency response during fire incidents.

3.10. Means of Egress (NFPA 101 / IBC)

- Three components: Exit Access → Exit → Exit Discharge
- Horizontal exits (permitted); stairs (permitted); elevators EXCLUDED except firefighter service
- Travel distance limits vary by occupancy type and sprinkler protection
- Safety Egress Time (SET): Evacuation Time = Notification Time + Delay Time + Travel Time
- Delay time factors: reaction time, pre-evacuation activity (collecting belongings), effectiveness of cues

EXAM TIP

Fire Triangle = 3 elements. Tetrahedron = 4 (adds chain reaction). Pentagon = 5 (adds dispersion for dust explosions). Flash point < Fire point < AIT. NFPA 101 governs life safety/egress.



4. Hazardous Materials Transportation & Security

4.1. DOT Hazard Classification System (49 CFR Parts 171–180)

Class	Description	Examples	Placard Color
1	Explosives (Divisions 1.1–1.6)	Dynamite, fireworks, ammunition	Orange
2	Gases (flammable, non-flammable, poisonous)	Propane, nitrogen, chlorine	Red/Green/White
3	Flammable/Combustible Liquids	Gasoline, alcohol, acetone	Red
4	Flammable Solids, Pyrophoric, Water-Reactive	Sodium, white phosphorus	Red-White / White
5	Oxidizers and Organic Peroxides	H ₂ O ₂ , ammonium nitrate	Yellow
6	Toxic and Infectious Substances	Cyanides, medical waste	White
7	Radioactive Materials	Uranium ore, medical isotopes	White/Yellow
8	Corrosives	Battery acid, caustic soda	Black & White
9	Miscellaneous Hazardous Materials	Dry ice, lithium batteries	Black & White stripe



CLASS 1-Explosives

CLASS 2-Gases

CLASS 3-Flammable liquids

CLASS 4-Flammable solids

CLASS 5-Oxidizers

CLASS 6-Toxic materials

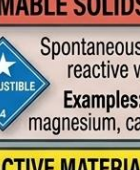
CLASS 7-Radioactive materials

CLASS 8-Corrosive materials

CLASS 9-Miscellaneous dangerous goods

DANGEROUS- Indicates a mixed load of hazardous materials

**CSP LECTURES: DOT 9-CLASS PLACARD
COLOR MAP – EXAM ESSENTIALS**

1. EXPLOSIVES (Class 1)  Mass explosion hazard, projectile, minor blast. Examples: Dynamite, fireworks, ammunition.	2. GASES (Class 2)   Flammable, non-flammable, toxic. Examples: Propane, Oxygen, Chlorine.	3. FLAMMABLE LIQUIDS (Class 3)  Low flashpoint liquids. Examples: Gasoline, paint thinner, alcohols.
4. FLAMMABLE SOLIDS (Class 4)   Spontaneous combustion, reactive with water. Examples: Matches, magnesium, calcium carbide.	5. OXIDIZERS & ORGANIC PEROXIDES (Class 5)  Yields oxygen, may cause combustion of others. Examples: Hydrogen peroxide, nitrates, fertilizers.	6. TOXIC & INFECTIOUS SUBSTANCES (Class 6)  Poisons and disease-causing agents. Examples: Pesticides, medical waste, biological samples.
7. RADIOACTIVE MATERIALS (Class 7)  Ionizing radiation hazards. Examples: Uranium, cobalt isotopes, medical scanners.	8. CORROSIVE SUBSTANCES (Class 8)  Destroys living tissue and materials. Examples: Sulfuric acid, car battery acid, caustic soda.	9. MISCELLANEOUS DANGEROUS GOODS  Presents a danger not covered by other classes. Examples: Dry ice, asbestos, magnetic materials.

DOT 9-CLASS PLACARD COLOR MAP: Visual Key for Quick Recall

DUAL ANCHOR: LAYOUT & EXAM FOCUS

4.2. HazMat Shipping Requirements

- Shipping Papers (Bill of Lading): Must include Proper Shipping Name, Hazard Class, UN/NA Number, Packing Group (I/II/III), Quantity, Emergency Contact
- Packing Groups: PG I (greatest hazard), PG II (medium danger), PG III (minor danger)
- UN Number: 4-digit international identifier (e.g., UN 1203 = Gasoline)
- Placarding: Bulk containers over 1,001 lbs require hazard class placards
- CHEMTREC: 1-800-424-9300 — 24-hr emergency hotline for chemical incidents; shipper notification
- Emergency Response Guidebook (ERG): Published by DOT/PHMSA; updated every 4 years; primary resource for first responders at spill scenes

4.3. GHS Physical Hazard Classification

The Globally Harmonized System of Classification and Labelling of Chemicals (GHS) is an internationally recognized system developed by the United Nations to standardize the classification, labeling, and communication of chemical hazards worldwide.

The purpose of GHS is to ensure that workers, employers, emergency responders, transporters, and regulatory agencies can consistently identify chemical hazards regardless of the country or manufacturer.

The chart illustrates the **Physical Hazard Classes and Categories** under GHS. Physical hazards describe the inherent properties of chemicals that can cause fires, explosions, violent reactions, or other hazardous physical events.

Examples include:

- Explosives
- Flammable Gases
- Flammable Liquids
- Flammable Solids
- Oxidizing Materials
- Self-Reactive Chemicals
- Organic Peroxides
- Pyrophoric Materials
- Self-Heating Chemicals
- Chemicals Reactive with Water
- Gases Under Pressure
- Corrosive to Metals
- Combustible Dusts

Within each hazard class, chemicals are assigned to **categories** (e.g., Category 1, 2, 3, 4 or Type A–G).

Generally:

- **Category 1 = Highest Hazard**
- Higher category numbers generally indicate lower hazard severity.

For example:

Flammable Liquid Category	Criteria
Category 1	Extremely flammable
Category 2	Highly flammable
Category 3	Flammable
Category 4	Combustible

This classification helps determine labeling requirements, storage practices, handling precautions, emergency response procedures, and training requirements.

PHYSICAL HAZARD CLASSES AND CATEGORIES

HAZARD CLASS	HAZARD CATEGORY						
	Unstable Explosives	Div 1.1	Div 1.2	Div 1.3	Div 1.4	Div 1.5	Div 1.6
Explosives							
Flammable Gases	1	2					
Flammable Aerosols	1	2					
Oxidizing Gases	1						
Gases under Pressure Compressed Gases Liquefied Gases Refrigerated Liquefied Gases Dissolved Gases	1						
Flammable Liquids	1	2	3	4			
Flammable Solids	1	2					
Self-Reactive Chemicals	Type A	Type B	Type C	Type D	Type E	Type F	Type G
Pyrophoric Liquids	1						
Pyrophoric Solid	1						
Pyrophoric Gases	Single category						
Self-Heating Chemicals	1	2					
Chemicals, which in contact with water, emit flammable gases	1	2	3				
Oxidizing Liquids	1	2	3				
Oxidizing Solids	1	2	3				
Organic Peroxides	Type A	Type B	Type C	Type D	Type E	Type F	Type G
Corrosive to Metals	1						
Combustible Dusts	Single category						

GHS CLASSIFICATION – QUICK REVIEW



WHAT IS GHS?

The Globally Harmonized System (GHS) of Classification and Labelling of Chemicals is a worldwide system developed by the United Nations to standardize the way hazards of chemicals are classified and communicated.



PURPOSE

- Protect human health and the environment
- Provide consistent hazard communication
- Facilitate international trade
- Improve safety in handling, transport and use of chemicals



KEY ELEMENTS

1. Classification of hazards
2. Labelling of containers
3. Safety Data Sheets (SDS) based on a consistent 16-section format.

GHS PHYSICAL HAZARD CLASSES (Example Pictograms)



Explosives
(Exploding Bomb)



Flammable
(Flame)



Oxidizers
(Flame Over Circle)



Gases under Pressure
(Gas Cylinder)



Corrosive to Metals
(Corrosion)



Self-Reactive / Organic Peroxides
(Exploding Bomb)



Pyrophoric / Self-Heating
(Flame)



Emits flammable gas with water
(Flame)



Combustible Dusts
(Exclamation Mark)

HOW TO READ A GHS LABEL (Example)

Acetone

DANGER
Highly flammable liquid and vapour.
Causes serious eye irritation.
May cause drowsiness or dizziness.



- Pictograms – show the type of hazard
- Signal Word – DANGER or WARNING
- Hazard Statements – describe the nature and severity of the hazard
- Precautionary Statements – how to prevent or respond
- Supplier Information – who supplied it



KEY TAKEAWAYS

- GHS covers physical, health and environmental hazards.
- Physical hazards include flammability, explosivity, oxidizing potential, reactivity and gases under pressure.
- Each hazard class has categories or types indicating the degree of hazard.
- Look for pictograms, signal words, hazard and precautionary statements on labels and SDS.

Relationship Between GHS and DOT/HAZMAT Classification

GHS Classification	DOT/HAZMAT Classification
Focuses on workplace hazard communication	Focuses on transportation safety
Used for labels, SDSs, and worker protection	Used for shipping, packaging, marking, placarding, and transport
Governed by UN GHS and OSHA HazCom	Governed by U.S. DOT (49 CFR), UN Recommendations, IMDG, IATA
Classifies physical, health, and environmental hazards	Classifies hazards during transportation
Uses GHS pictograms	Uses DOT hazard labels and placards

GHS Relationship with OSHA Hazard Communication Standard (HazCom)

The OSHA Hazard Communication Standard (HCS), 29 CFR 1910.1200, is the United States regulation that adopted the GHS framework for workplace chemical hazard communication.

Key Point

GHS provides the classification system, while OSHA HazCom is the legal regulatory framework that requires employers to communicate those hazards to workers.

In simple terms:

- GHS = International Classification System
- OSHA HazCom = U.S. Regulatory Implementation of GHS

How OSHA HazCom Uses GHS

OSHA requires chemical manufacturers and employers to use GHS elements for hazard communication.

1. Hazard Classification

Manufacturers must classify chemicals according to GHS criteria.

Example:

Acetone may be classified as:

- Flammable Liquid Category 2
- Eye Irritation Category 2A
- STOT-SE Category 3

2. Standardized Labels

Every hazardous chemical container must contain:

- Product Identifier
- Signal Word
- Hazard Statements
- Precautionary Statements
- Supplier Information
- GHS Pictograms

Example

Signal Word: DANGER

Hazard Statement:

"Highly flammable liquid and vapor."

Pictogram:

🔥 Flame Symbol

3. Safety Data Sheets (SDS)

OSHA requires a standardized **16-section SDS format** based on GHS.

Sections include:

1. Identification
2. Hazard Identification
3. Composition
4. First Aid Measures
5. Fire Fighting Measures
6. Accidental Release Measures
7. Handling and Storage
8. Exposure Controls/PPE
9. Physical and Chemical Properties
10. Stability and Reactivity
- 11–16 Additional Information

4. Employee Training

OSHA requires workers to be trained on:

- Chemical hazards
- GHS labels
- Pictograms
- SDS interpretation
- Protective measures

GHS Pictograms Commonly Seen Under OSHA HazCom

GHS HAZARD COMMUNICATION PICTOGRAMS

(OSHA HazCom Standard – 29 CFR 1910.1200)

1. EXPLODING BOMB  Hazards • Explosives • Self-reactives • Organic peroxides	2. FLAME  Hazards • Flammables • Pyrophorics • Self-heating • Emits flammable gas • Self-reactives • Organic peroxides	3. FLAME OVER CIRCLE  Hazards • Oxidizers	4. GAS CYLINDER  Hazards • Gases under pressure	5. CORROSION  Hazards • Skin corrosion/burns • Eye damage • Corrosive to metals
6. SKULL AND CROSSBONES  Hazards • Acute toxicity (fatal or toxic)	7. EXCLAMATION MARK  Hazards • Irritant (skin or eye) • Skin sensitizer • Acute toxicity (harmful) • Narcotic effects • Respiratory tract irritant • Hazardous to ozone layer (non mandatory)	8. HEALTH HAZARD  Hazards • Carcinogen • Mutagenicity • Reproductive toxicity • Respiratory sensitizer • Target organ toxicity • Aspirations hazard	9. ENVIRONMENT (NON MANDATORY)  Hazards • Hazardous to the aquatic environment	10. HEALTH HAZARD (BIOHAZARD – NON MANDATORY)  Hazards • Infectious materials



NOTE: Pictograms are part of the label and must be used in combination with signal words, hazard statements, precautionary statements, and product identifier.

PURPOSE: To provide at-a-glance recognition of chemical hazards and promote safe handling.



OSHA HazCom Requirements

Employers must:

- ✓ Maintain a written Hazard Communication Program
- ✓ Ensure containers are properly labeled
- ✓ Maintain SDSs for all hazardous chemicals
- ✓ Train employees on chemical hazards
- ✓ Make hazard information readily accessible

CSP Key Note

The GHS provides a globally harmonized system for classifying and communicating chemical hazards, while OSHA's Hazard Communication Standard (29 CFR 1910.1200) legally requires employers in the United States to use GHS-compliant labels, Safety Data Sheets (SDSs), and employee training programs to protect workers from chemical hazards.

References

- OSHA 29 CFR 1910.1200 – Hazard Communication Standard (HazCom)
- UN Globally Harmonized System of Classification and Labelling of Chemicals (GHS)
- OSHA HazCom Alignment with GHS (2012 Revision)
- ANSI Z400.1 Hazard Communication Standards

CLP is an equivalent system used in Europe as follows.

Hazard Labelling & Packaging according to the CLP Regulation

May, 2014

Information Sheet

The Classification, Labelling and Packaging (CLP) Regulation covers hazardous chemicals sold to professional users and consumers. This information sheet outlines the key requirements for the labelling and packaging of hazardous chemicals under the CLP Regulation.



4.4. NFPA 704 Hazard Identification System (NFPA Diamond)

The NFPA Diamond, also known as NFPA 704, is a hazard identification system developed by the National Fire Protection Association (NFPA) to provide emergency responders with quick information about the health, flammability, reactivity, and special hazards of chemicals during emergencies.

It is commonly displayed on:

- Chemical storage tanks
- Warehouses
- Industrial facilities
- Laboratories
- Chemical processing plants

NFPA Diamond vs GHS

NFPA 704	GHS
Emergency responder tool	Hazard communication system
Uses numbers (0–4)	Uses hazard categories and pictograms
Intended for emergency situations	Intended for workers and chemical users
Appears on tanks and buildings	Appears on labels and SDSs
Quick visual identification	Detailed hazard information

Key Difference

NFPA Diamond is designed for emergency response and firefighting, while GHS/HazCom is designed for workplace hazard communication, labeling, and training.

Examination Note

The NFPA 704 Diamond is a color-coded hazard identification system that communicates Health (Blue), Flammability (Red), Reactivity (Yellow), and Special Hazards (White) using a numerical scale from 0 (minimal hazard) to 4 (severe hazard). It is intended primarily for emergency responders during fire, spill, or chemical incidents.

Reference: National Fire Protection Association NFPA 704 – Standard System for the Identification of the Hazards of Materials for Emergency Response.

NFPA 704 HAZARD IDENTIFICATION SYSTEM

Quick Guide for Emergency Response to Hazardous Materials

HEALTH HAZARD BLUE DIAMOND

- 4 Deadly
- 3 Extreme Danger
- 2 Hazardous
- 1 Slightly Hazardous
- 0 Normal Material

Indicates the potential health hazard from exposure to a material.

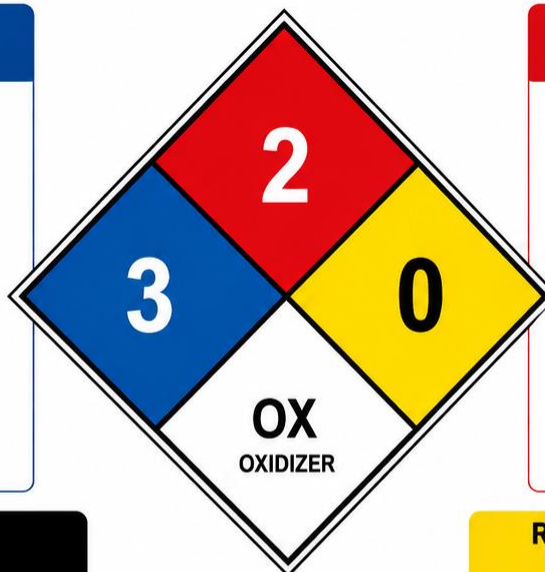


FIRE HAZARD RED DIAMOND

Flash Points

- 4 Below 73°F
- 3 Below 100°F
- 2 Above 100°F not exceeding 200°F
- 1 Above 200°F
- 0 Will not burn

Indicates the ease of ignition of a material.



SPECIFIC HAZARD WHITE DIAMOND

- ACID – Acid
- ALK – Alkali
- COR – Corrosive
- OX – Oxidizer
- Radioactive
- Use No Water



Indicates special hazards that require specific precautions.

REACTIVITY HAZARD YELLOW DIAMOND

- 4 May Detonate
- 3 Shock & Heat may detonate
- 2 Violent Chemical change
- 1 Unstable if heated
- 0 Stable



Indicates the stability of a material and its potential for violent reaction.

HOW TO READ

- Blue (Health) – Health hazard
- Red (Fire) – Flammability hazard
- Yellow (Reactivity) – Instability hazard
- White (Specific) – Special hazard



This rating indicates:

- Health Hazard: Extreme Danger (3)
- Fire Hazard: Hazardous – FP above 100°F not exceeding 200°F (2)
- Reactivity Hazard: Stable (0)
- Specific Hazard: Oxidizer (OX)



The NFPA diamond provides a quick visual summary to help protect people, property and the environment.



NOTE: NFPA 704 ratings are intended for emergency response personnel. They do not replace the Safety Data Sheet (SDS).



4.5. EPCRA Reporting Requirements

- Section 302: Facilities with EHS above TPQ must notify the Local Emergency Planning Committee (LEPC) and State Emergency Response Commission (SERC)
- Section 304: Immediate notification on release of EHS or CERCLA substance above Reportable Quantity (RQ)
- Sections 311–312: Annual SDS submission and Tier I/II chemical inventory reports to LEPC, SERC, and fire departments
- Section 313: Annual Toxics Release Inventory (TRI) reporting to EPA

Yates Reference — Ch. 29

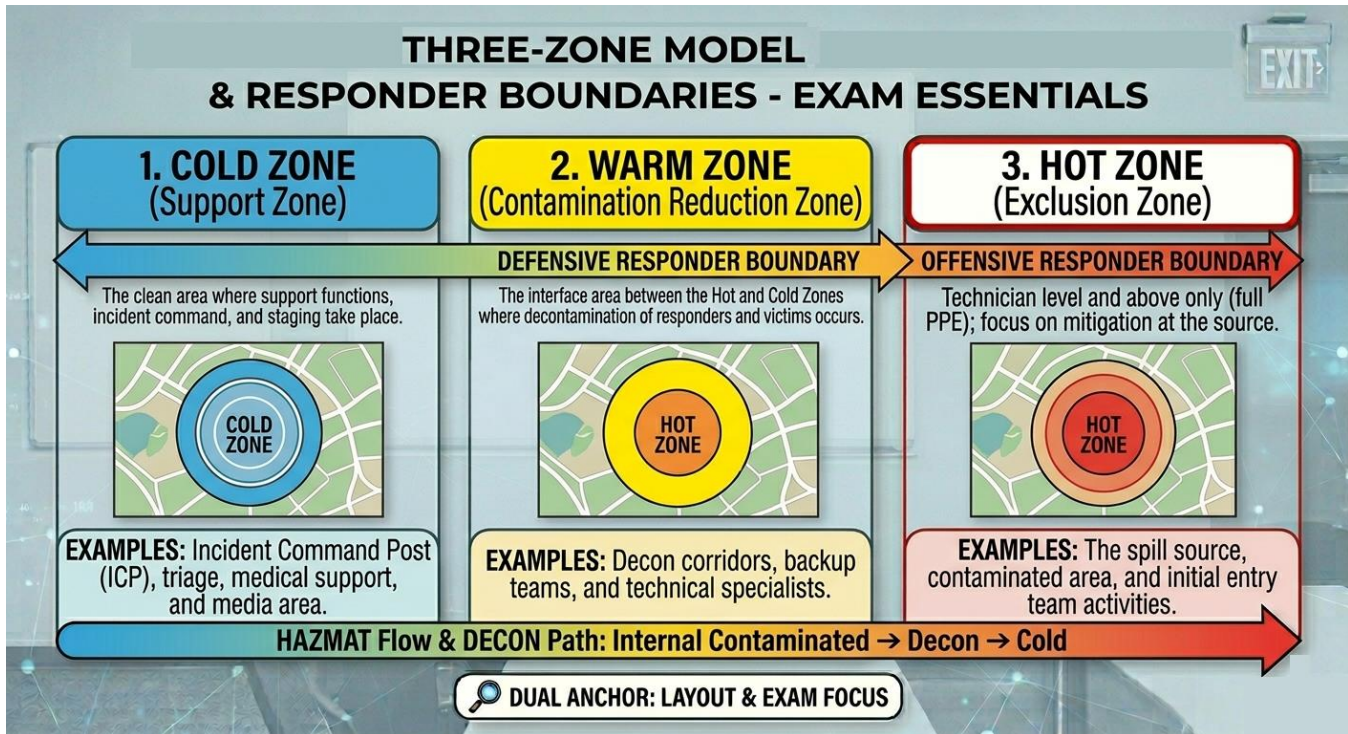
Yates covers hazardous materials management including storage segregation, secondary containment, and compatibility matrices.

Security plans for high-consequence HazMat (Tier 1 and Tier 2) required by PHMSA under 49 CFR Part 172 Subpart I.

Emergency Response: Defensive response = do NOT enter hot zone; Offensive response (HazMat Technician level) = entry with full protection.

EXAM TIP

ERG is published by DOT/PHMSA every 4 years. CHEMTREC = 1-800-424-9300. Packing Groups: I=highest hazard, III=lowest. Defensive responders never enter the hot zone.



5. Workplace Violence Prevention

5.1. Workplace Violence Definition & Scope

Workplace violence is any act or threat of physical abuse, harassment, intimidation, or other threatening, disruptive behaviour at the work site. OSHA classifies it as a workplace hazard under the General Duty Clause (Section 5(a)(1)). Workplace violence is the #2 cause of occupational fatality in the USA (after motor vehicle crashes).

5.2. Four Types of Workplace Violence (OSHA/NIOSH)

Type	Relationship to Workplace	Example	Primary Risk
Type I — Criminal Intent	No relationship to the workplace	Robbery, theft, terrorism	Highest fatality risk; money is the motive
Type II — Customer/Client	Legitimate relationship (patient, customer, student)	Patient attacks nurse; customer attacks cashier	Healthcare workers are at the highest risk (60% of assaults)
Type III — Worker-on-Worker	Current or former employee	Disgruntled ex-employee attack	Preceded by observable warning signs, termination risk
Type IV — Personal Relationship	Domestic violence spills into the workplace	Partner attacks employee at work	VPO (Victim Protective Orders) must reach security

5.3. Prevention Program Elements

- Written Policy: Zero-tolerance for violence; clear definitions; management commitment; signed by top executive
- Threat Assessment Team (TAT): Multidisciplinary — HR, security, legal, EAP, management; evaluates all threats reported
- Reporting System: Confidential, non-punitive; report to HR, security, or anonymous hotline
- Physical Security: Access control (key cards, badges, visitor sign-in); CCTV; panic buttons; security personnel
- CPTED (Crime Prevention Through Environmental Design): Lighting, sight lines, natural surveillance, elimination of hiding spots

- Employee Assistance Program (EAP): Confidential counselling for stress, mental health, substance issues
- Training: Warning sign recognition, de-escalation, active shooter response (Run–Hide–Fight / ALICE)
- Post-Incident Response: Critical Incident Stress Debriefing (CISD); trauma-informed support; investigation; control review

5.4. Active Shooter Protocol: Run–Hide–Fight

Action	When to Use	Key Steps
RUN	A safe escape path exists	Evacuate immediately; leave belongings; warn others; call 911 when safe
HIDE	Cannot escape safely	Lock/barricade doors; silence phones; turn off lights; stay out of sight
FIGHT	Last resort only; attacker is an imminent threat	Improvise weapons; swarm the attacker; commit aggressively

Yates Reference — Ch. 14

Yates identifies violence risk assessment as a proactive process including physical environment audits, policy review, and behavioural warning sign training.

Post-incident debriefing (CISD) is essential for employee recovery and organizational learning after violent incidents.

ESG and social responsibility frameworks increasingly require documentation of workplace violence programs and outcomes.

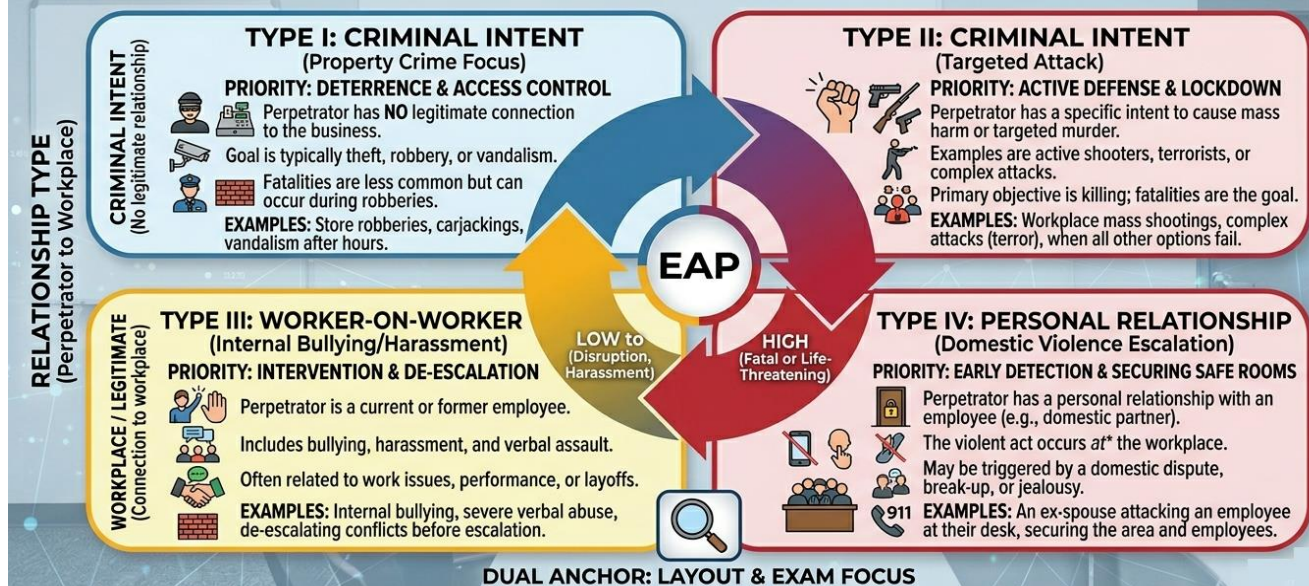
EXAM TIP

Run-Hide-Fight is the DHS protocol. CISD = Critical Incident Stress Debriefing (post-incident). CPTED = Crime Prevention Through Environmental Design. Healthcare workers = highest risk for Type II violence.

ACTIVE THREAT RESPONSE: RUN-HIDE-FIGHT DECISION TREE - EXAM ESSENTIALS



ACTIVE THREAT RESPONSE: 4-TYPE WORKPLACE VIOLENCE MATRIX - EXAM ESSENTIALS



Domain 4 Quick-Reference Summary

Topic	Key Facts & Numbers
OSHA EAP (1910.38)	Written EAP required if ≥ 10 employees; oral EAP permitted for < 10
NFPA 72 Temporal-Three	3 pulses (0.5s on/off); 1.5s pause; repeated — fire evacuation signal
NFPA 72 Temporal-Four	4 pulses; CO alarm signal
ICS Span of Control	Optimal 1:5 (range 1:3 to 1:7); Unity of Command = one supervisor
SARA/EPCRA	S302=EHS planning; S304=release notification; S311-312=inventory; S313=TRI
Emergency Priorities	1=Life safety, 2=Property, 3=Cleanup, 4=Operations
Fire Tetrahedron	Fuel + Oxygen + Heat + Chain Reaction (Pentagon adds Dispersion)
Flash / Fire / AIT	Flash < Fire < AIT (auto-ignition without ignition source)
DOT Classes	9 classes; PG I=greatest hazard; ERG updated every 4 years
CHEMTREC	1-800-424-9300; 24-hr hotline; used at spill scenes
Workplace Violence	#2 occupational killer; 4 types; healthcare workers = highest Type II risk
Run-Hide-Fight	Run=escape; Hide=barricade; Fight=last resort
Egress SET formula	Evacuation Time = Notification Time + Delay Time + Travel Time
BCP Metrics	RTO=max downtime; RPO=max data loss; MTD=total tolerable downtime

Key References

Roger Brauer, Safety and Health for Engineers, 3rd Ed.: Ch. 19 (Fire Protection), Ch. 36 (Emergency Planning), Ch. 37 (Disaster Recovery)

D.S. Yates, Occupational Safety and Health Management, 2nd Ed.: Ch. 14 (Violence), Ch. 22 (Crisis Management), Ch. 23 (BCP), Ch. 29 (HazMat Security)

OSHA 29 CFR 1910.38 — Emergency Action Plans

NFPA 72 — National Fire Alarm and Signalling Code

NFPA 101 — Life Safety Code

49 CFR Parts 171–180 — DOT Hazardous Materials Transportation

SARA Title III / EPCRA (40 CFR Parts 355, 370, 372)

FEMA IS-100 — Introduction to ICS

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