PIE Tech

POLLACHI INSTITUTE OF ENGINEERING AND TECHNOLOGY

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Department of Civil Engineering

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OSF351 Fire Safety Engineering

FIRE SAFETY

INTRODUCTION

Fire safety is the set of practices intended to reduce the destruction caused by fire. Fire safety measures include those that are intended to prevent ignition of an uncontrolled fire, and those that are used to limit the development and effects of a fire after it starts. Fire safety measures include those that are planned during the construction of a building or implemented in structures that are already standing, and those that are taught to occupants of the building. Threats to fire safety are commonly referred to as fire hazards. A fire hazard may include a situation that increases the likelihood of a fire or may impede escape in the event a fire occurs. Fire safety is often a component of building safety.

The staff/employees should have a working knowledge of basic fire science and chemistry. A fire, or combustion, is a chemical reaction. An understanding of the chemical reaction is the basis for preventing fires, as well as extinguishing fires once they initiate. A working knowledge of basic fire science and chemistry is essential for developing and implementing a successful fire safety program.

DEFINITION OF FIRE

A fire is a chemical reaction. There are many variables that can affect a fire. Effective fire safety management programs control the variables that can affect a fire. Therefore, it is imperative to understand the variables. A fire is self-sustained oxidation of a fuel that emits heat and light. A fire requires three variables to initiate: a fuel, oxygen, and heat.

The fire triangle is a well-known representation of the three variables needed to initiate a fire. In order to initiate a fire, fuel, oxygen, and heat are required.

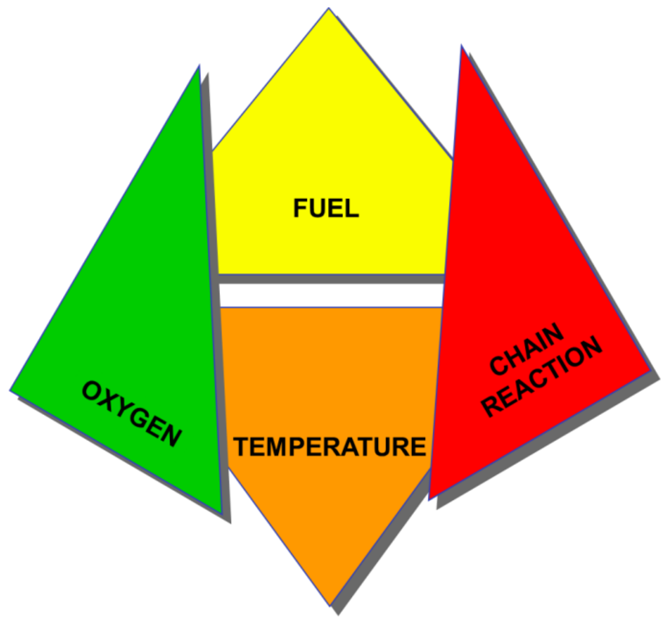
FIRE TETRAHEDRON

Fire prevention is the concept of preventing the variables of the fire triangle from coming into contact with each other to initiate a fire. Once a fire begins, it requires four variables to sustain the combustion reaction. The four variables required to sustain a fire are fuel, oxygen, heat, and chemical chain reactions. These four variables represent the fire tetrahedron.

Chemical chain reactions are a product of the combustion process. The chemical reactions ultimately produce combustion byproducts such as carbon monoxide, carbon dioxide, carbon, and other molecules, depending on the specific fuel. It is these byproducts of combustion found in the smoke that usually affect the safety and health of occupants and fire fighters.

Once a fire begins and is self-sustaining, the goal is to control and extinguish the fire. Fire extinguishment is done by eliminating one of the variables of the fire tetrahedron. By removing the fuel, oxygen, or heat, or inhibiting the chemical chain reactions, a fire can be extinguished. The concept of fire protection assumes fires will occur, and focuses on controlling fires by eliminating or otherwise controlling the variables of the fire tetrahedron. The concept of fire prevention differs from fire protection because fire prevention attempts to control the variables of the fire triangle before a fire occurs.

THE FIRE TETRAHEDRON



To further understand the fire triangle, it is necessary to analyze what influence each side of the fire triangle has in the combustion process. For the safety manager, this analysis is the key for understanding the concept of fire prevention. Fire prevention attempts to prevent fuels, oxygen, and heat from combining to start a fire. Fire prevention strategies include controlling fuels, controlling oxygen sources, and con- trolling heat sources. A discussion of fuels, oxygen, and heat sources follows.

FUEL:

A fuel is a combustible solid, liquid, or gas. Like in any chemical reaction, a source of energy is needed to sustain the heat required. The most common solid fuels are wood, paper, cloth, coal, and so forth. Flammable and combustible liquids include gasoline, fuel oil, paint, kerosene, and other similar materials. Propane, acetylene, and natural gas are some examples of gases that are flammable. Solid and liquid fuels share a common characteristic; they must be converted into a gas in order to support combustion. Gaseous fuels can undergo direct oxidation because the molecules are already in the gas state. Some liquid fuels can undergo direct oxidation because they produce vapors at ambient temperatures and pressures. Other liquid fuels and solid fuels, however, undergo sequential oxidation. This means that a fuel must be heated first to produce sufficient concentrations of gas to support combustion. From a fire safety standpoint, the safety manager should be aware of the different types of fuels located in the workplace.

The ease of ignition of a solid fuel is dependent on several factors. The most important factor is the surface to mass ratio of the fuel. The surface to mass ratio refers to how much of a fuel's surface area is exposed to the environment in relation to its overall mass. The safety manager should be concerned with two things regarding the surface to mass ratio of a fuel. First, the more surface area that is exposed, the easier it is for a fire to initiate and the more rapidly it can burn. Second, the more mass that a solid fuel has, the more difficult it will be to initiate and sustain combustion. Consider cotton as a fuel in a textile mill. Cotton dusts and lint will burn easier and faster than a tightly bound bale of cotton. Liquid fuels are affected by several factors. The safety manager should be familiar with the terms flash point, fire point, boiling point, and specific gravity. Chapter 4 explores these factors in detail. However, one of the most critical indicators of a liquid's flammability should be mentioned—flash point. The flash point refers to the temperature at which adequate vapors are produced to form an ignitable mixture in air. Therefore, a liquid heated to a temperature at or above its flash point will ignite in the presence of an ignition source such as a spark, cigarette, hot surface, or open flame.

OXYGEN:

The atmosphere contains approximately 21% oxygen by volume. During combustion, the oxygen necessary for oxidation is sufficiently provided from the surrounding air. When the oxygen content of the atmosphere falls below 15%, a free-burning fire will begin to smolder. When the oxygen content of the atmosphere falls below 8%, a smoldering fire will stop burning (Bryan, 1982). Oxygen can also be provided by other sources that release oxygen molecules during a chemical reaction. The safety manager should be aware of these oxidizers in the workplace and segregate them from any fuels.

HEAT:

The safety manager should be concerned with sources of heat commonly found in the workplace. This is a concern because sources of heat provide the energy necessary to initiate combustion. By preventing heat sources from contacting the ignitable fuel-air mixtures, fires can be effectively prevented from occurring. Some common sources of heat for ignition in the workplace are:

- Open flames such as from cutting and welding torches
- Cigarettes
- Sparks such as from electrical equipment, brazing, or grinding
- Hot surfaces such as electrical motors, wires, and process pipes
- Radiated heat from boilers or portable heaters
- Lightning
- Static discharges such as during the transfer of flammable liquids
- Arcing from wires and electrical equipment
- Compression such as hydraulic oil under pressure on a machine
- Exothermic chemical reactions
- Spontaneous ignition from slow oxidation or fermentation combined with proper insulation of a fuel

Heat is transferred by three methods: conduction, convection, or radiation. Conduction occurs when two bodies are touching one another and heat is transferred from molecule to molecule. Convection is the transfer of heat through a circulating medium rather than by direct contact. The medium can be either a gas or a liquid. Radiation is the transfer of electromagnetic waves through any medium. For the safety manager, recognizing how heat can be transferred in the workplace is helpful for preventing fires.

As mentioned, four fire extinguishing principles exist. They are highlighted below:

1. Control the fuel— Controlling the fuel is accomplished by two methods. First, the fuel can be physically removed or separated from the fire. For instance, a fire involving stacks of wood pallets could be controlled by removing any exposed stacks of pallets to a safe location. Another example is closing a valve feeding a gas or flammable liquid fire. Second, the fuel can be chemically affected by diluting the fuel.

2. Control the oxygen— Controlling the oxygen requires that the oxygen be inhibited, displaced, or the concentration of oxygen be reduced below 15% by volume. Smoldering fires should be diluted to an oxygen concentration below 8% by volume. The oxygen supply to a fire can be inhibited by smothering the fire. Smothering a fire places a barrier between the flame and the atmosphere. This can be accomplished with a blanket or applying a layer of foam to form a vapor barrier. Displacing and reducing the oxygen concentration involves applying an inert gas to the fire, such as carbon dioxide. The carbon dioxide displaces the oxygen thus lowering the concentration to a level that cannot sustain the fire. Applying an inert gas to a fire requires that the fire be located in a confined space. Personnel must be aware that displacing the oxygen or diluting the oxygen concentration affects their ability to breathe. Fire extinguishment using this method requires that personnel be absent from the confined area or protected by self-contained breathing apparatus.

3. Control the heat— Controlling the heat requires that the heat be absorbed. Combustion is an exothermic chemical reaction. If the heat emitted by the reaction can be absorbed faster than the reaction can produce the heat, then the reaction cannot be sustained. Water is the most common extinguishing agent. Water is also the most efficient extinguishing agent because it has the capability to absorb immense amounts of heat.

4. Inhibit the chemical chain reactions— Inhibiting the chemical chain reactions requires that a chemical agent be introduced into the fire. Certain chemical agents can interfere with the sequence of reactions by absorbing free radicals from one sequence that are needed to complete the next sequence. Dry chemical extinguishing agents commonly used in portable fire extinguishers have this ability.

CLASSES OF FIRE

Fires are classified based upon the type of fuel that is consumed. Fires are classified into categories so personnel can quickly choose appropriate extinguishing agents for the expected fire and associated hazards. Fires are classified into five general classes. Each class is based on the type of fuel and the agents used in extinguishment. The five classes of fire are described next:

• **Class A—** Class A fires involve ordinary combustibles such as wood, paper, cloth, rubber, and some plastics. Water is usually the best extinguishing agent because it can penetrate fuels and absorb heat. Dry chemicals used to interrupt the chemical chain reactions are also effective on Class A fires.

• **Class B—** Class B fires involve flammable and combustible liquids and gases such as gasoline, alcohols, and propane. Extinguishing agents that smother the fire or reduce the oxygen concentration available to the burning zone are most effective. Common extinguishing agents include foam, carbon dioxide, and dry chemicals.

• **Class C—** Class C fires involve energized electrical equipment. Non-conductive extinguishing agents are necessary to extinguish Class C fires. Dry chemicals and inert gases are the most effective agents. If it can be done safely, personnel should isolate the power to electrical equipment before attempting to extinguish a fire. Once electrical equipment is de-energized, it is considered a Class A fire.

• **Class D—** Class D fires involve combustible metals such as magnesium, sodium, titanium, powdered aluminum, potassium, and zirconium. Class D fires require special extinguishing agents that are usually produced for the specific metal.

• **Class K—** Class K fires most often occur where cooking media (fats, oils, and greases) are used, and most of the time are found in commercial cooking operations. Class K fire extinguishers are required in any location that cooks oils, grease, or animal fat. Any location that fries must have a Class K fire extinguisher. Every commercial kitchen should have a Class K extinguisher located in it to supplement the suppression system.

THREE STAGES OF FIRE

Fires evolve through several stages as the fuel and oxygen available are consumed. Each stage has its own characteristics and hazards that should be understood by safety managers and fire-fighting personnel.

INCIPIENT STAGE:

The incipient stage is the first or beginning stage of a fire. In this stage, combustion has begun. This stage is identified by an ample supply of fuel and oxygen. The products of combustion that are released during this stage normally include water vapor, carbon dioxide, and carbon monoxide. Temperatures at the seat of the fire may have reached 1000°F, but room temperatures are still close to normal.

FREE-BURNING STAGE:

The free-burning stage follows the incipient stage. At this point, the self-sustained chemical reaction is intensifying. Greater amounts of heat are emitted and the fuel and oxygen supply is rapidly consumed. Room temperatures can rise to over 1300°F. In an enclosed compartment, the free-burning stage can become dangerous. Because of the heat intensity, the contents within a compartment are heated. At some point, if the compartment is not well ventilated, compartment contents will reach their ignition temperature. A flashover occurs when the contents within a compartment simultaneously reach their ignition temperature and become involved in flames. It is not uncommon for room temperatures to exceed 2000°F following a flashover. Human survival, even for properly protected fire fighters, is difficult if not impossible for a few seconds within a compartment following a flashover.

SMOLDERING STAGE:

The smoldering stage follows the free-burning stage. As a free-burning fire continues to burn, the chemical reaction will eventually consume the available oxygen within the compartment and ultimately convert it into carbon monoxide and carbon dioxide. This causes the oxygen concentration within the compartment to decrease. When the oxygen concentration decreases to 15% by volume, the chemical reaction will not have sufficient oxygen to support free-burning combustion. Visibly, the flames subsist and the fuel begins to glow. A smoldering fire is identified by a sufficient amount of fuels and lower oxygen concentrations. Smoldering fires, especially when insulated within a compartment, can continue the combustion process for hours. Room temperatures can range from 1000–1500°F. The byproducts of combustion also fill the compartment and human survival is impossible. During the smoldering stage, an extreme hazard, called a backdraft, can develop. A backdraft occurs when oxygen is introduced into a smoldering compartment fire. The immediate availability of sufficient oxygen in the presence of sufficient fuel, heat, and chemical chain reactions causes flaming combustion again. In some cases, the backdraft is so violent that an explosion will occur. Human survival, even of properly protected fire fighters, is usually not possible.

IDENTIFICATION OF HAZARDOUS MATERIALS

In the past, chemical manufacturers labeled their products with the warnings "Caution," "Danger," and "Handle with Care." The terms were vague and did not indicate specific hazards associated with particular chemicals. The U.S. Department of Transportation labeling system contains requirements for the shipping, marking, labeling, and placarding of 1400 hazardous materials.

The objectives of this standard are to
(1) Provide an immediate warning of potential danger;
(2) Inform emergency responders of the nature of the hazard;
(3) State emergency spill or release control procedures; and
(4) Minimize potential injuries from chemical exposure.

The standard contains a hazardous materials table listing substances by name, prescribing requirements for shipping papers, package marking, labeling, and transport vehicle placarding. Table shows a comparison listing of

United Nations and DOT classifications for hazardous materials. The classes of hazardous materials that must be labeled and placarded are as follows: explosives, flammable and combustible materials, oxidizers, corrosives, poisons, compressed gases, etiologies, and radioactive materials.

TABLE 1
United Nations and Department of Transportation Classification of Hazardous Materials

United Nations Class	DOT Classification
1	Explosives: Class A, B, and C
2	Nonflammable and flammable gases
3	Flammable liquids
4	Flammable solids, spontaneously combustible substances, and water reactive substances
5	Oxidizing materials and organic peroxides
6	Poisons: Class A, B, and C
7	Radioactive I, II, and III
8	Corrosives
9	Miscellaneous materials which can present a hazard during transport, but are not covered by other classes

TABLE 2
Table of Evacuation (Isolation) Distances

1. Determine if the accident involves a *small* or *large* spill and if *day* or *night*. Generally, a *small spill* is one which involves a single, small package (i.e., up to a 208 liter [55 U.S. gallon] drum), a small cylinder, or a small leak from a large package. A *large spill* is one which involves a spill from a large package, or multiple spills from many small packages.

2. Determine the initial *isolation* distance. Direct all persons to move, in a crosswind direction, away from the spill to the distance specified in meters and feet.

3. Next, determine the initial *protective action distance*. For a given dangerous goods, spill size, and whether day or night, try to determine the downwind distance—in kilometers and miles—for which protective actions should be considered. For practical purposes, the Protective Action Zone (i.e., the area in which people are at risk of harmful exposure) is a square, whose length and width are the same as the downward distance.

4. Initiate protective actions to the extent possible, beginning with those closest to the spill site and working away from the site in the downwind direction. When a water-reactive PIH producing material is spilled into a river or stream, the source of the toxic gas may move with the current or stretch from the spill point downstream for a substantial distance.

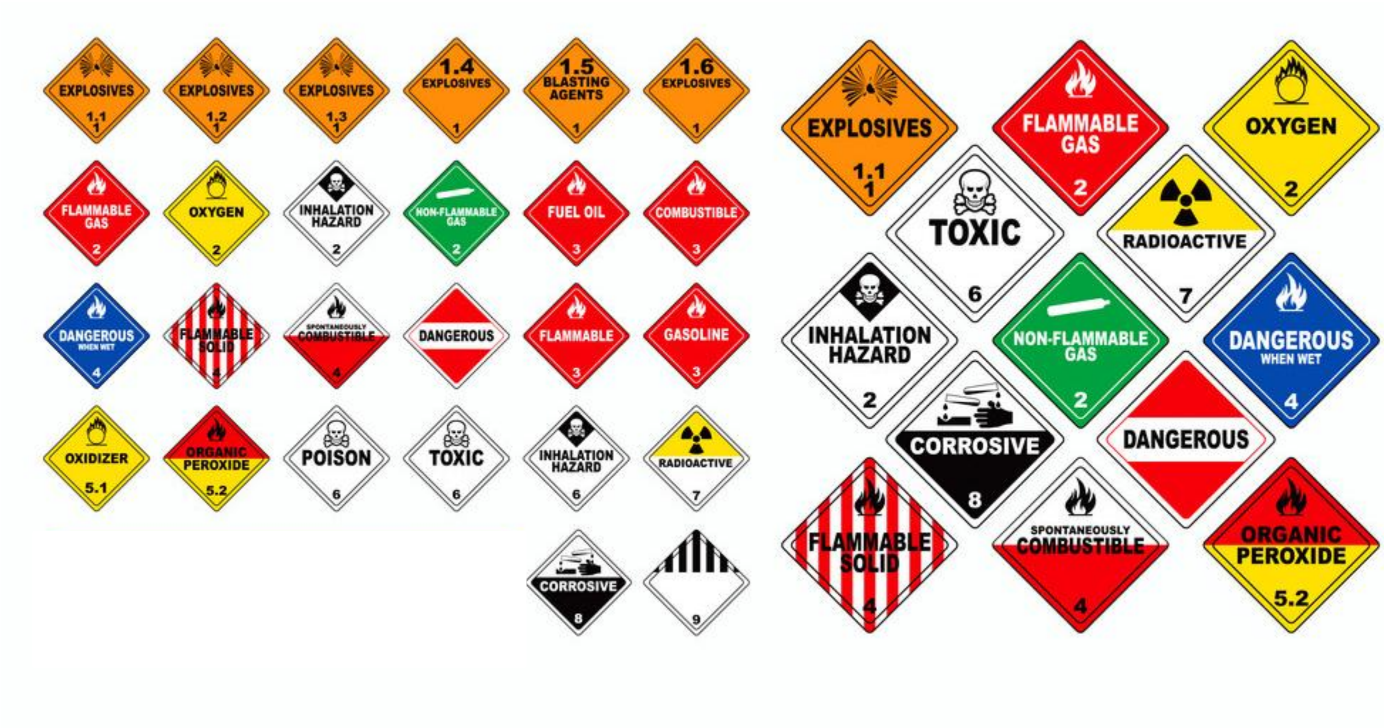


TABLE 3
Classes of Flammable Materials

Hazardous Class	Definition	Examples
Flammable Liquid	Any liquid with a flash point below 37.8°C (100°F).	Gasoline, pentane
Flammable Solid	Any solid material, other than one classified as an explosive, which is likely to cause fire by self-ignition through friction, absorption of moisture, chemical changes, or retained heat. Can be ignited readily and burn vigorously.	Phosphorus, fish meal
Flammable Solid (Dangerous when wet)	Same definition as above, with the additional fact that water will accelerate the reaction.	Magnesium scrap, lithium silicon
Flammable Gases	Any mixture or material in a container having an absolute pressure exceeding 40 psi at 70°F or any liquid flammable material having a vapor pressure exceeding 40 psi at 100°F.	Methane, methyl chloride
Combustible Liquid	Any liquid with a flash point at or above 37.8°C (100°F) and below 93.3°C (200°F).	Pine oil, ink, fuel oil

TABLE 4
Classification of Flammable and Combustible Liquids (*NFPA-30*)

Class I	Flammable Liquids—Flash point below 100°F (37.8°C)
	Volatile Class I Flammable Liquids
Class IA	Most hazardous, having flash points below 73°F (22.8°C) with boiling points below 100°F (37.8°C)
Class IB	Same flash point range but with boiling points at or above 100°F (37.8°C)
Class IC	Flash points between 73°F (22.8°C) and below 100°F (37.8°C)

Class II	Combustible Liquids—Flash points at or above 100°F (37.8°C) and below 140°F (60°C)
Class III	Liquids are included in the combustible liquid classification and are further classified
Class IIIA	Flash point between 140 and 200°F (60–93.4°C)
Class IIIB	Flash point 200°F (93.4°C) or above

NFPA CODE 704:

NFPA 704 provides an easy method of recognizing hazards. The NFPA 704 Diamond indicates the health, flammability, and reactivity (i.e., stability) hazards of chemicals by placing numbers in the three upper squares of the diamond

Health Hazards Are Indicated in the Left Square, Color-Coded Blue

4. Materials which on very short exposure could cause death or major residual injury.
3. Materials which on short exposure could cause serious temporary or residual injury.
2. Materials which on intense or continued, but not chronic, exposure could cause temporary incapacitation or possible residual injury.
1. Materials which on exposure would cause irritation but only minor residual injury.
0. Materials which on exposure under fire conditions would offer no hazard beyond that of ordinary combustible material.

Flammability Hazards Are Indicated in the Top Square, Color-Coded Red

4. Materials which will vaporize rapidly or completely at atmospheric pressure and normal ambient temperature, or which are dispersed readily and which will burn readily.
3. Liquids and solids which can be ignited under almost all ambient temperature conditions.
2. Materials which must be heated moderately or exposed to relatively high ambient temperatures before ignition can occur.
1. Materials which must be preheated before ignition can occur.
0. Materials that will not burn.

Reactivity (Stability) Hazards Are Indicated in the Right Square, Color-Coded Yellow

4. Materials which in themselves are readily capable of detonations or of explosive decomposition or reaction at normal temperatures and pressures.
3. Materials which in themselves are capable of detonation or explosive decomposition or reaction, but require a strong initiating source, or which must be heated under confinement before initiation, or which react explosively with water.
2. Materials which readily undergo violent chemical change at elevated temperatures, or which react violently with water, or which may form explosive mixtures with water.
1. Materials which in themselves are normally stable, but which can become unstable at elevated temperatures and pressures.
0. Materials which in themselves are normally stable, even under fire expo- sure conditions, and which are not reactive with water.

Special Information Is Indicated in the Bottom Square, Color-Coded White

0. The letter W with a bar through it indicates a material may have a hazardous reaction with water. This does not mean "use no water," but rather "avoid the use of water." Note that some forms of water (e.g., fog or fine spray) may be used. Because water may cause a hazard, it is advised that water be used very cautiously until fire fighters have proper information.

1. The radioactive “pinwheel” indicates radioactive materials.
2. The letters “OX” indicate an oxidizer.

HAZARD DIAMOND

TABLE 5
Classes of Oxidizing Materials

Hazardous Class	Definition	Examples
Oxidizer	A substance that yields O_2 readily to stimulate the combustion of organic matter.	Silver nitrate
Organic Peroxide	An organic derivative of the inorganic compound, hydrogen peroxide.	Lauroyl peroxide
Oxygen	An odorless, colorless, gaseous chemical element that supports combustion. At low temperatures the gas liquefies.	Oxygen

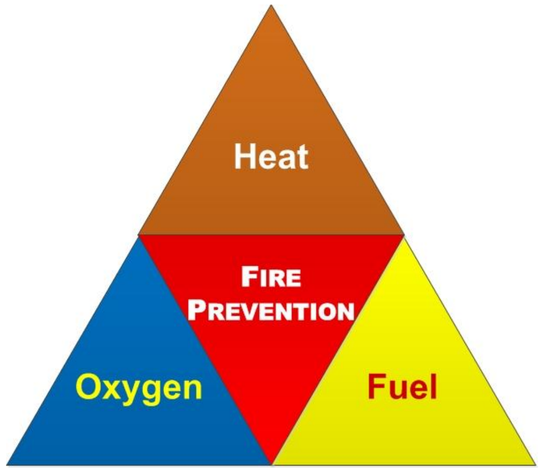
TABLE 6
Classes of Explosives

Hazardous Class	Definition	Examples
Explosive	Any chemical compound, mixture, or device, the purpose of which is to function by explosion, that is, with substantial instantaneous release of gas or heat.	
Class A	A detonating or otherwise maximum hazard.	Black powder, dynamite, blasting caps
Class B	Function by rapid combustion rather than detonation.	Special fireworks, flash powders
Class C	Materials that do not ordinarily detonate in restricted quantities—minimum explosion hazard.	Flares, small arms

FIRE PREVENTION & PROTECTION:

FIRE PREVENTION

Fire prevention requires segregating the three elements of the fire triangle. A fire needs three elements - heat, oxygen and fuel. Without heat, oxygen and fuel a fire will not start or spread. A key strategy to prevent fire is to remove one or more of heat, oxygen or fuel. .



HEAT

Heat can be generated by work processes and is an essential part of some processes such as cooking. This heat must be controlled and kept away from fuel unless carefully controlled. Heat generated as a by-product of a process must be dealt with properly.

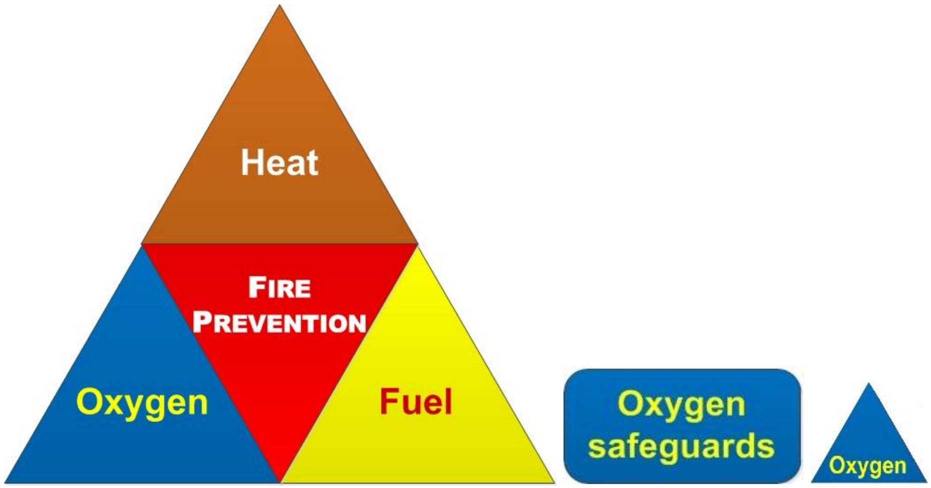
Heat Safeguards

- Ensure employees are aware of their responsibility to report dangers
- Control sources of ignition
- Have chimneys inspected and cleaned regularly
- Treat independent building uses, such as an office over a shop as separate purpose groups and therefore compartmentalize from each other
- Ensure cooking food is always attended
- Use the Electricity Supply Board's Safety webpage
- Have regard to relevant Authority Safety Alerts, e.g. Mobile Phone "*Expert XP-Ex-1*", Filling LPG Cylinders
- Use the Code of Practice For Avoiding Danger From Underground Services

OXYGEN

Oxygen gas is used

- in welding, flame cutting and other similar processes
- for helping people with breathing difficulties
- in hyperbaric chambers as a medical treatment
- in decompression chambers
- for food preservation and packaging
- in steelworks and chemical plants



The air we breathe contains about 21% oxygen. Pure oxygen at high pressure, such as from a cylinder, can react violently with common materials such as oil and grease. Other materials may catch fire spontaneously. Nearly all materials including textiles, rubber and even metals will burn vigorously in oxygen.

With even a small increase in the oxygen level in the air to 24%, it becomes easier to start a fire, which will then burn hotter and more fiercely than in normal air. It may be almost impossible to put the fire out. A leaking valve or hose in a poorly ventilated room or confined space can quickly increase the oxygen concentration to a dangerous level.

The main causes of fires and explosions when using oxygen are

- oxygen enrichment from leaking equipment
- use of materials not compatible with oxygen
- use of oxygen in equipment not designed for oxygen service
- incorrect or careless operation of oxygen equipment

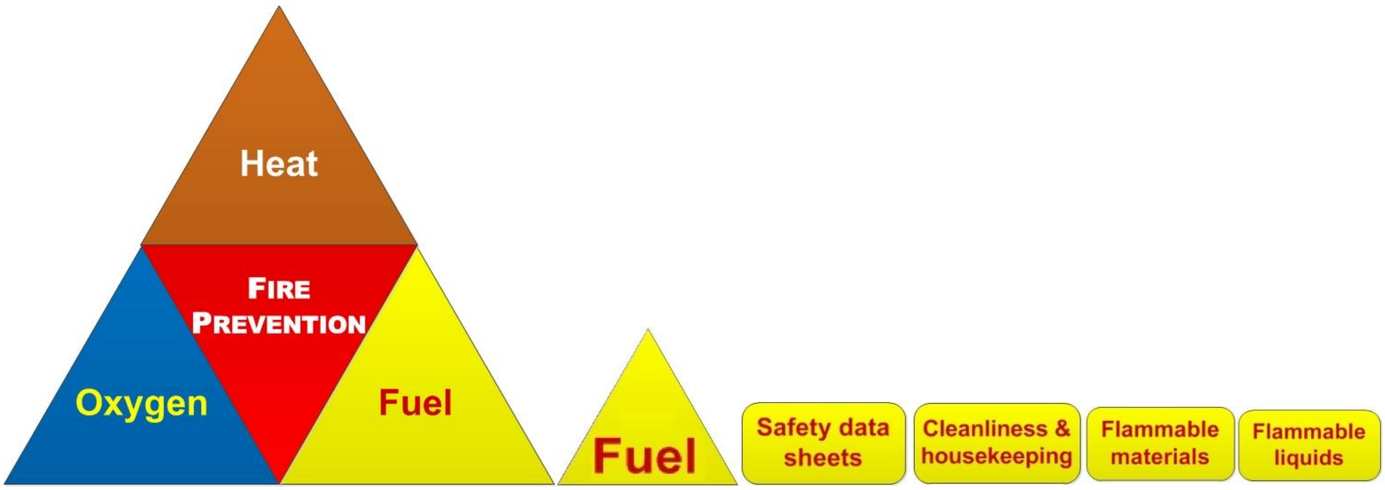
Oxygen Safeguards

- Ensure employees are aware of their responsibility to report dangers
- See safeguards in the Code of Practice for Working in Confined Spaces
- Oxygen should never be used to “sweeten” the air in a confined space
- **Where oxygen is used,**
    - follow safety advice from the supplier
    - follow the safeguards on the safety data sheet
    - keep the safety data sheet readily available
- Be aware of the dangers of oxygen if in doubt, ask
- Prevent oxygen enrichment by ensuring that equipment is leak-tight and in good working order
- Check that ventilation is adequate
- Always use oxygen cylinders and equipment carefully and correctly
- Always open oxygen cylinder valves slowly
- Do not smoke where oxygen is being used
- Never use replacement parts which have not been specifically approved for oxygen service
- Never use oxygen equipment above the pressures certified by the manufacturer
- Never use oil or grease to lubricate oxygen equipment
- Never use oxygen in equipment which is not designed for oxygen service
- Operators of locations storing large amounts of oxidising substances

FUEL

Workplaces in which large amounts of flammable materials are displayed, stored or used can present a greater hazard than those where the amount kept is small.

In relation to fire, fuel consists of flammable material. Flammable material is material that burns readily in a normal atmosphere. Flammable materials include flammable liquids (e.g. petrol), flammable gasses (e.g. propane and butane) and flammable solids (e.g. charcoal, paper). It is important to identify all flammable materials that are in your workplace so that proper controls can be put in place.



Great care is required in the storage, handling and use of flammable materials. Safety Data sheets may provide detailed advice.

Fuel Safeguards

- Identify all flammable materials so that proper controls can be put in place
- Identify use of substances with flammable vapours (e.g. some adhesives)
- Reduce quantities of flammable materials to the smallest amount necessary for running the business and keep away from escape routes
- Replace highly flammable materials with less flammable ones
- Store remaining stocks of highly flammable materials properly outside, in a separate building, or separated from the main workplace by fire-resisting construction
- Provide clearly marked separate storage for flammable chemicals, gas cylinders, and waste materials
- Train employees on safe storage, handling and use of flammable materials
- Keep stocks of office stationery and supplies and flammable cleaners' materials in separate cupboards or stores. They should be fire-resisting with a fire door if they open onto a corridor or stairway escape route.
- This is highly specialised work and a detailed risk assessment must be conducted
- Detailed work instructions must be put in place
- Advice should be sought from the gas supplier as needed
- Workers must be properly trained and supervised
- The quantity of flammable liquids in workrooms should be kept to a minimum, normally no more than a half-day's or half a shifts supply
- Flammable liquids, including empty or part-used containers, should be stored safely. Small quantities (Tens of Litres) of flammable liquids can be stored in the workroom if in closed containers in a fire-resisting (e.g. metal), bin or cabinet fitted with means to contain any leaks
- Flammable liquids should not be decanted within the store. Decanting should take place in a well-ventilated area set aside for this purpose, with appropriate facilities to contain and clear up any spillage
- Container lids should always be replaced after use, and no container should ever be opened in such a way that it cannot be safely resealed

- Flammable liquids should be stored and handled in well ventilated conditions. Where necessary, additional properly designed exhaust ventilation should be provided to reduce the level of vapour concentration in the air
- Storage containers should be kept covered and proprietary safety containers with self-closing lids should be used for dispensing and applying small quantities of flammable liquids
- There should be no potential ignition sources in areas where flammable liquids are used or stored and flammable concentrations of vapour may be present at any time. Any electrical equipment used in these areas, including fire alarm and emergency lighting systems, needs to be suitable for use in flammable atmospheres
- Avoid accumulations of combustible rubbish and waste and remove at least daily and store away from the building
- Never store flammable or combustible rubbish, even temporarily, in escape routes, or where it can contact potential sources of heat
- Position skips so that a fire will not put any structure at risk
- Clean cooking surfaces on a regular basis to prevent grease build-up
- Rags and cloths which have been used to mop up or apply flammable liquids should be disposed of in metal containers with well-fitting lids and removed from the workplace at the end of each shift or working day
- Handle material in accordance with the advice on the safety data sheet
- Keep safety data sheets readily available
- Keep safety data sheets safely available in the event of a fire so that the information is available for emergency services

FIRE PROTECTION

Fire is a chemical reaction that requires three elements to be present for the reaction to take place and continue. The three elements are:

- Heat, or an ignition source
- Fuel
- Oxygen

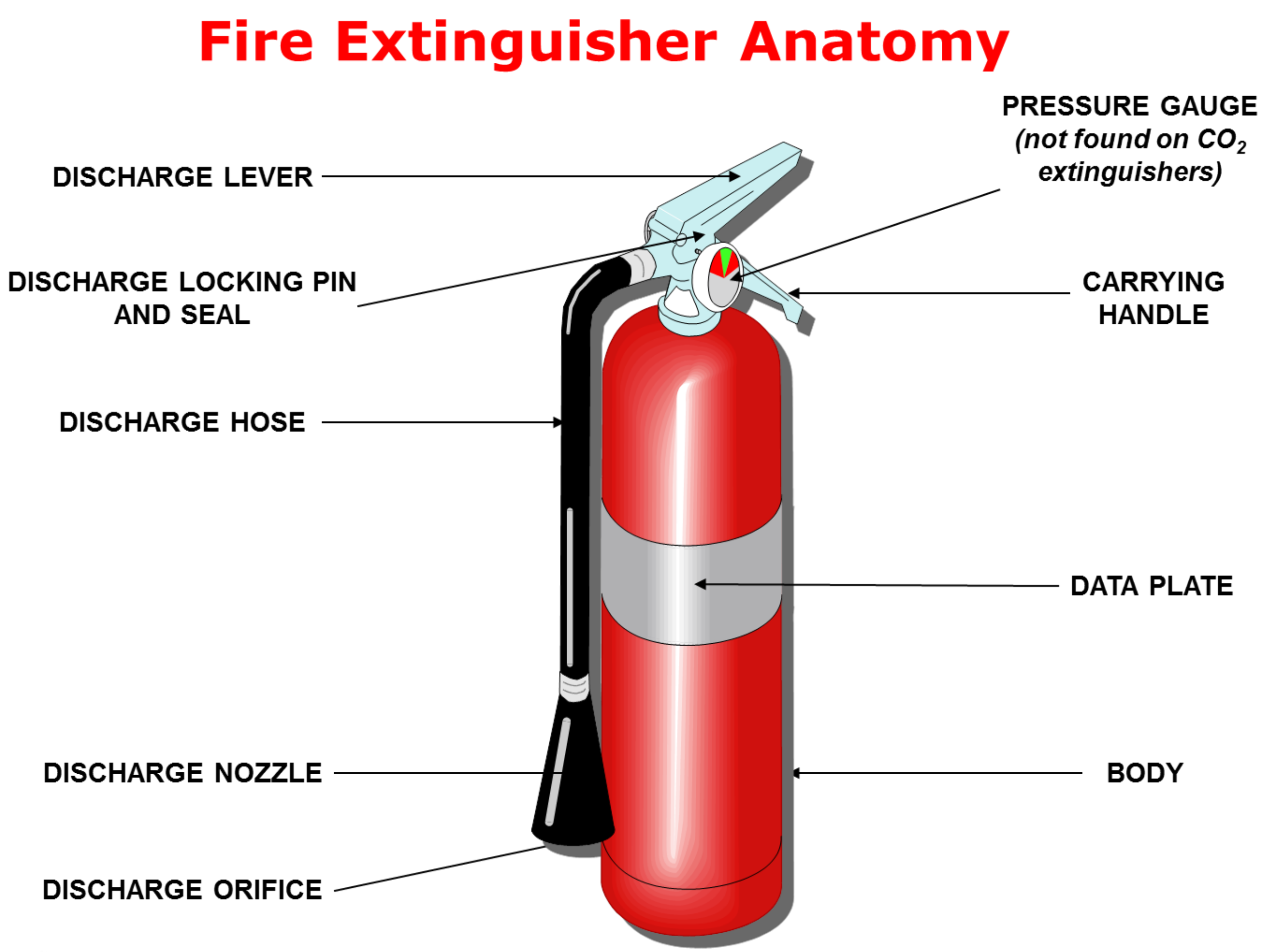
These three elements typically are referred to as the “fire triangle.” Fire is the result of the reaction between the fuel and oxygen in the air. Scientists developed the concept of a fire triangle to aid in understanding of the cause of fires and how they can be prevented and extinguished. Heat, fuel and oxygen must combine in a precise way for a fire to start and continue to burn. If one element of the fire triangle is not present or removed, fire will not start or, if already burning, will extinguish.

Ignition sources can include any material, equipment or operation that emits a spark or flame —including obvious items, such as torches, as well as less obvious items, such as static electricity and grinding operations. Equipment or components that radiate heat, such as kettles, catalytic converters and mufflers, also can be ignition sources. Fuel sources include combustible materials, such as wood, paper, trash and clothing; flammable liquids, such as gasoline or solvents; and flammable gases, such as propane or natural gas. Oxygen in the fire triangle comes from the air in the atmosphere. Air contains approximately 79 percent nitrogen and 21 percent oxygen. OSHA describes a hazardous atmosphere as one which is oxygen-deficient because it has less than 19.5 percent oxygen, or oxygen enriched because it has greater than 23.5 percent oxygen. Either instance is regarded by OSHA as an atmosphere immediately dangerous to life and health (IDLH) for reasons unrelated to the presence of fire. Depending on the type of fuel involved, fires can occur with much lower volume of oxygen present than needed to support human respiration. Every roofing project has all three of the fire triangle elements present in abundance. The key to preventing fires is to keep heat and ignition sources away from materials, equipment and structures that could act as fuel to complete the fire triangle.

Fire Classifications Fires are classified as A, B, C, D or K based on the type of substance that is the fuel for the fire, as follows:

Class A—fires involving ordinary combustibles, such as paper, trash, some plastics, wood and cloth. A rule of thumb is if it leaves an ash behind, it is a Class A fire.
Class B—fires involving flammable gases or liquids, such as propane, oil and gasoline
Class C—fires involving energized electrical components
Class D—fires involving metal. A rule of thumb is if the name of the metal ends with the letters “um,” it is a Class D fire. Examples of this are aluminum, magnesium, beryllium and sodium. Class D fires rarely occur in the roofing industry.
Class K—fires involving vegetable or animal cooking oils or fats; common in commercial cooking operations using deep fat fryers.

Fire Extinguishers There are different types of fire extinguishers designed to put out the different classes of fire. Selecting the appropriate fire extinguisher is an important consideration for a roofing contractor. The wrong extinguisher actually may make a fire emergency worse. For example, failing to use a Crated extinguisher on energized electrical components may endanger workers by causing the extinguishing material to be electrified by the energized components that are on fire. C-rated fire extinguishers put out the fire by using a chemical that does not conduct electricity.



The following table illustrates the types of extinguishers, fire classes for which each is used and the limitations of each extinguisher.

Fire Extinguisher Type	*Class of Fire it Extinguishes*	*Extinguisher Limitations/ Comments*
Dry Chemical (multipurpose)	*A, B, C*	*Generally good for use in roofing industry*
Foam—alcohol-resistant and aqueous film-forming foam (AFFF) types	*B*	*Expensive; effective on Class B only; limited shelf life; generally not needed in roofing industry*
Water	*A*	*Good only for Class A fires*
Metal X	*D B, C;*	*Expensive; must be kept dry; ineffective on A, typically not needed in roofing industry*
Carbon Dioxide	*B, C*	*If used in confined areas, will create oxygen deficiency; not effective in windy conditions; can cause frostbite during discharge; typically not used in roofing industry*
Halon	*B, C*	*Expensive; not effective in windy conditions; toxic gases may be released in extremely hot fires because of decomposition; generally not used in roofing industry*
Potassium Acetate	*K*	*Expensive, wet chemical extinguisher for commercial cooking operations using oils and fats*

Remember this easy acronym when using an extinguisher - P.A.S.S.

Pull the pin.

Aim the nozzle.

Squeeze the handle.

Sweep side to side at the base of the fire.

Employees should be instructed that if a fire cannot be extinguished using one full extinguisher, they should evacuate the site and let the fire department handle the situation.

EMERGENCY EVACUATION

Emergency evacuation is the urgent immediate egress or escape of people away from an area that contains an imminent threat, an ongoing threat or a hazard to lives or property.

Examples range from the small-scale evacuation of a building due to a storm or fire to the large-scale evacuation of a city because of a flood, bombardment or approaching weather system, especially a Tropical Cyclone. In situations involving hazardous materials or possible contamination, evacuees may be decontaminated prior to being transported out of the contaminated area.

Evacuation Sequence-

The sequence of an evacuation can be divided into the following phases:

1. detection
2. decision
3. alarm
4. reaction
5. movement to an area of refuge or an assembly station
6. transportation

The time for the first four phases is usually called pre-movement time. The most common equipment in buildings to facilitate emergency evacuations are fire alarms, exit signs, and emergency lights. Some structures need special emergency exits or fire escapes to ensure the availability of alternative escape paths.

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MODULE II

FIRE SAFETY

1.Introduction to toxity of product of combustion

Hazardous substances are used in many workplaces today. Working people are discovering that they need to know more about the health effects of chemicals, which they use or may be exposed to on the job. Textbooks, fact sheets, and material safety data sheets (MSDSs) provide important information, but they are often written in hard-to- understand technical language. To help you better understand technical information about hazardous workplace chemicals, this booklet explains how chemicals can affect the body, what to look for when reading health information, the different types of exposure limits for chemicals in the workplace, tips on how to know if you are exposed, what you can do to reduce exposure, and where to go for additional information.

1.1 What makes a chemical toxic?

The toxicity of a substance is its ability to cause harmful effects. These effects can strike a single cell, a group of cells, an organ system, or the entire body. A toxic effect may be visible damage, or a decrease in performance or function measurable only by a test. All chemicals can cause harm. When only a very large amount of the chemical can cause damage, the chemical is considered to be practically non-toxic. When a tiny amount is harmful, the chemical is considered to be highly toxic.

The toxicity of a substance depends on three factors: its chemical structure, the extent to which the substance is absorbed by the body, and the body's ability to detoxify the substance (change it into less toxic substances) and eliminate it from the body.

1.2 Are "toxic" and "hazardous" the same?

No. The toxicity of a substance is the potential of that substance to cause harm, and is only one factor in determining whether a hazard exists. The hazard of a chemical is the practical likelihood that the chemical will cause harm. A chemical is determined to be a hazard depending on the following factors:

Toxicity: how much of the substance is required to cause harm, route of exposure: how the substance enters your body,

Dose: how much enters your body,

Duration: the length of time you are exposed,

Reaction and interaction: other substances you are exposed to at the same time,and,

Sensitivity: how your body reacts to the substance compared to other people.

Some chemicals are hazardous because of the risk of fire or explosion. These are important dangers, but are considered to be safety rather than toxic hazards. The factors of a toxic hazard are more fully explained below.

Vapor cloud : Vapor cloud is vapor which has gathered in one place. An estimated 30 tons of cyclohexane volatilized and formed a large vapor cloud. A rupture of a pipeline carrying liquefied petroleum gas may lead to the formation of a vapor cloud.

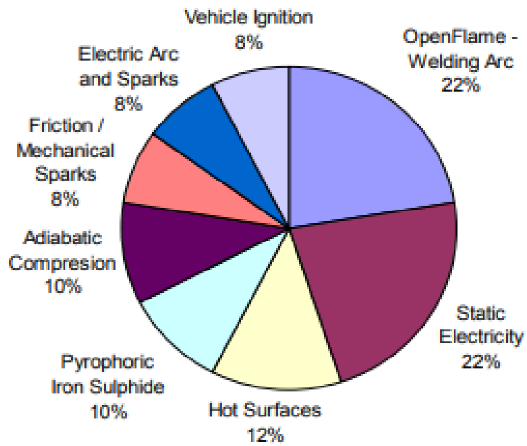
A flash fire :A flash fire is a sudden, intense fire caused by ignition of a mixture of air and a dispersed flammable substance such as a solid (including dust), flammable or combustible liquid (such as an aerosol or fine mist), or a flammable gas. It is characterized by high temperature, short duration, and a rapidly moving flame front.

Jet fire: A fire type resulting from the discharge of liquid, vapor, or gas into free space from an orifice, the momentum of which induces the surrounding atmosphere to mix with the discharged material.

Pool fire :A pool fire is a type of diffusion flame where a layer of volatile liquid fuel is evaporating and burning. The fuel layer can be either on a horizontal solid substrate or floating on a higher-density liquid, usually water

Auto ignition: Auto ignition: is defined as the self-ignition of the vapors emitted by a liquid heated above its ignition temperature and that, when escaping into the atmosphere, enter into their explosive range.

Ignition Sources: The information on this section of the site looks at the many possible ignition sources found in the upstream oil and gas industry. Some are well understood and readily identified, while others deserve further examination. Identifying Ignition Sources Hot Work Static Electricity Hot Surfaces Pyrophoric Iron Sulphides Pressure (Compression Ignition) Friction and mechanical Sparks Sudden Decompression Catalysts



Hot Work: Hot work has been defined as any operation that can produce enough heat from flame, spark or other source of ignition, with sufficient energy to ignite flammable vapours, gases, or dust. Welding, cutting, grinding, brazing, flaming, chipping, air gouging, riveting, drilling, and soldering are all forms of hot work that can create sparks or high temperatures .

Static Electricity: Definition "Static electricity is the electrical charging of materials through physical contact and separation and the positive and negative electrical charges formed by this process. If the process is not or cannot be properly grounded, allowing the charge build-up to be safely dissipated, the charge may build up to the point where it will discharge with a static arc, which may provide an ignition source to a nearby mixture of fuel vapour and air. This is shown schematically in the Static Charge Generation diagram later in this section. Static electricity can be generated in many different ways.

Pyrophoric Iron Sulphides: Pyrophoric iron sulphides form when iron is exposed to hydrogen sulphide, or any other compound that contains sulphur, in an oxygen deficient atmosphere . They are found frequently in vessels, storage tanks, and sour gas pipelines. Pyrophoric iron sulphides present a hazard when equipment and tanks are opened for cleaning, inspection, and maintenance. As the iron-sulphide compounds dry out and come in contact with air, they react with the oxygen and spontaneously ignite .

Pressure (Compression Ignition):

When gases are compressed, heat is generated, or more accurately, energy is transferred. If the rate of heat generation within a system exceeds the rate of heat loss (energy transfer) to the surroundings, the temperature of the system will rise. If the rate of compression is rapid enough such that the heat loss may be considered negligible, resulting in "adiabatic compression", the temperature rise will depend on compression ratio. Diesel engines work on this basic principle.

Friction and Mechanical Sparks: Mechanical sparks occur when there is excessive friction between metals or extremely hard substances. As the two substances rub against each other, small particles are torn off the surfaces. This tearing is due to the large amount of friction. For a metal to spark, it must satisfy three conditions: ƒ

- The energy, which supplies the tearing off of the particles, must be sufficient to heat the metal to high temperatures. Softer metals usually deform before they spark. ƒ
- The metal must be able to oxidize and burn easily. Generally, a metal's sparking temperature is the same as its burning temperature. ƒ
- The metal's specific heat is the last factor. A metal with a low specific heat will reach a higher temperature for the same amount of energy input.

Sudden Decompression: Sudden Decompression of air-hydrocarbon mixtures, particularly air-liquid hydrocarbon mixtures, is not well understood. In the presence of air, liquid hydrocarbons may oxidize forming products such as hydroperoxides, aldehydes, ketones etc. Higher temperatures and pressures will increase this reaction rate. Some of these compounds are highly unstable especially when subjected to sudden pressure and temperature changes. Decomposition of such products can yield significant energy rapidly and may provide an ignition source for the air-hydrocarbon mixture. In addition, during sudden decompression of air-hydrocarbon mixtures, the release of dissolved gases within the liquid hydrocarbons may atomize the liquid hydrocarbons thus enhancing their reactivity

Catalysts When added to hydrocarbons, some chemicals may substantially increase the reactivity of the mixture. Some metals may also act as a catalytic surface.

2. Different Classes of Fires

Class A: solid materials such as wood or paper, fabric, and some plastics
Class B: liquids or gas such as alcohol, ether, gasoline, or grease
Class C: electrical failure from appliances, electronic equipment, and wiring
Class D: metallic substances such as sodium, titanium, zirconium, or magnesium
Class K: grease or oil fires specifically from cooking

Understanding the 5 different classes of fires can help you determine the biggest fire risks at your facility, depending on the fuels and fire hazards present as well as how best to prepare in case of a fire emergency.

Let's break down each of the 5 different classes of fires more thoroughly.

2.1 Class A Fires: "Ordinary" Fires

They occur when common combustible materials like wood, paper, fabric, trash, and light plastics catch fire. These accidental fires are ubiquitous across a variety of industries, so it's recommended to have adequate protection against "ordinary" fires in addition to other condition-specific fires.

Despite being “ordinary”, don’t rule this class of fire as low-risk. If there’s an abundance of fuel present, these fires can intensify quickly. It’s best to put out a Class A fire quickly before it spreads using water or monoammonium phosphate.

2.2 Class B Fires: Liquids & Gases

Class B fires involve flammable liquids and gases, especially fuels like petroleum or petroleum-based products such as gasoline, paint, and kerosene. Other gases that are highly flammable are propane and butane, which are common causes of Class B fires. The best way to deal with these types of fires is by smothering them or removing oxygen using foam or CO_2 fire suppression equipment.

2.3 Class C Fires: Electrical Fires:

Electrical fires fall under Class C and are common in facilities that make heavy use of electrical equipment, but they can occur in a wide range of industries. For example, data centers might be an obvious risk area for Class C fires. They must have safeguards in place to deal with electrical fires.

Electrical fires require non-conductive materials to extinguish the flame, so water alone is not a good solution. Facilities with sensitive equipment may prefer clean agent suppression because it won’t leave residue or damage electrical equipment.

2.4 Class D Fires: Metallic Fires

Class D fires are not as common as the other classes, but they do require special attention because they can be especially difficult to extinguish. Metallic fires involve flammable materials like titanium, aluminum, magnesium, and potassium — all commonly occurring in laboratories. Class D fires cannot be addressed with water, as this can exacerbate the fire and be potentially dangerous. Dry powder agents are the best solution for smothering the flames and limiting damage to property or people.

2.5 Class K Fires: Grease Fires or Cooking Fires

Class K fires involve flammable liquids, similar to Class B fires, but are specifically related to food service and the restaurant industry. These common fires start from the combustion of liquid cooking materials including grease, oils, and vegetable and animal fats.

Because they can spread quickly and be difficult to manage, Class K fires are some of the most dangerous. Water can make the situation worse, but smothering the flames or using a wet agent fire extinguisher is effective.

Now that we understand how each fire starts, we can prepare for how to fight them — or better yet, prevent them from happening in the first place.

3. Fire Extinguisher:

Fire extinguishers are portable devices used to extinguish small fires or reduce their destruction before firefighters arrive at the scene. These are kept handy at places, namely fire points, in buildings, factories, public paces or transportation. The types and numbers of extinguishers legally required for an area are governed by the safety regulations in force in that particular area.

Different types of fire extinguishers exist in order to address the 5 different classes of fires. Each fire class describes the fuel or material a fire is burning or what caused it to start — therefore, using the right extinguisher is essential to put out the fire safely.

Fire Class	Fuel Type	How to Suppress	Fire Extinguisher Type
Class A	Freely burning combustibles	Water, Smothering	ABC/powder, water, water mist, foam
Class B	Burning liquid or gas	Smothering	ABC/powder, CO2, water mist, clean agent
Class C	Electrical fire	Non-conductive chemicals	ABC/powder, CO2, water mist, clean agent
Class D	Metallic fire	Dry powder agent	Powder
Class K	Cooking or grease fire	Smothering, wet chemical	Wet chemical, water mist

3.1 Carbon dioxide fire extinguisher

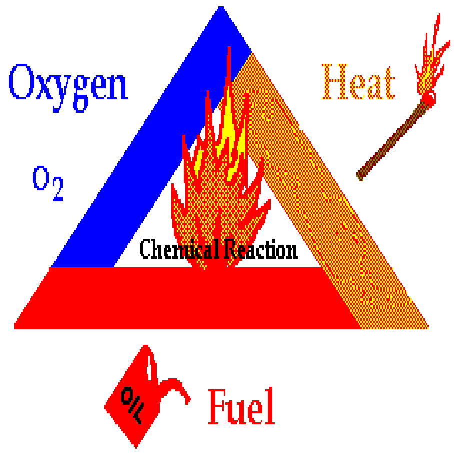
CO_2 fire extinguishers are mainly aimed at electrical fires but are also suitable for Class B liquid fires and are used in different ways depending on the type of fire they are being used on. Do not use CO_2 extinguishers in small rooms as CO_2 gas is poisonous at only 4% concentration and can kill at just 8%.

Only tackle small fires with an extinguisher. If the fire has taken hold do not fight the fire but evacuate immediately and warn others of the fire, then call the fire and rescue service. If you tackle the fire make sure you stay at a safe distance and follow the instructions below.

1. Pull the safety pin **(Fig.2)**, this will break the tamper seal
2. Do not hold the horn, unless it is a frost-free horn, as it becomes extremely cold during use and can lead to severe frost burns. Only purchase CO_2 extinguishers with frost-free horn to prevent this happening.
3. Squeeze the lever to start discharging the extinguisher. Please note that the CO_2 extinguishers make a very strong discharge noise, which is normal.
4. Aiming the extinguisher:
   - **Flammable liquids:** Aim the horn at the base of the fire and move across the area. Be careful not to splash the burning liquid with the powerful jet of the CO_2 extinguisher.
   - **Electrical equipment:** Switch off the power, where safely possible, to prevent later re-ignition and then direct the horn straight at the fire
5. Please note that a CO_2 extinguisher only has a very short discharge time.
6. Ensure all the fire has been extinguished as re-ignition is easily possible when a CO_2 extinguisher has been used. CO_2 gas drifts off after use and if the fire is still very hot it might just re-ignite.

3.2 What is the Fire Triangle

The fire triangle, or combustion triangle, is the three components needed to ignite and sustain a fire. The three ingredients of a fire triangle are; **heat**, **fuel** and **oxygen**.



Heat A source of heat is required in order for ignition to occur, and different materials have different 'flash points' e.g. the lowest temperature at which they ignite.

Unfortunately, combustion reactions also produce heat as they burn, further increasing the temperature of the fuel. For some types of fire, the heat can be cooled with the application of water.

Fuel:A fire cannot begin if there is no material to burn. Homes and businesses are full of flammable materials, such as paper, oil, wood and fabrics. Any of these can serve as a fuel for a fire. Some materials burn more easily than others. Fuels are probably the most difficult 'side' of the fire triangle to remove, so it's wise to store them appropriately to prevent them becoming a fire hazard.

Oxygen: To sustain the combustion reaction, oxygen (or an oxidising agent) is needed, as it reacts with the burning fuel to release heat and CO2. Earth's atmosphere consists of 21% oxygen, so there is plenty available to trigger a fire if the other two components are present.

Fire blankets and certain fire extinguishers remove the oxygen 'side' of the triangle by removing it or displacing it, causing suffocation and thereby ceasing the combustion reaction.

3.3 Fire Hazards

Fire hazards are workplace hazards that either involve the presence of a flame, increase the probability that an uncontrolled fire will occur, or increase the severity of a fire should one occur.

Fire hazards include:

- Flames
- Sparks
- Hot objects
- Flammable chemicals
- Chemicals accelerants, which can increase a fire's rate of spread

A Fire Hazard Analysis (FHA)) is a method of evaluating the hazards present and subsequent consequence potential at a processing plant or storage facility that requires an in-depth assessment of fire risk due to significant quantities of flammable materials. These assessments are based on specific review criteria that are dependent upon the types of hazards being assessed, as well as commodities stored and facility processes.

4. Steps of a fire hazards analysis

Performing an FHA is a fairly straightforward engineering analysis. The steps include the following:

1. Selecting a target outcome
2. Determining the scenario(s) of concern that could result in that outcome
3. Selecting an appropriate method(s) for prediction of growth rate of fire effects
4. Calculating the time needed for occupants to move to a safe place
5. Analyzing the impact of exposure of occupants or property to the effects of the fire
6. Examining the uncertainty in the hazard analysis
7. Documentation of the fire hazard analysis process, including the basis for selection of models and input data Fire hazard analysis can also be used as part of the performance-based design process.

4.1 WHAT TO DO AFTER THE FIRE

Now that the fire is out, there are a few things you need to know. Here is a check list to follow:

Step 1 - Securing the site

- Protect the fire site from any further damage by weather, theft or vandalism. Do not leave the site unsecured.
- If you are the owner it is your responsibility to see that openings are covered against rain and entry. Make sure outside doors to the property can be locked and secured. Fire and Rescue NSW will help secure the premises until responsibility can be handed over to the occupier or insurance company.
- If you are the occupier, contact your real estate agent or landlord and inform them of the fire. If you cannot contact them and you need professional assistance in boarding the premises, a general contractor or fire damage restoration firm can help. Check your telephone directory.
- If you plan to leave the site, try to remove any valuables remaining in the building.
- Contact your own insurance agent to report the loss.

Step 2- Cautions

- Household wiring which may have been water damaged should be checked by a licensed electrician before power is turned back on.
- Check for structural damage caused by the fire as roofs and floors may be weakened. The local Council's Building Inspector may be able to help.
- Food, drink and medicines exposed to heat, smoke or soot may be discarded in the appropriate manner.
- Refrigerators and freezers left unopened will hold their temperature for a short time. However do not attempt to refreeze thawed items.
- Fire and Rescue NSW will call for the services of the local gas, fuel and electricity suppliers to disconnect services before they leave the site.
- If a utility (gas, electricity or water) is disconnected, it is your responsibility to have the services checked and reconnected by a licensed trade person. Do not attempt to reconnect the service yourself.

- Start collecting receipts for any money you spend. These are important because you can use them to show the insurance company what money you have spent relating to your fire loss and also verifying losses claimed.

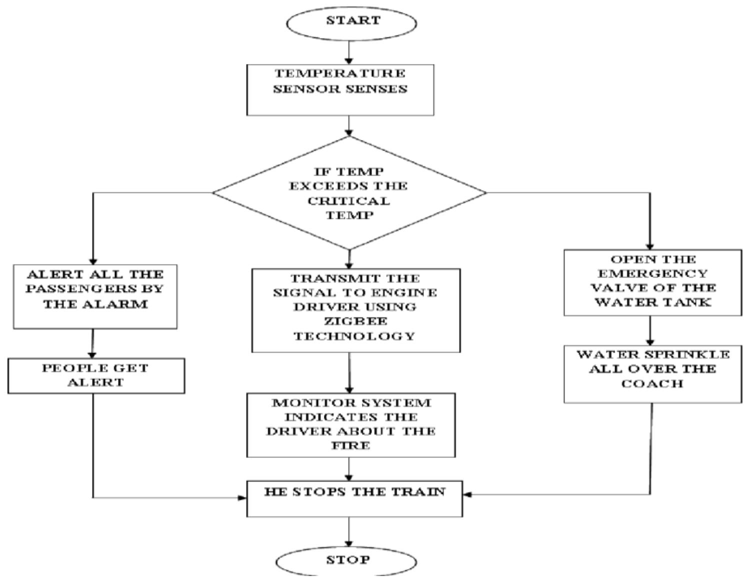
Step 3 - Insurance Claims

- Make personal contact with the insurance claims manager.
- Advise the claims manager of loss or damage and give them a forwarding address and telephone number if the circumstances have forced you to leave the damaged fire building.
- The sooner the insurance company is alerted, the quicker the insurance claim can be processed, as the company has to alert the insurance assessor to carry out the inspection.
- Try to form an inventory, as soon as possible, of household items either inside or outside the buildings which have been damaged by fire. The inventory of damaged items will further speed the claim when the loss assessor makes contact. Do not throw away any damaged goods until after the inventory is made by the insurance assessor.
- Should you be unable to recall the name of your insurance company, contact the Insurance Council of Australia [external link].

Step 4 - Leaving your home

- If you have to leave your home because the fire has left it unsafe, contact the local police. They can keep an eye on the property in your absence.
- Check with your insurance company to find out whether you are entitled to stay in hotel as part of a temporary housing clause in your policy, or how soon you might get an advance on your eventual insurance claim settlement.
- Provided it is safe to do so, try to locate the following to take with you:
  - Identification such as wallets and passports.
  - Vital medicines, such as blood pressure regulating drugs or insulin.
  - Eyeglasses, hearing aids, prosthetic devices or personal aids.
  - Valuables such as credit cards, cheque-books, insurance policies, savings account books, money and jewellery.

Flow chart after fire occurrence



5. First aid for burns

- **First degree.** The skin turns red, but it does not blister. It is somewhat painful, like a sunburn.
- **Second degree.** The outer layer of skin is burned, and some part of the dermis is damaged. The burn will be very painful and will likely develop blisters.
- **Third degree.** The skin will be charred or white. The epidermis and dermis (top two layers of skin) are irreversibly damaged.

DO's

- Stop the burning process: cool the burn with running cool (not cold) water for at least 5 minutes. But do not use ice, as this may cause further skin damage. Do not over cool! If the victim starts to shiver, stop the cooling process.
- Remove all jewelry, watches, rings and clothing around the burned area as soon as possible.
- Administer an over-the-counter pain reliever such as ibuprofen or acetaminophen for pain control. Follow the directions on the label. Consult a physician or health care provider if

pain is not relieved.

- Cover the burn with a sterile gauge bandage or clean cloth. Wrap the burned area loosely to avoid putting too much pressure on the burn tissue.
- Minor burns will usually heal without further treatment.
- For small area burns, apply soothing lotions that contains aloe vera to the burned area to help relieve the pain and discomfort.
- Seek medical attention if there is a persistent fever not relieved by medication or redness that may extend beyond the border of the burn or pain is not controlled by ibuprofen or acetaminophen.
- Drink plenty of fluids (electrolyte containing solutions such as gator aid) if the person appears to be dehydrated.

DON'TS

- Do not apply ice – this may cause further damage to the skin.
- Do not use any butter, ointments or other home remedies on the burn. Such substances may trap the heat in the tissue and makes the burn worse.
- Do not break any blisters…leave intact.
- Do not delay seeing medical attention if the burn is larger than the size of the victim's palm.

6. Portable fire extinguisher11

A portable fire extinguisher by definition is an item of equipment for the purpose of extinguishing a fire. The reality is however that a portable fire extinguisher is effective only for the type and size of a fire that it is rated for.

Portable fire extinguishers are generally provided as "first attack" units in fire fighting and should be used only in early stages of fire before the fire grows to a stage that is beyond the capacity of the extinguisher. There are broadly six types of fire extinguisher;

1. Air-Water;

2. Air-Foam;
3. Wet Chemical;
4. Dry Chemical Powder;
5. Carbon Dioxide.

Portable fire extinguishers are distinguishable by their labels and their colouring. In 1997 the standard colour of portable fire extinguishers changed. From this date, extinguishers supplied to the market are required to be painted red or be polished stainless steel. As this change was relatively recent it is still common to find extinguishers using both Pre 1997 and Post 1997 extinguisher colour schemes.

There is no one type of fire extinguisher that is universally acceptable for all classes of fire. Careful consideration needs to be given to the selection of the most suitable type of fire extinguisher, or combination of fire extinguishers for each application.

A water based extinguisher also referred to as a Stored Pressure Air-Water fire extinguisher is an extinguisher that is filled with water which is stored under pressure (normally by air). These extinguishers are only appropriate for use on Class A fires.
A water extinguisher is effective because it cools the fire, interrupting the exothermic reaction of a self-sustaining fire.

A water extinguisher operates when water, stored under pressure and contained within the extinguisher container is expelled after the valve, operated by a hand-held trigger is depressed.

Extinguisher Operation

Fire extinguishers contain an agent that is expelled from the extinguisher help to try and extinguish a fire. The agent in each of the extinguishers explained in this document is stored under pressure. The valve is operated when the hand-held trigger is depressed.

Some fire extinguishers are also fitted with a pressure gauge that provides a visual indication of the extinguishers pressurized state. Gauges may illustrate a numerical value or a color coded pressure range where green illustrates the extinguisher is pressurized and is in a state of readiness.

7. Fire detection, fire alarm and fire fighting system

Fire detection systems are designed to discover fires early in their development when time will still be available for the safe evacuation of occupants. Early detection also plays a significant role in protecting the safety of emergency response personnel. Property loss can be reduced and downtime for the operation minimized through early detection because control efforts are started while the fire is still small. Most alarm systems provide information to emergency responders on the location of the fire, speeding the process of fire control.

To be useful, detectors must be coupled with alarms. Alarm systems provide notice to at least the building occupants and usually transmit a signal to a staffed monitoring station either on or off site. In some cases, alarms may go directly to the fire department, although in most locations this is no longer the typical approach.

These systems have numerous advantages as discussed above. The one major limitation is that they do nothing to contain or control the fire. Suppression systems such as automatic sprinklers act to control the fire. They also provide notification that they are operating, so they can fill the role of a heat detection-based system if connected to notification appliances throughout the building. They will not, however, operate as quickly as a smoke detection system. This is why facilities where rapid notice is essential, even when equipped with sprinklers, still need detection and alarm systems.

7.1 Different Types of Fire Alarm Detectors:

At the core of a fire alarm system are the detection devices, from sophisticated intelligent smoke detectors to simple manually operated break glass units, there are a wide array of different types, but we can divide them into groups including:

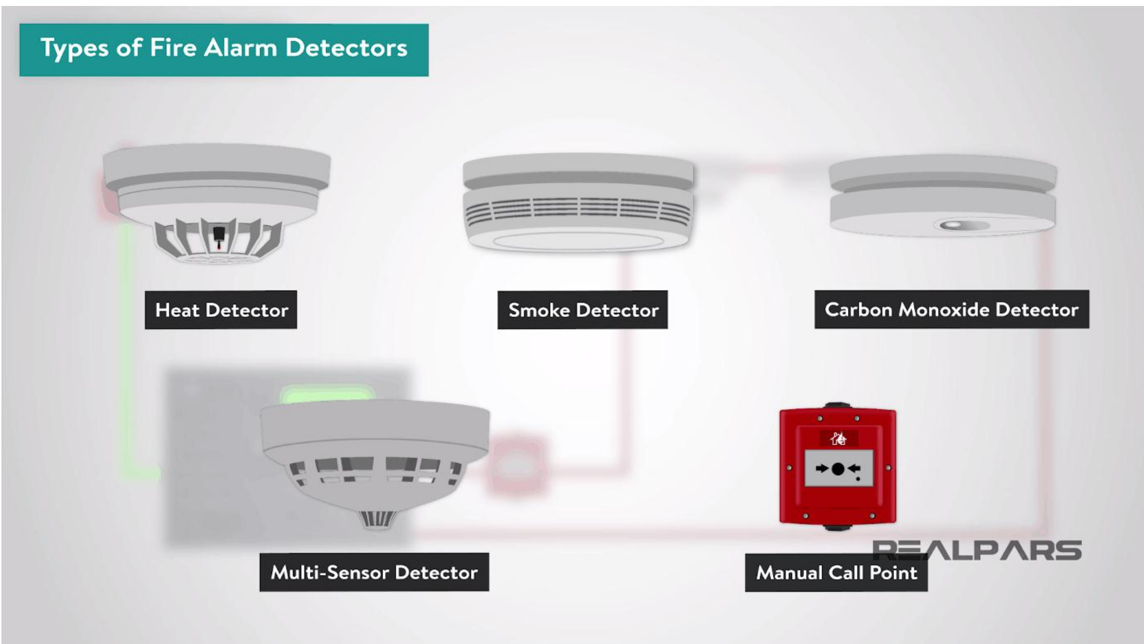
– Heat detectors

– Smoke detectors

– Carbon Monoxide detectors

– Multi-sensor detectors

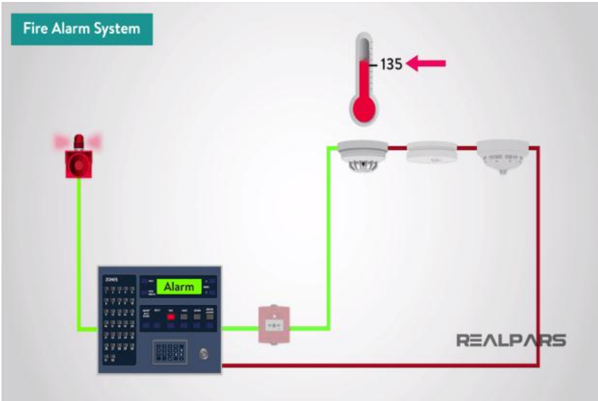
– Manual Call Points

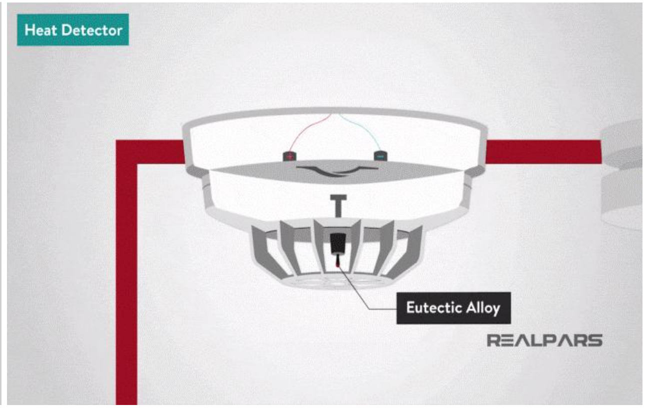


7.1 Heat Detectors

Heat detector can either work on a fixed temperature basis, where it will trigger an alarm if the temperature exceeds a pre-set value or they can work on the rate of change in temperature.

Commonly Heat detectors work in a similar way to an electrical fuse, the detectors contain a eutectic alloy which is heat sensitive when a certain temperature is reached the alloy turns from a solid to a liquid which in turn triggers the alarm.





7.2. Smoke Detectors

There are three basic types of smoke detectors including:

– Ionization

– Light Scattering

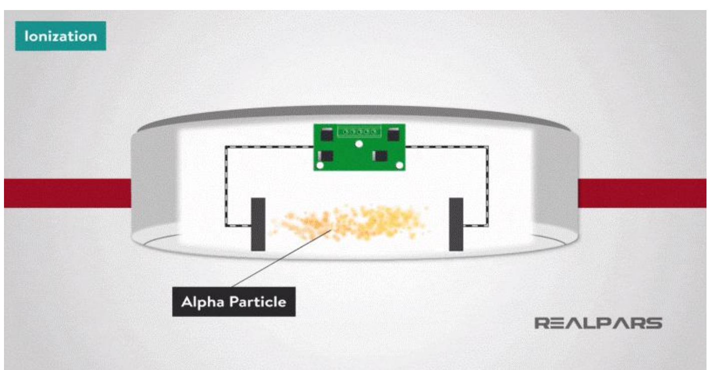
– Light Obscuring

2.1. Ionization Smoke Detector

Ionization Smoke detector generally contains two chambers. The first is used as a reference to compensate for changes in ambient temperature, humidity or pressure.

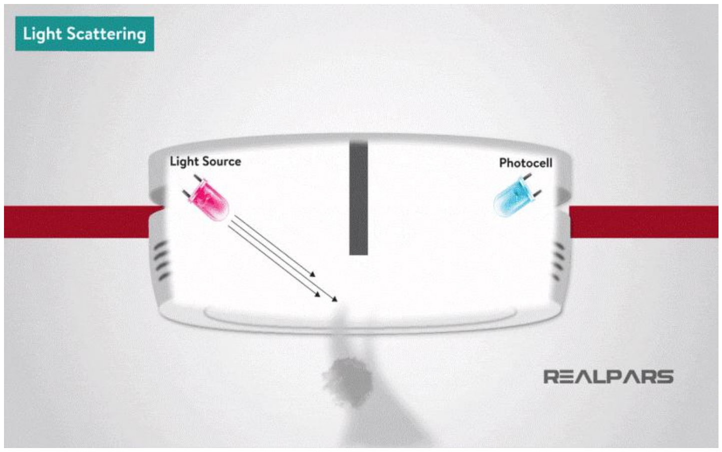
The second chamber contains a radioactive source, usually alpha particle, which ionizes the air passing through the chamber where a current flows between two electrodes.

When smoke enters the chamber the current flow decreases. This drop in current flow is used to initiate an alarm.



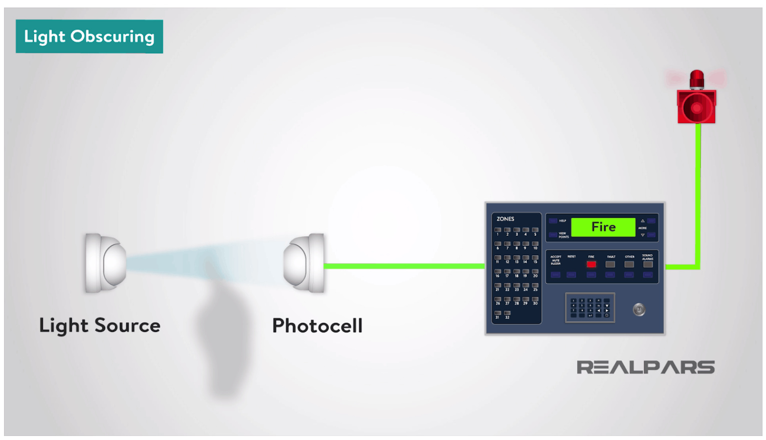
2.2. Light Scattering Smoke Detector

The light scattering smoke detector operates on the [Tyndall effect]; a photocell and light source are separated from each other by a darkened chamber such that the light source does not fall on the photocell. The passage of smoke into the chamber causes the light from the source to be scattered and fall on the photocell. The photocell output is being used to initiate an alarm.



2.3. Light Obscuring Smoke Detector

In the Light obscuring smoke detector, smoke interferes with a light beam between a light source and photocell. The photocell measures the amount of light it receives. The variation in photocell output, is being used to initiate an alarm. This type of fire detection equipment can be used to protect large areas with the light source and photocell positioned some distance apart.



3. Carbon Monoxide Detectors

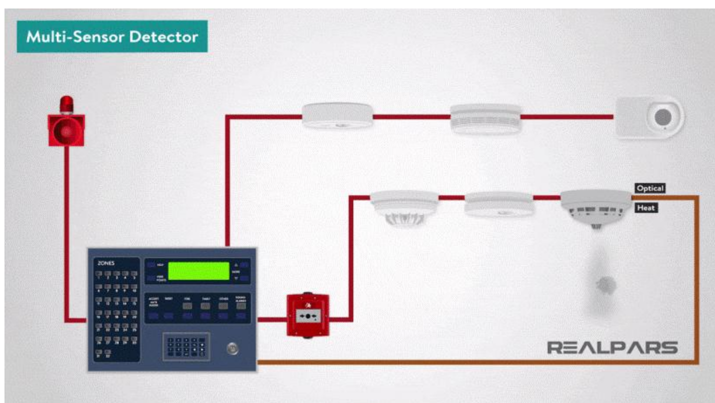
Carbon monoxide detectors are known also as CO fire detectors are electronic detectors used to indicate the outbreak of fire by sensing the level of carbon monoxide in the air. Carbon monoxide is a poisonous gas produced by combustion. In this instance, these detectors are not the same as Carbon monoxide detectors used in the home for protecting residents against carbon monoxide produced by incomplete combustion in appliances such as gas fires or boilers.

Carbon Monoxide fire detectors use the same type of sensor as those in the home but are more sensitive and respond more quickly.Carbon monoxide detectors have an electrochemical cell, which senses carbon monoxide, but not smoke or any other combustion products

4. Multi-Sensor Detectors

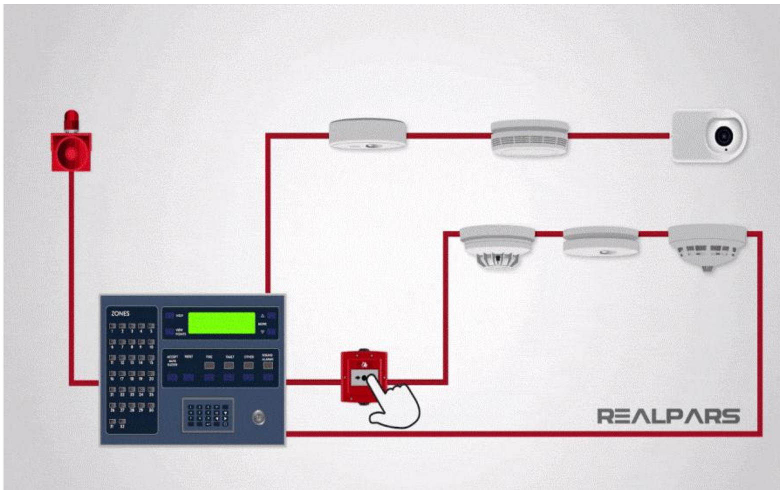
The Multi-sensor detectors combine inputs from both optical and heat sensors and process them using a sophisticated algorithm built into the detector circuitry.

When polled by the control panel the detector returns a value based on the combined responses from both the optical and heat sensors. They are designed to be sensitive to a wide range of fires.



5. Manual Call Points

A Manual Call Point or Break Glass Call Point is a device which enables personnel to raise the alarm by breaking the frangible element on the fascia; this then triggers the alarm.



7.2 Different Types of Fire Alarm Systems

Fire Alarm Systems can be broken down into four main types;

– Conventional

– Addressable

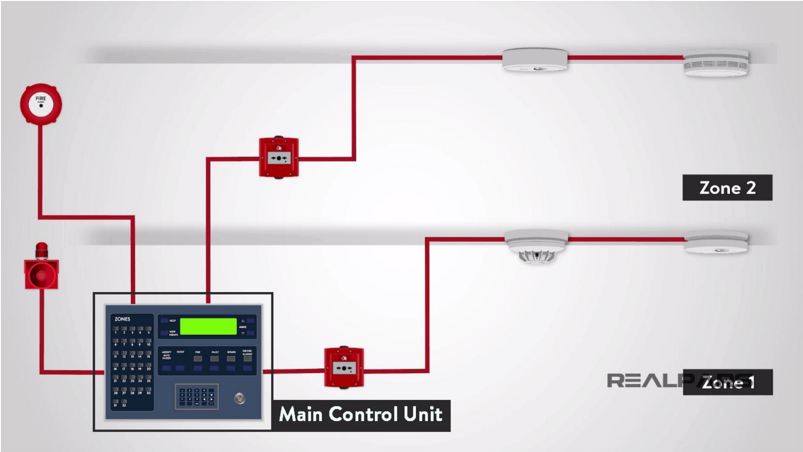
– Intelligent

– Wireless

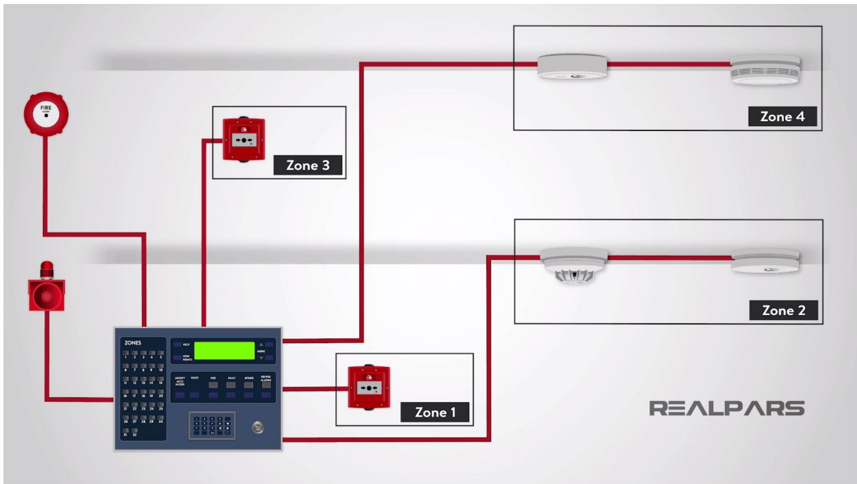
Let’s spend some time considering each.

1. Conventional Fire Alarm Systems

In a Conventional Fire Alarm System, physical cabling is used to interconnect several call points and detectors, the signals from which are wired back to the main control unit.

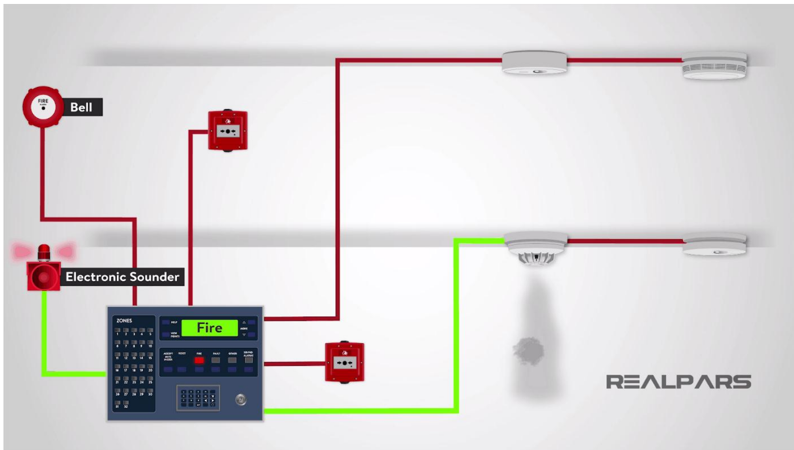


Call points and detectors are arranged in “Zones” to simplify locating the cause of the alarm, this is important for both the fire brigade and general building management. Each zone is indicated at the Fire Alarm Control Panel either with an indicator lamp, a text display or in some cases both. It makes sense that the more we can divide a building into zones, the more accurate locating the alarm trigger will be.



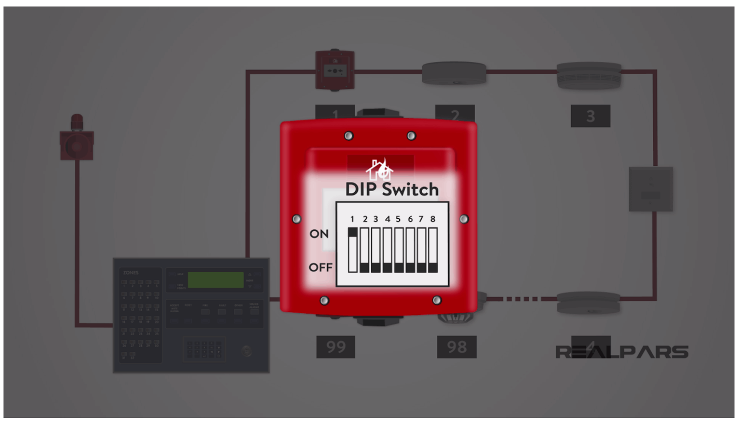
The Control Panel is wired to a minimum of two sounder circuits which could contain bells, electronic sounders or other audible fire alarm devices.

It is these devices which sound the alarm when triggered.

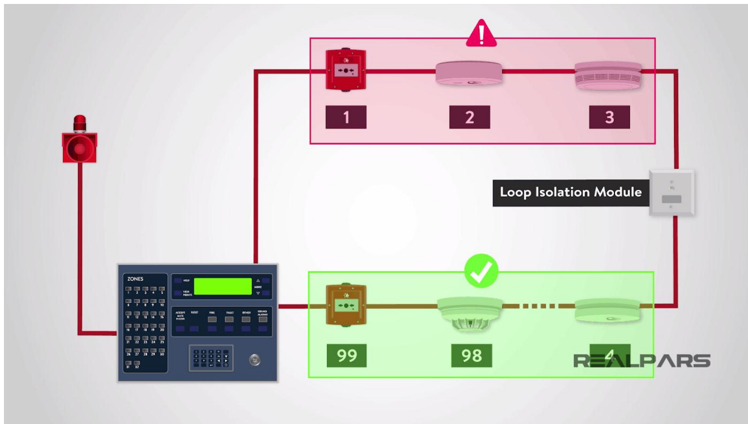


2. Addressable Fire Alarm Systems

The detection principle of an Addressable System is the same as a Conventional System except that each detector is given a set Address (usually by means of a dip-switch) and the Control Panel can then determine exactly which detector or call point has initiated the alarm.



The detection circuit is wired as a loop and up to 99 devices may be connected to each loop.
It is common for the loop to be fitted with Loop Isolation Modules so that the loop is sectioned in order to ensure that a short circuit or single fault will only cause the loss of a small part of the system; allowing the rest of the system to function normally.



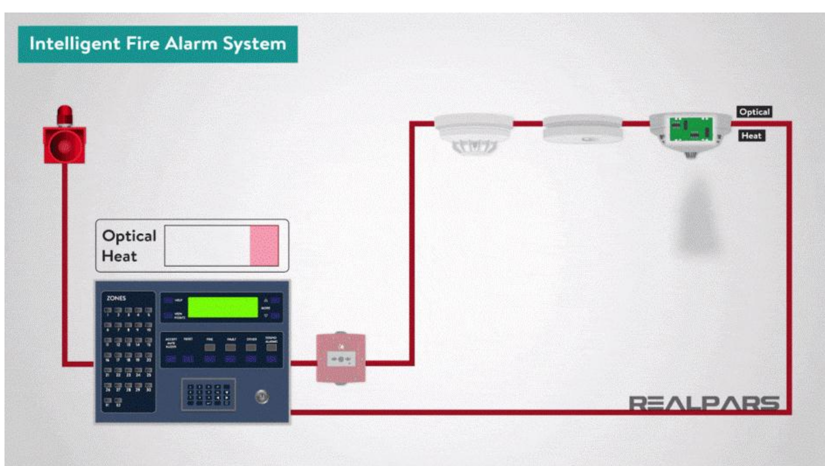
In the previous two systems, the “Conventional Fire Alarm System” and the “Addressable Fire Alarm System” the detectors are not considered “intelligent” as they can only give output signals representing the value of detected phenomena.

It is left up to the Control Unit to decide whether there is a fire, fault, pre-alarm or other.

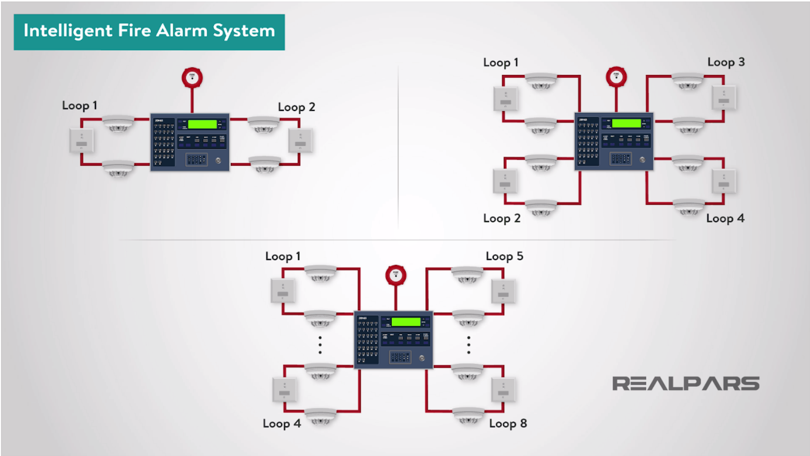
3. Intelligent Fire Alarm Systems

However, in our next type of System, which is an Intelligent Fire Alarm system, each detector effectively incorporates its own computer which evaluates the environment around it and communicates to the Control Panel whether there is a fire, fault or the detector head needs cleaning.

Essentially Intelligent Systems are far more complex and incorporate far more facilities than Conventional or Addressable Systems. Their primary purpose is to help prevent the occurrence of false alarms.

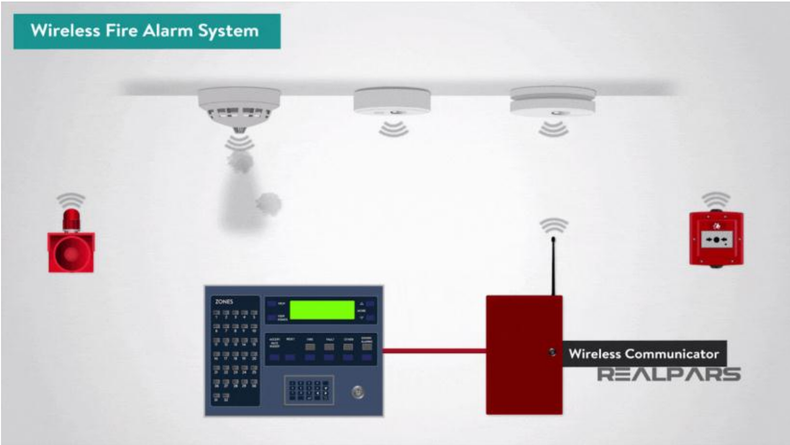


Intelligent Fire Alarm Systems are available in 2, 4, and 8 loop versions which means large premises can be monitored from one single panel.



4. Wireless Fire Alarm Systems

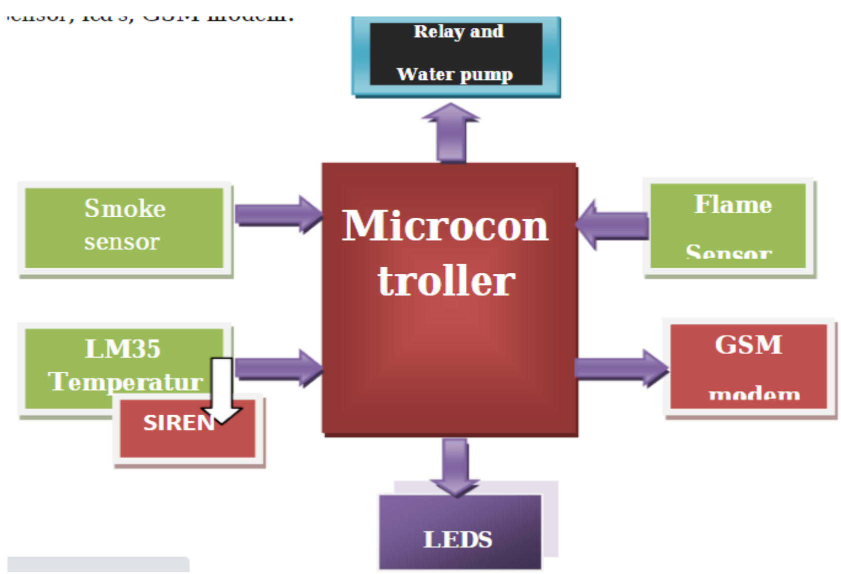
The final type of system we will consider is the Wireless Fire Alarm System.These are an effective alternative to traditional wired fire alarm systems for all applications. They utilize secure, license-free radio communications to interconnect the sensors and devices with the controllers. It is a simple concept, which provides many unique benefits and is a full intelligent fire detection system without the need for cabling. In this article, we have learned that Fire Alarm systems are fitted in many buildings we encounter every day and that they are used to warn people within the building of an emergency fire-related situation.



Fire fighting System is used to prevent, extinguish, localize, or block fires in enclosed spaces. Automatic fire-fighting systems are installed in buildings and rooms where the fire hazard is comparatively high. A distinction is made between systems that are actuated automatically and operate according to a predetermined program and those that are actuated by an operator; the former are called automatic fire protection systems, the latter fire protection units. An automatic fire-fighting system includes a sensor capable of detecting combustion, alarm signaling devices, fire-extinguishing equipment, starting and stopping devices, and feeders for the fire-extinguishing substance. Atomizers, foam generators, and pipe nozzles form and direct the stream of the fire-extinguishing substance, which may be a liquid, foam, powder, or gas. Fire-extinguishing substances are fed into the system from a centralized supply, such as a water supply, or from self-contained or combined feeders. The most widely used systems employ water (sprinkler and drencher systems), carbon dioxide, aerosols, or powders. A sprinkler system consists of a grid of pipelines located on the ceiling of the room, with sprinkler heads attached to the pipes by threaded connections. The opening of a sprinkler is kept closed by a disk held in a closed position by a thermal lock. If the room temperature rises to a specified point, the lock is destroyed and the disk opens, admitting water to the room.

Drencher systems, which use nozzles without thermal locks, are actuated either by a sprinkler installed in a trigger air line or by a cable-type thermal lock. Automatic fire protection systems are classified according to the time elapsed between the start of the fire and the actuation of the system as ultrahigh-speed (to 0.1 second),

high-speed (to 3 seconds), and standard (to 180 second). The fire-extinguishing substance can be applied for periods ranging from 30 second to 3600 second.



Block diagram of the wireless fire fighting system

7. Fire Detection in the Power Plant:

In power plants, burners are critical equipment, heart of energy production system. They produce energy as thermal; deliver it to air (that directly used in gas turbine) and water (for thermal and combined cycle). Hot air and steam in turns rotate the gas and steam turbines. Eventually electrical energy is delivered at generator terminals (The generator which is coupled with turbines). Where is fuel (in burners), we have the risk of explosion. In such a high energetic environment; boilers in thermal and combustion chambers in gas turbine power plant (temperature is more than 1000 °C), ordinary gas analyzer or temperature sensors could not be used and one of the most suitable devices, is optical flame detector. The flame monitoring system issue the order, cut off the inlet fuel in the flame out, lowering the risk of high accumulation of fuel result to explosion. There are 3 main type of fuels uses in Iran power plants : heavy oil , light oil and natural gas , in two former infrared (IR) and in the latter ultraviolet (UV) detectors are used , according to their light wave length. In this paper main principal and performance of the system is described briefly.

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MODULE III

MECHANICAL SAFETY

Safety Guards

Safety guard: **Safety guard** means an enclosure for protection from emission or accidental contact.

Safety guard means an enclosure designed to restrain the pieces of the grinding wheel and furnish all possible protection in the event that the wheel is broken in operation.

Types of Machine Guards

- Fixed guards.
- Interlocking guards.
- Adjustable guards.
- **Self**-adjusting guards.

1 Fixed guards often are **used** to protect workers from the hazards associated with flywheels, fan blades, screw conveyors and power transmission equipment.

Fixed guards are permanent parts of a machine.

Every fixed guard (or other guards) on point of operation should prevent entry of fingers (preferably the smallest finger) or hands by reaching over, under or around the guard into the point of operation. Its fasteners should not be easily openable to prevent misuse or accident.

2 Interlocked guards: Shut down the machine when the guard is not securely in place or is disengaged. The main advantage of this type of guard is that it allows safe access to the machine

3 Adjustable guards: Provide a barrier against a variety of different hazards associated with different production operations. They have the advantage of flexibility. However, they are not dependable barrier as other guards, and they require frequent maintenance and careful adjustment.

4 Self adjusting guard: The openings of these barriers are determined by the movement of the stock. As the operator moves the stock into the danger area, the guard is pushed away, providing an opening which is only large enough to admit the stock. After the stock is removed, the guard returns to the rest position. This guard protects the operator by placing a barrier between the danger area and the operator.

Interlocking guard

MECHANICAL HAZARDS

Mechanical hazards are hazards created by the use of or exposure to either powered or manually operated equipment, machinery and plant. Mechanical injuries are mostly caused either by contact or entanglement with machinery. Part of the machinery that could be hazardous to workers include sharp edges, hot surfaces, moving parts, flywheel, pulley, belt, etc.

Where Mechanical Hazards occurs

It occurs majorly in three (3) area:

- **The point of operation:** Point where work is performed on the material, such as cutting, shaping, boring, etc
- **Power transmission apparatus:** Components of the mechanical system that transmit energy to the part of the machine performing the work. Example, flywheels, pulleys, belts, connecting rods, couplings, cams, spindles, chains, cranks, gears, etc.
- **Machine moving parts:** Parts of the machine that move while the machine is working. These may include reciprocating, rotating, and transverse moving parts, as well as feed mechanisms and auxiliary parts of the machine.

6 Major types of hazards you should know

Common Mechanical injuries

- **Fracture:** Fracture is the medical term for a broken bone. It can be classified as simple, compound or complete fracture.
- **Puncturing/Stabbing:** Puncturing results when an object penetrates straight into the body and pulls straight out, creating a wound in the shape of the penetrating object.
- **Straining and spraining:** A strain results when muscles are overstretched or torn. Strains and sprains can cause swelling and intense pain.
- **Impact:** Being hit by ejected parts of the machinery or equipment
- **Friction and abrasion:** A section of the skin being rub away by the machine.
- **Entrapment:** Being caught in a moving part of a machine or equipment or plant.
- **Crushing:** Collision of plant with a person can result to crushing.
- **Shear:** Can be two moving parts (sharp or otherwise) moving across one another.
- **High pressure injection:** This is an injury caused by high-pressure injection of oil, grease, diesel fuel, gasoline, solvents, water, or even air, into the body.
- **Cut:** Severing of a human body part by a cutting motion e.g. amputation

What Are the Most Common Hazards in a Workplace?

The words 'risk' and 'hazard' are often used interchangeably. However, if you are responsible for managing the health and safety in your workplace, it's important that you understand the difference between them. The rest of this article focuses on hazards, including where they might be found in different workplaces. We also provide you with a range of further resources to make your risk assessment process as smooth as possible.

The six main categories of hazards are:

- **Biological.** Biological hazards include viruses, bacteria, insects, animals, etc., that can cause adverse health impacts. For example, mould, blood and other bodily fluids, harmful plants, sewage, dust and vermin.
- **Chemical.** Chemical hazards are hazardous substances that can cause harm. These hazards can result in both health and physical impacts, such as skin irritation, respiratory system irritation, blindness, corrosion and explosions.
- **Physical.** Physical hazards are environmental factors that can harm an employee without necessarily touching them, including heights, noise, radiation and pressure.

- **Safety.** These are hazards that create unsafe working conditions. For example, exposed wires or a damaged carpet might result in a tripping hazard. *These are sometimes included under the category of physical hazards.*
- **Ergonomic.** Ergonomic hazards are a result of physical factors that can result in musculoskeletal injuries. For example, a poor workstation setup in an office, poor posture and manual handling.
- **Psychosocial.** Psychosocial hazards include those that can have an adverse effect on an employee's mental health or wellbeing. For example, sexual harassment, victimisation, stress and workplace violence

FORK LIFT SAFETY INFORMATION

Forklifts are extremely useful workplace vehicles, as long as they are used safely and appropriately by operators who are appropriately trained and competent to use them

What is a forklift?

A forklift is a powered truck used to carry, lift, stack ortier materials. They include pallet trucks, rider operated forklifts, fork trucks, or lift trucks.

They can be powered by electric battery orcombustion engines.

Safe Operation

Always:

✓ Wear appropriate personal protective clothing as provided by employer. Hard hat, protective footwear and high visibility clothing are
recommended as a minimum when working aroundforklifts. Other equipment may be needed depending on the working environment

✓ Carry out a pre-shift check of the forklift

✓ Report defects immediately to supervisor

✓ Make sure work path is free of obstructions

✓ Wear operator restraints, where fitted

✓ Look all around before moving off

✓ Look in the direction of travel

✓ Travel at a speed suitable for the location and theload carried

✓ Travel with the forks lowered, but clear of theground

✓ Watch out for pedestrians

- ✓ Avoid sudden stops and violent braking
- ✓ Take care when driving on wet, icy , slippery orloose surfaces

SAFETY INSTRUCTIONS FOR THE USE OF MACHINE TOOLS

1 STATIONARY POWER TOOLS SAFETY

Many of the safety practices used for portable tools apply to stationary power tools. However, stationary tools tend to be larger, more powerful, and more complex. These factors can lead to serious injuries. These are reviewed below, followed by specific safety measures for a variety of stationary power tools:

1 Safety devices and guards must always be in place. These devices were designed by the manufacturer tobe used with the tool.

2 Always keep blades and cutting edges sharp!

3Perform maintenance, accessory changes, and adjustments only when the tool is off and unplugged.

4 Don't wear loose fitting clothing. High-powered stationary tools can catch clothing and draw the operator’s body into the tool.

5 When using any type of stationary saw, never use gloves. They can get caught in the saw.

6 Never put your fingers and hands in front of saw blades and other cutting tools.

7 Never turn or feed the material or work piece at excessive speed. This increases stress on both thework piece and the machine.

8Because stationary tools tend to be complex, tools from different manufacturers can vary in safety and operation procedures and precautions. Read the owner’s manual and safety precautions before using.

9 Many stationary tools are equipped with emergency- off switches. Know the location of these switchesand the tool power switch.

10 Make sure that blades, bits, and accessories are properly mounted. In addition, make sure all locking handles and clamps are tight before using a tool.

11 Watch for flying objects. Keep unnecessary personnel away from machines when in use.

2 TABLE SAW.

The circular blade of a table saw moves at very high speed. Employ the following precautions when using thistool:

1 Use the saw guard at all times. No operation shall be done with the guards removed.

2 Never reach over the saw blade to remove scraps, or to provide support to the work piece. If you areoff- balance, you could fall into the saw.

3 Always stand to the side of the saw, and never directly in line with the blade. If the saw catches thematerial you are working on, the saw will throw it in line with the blade.

4 To prevent kickback never use a dull blade and never cut without the guide and splitter guard in place. Inaddition, don't drop wood on top of the saw blade.

5 When cutting, NEVER PULL the work piece through the saw. Start and finish the cut from the front ofthe saw.

6 Never feed the work piece from the back of the saw.

7 When crosscutting, hold the work piece firmly against the miter gauge. Make sure that the miter gauge works freely in the slot and that it will clear both sides of the blade when tilted. Note that on some saws the miter gauge can be used only on one side when the blade is tilted.

8Use a push stick according to the manufacturer's guidelines. In general, when using a push stick or push block, the trailing end of the board must be square. A push stick against an uneven end could slip off or push the work away from the fence. The fence is the stop plate or barrier used to guide the work piece.

3 RADIAL ARM SAW

The radial arm- saw is a very versatile tool and is one of the most used tools in the shop. Because of its ability to cut a variety of ways, it presents a variety of hazards. However, if used properly it can be one of the safest tools in the shop. Follow these precautions when using a radial arm saw:

1. Never stand directly behind or in- line with the saw. Stand to either side of the saw.
2. The motor/ saw assembly must be returned to the rear of the table (against the column) after each cut.Never remove the work piece from the table until the saw has been returned to the rear.
3. When crosscutting, make sure the work piece is held against the guide fence. This will virtually eliminatekickback.
4. It's easy to overload the motor of a radial arm saw. If the motor overloads, check the motor and blades.Don't feed the work piece too quickly.
5. To minimize vibration, the saw should be maintained in good alignment and adjustment.
6. When lowering the blade, keep your hands and arms out of the way of the blade!
7. When ripping, make sure that the blade rotates toward you and always feed the work piece under the safety guard from the side opposite to the anti- kickback fingers. When ripping narrow stock, use a push stick to complete the cut.

4 BAND SAW AND JIG SAW.

A main safety concern with the band saw is the breakage of the blade. In addition, because both the band saw and jig saw allow for intricate cuts, the fingers can come close to the saw blade. The following rules can minimizeinjuries from these hazards:

Band Saw:

1 Always stand to the left of the band saw. In the event of a broken blade, the blade will fly off to the right.

If the blade breaks, shut- off the power and stay away from the saw until it stops.

1 Care should be taken in uncoiling, removing, and installing the band saw blade. Use gloves. The blade shallbe adjusted and tensioned properly.

2 The blade guard is very important when using the band saw and jig saw. Keep your fingers away fromexposed parts of the blade.

3 Follow the manufacturer's guidelines for adjustment of the sliding bar or post. If the guide is too high, theblade will not have the proper support.

2 Avoid backing out of the cut. This could push the blade off the wheels.

3 Never cut a small radius with a wide blade unless you make relief cuts first.

Jig Saw:

1. Always install the blade with the teeth pointing down.
2. Adjust the tension according to the manufacturer's guidelines. Turn the pulley over by hand to make surethat the blade operates properly before turning on the power.
3. Do not place excess force on the jigsaw blade. It can easily break and fly off.
4. Adjust the blade guide and hold down properly.

5 WHEEL GRINDERS, BENCH GRINDERS

.

The chief hazards from wheel grinders are flying pieces of a shattered grinding wheel and being cut by the grinding wheel. Follow these precautions to avoid these hazards:

5. Before each use, inspect the grinder to ensure that the grinding wheels are firmly attached and that the work rests are tight.
6. Because some grinders can be converted to buffers, guards are often removed. When using the unit as a grinder, always have a guard in-place.
7. Always inspect the grinding wheel before use. The wheel should be free of cracks. All grinding wheelsshall be ring-tested prior to installation.

8. Too much pressure on the wheel can cause it to fracture. Spend more time at lighter pressure. Always use grinding discs that are marked with a rating speed above the maximum speed of the grinder. Never use an unmarked grinding wheel. Check the spindle speed before mounting the wheel.

6 LATHES

The lathe is different from some of the tools presented thus far. While most tools rotate or move a blade or bit to cut, the lathe moves the work piece being cut. If the work piece is not fastened to the lathe properly or is defective, it can fly off or beak apart, causing injury.

To minimize this and others, follow these safety rules:

1. Stand to the side of the lathe. This will also minimize the chance of being hit by a tool if it catches.
2. The work piece (especially wood) should be free of cracks, knots, and other defects. Check for weak glue joints.
3. Watch out for flying chips and shavings. Always wear safety glasses with side shields. Make sure that anyone in close proximity to the lathe is doing the same.
4. Adjust the tool rest as close as possible to the work piece. Then revolve the stock by hand to make sure that it clears the rest.
5. Avoid long nods projecting from the rear of the headstock at high speeds. The whipping action can cause serious injuries.
6. Always run the lathe at low speed until the work piece is rounded.
7. Check to make sure that the chuck is secured before turning the lathe on.
8. DANGER! Lathe chips are sharp; do NOT remove them with your hands. An air hose should NEVER be used to remove chips. The flying particles might injure you or a nearby person.
9. No attempt should be made to operate a lathe until you know the proper procedures and have been checked out on its safe operation by your instructor.
10. Dress appropriately! Remove necktie, necklace, wrist watch, rings and other jewelry, and loose fitting sweaters. Wear an apron or a properly fitted shop coat. Safety glasses are a must!
11. Clamp all work solidly! Use the correct size toot and work holding device for the job. Get help when handling large sections of metal and heavy chucks and attachments.
12. Check work frequently when it is being machined between centers. The work expands as it heats up and could damage the tailstock center.
13. Be sure all guards are in place before attempting to operate the machine.
14. Turn the faceplate or chuck by hand to be sure there is NO binding or danger of the work striking any part of the lathe.
15. Keep the machine clear of tools!

16. Stop the machine before making measurements and adjustments.
17. Remember--chips are sharp! Do NOT try to remove them with your hands when they become "stringy"and build up on the tool post. Stop the machine and remove them with pliers.
18. Do NOT permit small diameter work to project too far from the chuck without support from the tailstock. Without support, the work will be tapered, or worse, spring, up over the cutting tool and/or break.
19. Be careful NOT to run the cutting tool into the chuck. Check any readjustment of work or tool for ample clearance when the cutter has been moved left to the farthest point that will be machined.
20. Stop the machine before attempting to wipe down, a machine surface.
21. Before repositioning or removing work from the lathe, move the cutting tool clear of the work area.This will prevent accidental cuts from the cutter bit.
22. Avoid talking to anyone while running a lathe! Do NOT permit anyone to fool around with the machine while you are operating it. You are the only one who should turn the machine on or off, or make adjustments to the lathe.
23. If the lathe has a threaded spindle nose, never attempt to run the chuck on or off the spindle using power. It is also dangerous- practice to stop such a lathe by reversing the direction of rotation. The chuck could spin off and cause serious injury to you. There is also the danger of damaging the machine.
24. You should always be aware of the direction of travel and speed of the carriage before engaging the half-nuts or automatic feed.
25. Always remove the key from the chuck. Make it a habit NEVER to let go of the key until it is out of thechuck and clear of the work area.
26. Tools must NOT be placed on the lathe ways. Use a tool board or place them on the lathe tray.
27. When filing on the lathe, be sure the file has a securely fitting handle.
28. Stop the machine immediately if some off sounding noise or vibration develops during operation. If you cannot locate the trouble, get help from your instructor. Under no condition should the machine beoperated until the trouble has been corrected.
29. Remove sharp edges and burrs from work before removing it from the machine.
30. Plan your work thoroughly before starting. Have all needed tools on hand.

Use care when cleaning the lathe. Chips sometimes stick in recesses. Remove them with a brush or short stick.NEVER clean a machine tool with compressed air.

DANGER! Stop the machine before making measurements or cleaning out chips.

SAFETY NOTE! NEVER turn on the lathe until checking that you did NOT accidentally leave the chuck key inthe chuck.

7 BENDING MACHINE OR BRAKE

Though the bender is powered by human force alone, the long push arm, counterweight can generate a great deal of force. If body parts get caught in the brake, they can be easily broken or amputated. It's easy to prevent this and other injuries from occurring. Follow these safety rules when using the brake:

1 Never place any body part in the blade area.

2 Always check the work area around the brake. Be sure that the area is free from people.

3 Before using the brake, check the counterweight rods and counterweights to make sure they are secure.

4 Never place material in the brake, which is too rigid for the capacity of the brake. Overstraining thebrake can cause the arm and other parts to break and possibly cause injury.

8 WELDING MACHINE

The high-energy arc of even the smallest welding machine can cause severe burns. When welding, the following precautions must be observed:

1. Ideally, welding should be performed in a separate, well-ventilated room with a fire-resistant flooring material. If welding is to be conducted in other areas, the area must be free of flammable materials.
2. Non-flammable clothing, eye, and hand protection must be worn to protect from molten metal and hot sparks. Eye protection must provide appropriate shading according to the guidelines of the AmericanNational Standards Institute (ANSI).
3. Consult your safety representative for help in determining the appropriate eye protection, and otherprotective equipment, for your operation.

9 SHEET METALS SHEARS

When using shears, follow these precautions:

1 Keep fingers away from the cutting blade.

2 Wear leather gloves when handling sheet metal to avoid cuts from sharp edges.

3 Keep objects other than the piece being cut away from the blade.

10 TAPS

Hand threading safety:

1. If a tap or threaded piece must be cleaned of chips with compressed air, protect your eyes from

flyingchips by wearing goggles. Take care **NOT** to endanger persons working in the area near you!

2. Chips produced by hand threading are sharp. Use a brush or piece of cloth, **NOT** your hand, to removethem!
3. Newly cut external threads are very sharp. Again, use a brush or cloth to clean them.
4. Wash your hands after using cutting fluids or oils! Some cause skin rash. This can develop into a seriousskin disorder if the oils are left on hands for extended periods.
5. Have cuts treated by a qualified person. Infections can occur when cuts and other injuries are NOTproperly treated.

11 **DRILL PRESS AND MILLING SAFETY**

Many of the safety rules of the portable drill apply to the drill press. In addition, follow these rules:

1. Always secure the material being drilled.
2. When lowering the press, keep your hands out of the way of the bit.
3. Never use a hand bit or auger bit. Use bits designed only for the drill press.
4. Never try to stop the machine by taking hold of the chuck after the power is off.
5. Check to make sure the chuck is secured before turning the drill press on.
6. Remove neckties and tuck in loose clothing so there is no chance of them becoming entangled in therotating drill!
7. Check out the machine! Are all guards in place? Do switches work? Does the machine operate properly?Are the tools sharpened for the material being worked?
8. Clamp the work solidly. Do NOT hold work with your hand. A "merry-go-round" can inflict serious andpainful injuries.
9. Wear goggles!
10. Place a piece of wood under drills being removed from the machine. Small drills can be damaged whendropped and the larger tools can injure you if dropped.
11. Use sharp tools
12. Clean chips from the work with a brush, NOT your hands!
13. Treat cuts and scratches immediately!
14. Always remove the key from the chuck BEFORE turning on the power.
15. Let the drill spindle stop on its own after turning off the power. Do NOT attempt to stop it with yourhand!
16. Keep the work area clear of chips.
17. Wipe up all cutting fluid that spills on the floor right away.
18. Avoid trying to clean the tapered opening in the spindle while it is rotating.

19. After using a drill, wipe it clean of chips and cutting fluid. Replace the tool to proper storage.
20. Never start a cut until you are sure there is adequate clearance on all moving parts!

DRILLS

- **SAFETY NOTE!** NEVER attempt to operate a drilling machine while your senses are impaired bymedication or other substances.
- **DANGER!** Always remove the key from the chuck before turning on the drill press. It could hitsomething or fly out with considerable force.
- **DANGER!** Serious injury can result from work that becomes loose and spins about on a drill press ormilling machine. This dangerous situation is nicknamed a "merry-go-round".
- **DANGER!** NEVER insert a tap into the drill chuck and attempt to use drill press POWER to run the tapinto the work. The tap will shatter when power is applied. Turn the tap by hand!

12 MILLING MACHINE

Milling machines present similar hazards as drill presses and lathes. Follow these general safety rules when usingthe milling machine:

1. Become thoroughly familiar with the milling machine before attempting to operate it. When in doubt,obtain additional instructions.
2. Wear appropriate clothing and approved safety glasses!
3. Stop the machine before attempting to make adjustments or measurements!
4. Get help to move any heavy machine attachment, such as a vise, dividing head, rotary table or largework.
5. Stop the machine before trying to -remove accumulated chips.
6. Never reach over or near a rotating cutter!
7. Be sure the work holding device is mounted solidly to the table, and the work is held firmly. Spring orvibration in the work can cause thin cutters to jam and shatter!
8. Avoid talking with anyone while operating a machine tool, nor allow anyone to turn your machine on foryou.
9. Keep the floor around your machine clear of chips and wipe up spilled cutting fluid immediately!
10. Be thoroughly familiar with the placement of the machine's STOP switch or lever.
11. Treat any small cuts and skin punctures as potential infections! Clean them thoroughly. Apply antiseptic and cover injury with a bandage. Report any injury, no matter how minor, to your instructor or supervisor.
12. Never "fool around" when operating a milling machine! Keep your mind on the job and be ready for

any emergency!

13. Be sure all power to the machine is turned off before opening or removing guards and covers.
14. Secure the work piece in a vice or clamp to the table.
15. Maintain cutting fluids properly. Prevent coolant from getting on the floor.
16. Keep fingers from rotating cutters.
17. Use appropriate feeds and speeds for the material machined.
18. Avoid performing a machining operation on the milling machine until you are thoroughly familiar with how it should be done.
19. Some materials that are machined produce chips, dust and fumes that are dangerous to your health. NEVER machine materials that contain asbestos, Fiberglass, beryllium and beryllium copper unless you are fully aware of the precautions that must be taken.
20. Be sure the cutter rotates in the proper direction. Expensive cutters can be quickly ruined.
21. Carefully store milling cutters, arbors, collets, adapters, etc., after use. They can be damaged if not stored properly.

Precautions for the Use of Jib Cranes

In the assembly workshop, Jib cranes are widely used as small lifting equipment. Every company should pay attention to the safety management and operation of jib cranes.


The following points should be paid attention to when using the Jib crane:

1.Operators should check carefully, check the hooks, ropes, alarms, and safety devices for a long time, and report abnormalities in time.
2.Before starting, confirm that the following conditions are in a safe state:

(3) Whether all controllers are set to zero position;

(4) Whether there are irrelevant persons in the working area of the crane should evacuate to a safe area;

(5) Whether there are obstacles in the operating range of the crane;

(6) Whether the minimum distance between the crane and other equipment or fixed buildings is more than 0.5m;

(7) Whether the power circuit breaker is locked or has a warning sign;

(8) Whether the mobile Jib crane has leveled the site as required and laid the outriggers firmly and reliably.

(9) The operator shall not have the following behaviors during normal operation

(10) Use the stopper at the extreme position as a brake;

(11) Use the opposite direction as a brake;

(12) The jib crane is inspected and repaired while working;

(13) When lifting materials, cranes must not pass over people's heads, and people must not stand under the hanging objects and boom.

General Safety Precautions for Storage of Cylinders

1. The gas cylinder storage shed must be located in an isolated area, as far as practicable.
2. The gas cylinder
3. Storage shed shall have roofing to protect from direct sunlight and have adequate ventilation.
4. Gas cylinders shall not be stored in exits or egress routes.
5. Gas cylinders shall not be stored in damp areas, near salt or corrosive chemicals, fumes, heat or in areas having exposure to the weather.
6. The gas cylinder storage shed shall not be located close to any inflammable chemicals / fuel storage area / source of combustion activities / open flames / steam pipes.
7. Full and empty cylinders are to be stored separately.
8. The gas cylinders shall be stored in segregated manner, considering incompatibility [example bulk DA (Dissolved Acetylene) & bulk Oxygen; bulk Hydrogen & bulk Oxygen, bulk LPG & bulk Oxygen, toxic and flammable gas cylinders]. Incompatible gas cylinders must be stored at least at a gap of 3 meters.
9. Incompatible gas cylinders must not be transported together.
10. The store in-charge / supervisor shall maintain the up-to-date inventory of Gas cylinders.

11. Other than notified gas cylinders, no other material of any kind shall be stored inside the

area.

12. All the gas cylinders shall be kept in upright position with chaining to prevent accidental fall.
13. A system of marking of gas cylinders for their individual identification & record of their hydrostatic test to be maintained by custodian deptt.
14. All gas cylinders shall be capped when not in use.
15. All gas cylinders shall be stored so that cylinders are used in the order in which they are received.
16. The gas cylinder storage area shall not have any loose electrical cables, wires or lines in the vicinity.
17. Do not keep cylinders in battery room or oil storage room.
18. Adequate warning signs / labeling / no smoking caution / safety instructions shall be displayed in the gas cylinder storage area in legible manner.
19. Display of Material Safety Data Sheet (MSDS) of the stored gas to be done at appropriate place in legible & in local language/ English.
20. Avoid storing cylinders in confined location with improper ventilation.
21. Oxygen and Fuel cylinders shall be kept separately.
22. Restrict entry to the cellar, allowing only trained persons to enter and work there. xxii) Clean up spillages immediately to prevent slipping hazards.
23. Ensure the cellar has adequate lighting.
24. Avoid placing cylinders on uneven surface. The cylinder may fall, causing injury or damage.
25. Explosive gases like hydrogen to be stored in separate sheds with proper fencing as per the guidelines.
26. Acetylene and LPG must never be stacked horizontally in storage or in use.
27. Regularly check for leakages, if any. xxviii) Depending on the properties of gases stored, maintain proper temperature in the storage area, avoiding excessive or low temperature build up.

Corrosive Chemicals – Procedures for Safe Handling and Storage

Corrosives (liquids, solids, and gases) are chemicals that cause visible destruction or irreversible alterations to living tissue by chemical action at the site of contact. Corrosive effects can occur not only to the skin and eyes, but also to the respiratory tract through inhalation and to the gastrointestinal tract through ingestion. Corrosive liquids have a high potential to cause external injury to the body, while corrosive gases are readily absorbed into the body through skin contact and inhalation. Corrosive solids and their dusts can damage tissue by dissolving rapidly in moisture on the skin or within the respiratory tract when inhaled. In order to minimize these potential hazards, precautionary procedures must be observed when handling corrosives.

Handling:

- Appropriate personal protective equipment (e.g., gloves, fire-resistant or all cotton lab coat, and safety goggles) must be worn when working with corrosive chemicals. A face shield, rubber apron, and rubber booties may also be appropriate depending on the work performed.
- Appropriate protective gloves that are resistant to permeation or penetration from corrosive chemicals must be selected and tested for the absence of pin holes prior to use.
- Eyewashes and safety showers must be readily available in areas where corrosive chemicals are used and stored. In the event of skin or eye contact with a corrosive chemical, the affected area should be immediately flushed with water for 15 minutes. Contaminated clothing should be removed and medical attention sought.
- Corrosive chemicals should be handled in a fume hood to ensure that any possible hazardous or noxious fumes generated are adequately vented.
- When mixing concentrated acids with water, add the acid slowly to the water. Allow the acid to run down the side of a container and mix slowly to avoid violent reactions and splattering. Never add water to acid.
- Appropriate spill clean-up material should be available in areas where corrosive chemicals are used and stored.
- Protective carriers shall be used when transporting corrosive chemicals.

Storage:

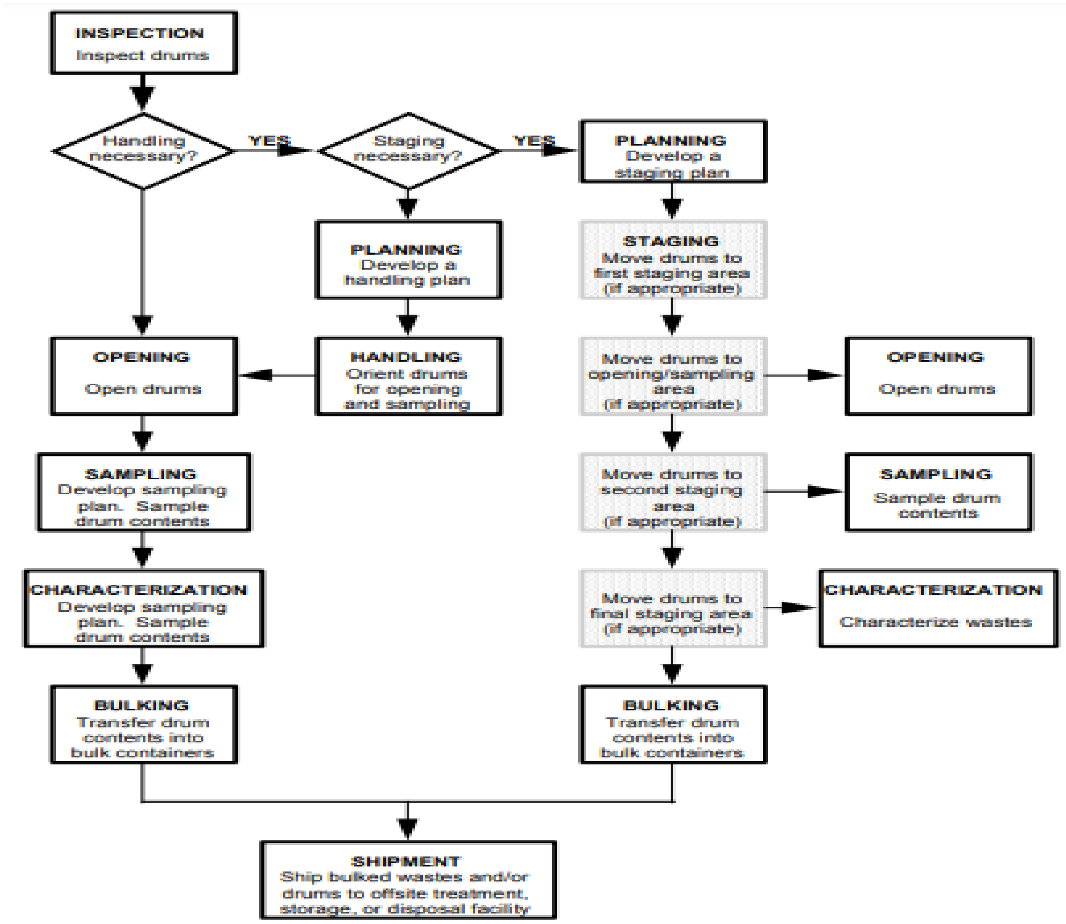
- Containers and equipment used for storage and processing of corrosive material must be corrosion resistant.
- Corrosive chemicals must be stored below eye level, preferably near the floor to minimize the danger of their falling from cabinets or shelves.
- Acids and caustics (i.e. bases) must be stored separately from each other. Secondary containers or trays must be used to separate acids and bases or other incompatible corrosives within a corrosive cabinet.
- Oxidizing acids must be separated from organic acids and flammable/combustible materials (oxidizing acids are particularly reactive with organics and flammable/combustible materials).

• Acids must be segregated from active metals (e.g., sodium, potassium, and magnesium) and from chemicals that can generate toxic gases (e.g., sodium cyanide and iron sulfide).

• Corrosive gas cylinders must be returned for disposal every two year

SAFETY WHILE HANDLING WASTE DRUM AND CONTAINERS

A flow chart showing one set of possible procedures for drum handling is given in Figure 11-1.



Industrial 205-litre drums and barrels can weigh up to 350kg when full, these weights are well in excess of manual **handling** – the male and female upper limit is 25kg and 16kg respectively. With drum weights potentially being 22 times greater than guideline manual handling limits, these containers pose a severe health and safety risk to people who handle them.

For companies that use barrels and drums within their operation, drum handling safety should be an important part of work culture. Employers must look at the risks of loading and unloading heavy drums/barrels and put sensible health and safety measures in place to avoid the need for hazardous manual handling. In this post we are going to discuss the current landscape, risks and recommendations surrounding incorrect drum handling and ways to improve drum handling safety during daily operations.

The following procedures can be used to maximize worker safety during drum handling and movement: ·

1. Train personnel in proper lifting and moving techniques to prevent back injuries. ·
2. Make sure the vehicle selected has sufficient rated load capacity to handle the anticipated loads, and make sure the vehicle can operate smoothly on the available road surface. ·
3. Air condition the cabs of vehicles to increase operator efficiency; protect the operator with heavy splash shields. ·
4. Supply operators with appropriate respiratory protective equipment when needed. Normally either a combination SCBA/SAR with the air tank fastened to the vehicle, or an airline respirator and an escape SCBA are used because of the high potential hazards of drum handling. This improves operator efficiency and provides protection in case the operator must abandon the equipment. ·
5. Have over packs ready before any attempt is made to move drums.
6. Before moving anything, determine the most appropriate sequence in which the various drums and other containers should be moved. For example, small containers may have to be removed first to permit heavy equipment to enter and move the drums. ·
7. Exercise extreme caution in handling drums that are not intact and tightly sealed. ·
8. Ensure that operators have a clear view of the roadway when carrying drums. Where necessary, have ground workers available to guide the operator's motion.

Drums Containing Radioactive Waste ·

1 If the drum exhibits radiation levels above background immediately contact a health physicist. Do not handle any drums that are determined to be radioactive until persons with expertise in this area have been consulted.

Drums that May Contain Explosive or Shock-Sensitive Waste

1. If a drum is suspected to contain explosive or shock-sensitive waste as determined by visual inspection, seek specialized assistance before any handling. ·

2 If handling is necessary, handle these drums with extreme caution. ·

Prior to handling these drums, make sure all nonessential personnel have moved a safe distance away.

3 Use a grappler unit constructed for explosive containment for initial handling of such drums. 4 Palletize the drums prior to transport. Secure drums to pallets. ·

5 Use an audible siren signal system, similar to that employed in conventional blasting operations, to signal the commencement and completion of explosive waste handling activities. 6 Maintain continuous communication with the Site Safety Officer and/or the command post until drum handling operations are complete.

Bulging Drums

1 Pressurized drums are extremely hazardous. Wherever possible, do not move drums that may be under internal pressure, as evidenced by bulging or swelling.

2 If a pressurized drum has to be moved, whenever possible handle the drum with a grappler unit constructed for explosive containment. Either move the bulged drum only as far as necessary to allow seating on firm ground, or carefully over pack the drum. Exercise extreme caution when working with or adjacent to potentially pressurized drums.

Drums Containing Packaged Laboratory Wastes (Lab Packs)

Laboratory packs (i.e., drums containing individual containers of laboratory materials normally surrounded by cushioning absorbent material) can be an ignition source for fires at hazardous waste sites. They sometimes contain shock-sensitive materials. Such containers should be considered to hold explosive or shock-sensitive wastes until otherwise characterized. If handling is required, the following precautions are among those that should be taken:

1 Prior to handling or transporting lab packs, make sure all non-essential personnel have moved a safe distance away. ·

2 Whenever possible, use a grappler unit constructed for explosive containment for initial handling of such drums. ·

3 Maintain continuous communication with the Site Safety Officer and/or the command post until handling operations are complete. ·

4 Once a lab pack has been opened, have a chemist inspect, classify, and segregate the bottles within it, without opening them, according to the hazards of the wastes. An example of a system for classifying lab pack wastes is provided in Table 11-3. The objective of a classification system is to ensure safe segregation of the lab packs' contents. Pack these bottles with sufficient cushioning and absorption materials to prevent excessive movement of the bottles and to absorb all free liquids, and ship them to an approved disposal facility. ·

5 If crystalline material is noted at the neck of any bottle, handle it as a shock-sensitive waste,

due to the potential presence of picric acid or other similar material, and get expert advice before attempting to handle it. ·

6 Palletize the repacked drums prior to transport. Secure the drums to pallets.

Leaking, Open, and Deteriorated Drums ·

1 If a drum containing a liquid cannot be moved without rupture, immediately transfer its contents to a sound drum using a pump designed for transferring that liquid.

2 Using a drum grappler, place immediately in over pack containers:

3 Leaking drums that contain sludges or semi-solids.

4 Open drums that contain liquid or solid waste. ·

5 Deteriorated drums that can be moved without rupture.

MODULE-4

ELECTRICAL SAFETY

1 Introduction to Electrical Safety

What is Electricity?

Though you cannot see electricity, you are aware of it every day. You see it used in countless ways. You cannot taste or smell electricity, but you can feel it. Basically, there are two kinds of electricity - static (stationary) and dynamic (moving). This module is about dynamic electricity because that is the kind commonly put to use.

Electricity (dynamic) is characterized by the flow of electrons through a conductor. To understand this phenomenon, you must know something about chemical elements and atoms.

Elements and Atoms

Elements are the most basic of materials. Every known substance - solid, liquid, or gas - is composed of elements.

An atom is the smallest particle of an element that retains all the properties of that element. Each element has its own kind of atom; i.e., all hydrogen atoms are alike, and they are all different from the atoms of other elements. However, all atoms have certain things in common. They all have an inner part, the nucleus, composed of tiny particles called protons and neutrons. An atom also has an outer part. It consists of other tiny particles, called electrons, which orbit around the nucleus. Neutrons have no electrical charge, but protons are positively charged. Electrons have a negative charge. The atoms of each element have a definite number of electrons, and they have the same number of protons. An aluminum atom, for example, has thirteen of each. The opposite charges - negative electrons and positive protons - attract each other and tend to hold electrons in orbit. As long as this arrangement is not changed, an atom is electrically balanced. This is illustrated in the figure below.

Electrical Materials A material that contains many free electrons and is capable of carrying an electric current is called a conductor. Metals and (generally) water are conductors. Gold, silver, aluminum and copper are all good conductors. Materials that contain relatively few free electrons are called insulators. Non-metallic materials such as wood, rubber, glass and mica are insulators. Fair conductors include the human body, earth, and concrete.

Generating Electricity There are several ways to produce electricity. Friction, pressure, heat, light, chemical action, and magnetism are among the more practical methods used to make electrons move along a conductor. To date, magnetism is the most inexpensive way of producing electrical power and is therefore of most interest to us. Because of the interaction of electricity and magnetism, electricity can be generated economically and abundantly and electric motors can be used to drive machinery. Electricity is produced when a magnet is moved past a piece of wire. Or, a piece of wire can be moved through a magnetic field. A magnetic field, motion, and a piece of wire are needed to produce electricity.

1.1 Voltage, Current and Resistance

i) **Voltage**

A force or pressure must be present before water will flow through a pipeline. Similarly, electrons flow through a conductor because a force called electromotive force (EMF) is exerted. The unit of measure for EMF is the volt. The symbol for voltage is the letter E. A voltmeter is used to measure voltage.

ii) Current

For electrons to move in a particular direction, it is necessary for a potential difference to exist between two points of the EMF source. The continuous movement of electrons past a given point is known as current. It is measured in amperes. The symbol for current is the letter I and for amperes, the letter A. It is sometimes necessary to use smaller units of measurement. The milliampere (mA) is used to indicate 1/1000 (0.001) of an ampere. If an even smaller unit is needed, it is usually the microampere (μA). The microampere is one-millionth of an ampere.

An ammeter is used to measure current in amperes. A microammeter or a milliammeter may be used to measure smaller units of current.

iii) Resistance

The movement of electrons along a conductor meets with some opposition. This opposition is known as resistance. Resistance can be useful in electrical work. Resistance makes it possible to generate heat, control current flow, and supply the correct voltage to a device. The symbol for resistance is shown in the accompanying figure.

In general, resistance in a conductor depends on four factors: the material from which it is made, the length, the cross-sectional area, and the temperature of the material.

iv)Material. Different materials have different resistances. Some, such as silver and copper, have a low resistance, while others, such as iron have a higher resistance.

v) Length. For a given material that has a constant cross-sectional area, the total resistance is proportional to the length. The longer the conductor, the greater the resistance.

vi) **Cross-Sectional Area**. Resistance varies inversely with the cross-sectional area of the conductor. In other words, the resistance decreases as the cross-sectional area increases.

vii) Temperature. Generally, in metals, the resistance increases as the temperature increases. For non-metals, the reverse is usually true.

The symbol for resistance is the letter R. Resistance is measured by a unit called the ohm. The Greek letter omega (S) is used as the symbol for electrical resistance. The figure below summarizes the factors that affect resistance.

2 List and Explain the common electrical hazards

Electricity is part of our daily lives, right from the time we wake up and throughout the day. We take it for granted and have forgotten how powerful it is and can also be dangerous. While at home, we are aware of the electrical risks and we follow safety rules such as unplugging unused devices, putting off switches when not in use, no open or live wires lying around, using circuit breakers and various other precautions.

While at our workplace, where most of the work tasks are done while sitting in a chair in an air conditioned office building, would seem perfectly safe. However, a surprising number of hazards can be present in an office setting. To keep you safe at your workplace, we have listed a few common electrical hazards that you should be aware of and take necessary precautions.

i) Faulty or Damaged Wiring

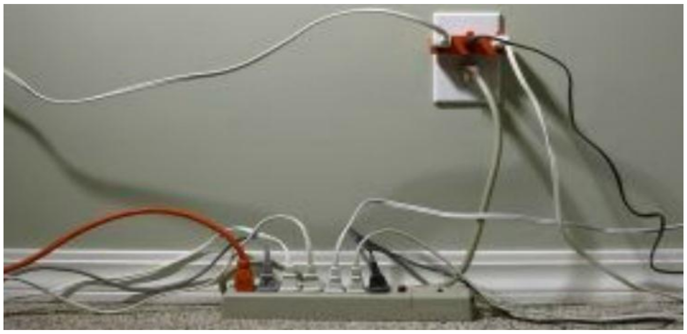
Non-functioning wires or cables should be removed at once. Cables which are frayed, loose or have exposed wires should be attended to and replaced. Damaged wires and cables can cause electric shocks and fires.

ii) Overloading Circuits

If too many devices are plugged into a circuit, the current will heat the wires to a very high temperature, which may cause a fire. If the wire insulation melts, arcing may occur and cause a fire in the area where the overload exists or even inside a wall.

iii) Use of Extension Cords

Extension cords tend to develop cracks and other defects that can lead to shocks. And these problems cannot be covered with electrical tape. Better to be safe and position your electrical devices within reach of an electrical outlet rather than to use an extension cord.



iv) Water Spill on Electrical Devices

No electrical equipment should be operated or even switched in case of contact with water. Water greatly increases the risk of electrocution especially if the equipment has damaged insulation. Switch off the main power connection, then unplug all the wet or damp equipment. Make sure you dry them out well. Have a certified electrician check the device to confirm it is no longer a danger and can be switched back on.

v)Improper Grounding

Every electrical equipment, appliance or device must be Earthed or grounded to obtain a low resistance path for dissipation of current into the earth. Ground fault current directly has an impact on human safety, can cause fires and electrical shock. Additionally, ungrounded electrical systems can be potentially hazardous to your electronics. This important safety feature takes the extra electricity away from your device, which can save your electronics from damages.

vi)Incorrectly placed Electrical Cords

Electrical cords should be installed in a proper manner and with safety in mind. They are mostly located within or along walls. There should not be any loose wires as well. Also ensure that no electrical cables run through high-traffic areas, under carpets or across doorways.

vii) Loose Fitting Plugs

Plug for all electrical equipment's should be firmly fitted in its socket. Be aware that loose-fitting plugs can potentially cause equipment to overheat and catch fire. It may require periodic physical checks to ensure that the plug has not loosened. Be wary when cleaning of work location takes place and equipment is moved during cleaning, causing the plug to get loosen from the socket.

3. Prevent Electrical Accidents:

i) Proper grounding

Grounding an electrical instrument creates a low-resistance path that connects to the earth. This helps in preventing the build-up of voltages that may cause an electrical accident.

1. Make sure that all equipment is grounded so that you are not at risk of getting an electrical shock. Proper grounding eliminates unwanted voltage and reduces the risk of electrocution.
2. You can use guarding as a secondary protective measure to further reduce the risk of electrical hazards.

ii) Guard electrical equipment

Guarding electrical equipment means that you locate or enclose them so that people do not accidentally come in direct contact with them.

1. It is important to guard all the exposed electrical wires or components. Use electrical connectors wherever necessary. They join electrical terminators and create an electrical circuit.
2. Disconnect machines before you service or repair them.
3. Use insulators such as mica, glass, plastic or rubber over metals and conductors to reduce the flow of current.

iii) Extension cord safety

Electrical equipment will have cords and wires. Make sure you practice cord safety in the workplace.

1. Do not plug two extension cords together. Try to minimize the use of extensive cords as much as possible.
2. Never nail the extensive cords into place. Use electrical tape for the same. Nails will damage the cords, which may lead to shocks and electrical fires.
3. Do not cover power and extension cords with rugs and mats. This may create tripping hazards or cause issues with the wires.
4. Do not pull the cords or yank them. Carefully, unplug them from the outlet by gripping the plug.
5. Do not use equipment with broken cords or plugin anything that has a missing prong.

Inspect all the electrical cords regularly. If you see any signs of cord damage, stop using the equipment immediately and call a professional.

iv) Never operate in wet conditions

Water greatly increases the risk of electrocution. The risk will be greater if the equipment's insulation is damaged.

1. Do not keep or use electrical equipment near wet surfaces or in wet locations.
2. Never operate electrical equipment with wet hands or when the equipment is wet.
3. Bring in a qualified electrician to inspect electrical equipment if it got wet. Do not energize it before getting it checked.

v) Circuit protection

Use circuit protection devices as they will limit or stop the current flow automatically in the event of a ground fault, short circuit or overload in the wiring systems. Some circuit protection devices include circuit breakers, fuses, arc-fault circuit interrupters and ground-fault circuit interrupters.

1. Make sure you do not plug multi-outlets bars to other multi-outlet bars.
2. Do not overload the sockets. If there are multiple connections, use a power board. Use just one power board per wall outlet.
3. Notice if the wires are getting heated. There is a high risk of electrical fires when the wires become overheated. Ensure that the wires are suitable for their electrical load.

Do not ignore electrical hazards as they can lead to serious bodily injuries. It is of utmost importance that you take proper precautions when you deal with electrical equipment. Conduct a safety assessment test of the workplace to identify different hazards. Then, create a plan on how to address the hazards so that it does not lead to any serious accident.

4. Electrical protection system

4.1 What is a Relay

- Device which receives a signal from the power system and determines whether conditions are "normal" or "abnormal" (measuring function)-
- If an abnormal condition is present, relay signals circuit breaker to disconnect equipment that could be damaged (Switching or signaling function)
- "Relays" signal from system to circuit breaker

What is the Purpose of the Relay

The purpose of the protective relaying systems is to isolate only the faulty component of power system. Relaying equipments are classified into two groups: 1. Primary relaying equipment. 2.

Back-up relaying equipment. Primary relaying is - the first line of defense for protecting the equipments. Back-up protection relaying works only when the primary relaying equipment fails (they are slow in action).

4.2. FUSE An electric fuse is an electric device which interrupts the flow of current in an electric circuit. It is installed in a circuit to stop the flow of excessive current. A fuse is usually a short piece of wire. The fuse is made up of a material which has high resistivity and low melting point, so that it melts down due to overheating of the wire during high current flow.

The thickness of the fuse wire is determined based on the amount of current flow in the circuit. Normally an alloy of tin and lead is used as the fuse wire, as it has high resistivity and low melting point.

Function of Fuse

Here is a list of some major functions of an electric fuse.

- An electric fuse acts as a barrier between an electric circuit and the human body.
- It prevents any damage to the electric device by restricting excess current flow.
- It prevents overload of current. When too many appliances are connected in a single circuit, it leads to overload which requires a fuse to terminate the circuit connection.
- It prevents damage that occurs due to mismatched loads.
- Prevents blackouts: if any dis-function occurs in the components of the circuit, the nearest circuit breaks.

Information about the ampere rating, voltage rating, approval standards of the fuse and interrupt rating are generally marked on the fuse. This information must be checked and verified before buying a fuse.

Working of Fuse

An electric fuse is based on the principle of heating effect of electric current. It is made up of thin metallic wire of non-combustible material. A fuse is always connected between the ends of the terminal in a series connection with the circuit.

When an excessive current flows in the circuit, it generates heat in the circuit which leads to melt the fuse due to its low melting point, and it also opens the circuit. The excessive flow of current may lead to breakdown of the circuit and stop the current flow. Once a fuse melts, it can be changed or replaced with a new fuse.

Fuse is normally made up of elements like zinc, copper, aluminum and silver.

A fuse acts as a circuit breaker and breaks the circuit in case any fault occurs in the circuit. It acts as a protector of electric appliances and also as a safety measure for humans. The figure below represents a fuse operation, fuse barrel and fuse link.

4.3 Circuite Breaker

A circuit breaker is a switching device that interrupts the abnormal or fault current. It is a mechanical device that disturbs the flow of high magnitude (fault) current and in additions performs the function of a switch. The circuit breaker is mainly designed for closing or opening of an electrical circuit, thus protects the electrical system from damage.

Working Principle of Circuit Breaker

Circuit breaker essentially consists of fixed and moving contacts. These contacts are touching each other and carrying the current under normal conditions when the circuit is closed. When the circuit breaker is closed, the current carrying contacts, called the electrodes, engaged each other under the pressure of a spring.

During the normal operating condition, the arms of the circuit breaker can be opened or closed for a switching and maintenance of the system. To open the circuit breaker, only a pressure is required to be applied to a trigger.

5. Overvoltage and Under Voltage Protection System

5.1 Protections of over voltage electric shock

There is always a chance of suffering an electrical power system from abnormal over voltages. These abnormal over voltages may be caused due to various reasons such as, sudden interruption of heavy load, lightening impulses, switching impulses etc. These over voltage stresses may damage insulation of various equipments and insulators of the power system. Although, all the over voltage stresses are not strong enough to damage insulation of system, but still these over voltages also to be avoided to ensure the smooth operation of electrical power system. These all types of destructive and non destructive abnormal over voltages are eliminated from the system by means of overvoltage protection.

i) **Over voltage surge:**

The voltage surges appear in the electrical power system due to switching surge, insulation failure, arcing ground and resonance are not very large in magnitude. These over voltages hardly cross the twice of the normal voltage level. Generally, proper insulation to the different equipment of power system is sufficient to prevent any damage due to these over voltages. But over voltages occur in the power system due to lightning is very high. If over voltage protection is not provided to the power system, there may be high chance of severe damage. Hence all over voltage protection devices used in power system mainly due to lightning surges.

ii) Switching Impulse or Switching Surge:

When a no load transmission line is suddenly switched on, the voltage on the line becomes twice of normal system voltage. This voltage is transient in nature. When a loaded line is suddenly switched off or interrupted, voltage across the line also becomes high enough current chopping in the system mainly during opening operation of air blast circuit breaker, causes over voltage in the system. During insulation failure, a live conductor is suddenly earthed. This may also caused sudden over voltage in the system. If emf wave produced by alternator is distorted, the trouble of resonance may occur due to 5th or higher harmonics. Actually for frequencies of 5th or higher harmonics, a critical situation in the system so appears, that inductive reactance of the system becomes just equal to capacitive reactance of the system. As these both reactance cancel each other the system becomes purely resistive. This phenomenon is called resonance and at resonance the system voltage may be increased enough.

But all these above mentioned reasons create over voltages in the system which are not very high in magnitude.

But over voltage surges appear in the system due to lightning impulses are very high in amplitude and highly destructive. The affect of lightning impulse hence must be avoided for over voltage protection of power system.

Methods of Protection Against Lightning:

These are mainly three main methods generally used for protection against lightning. They are

- Earthing screen.
- Overhead earth wire.

• Lighning arrester or surge dividers.

Earthing Screen:

Earthing screen is generally used over electrical substation. In this arrangement a net of GI wire is mounted over the sub-station. The GI wires, used for earthing screen are properly grounded through different sub-station structures. This network of grounded GI wire over electrical sub-station, provides very low resistance path to the ground for lightning strokes. This method of high voltage protection is very simple and economic.

Overhead Earth Wire:

This method of over voltage protection is similar as earthing screen. The only difference is, an earthing screen is placed over an electrical sub-station, whereas, overhead earth wire is placed over electrical transmission network. One or two stranded GI wires of suitable cross-section are placed over the transmission conductors. These GI wires are properly grounded at each transmission tower. These overhead ground wires or earth wire divert all the lightning strokes to the ground instead of allowing them to strike directly on the transmission conductors.

Lightning Arrester

The lightning arrester is a devices which provides very low impedance path to the ground for high voltage travelling waves. The concept of a lightning arrester is very simple. This device behaves like a nonlinear electrical resistance. The resistance decreases as voltage increases and vice-versa, after a certain level of voltage.The functions of a lightning arrester or surge dividers can be listed as below. Under normal voltage level, these devices withstand easily the system voltage as electrical insulator and provide no conducting path to the system current. On occurrence of voltage surge in the system, these devices provide very low impedance path for the excess charge of the surge to the ground.

There are different types of lightning arresters used in power system, such as rod gap arrester, horn gap arrester, multi-gap arrester, expulsion type LA, value type LA. In addition to these the most commonly used lightning arrester for over voltage protection now-a-days gapless ZnO lightning arrester is also used.

5.2 Under Voltage protection system.

A low voltage electric shock occurs when a person comes into contact with a source of low voltage electricity which directly or indirectly sends an electrical current passing through the person's body, potentially causing both internal and external injuries

A low voltage electric shock is dangerous because it can cause electrocution and fatal injuries even though there are no visible signs of external injury. It transmits through tissues with low resistance such as the brain, heart, internal organs, blood vessels and the central nervous system. This is very serious because electrical damage to the brain may result in a permanent seizure disorder, depression, anxiety, or other personality changes. Additionally, electrical shock can

Three conditions of exploitation must be respected in order to provide satisfactory fault protection:

- No live conductor at SELV must be connected to earth
- Exposed-conductive-parts of SELV supplied equipment must not be connected to earth, to other exposed conductive parts, or to extraneous-conductive-parts
- All live parts of SELV circuits and of other circuits of higher voltage must be separated by a distance at least equal to that between the primary and secondary windings of a safety isolating transformer.

These measures require that:

- SELV circuits must use conduits exclusively provided for them, unless cables which are insulated for the highest voltage of the other circuits are used for the SELV circuits
- Socket outlets for the SELV system must not have an earth-pin contact.

The SELV circuit plugs and sockets must be special, so that inadvertent connection to a different voltage level is not possible.

6. What is electric shock?

An electric shock is the physiological effect of an electric current through the human body. When a current exceeding 30 mA passes through human body, the person concerned is in serious danger if the current is not interrupted in short time.

An electric shock occurs **when a person comes into contact with an electrical energy source**. Electrical energy flows through a portion of the body causing a shock. Exposure to electrical energy may result in no injury at all or may result in devastating damage or as fatal as death also.

7. Primary electric shock

Just like any other works, welding also has its own probability where accidents happen. Most often accidents happen because of the improper precautionary steps taken by the **welders** or when it happened due to the instrument fault.

One of the accidents that happen during **the** process of welding is Electric shocks. The primary shock is a condition when the primary voltage shock - at **115 volts** to as high as **600 volts** passes through the victim's body. This Electric shock is even dangerous than the much greater voltages.

A person can experience a primary shock if he happens to get in contact with touch a lead or other electrically hot element inside the **welder**. Especially when the body of the victim stays in contact with **welder** case or other grounded metal with the power to the **welder**. You can identify a grounding lead in the input power cable when the input power grounding lead has got green insulation or when it has got no insulation.

Secondary electric shock: Not getting proper material
/

8. AC and DC Electric current shock:

8.1 DC current shock:

Victims who have experienced the electric shock with DC current says that they are unable to pull their hand back because DC current flows continuously. This effect is similar to an electric doorbell supplied with DC current. Hence, it is believed that the DC current shock is more dangerous. Whereas, in the case of AC current, the person experiencing the electric shock can pull their hand back as the current goes to zero. Hence, it is believed that the AC current shock is least dangerous than DC current.

8.2 AC Current shock:

Whereas in the case of AC current, a person experiencing electric shock undergoes a series of muscle contraction. Series of muscle contraction causes very severe damage to the muscles. Due to the capacitive behaviour of the skin coming in contact with the current carrying conductor, more current can pass through the body if the voltage is rapidly changing. Studies have shown that twofold of increase in the voltage increases sevenfold increase in the current.DC current “let-go” threshold is higher than the AC “let-go” threshold. More DC current is required to produce a similar effect as of AC current.

These arguments are not only based upon experiments being carried out on men and women but also have been studied medically. Hence, the argument in favor of AC current holds the truth.

Now, it can be summarized that AC Current is more dangerous than DC Current. Well, one should not be afraid of electricity, but one must remember that both AC current and DC current can be dangerous to the human body and safety measures must be taken into the consideration when working with any of them.

Facts about Electric Shock

- It is the magnitude of current and the time duration that produces effect. That means a low value current for a long duration can also be fatal. The safe current/time limit for a victim to survive at 500mA is 0.2 seconds and at 50 mA is 2 seconds.
- The voltage of the electric supply is only important as it ascertains the magnitude of the current. As Voltage = Current x Resistance, the bodily resistance is an important factor. Sweaty or wet persons have a lower body resistance and so they can be fatally electrocuted at lower voltages.
- Let-go current is the highest current at which subject can release a conductor. Above this limit, involuntary clasping of the conductor is present. It is 22 mA in AC and 88 mA in DC.
- Apart from electric shock the other equally dangerous hazards of playing (or working) with electricity are electrical arc flash and electrical arc blast.
- Placing your hand in your pocket may protect you by preventing a current from traveling through the heart making a shock non-lethal.
- The severity of the electric shock depends on the following factors: body resistance, circuit voltage, amplitude of current, path of the current, area of contact, and duration of contact.
- Death may also occur from falling in case of electric shock.
- Burn injury may occur at both the entrance and exit of the current.
- Low frequency AC is more dangerous than high frequency AC.
- AC and DC both kill so treat them with respect.

9. Safety precaution against electric shock

1 Avoid water at all times when working with electricity. Never touch or try repairing any electrical equipment or circuits with wet hands. It increases the conductivity of the electric current.

2 Never use equipment with frayed cords, damaged insulation or broken plugs.

3. If you are working on any receptacle at your home then always turn off the mains. It is also a good idea to put up a sign on the service panel so that nobody turns the main switch ON by accident.

4. Always use insulated tools while working.

5. Electrical hazards include exposed energized parts and unguarded electrical equipment which may become energized unexpectedly. Such equipment always carries warning signs like “Shock Risk”. Always be observant of such signs and follow the safety rules established by the electrical code followed by the country you’re in.

6. Always use appropriate insulated rubber gloves and goggles while working on any branch circuit or any other electrical circuit.

7. Never try repairing energized equipment. Always check that it is de-energized first by using a tester. When an electric tester touches a live or hot wire, the bulb inside the tester lights up showing that an electrical current is flowing through the respective wire. Check all the wires, the outer metallic covering of the service panel and any other hanging wires with an electrical tester before proceeding with your work.

8. Never use an aluminum or steel ladder if you are working on any receptacle at height in your home. An electrical surge will ground you and the whole electric current will pass through your body. Use a bamboo, wooden or a fiberglass ladder instead.

9. Know the wire code of your country.

10. Always check all your GFCI’s once a month. A GFCI (Ground Fault Circuit Interrupter) is a RCD (Residual Current Device). They have become very common in modern homes, especially damp areas like the bathroom and kitchen, as they help avoid electrical shock hazards. It is

designed to disconnect quickly enough to avoid any injury caused by over current or short circuit faults.

10 Explain the effect of electric current on human heart and lungs

The severity of injury from electrical shock depends on the amount of electrical current and the length of time the current passes through the body. For example, 1/10 of an ampere (amp) of electricity going through the body for just 2 seconds is enough to cause death. The amount of internal current a person can withstand and still be able to control the muscles of the arm and hand can be less than 10 mill amperes (milliamps or mA). Currents above 10 mA can paralyze or "freeze" muscles. When this "freezing" happens, a person is no longer able to release a tool, wire, or other object. In fact, the electrified object may be held even more tightly, resulting in longer exposure to the shocking current. For this reason, handheld tools that give a shock can be very dangerous. If you can't let go of the tool, current continues through your body for a longer time, which can lead to respiratory paralysis (the muscles that control breathing cannot move). You stop breathing for a period of time. People have stopped breathing when shocked with currents from voltages as low as 49 volts.Usually
The table shows what usually happens for a range of currents (lasting one second) at typical household voltages. Longer exposure times increase the danger to the shock victim. For example, a current of 100 mA applied for 3 seconds is as dangerous as a current of 900 mA applied for a fraction of a second (0.03 seconds). The muscle structure of the person also makes a difference. People with less muscle tissue are typically affected at lower current levels. Even low voltages can be extremely dangerous because the degree of injury depends not only on the amount of current but also on the length of time the body is in contact with the circuit.

11. Explain the root cause of electric accident at construction site

Construction workers can be exposed to dangerous amounts of electrical currents in a number of ways. Common causes of these deadly accidents include:

- Being in contact with live power lines
- Failing to provide ground-fault protection for workers
- Failing to properly ground electrical equipment
- Not following manufacturer instructions

- Not using extension cords properly

Serious Injuries That Workers Can Suffer

Contact with as little as two amps of electricity can cause a construction worker to suffer serious injuries. Common injuries from electrical accidents fall into four main categories:

- Electrocutions
- Electrical shock
- Electrical burns
- Falls resulting from electrical accidents

The extent of a worker's injuries will depend on a number of factors. Some of these include:

- The length of time he was exposed to an electrical current
- The amount of current that went through his body
- The path of the current through his body
- The amount of moisture present, including on his skin
- The voltage of the current going through his body
- The phase of his heart cycle at the time he is exposed to the electrical current
- His general health

Construction workers can suffer many life-threatening injuries from exposure to electrical currents. Common injuries can include:

Cardiovascular: A worker can suffer the lack of cardiac rhythm or a chaotic and useless fluttering of his ventricles—often fatal if not treated immediately—and other heart problems.

Respiratory: While these injuries are rarer, if the current passes through the chest muscles or the portion of the brain controlling breathing, the person can go into respiratory arrest where he stops breathing—with deadly results.

Central nervous system: Victims of electrical accidents often fall and suffer additional injuries. These can include spinal cord injuries, head injuries, nerve damage, and seizures.

Musculoskeletal: When victims fall after being shocked, they can suffer serious fractures and internal organ damage—sometimes permanent.

Burns: A worker can suffer serious, disfiguring burns from contact with electricity.

12. Explain ten preventive measures to prevent shock in a substation:

Personal protective equipment is an integral part of substation safety requirements. It serves to provide adequate protection against hazards of different severity levels that personnel are likely to be exposed during their routine jobs at the substation. It is the responsibility of the employer to accurately assess the various risks in the work environment, determine their severity and accordingly choose PPEs that offer the best protection. The choice of PPEs must be based on the findings of the most recent arc flash analysis and risk assessment exercise to provide effective cover.

PPES REQUIRED TO ENTER A SUBSTATION

Most utilities and industrial firms spell out PPE requirements, usage and maintenance instructions as a part of their safety protocol. Employers must make sure the PPEs available on site include:

- Hard hats (with full/partial brims as necessary)
- Safety glasses with side shields
- Face masks/shields
- Suitable footwear (safety/steel-toed boots, rated dielectric footwear)
- Insulating gloves (rated, used along with leather/cloth linings for shock protection)
- Insulated tools
- Electrical/insulation blankets
- Live-line tools/hot sticks

Batteries and other chemicals that find use in substations pose a chemical hazard in the environment, which may require the use of respirators and other chemically resistant PPEs, clothing, gloves and footwear to safeguard personnel.

Special safety equipment designed for use in confined/cramped spaces, barricades, scaffolding, gas/smoke detectors must also be available on demand.

TACKLING VISIBLE AND HIDDEN DANGERS

Potential electrical hazards at a substation are not to be taken lightly. While all danger areas and high-voltage equipment/installations are usually enclosed, shielded from access or prominently labelled, there are several other imminent hazards throughout the place that need to be tackled on a daily basis.

Not all live transmission lines, equipment or components within the substation are insulated as in conventional wiring. Accidental contact or even breaching the recommended minimum access distance can prove quite dangerous in certain areas. Even insulated components/parts are likely to be energised during an arc-flash, posing a serious safety threat to those in contact with the component or in the path of the arc, and not adequately protected.

Residual energy in certain parts of de-energised equipment is another latent threat that catches people off guard. Actuators and springs in the breakers may not be fully discharged even after power supply to the equipment has been shut off, making the use of recommended PPEs mandatory to avoid undue surprises.

It is important for personnel to keep in mind the PPEs do not totally mitigate the impact of hazards and are not replacements for safety protocols and procedures. De-energising equipment (risky in few cases), maintaining prescribed clearances and remote operations wherever possible are bound to ensure safe working conditions. Donning an arc-flash rated suit will at best reduce impact of the incident and, hence, the overall severity of injuries – only if adequate precautions are taken and safety procedures followed.

TRAINING ON USE AND MAINTENANCE OF PPES

Apart from providing the right arc-rated PPEs for the job, employers must also ensure that all employees who have access to the substation, especially restricted, high-risk areas within are trained on:

- The safety and emergency procedures
- Likely hazards on specific tasks and how to use PPEs in a proper manner for personal safety
- Inspection of PPEs for any damages that may compromise the level of protection
- Maintenance and care of PPEs

PRO-ACTIVE PERSONAL PROTECTION

Substation workers must strictly adhere to safety regulations and use the right PPEs that offer best protection against risks involved in a specific task. This is to safeguard themselves from imminent hazards to which they are likely to be exposed.

Complacency can prove fatal. Even the most experienced and qualified personnel on site may not be able to anticipate an arc-flash. It is never safe to enter the work area without adequate precautions. Customary inspections are mandatory to ensure de-energisation and grounding. It is mandatory to maintain the recommended clearance from live units, wear the necessary protective garments and gear, and follow instructions meticulously when inside the substation. Workers must take time to carefully inspect the PPEs before use, report damages if any, and get the units replaced/ repaired/ tested for safety.

13. Ten ways to prevent electrical accident:

1. Never touch anything electrical with wet hands or while standing in water. Wear rubber shoes in wet areas. If you get a tingle or shock when touching a sink, tub, or other wet area, turn off the power at the main panel (if it's safe) and immediately call an electrician.
2. Don't use frayed or broken cords or plug in anything with a missing prong.
3 Cover unused outlets. Keep metal objects such as silverware away from outlets.
4 Don't overload sockets. Use a power board with a safety switch and only use one per wall outlet.
5 When unplugging, don't yank! Pull by the plug, not the cord.
6 Don't run cords under rugs or furniture. Also keep them away from pets that like to chew.
7 Always clean the lint filter for your dryer. If an item says "do not put in dryer", trust the warning!
8 Test safety switches each year.
9 Don't fly kites near power lines. The kite or string can conduct electricity sending it right through you to the ground.
10 Never touch a downed power line or climb a utility pole.

14. Safety precaution in small and residential building installation

Before a utility will connect an installation to its supply network, strict pre-commissioning electrical tests and visual inspections by the authority, or by its appointed agent, must be satisfied.

These tests are made according to local (governmental and/or institutional) regulations, which may differ slightly from one country to another. The principles of all such regulations however, are common, and are based on the observance of rigorous safety rules in the design and realization of the installation.

IEC 60364-6 and related standards included in this guide are based on an international consensus for such tests, intended to cover all the safety measures and approved installation practices normally required for residential, commercial and (the majority of) industrial buildings. Many industries however have additional regulations related to a particular product (petroleum, coal, natural gas, etc.). Such additional requirements are beyond the scope of this guide.

The pre-commissioning electrical tests and visual-inspection checks for installations in buildings include, typically, all of the following:

- Electrical continuity and conductivity tests of protective, equipotential and earthbonding conductors
- Insulation resistance tests between live conductors and the protective conductors connected to the earthing arrangement
- Test of compliance of SELV (Safety Extra Low Voltage) and PELV (Protection by Extra Low Voltage) circuits or for electrical separation
- Insulation resistance/impedance of floors and walls
- Protection by automatic disconnection of the supply
  - For TN, by measurement of the fault loop impedance, and by verification of the characteristics and/or the effectiveness of the associated protective devices (overcurrent protective device and RCD)
  - For TT, by measurement of the resistance RA of the earth electrode of the exposed-conductive-parts, and by verification of the characteristics and/or the effectiveness of the associated protective devices (overcurrent protective device and RCD)
  - For IT, by calculation or measurement of the current Id in case of a fist fault at the line conductor or at the neutral, and with the test done for TN system where conditions are similar to TN system in case of a double insulation fault situation, with the test done for TT system where the conditions are similar to TT system in case of a double insulation fault situation.
- Additional protection by verifying the effectiveness of the protective measure

- Polarity test where the rules prohibit the installation of single pole switching devices in the neutral conductor.
- Check of phase sequence in case of multiphase circuit
- Functional test of switchgear and controlgear by verifying their installation and adjustment
- Voltage drop by measuring the circuit impedance or by using diagrams

These tests and checks are basic (but not exhaustive) to the majority of installations, while numerous other tests and rules are included in the regulations to cover particular cases, for example: installations based on class 2 insulation, special locations, etc.

The aim of this guide is to draw attention to the particular features of different types of installation, and to indicate the essential rules to be observed in order to achieve a satisfactory level of quality, which will ensure safe and trouble-free performance.

The methods recommended in this guide, modified if necessary to comply with any possible variation imposed by a utility, are intended to satisfy all precommissioning test and inspection requirements.

After verification and testing an initial report must be provided including records of inspection, records of circuits tested together with the test result and possible repairs or improvements of the installation.

15. Safety procedure in electric plant

Electricity is a necessary source of energy in industrial plants but it can also be a serious workplace hazard. It exposes employees to electrocution, shock, fires, burns and explosions. According to OSHA, electrical accidents rank sixth amongst the causes of work-related fatalities in the United States. Hundreds of employees have lost lives due to electrical accidents and thousands have required time off to recover from injuries caused by them. The good news is that you can prevent electrical hazards by implementing the best electrical safety practices. Read on to know more.

Keeping the Employees Safe

Employees are the most important asset to your company, which is why you need to protect them from electrical hazards. The first step would be to acknowledge that hazards exist within your facility and decide on safe practices that must be employed in different work areas. Employee training is critical.

Make sure that the workers are qualified to perform the electrical tasks at hand. Ensure that employee knowledge is up to standard and monitor their daily work habits. Additionally, monitor the established processes to ensure compliance.

Role of Employers in Establishing Safety Practices

As an employer, you must undertake the following tasks to implement safety practices:

- Use due diligence to hire qualified candidates for the electrical work. At the same time, consider that the new hires have neither been tested nor been measured for understanding or qualified candidates and train them from scratch.
- Audit the workplace to determine the existing level of qualification and compliance.
- Separate the electrical work tasks into the categories of operations or maintenance and conduct audit performance to ensure that this separation remains.
- Don't ever assume that your employees know how to handle electrical equipment safely. Provide them with company expectations on how to work with energized and de-energized equipment and demonstrate skills that would be necessary to conduct the tasks safely. It is important to periodically monitor for compliance and understanding. Lastly, measure the level of employee qualification.
- Audit the electrical safety program to ensure compliance with current standards and measure against industry best practices. It also helps in identifying various shortfalls in providing a safe work environment.
- Ensure that all the technically competent workers are aware of and can understand the hazards that they may encounter while working and how they can keep themselves and their peers safe while doing it.

Implementing Safety Model

You can give your employees the framework for safe work practices by introducing a safety model as a part of electrical hazard awareness orientation. The model would also encourage them to understand their tasks better, enabling them to identify and avoid potential risks when they are working with or around electricity. Safety model helps in the following three ways:

- It helps in recognizing the hazards in the workplace to avoid and control them. At this stage, the risk of injuries can be reduced and awareness can be increased by discussing and planning with supervisors and co-workers.
- It helps in evaluating the risks of injuries from each identified hazard, which helps you apply the appropriate method of control. Remember that risk evaluation is a continuous process to keep up with the constant changes in the workplace.

MODULE 5

CHEMICAL SAFETY

Introduction

A wide range of chemicals are being used in Institute laboratories. The hazards associated with these chemicals vary depending on their properties and mode of handling and usage.

Inherent hazards are also associated with the reactions that are carried out with these chemicals and the equipment being used.

The risks involved include serious injuries and adverse health effects. This calls for utmost care in handling of chemicals from the time of receipt to disposal.

Prevention of mishaps requires a proactive approach in identifying hazards and putting control measures in place.

Routes of Entry

The chemicals being handled can adversely affect the health of the person if it finds its way into the body.

This can happen either through the

- respiratory system by inhalation,
- skin absorption and
- Ingestion

Among these three modes, the respiratory system is the main route of entry of chemicals into the body. **Inhalation :** Inhalation is the most common route of entry for chemicals into the body. The vapors or fumes released from chemical containers or during the chemical reaction being carried out can enter the respiratory system if adequate precautions are not taken.

The impact on the respiratory system will depend upon the type of chemical, its properties, ambient concentration of the chemical and duration of exposure.

The chemical vapours can cause severe irritation of the respiratory tract or it can be absorbed into the blood stream to be carried to target organs.

The respiratory system has its own defense mechanism against foreign materials entering it.

The mucous secretion along the nasal cavity and millions of tiny hairs called cilia lining the respiratory tract help in expelling foreign material. In addition to this, macrophage cells attack and expel the dust particles reaching the lower respiratory passages. But these defense mechanisms are often overwhelmed when foreign materials enter the body in excess amounts.

Skin absorption

Next to inhalation, absorption through the skin forms the main route of entry of chemicals into the body.

Absorption through the skin can happen when the chemical handled comes in contact with unprotected body parts. This happens when the person handling the chemicals is not wearing appropriate clothing or personal protective equipment.

Cuts and abrasions on the skin can be a source of absorption of the chemical into the blood stream. Chemicals can also be absorbed through the intact skin.

Gastrointestinal introduction of toxins

This route of entry of chemicals into the body is rare when compared to other means of entry. Ingestion of the chemical can result from the consumption of food items inside the labs, contamination of food items stored in refrigerators meant for chemicals, mouth pipetting, and accidental ingestion of chemicals stored in drinking water bottles and poor personnel hygiene

Types of chemicals

Corrosives

-Corrosives are chemicals which cause burns on the skin, mucous membrane and eyes. Chemical burns are also caused when tissues come in contact with corrosive solids, corrosive liquids dispersed in the air as mists.

- It includes mainly acids and alkalies.
- Acid mists or fumes can corrode structural materials and equipment.
- Corrosives chemicals have other dangerous properties as well. For example, perchloric acid, in addition to being highly corrosive, is also a powerful oxidizing agent which can cause fire and explosions.

- Facilities like emergency eyewash and shower must be available in the labs handling corrosives.
- Splashing of corrosives into the eyes can result in partial or total loss of vision if not flushed with copious amount of water immediately. Caustics can cause serious skin burns as they penetrate deep into the tissue.
- Corrosive chemicals, both solid and liquid, can generate large amounts of heat when mixed with water. This can cause the solution to boil or even erupt violently.
- When water is added into a container of concentrated sulfuric acid it is converted instantly to steam which will eject the entire contents into the air. To prevent this always add corrosives to water, slowly, in small amounts, with frequent stirring.
- Always use personal protective equipment like safety goggles, face shields, chemical apron/coverall and hand gloves with long sleeves while handling corrosive chemicals.

Examples of corrosives include

- Nitric acid
- Sulphuric acid
- Calcium hydroxide
- Hydrofluoric acid
- Sodium hydroxide
- Bromine

Oxidisers

- Oxidisers are a hazard as they support combustion. Fires can burn violently in their presence.
- Oxidisers must be stored away from flammables, since they can start a fire if they come in contact with each other.
- Oxidizing materials which start to decompose at temperatures marginally above normal room temperatures must be stored well below their decomposition temperature.
- Do not use sawdust or other combustible substances to clean up spills of oxidizing materials.

Examples of oxidisers include

- Nitric acid

- Perchloric Acid
- Permanganates
- Nitrates
- Perchlorates

Flammables

- Flammable chemicals are a fire hazard. The lower the flashpoint (the lowest temperature at which a liquid fuel will give off enough vapour to form a momentarily ignitable mixture with air.) of the chemical, greater the hazard.

- Flammable chemical bottles must not be kept open without caps. They must not be kept near ignition sources.

- They must not be left on the lab bench after use, but to be stored in safety cabinets after use.
- A fire in a laboratory can easily get out of control if it involves any flammable solvents.

- Flammable chemicals must not be kept open in beakers or containers as they readily release vapour. The released vapours can form a flammable vapour air mixture which can ignite in the presence of a source of ignition.

- Open flames must be prohibited where solvents are handled and stored. The amount of solvent storage inside the labs must be only those required for immediate use.

- Flammable chemicals must not be stored along with oxidisers.

- Flammable chemical bottles or open containers with flammable chemicals must not be stored in domestic refrigerators. The vapours released can be ignited by the lighting unit or the thermostat inside. Intrinsically safe lab-purpose refrigerators must be used for the purpose of storing flammable chemicals.

- Distillation of solvents must only be done inside a chemical fume hood.

- Flammable chemicals must not be heated with Bunsen burners, use a water bath for the same. Examples of flammable chemicals are

- Acetone
- Toluene
- Methyl alcohol

1.Labelling of chemicals:

- Chemicals when transferred to secondary bottles/cans must be provided with proper labels.

- Chemical formulae or short forms must not be used for labelling of the containers.

The label must contain

- the full name of the chemical,
- its hazards,
- information for safe handling and
- the signage/pictogram indicating the hazard class.

- Labels of bottles which got deteriorated or worn off must be replaced immediately.

- Chemical bottles without labels or improper labeling can result in the wrong chemical being used.

- Further it will also cause difficulty in case of a spill or body contact or at the time of disposal of the chemical. Pictograms as per Globally Harmonized System of Classification and Labeling of Chemicals created by the United Nations are as follows.

	• Oxidizers
	• Flammables/Emits Flammable Gas • Self Reactives/Self Heating • Pyrophorics • Organic Peroxides
	• Explosives • Self Reactives • Organic Peroxides
	• Acute toxicity (Severe)

	• Corrosives
	• Carcinogen • Respiratory Sensitizer • Reproductive Toxicity • Target Organ Toxicity • Mutagenicity • Aspiration Toxicity
	• Environmental Toxicity
	• Irritant • Dermal Sensitizer • Acute toxicity (harmful) • Narcotic Effects • Respiratory Tract • Irritation

2. Procedures Used in Safety Audit Practice

It is an essential requirement of an audit system that it will originate, like any safety policy or safety programme, with the policy-making executive because of the monetary implications, e.g.:

• Implications of a major disaster.

• Running cost of a safety audit team.

• Cost of recommended alterations.

It is important that line management accepts the objectives and supports the activity; properly assessing the audit findings and ensuring that agreed actions are carried out.

Safety Programmes embody three essential elements:

• Safety Audits

• Safety Inspections

• Safety Walks.

See Appendix A for a Summary of Proposed Characteristics of Safety Audits, Safety Inspections and Safety Walks.

2.1 Safety Audits

21.1 Preparation

In view of reaching the aims described, every safety audit should be carefully prepared.

Questionnaires should be established for each activity and plant by the safety audit team and be approved by Company Management. Safety audit questionnaires will also include questions on general organisation, management and training. Previous audit reports must be studied prior to the next audit to ensure that all actions from the previous audit either have been carried out satisfactorily or are included as an additional item on the current audit report.

2.1.2 Frequency of Safety Audits

As safety audits are by nature in-depth assessments of the safety situation of an activity, a frequency of one every three or four years seems to be appropriate. The frequency will enable the audit team to better identify technical and personnel changes, evaluate the effectiveness of training at all levels, review the application of codes of practice and recent statutory regulations.

2.1.3 Safety Audit Team

Safety audits should be carried out at general management level and at each plant or site. The audit team members should be carefully selected for their knowledge and experience in the field of audit, from general management, plant management, and other safety specialists.

For example, at plant level, the team should consist of, as a minimum:

- Site Plant Manager
- Site Plant Foreman
- Safety Specialist.

As safety audits are carried out at a number of levels in a factory, e.g. small department, followed by operating and then general management level, it is essential that a team member at the lowest level is

also incorporated in the next level team, and so on, so as to ensure a common approach, improved ease of reporting and communication. When safety audits are carried out at a Main Branch satellite works, it is recommended that one of the Safety Audit Team who conducted the audit at the satellite works, participate in the Main Branch Team. The indications given for frequency, duration, team composition and areas of activity may be adjusted according to plant size.

2.1.4 Safety Audit Report

Local management must be involved in the review of the findings of the audit team before the audit team leaves site

Following the audits, a report should be issued containing the following:

- A description of all findings relative to items needing a proposal for remedial action.
- A description of any defects detected on equipment and initial proposals for remedial actions.
- The names and job titles of those people who are responsible for initiating remedial actions.

• The need for any revision of operating instructions or company standards.

• Agreed target dates for completion (which realistically allow sufficient time for thorough technical assessment and consequent changes, if necessary).

Copies of the audit report shall be given to the local plant manager and to the company management, who will take decisions and supervise follow-up actions agreed by the safety audit team.

2.1.5 Monitoring and Follow-up

Monitoring of approved safety audit conclusions and recommendations is an important activity to ensure improvement of the safety level of a plant or company. It is the responsibility of the Plant Manager to see that audit conclusions and recommendations are implemented by the agreed target dates.

2.2 Safety Inspection

A safety inspection is a scheduled inspection of a plant area, conducted by the plant supervisor or plant management member, one of the plant employees and a company safety officer. Safety inspections will be carried out with a frequency of one year, and may last up to one or two days.

Safety inspections may cover the following subjects:

• Housekeeping

• Unsafe acts or conditions

It will use lists referring to specialised equipment and procedures according to activity.

The result of the safety inspection, provided by the checklists filled in by the visiting team, will be handed over to the plant manager who will be responsible for monitoring all resultant actions and follow-up.

2.3 Safety Walks

A safety walk is a scheduled or non-scheduled inspection of a plant area, conducted by local personnel, e.g. a plant management member assisted by one of the plant employees.

It will cover the following subjects:

• Housekeeping

• Visible unsafe acts and conditions.

The use of a simple aide memoire is of assistance in reminding those involved of the objectives.

The result of the safety walk will be recorded and reported to the plant manager who will decide on the follow-up to be given. The team conducting the safety walk should have received adequate training in observing unsafe acts and conditions.

When scheduled, a safety walk of a plant area may be carried out every month and last one hour.

3. Safety Precautions using CNG

CNG cars have their own set of drawbacks. When compared with diesel or petrol. CNG is highly combustible. Just one spark is required to set the car on fire. Therefore, to guarantee that you are driving safely in your CNG-powered vehicle, you must take a few precautions.

Listed below are precautionary measures that every CNG driver must take.

1. Do Not Use Unauthorized CNG Kits: Even though it is advisable for people to buy a CNG car with the factory-installed CNG cylinder, many people try to convert their petrol cars into CNG by installing the fuel kit in their car. Besides they get the installation done by a roadside dealer or mechanic instead of an authorized dealer. This can not only spoil the car's mechanics and result in leakage leading to a fire. Therefore, you must avoid installing unauthorized CNG cylinder in your car.
2. Avoid Using Substandard/Mismatched Accessories: When installing the CNG cylinder in your car, you must make sure that the fuel kit and cylinder suits the model of the car. The CNG cylinder needs to be compliant with the car's original fixtures and wiring. Additionally, the CNG cylinder must be of approved brand and manufactured according to the relevant standards. There are increasing risks of fire/damage due to different voltages and current ratings if a substandard/mismatched CNG cylinder is installed in the car.
3. Regular Maintenance: Ensure that the car is thoroughly checked before conversion. You must get your car regularly checked/serviced. Old wires typically lose insulation, leading to a short circuit, as such they must be replaced immediately. The CNG cylinder must also be tested before installation.
4. Test Certificate: Once the CNG kit has been installed, you must obtain a "CNG Cylinder Test Certificate" by the CNG licensee or retrofitter. The certificate acts as a proof for installing an approved CNG cylinder in the car.

5. Thorough Leak Test of the Gas System: Do not overfill the fuel tank or have an incorrect fitting or a gradual leak in your fuel tank since this could be very dangerous. This will lead to the outbreak of fire and the explosion of the fuel tank.
6. Replace Spark Plugs: You must make sure the car's spark plug is compliant with the CNG cylinder. This is crucial since spark plugs wear out faster when used on CNG. If there is no special CNG-compatible spark plug available it is important to reduce the gap between the spark source and the metallic plug tip.
7. Follow the Rules: The car's functioning on CNG must meet the terms as stipulated in the central motor vehicles rules. Activities like smoking in the car, firecrackers near the car, using mobile phones or any electronics when refilling the cylinder, carrying/transporting inflammable materials, and prolonged use of the car heater can be risky.

4. Safety Precautions using CNG

Here are safety tips to observe when using LPG in your home.

1. Never leave your gas stove unattended when cooking.
2. Leave the LPG cylinder in an upright position in a safe space for storage.
3. Ensure all your equipment is up to date.
4. Open a window for ventilation

1) Never leave your gas stove unattended when cooking

Is it risky to leave an LPG stove on? The answer is yes. Leaving a gas stove on can turn into a hazardous condition. Unattended gas stoves are the main reason that **kitchen fires** get started. Always switch off your gas stove when not in use.

2) Leave the LPG cylinder in an upright position in a safe space for storage

Always keep LPG cylinders in a standing position (whether full or empty) and ensure the valves are at the top of the cylinder. Also, make sure the storage area has enough fire extinguishers, especially the dry powder type. Finally, keep the safety gadgets at an easily accessible location and maintain them regularly.

3) Ensure all your equipment is up to date

When using LPG cylinders, ensure you are using the correct and updated equipment. Check in the market the recommended brands to avoid buying substandard apparatus. Also, make sure you check the equipment’s condition before each use. Most importantly, avoid using damaged or rusty canister seals to evade gas leakage.

4**) Open a window for ventilation**

One of the most significant factors to consider when using LPG in your house is ventilation. Always place your LPG cylinder in an open place such as a door or window to ensure adequate air circulation. Never keep your cylinder close to other heat sources like electric outlets and danger-prone locations in the house to avoid ignitions.

Acid Hood Purpose and Importance

The laboratory chemical fume hood is the most common local exhaust ventilation system used in laboratories and is the primary method used to control inhalation exposures to hazardous substances. When used properly, fume hoods offer a significant degree of protection for the user. Understanding the limitations, the appropriate maintenance techniques, and overall design of the fume hood will ensure your safety while using hazardous materials. The purpose of a chemical fume hood is to prevent the release of hazardous substances into the general laboratory space by controlling and then exhausting hazardous and/or odorous chemicals. In the event of an accidental spill, the fume hood will contain the spilled chemicals and exhaust the fumes away from the user and laboratory zone.

5.1 Safety and Precautions while handling Acid Hoods

• Untrained users should not handle acids or their containers.

• Always use proper PPE when working with acids. In addition to standard cleanroom attire, this includes an apron, face shield, arms sleeves and extended gloves, all of which must be resistant to corrosive chemicals.

• Never work with acids while alone in the cleanroom. Make sure that at least one of the present users is aware of the nature of your work and is close enough to assist you in the case of an emergency.

• Be aware of the nearest shower and eye wash station, as well as its proper use, before beginning.

• Always keep chemicals at least a foot away from the edge of the hood. This will reduce the likelihood of accidents and will prevent fumes from escaping into the cleanroom. Laminar air flow is only effective below the sash and within this 1-foot perimeter.

• Use proper pouring technique, as described later in this document, and place wipes under glassware to capture small spills.

• Clean any spilled chemicals immediately.

• Ensure that the lab ware and utensils you are using are compatible with your chemicals. Glass should not be used with HF and many types of tweezers are not suitable for acids. Contact NUFAB staff if you are unsure of compatibility.

• All chemicals that are left unattended must be clearly marked with chemical name, owner's name, contact information, time that the chemical will be removed and instructions for other users who will be working in the vicinity of the unattended chemical. Never leave an unlabeled chemical unattended.

• All chemicals for use in NUFAB are approved by NUFAB management. Please send email requests with chemical name, SDS, and quantity. • Only open the cap of any chemical bottle inside the hood and under the sash.

• No waste goes down the drain. All waste must be handled according to the waste procedures.

• Do not mix chemicals without first verifying compatibility – never mix acids and solvents.

• When mixing etches, always add acid (AAA). Never add water (NAW) to acid.

• Do not use more chemical that is required for your experiment.

• Do not remove acids from samples or containers using the hood's spray guns – this will cause splashing of the acid.

• Refer to the SDS of every chemical that is to be used before handling that chemical.

• Follow all chemical safety rules.

6. Shower and Eye washer

6.1 Shower:

A safety shower is a unit designed to wash an individual's head and body which has come into contact with hazardous chemicals. Large volumes of water are used and a user may need to take off any clothing that has been contaminated with hazardous chemicals. Safety showers cannot be used for flushing an individual's eyes, due to the high pressure of water from the shower, which can damage a user's eyes.

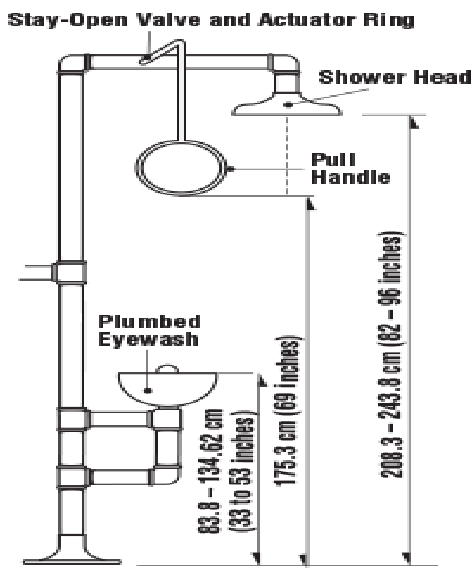


Fig.1 Shower Station

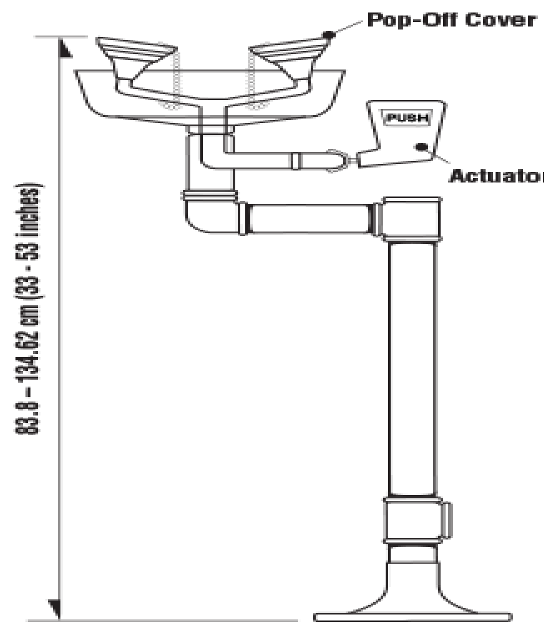


Fig.2 Eye wash station

6.2 Eyewash and Eye/Face Wash Stations

Eyewash stations should be designed to deliver fluid to both eyes simultaneously at a volume of not less than 1.5 litres/minute (0.4 gallons/minute) for 15 minutes. The combination eye and face wash stations require 11.4 litres per minute (3.0 gallons per minute). However, in either case, the volume should not be at a velocity which may injure the eyes. The unit should be between 83.8 and 134.6 cm (33 to 53 inches) from the floor, and a minimum of 15.3 cm (6 inches) from the wall or nearest obstruction.A pH neutral solution for emergency eyewash[3] may also be chosen to reduce the danger from contaminants if strong acids or alkali chemicals are presented.

With an eye wash station, the user should be able to open their eyelids with their hands and still have their eyes in the liquid. In the case of the eye/face wash, the user should have enough room to allow the eyelids to be held open with the hands while the eyes and face are still in the stream. As with the shower, the unit should also be designed so that it can be activated in less than 1 second, and it remains operational without the operator's hand on the valve (or lever, handle, etc.) with the valve being located in an easily located place. Since the nozzles to eyewash stations typically need to be protected from airborne contaminants, the units are to be designed such that the removal of these covers should not require a separate motion by the user when the unit is activated.

7. Safety policy of the company:

Company policy: It is the policy of this company to ensure a safe, healthful workplace for all its employees. Injury and illness losses from incidents are costly and preventable. This company will employ an effective accident and illness prevention program that involves all its employees in the effort to eliminate workplace hazards.

Management: Management is accountable for preventing workplace incidents, injuries and illnesses. Management will provide top-level support of safety program initiatives. Management will consider all employee suggestions for achieving a safer, healthier workplace. Management also will keep informed about workplace safety and health hazards, and it will regularly review the company safety and health program.

Supervision: Supervisors are responsible for supervising and training workers in safe work practices. Supervisors must enforce company safety rules and work to eliminate hazardous conditions. Supervisors shall lead safety efforts by example.

Safety Committee: The safety committee includes employer and employee representatives who are responsible for recommending safety and health improvements in the workplace. The committee is also responsible for identifying hazards and unsafe work practices, removing obstacles to incident prevention and helping the company evaluate the accident and illness prevention program.

Employees: All employees are expected and encouraged to participate in safety and health program activities including the following: reporting hazards, unsafe work practices and accidents immediately to their supervisors or a safety committee representative; wearing required personal protective equipment; and participating in and supporting safety committee activities.

- All incidents must be reported immediately to your supervisor/foreperson, and prior to leaving the workplace.
- All workers must have proof of training indicating that they are trained in WHMIS.

- Workers must wear appropriate PPE when and where required.
- Workers must perform all work following safe work practices and safe job procedures.
- Workers must maintain good housekeeping.
- No fighting or horseplay is permitted at the workplace.
- No theft or vandalism will be tolerated at the workplace.
- No possession or consumption of alcohol or illegal drugs is permitted while at the workplace.
- You are not permitted to arrive or remain at work if your ability to perform the job safely is impaired.
-

8. Entry into a Confined Space :

Entry into a confined space is defined as the action by which a person passes through a limited opening into a restricted or potentially hazardous work area. Entry is considered to occur as soon as any part of the entrant's body breaks the plane of the entry point into the confined space.

8.1 Hazards

Anything, by its nature that will or may, endangers the safety or health of a worker. Hazards may include;

- Toxic vapors, mists, or dusts from welding, cleaning, or powder coating.
- Explosive atmospheres.
- Lack of Oxygen, causing asphyxiation.
- Electrical shock from powered tools or lights.
- Physical hazards such as slipping or falling.
- Entering a confined space without testing the atmosphere.
- Leaking cutting/welding hoses inside the confined space.
- Improper use, or not using, Personnel Protective Equipment.
- Noise • Temperature extremes.
- Insufficient rescue equipment or procedures.
- Not following confined space entry procedures.

9. Confined Space "Safe Entry Tag"

The “Safe Entry Tag”, is Company Name Confined Space Entry Permit and this tag is used to ensure that the existing hazards of a confined space have been properly identified, assessed (evaluated) and that necessary preventive and protective measures and procedures are put into place for the safety and health of workers involved in confined space work.

9.1 Responsibilities

Supervisor

- The supervisor in charge of the area for which the confined space entry will occur, is responsible to ensure that all preparations are in place for the safe entry of any worker.
- Ensure workers involved in the confined space are trained in the conditions of entry and the nature of any hazards they may be exposed to.
- Ensure the appropriate PPE is available and in good working order.
- Ensure rescue procedures, equipment and trained rescue personnel are in place.
- Ensure a Confined Space “Safe Entry Tag” is completed.
- Identify the “Class” of Confined Space.
- Assign a safety watch person on the outside of the tank.
- Periodically check the confined space entry jobs to ensure all Health & Safety procedures are being followed.
- To immediately shut down any unsafe confined space entry job. 3 Worker and any other Personnel entering the Confined Space
- The worker prior to entering the confined space will ensure that all necessary precautions and procedures are in place to their satisfaction and then sign the Confined Space “Safe Entry Tag”.
- Will wear all Personal Protective Equipment assigned to them, to ensure their safety and health according to the hazards of the confined space job.
- Will inspect and use equipment and tools required to do the jobs inside the confined space, according to safe work practices and procedures.
- Will monitor conditions inside the confined space and if conditions should change inside that are not accounted for on the “Safe Entry Tag” they will discontinue the work and exit the confined space until the new hazards have been addressed.

10. Risk = Hazard x Exposure

When it comes to chemical management, a distinction must be made between hazard and risk. **Hazard** defines the inherent property of a chemical having the potential to cause adverse effects when an organism, system or population is exposed to that agent. **Risk** however, establishes the probability of the adverse effect occurring.

To be more specific, the risk of a chemical depends on the following 2 factors:

- The inherent toxicity of the chemical **(hazard**);
- How much of a chemical is present in an environmental medium (e.g., water, soil, air) and how much contact a person or ecological receptor has with the chemical substance (**exposure**).

A hazardous chemical substance poses no risk if there is no exposure. For example, sulfuric acid is very corrosive. It is of no or little risk to ordinary people who do not handle them. For some people who may be exposed to sulfuric acid (scientists, workers), risk management measures (i.e, wearing goggles and gloves) can be taken to minimize the risk.

10.1 Chemical Risk Assessment: Purpose, Procedure and Tasks

The goal of chemical risk assessment is to have a full understanding of the nature, magnitude and probability of a potential adverse health or environmental effect of a chemical. **It takes into account of both hazard and exposure**. Risk assessment forms the foundation of regulatory decisions for industrial chemicals, pesticides, pharmaceuticals, cosmetics, food additives and food contact substances in developed countries today.

In general, chemical risk assessment consists of the following three steps:

- **Hazard characterization**:
  Dose-response determination (LD50/LC50, NOAEL, T25, EC50, NOEC, etc), determining the relationship between the magnitude of exposure to a hazard and the probability and severity of adverse effects.
- **Exposure assessment**: identifying the extent to which exposure actually occurs. Exposure levels are usually estimated or measured.
- **Risk characterization**: combining the information from the hazard characterization and the exposure assessment in order to form a conclusion about the nature and magnitude of risk, and, if indicated, implement additional risk management measures.

The picture below summarizes the complete procedure of chemical risk assessment under REACH. The table below summarizes the detailed tasks of hazard characterization, exposure assessment and risk characterization for human health and the environment.