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Hydro Fog Fire Fighting System

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Abstract:
As Fire Fighting plays a vital role in maintaining the safe working condition of the vessel without any fire hazard, it has to be adopted with advanced technologies to ensure maximum safety for the ship and the crew. Even though Plenty systems and Techniques are available for fighting the fire onboard, fire accidents are inevitable. Many researches are been carrying out by shipping industries to minimize fire accidents. This project report deals with the "Fixed Water Fog Fire Fighting System". The progress on the research and application of water mist systems in fire suppression has been substantial over the last decade. To bring this work into focus, a model is made on Total Flooding System with the application of water mist. This report also discusses the properties of water mist, extinguishing mechanisms and the effectiveness of water fog in fire suppression.

I. INTRODUCTION

Seafarers will be familiar with the fire triangle, with sides representing fuel, heat and oxygen. Removal of any side results in the collapse of the triangle and the extinguishing of the fire. Without contradicting this, it is more appropriate to use a fire tetrahedron (see figure below) to illustrate the nature of fire and, in particular, extinguishing action of modern extinguishing media such as halogenated hydrocarbons (halons) and certain dry chemicals. (NB: Halons are to be phased out due to their ozone layer depletion effects).

1.1 WATER FOG FIRE EXTINGUISHING SYSTEM

Water has favorable physical properties for fire suppression. Its high heat capacity(4.2 J/.Kg) and high latent heat of vaporization (2442 J/g) can absorb a significant quantity of heat from flames and fuels. Water also expands 1700 times when it evaporates to steam, which results in the dilution of the surrounding oxygen and fuel vapor. With the formation of fine droplets, the effectiveness of water in fire suppression is increased, due to the significant increase in the surface area of water that is available for heat absorption and evaporation.
Water mist refers to fine water droplets in which 99% of the volume of the spray is in drops with diameters less than 1000 microns. Advantages of water mist over gaseous agents are that water is non-toxic, readily available, and lower in cost than most chemicals or patented mixtures. Water mist provides effective cooling for fuel and for the compartment that cannot be provided by the gaseous agents, potentially preventing re-ignition that may occur if a gaseous agent concentration cannot be maintained for a sufficient period of time. With effective cooling and less clean-up time, water mist allows the space to be reoccupied and operational in a short time following a fire. Advantages of water mist over conventional sprinklers include reduced water flow rates and therefore less water damage to sensitive equipment or occupancies. Low water flow rates also provide a clear advantage in terms of space and weight requirement for the water supply. In addition, water mist is able to control flammable liquid fires that conventional sprinklers cannot control due to splashing and spillage of the fuel.

The use of water mist in fire suppression, compared to the use of gaseous agents and conventional sprinkler systems, has demonstrated advantages including the following:

(1) No toxic and asphyxiation problems;
(2) No environmental problems;
(3) Low system cost;
(4) Limited or no water damage; and
(5) High efficiency in suppressing certain fires.

One of the most effective ways of fighting fire is to provide quick and effective cooling at the source of the fire. To achieve cooling, suppression and extinguishing of a fire using water in a conventional way via a hose or standard sprinkler often requires many thousands of liters of water. The primary reason for this is that the vast majority of the water used is wasted; this can be seen by the amount of pools of water left on the floor, known as 'run off. This is because only the surface area of the water drop or stream comes into contact with the energy from the fire (the heat) the rest is wasted.

II. THEORITICAL DEVELOPMENT

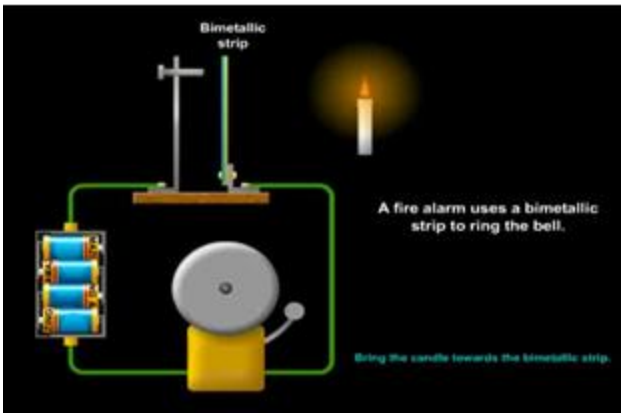
2.1 FIRE DETECTION SYSTEM USED IN PLANT

The heat detectors are mainly of two types namely,

- ✓ Fixed temperature or pre-determined temperature type
- ✓ Rate of temperature rise.

2.1.1. Fixed Temperature or Pre- Determined Type

The means of operation is extremely simple, usually being either a bi-metallic strip or a soldered joint. In the first type, the bi-metallic strip is used to make or break an electric current at a pre-set temperature. When it is arranged to make a circuit, the contacts are usually encapsulated in a glass cover to avoid the contact becoming affected by the atmosphere, since any corrosion may prevent the passage of current when the contacts are required to make a circuit. The second type may consist of two electric contacts joined through light springs by low melting point solder. Thus, when the air temperature reaches the melting point of the solder, the joints pulls apart under the action of the spring and the alarm is sounded.



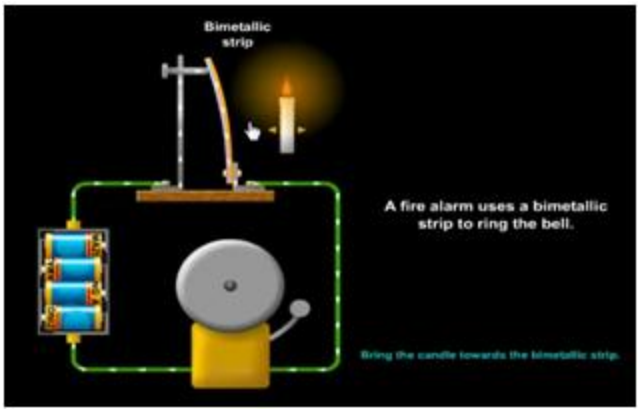


Figure.2.1 Fire Detection System-Heat Detectors Bi- Metal Strip Type

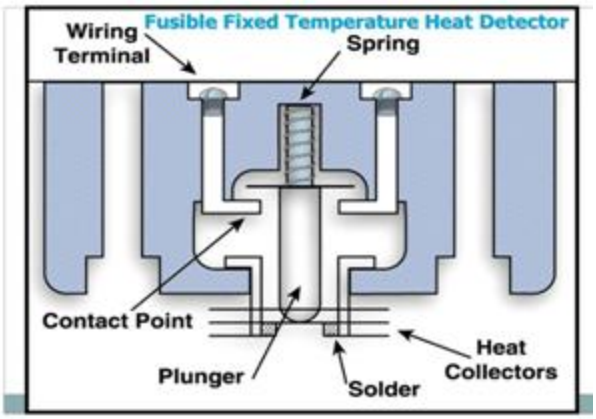


Figure.2.2. Fire detection system-heat detectors fusible link type

2.1.2 Rate of Temperature Type

- This type of detectors works on the principle that providing the rate of increase in the temperature of the surrounding air is above a given minimum, the detector will operate between given limits, the latter depending on the rate of increase of temperature.
- They are two types of detectors, namely pneumatic and bimetallic strip. o In the pneumatic type, a sealed chamber when subjected to heat expands and pushes up a flexible diaphragm and makes an electrical contact and completes the circuit for the alarm.
- To avoid alarm being raised in the normal rise ambient temperature, a bleed orifice fitted on the sealed chamber will allow a certain amount of air to escape.
- But when the temperature rise is rapid, the chamber expands more rapidly than the orifice can release the air, thus allowing the electric contact to be made for the alarm.
- The bimetallic type consists of two strips, one insulated from rapid changes of temperature and the other exposed to such changes. Contacts on the ends of the strips form part of an electric circuit.
- On slow rise of temperature, due in normal climatic conditions, the heat input to both strips is similar and hence the contacts remain apart.
- On rapid increase in temperature, the unprotected strip(responds more quickly than the insulated strip with the result that the contacts meet and the alarm sounds.

2.2 FIRE DETFCI ION SVSITNI-SMOKE DFIECTORS

The smoke detectors are mainly of two types namely,

- ✓ photo Electric Type
- ✓ Ionization Type

There are two types of photo electric type smoke &doctors namely,

- ✓ Light obscuration type
- ✓ Light scatter type

3.2.1 Light obscuration type

A beam of light is arranged to fail on a photo electric cell and if the atmosphere between the light sources and the cell is clear, the balance of the electric, circuit is not disturbed On smoke passing, by convection across the detector, however, the intensity of light falling on the photo electric cell is reduced, the change in the al output bang used to op -gyrate at a pre-determined level.

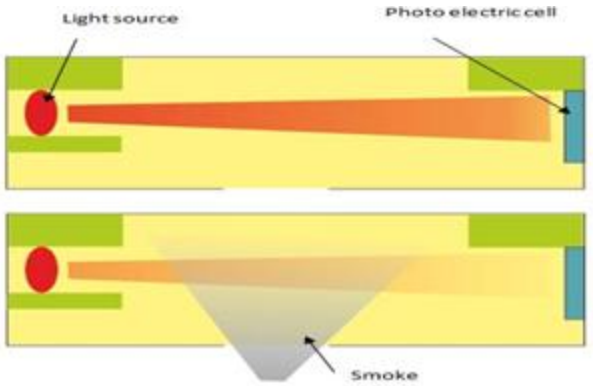


Figure .2.3. Fire detection system-smoke-light obstruction type

2.2.2 Light scatter type

When a beam of light transverse a transparent medium, e.g. air, its intensity is reduced by absorption and partially by scattering. The latter arises due to suspended partials suds as dust or liquid particles. The beam of light is prevented from illuminating the photo electric cell by a light barrier The surrounding atmosphere circulates through the detector head by virtue of the normal air currents and providing no dust Or smoke particles, present in it, the electrical bola Mt of the detector circuitry remains undisturbed On smoke entering the detector however, the light rays are or scattered around the light barrier and reach the photo electrical cell, the change in current being used to signal the alarm.

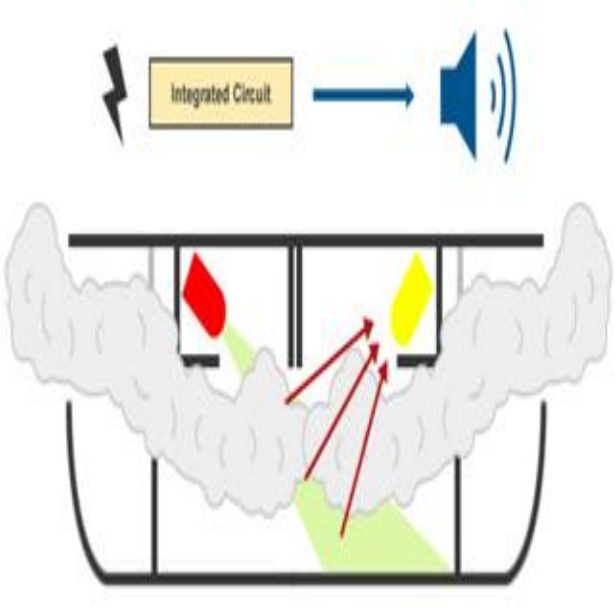


Figure .2.4. Fire detection system-smoke detectors-light scattering type

2.2.3 Ionizing Type

- When an ionization source capable of removing electrons or ions from an atom this process is known as ionization.
- Alpha rays produced from americium 241 separates the atom of N&O as N++ N+N+ and 0-, 0- they are called ions.
- It works on battery or AC current or UPS.
- Two plates connected to the battery of each terminal so one plate become positive and another plate becomes negative.

✓ Americium 241 is used as ionization source.

✓ 1/5000=1 gram is used in americium life is 432 years.

✓ It produces alpha rays which is harmless.

✓ N++ ions go to the negative plate's 0—ions goes to the positive plate.

✓ Because of the circulation, current is developed.

✓ Since the current is too small, so the amplifier is used to rise of the current

✓ Ammeter is used to measure the current.

✓ A sensor is fitted to monitor the constant current flow

✓ when the smoke enters the unit. The smoke will neutralize the ions.

✓ The sensor senses the dropping of current between the plates.

✓ It will trigger the alarm.

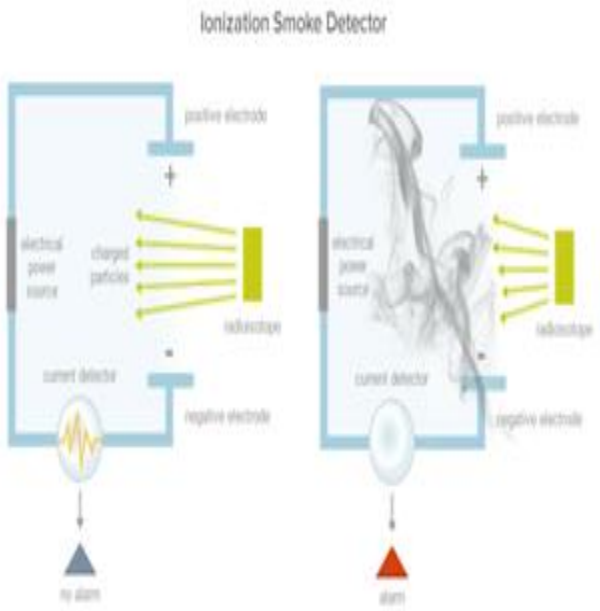


Figure.2.5. Fire detection system-smoke detectors-ionization type

2.3 FIRE DETECTION SYSTEM-FLAME DETECTORS

Detectors of this type can be of Infra-Red [IR] (or) Ultra-Violet [UV] type, but only infra-red type is used extensively. These detectors are intended to respond to radiated heat and light, and to avoid false alarms being given by natural or artificial light, they have been designed to respond only to that particular part of the spectrum which is characteristics of flame.

Functioning of IR type:

✓ Unique property for a flame 14 Hz-15 Hz.
✓ The time is 12 sec-15 sec.
✓ The filter, timer, PE cell, amp, and alarm are all place in a quartz bulb.
✓ During flame expose from the fire, the IR rays will fall on the quartz bulb.
✓ The filter will allow the IR rays having different frequency of 14Hz-15Hz per second.
✓ The filter will not allow any rays having different frequency below 14Hz.
✓ The different frequency of IR rays come from gas welding sunlight, lighting, and tungsten lamp.
✓ The timer will check the IR rays stays 12sec-15sec.
✓ The IR rays will fall the photo electric cell.
✓ The photo electric cell produced on the small amount in mille ampere (mA).
✓ An amplifier is used to send a signal, if the current produced reaches value for IR rays which originated from fire.
✓ It will activate the alarm.

Only one drawback of such detectors is that if smoke screens the detector from fire before the detector has an opportunity of sensing it, its operation is unlikely, the radiation type of detectors is normally used with other detectors.

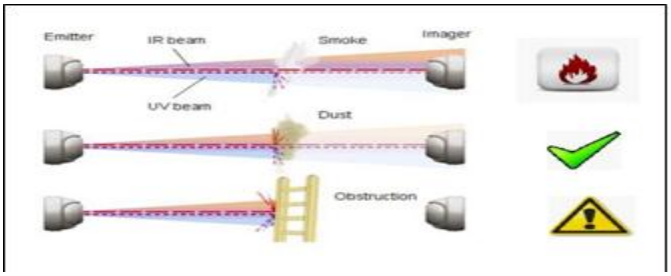


Figure .2.6. Fire Detection System-Flame Detectors-Ir Type

III. FIRE AND CLASSIFICATION

Fire is the release of heat and light from rapid combination of oxygen and other materials, It is a chemical reaction. It is involving rapid oxidation and burning of a material. For fire to exist, a combustible substance must be present, the temperature must be high enough to cause combustion, and enough oxygen must be present to sustain rapid combustion.

3.1 MECHANISM OF FIRE

The fire is sustained through a process called chain reaction.
Fuel + oxygen +Energy --> FIRE (Light +Heat+ Products of combustion)
Fire comes from a chemical reaction between oxygen in the atmosphere and sort of fuel (wood or petrol, for example). The fuel does not spontaneously catch on fire just because they are surrounded by oxygen. For the combustion reaction to happen, you have to heat the fuel to its ignition temperature.
The most flammable compounds contain carbon and hydrogen, which recombine with oxygen relatively easily to form carbon dioxide, water and other gases.
The chemical equations for the oxidation of carbon and hydrogen are:

C +0, ---> CO_2 (This reaction occurs when there is enough oxygen for the formation of carbon dioxide.)

2C +0, ---> 2C0 (This reaction occurs when there is only enough oxygen for the formation of carbon monoxide.)

2H2 + 0_2 ---> 2$H_2$0 (These reactions release the energy you feel as heat and light.)

3.2 STAGES OF FIRE

Fire may be categorized into four stages:

1. Incipient stage – invisible products of combustion giving off no visible smoke, flame or heat.
2. Smoldering stage — combustion products visible as smoke. Flame or heat still not present.
3. Flame stage — flame is present; heat not present in appreciable amount but follows almost simultaneously. Actual fire now exists.
4. Heat stage —Uncontrolled heat and rapidly expanding tire in space.

3.3 REQUIREMENTS FOR FIRE

Three things are needed to occur a fire:

A fuel —some sort of combustible solid, liquid or gas
Oxygen — to react with the fuel
Heat — there must be enough heat to get the fuel above its flash point.

3.4 FIRE TRIANGLE

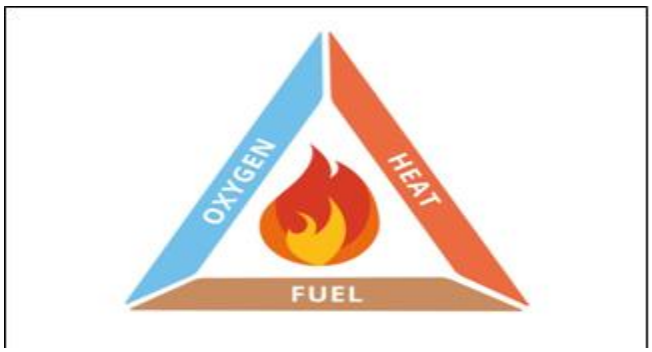


Figure. 3.1 Fire Triangle

These three components fuel, oxygen and source of heat are represented by a triangle called **fire triangle**.
Nowadays when the fire is actually taking place there are four components. They are fuel, oxygen, temperature or heat source of ignition and chemical and chain reaction. These four components can be own diagrammatically by a tetrahedron each side representing one of the components.

3.5 FIRE TETRAHEDRON

Figure. 3.2 Fire Tetrahedron

3.6 SOURCE OF IGNITION

The Potential sources of ignition are:

1. Electrical
2. Open flames
3. Friction
4. Sparks
5. Self-oxidation or spontaneous ignition

3.7 CLASSIFICATION OF FIRE (as per is-2190:1922)

- All fire is not identical to each other different techniques and media should be used to fight different fires.
- Depending upon the material involved in the fire. This classification was said by (NFPA) national fire protection agency.

  - ❖ Class A
  - ❖ Class B
  - ❖ Class C

- ❖ Class D
- ❖ Class E
- ❖ Class F (or) class k

Table 3.1source Of Ignition

SL.NO	TYPE	SOURCE
1	Electrical	Spark or arc, electrostatic discharge, short circuit
2	Open flame	Matches and lighters, pilot lights, welding and cutting torches, lighted cigarettes
3	Friction	Drive belts and pulleys, poorly lubricated machinery, impact between hard materials
4	Sparks	Engine exhausts and electrical systems , tools, shoe nails, striking other materials
5	Self oxidation/spontaneous ignition	Oxidation of combustible materials

3.7.1 Class "A" Fire

- Fires involving solid combustible materials are organic nature such as wood, paper, rubber, plastic, etc.....
- Where the cooling effect the water is essential for extinguishing the fire.

Figure. 3.3 class a fire

3.7.2 Class "B" Fire

- Fire involving flammable liquid (or) liquefiable solid.
- Where a blanketing effect is essential for extinguishing the fire.
- (e.g.) petroleum product, paint, warmish, oils, etc.....

Figure 3.4 Class B Fire

3.7.3 Class "C" Fire

- Fire involving gaseous substance under pressure including liquefied gas.
  (e. g) LPG, Methane, Hydrogen, etc….

Figure 3.5 Class C Fire

3.7.4 Class "E" Fire

- Fire involving combustible materials and reactive chemicals
  (e.g) magnesium, aluminum, zink, iron, pasporas, potassium, ect….

Figure 3.6 Class D Fire

3.7.4 Class "E" Fire

- Fire involving electrical and electronic equipment. Such as cable wires, electrical lamp, computer, etc….

Figure 3.7 Classes E Fire

3.7.5 Class "F" Fire

- Fire involving kitchen material like edible oil, etc….

Figure 4.8 Class F Fire

3.8. PHYSICAL PROPERTIES OF FIRE

- Flash point
- Fire point
- Auto ignition temperature or ignition point

3.8.1. Flash point

Flash point is the lowest temperature at which vapors or gases form on the surface of the solvent and flash upon the application of an external source of ignition.

3.8.2 Fire point

Fire point is the lowest temperature at which the fire can occur.

3.8.3 Auto ignition temperature

This is the temperature at which flammable liquids or gases will be ignited on its own without the application of external ignition sources.

3.9 CHEMICAL PROPERTIES OF FIRE

Whenever a substance undergoes chemical change by combining with oxygen, it is usually liberates certain amount of heat. The chemical change called oxidation. This oxidation is called exothermic reaction as it is evolves heat.

3.9.1 Flammable limits

Lower flammable limits (or) lower explosive limit (LEL)
Upper flammable limit (UFL) (or) upper explosive limit (UEL)

3.9.2 Flammable limits

For vapor (or) gas to burn the correct mixture of fuel and oxygen must present if there is too much or too little vapor of oxygen the fire will not occur.

3.9.3 Lower flammable limits

The minimum concentration of gas (or) vapor in air by volume below which propagation of flame doesn't occur on contact with a source of ignition.

3.9.4 Upper explosive limit

The maximum concentration of vapor (or) gas in by volume above which propagation of flame present occur on contact with a source of ignition.

3.9.5 Lower explosive limit

The minimum concentration of vapor (or) gas in by volume above which propagation of flame present occur on contact with a source of ignition.

IV. FIRE FIGHTING AND CLASSIFICATION

4.1 ACTIVE AND PASSIVE FIRE PROTECTIVE SYSTEM

- ✓ Fire protection prevention and detection of hazards associated with fire.
- ✓ The fire department is two basic fire related functions.
  - ➢ Prevention.
  - ➢ Suppression.
  - ➢
- ✓ Fire prevention activities aim to keep fires from starting.
- ✓ Fire suppression activities seek to put out fire once has started to rescue individual.
- ✓ To protect properties from the fire.

4.1.1 Active Fire Protection

- ✓ It means the system activated mechanically (or) electronically.
- ✓ Active fire protection system are those which help in extinguishing the fire directly.
- ✓ Active fire protection system are classified into two types:
  - ➢ Fixed system.
  - ➢ Portable systems

4.1.2. Passive Fire Protection

- ✓ Passive fire protection system are those which do not fight the fire actively preventing the spared of fire.
- ✓ Conations the fire in a particular area and allow for fire fighting.
- ✓ Passive fire fighting system can be provide under the following:
  - ➢ Fireproof doors
  - ➢ Fire proof walls
  - ➢ Wired glass windows
  - ➢ Fire proof cables
  - ➢ Fire proof materials
  - ➢ Dampers
  - ➢ Fire proof paints

4.2 TYPES OF FIRE EXTINGUISHER AND EXTINGUISHING MEDIUM

According to the mobility of the extinguisher, they are classified into three types namely,

- ➢ Fixed Fire Extinguishing System
- ➢ Portable Fire Extinguishing System

- Semi-Portable Fire Extinguishing System

Extinguishing Media Used in Extinguishing System

- Water
- Foam
- Powder agent
- Gaseous agent
- Vaporizing agent

- **Table 4.1 Extinguishing Agents**

EXTINGUISHING MEDIUM	RECOMMENDED FOR USE ON FIRES
Water	Wood, Paper, Textile, And Similar Materials
Foam	Wood, Paper, Textile And Flammable Liquid
Dry Chemical	Flammable Liquid, Electrical Equipment And Flammable Gases
Dry Powder	Combustible Materials
Carbon dioxide	Flammable Liquid, Electrical Equipment

V. EXTINGUISHING MECHANISM

5.1 FIRE CAN BE EXTINGUISHED IN THREE WAYS

- Starvation: cutting off combustibles
- smothering : removal of oxygen
- Cooling: removal of heat

5.2 STARVATION

- ✓ Means to deprive the burning fuel of more fuel, whereby once the fuel is exhausted, the fire will automatically die-out.
- ✓ By removing the combustible materials from the neighborhood of the fire.
- ✓ By removing the fire from the neighborhood of the combustible materials.
- ✓ By sub-dividing the burning material.

5.3 SMOTHERING

- ✓ The very small droplets in a high-pressure water mist system quickly absorb so much energy that the droplets evaporate and transform from water to steam, because of the high surface area relative to the small mass of water. This means that each droplet will expand more than 1700 times, when getting close to the combustible material, whereby oxygen and combustible gasses will be displaced from the fire, meaning that the combusting process will increasingly lack oxygen.

5.4 REMOVAL OF HEAT

- ✓ To fight a fire, a traditional sprinkler system spreads water droplets over a given area, which absorbs heat **to** the cool the room. Due to their large size relatively small surface, the main part of the droplets will not absorb enough energy to evaporate and they quickly fall to the floor as water. The result is **a limited** cooling effect

- ✓ By contrast high pressure water mist consists of very small droplets, which falls more slowly. Water **mist** droplets have a large surface area relatively to their mass and during their slow descent towards the floor, they absorb mucl˙: more energy

- ✓ A great amount of the water will follow the saturation line and evaporation, meaning that water mist absorbs much more energy from the surroundings and thus the fire

- ✓ That's why high pressure water mist cools efficiently per liter of water up to seven times better than can be obtained with one liter of water used in a traditional sprinker system

- ✓ The water mist with fine sprays was very efficient in controlling liquid and solid fuel fires, and suppressing hydrocarbon mist explosions method of generating water mist and some factors that influence performance of water mist.

5.5 WATER MIST EXTINGUISHING MECHANISM

There are two types of extinguishment was done by water mist, that as follows

5.5.1 Primary Mechanisms

1. HEAT EXTRACTION

- Cooling **of** fire plume
- Wetting/cooling of the fuel surface

2. DISPLACEMENT

- Displacement of oxygen
- Dilution of fuel vapor

5.5.2 Secondary mechanism

- Radiation attenuation

5.6 Heat Extraction (Cooling)

The cooling mechanism of water mist for fire Suppression can be divided broadly into cooling of the fire plume and wetting of fuel surface. Flames cooling by water mist is attributed primarily to the conversion of water to steam that occurs when a high percentage of small water droplets enter a fire plume rapidly evaporate .A fire will be extinguished when the adiabatic flame temperature is reduced to the lower temperature limit , resulting in the termination of the combustion reaction of the fuel air mixture. ForMost hydrocarbon and organic vapors, this lower temperature limit is approximately 1600k.The rate of vaporization of a droplet depends on surrounding temperature.

5.7 Heat Extraction (Cooling)

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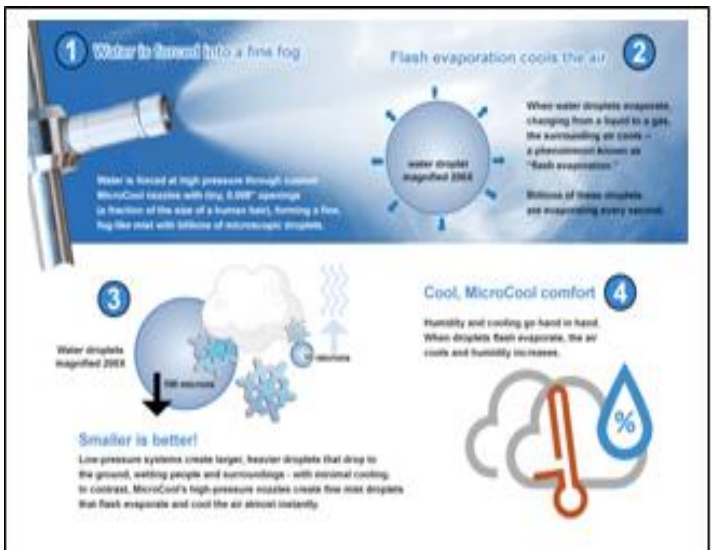

Figure .5.1 Fog Operation Model

VI. EXPERIMENTAL SET-UP

6.1 FOG MODEL

To demonstrate the fixed water fog system, a model is made with the use of following components.
1. A model compartment

2. Water misting Nozzles

3. Pipelines

4. Hand operated hydraulic line testing pump

5. Fire source

6.2 COMPARTMENT MODEL

➢ MI sheet of l mm thickness is used to prepare a model compartment

➢ MI Sheet is made into a compartment of 1200mm X 600 mm X 600mm

➢ A frame is made for both ends of the compartment for strengthening purpose by using L-angle of size 600mm X 600mm
➢ By using Metal Arc welding, the frame is fixed to the compartment.
➢ Both longitudinal ends of the compartment is kept unclosed for demonstration and observing purpose.

➢Operation : spring tensioned
➢Nozzle tip material : ceramic
➢ Number of tip : one

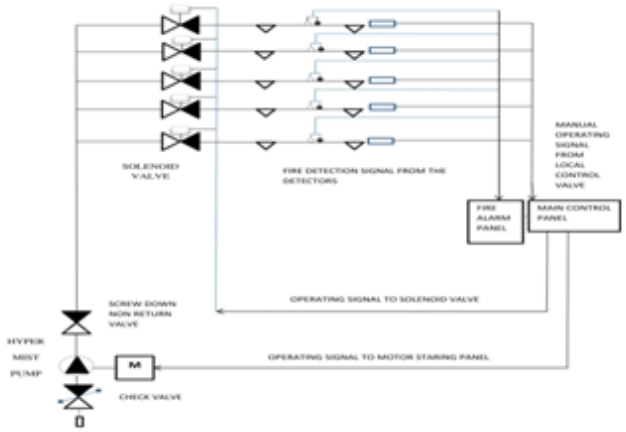

Figure .6.1. Line Diagram For Fog Model Set Up

VII. CONCLUSION

As stated by the scholars, Hydro Fog is a passive fire protection system. Since it do not fight the fire actively and prevents the spread of fire. Most may argue that the preexisting active firefighting system, the Sprinklers. But being innovatively used in high rise building, it topples the sprinklers in many ways

• Water Mist uses less than $1/4^{th}$ of water used in sprinklers
• Like sprinkler heads. Mist nozzle doesn't need any replacement after operation, It is a conventional type.
• The main advantage of Mist over any other Fire protection system is that it does not affect the appliance exposed to it.
• It won't cause any electrocution in case of any. And By absorbing the heat from the fire the water mist itself evaporate into stream hence easy to clean while other mediums take minimum of seven to nine days for cleaning.
• As stated above it reduces the wastage of water comparatively to that of sprinklers and water fall system.

The reason for using both Manual and automatic, gives the benefit of using Manual in case of any failure in automatic system. By automatic installation, the hyper mist can extinguish fire in its initial stage. And prevents fire spread to greater degree by reducing the temperature bellow auto ignition of the material. By the usage of Solenoid valve, a particular section of the entire building alone subjected to fire activate the mist system and not the entire building. With Specific requirements and specification, it can be installed in any of the buildings.

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