
UNIT 4 FIRE SAFETY

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4.1 INTRODUCTION

Fire is a combustion process which takes place as a result of chemical reaction between some sort of fuel and oxygen present in air. The outcome products of fire are different as compared to the starting material. In order to lead combustion to take place it is desirable to heat up the fuel to its ignition temperature. Whenever any structure or building is constructed all the measures are set up to prevent the nuisance of fire in that particular building. The main step which is considered to be important is to stop the fire hazard at its original source itself thereby preventing initiation of the reaction. There are basic three elements that lead to fire- fuel, oxygen and heat. While if any one of these three elements is missing then fire will not proceed or initiate. So if any case fire is initiated due to any reason, then in that case fire can be stopped by removing or cutting off any one of these three sources. For consideration of this it is also important that proper prevention strategies are undertaken for conducting proper fire risk assessment in a plant or building. In other words proper risk assessment techniques could possibly aid in achieving success by preventing this process of exothermal oxidation of ignition of fuel. The energy released from this fire will be in exothermal radiation form. This fuel can be in the form of gaseous, vapor, liquid or solid form.

This unit will bring forth the concepts related to fire, elements of fire, fire triangle and its related concepts. All the chemical reactions that are involved in the combustion process are explained in this chapter. Later in this unit you will be introduced to the leading causes of the fire, and extinguishment of fire. This unit also introduces to the types of fire, different agents to fight fire, fire detection and warning systems, maintenance and inspection of fire extinguishers, and use of extinguishers to fight different types of fires.

Objectives

After studying this unit you should be able to:

- define the fire, chemical reactions and concept of fire triangle;
- define the controlling factors and methods for the extinguishment of fire;
- classify fires by different type;
- identify different agents to fight fire, detection and warning systems for fire safety;
- identify the need for maintenance and inspection of fire extinguishers, use of extinguishers to fight different types of fires.

4.2 INTRODUCTION TO FIRE

The visible effect of combustion process which includes various chemical reactions into it is called as fire. The fire generally takes place amongst some sort of fuel and atmospheric oxygen thereby giving distinguished resulting outcome as compared to the starting one. Attainment of ignition temperature is desirable for the combustion process of fuel to convert it into fire. The presence of oxygen, fuel and heat aids in continuing the process of fire, this is generally termed as fire triangle. The process in which fuel reacts with the oxygen and thereby releasing resultant heat energy is termed as combustion process. The speed of combustion process can be slower or faster depending upon the availability of oxygen. The process resulting in flame can be termed as burning process due to fast combustion. Combustion process only takes place amongst gases.

For industrial buildings fire incident is considered as a very serious hazard. Fire at factories usually takes place due to some electrical fault or somebodies carelessness due to which these factories are considered to be at high risk of fire incidents. These fire incidents in industries are costing in billions of dollars every year to the companies as well as the government. Also in addition to this, loss of life is also associated with such incident which is irrecoverable thing. These fire incidents are resulting in number of civilian deaths, various civilian injuries and also loss and damage to property. There are many reasons for happening of these fire incidents in factories. Fire disaster may take place due to unawareness of the related risks surrounding the labours at their everyday work.

4.2.1 Chemistry and Definition of Fire

Fire generally takes place due to the combustion of fuel which can be in any form i.e. solid, liquids or gases. Gases are released from the surface of fuel once it is heated up to an extent which further leads to the chemical reaction leading to fire. In combustion process different gases made up of molecules reacts with each other. These molecules of gases fragments apart once the gases are heat up to such an extent that causes them to break into fragments of gases which further reacts with the oxygen present in air to form new product molecules (H_2O and CO_2) plus lots of heat and other byproducts as well in case if burning is not complete. The proper mixture or combination of three major elements i.e. heat, fuel and oxygen leads to chemical reaction resulting in fire. Once ignited, fire must be able to sustain its own heat by releasing more heat energy into the atmosphere. Presence of oxidizer gas (O_2) is also necessary to produce convection for continuing the fire.

4.2.2 Concept of Fire Triangle

Fire triangle illustrates all the three major elements which are required for igniting a fire as shown in Figure 4.1. These elements are heat, fuel and oxidizing agents and combination of these elements in right mixture leads to event of fire. Fire triangle indicates that fire can be stopped if any one of these three elements could be prevented or extinguished from the fire triangle. Suppose by covering the fire with fire blanket could stop oxygen supply to that part and hence could help in extinguishing the fire. Whereas in case of fire in industries it takes place in an extended area so eliminating oxygen factor is not possible so firefighters are called upon for controlling the fire. This fire triangle model conveys components of a fire.

The first element is heat in a fire triangle which is considered as the most leading factor due to absence of which fire cannot be ignited. Unless there is certain amount of heat provided the event of fire cannot take place. Once the fire incident takes place the foremost thing the firefighters do it to stop fire from expanding by applying water on it which acts as a cooling agent. By removing source of heat from the entire building would also assist in eliminating the fire (example wood embers, turning off electricity supply etc.).

Fuel holds the second position in the fire triangle which is also required by fire to take place in actual. A fuel is also desirable for the fire to occur. Anything which is flammable could be considered as fuel source like fire hazardous chemicals, fabrics, paper or wood. Once this fuel element is eliminated the fire will also be extinguished.

Oxygen is another essential element which holds third position in a fire triangle. For starting and beginning the fire the presence of oxygen is highly desirable. Extinguishing small fire with non-flammable blanket or sand will discontinue the oxygen content and ultimately stopping the fire. Therefore a

combustion process could be retarded by decreasing the concentration of oxygen. But this is not feasible in case of large fires occurring in an extended area.

Lastly the fire triangle is holding a center position for another element aiding in fire that is called as chemical reaction. So firefighters need to utilize a different approach while dealing with fires concerning with metals like magnesium, lithium, titanium as these chemical leads to chemical reactions. This is also called as class-D fire and this type of fire cannot be stopped with water supply as these metals reacts more with water rather than oxygen and further releases more energy as a result of their reaction. The exothermic reaction takes place once the fire has taken place and allow it to keep going until and unless one of the element causing fire is eliminated or blocked.

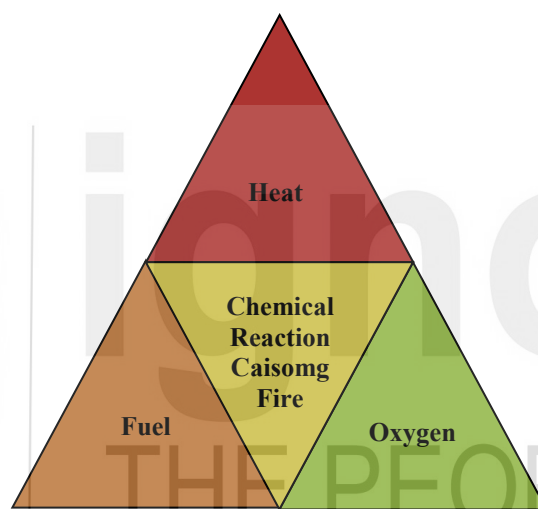


Figure 4.1: The Fire Triangle

4.2.3 Main causes of fire

An industrial fire involves large and destructive fire that often, but not always occurs with explosions. These fires generally occur in the areas which are involving a lot of flammable materials (examples includes petroleum products, oil depots, chemical plants, natural gas processing plants, etc.). The leading causes of fire are shown in Figure 4.2 and other ruling causes occurring in wood working industries, chemical industries, food industries, metal working industries as well as pharmaceutical manufacturing industries is due to presence of deadly combustible dust in atmosphere which is generally overlooked by the employers, managers and labours working in those environment. Also those materials which are not possessing any risk when in larger form but they may become the reason of combustion while converted in dust form.

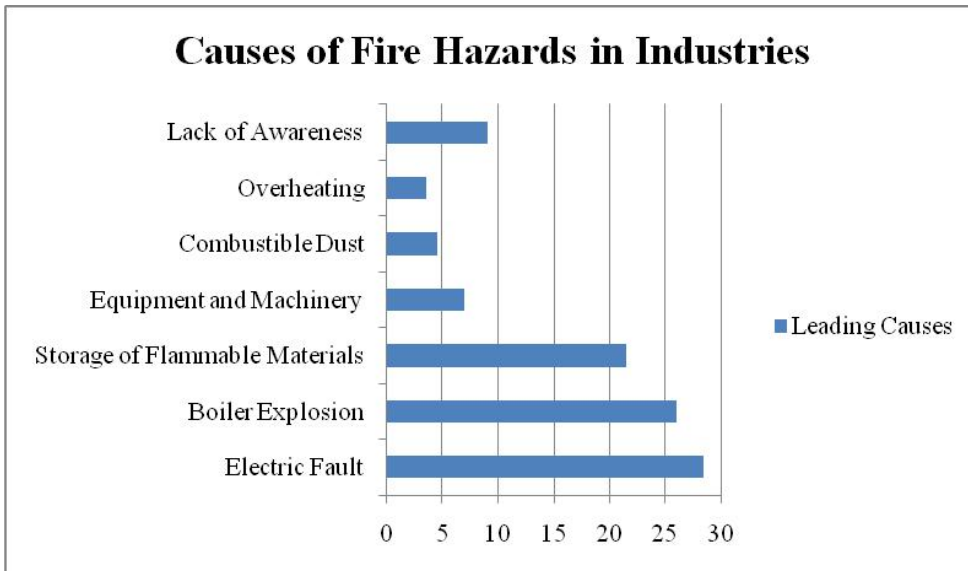


Figure 4.2: Leading Causes of Fire Hazards in Industries

- **Combustible Dust**

Sometimes there are chances that some small incidents of fire may take place at the worksite and that may go as unreported incident but these small fires also cause harm to the employee, loss to the products kept in the vicinity of that area and ultimately loss of time. The result of such small fire incidents can be devastating like if that particular area is involving combustion dust in the atmosphere then secondary explosion might take place by spreading and reacting with the atmospheric dust and further multiplying the severity of the fire incident. Also these combustible dusts could ignite by themselves and could cause severe explosion inside the factory causing break down of entire facilities, leading to devastating losses and fatalities. These dust explosions are capable of causing potential damage to the entire building, loss of life, involves multiples injuries and damage to the environment and surrounding communities. The dust itself acts as a key ingredient for dust fires and explosions.

Controlling dust related fire: The major role in controlling the combustible dust related fire in the environment will be played by the employee and his employer. Employers should provide provision for conducting safety equipment training for his employees and labours from time to time. He should also ensure that his employee is wearing that safety equipment while delivering his job on workplace. Employee should make use of safest industrial vacuum for his desired application so that he can stay safe by selecting proper equipment.

- **Hot Working Activities**

All those industrial activities which involve hot working practices like brazing, soldering, welding, burning, heating, torch cutting, grinding, chipping, drilling are prone to fire incidents. These practices pose fire hazards as they generate sparks, flames and heat which can sometimes leads to fire.

These resulting sparks can help combustible dust in the surrounding area to ignite and lead to huge fires.

Controlling hot work related fire:

Hot work related fires can be inhibited by adopting few safety procedures. Although avoiding hot working practices is not possible solution but if some alternative is there then one must adopt that procedure to lessen the chances of fire or explosion. The personal performing hot work related job must be trained enough and he must be aware of the possible hazards associated with the hot work. One must also be familiar with the site related hazards, use of safety equipments and must have knowledge of policies and procedures too. The supervisor must also makes sure that the area in which hot work related activities are being performed is clear of flammable and combustible materials that may be in any of the form like gaseous form, liquid form or in dust form.

- **Equipment and Machinery**

Industrial fires could also be caused due to faulty equipment and machineries. The largest issues are faced due to equipments which are related to heating and hot working activities like furnaces which are not maintained or serviced for longer period of time. Moving parts of equipment results into friction that in result becomes a leading reason for fire hazard.

Controlling equipment and machinery related fire:

The fire hazard related to equipment and machinery could be eliminated by simply performing regular cleaning and maintaining the equipment like by lubricating different parts of it. Under unfortunate conditions even harmless equipments or machineries could become hazardous equipments. Keeping equipment surrounding area clean can prevent chances of fire incidents to a great extent. By adopting and following manufacture's maintenance procedures for the delivered equipments could also reduce the risk of fire in plant by preventing over heating of the machinery.

- **Electrical Hazards**

There are numerous fire hazards which may be confronted in an industry owing to electrical faults. Electrical systems in any industry include extension cords, overloaded outlets, static discharges and overloaded circuits. From Figure 4.2 it can be clearly depicted that electrical faults are the leading causes for fire hazards in industries. A small spark in any equipment or machinery may turn into a big hazard if overlooked and not checked on routine basis.

Controlling electrical related fire:

Electrical related hazards could be eliminated by preventing overloading of electrical equipments of circuits. Also making use of antistatic equipment reduces chances of electrical related fire hazard. Make preventive steps for

eliminating combustible dust and hazardous materials from the environment where machineries and equipments are running. Fire hazard could also be eliminated by providing provisions for reporting system which alarms in case whenever incident of fire takes place. By conducting regular dust hazard analysis can help in preventing fire and explosion hazards in industries. Establishing fire escape plans and prevention and emergency procedures could also help in reducing the risks related to fire in a plant. Making use of personal protective equipments also helps in preventing fire related hazards and also it prevents from electrical shocks. Attaining fire safety training could also help in eliminating risks related to electrical fire hazards.

- **Lack of Awareness and Human Error**

Human errors play a significant role in industrial fire as this is the most common fault from worker's side. Huge fires could be resulted from a silly mistake or worker. Suppose a person by mistake spills flammable liquid on shop-floor or some combustible dust has accumulated in the environment of factory and he forgets to clean it, then this flammable liquid or dust might ignite due to heat and can leads to fire. Also secondary fire could be faced if primary fire is not suppressed on time.

Controlling human error related fire:

Human error related and other causes leading to fire could be ceased by installing fire alarms for notifying the workers in the building or plant. Fire outbreak could also be notified to the labours by installing tank fire control system in the plant.

Although it nearly impossible to completely reduce the industrial fires and explosions but by taking proper preventive steps the employees and worker's life could be saved.

4.3 EXTINGUISHMENT OF FIRE

The fire can only be extinguished by eliminating or suppressing any one of the element from fire triangle viz. fuel, heat or oxygen, or disturbing the chemical chain reaction. Until and unless any one of these elements is not stopped the fire will keep on burning causing huge losses. Fire extinguishment could be achieved by undertaking following processes:

- **Starving the fire:**

This is a method of removing the fuel from the picture like removing the unburnt material from the place and turning off the gases in the case of Class-C fire.

- **Smothering the fire:**

This is a method of preventing combination of oxygen with the fuel in case of the fire. For this purpose fire resistant blanket could be used for cutting off the oxygen supply.

- Cooling the fire:

This is a method of bringing down the burning temperature of substance or material below its ignition temperature. Burning of solid combustible materials causing Class-A fire could be prevented by using water as extinguishing agent.

- Interrupting or disturbing the chemical chain reaction:

Fire can be extinguished by interrupting the chemical chain reaction by using dry chemical powder extinguisher. Some of the fire extinguishers are capable of disturbing the chain reaction and fire at the same time.

Fire extinguishment can be accomplished by any one of the four following methods:

- **Hand extinguishers:**

This is a portable extinguisher which is operated by civil service or military personal to control the fire.

- **Automatic sprinkler system:**

This system gets activated as soon as it detects smoke in its vicinity and releases water from sprinklers. This system gets activated in temperature range of 135 °F – 280 °F.

- **Hose lines:**

This system is generally utilized by civil service people, military people and by fire fighters also to suppress the fire with water.

- **Volume extinguishment system:**

This system generally releases gases into the room atmosphere which combats with the chemical reaction causing the combustion process.

4.4 CLASSIFICATION OF FIRES BY DIFFERENT TYPE

There are different types of fires that are categorized into following classes:

Class-A Fires:

This class of fire generally takes into account fire caused due ordinary combustible materials. This type of fire leaves ash behind. Common examples generally include rubber, pulp, paper, wood, cloth, and plastics of various types. This method generally focuses on extinguishing fire via heat removal method. Common types of agents that can be utilized for extinguishing fire of this class include water, halon, dry chemicals, halogenated agents and foams. Table 1 depicts all the class of fire along with their extinguishing agent types.

Class-B Fires:

This class of fire generally takes into account fire caused due to flammable and combustible liquids or gases which may include propane, gasoline, oil, tar, paint and natural gas. Various types of fire extinguishing agents are available to suppress the fire of this class type making use of all the theories of fire extinguishment. The type of agent to be utilized depends upon the circumstances involved. Usually these flammable liquids do not ignite by themselves but the vapors generating from these liquids ignites and leads to fire. The combustion process starts in this case once the ignition source interacts with the mixture of oxygen and vapors.

Class-C Fires:

This class of fire generally takes into account fire caused due to live electrical equipment. Therefore this class of fire could be suppressed by making use of extinguishing agent which does not conduct electricity back to the fire extinguishing personal. Electricity here acts as a source of energy or source of ignition, but it will not burn on its own. Instead, these electrical equipments act as a source of ignition for Class-A type fire or for Class-B fire.

Class-D Fires:

This class of fire generally takes into account fire caused due to combustion of exotic metals like sodium, magnesium, titanium, and zirconium. These fires are suppressed by using special agents like dry powder etc. The extinguishers which are utilized for suppressing class A, B, or C fires cannot be utilized here for this class of fire. Suppose firefighter tries to suppress the fire with water, he may help the fire to expand by reacting with burning metals and increase the intensity of fire.

Table 4.1: Types of fire and type of Extinguisher

Fire Class	Type of Fire	Type of Extinguishing Agent
Class-A Fires	Includes ordinary combustible: rubber, pulp, paper, wood, cloth, and plastics	Water, Halon, Dry Powder
Class-B Fires	Includes flammable liquids and gases like propane, gasoline oil and natural gas	CO ₂ , Halon, Dry Powder
Class-C Fires	Fire caused due to live electrical equipments	CO ₂ , Halon, Dry Powder
Class-D Fires	Fire caused due to combustible metals or metal alloys like Magnesium, Titanium, potassium, and sodium	Special Agents like dry powders and special application techniques

Class-K Fires	Fire caused due to cooking appliances that involve combustible cooking media like animal oils, vegetable, and fats	Wet chemical extinguishers
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Class-K Fires:

This class of fire generally takes into account the fire that is caused due to cooking appliances that involve combustible cooking media like animal oils, vegetable, and fats. Special agents like wet chemical extinguishers and extinguisher which is alkaline in nature and possesses cooling capabilities are used to suppress fires of this class.

4.5 DIFFERENT AGENTS TO FIGHT FIRE

While using these agents, the personal should have complete knowledge about the type of fire to be controlled as wrong extinguisher in such case may promote the fire or reignite the fire. There are following ranges of fire extinguishing agents available in market:

- **Water and Foam extinguishing agents**

The extinguishers which are capable of eradicating heat element from the fire triangle are composed of water and foam as extinguishing agents. Water extinguishers are used for suppressing Class-A type fires only. As it is a known fact that water has low boiling point, possesses high heat capacity, is non-toxic, is cheap, and easily available which is why it is used as extinguishing agent for fire caused due to ordinary combustible materials.

These types of extinguishers are use in case of fire due to organic materials like paper, wood, fabrics, coal, textiles etc.

Foam agents are generally of two types; chemical foam and mechanical foam. Amongst these two, chemicals foams are obsolete and generally do not find its applications these days. Chemical reactions are generated amongst two materials that generates form layer which covers the flammable liquid surface and thereby securing the resulting vapors. Mechanical foams make use of mechanical injection to inject air for expanding and forming bubbles. These agents are either aqueous foam or film forming foam. Mechanical foams include aqueous film forming foam (AFFF), protein foam fluoroprotein foam, Alcohol type AFFF/FFFP, Mid/High expansion foam etc. Water and foam based extinguishing agents cannot be utilized in case of fire caused due to electrical fault, kitchen fires, flammable metals, gases or liquids.

- **Halogenated or clean extinguishing agents**

The fire in a combustion process is suppressed by terminating the chemical chain reaction with the help of halogenated agents which reacts with fire chemically instead of physically. How this chain reaction breaks is not understood completely till now. The agent that is utilized for suppressing the

fire releases bromine the helps in decomposing the fire by carrying away the free radicals which helps the combustion process to outgrow. Thus in case of huge fire more bromine is required to break the chemical chain reaction process. Most of these halogenated extinguishing agents are considered as ozone depleting agents. But there are manufacturers in the market who have developed such extinguishers after use of such agents, recapturing of these agents is possible and thereby inhibiting their release into the environment under non fire situations. All the features related to service, usage and maintenance related questions associated with the equipment are enclosed and provided by the manufacturer in the user manual. Halogen agents provide a big advantage that there is no cleaning required after their usage. Sometimes by discharging other agents like water or dry chemical in some environment involving electronics, high tech equipments, jet engines and data processing may leads to devastating loss to the property than the fire itself. These are usually used for Class-B and C type fires.

- **Dry powder extinguishing agents**

Powder or granular particles make up this type of extinguishing agents that are specifically utilized to suppress the fire of Class-D type which includes fires due to metals and metal alloys. There are various powder agents available to extinguish fire caused due to metals like copper, sodium chloride, and graphite. These dry powder based extinguishers are selected based upon the type of metal that is the reason for fire. These agents are capable of eliminating any one of the elements either O_2 or by removing heat element from the fire triangle. These are limited to be utilized for combustible metal fires only. Whereas these agents are incapable of extinguishing fires in other class type fires which may involve fires due to cooking oil, electrical equipments, etc.

- **Carbon dioxide (CO_2) extinguishing agents**

Unlike water and foam based extinguishing agents, CO_2 based extinguishers are utilized for suppressing fires caused due to Class- B and C type by eliminating oxygen element from fire triangle. This type of extinguisher is also capable of eradicating heat element from the triangle with a cold discharge thereby inhibiting the fire. CO_2 based extinguishers are ineffective for Class-A type fires. CO_2 gas is characterized as dry and non-corrosive gas which is inert as soon as it comes in contact with the other substances. Its main advantage is that it does not leave behind any residue which can damage the machines or electrical equipments. Fires due to reactive metals or alloys (titanium, potassium, sodium, etc.) cannot be suppressed by CO_2 extinguishers. Reason for this is that owing to high temperature these reactive metals causes decomposition of CO_2 and thereby continues to burn. Care must be taken while dealing with CO_2 extinguishers in confined spaces as this gas may lead to unconsciousness, suffocation and death.

- **Dry chemical extinguishing agents**

These agents are capable of extinguishing the fire by disturbing the chemical chain reaction of fire triangle. These are also called as multipurpose dry chemical extinguishers as these are effective in suppressing fire of Class A, B, and C type fires. In Class-A fires these agents build a barrier between oxygen and fuel element.

- **Wet chemical extinguishing agents**

These extinguishing agents build a barrier between oxygen and fuel element of the fire triangle resulting in removal of heat element. This type of extinguishers finds their applications in case of Class-K fires. These extinguishing agents are capable of preventing re-ignition. Commercial cooking operations like deep fat fryers are prone to fire accidents. For such operations wet chemical extinguishing agents are utilized in case of fire accident. These can be used for suppressing fires related to commercial kitchens as well (Class-A type fire).

- **Water mist extinguishing agents**

These types of extinguishers are recently developed extinguishers that are capable of suppressing fire by taking heat element away from fire triangle. They are substitute for clean agent extinguishers where main concern was contamination of agent. Water mist extinguishers are capable of suppressing fire of Class-A fires and Class-C fires.

4.6 DETECTION AND WARNING SYSTEMS

It is higher authorities responsibility to ensure the safety of its work force in advance and must be prepared if any incident of fire take place inside the plant or building. In order to detect fire in the areas fire detecting devices and warning systems are installed inside the building that are capable in notifying the labors so that they can undertake evasive actions to evacuate the building. A fire detection and warning system is designed in such a way that it can detect smoke, excessive heat as well as fire in a particular area and alerts workforce about the possible hazard. If any fire event is sensed by these detectors, these systems warn the labors in advance. While working in any department of industry, each and every individual must be aware of all the associated hazards, must be able to assess possible risks and must be aware of fire safety risk assessment. Detection and warning system must also be installed inside the building so that labors could be warned about the possible fire hazards and they can escape the plant in case of emergency. If proper detection and warning systems are implanted inside the plant then proper preventive measures could be taken to fight the fire and workers could be evacuated on time from the accident place.

All the places inside the plant should have installed fire detecting alarms. More attention must be paid to those areas where fire could start and spread to other parts unnoticed. These places could be basement or storage areas that

don't need regular visits, or it can be a part of building that has been abandoned for some time like while having mealtime. Serious dangers must be faced by the workers in the workplace if any fire incident erupts and spread undetected. Workplace must include escape routes like staircase or fire resisting doors that could be used in case of fire.

Installing effective and reliable automatic fire detectors in the workplace will warn working people about the fire. These warning systems can also help people in evacuating the plant on time. These fire detection and warning system are considered to be the cost-effective and advantageous system in case of protecting against hazards of fire. High degree of structural protection is also ensured by utilizing these fire detection systems. Sometimes choosing false fire detectors for plant may result into fatal accidents without warning about the incident. So choosing right type of fire detectors is also imperative to protect the labor against risks associated with the fire. Manufacturing practices and business activities gets severely affected by false alarms by these detectors.

All the buildings must have installed fire alarm sounders with a manual call points near the exit routes. Warnings send by these alarms must be clearly audible to all the labors working inside the plant. The sound used by these alarms must be different from those sounds which are heard on the shop floor. In case where hearing impaired workforce is working, provision for visual alarm must be provided that can warn these labors by different flashing and rotational lighting system. Voice evacuation system must be installed in case of complex buildings like retail shops and where people are unaware of the fire warning systems. Supervision of fire control system and all related suppression system must be done on regular basis to ensure their smooth operational conditions. There are different types of detectors available in the market depending upon the fire type (Figure 4.3).

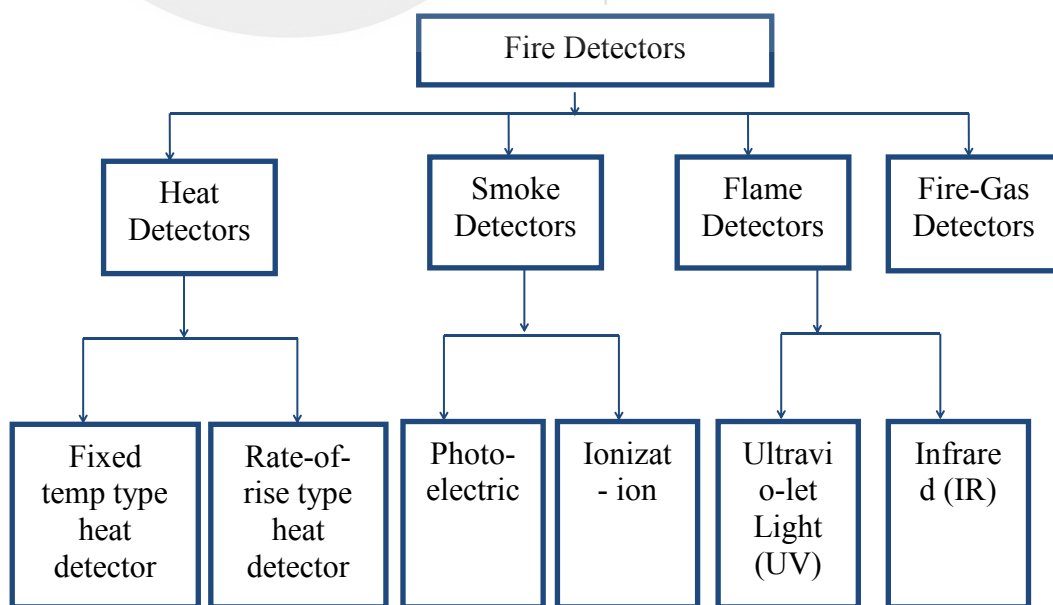


Figure 4.3: Types of Fire Detectors Available

4.7 MAINTENANCE AND INSPECTION OF FIRE EXTINGUISHERS

The fire extinguisher inspection, maintenance and testing must be done in accordance with local, state and national codes and regulation on regular basis so as to reassure its proper working. This inspection can be done manually or by use of electronic means at frequent intervals so that they can maintain their effective working order. These inspections are done for checking the expellent gases, fire extinguishing agents, and mechanical parts of extinguisher. For conducting these inspection only trained and experience professional are called upon as they only are aware of proper actions to be taken by looking at the manuals, parts, lubricants, tools, etc. These fire extinguishers require quick checks within every 30 days. Following questions may be answered to check the functioning of fire extinguishers;

Whether the fire extinguisher is placed in correct location?

Is that fire extinguisher visible as well as accessible to all?

Does the pressure gauge or indicator displaying correct pressure or not?

Also there are certain procedures or checks that must be followed to check for any problem in the extinguisher:

- Designated position of the extinguisher and mounted correctly
- Easily approachable or visible to all
- Operating instructions are facing outwards and are clearly readable
- Check for broken or missing safety seals and tamper seals
- Check for fullness by weighing or by lifting
- Examine the extinguisher cylinder for any sort of physical damage, leakage, visible dents, clogged nozzle, cracks or corrosion.
- Check for pressure gauge reading or indicator.
- Check for appropriate condition of hose (if attached), wheels, tires and nozzles

The expert person conducting these checks must record all these corrective or defective things. These inspections must be performed on monthly basis and details of the person conducting the tests with date must also be recorded.

Figure 4.4 indicates all the anatomy related to fire extinguisher.



Figure 4.4: Labeled Diagram of a Fire Extinguisher

4.8 USE OF EXTINGUISHERS TO FIGHT DIFFERENT TYPES OF FIRES

While using these extinguishers, the personal should have complete knowledge about the type of fire to be controlled as wrong extinguisher in such cases may promote the fire or reignite the fire. There are following ranges of fire extinguishers available in market:

- **ABC powder fire extinguisher**

This extinguisher is a multi-purpose extinguisher that possesses distinguished advantages and the most commonly used amongst all the available extinguishers. This is called as powder extinguishers because they spray a very fine chemical powder that is generally composed of monoammonium phosphate. This thin layer of powder acts as a layer between fire and cuts of oxygen supply and thereby suffocating the fire. Fires of Class-A, B and C type can be suppressed by using this type of extinguisher. But this extinguisher is not capable in suppressing fire related to electrical hazards.

- **CO₂ fire extinguisher**

CO₂ extinguisher is considered to be the cleanest type of extinguisher because after utilization it leaves no residue and also does not require any cleanup. It is capable of starving fire for oxygen as it eliminates oxygen element from the fire triangle and thereby suffocating the fire. This type of extinguisher is capable of extinguishing fire caused due to flammable liquids and fires due to electrical faults (Class-B type fire).

- **Wet chemical fire extinguisher**

This fire extinguisher is capable of extinguishing fire caused due to kitchen cooking media like oil, animal and vegetable fats. Potassium solution in this extinguisher sprays two prolonged assault upon fires. In

first step, the sprayed mists cools the fire and in second stage a thick soap like foams are formed due to chemical reaction between cooking medium and mist of extinguishing agent. This aids in preventing the liquid to re-ignite. This type of extinguisher prevents fire due to Class-K type fire. Whereas they are found to be useful for shutting down fire due to wood and paper as well.

- **Water mist fire extinguisher**

These days these sets of extinguisher are capable of shutting down fire across most class of fires. They are also considered to be the most versatile extinguishers. The microscopic water molecules that are released through this extinguisher are capable of fighting fire at different levels. This mist releases water in such a microscopic fog like form that oxygen concentration is reduced in the air, thereby suffocating the fire. In second stage it cools down the fire by reducing the temperature. Water is de-ionized in this case of extinguisher so these extinguishers are capable in shutting down fires that are taking place due to electrical faults. These extinguishers are utilized for fires due to Class-A, B, C and K type fires.

- **Foam fire extinguisher**

Foam agents are generally of two types; chemical foam and mechanical foam. Amongst these two, chemicals foams are obsolete and generally do not find its applications these days. Chemical reactions are generated amongst two materials that generates form layer which covers the flammable liquid surface and thereby securing the resulting vapors. Mechanical foams make use of mechanical injection to inject air for expanding and forming bubbles. These agents are either aqueous foam or film forming foam. Mechanical foams include aqueous film forming foam (AFFF), protein foam fluoroprotein foam, Alcohol type AFFF/FFFP, Mid/High expansion foam etc. Water and foam based extinguishing agents cannot be utilized in case of fire caused due to electrical fault, kitchen fires, flammable metals, gases or liquids.

- **Clean agent fire extinguisher**

The fire in a combustion process is suppressed by terminating the chemical chain reaction with the help of halogenated agents which reacts with fire chemically instead of physically. These agents are capable of suppressing fires due to gases. These are non-conductive, leave no residues and are eco-friendly. It reduces oxygen level in the air and interrupts chemical chain reaction thereby ultimately suffocating the flame or fire. Halon is generally utilized gas in this sort of extinguishers.

SAQ 1

a) State True or False

T/F

- i) The dust itself acts as a key ingredient for dust fires and explosions.
- ii) Class-D type of fire cannot be stopped with water supply.
- iii) The automatic sprinkler system gets activated in temperature rang of 135 °F – 280 °F.
- iv) The extinguishers which are utilized for suppressing class A, B, or C fires can also be used to suppress Class-K fire.
- v) Halogenated agents react with fire physically.

b) What is fire? Explain general chemistry of fire.

c) What is the basic concept of fire triangle? Explain all the three elements of fire triangle.

d) What are the leading causes of fire in industries?

e) How fires can be classified under different classes?

4.9 LET US SUM UP

Fire is a combustion process which takes place as a result of chemical reaction between some sort of fuel and oxygen present in air. The outcome products of fire are different as compared to the starting material. In order to lead combustion to take place it is desirable to heat up the fuel to its ignition temperature. Whenever any structure or building is constructed all the measures need to be set up in advance to prevent the nuisance of fire in that particular building. The presence of oxygen, fuel and heat aids in continuing the process of fire, this is generally termed as fire triangle.

For industrial buildings fire incident is considered as a very serious hazard. Fire at factories usually takes place due to some electrical fault or somebodies carelessness due to which these factories are considered to be at high risk of fire incidents. These fire incidents in industries are costing in billions of dollars every year to the companies as well as the government. Also in addition to this, loss of life is also associated with such incident which is irrecoverable thing. These fire incidents are resulting in number of civilian deaths, various civilian injuries and also loss and damage to property. There are many reasons for happening of these fire incidents in factories. Fire disaster may take place due to unawareness of the related risks surrounding the labours at their everyday work.

4.10 KEY WORDS

Dangerous goods – Also referred to as hazardous materials. Any solid, liquid, or gas that can harm people, other living organisms, property, or the environment.

Fire precautions: The measures taken and the fire protection features provided in a building (e.g. design, systems, equipment and procedures) to minimise the risk to the occupants from the outbreak of fire.

Fire prevention: The concept of preventing outbreaks of fire, of reducing the risk of fire spreading and of avoiding danger to persons and property from fire.

First aid: The skilled application of accepted principles of treatment on the occurrence of an accident or in the case of sudden illness, using facilities or materials available at the time.

Risk -When we refer to risk in relation to occupational safety and health the most commonly used definition is 'risk is the likelihood that a person may be harmed or suffers adverse health effects if exposed to a hazard.

Explosion -An **explosion** is the result, not the cause, of a rapid expansion of gases. It may occur from physical or mechanical change.

Toxic- It is a chemical that has a median lethal concentration (LC_{50}) in air of more than 200 parts per million (ppm) but not more than 2,000 parts per million by volume of gas or vapor, or more than 2 milligrams per liter but not more than 20 milligrams per liter of mist, fume or dust, when administered by continuous inhalation for 1 hour.

4.11 ANSWERS TO SAQS

SAQ 1

- a)
 - i) True
 - ii) True
 - iii) True
 - iv) True
 - v) False
 - vi) False

- b) The visible effect of combustion process which includes various chemical reactions into it is called as fire. The fire generally takes place amongst some sort of fuel and atmospheric oxygen thereby giving distinguished resulting outcome as compared to the starting one. Attainment of ignition temperature is desirable for the combustion process of fuel to convert it into fire.

Fire generally takes place due to the combustion of fuel which can be in any form i.e. solid, liquids or gases. Gases are released from the surface of fuel once it is heated up to an extent which further leads to the chemical reaction leading to fire. In combustion process different gases made up of molecules reacts with each other. These molecules of gases fragments apart once the gases are heat up to such an extent that causes them to break into fragments of gases which further reacts with the oxygen present in air to form new product molecules (H_2O and CO_2) plus lots of heat and other byproducts as well in case if burning is not complete. The proper mixture or combination of three major elements i.e. heat, fuel and oxygen leads to chemical reaction resulting in fire. Once ignited, fire must be able to sustain its own heat by releasing more heat energy into the atmosphere. Presence of oxidizer gas (O_2) is also necessary to produce convection for continuing the fire.

- c) Fire triangle illustrates all the three major elements which are required for igniting a fire. These elements are heat, fuel and oxidizing agents and combination of these elements in right mixture leads to event of fire. Fire triangle indicates that fire can be stopped if any one of these three elements could be prevented or extinguished from the fire triangle.
1. The first element is heat in a fire triangle which is considered as the most leading factor due to absence of which fire cannot be ignited. Unless there is certain amount of heat provided the event of fire cannot take place. By removing source of heat from the entire building would also assist in eliminating the fire (example wood embers, turning off electricity supply etc.).
 2. Fuel holds the second position in the fire triangle which is also required by fire to take place in actual. A fuel is also desirable for the fire to occur. Anything which is flammable could be considered as fuel source like fire hazardous chemicals, fabrics, paper or wood. Once this fuel element is eliminated the fire will also be extinguished.
 3. Oxygen is another essential element which holds third position in a fire triangle. For starting and beginning the fire the presence of oxygen is highly desirable. Extinguishing small fire with non-flammable blanket or sand will discontinue the oxygen content and ultimately stopping the fire. Therefore a combustion process could be retarded by decreasing the concentration of oxygen. But this is not feasible in case of large fires occurring in an extended area.

Lastly the fire triangle is holding a center position for another element aiding in fire that is called as chemical reaction. So firefighters need to utilize a different approach while dealing with fires concerning with metals like magnesium, lithium, titanium as these chemical leads to chemical reactions.

d) The following are the leading causes of fire in industries:

- **Combustible Dust**

Sometimes there are chances that some small incidents of fire may take place at the worksite and that may go as unreported incident but these small fires also cause harm to the employee, loss to the products kept in the vicinity of that area and ultimately loss of time. The result of such small fire incidents can be devastating like if that particular area is involving combustion dust in the atmosphere then secondary explosion might take place by spreading and reacting with the atmospheric dust and further multiplying the severity of the fire incident. Also these combustible dusts could ignite by themselves and could cause severe explosion inside the factory causing break down of entire facilities, leading to devastating losses and fatalities.

- **Hot Working Activities**

All those industrial activities which involve hot working practices like brazing, soldering, welding, burning, heating, torch cutting, grinding, chipping, drilling are prone to fire incidents. These practices pose fire hazards as they generate sparks, flames and heat which can sometimes leads to fire. These resulting sparks can help combustible dust in the surrounding area to ignite and lead to huge fires.

- **Equipment and Machinery**

Industrial fires could also be caused due to faulty equipment and machineries. The largest issues are faced due to equipments which are related to heating and hot working activities like furnaces which are not maintained or serviced for longer period of time. Moving parts of equipment results into friction that in result becomes a leading reason for fire hazard.

- **Electrical Hazards**

There are numerous fire hazards which may be confronted in an industry owing to electrical faults. Electrical systems in any industry include extension cords, overloaded outlets, static discharges and overloaded circuits. A small spark in any equipment or machinery may turn into a big hazard if overlooked and not checked on routine basis.

- **Lack of Awareness and Human Error**

Human errors play a significant role in industrial fire as this is the most common fault from worker's side. Huge fires could be resulted from a silly mistake or worker. Suppose a person by mistake spills flammable liquid on shop-floor or some combustible dust has accumulated in the environment of factory

and he forgets to clean it, then this flammable liquid or dust might ignite due to heat and can lead to fire. Also secondary fire could be faced if primary fire is not suppressed on time.

e) Class-A Fires:

This class of fire generally takes into account fire caused due to ordinary combustible materials. This type of fire leaves ash behind. Common examples generally include rubber, pulp, paper, wood, cloth, and plastics of various types. This method generally focuses on extinguishing fire via heat removal method. Common types of agents that can be utilized for extinguishing fire of this class include water, halon, dry chemicals, halogenated agents and foams.

Class-B Fires:

This class of fire generally takes into account fire caused due to flammable and combustible liquids or gases which may include propane, gasoline, oil, tar, paint and natural gas. Various types of fire extinguishing agents are available to suppress the fire of this class type making use of all the theories of fire extinguishment. The type of agent to be utilized depends upon the circumstances involved.

Class-C Fires:

This class of fire generally takes into account fire caused due to live electrical equipment. Therefore this class of fire could be suppressed by making use of extinguishing agent which does not conduct electricity back to the fire extinguishing personal. Electricity here acts as a source of energy or source of ignition, but it will not burn on its own. Instead, these electrical equipments act as a source of ignition for Class-A type fire or for Class-B fire.

Class-D Fires:

This class of fire generally takes into account fire caused due to combustion of exotic metals like sodium, magnesium, titanium, and zirconium. These fires are suppressed by using special agents like dry powder etc. The extinguishers which are utilized for suppressing class A, B, or C fires cannot be utilized here for this class of fire. Suppose firefighter tries to suppress the fire with water, he may help the fire to expand by reacting with burning metals and increase the intensity of fire.

Class-K Fires:

This class of fire generally takes into account the fire that is caused due to cooking appliances that involve combustible cooking media like animal oils, vegetable, and fats. Special agents like wet chemical extinguishers and extinguisher which is alkaline in nature and possesses cooling capabilities are used to suppress fires of this class.

4.12 REFERENCES AND FURTHER STUDIES

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