Introduction to Fire & Safety Engineering

Semester VII

Course Code: 2CHOE26

L:T:P:C :: 3:0:0:3

UNIT 6: Fire Extinguishers

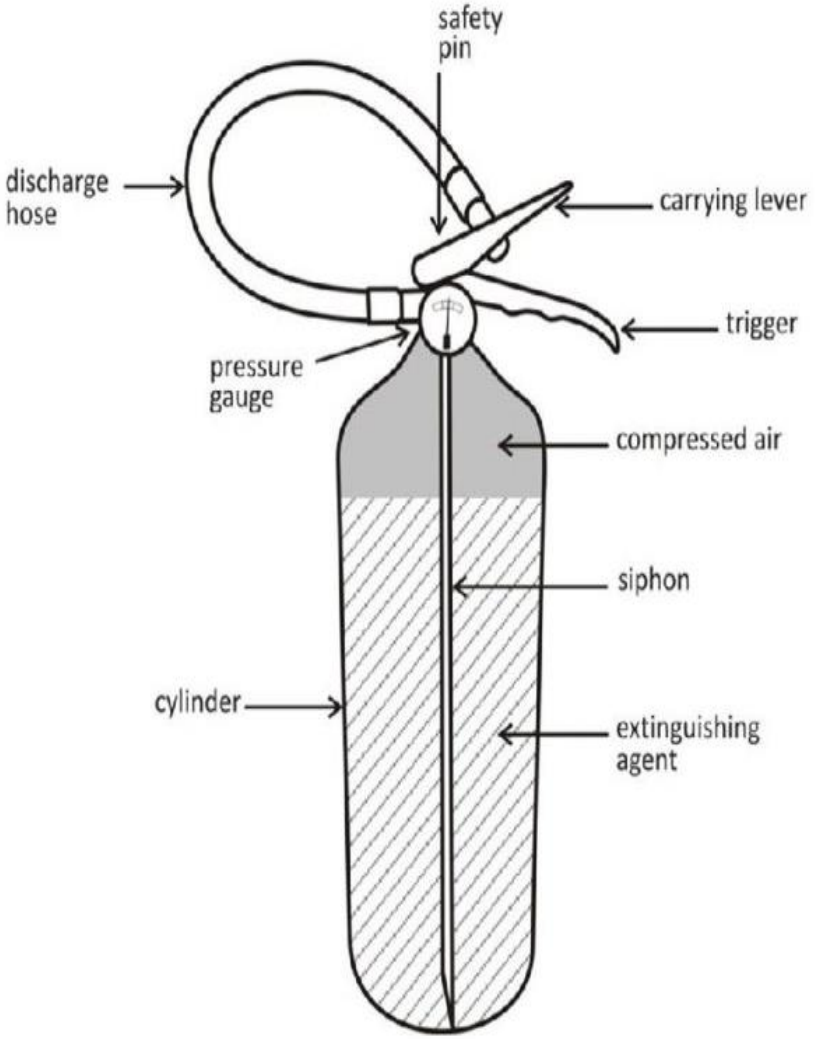
Fire Fighting Fundamentals

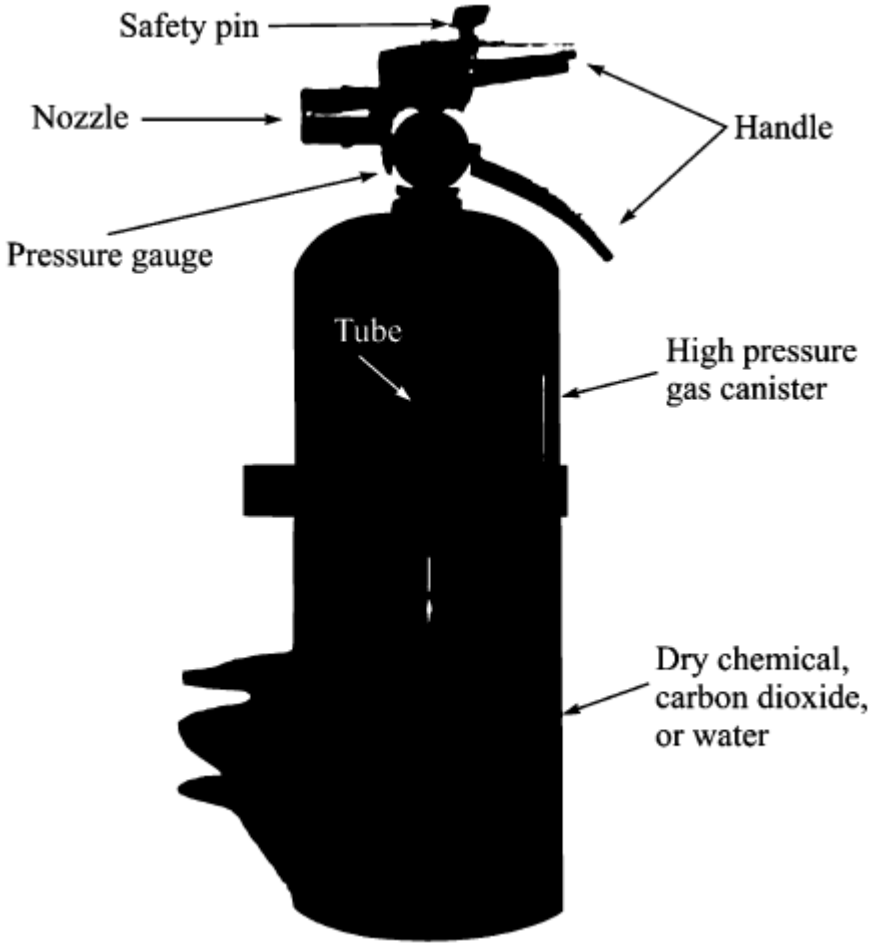
- If fire is there, the first thing one has to do is to control the growth of fire.
- For small fire, fire buckets or hand-held extinguishers can be used.
- But for a large fire, hydrants, sprinklers, fire tenders, foam tenders, CO_2 tenders or other methods can be used.
- **As per NFPA 750**:
- **Fire control** refers to limiting fire growth by pre-wetting adjacent combustible and controlling ceiling gas temperatures to prevent structural damage.
- **Fire suppression** is the sharp reduction of heat release rate of a fire an prevention of regrowth.
- **Fire extinguishment** implies complete suppression of a fire until no combustible materials are burning.

First-Aid Fire Fighting Extinguishers

- The First-Aid fire fighting extinguishers are meant for the use by the victim to fight fire before the professional fire fighters arrive.
- This is the reason why at least one trained person should be present in the premises all time to face the emergency situation.
- Fire extinguisher will remove at least one side of the fire triangle so that the fire will no longer be active.
- Different fire extinguishers are available such as: water, carbon dioxide, mechanical foam, dry chemical powder (DCP) etc.
- There are specific codes on these fire extinguishers for different types of fires and the fire fighter must understand these code, other wise the fire may get the dangerously extended over the wide area even though the fire extinguishers are used.
- The codes describes the suitability of different types of extinguishers based on the material that is burning and are classified accordingly.

- They have guidelines for inspection, testing, maintenance, recording and expiry date also.
- Different extinguishing media are suitable for different types of fuels.
- All extinguishers (except carbon dioxide) contain the specific extinguishing agent that is expelled by pressure either by gas or air contained within the shell.
- Each of the extinguisher types also has its respective specification of construction and performance.
- Larger extinguishers are mounted on trolleys for easy mobility.




Safety pin
Nozzle
Handle
Pressure gauge
Tube
High pressure gas canister
Dry chemical, carbon dioxide, or water


Valve Assembly
Release Lever
Tamper Seal
Pull Pin
Handle
Extinguishing Agent
(Inside Tank)
Hose
Propellant
(Inside Tank)
Cylindrical Tank
INSTRUCTIONS
PULL RING PIN.
START FROM 8 FEET BACK. AIM AT BASE OF FIRE.
USE EXTINGUISHER UPRIGHT. SQUEEZE THE LEVER.
SWEEP FROM SIDE TO SIDE.
ABC DRY CHEMICAL
ADVANTAGE

Common Features of Extinguishers

- The portable extinguishers contain extinguishing media that require a moving force to be expelled.
- Pressurized air or a cartridge of carbon dioxide is used in the case of water, foam or DCP.
- Specialized gas is being used to charge the metal dry powder and halocarbon extinguishers.
- CO_2 extinguishers are simply CO_2 gas cylinders and can be directly used.
- The size of these cylinders and cartridge are different accordingly the size of fire.
- There is stored pressure type extinguishers that are filled with air or nitrogen and a pressure gauge is mounted at the top of the extinguisher so that the adequate pressure can be observed.
- While actuating, the safety pin is pulled and valve lever is depressed to force out the extinguishing media through an internal siphon tube into the delivery hose and nozzle.

- The cartridge type extinguishers have a CO_2 cartridge with a sealing disc screwed to the cap of the extinguisher.
- The plunger has a piercing nail attached to it which punctures the disc of the cartridge when pushed down.
- CO_2 gas pressurizes the extinguishers up to 6-7 kg/cm^2 pressure and expels the media in the case of stored pressure type extinguishers.
- The cartridge must be weighed periodically and if the mass loss is more than 10% is observed, it must be replaced.
- After each use also the cartridge must be replaced.
- All the extinguishers look similar but they are different and used for different types of fires and hence it should be used for a specific type of fire only other wise it can damage more.
- Different mode of expelling of extinguishing media are given in the table.

Extinguishing materials	*Expelling methods*		
	Self-expelling	*Gas cartridge or cylinder*	*Stored pressure*
Water			✓
Foam		✓	✓
Carbon dioxide	✓		
Dry chemical powder		✓	✓
Clean agent	✓		

Types of Extinguishers

- Different types of extinguishers are used for different types of fires.
- Some of the extinguishers are listed below:

  - ✓ Water extinguishers
  - ✓ Foam extinguishers
  - ✓ Carbon dioxide (CO_2) extinguishers
  - ✓ Dry chemical powder (DCP) extinguishers
  - ✓ DCP for metal fires
  - ✓ Water-mist extinguishers
  - ✓ Clean agent extinguishers
  - ✓ Modular automatic extinguishers

Water Extinguishers

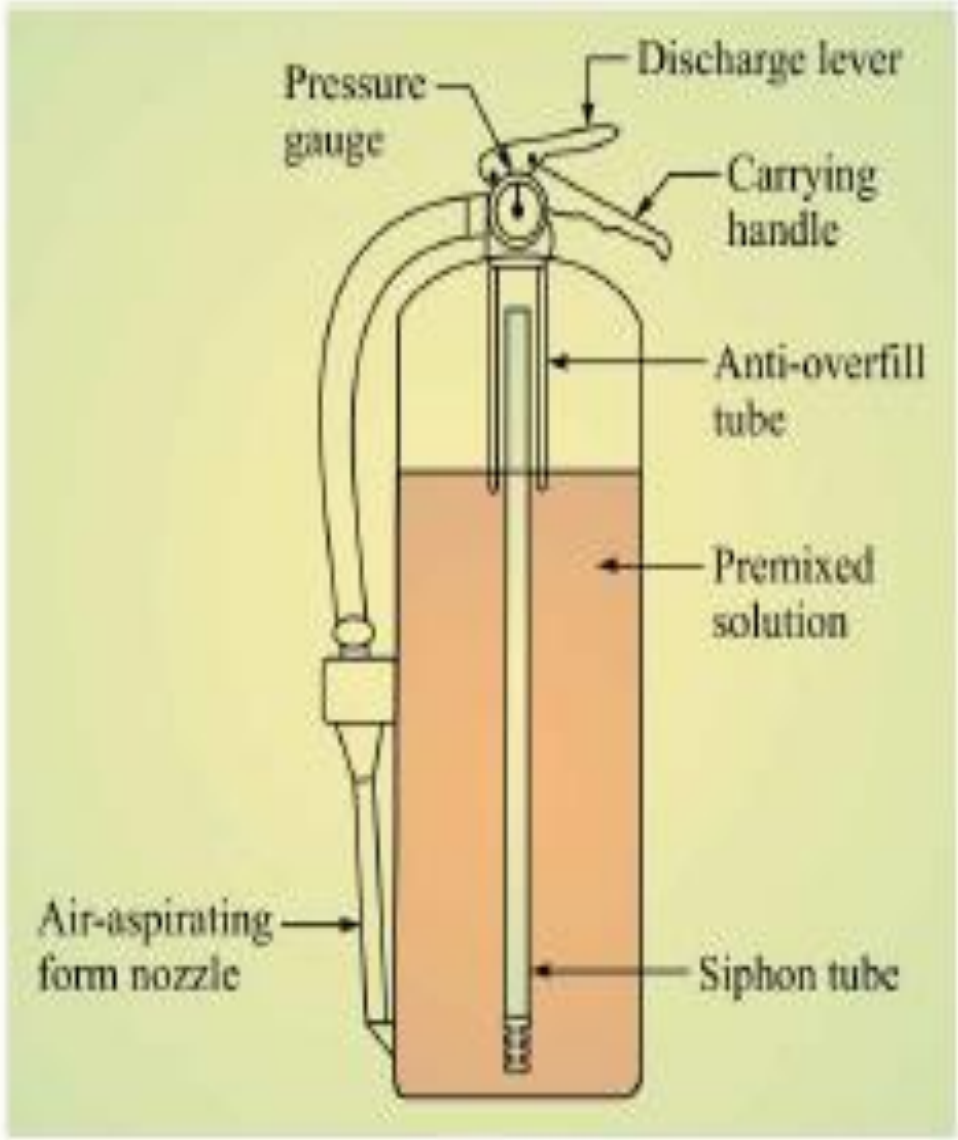
- Common combustible materials can be extinguished by cooling action and the best cooling agent is water.
- This is the reason why water extinguishers are installed in high-rise buildings is a mandatory condition for all the builders nowadays.
- This fire extinguishers can be used where Class A fires are there.
- The extinguisher shell contains water and some times additives.
- The reach of the water stream is about 6 m minimum and a 9 litre discharge should be there for at least two minutes.

Foam Extinguishers

- This is some what similar fire extinguisher to that of water type except the discharge nozzle has a small foam making branch.
- The foaming agents are mixed with water in a specific or required ratio.
- Mechanical foam is formed by the action similar to detergents.
- Previously chemical foam was used but now it is out of use or obsoleted.
- Basically foaming agents are used which are surfactants or surface active agents that reduces the surface tension of water.
- Generally foaming agents content natural proteins, hydrocarbon based detergents and fluorocarbon surfactants.
- When these agents are agitated with air and water, the foam is produced in which comprises trapped air bubbles.
- These bubbles will blanket over the burning surface and fire triangle will be lost and the fire will get extinguished.
- A special type of mechanical foam is Aqueous Film Forming Foam (AFFF) which can produce a thin blanket of water of low specific gravity and hence it can float.

- Thus in addition to removal of the fuel and air of the tetrahedron, cooling effect due to water is also very useful to extinguish the fire.
- This AFFF is also known as **LIGHT WATER**.
- In case of liquid fire, the foam extinguisher should be applied from distant wall in such a manner so that blanket is formed to cover the entire burning surface.
- If it is applied directly on liquid, the fire may spread more.
- If the liquid is an open spill and there is no distant wall the foam should be sprinkled from upward and the droplets of foam should fall on the liquid surface.
- Petroleum fractions like petrol, diesel, kerosene, jet fuel etc. are non-polar liquids and are not miscible with water, hence not to use water extinguishers.
- Methanol and ethanol mix readily with water and are polar liquids and polar solvents have the ability to break down the standard foam blankets.
- Hence, only alcohol resistant foam which are also known as AR foams should be used on fire in polar liquid fuels.

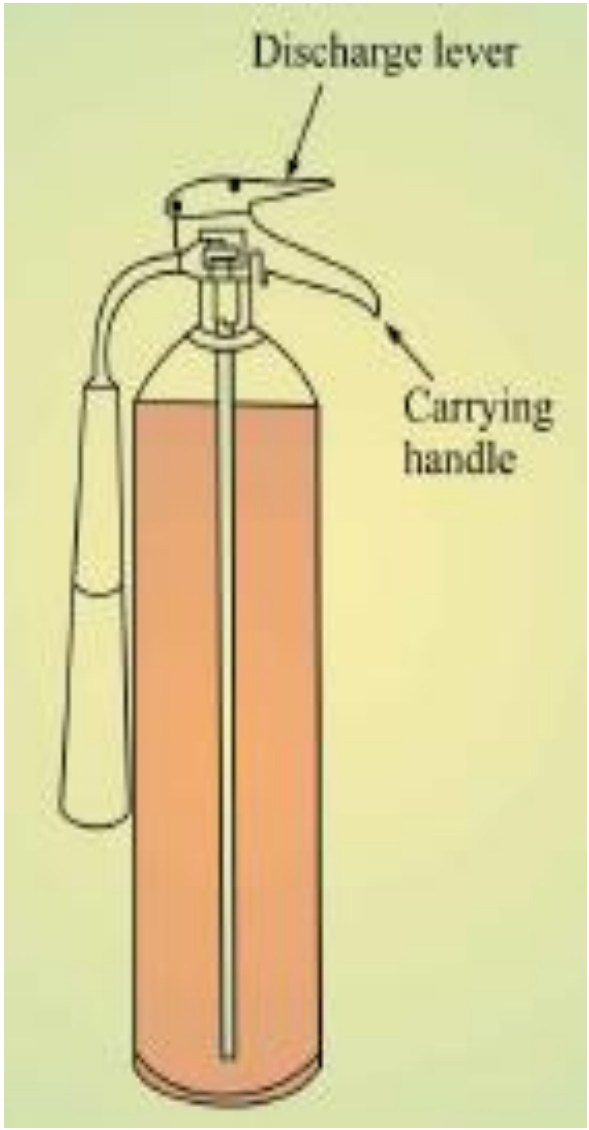

FOAM
Ultra


Pressure gauge
Discharge lever
Carrying handle
Anti-overfill tube
Premixed solution
Air-aspirating form nozzle
Siphon tube


FOAM
FIRE EXTINGUISHER
USE EXTINGUISHER UPRIGHT
PULL RING PIN
AIM AT BASE OF FIRE
SQUEEZE LEVER
SWEEP SIDE TO SIDE
A
B

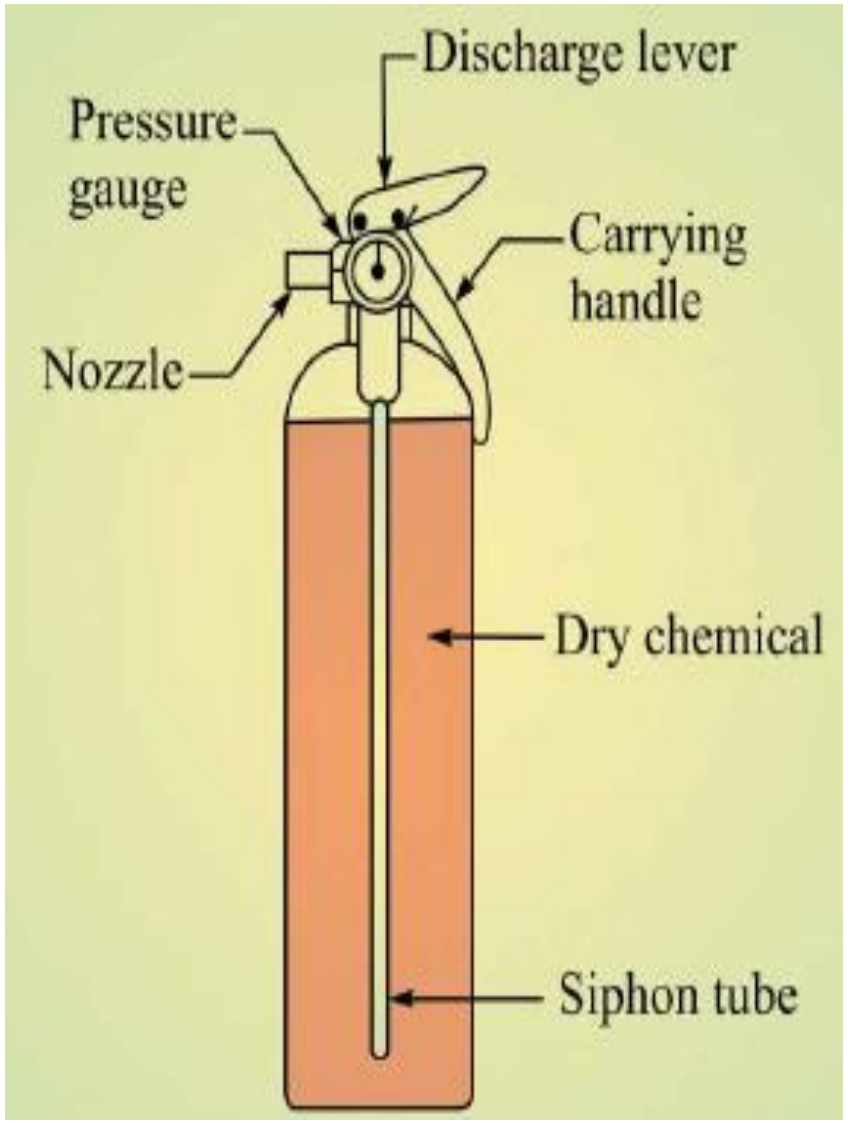
Carbon Dioxide (CO_2) Extinguishers

- These are basically CO2 gas cylinders with non-metallic discharge horn.
- The discharge of carbon dioxide over the fire acts to displace the air from the area of fire, which is one of the major requirement for fire will be lost and fire will get extinguished.
- The cylinders need to be regularly checked for the cartridges and should be weighed periodically and if the mass loss is 10% or more than that, they should be refilled or replaced.
- The Gas Cylinder Rules, 2004, by the government should be followed.

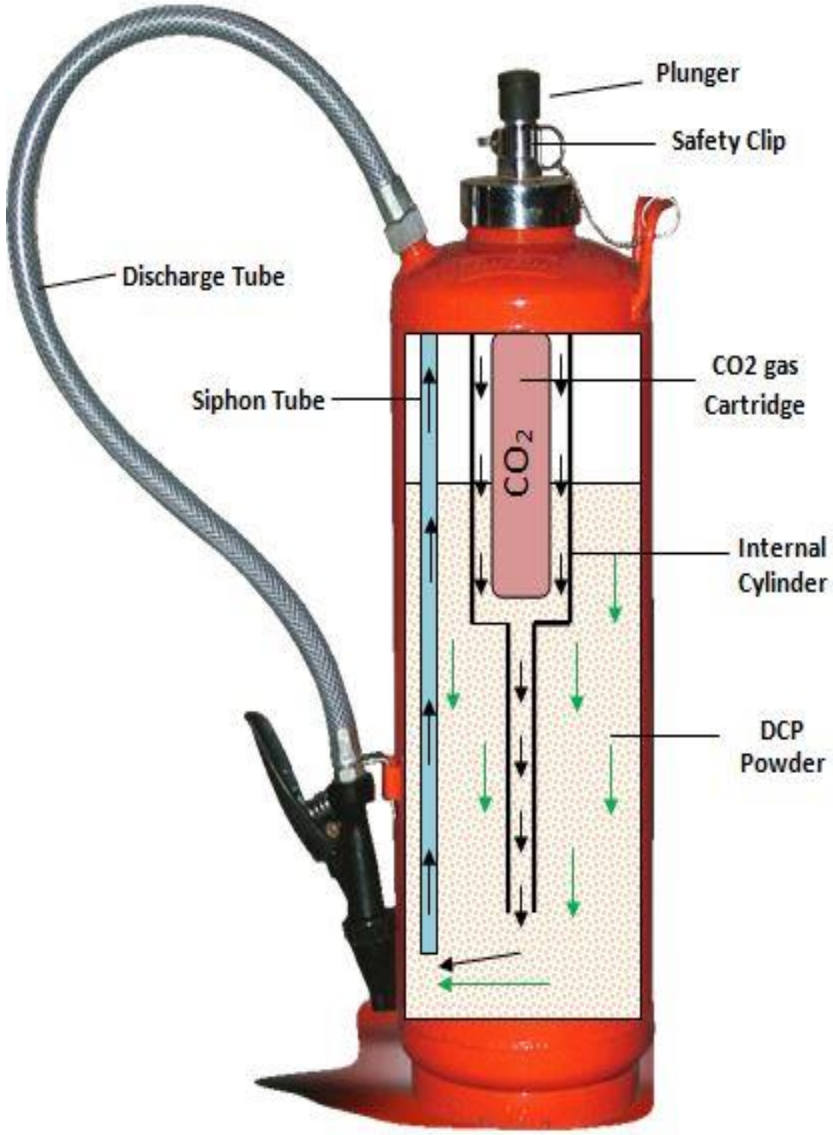


Dry Chemical Powder (DCP) Extinguishers

- The shell of DCP extinguisher has a protective coating on the inner wall.
- The extinguisher is fitted with a siphon tube connector the the body with a small length of high pressure flexible hose terminating into a squeeze grip type nozzle attached to its end.
- The nozzle is protected with a rubber cap against entry of moisture.
- The dry chemical power should be filled in the right quantity as per the capacity of the cylinder.
- This extinguisher can be used for liquid or gas fires which can have a base of sodium, potassium bicarbonate, urea, potassium chloride or ammonium phosphate.
- Sometimes DCP are mixed with small quantity of finely powdered silica to improve the fluidity and reduce the caking rate as we know that silica is also used as a primary fire extinguishers until the fire brigade comes.


Discharge lever
Pressure gauge
Carrying handle
Nozzle
Dry chemical
Siphon tube


Powder
FIRE EXTINGUISHER
Use upright
Pull out safety pin
Free hose
Aim nozzle
at base of fire
Squeeze handles
COMMANDER EDGE


Plunger
Safety Clip
Discharge Tube
Siphon Tube
CO2 gas
Cartridge
CO_2
Internal
Cylinder
DCP
Powder

Dry Chemical Powder (DCP) for Metal Fire

- Different DCPs are used for metal fire for the formation of crust, smothering or heat transfer. The DCPs are listed below.
- Sodium chloride based DCP
  - Very effective involving Mg, Na, K and Na-K alloys
  - Fire due to Zr, Ti and Al can be controlled by this type of powder.
  - The heat from the fire causes it to cake and form a crust, free of air and withdraws heat from the burning metal.
- Copper based DCP
  - It smothers the fire and provides an excellent heat sink for the Li-fire.
- Ternary Eutectic Chloride (TEC) powder
  - Ba, Na and K based TECs fuse at a low temperature to form a crust on the burning material and has very high heat absorption capacity.
  - Suited for the high intensity fires (above 1200 $^{\circ}$C) in metals like Na, K, Ca, Al, Ti, Zr and various other alloys.
  - $BaCl_2$ releases toxic product when applies on metal fire so user must use mask.

- Graphite-based Powder
  - This has been seen to be very effective for the fire involving high-melting point metals such as Zr, Ti, Na and K.
  - If there is no special extinguisher is available at the site of metal fire, even ordinary sand may be used with a long handled shovel because the traces of moisture may result in a “Steam Explosion” and spread burning molten metal around.
  - Sometime even though the portable extinguishers are available for the metal fire but, they are inadequate.
  - Hence the appropriate DCP should be available and need to be applied on fire to achieve the extinguishing effect.

Water-Mist Extinguishers

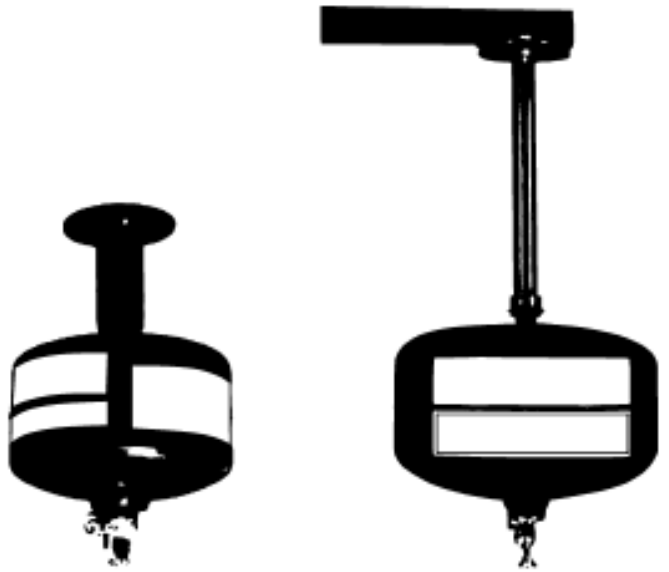
- This is water in superfine spray form which is discharged from the extinguishers as mist through the special nozzles at the end of the discharge hose.
- The droplets produced are of 25 microns diameter which is very effective in cooling fire by drawing its latent heat of vaporization.
- De-ionized water containing zero ionic species is being used in this type of extinguishers to render the mist safe for the use on live electrical equipment.
- There are no adverse effect on people's health as well as assets on using this fire extinguisher and the efficient cooling can be achieved.
- It is safe on food as well and cheap way of fire fighting.

Clean Agent Extinguishers

- From 1980-1990, Halons were the most preferred fire extinguishers but due to their ozone depleting potential (ODP) now they are banned.
- Though Halon 1211 is still permitted in aircrafts.
- Now the alternative products such as Halotron and inert gas based products are used.

Modular Automatic Extinguishers

- This is a useful innovation in the category of extinguishers.
- It contains a design quantity of extinguishing medium in a sealed container.
- The seal has a fixed temperature detector and mounted on the wall or a ceiling.
- When the detector senses the design temperature, the seal opens and the medium is discharged on fire.
- Generally these type of fire extinguishers are installed in industries, auditoriums, stadiums, multistory buildings etc.
- They may contain DCP or clean agents.
- There are many advantages of this system.
  - Detect and extinguishes fire quickly and efficiently.
  - Provides high fire protection for vital equipment.
  - Cost-effective
  - Easy to install.
  - No power supply is required.



Classification of Fires

- When faced with a fire, knowing how to extinguish it is necessary.
- Use your best judgment and proceed with caution, especially because when it comes to extinguishing a blaze or glare, identifying the type of fire will become incredibly important.
- Fires can be classified in five different ways depending on the agent that fuels them.
- Fires can be classified in five different ways depending on the agent that fuels them: Class A, Class B, Class C, Class D, Class E and Class F (also called Class K).
- All the common fire extinguishers can’t be used for any fire as it may lead to create more dangerous situation.

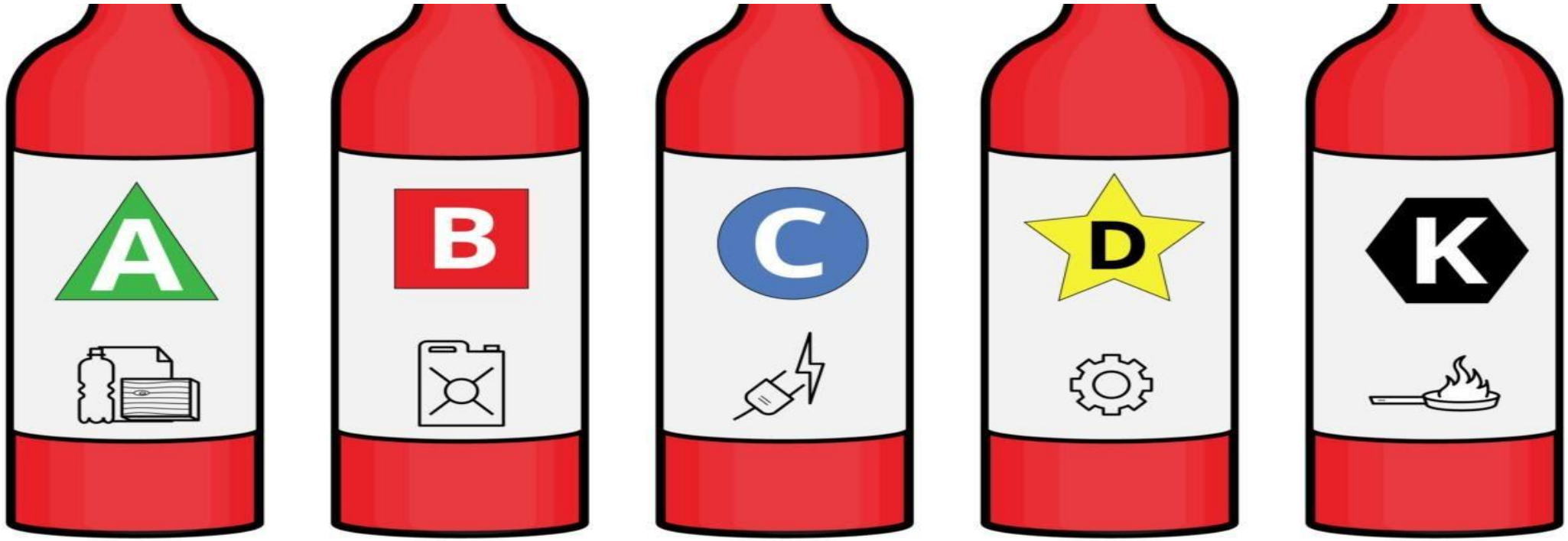
CLASSIFICATION		RISK
	CLASS A	These are fires that involve solid materials like paper, wood or textiles.
	CLASS B	These are fires that involve liquids, like oils, petrol or diesel.
	CLASS C	These are fires that involve flammable gases, such as propane, butane or methane.
	CLASS D	These are fires that involve metals, like aluminium, magnesium, titanium or swarf.
	CLASS E	These are fires that involve live electrical equipment, like computers or phone chargers.
	CLASS F	These are fires that involve cooking oils and fats, such as in deep-fat fryers.

Fire Extinguishing Agents for Different Fires

	Class A Flammable Materials	Class B Flammable Liquids	Class C Flammable Gasses	Class D Flammable Metals	Class E Electrical Equipment	Class F Cooking oils and fats
 Water	✓	✗	✗	✗	✗	✗
 Dry Chemical Powder[1]	✓	✓	✗	✗	✓	✗
 Carbon Dioxide	✓	✓	✗	✗	✓	✗
 Foam	✓	✓	✗	✗	✗	✓
 Wet Chemical	✓	✗	✗	✗	✗	✓
 Vapourising Liquid	✓	✓	✓	✗	✓	✗


CLASS OF FIRE
A
B
C
D
K


FIRE
CLASSES
A
Ordinary Combustibles
B
Flammable Liquids
C
Electrical Equipment
D
Combustible Metals
K
Combustible Cooking



- cloth
- wood
- rubber
- paper
- plastics

- gasoline
- grease
- oil

electrical fires

combustible metals

kitchen fires

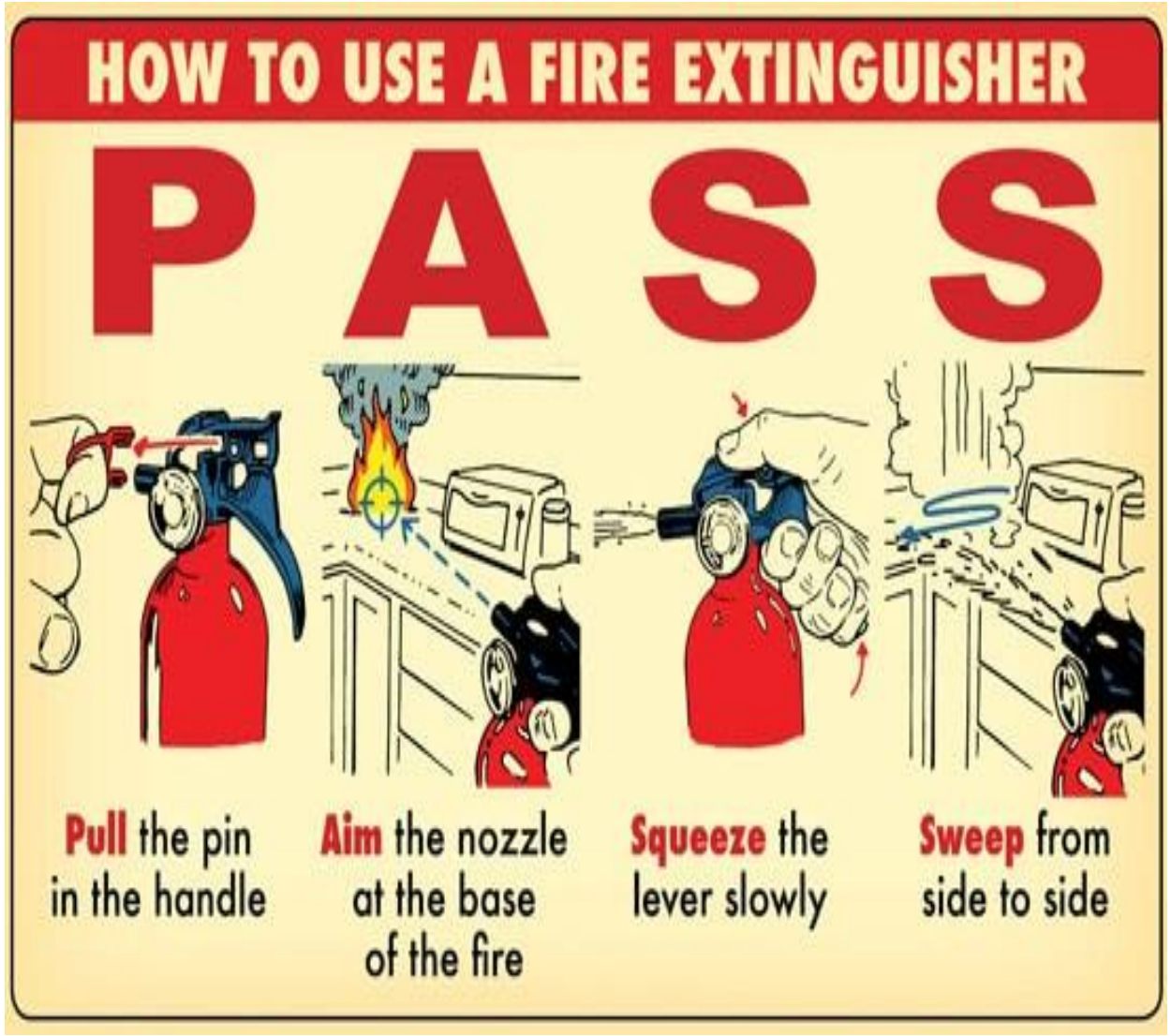
Important Note

- Gas fires can be positively extinguished only by stopping the outflow of gas.
- For fires on polar flammable liquids, like alcohol, alcohol-resistant foam should be used.
- For fires involving live electrical appliances, non-conductivity of the extinguishing media is vital and extinguishers expelling dry powder or carbon dioxide, clean agents or water mist may be used. Once the equipment is de-energized other extinguishers may also be used.
- Even though water-mist type extinguishers are available, they are not referred by International standards.
- Some differences are there in various standards.
- USA does not have class of gas and electrical fires.
- Terms Class K for Kitchen in USA and Class F for Fat in UK used, but with reference to the kitchen fires involving fat and edible oils.

Working principle of Different Fire Extinguishers

Medium	*Working principle*
Water	Apply at base of flame to cool fuel to inhibit pyrolysis and vaporisation. Must not be used on live electrical equipment.
Foam	Blankets (smothers) liquid surface, inhibits fuel vaporisation, cuts off contact with air.
Carbon dioxide	Displaces air to remove contact of fuel vapours with air; can reignite if fuel is heated to above ignition temperature.
Dry powder	Inhibits flame chain reaction; can reignite after the powder is dissipated if the fuel is heated to above ignition temperature.
Halon	Inhibits flame chain reaction.
Dry powder (metal)	The heat of the fire causes the dry powder to melt and form a crust that excludes air and withdraws heat from the burning metal. Specific powders are suited to fires in different metals and alloys.
Water mist	Draws latent heat of vaporisation from the fire and the discrete globules of deionised water offers safety during application on live electrical systems.

How to Use Fire Extinguishers (PASS Formula)



Rating of Fire Extinguishers

- The formulation of IS:15683-2006, Specification for performance and construction of portable fire extinguishers added the new dimension of rating extinguishers to indicate the size of a fire, a particular extinguishers can be used.
- The rating of a fire extinguisher is designed to help users understand the class and size of a fire in which the extinguisher is meant to be used.
- Only two classifications of fire include a number with the rating, Class A and B. Because of this, the labelling of extinguishers both with the class of fire and size of fire.
- Due to this regulations, accordingly the classes of fire extinguishers are separated.
- With the help of these codes minimum effective discharge times have been decided.

Hazard Categorization and Placement of Extinguishers

- The IS:2190-2010 recommends the installation of related extinguishers in Class A and Class B areas where in density of extinguishers and recommended travel distances are in variance with the recommendation.
- As per the regulations, for any property, the basic protection should be appliance suitable for Class A fires.
- In general water-type extinguishers are proposed and if required then the other type of extinguishers can be recommended.
- It also emphasis on fire buckets (water & sand).
- For the housing electrical equipment, at least 2 kg DCP or CO_2 extinguishers should be provided within 15 m of apparatus.
- When electrical motor with other electrical equipment are installed in a room, 5 kg DCP or CO_2 extinguishers should be installed within 15 m thereof.
- The number and placement of extinguishers should be based on a study of premises activities and location of specific hazards.

Thank You