Basics of Fire Prevention & Protection.

National Safety Council , Hqs.
98-A,Institutional Area, Sector 15,
CBD Belapur , Navi Mumbai
Maharashtra – 400614.
India

Contents

1 FIRE AND EXPLOSION HAZARDS

1. DEFINITIONS (A Terms connected with Fire & Explosion)

1.1 Flammability Characteristics

Flammability of liquid varies at the rate at which it vaporizes and it greatly depends on the vapour pressure. Vaporisation increases with rise in temperature and a flammable liquid at an elevated temperature is more hazardous than the same liquid at normal temperature.

The combustion of a flammable gas air mixture occurs if the composition of the mixture lies in the flammable range and if the condition exists for ignition, which is caused either by bulk gas temperature or by local ignition.

1.2 Flammability Limits

A flammable gas burns in air within a limited range of composition. The lower flammability limit is such that below this limit mixture is too lean to burn and is also called as lower explosive limit. While above a certain concentration, the upper flammability limit, it is to rich and is also called upper explosive limit. The concentration between these limits constitute the flammable range.

Flammability limits are affected by pressure, temperature, direction of flame propagation, gravitational field and surroundings. Decrease in pressure below atmospheric can narrow the flammable range by raising the LFL and reducing the UFL until the two limits coincide and the mixture becomes non flammable. Conversely, an increase in pressure above atmospheric can widen the flammable range. The flammability limits are also affected by the addition of an inert gas such as nitrogen, carbon dioxide or steam. In general, carbon dioxide causes a greater narrowing of the flammable range than does nitrogen.

There are also flammability limits for combustion in pure oxygen. In general, the lower flammability limit of a gas is almost the same in oxygen as in air but the upper flammability limit is much greater in oxygen than in air. The flammability range in oxygen is thus wider than it is in air. There are also flammability limits for substances which burn in chlorine.

1.3 Ignition Temperature

If the temperature of a flammable gas air mixture is raised in a uniformly heated apparatus it eventually reaches a value at which combustion occurs in the bulk gas. Flammable mixture has lowest ignition temperature which is known as minimum spontaneous ignition temperature or auto ignition temperature. Some substances have quite low auto ignition temperature like carbon disulphide has 90^{o}c. The auto ignition temperature may be reduced by as much as 100 – 200^{o}c for surfaces, which are lagged or are contaminated by dust.

1.4 Flash Point

The flash point of a flammable liquid is the temperature at which the vapour pressure of the substance is such as to give a concentration of vapour in the air, which corresponds to lower flammability limit. There are two methods of measuring of flash point, the closed cup test and the open cup test. The open cup flash point is usually a few degrees higher than the closed cup flash point. A liquid, which has a flash point below ambient temperature and can thus give rise to flammable mixtures under ambient conditions, is generally considered more hazardous than on with a higher flash point.

1.5 Fire Point

The fire point of a flammable liquid is the lowest temperature at which the liquid, when placed in an open container will give off sufficient vapour to continue to burn when once ignited. The fire point is usually a few degrees above the open cup flash point.

1.6 Ignition Energy

Ignition of a flammable gas-air mixture by a local source of ignition by electrical discharge occurs only if the later possesses a certain minimum energy. This minimum energy usually occurs close to the stoichometric mixture.

1.7 Vapour Pressure

Vapour pressure is exerted by a gas or vapour in all directions in a closed container at a given temperature.

The vapour pressure of a liquid at any given temperature at which the vapour and liquid phases or the substances are equilibrium in a closed container. Relative rates of evaporation of the liquids are indicated by their vapour pressure. A high vapour pressure indicates a high rate of evaporation. The percentage of vapour is in direct relationship between the vapour pressure of the liquid and the pressure of air.

1.8 Vapour Density

Density of petroleum vapour or gas is greater than air (heavier than air) and tend to remain in ground level, in pits or flow a long distance through drain or ditch. Once ignited, it will travel back to the source of release (flash back). Petrol vapour is about 3-4 times heavier than air and it can settle in low areas, ditches or drains and travel a long distance to cause ignition and flash back.

1.9 Boiling Point

The lower the boiling point, the substance is more volatile and consequently more hazardous such as a flammable liquid. As boiling point decreases, the vapour pressure & evaporation rate increases.

1.10 Viscosity

Viscous liquids spread slowly when released & fire in them generally burn slowly in a smaller area than equal volume of less viscous and free flowing flammable liquids. However, a viscous oil sprayed in mist form with 10 micron size evaporate fast & behave like vapour.

In a Tank Viscous liquid layer containing small quantity of water by heat conduction boils to form steam expanding about 1700 times to its water volume. This cause Boil over of liquid forcing the liquid under violent force. In case of large Tank, the burning oil can cover a wide area.

1.11 Kindling Temperature

This is a term used to express the temperature of which a solid matter such as paper wood must be raised to begin burning.

General Classifications of Hazardous Area And Safety Aspects Including Flameproof Electrical Equipment

HAZARDOUS AREA CLASSIFICATION

The classification of areas for electrical installations in petroleum refineries and other similar areas. These are hazardous areas where hazards of explosion due to gases and vapours exist and in which flammable gases and volatile liquids are processed, stored or loaded, unloaded and otherwise handled.

The classification of areas has been done according to the extent of risk involved so that it provides a guideline to the choice of equipment to be installed in different areas on the basis of the extent of hazard.

To determine the type of electrical installation appropriate to a particular situation, the areas have been divided into three main Divisions namely - Division-0, Division-1, and Division-2, according to the degree of probability of the presence of hazardous atmosphere.

Division-0 Area

An area in which a hazardous atmosphere is continuously present shall fall under this category. Since a hazardous atmosphere exists continuously any failure of electrical apparatus installed in Division 0 area would almost certainly lead to fire or explosion or both. Therefore, any installed electrical apparatus must afford a degree of protection as near as practicable to the absolute.

It is recommended that the use of electrical apparatus should, where practicable, be completely excluded from Division 0 areas; but when this is not practicable the recommendations laid down in IS: 5571 (guide for selection of electrical equipment for hazardous areas) should be followed.

Division 1- Area

An area in which a hazardous atmosphere is likely to occur under normal operating condition shall fall under this category. This classification is applied to areas in which a hazardous atmosphere is likely to occur at any time and which therefore, require the fullest practicable application of measures to prevent the occurrence of a hazardous electrical condition at any time and in any circumstances. Recommended types of electrical apparatus and wiring for use in Division-I areas are given in IS: 5571.

Division-2 Area

An area in which a hazardous atmosphere is likely to occur only under abnormal operating conditions shall fall under this category. This classification is applicable only where a fire and explosion hazard is unlikely and may be caused only by simultaneous and improbable occurrence of an arc or spark resulting from an electrical failure and a hazardous atmosphere arising through failure of the conditions of control. It pre-supposes that any hazardous atmosphere resulting from an abnormal occurrence is rapidly dispersed, so that it's possible contact with the electrical apparatus of minimum duration. Any situation which allows a hazardous atmosphere to collect such as a pit or trench although it may be in open air shall in itself be classed as Division-I area, even though the surrounding area is classified as Division-2.

Safe Area

Although generally speaking safe areas may be ascertained without difficulty, the following examples are given of 0 cases where this classification may not immediately be apparent.

(a) Enclosed premises in which a plenum or purging steam of safe atmosphere is continuously maintained so that no opening therein may be a point of ingress of gases or vapours coming from an external source of hazard should be classified as safe.

(b) Pipes carrying petroleum or petroleum product laid in the open outside hazardous area should be classified as safe.

Safety of Flameproof Equipment

Flameproof apparatus is achieved by fitting the electrical equipment into an appropriate flameproof enclosure designed such that if a flammable vapour enters and is ignited by a spark, the flame and the products of combustion are contained by the enclosure and do not ignite an external flammable atmosphere. The enclosure must also have sufficient strength to contain the pressure of the internal explosion.

Health Hazards due to Fire & Explosion

The main threat of fires are gases, heat and oxygen deficiency. The temperature in a room in a house can easily reach 500 – 1000 degree C and as many as 400 toxic compounds can be demonstrated in the smoke. The principle toxic constituents of smoke are soot, Carbon monoxide, Carbon dioxide, Nitrogen Oxide, hydrogen Chloride, Sulphur dioxide, hydrogen fluoride, hydrogen sulphide, isocyanates, acrolein, benzene, phenol, formaldehyde, a range of chlorinated hydrocarbon. Carbon monoxide is an important factor in 50 – 80 % of all fire fatalities.

Even if not directly fatal themselves, carbon monoxide and hydrogen cyanide singly or in combination may lead to the rapid incapacitation of the individual who is then unable to escape. The other toxic gases can cause acute airways and lung injury or may obscure vision through causing eye irritation. An elevated carbon dioxide level will induce hyperventilation and hyperpnoea and increase exposure to the combustion gases. In most fires these toxic factors are usually more important to survival than heat. However, intense fires can lead to severe burning from hot air or thermal radiation and in some fires direct burning from heat of the flame can be the cause of death. Thermal injury to the airways and lungs is not as common as toxic damage, since the upper respiratory tract rapidly conducts away heat from the inspired air. Nevertheless air containing hot respirable particles or steam can cause injury as deep as the bronchioles.

First-aid Measures

Regardless of the kind of gas involved the victim should be moved immediately to fresh air. If breathing has stopped or cardiac arrest has supervened then cardiopulmonary resuscitation should be begun. If hydrogen cyanide is suspected then a manual resuscitation should be used to maintain respiration so that mouth-to-mouth resuscitation is avoided.

Simple asphyxiant gases or lack oxygen will cause loss of consciousness without irritation of the eyes or mucous membranes of the respiratory tract. Unless the hypoxia is severe the victim will recover consciousness in fresh air. If the patient is breathing and oxygen is available, 100% oxygen should be given by oronasal mask until more specific treatment can be instituted. Skin burn area should be poured with cold water.

Deal with a person whose cloths have caught fire :

(a) Put out the flames by whatever means available. Water is readily available to quench the flame, water also cools the burn area causing less damage to occur.

(b) Do not allow the person to run about. This only fans the fire and makes the flame spread.

(c) Hold a rug, blanket, coat or table cover in-front of you, while approaching a man whose cloths have caught fire.

(d) Lay him down quickly on the ground and wrap tightly with any thick

(e) Piece of cloth, rug, blanket or coat.

2. CHEMISTRY AND CLASSIFICATION OF FIRE

1. INTRODUCTION

Uncontrolled fires burned on the face of the earth long before the arrival of primitive man. Electrical thunderstorms generated lightning and volcanoes erupted hot molten lava.

With the development of civilization, man learned relatively crude methods of kindling fires. Gradually, he learned to use the energy of fire. For centuries, however, fire remained aloof as a sacred, powerful force, a god to be honoured and worshiped.

The view that fire was a constituent of all materials was accepted till the early 1700s. At that time, a theory was put forward that all combustible materials supposedly contained a common substance called phlogiston, which escaped when a material burned. Then, for the first time, Lavoisier measured the weights of substances involved in the burning process, thus destroying the earlier theories.

As fire became more and more useful to man, it also became one of his worst enemies. The London fire of 1666 was incidental to the establishment of the first laws on fire protection and fire insurance.

2. COMBUSTION

Combustion can be defined as a heat-producing process that ma take place at any rate and at almost any temperature. It can be extended to include even the slow and mild process of rusting or reactions as violent as the explosion of hydrogen and oxygen which involves temperatures upto 3000 ^{o}C. Combustion does not necessarily involve oxygen, but the fire service is mainly concerned with combustion that requires oxygen. Some metals, such as magnesium, may burn in nitrogen, and certain substances, such as hydro zinc, hydrogen peroxide and ozone can burn in the absence of any medium except themselves; that is, at sufficiently high temperatures they decompose and give off heat without combining with another substance.

When combustible organic material such as wood, textiles or flammable liquids, burn freely in an atmosphere containing plenty of oxygen, the volatile products are mainly carbon-di-oxide and water vapour. In an atmosphere that is deficient in oxygen, appreciable quantities of carbon monoxide, smoke and other products of incomplete combustion may also be present.

The idea of combustion seems simple enough. This despite the fact that virtually none of the known common fuels for fire do actually burn. What happens is that when organic compounds like coal, wood, plastics, etc. are heated, they decompose to smaller molecules with greater volatility and flammability. Chemically, this process is known as pyrolysis. It is the fundamental explanation of nearly all phenomena that we term and regard as fires.

The process of pyrolysis releases gaseous materials, which actually burn, create and feed the flames. (The heating of volatile liquid fuels produces a vapour which burn readily well before pyrolysis would take place) Such gases, driven by air currents, produce, for example, the ‘fireballs’ seen by witnesses of forest-fires, aviation accidents and other fire spectaculars.

Many common flammable liquids consist of carbon and hydrogen chemically combined in various proportions (hydro-carbons) or of carbon, hydrogen and oxygen in combination (alcohols, organic acids, aldehydes, ketones, other). Excepting those substances which undergo exothermic decomposition, the chemically combined oxygen is not available for the usual combustion reactions.

3. SPONTANEOUS IGNITION

Spontaneous ignition results from a chemical reaction in which there is a slow generation of heat from oxidation of organic compounds that, under certain conditions, is accelerated until the ignition temperature of the fuel is reached. The condition is reached only where there is sufficient air for oxidation but not enough ventilation to carry away the heat as far as it is generated.

The presence of moisture also can advance spontaneous heating unless the material is wet beyond a certain point. Materials like unslaked lime promote spontaneous ignition, particularly, when wet. Such chemicals should be stored in a cool, dry place, away from combustible material.

It is generally agreed that at ordinary temperatures some combustible substances oxidize slowly and, under certain conditions, can reach their ignition point. These include vegetable and animal oil and fats, coal, charcoal, and some finely divided metals. Rags of waste saturated with linseed oil or point often cause fires too.

The best preventive measure against spontaneous ignition are either total exclusion of air or good ventilation. With small quantities of material, the former method is practicable. With large quantities of material such as storage piles of bituminous coal, both methods have been used with success.

Temperature of 140^{o}F (60^{o}C) are considered dangerous in coal piles. If temperatures rapidly approach or exceed the figure, it is generally advisable to move the pile or rearrange it to allow better circulation of air.

Certain agricultural products are susceptible to spontaneous ignition. Sawdust, hay, grain, jute, hemp, etc. ay ignite spontaneously, especially if exposed to external heat or to alternate heating and drying. Here again, the best preventive is circulation of air, removal of external sources of heat, and storage of material in smaller quantities.

Fires in iron, nickel, aluminium, magnesium and other finely divided metals are sometimes attributed to spontaneous ignition believed to result from the oxidation of cutting or lubricating oils or possibly from chemical impurities.

6. FIRE GENERAL

The science of fire protection is concerned with the uncontrolled fire, that is, a fire whose size, intensity, location and rate of growth are not exactly predictable or, except for extinguishing activity, subject to human direction. These factors are determined only by the randomly existing conditions at the site of the fire. In understanding of the general principles governing what is taking place in and around on uncontrolled fire helps in understanding the influence of the existing conditions on the fire.

Details of the chemistry and physics of the fire process are complex. In spite of much study, only simple aspects most like controlled combustion can be completely analyzed. It is possible, however, with the aid of a few principles to predict in a given situation whether a fire will continue or go out, whether the spread will be relatively fast or slow, and whether or not the fire will be difficult to extinguish.

7. DEFINITIONS OF FIRE

There are many definitions of fire including legal, chemical and physical ones. For most fire-protection purposes, fire means fire in the ordinary sense that is, the combining of fuel and oxygen in blazing combustions. This meaning excludes some types of fires that might be included in other definitions, such as spontaneous heating or the glowing combustion of coals.

In general, fire is any combustion intense enough to emit heat and light. It may be a quietly burning flame or a flammatic explosion. Fire grows and sustains itself in the reacting medium by the heat it produces. However, heat is not always the sole, nor even the principal agent that initiates flames and explosions. Fire may be started by a chemical process known as branching of reaction chains similar to the nuclear chain reaction of the atomic bomb.

Fire Triangle

The fire process can be symbolized in the fire triangle. This figure represents graphically hat in order to have a fire, fuel, oxygen and heat must be present simultaneously. If any of these three factors is omitted, there will be no fire.

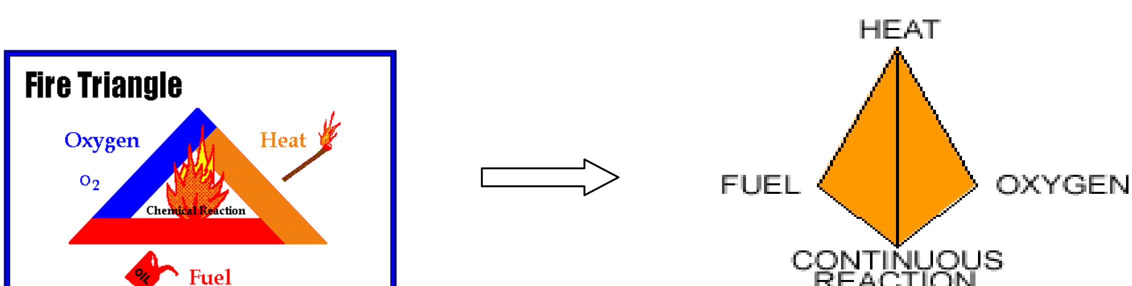
Recent studies in fire chemistry have resulted in certain revisions and expansions in the theories of fire extinguishments. In analyzing the anatomy of a fire, the original fuel molecules appear to combine with oxygen in a series of successive intermediate stages, called branched chain reactions, in arriving at the final products of combustion. It is these intermediate stages, which are responsible for the evolution of flames.

As molecules break up in these branched chain reactions, unstable intermediate product called free radicals such as hydrogen (H+) and hydroxyl (-OH) are formed. The concentration of these groups determine flame speed. The almost simultaneous formation and consumption of free radicals appears to be the lifeblood of the flame reaction.

It is the free radicals in these branched chain reactions which are removed from their normal function as a chain carrier by dry chemical and halogenated extinguishing agents.

The effects that various dry chemicals agents (sodium bicarbonate-base) have on capturing free radicals depends upon their individual molecular structure. Potassium bicarbonate dry chemical is the most effective because of the large size of the potassium ion.

For years we have used the principle that there are three ways in which an ordinary fire can be extinguished – remove fuel, limit oxygen, or reduce heat. This concept picturised by the 'fire triangle' should be revised to include this forth way: "inhibit the flame chain reaction". Thus we arrive at the 'fire tetrahedron' as depicted below:



Fire Tetrahedron

3. PRINCIPLES OF FIRE EXTINGUISHING

Basic Primary Methods of Fire Extinguishing:

- (i) Removal of Fuel
- (ii) Reduction of heat
- (iii) Reduction / removal of Air (oxygen)
- (iv) Inhibition of flame chain Reaction
- (v) Shock waves
- (vi) Critical vibrations
- (vii) Ion separations

(1) Removal of Fuel

The method is self explanatory. Remove the combustible and there will be nothing to burn, and fire will die. This method is useful in petrochemical complexes, at various stages where processes where the flow of the fuel can be controlled, at various stages where copper tubing is used to convey solvents and gases, fires have been put out by crimping the tubing and thus shutting off the supply. The fuel from the storage tank on fire is often pumped out from the bottom to other tanks, thus reducing the quantity of fuel to be destroyed by fire. Back firing techniques used in forest and bush fires also achieve the same things.

(2) Reduction of Heat

Total output of heat from flames achieves thermodynamic stability when the fire reaches the peak of ferocity. The heat energy is dissipated in the form of radiation, conduction and convection to the surroundings including to the unburnt fuel. The fuel absorbs this energy mostly in the form of radiant energy, and in the first stage undergoes physical change i.e. from solid to gas, from liquid to vapour etc. and then undergoes chemical change i.e. vapour breaks up into simpler hydrocarbon molecules. These molecules further absorb energy and get primed up to start on the chain reaction of oxidation.

In fires, we have seen that flame temperature attained is from 2500 F to 4500 F (1,370°c). There is a critical temperature below which flame propagation stops. To quote an example, methane flame has a critical temperature of 2400 F (1,330°c). The principle of fire extinction that suggests itself is to reduce the flame temperature below its critical value and thus stops its propagation. When water drops or particles of dry powder enter the flaming zone, they remove the heat and thus bring down the flame temperature. Water vapour by absorbing heat converts itself into steam. No part of the steam chemically reacts with free carbon in the flame zone and further absorbs heat. The bulk of the steam reduces the oxygen supply and thus slows the chain reactions. Further, the water that falls on the un-burnt fuel surface cools it down, and thus impedes the process of both physical and chemical change. This reduces the supply of primed fuel molecules needed to sustain the chain reactions. It is thus seen that the process is actually more complicated.

(3) Reduction / Removal of Air

It is a common knowledge that a fire burns fiercely when fanned by wind. A slow burning stick will explode into flames in oxygen rich atmosphere. It is the quantity of oxygen available which governs the velocity of combustion. If the air supply is restricted or the oxygen content per specific volume reduced, the rate of heat generation and increases the heat losses, so much so that the flame temperatures fall below the critical point causing eventual extinction.

Flooding the fire area inert gases like Nitrogen, Argon, Helium, etc. brings about this condition. Even CO_2 and steam react in this fashion, but they also induce some other reactions.

(4) Inhibition of Chain Reactions

We have seen that the flame propagation takes place due to repeated generation and conciliation of radicals like (OH), (H), (O) in a chain reactions. Any interference by foreign matters with the chain carrying radicals has a telling effect on the flame. As the radicals get absorbed a very few are available to propagate the flame which consequently dies out. In fact it is found that interference with chain reaction is very powerful weapon to fight fire, and is being developed on scientific lines.

Fire Extinction, in principle, consists of the limitation of one or more of these factors, and the methods of fire extinction may therefore classified under the following headings:

- Starvation - Removal of fuel
- Smothering - Removal of oxygen.
- Cooling - Lowering the temperature

CLASSIFICATION OF FIRES (IS: 2190-1971)

For all practical purposes, fire may be classified under the following heads:

1. Class ‘A’ fires: fires involving ordinary combustible materials such as wood, paper, textiles, etc. where the cooling effect of water is essential for the extinction of fire.

2. Class ‘B’ fires: Fires in flammable liquids like oils, solvents, petroleum products, varnishes, paints, etc. where a blanketing effect is essential.

3. Class ‘C; fires: Fires involving gaseous substances under pressure where it is necessary to dilute the burning gas at a very fast rate with an inert gas or powder.

4. Class ‘D’ fires: Fires involving metals like magnesium, aluminium, zinc, potassium, etc., where the burning metal is reactive to water and which require special extinguishing media or techniques.

4 PORTABLE FIRE FIGHTING SYSTEM
- FIRST AID FIRE FIGHTING APPLIANCES

1. INTRODUCTION

Fire from the ancient time is regarded as God (AGNIDEVTA) for its, great utility as well as for its tremendous power of destruction.

Since centuries FIRE has been playing havoc with the human race, and shall continue to do so in future also. We have faced it and will face it. We have evolved methods to deal with it effectively and thus have been able to save our lives and property by its ravages. Our experiment with fire has proved that in well-trained and resolute hands, even the simplest appliances and tools can be more effective in dealing with immediate threat of fire than the costly and heavy machines and equipment. As readiness, watchfulness and speed in action are the watchwords in fire fighting. It is not so much the possession of or ability to use heavy and expensive equipment, as immediate availability of the speed with which appliances can be used, which is of real importance. We know that every big fire is the outcome of a small fire which ignites, in our house, in our factory, in our office and elsewhere. Our aim should be to deal with fires in their incipient stages and to extinguish them before they spread and assume serious proportions. For small fires we need small and portable appliances. As we use First Aid Box in case any of us ‘portable appliances. As we use First Aid Box in case any of us gets slightly injured or suffers a wound and we don’t need a Civil Surgeon to deal with a petty injury. In the same way this cannot be achieved by the use of heavy equipment which are costly and difficult to handle and some time also beyond reach of an average house-holder, or owner of a premises where he runs his business or carries out activities to produce some thing. Here First Aid Appliances are of prime importance as they are not costly and intricate, but are cheap and handy and have added advantage of simple mechanism that can be handled by any layman. Even women and children can use them in dealing with fires in their incipient stages.

These simple tools are known as the First Aid Fire Fighting Appliances.

2. THE FIRST AID FIRE FIGHTING APPLIANCES IN COMMON USE

(a) Fire Buckets
(b) Fire Bat or Fire Beater
(c) Asbestos Blanket
(d) First Aid Hose Reel
(e) Chemical Extinguishers.

2.1 Fire Buckets

An ordinary bucket which is specifically used for extinguishing, a fire is known as Fire Bucket, but it is not as such always. A fire bucket is made according to a particular specification duly approved by the I.S.I., according to which its shape and colour is quite different from that we ordinarily use in our household.

Its capacity is 2 gls., round bottom, outside painted in Post office Red, inside with white line and letters FIRE in 3”size are written on its body in black or white. The bottom is also painted black. An extra handle is also provided one side to enable the user to throw water upto a longer distance. This specification and design has excluded it from our common buckets.

Some time fire buckets are also flat bottomed to be used in conjunction with stirrup pumps as round bottomed buckets can not be placed on the ground. They are also painted in Red so that one should know that they are not to be used for any other purpose except fire fighting.

Every such bucket must be kept full with clean water. It must be impressed that cigarette ends and such rubbish must not be thrown into fire buckets for they would block the pumps or spoil the water meant for fire fighting.

The buckets should be inspected regularly to ensure that they do not leak and are filled up with clean water all the time. They are to be placed on hooks near the exits at a height of 1.25 metres.

Dry sand should always be used in fire buckets meant for fires on which water is not to be used. Earth should never be kept in sand buckets as particles of earth when damp stick to each other make a lump of it while sand can be sprinkled on a larger area to cover the burning.

They should not be massed in one place for, sometime it may be impossible to get at them when required. But they should be so distributed that whenever a fire occurs a sufficient number of them is within reach. Namely 4 Fire Bucket along with 1 chemical Fire Extinguisher (one unit of F.A.F.P. Equipment) is sufficient to cover an area of 1200 sq. yards.

2.2 Fire Bat or Fire Beater

A fire Bat consist of a wooden or flexible shaft approximately 3’ to 4’ in length at one end of which is secured a piece of reinforced canvas about 18” long and 9” wide. Fire Bats are used for beating out bush are grass fires.

May other types of beaters can also be improved, such as:-

(a) A sack is passed over a frame work made from wire, the neck of the sack being tied around the handle. This type should be kept drenched while in use.

(b) A fire beater can also be made of wire netting laid over a metal frame and attached to a handle. Green branches of trees can also be used to make a satisfactory fire beater. When using a beater, it is advisable not to raise it above shoulder both to avoid unnecessary effort and to prevent sparks flying about. A sweeping motion should be employed in a direction, which will tend to drive the sparks raised back into the fire. Where possible, the fire should be rubbed out rather than beaten.	

2.3 Asbestos Blanket

The blanket is made from asbestos, a mineral capable of being woven into an incombustible fabric. It is made in different sizes in 6’ X 4’, 5’ X 5’ & 4’ X 4’. For instant availability and recognition the blanket is kept in red cylindrical steel container, which can be suspended in convenient position.

The blanket is principally used for extinguishing fires by smothering method. It is quick, clean & safe to used and provides valuable protection for the fire fighter. It is effective on all types of small fires. This is however, a costly item and not easily available. Hence, its utility for an average House holder is very limited. It is highly fire resistive and is a bad conductor of Electricity and is very safe when used on such fires.	

2.4 First Aid Hose Reel

The Hydraulic Hose Reel consists of a hallow rotating shaft to the center of which water is fed through a stuffing box gland. Unbreakable fabric reinforced rubber hose of 3/4 "or 1" diameter is connected to the outlet on the rotating shaft. The hose is fitted with a light branch and a shut off nozzle. The reel is connected to the nearest water supply and a value is fitted to control the supply of water to the Reel.

To get to work with the Hose Reel, all that is necessary is to turn the valve, hold the branch and pull the necessary length of tubing from the reel and opening the shut off nozzle when the fire is reached. The length of the rubber Hose can also be obtained according to the floor area that is required to be protected.

2.6 Chemical Extinguishers

Chemical Extinguishers are handy and potable containers charged with a small quantity of extinguishing media each capable of extinguishing a particular type of fire.

The chemical extinguishers can be broadly classified under the following 4 groups :

(a) Extinguishers which expel water or dilute chemical solutions suitable for class 'A' Fires.
(b) Extinguishers which expel foam suitable for class 'B' fires.
(c) Extinguishers which expel gases or vapour forming liquids suitable for class 'C' fires.
(d) Extinguishers which expel dry powder suitable for all types of fire.

2.6.1 Advantages of Using a Fire-Extinguisher

i) Easy to operate and quick in action.
ii) Needs only one man to operate and can be carried easily.
iii) Very useful in the initial stages of a fire.
iv) Very effective against some types of fire.

2.6.2 Disadvantages of using a Fire-Extinguisher

i) Their utility is limited, as the duration of the working is approximately one to two minutes.
ii) The cost of extinguishers and their refills is high and they cannot be maintained by the average house holder.
iii) The extinguishers requires constant inspection, care and maintenance.
iv) They can be discharged by careless handling.

2.6.3 Types of Chemical Extinguishers

There are 4 types of Chemical Extinguishers in common use :

(a) Water – CO_2 Type Extinguisher

It may be gas cartridge type or trolley mounted type. Water expelling fire extinguishers have water as an extinguishing agent which is released in the form of a jet by means of gas pressure in the upper part of the container. The gas pressure may be induced by chemical reaction or by mechanical means.
Water expelling fire extinguishers are used mainly in class A fires (IS 2190-1979) involving ordinary combustible materials like wood, paper, textiles, etc. which are put out by the cooling action of water. Besides, water when applied to burning material is converted to steam which reduces the percentage of available oxygen. Water expelling type extinguishers should not be used on fires involving electrical equipment without de-energising them.

The various types of water-expelling extinguishers are –

(1) Gas Pressure actuated type IS : 940 – 1976
(2) Constant Air Pressure type IS : 6234 – 1971

(b) Mechanical Foam Extinguisher

This extinguisher is also a container of 2 gallon capacity, and its shape is cylindrical. This type of extinguisher is mainly used on small liquid fires, e.g. petrol, oil and spirit.

Operation :

i) As in the case of S.A. Extinguisher, it has two containers. The outer container is meant for the solution of sodium bicarbonate treated with one or the other stabilizer, e.g. Glacowe, sapanine or Turkey Red Oil. The inner container holds the solution of Aluminium Sulphate.
ii) With a view to keep the two solutions separate and to prevent the liquid from possible evaporation, a sealing arrangement is employed. Generally this device embodies two valves one of which sits upon a shoulder in the inner container just below the portholes, whilst the other seal the small outlet space in the cap.

iii) The extinguisher is brought into operation by releasing the valve and inverting the container, which makes the two solution mix.

The form is produced by the reaction caused by the mixing of the solutions. The extinguisher is capable of throwing a jet of foam to a distance of 20 to 25 feet.

Care and Maintenance :

i) Quarterly checking : The extinguisher should be opened up every quarter for inspection. Solutions in both the containers should be stirred up. Care should be taken to use separate sticks to stir the two solutions.

The nozzle should be blown through to ensure that there is no obstruction. The treads in the cap should be slightly greased and screwed down tightly, so that the cap may not get jammed.

ii) Annual Test and Refilling : The extinguisher should be discharged at the expiry of every year and filled afresh, if not used during the year.

iii) Hydraulic Pressure Test : The outer container should be tested biannually to stand a pressure of 350 lbs. per sq. inch.

(c) Carbon Dioxide Extinguisher

Carbon dioxide gas is non-supporter of combustion, hence the principle on which this type of extinguisher is based is that it reduces the proportion of oxygen in the air, which results in the extinction of fire.

CO_2 Extinguishers are available in cylinders with capacity varying from 2 lbs. to 12 lbs. liquefied gas. At normal temperature and pressure it is a gas but when compressed in cylinders it becomes liquid. When released the liquid vaporises and the rapid expansion lowers the temperature and part of the gas is solidified in small particles. Whilst the cooling effect lowers the temperature to some extent, it is actually the exclusion o f oxygen that extinguishes the fire.

Use : It is especially suited for fires in electric and oil installations. It is also very useful on fires in substances which are susceptible to damage by water, like books, costly garments, etc.

Care and Maintenance : These extinguishers should be tested six monthly by weighing. If the weight loss is more than 10% the extinguisher should be got recharged.

(d) Dry Chemical Extinguisher

This is also known as Dry powder Extinguisher.

Construction : These extinguishers are available in different sizes – their capacity varying from 7 to 20 lbs. It consists of the following main parts:-

- Cylinder
- Cam Assembly with plunger &
- Gas Cartridge.

Chemical charges vary with the manufacturers. One formula for this type of Power contains:

Sodium Bicarbonate : 97 %

Magnesium Stearate	:	1½ %
Magnesium Carbonate	:	1% %
Tricalcium Phosphate	:	½ %

Use : It is especially suited for oil and electrical fires, though it can also be used on fires involving carbonaceous material. It is also very effective on fires involving magnesium.

Operation : The charge of dry chemical is expelled by the gas released from the cartridge by striking the plunger.

A B C" Stored pressure type: ABC fire extinguisher is useful for fires of A, B and C types. Fire breaking out in these types involves cotton, wood, grease, flammable liquids, electrical wiring, live machinery and others. The blanketing effect of extinguishers helps in decomposing fire rapidly.

2.6.4 Banned Extinguishers

i. Chemical Foam Extinguisher

ii. Soda Acid Extinguisher

iii. Halogen Extinguisher

3. INSPECTION AND MAINTENANCE OF FIRE EXTINGUISHERS

Once a fire extinguisher has been purchased, it becomes the responsibility of the purchaser or an assigned agent to maintain the device. Adequate maintenance consists of : (1) periodically inspecting each extinguisher, (2) recharging each extinguisher following discharge, and (3) performing hydrostatic tests as needed.

A fire equipment servicing agency is usually the most reliable way for the general public to maintain extinguishers, but large industries often train employees to handle this maintenance themselves.

3.1 Inspection

An inspection is a quick check that visually determines that the fire extinguisher is properly placed and will operate. Its purpose is to give reasonable assurance that the extinguisher is fully charged and will function effectively if needed. An inspection should determine that the extinguisher :

(a) is in its designated place,
(b) is conspicuous,
(c) is not blocked in any way,
(d) has not been activated and partially or completely emptied,
(e) has not been tampered with,
(f) has not sustained any obvious physical damage or been subjected to an environment which could interfere with its operation (such as corrosive fumes), and
(g) if the extinguisher is equipped with a pressure gage and/or tamper indicators, that each shows conditions to be satisfactory. In addition, the maintenance tag can be checked to determine the date of the last thorough maintenance check.

In order to be effective, inspections must be frequent, regular, and thorough. In a small building with few extinguishers, the manager, property owner, or some designated person can check extinguishers at the beginning of each work day. If a building is large enough to employ security guards or watchmen, extinguishers should be inspected at least once during each 8 hour shift. In industrial plants, the plant fire brigade or fire inspector often inspects extinguishers either daily, weekly, or monthly.

An individual evaluation must be made of each property to determine how frequent inspections should be made. If a particular operation is "fire prone" or is crucial to the use of the property, more frequent inspections should be made. For example, if all the products manufactured in a particular industrial plant had to be painted, a fire in the painting room could be disastrous, and here inspections should be very frequent. Some items which should be considered are :

(a) the nature of the hazards present (which would influence the potential use of the equipment),
(b) whether an extinguisher is exposed to tampering, vandalism, and malicious mischief,
(c) whether there are extraordinary weather conditions,
(d) the likelihood of the equipment being accidentally damaged, and
(e) the possibility that visual or physical obstructions might interfere with the accessibility of extinguishers.

3.2 Maintenance

Maintenance, as distinguished from inspection, means a complete and thorough examination of each extinguisher. A maintenance check involves disassembling the extinguisher, examining all its parts, cleaning and replacing any defective parts, and reassembling, recharging, and, where appropriate, re-pressuring the extinguisher. Maintenance checks sometimes reveal the need for special testing of extinguisher, shells or other components. They may, for example, reveal that the extinguisher container should be hydrostatically tested or even scrapped and replaced.

Maintenance should be performed periodically, but at least once a year, after each use, or when an inspection shows that the need is obvious. For example, if during an inspection there is evidence of serious damage by corrosion, the extinguisher should be subjected to a thorough maintenance check even though it may have recently undergone one. Similarly, if an inspection shows evidence of tampering, agent leakage, or physical damage, a complete maintenance check should be initiated.

3.2.2 Maintenance of Portable Fire Extinguishers

Portable fire extinguishers are the first-aid fire fighting equipment as they are very valuable in the inception of fire when used promptly and effectively. In order to ensure that the extinguishers operate properly when needed, a periodic maintenance is required.

A well-planned and approved maintenance schedule is essential to ensure that an extinguisher will operate properly between the time intervals stipulated in the maintenance programme for periodical inspection/ maintenance & will not constitute a potential hazard to persons in its vicinity or to those who operate or recharge the extinguishers.

Schedule for refilling, operational and hydraulic pressure tests and life

The recommended schedule for refilling/ performance test, hydraulic test on life of extinguishers as per IS: 2190-2010 'Code of practice for selection, installation and maintenance of first-aid fire extinguishers' is tabulated as below:

Type of Extinguisher	**Refilling/ Performance Test once in ***	**Hydraulic Pressure Test (interval year) #**	**Life in year @**
Water Type (stored pressure)	2 Years	2 years	10
Water Type 9 & 50 litres (gas cartridge)	5 Years	3 years	10
Mechanical Foam Type (stored pressure)	2 Years	3 years	10
Mechanical Foam Type 9 & 50 litres (cartridge type)	5 Years	3 years	10
BC and ABC Powder	3 years	3 years	10
Higher Capacity Dry Powder (trolley mounted)	5 years	3 years	10
Dry Powder	5 years	3 years	10
CO2 Type (portable and trolley mounted)	5 Years	At every recharging, but at least once in 5 years.	15
Clean agent	5 years	3 years	10

Notes - * - In corrosive environment, it is desirable to have the discharge test carried out at half of the frequency mentioned.

- The CO2 type and clean agent type fire extinguishes shall be pressure tested every time when the cylinders are sent for recharging.

@ - i) Life considered from date of manufacture.

ii) In case of failure in hydraulic pressure testing, rejected immediately before the life time given.

Extinguishing agent	Limitations
Water Has better cooling properties than any other agent and is therefore best used on Class A fires. Class A fires can re-ignite if not adequately cooled. Water will also penetrate readily to reach deep-seated fires.	Water is a conductor of electricity and can be highly dangerous if used on Class C fires, ie, fires in the vicinity of live electrical current. Will cause Class B fires to fare up and spread and if used on Class D fires may cause violent explosions.
Dry powder Dry powder is generally the best extinguishing medium for use on Class B fires. Extinguishers containing dry powders are capable of dealing with burning flammable liquids, spread over large areas, more effectively than other extinguishers of comparable size. They are effective on fires involving free-flowing liquids, eg, spillages over vertical surfaces. Since dry powder is a non-conductor of electricity it is safe to use on Class C fires.	Dry powder has no cooling properties and will therefore not prevent re-ignition*. For this reason it is not as effective as foam on contained flammable liquid fires which have been burning for a long time. Generally powders are messy and some form sticky deposits on surfaces and must be scraped and washed away after the fire. These deposits can have a detrimental effect on delicate machinery and equipment. * Re-ignition of Class A fires is prevented by using multipurpose (ABC) powders.
Foams Foam extinguishes Class B fires by forming a blanket of bubbles on the surface of the liquid and therefore has a smothering effect on the fires. Foam extinguishers are best suited for dealing with small contained flammable liquid fires or for fires which have been burning for some time causing the contained to become very hot and - increasing the chances of re-ignition.	Most foams have to form a blanket to extinguish the fire, and since it is not possible to cover flowing flammable liquids, foams are not very effective. Foam is water based and therefore a conductor of electricity. It is dangerous to use it on live electrical equipment. Some foams tend to break down when in contact with liquids such as alcohols, and this can prevent the production of an effective blanket.
Carbon dioxide Carbon dioxide extinguishers are suitable for dealing with small Class B fires, whether spillages or contained. CO_2 gas is a non-conductor of electricity and is therefore one of the safest media to use on live electrical equipment. The gas will not contaminate foodstuffs or cause a mess and because it is emitted as a gas, will not cause unnecessary damage through fierce impact as in the case of solid material eg, dry powder.	The cooling properties of CO_2 gas are limited and it therefore provides very little protection against re-ignition. Since CO_2 is a gas, drafty or windy conditions will affect its performance. The effective range of a CO_2 extinguisher is also limited. Direct impingement of CO_2 onto delicate electrical or electronic equipment could cause additional damage through cold shock. Under dry conditions, the discharge of CO_2 extinguishers generates static electricity which can be uncomfortable to the user.

5. FIXED FIRE FIGHTING SYSTEM

Fixed fire fighting system comprises of –

a) Hydrant System
b) Sprinkler System
c) Automatic CO_2 Flooding System
d) Fire Detection and Alarm System
e) Central Monitoring System

5.1 HYDRANT SYSTEM

It is the oldest and still one of the most effective systems. The entire pipeline is kept pressurize by a jockey pump which compensates for the small leakages through the glands, etc. Fall in pressure is through the pressure switch, automatically starts the jockey pump set, when the pressure reaches the desired level, it is again sensed by a pressure which switch automatically stops the jockey pump. When anyone notices a fire and open hydrant / landing valves, the pressure in the pipe network drops drastically and jockey pump set would not be able to compensate for the loss and pressure would fall further and when the pressure reaches the designated level, fire pump would start automatically. In case the main fire pump fails to start, the standby (preferably diesel engine driven) would come into operation when the pressure falls further. If diesel engine driven fire pump set cannot be installed for commercial reasons / scale of the project, the diesel generator should be adequately rated to take care of the fire pump set load and separate power supply cable should be laid directly from the generator to the fire pump set. The generator should preferably have an AMF panel for auto-start. Riser of adequate sizing and numbers as prescribed in Tariff Advisory Committee / National Building Code should feed water up to the highest landing valve. In each landing, a landing valve, houses hose boxes, branch pipe with nozzle, first aid hose reel should be installed. Yard hydrants should be installed for coverage of the ground floor from all sides.


4.2 SPRINKLER SYSTEM

A system of water pipes fitted with sprinkler heads at suitable intervals and heights designed to actuate automatically, control and extinguish a fire by the discharge of water.

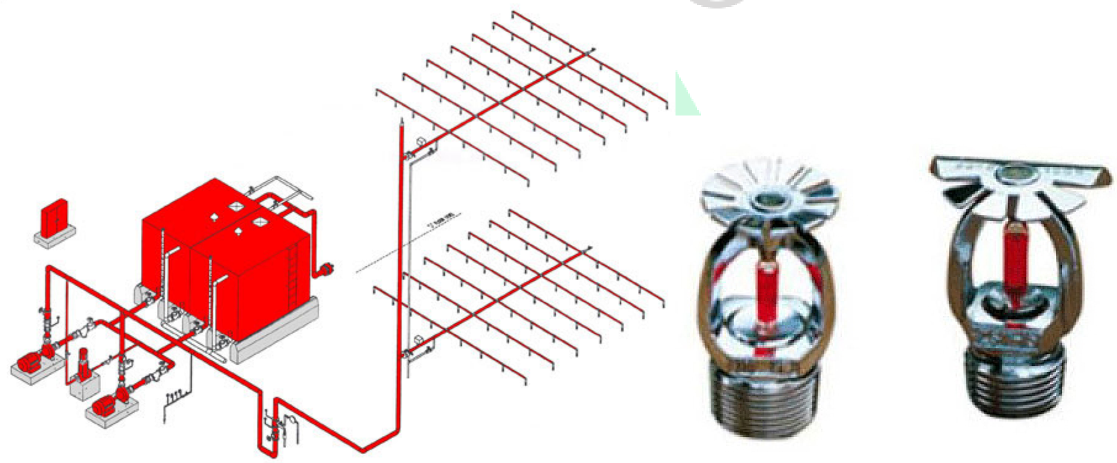
Types :

There is a wide range available of fixed protection equipment using water as the medium.

Continuing development of such systems is directed to improve the form of water application for the increasing diversity of risk and achieving extinguishments or control with the minimum amount of water. The following is a list of the main types of systems available with a brief description of the main application.

6.1 Automatic sprinklers

Although automatic sprinkler installations have been commercially available since 1882 and have since been installed in a steadily increasing range of industrial and commercial premises, it is true to say that many facets of sprinkler protection are little understood. It may be worthwhile, therefore, to describe briefly the basic principle involved. Sprinklers fixed on pipe work charged with water spaced at regular intervals installed throughout the protected building and are connected to a reliable water supply. When a fire occurs, only the sprinklers in the immediate vicinity of the fire automatically operate and discharge water to control the fire. Sprinklers are not so sensitive that they operate at a stake when prompt manual first aid operations still have a chance of success. These factors limit the damage to very low proportions. The operation of any one sprinkler causes an alarm to sound to bring help to the scene so that the water may be shut off a soon as the fire has been extinguished.



6.2 Automatic CO_2 System

CO_2 Fire Extinguishing System is the best method to minimize damage of rotating electric machinery from fire hazards and the application of this system became the usual practice in USA and Japan. By the end of 1893, a large number of rotating equipment particularly. Hydel generators were protected by CO_2 System. Among them were the 100,000 KVA generators of the Shinho Power Plant in Korea and the 75,000 KVA generators installed at the Sungari Power Plant in Manchuria As a result of experience and study, many refinements and improvements were made and many patents were taken out. The system of prolonged CO_2 discharged which is today a standard requirement because of its economy and reliability was patented by a Japanese Company in 1950.

In India we find one of the first installations in new Cossipore Generating Station (in Kolkata) of CESC for OCB s in 1953. First set of Hydel Generators were protected in Maithon.

Two Methods for Smothering Fire With CO_2

As CO_2 gas is stable and non-inflammable, a fire may be extinguished by

a) Completely surrounding the fire with CO_2 gas

b) Reducing the oxygen content of the atmosphere around the fire by the introduction of CO_2 to less than 15%.

Characteristics of CO_2 as a Smothering agent :

1) Non poisonous and odourless.
2) Electrically Nonconductive Gas.
3) Excellent power to overlay air because of its weight.
4) Economical in the cost of containers for instance, the container capacity ration of N_2 and Co_2 is 1 to 2.66.
5) Non – corrosive to metals, insulators and the brining material itself.
6) Minimum damage since the smothering action is speedy because of its rapid discharge.

Standards for Fire Fighting system :

Fire fighting system, specially the extinguishers should to be maintained, refilled, discharged, examined and tested fire per standardised methods and procedures. The following **Indian / International Standards** may be followed for the above purposes.

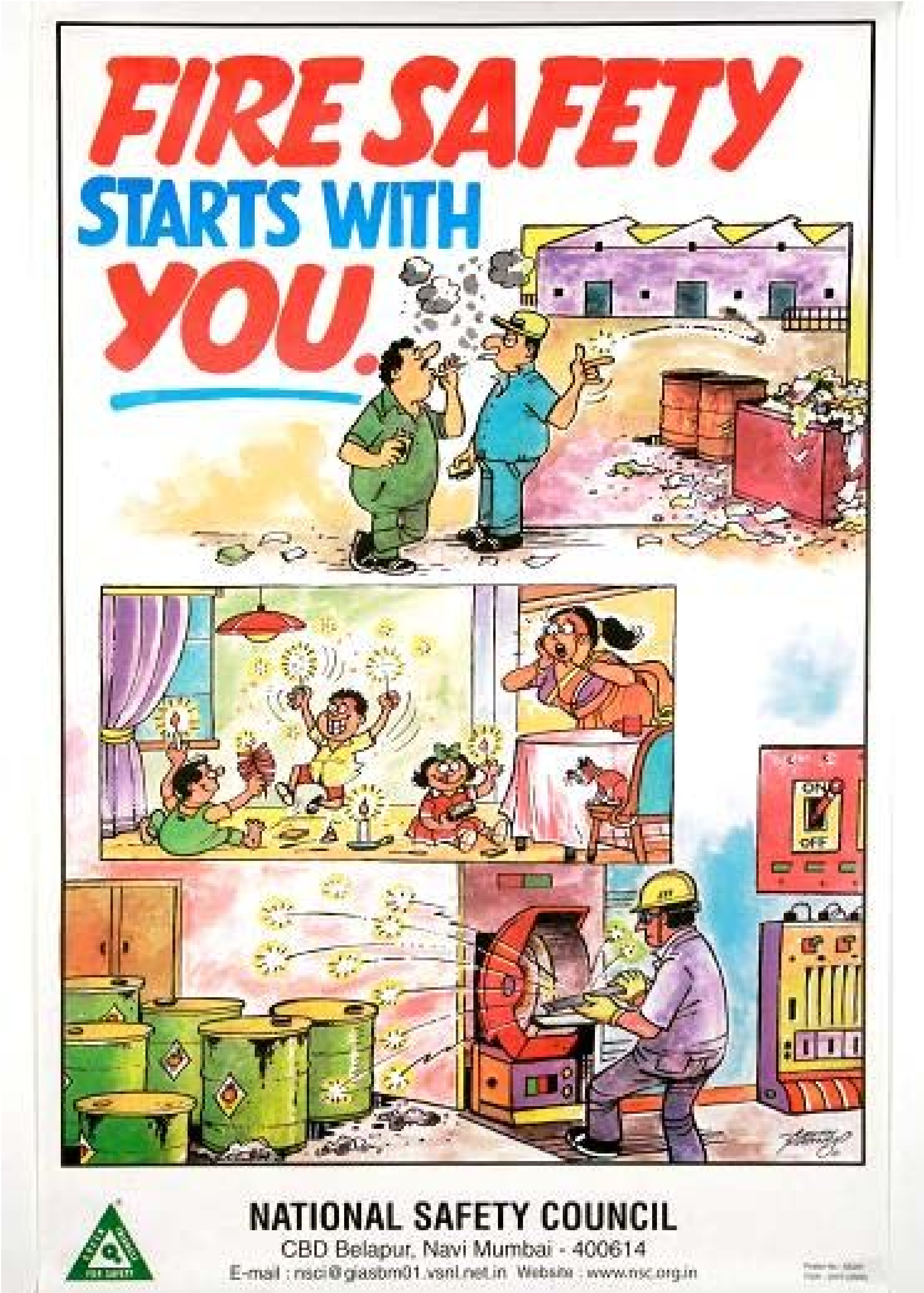
1. INDIAN STANDARDS – Some of them are listed below :

1. **IS 940:2003** Portable Fire Extinguishers Water Type (Gas Cartridge)
2. **IS 2171:1999** Portable Fire Extinguishers Dry Powder Type (Cartridge)
3. **IS2878:2004** Fire Extinguishers Carbon Dioxide Type (Portable and Trolley - Mounted)

4. **IS 6234:2003** Portable Fire Extinguishers Water Type (Stored Pressure)
5. **IS 10204:2001** Portable Fire Extinguishers Mechanical Foam Type
6. **IS 10658:1999** Higher Capacity Dry Powder Fire Extinguishers (Trolley-Mounted)
7. **IS 11833:1986** Dry Powder Fire Extinguishers for Metal Fires
8. **IS 13385:1992** Specifications for Fire Extinguishers 50 liters Wheel-Mounted Water type (Gas Cartridge)
9. **IS 13386:1992** Specifications for Fire Extinguishers 50 litre Mechanical Foam Type
10. **IS 13849:1993** Portable Fire Extinguishers Dry Powder Type (Constant Pressure)

2. INTERNATIONAL STANDARDS

11. National Fire Protection Association (NFPA) 10 Edition 2007 deals with **Standards on Portable Fire Extinguishers**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YOU.
ON
OFF
NATIONAL SAFETY COUNCIL
CBD Belapur, Navi Mumbai - 400614
E-mail : nsci@giasbm01.vsnl.net.in Website : www.nsc.org.in