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ANALYSIS OF FIRE DETECTION SYSTEMS AND INTRODUCTION OF NEW FIRE PROTECTION METHODS

Kulderen Canselen

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Kulderen Canselen : Analysis of Fire Detectors and Introduction of a New Installation Method

Approval of the Graduate School of Applied and Social Sciences

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We certify that this thesis is satisfactory for the award of the Degree of Master of Science in Electrical and Electronic Engineering

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Abstract

Fire is the most dangerous hazard ever known to mankind. Once it started it is very difficult to stop it. It spreads very quickly and destroys everything where it contacts upon. Many lives, properties and valuable belongings are lost because of it. Even if it is extinguished it's scars remain there for a long time, i.e.: through loss of valuable assets, priceless memories, etc.

Depending on the funds available some of the valuable assets may be replaced but some of them which have sentimental values may never be replaced and they are there to stay, probably a lifetime.

It is for this reason that prevention of fire, before its outbreak is very important. With certain measures great fires can be prevented before they can occur. The Great London Fire happened to be one of them.

Fire sensing and suppression techniques are the methods that developed by mankind to act on the spot or just in time before their commencement in order to stop it completely or prevent its spreading further which may end up with devastating results. The objectives of this thesis is to introduce an in-depth knowledge about the building fire warning systems for those who intend to get some knowledge relevant to the subject. The task incorporates an analysis relevant to the detection and warning systems and an in depth study on fire protection equipment, their working parameters and application methods.

CONTENTS

INTRODUCTION

Detection and alarm systems are that part of the electrical installation, that are increasingly integrate with the Building Management Systems. In the last decade heating, ventilating and air-conditioning systems are used as part of the control of the movement of smoke and for presurisation of stairwells and escape routes. Active fire fighting and fire suppression systems are part of the services installed in a building.

This project studies the nature of the fire, the characteristics of some products of combustion and mainly the fire detection and warning systems.

First chapter gives an overview the nature of the fire, some combustible materials, definitions and example calculations of the fire load, propagation of the smoke, types of sensing elements, the role of infrastructure of the building involved in a fire, toxicity of the materials, methods of movement of smoke within the buildings, and the basic structure of a fire detection system.

Second chapter deals with the fire sensing and warning systems. It describes the conventional systems, digital and analogue addressable systems, wireless systems and air sampling systems.

Chapter 3 analyses the methods of detection and the methods warning algorithm. In the range of the devices used for the fire detection and warning systems are the Ionisation, Optical, Heat, Infra red and Ultra violet detectors.

Chapter 4 looks into the Fire Control Systems and their behaviour. The investigations cover the Central processing units, input output ports, visual warning systems, external communication systems, sirens and public address systems.

Chapter 5 studies the design principles of the detection and warning systems. In the analysis, the selection of various detection devices, their configurations, their testing and their protection criteria considerations relevant to fire risk factors are discussed.

Chapter 6 Analyses the risk factors in buildings and in various enclosures. It looks into the reasons of fire breaks in general areas and where the customers rooms are concerned.

Chapter 7 discusses the passive and active protection measures. It lays down the administrative and management responsibilities relevant to the steps required to be taken in order to achieve the needed protection in their establishments.

Chapter 8 discusses the software used in the detection and warning systems and the master command centre and their related equipment.

Chapter 9 concludes the dissertation.

The aim of this thesis is to analyse the existing fire detectors that are used in many public buildings and introduce a new approach method that will reduce the level of faults in fire fighting activities.

CHAPTER 1

1. FIRE PROPAGATION IN BUILDINGS

1. 1. Overview

Fire is the most devastating phenomenon ever known to mankind. Its potential exists every where when flammable environment exists in the vicinity. Three elements are required to cause fire; heat, oxygen and burning material. Almost all materials on earth can burn provided they have the right ambience. Steel will burn at temperatures over 1500°C as in oxy-propane cutting. It can even been ignited under ambient conditions, e.g: in the form of steel wool across a 6 or 12 v battery, ignition in the powder steel form, etc. What about the liquids? Do they also burn? As a general rule liquids do not burn. When they become vapour, it is this form of the liquids that will burn when they mix with the air. The heat of this combustion evaporates more of the liquid to provide a continuing supply of vapour which enables a source of combustion. Certains mixture even cause explosions, e.g: natural gas or propane, in a closed environment.

This chapter projects the fire propagation in buildins, the combustion materials and their calorific value in a fire, the methods of determination of a fire load in building, the toxidity value produced in a fire, spreading and movement characteristics of fire and smoke. It also introduces the devices that are used in protection from fire.

1.2. Combustion of Materials

The heat produced by the combustion of a material is called 'heat of combustion' or 'calorific value' of the material involved in a fire. The combustion of a material is usually measured in MJ/kg. Typical values of some materials are:

Soft wood	22.5 MJ/kg
Hard wood	19.0 MJ/kg
Paper	17.6 MJ/kg

Kerosine	39.4 MJ/kg
Propane	46.3 MJ/kg
Polyethylene	48.4 MJ/kg
Polystyrene	41.8 MJ/kg
Polyurethene	35.2 MJ/kg

It is very likely to come across all these materials in a public building or several of them. The fire load of a building is evolved from burning of all these materials[1].

1.3. Fire Load

It is the heat that the structural nature of a building should withstand. This is where assessment of fire load becomes very important. The fire load of a building is the total combustible material present in a building including any combustible sunstances in the structure of the building. The density of this load can be calculated by the division of the combustible materials present in the area over the total floor area, i.e.: say, the area have:

Soft wood	10 kg
Hard wood	15 kg
Polystyrene materials	8 kg
Polyurethane materials	12 kg

Dimensions of the room are:	width	5 m
	Length	6 m

Determination of the fire load of that area of the building would be:

Soft wood	10 × 22.5	= 225	MJ
Hard wood	15 × 19.0	= 285	MJ
Polystyrene materials	8 × 41.8	= 334.4	MJ
Polyurethane materials	12 × 35.2	= 422.4	MJ
Total heat that will be created		1266.8	MJ

Area of the room $5 \times 6 = 30\ m^2$

Then the density of the fire load will be:

$$1266.8 \div 30 = 42.23\ MJ/m^2$$

Fire loading in a building gives the level of the fuel available for the fire in case of such event.

1.4. Toxicity

The smoke produced by fire will vary in both, from fire to fire and with time at the same fire. The gases just above the plume of fire is composed of:

a) hot vapour and gases given off by the burning material
b) unburnt decomposition products and condensation matter which may vary in appearance from light colour to black and sooty
c) air heated by the fire is carried along the plume of fire

The mass of smoke produced is given by:

$$M = 0.188\ Py^{3/2}$$

Where M is the mass rate of smoke production (kg/s)
P is the perimeter of the fire (m)
Y is the height of the clear space above the fire

In the calculations below, the density of air at 17°C may be taken as $1.22\ kg/m^3$.
Using the law of gases we can convert the given mass to a volume in Kelvin (K):

$$1.22 \times (290/(T+273))\ kg/m^3$$

In practice it is not so easy to calculate the volume of the smoke as indicated earlier but it will give us an idea with what we are dealing with. The lethal effects of the combustive products of a fire are the functions of temperature and toxic components in the smoke. The toxic products found in the smoke will depend largely on the nature of material which is burning.

The following permissible quantities for short term exposure (i.e.: 10 minutes) are taken from the "Occupational Exposure Standards":

Carbon monoxide		300	ppm*
Nitrogen oxide		5	ppm
Hydrogen cyanide		10	ppm
Acrolin		0.3	ppm
Sulphur dioxide		5	ppm
Halogen acids:	HCl	5	ppm
	HBr & HF	3	ppm
Phosgene		0.1	ppm
Ammonia		35	ppm
Benzene		15	ppm
Isocynates		0.07	ppm

* ppm : parts per million

These figures therefore can be taken as a mesure in designing or calculating the safety factors.

1.5. Spreading of Fire

Fire is spread from the room in which it started towards the rest of the building, through conduction, convection and radiation. Heat can be conducted through walls, doors and structural steelworks to cause ignition of flammable materials in other places. The plume of hot gases from the fire is not confined and will be spread by convection along any routef it can find, i.e.: corridors, stare cases, lift shafts, service ducts and cavities. Openings will allow radiated heat to transfer the fire to other rooms and other buildings.

1.6. Movement of Smoke

Smoke in the buildings moves pertinent to the following reasons:

a) it is hot and therefore floatable because its dense is lesser than the surrounding air

b) The smoke in the rooms draw large quantity of air in order to support its combustion, causing movement of smoke at a high rate

c) Under normal conditions there is a normal movement of air within the building. This movement, albeit to modified effects of the fire, still will continue to move within the building, causing smoke to move also.

1.7. Precautions Against Fire

In order to protect the people and the property from the hazards caused by fire, certain precaustions are necessary to be taken before the construction, during the construction and after the construction throughout the lifetime of the building.

In line with this requirement, governments of many countries are introduced certain Fire Safety Legislations and Regulations to make sure that such steps are taken and enforced in time and where necessary.

This thesis investigates the fire detection and warning systems that can be installed in the buildings as a measure to fullfil the legislations and regulations as well as the protection of the occupants and their possessions in the public buildings.

In the investigation of the methods applied for the protection of the buildings the methods of operation of the following sensing equipment are analysed.

a) Smoke detectors
b) Infra-red detectors

c) Ultra-violet detectors
d) Heat detectors
e) Ionisation detectors
f) Optical detectors

1.8. Basic Protection Concept

It is the nature of that threat that forced the mankind to develop certain techniques to protect themselves and their properties from fire. Many techniques were developed throughout the history. The earlier techniques were not very advanced but today technology is so advanced that fire can be detected much earlier that it can happen. Technology is still working on much more advanced techniques that already exsists. The huge industrial places, hotels, etc. are using these new technologies to sense and warn and suppress the fire on the spot.

The most important property of the fire sensing and warning systems is to sense the fire in a short time or even earlier than that and inform the exact location of the fire and take action to suppress it. Before investigating these systems in detail it is convenient to have a look at the basic structure of these systems. A fire sensing and alarm systems (FİSAS) has three basic parts.

1- Input Devices
2- Processing Unit
3- Output Devices

This chapter presented the fire propagation in buildings, the combustion materials and their calorific value in a fire, the methods of determining the fire load in building, the toxidity values produced in a fire, spreading and movement characteristics of fire and smoke. It has also introduced the devices that used in protection from fire that will be discussed later on in detail.

CHAPTER 2

2. FIRE SENSING AND WARNING SYSTEMS

2.1. Overview

Fire sensing and warning system is a programmable control system that sense the formation of a fire, before or just it is beginning to start and take necessary precautions, send signals and commands to the related systems and centres for evacuation or for extinguishing. Figure 2.1 shows a complete system relevant to the subject.

The chapter describes currently available conventional systems that are commonly used in many buildings and their addressing possibilities and highlights the differences in digital and analogue addressing concepts. It introduces the wireless warning systems, their methods of communication and the places they are used. It also discusses the air sampling systems and how they are used in early warning systems.

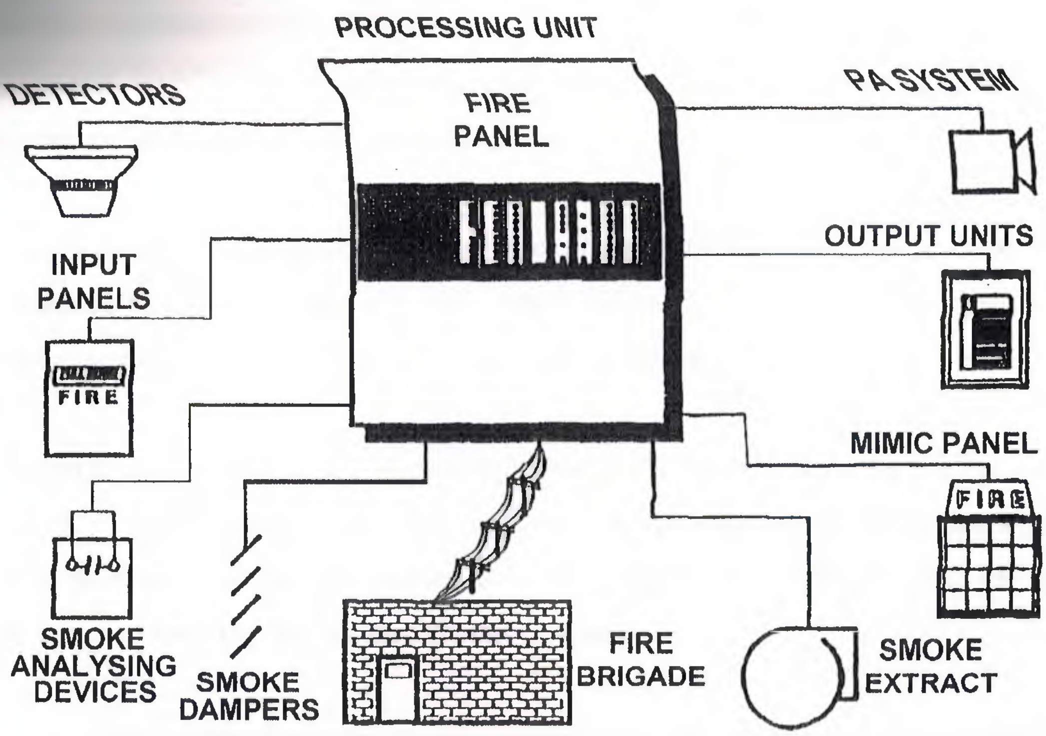


Figure 2.1. General concept of the Fire Detection and Warning System

Generally a fire sensing and warning system should carry out the following tasks:

- Accept the data coming from manual and automatic warning devices and evaluate it accordingly.
- Show the signals on the control panel by sound or light.
- Follow the system continuously and show the faults on the panel by light and sound.
- If a warning signal is present activate the warning and output devices.

It is possible to separate the fire sensing and warning devices into three groups.

1- Conventional systems.
2- Systems with addresses.
3- Air sampling systems.

2.2. Conventional systems

The sensors used in these systems are two positional devices. They keep their normal position as long as electrical energy is applied.

In conventional systems, the sensors are grouped to form areas and each area is connected to the control panel with a separate line. (Figure 2.1) By this system panel can sense and view only the area but not the exact place.[8]

To find the source of fire it is necessary to search the specific area. As it is necessary to do this in a short time, some limitations are applied while forming the areas. There are some international standard limitations for this purpose. e.g. Not to exceed 20 sensors per area and limit the area in specific meter square.

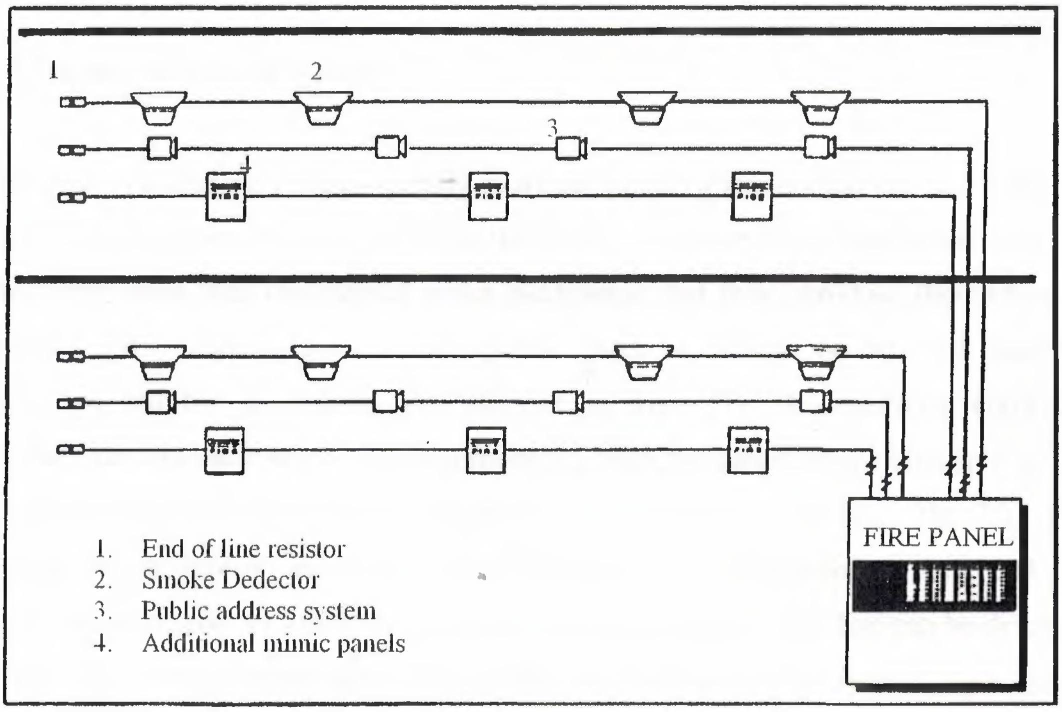


Figure 2.2. A conventional fire detection and warning system

It is possible that some doors may be locked in the area of fire and this may delay the action to extinguish the fire. This is the reason why each door in places like office buildings should have parallel warning lamps outside. These lamps will be connected to the sensors inside the room and help to detect the specific place of fire.

One of the properties of the panel is that it senses the faults on the cables if a short or open circuit is present and gives warning.

Detectors are two positioned devices but they inform the panel as normal, alarm and fault per area.

In order to have continuity in controlling a line tree like structure should be used for the lines. While cabling no tree like structure is used for conventional systems all devices are connected to each other as input / output [4]. One of the disadvantage of the conventional systems is that the two command sensors loose their sensitivity in time due to the dust. If periodic maintenance is not done, they may give false alarm. The conventional systems have low initial cost for the small and medium size buildings. [5,7]

2.2.1 Digital Addressed systems

Addressed systems are technologically more advanced systems than the conventional systems. Each sensor in this system has the ability to communicate (digitally) with the panel. They have their own digital codes (addresses) that they introduce themselves to the panel. This is the reason that the specific place of fire can be detected from the panel. The number of sensors per line differs from 50-128 depending upon the manufacturer. As each sensor can communicate with the panel independently it is not necessary to seperate the building into areas while cabling (instullation) (fig. 2.2). The grouping of the sensors are done by the software while programming the panel. As panel is scanning the sensors in sequence the sensors having a fault line can be detected immediately. It is possible under this circumstance to have a tree like structure. Some manifacturers are not allowing the tree like structure as their communication technologies differ. The most important advantage of this system is that it is possible to detect the exact place of fire. They are more costy systems than conventional systems from the materials they used. But they are more economical systems from installation point of view and into parallel warning lamps are necessary.

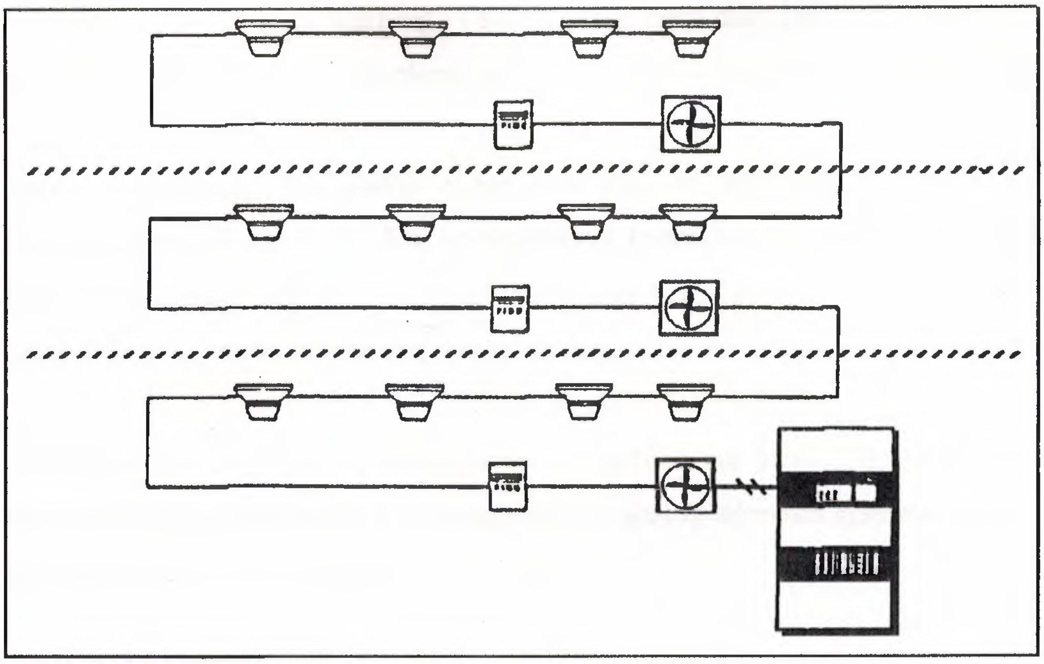


Figure 2.3. Addressable fire detection and warning system

Without loosing the advantages of this system an intermediate system called group adressed system is formed which is more economical system. For example in large meeting rooms or hallways where more than one sensors are necessary the sensors are given the same adress. In some cases conventional sensors are connected to a special adressed sensor and in some cases a group of sensors are cennected to the same adress. [4,5,6,7,8,10]

2.2.2. Analogue Addressed Systems

In both cenventional and adressed systems the sensors send either normal or warning signals to the panel. In analog adressed systems there is a different approach. In this system the amount of smoke or heat measured is send to the panel. The panel collects the data from sensors and compares with the data in the software. For each sensor a different level is determined.

e.g. in a smoking area in order to prevent false alarms a different smoke level is determined. (low sensitive sensor). In areas like computer rooms (high sensitivity) out of working hours when the building is empty it is possible to increase the sensitivity of the panel to achieve an effective protection. It is possible to get a prewarning before the smoke reaches the level of warning. This way the user may have an idea about the abnormality and have a chance to check before warning is given for the whole building.

As panel is following the analog value measured by the sensors it may give a maintenance warning due to the dust accumulation. Instead of cleaning all the sensors it is possible to clean only the sensors that panel tells us to clean. This is very adventageous in the buildings having many sensors.

For this reason the usage of the analog adressed systems are increasing treamendously. As almost all the manufacturers start producing the analog adressed systems the cost fall to digital adressed system levels. [4,5,6,7,8,10]

2.2.3. Wireless systems

In these systems the sensors communicate with the panel through a small transmitter. Power is supplied through a battery. They have high cost but device placement is very easy.

e.g. Historical buildings instead of installing cables which may damage the building wireless system is prefered. [1,9]

2.3. Air sampling systems

These systems are produced as a result of a new sensing logic. In all the sensing systems the smoke should reach the sensor and the density should be at a specific level. The logic here is to pull the smoke to inside the detector with holes on it. It is composed of a pipe system (determined by a flow calculation) and an inspiratory unit and sensing unit. The pipe system is istalled inside the room. When aspirator is working the samples from the medium comes inside the sensing pool. The smoke analysis is done here and if the smoke is above the level predetermined warning is given. Different analysis systems are used by the manufacturers.

e.g. Xenon lamp

Laser beam

It is better to use these systems in high ceiling buildings and computer rooms. It is proved that it is 1000 times more sensitive than point to point sensor systems and also it is 15000 times faster sensing system than the conventional systems. [2]

2.4. Summary

In this chapter the currently available conventional systems that are commonly used in many buildings and their addressing possibilities are discussed. The differences of digital and analogue addressing concepts has been highlighted. Further the wireless warning systems, their methods of communication and the places that they are used have been introduced. We also discussed the air sampling methods and how they are used in early warning systems.

CHAPTER 3

3. FIRE DETECTION DEVICES

3.1. Overview

This Chapter mostly cover the fire detection devices. Most of the mechanical and electrical structure and the installaetion of fire detection devices, like ionization smoke detectors, optical smoke detectors and heat detectors are investigated and their characteristics are highlighted.

The chapter also discusses the method of construction of various detectors and their usage. Additionally it looks into their method of installation and the points required to be observed in installation and in their configuration.

3.2. Ionisation Smoke Sensors

This type of sensors are formed by two electrodes excited by a voltage with Americium 241 radioactive source placed in between the electrodes. (fig. 3.1) The * alpha particles spreading from Americium 241 ionize the air in ionizing cell. The positive and negative ions formed more towards the electrodes and as a result 2 x 10 ampere current flows.

Ionizing cell is effected by the weather conditions (humidity, atmospheric pressure, wind etc.). This is the reason why the ionizing cell is seperated into two parts as reference cell and open cell. Reference cell is half closed effected by only the weather conditions (fig. 3.2-3.3)

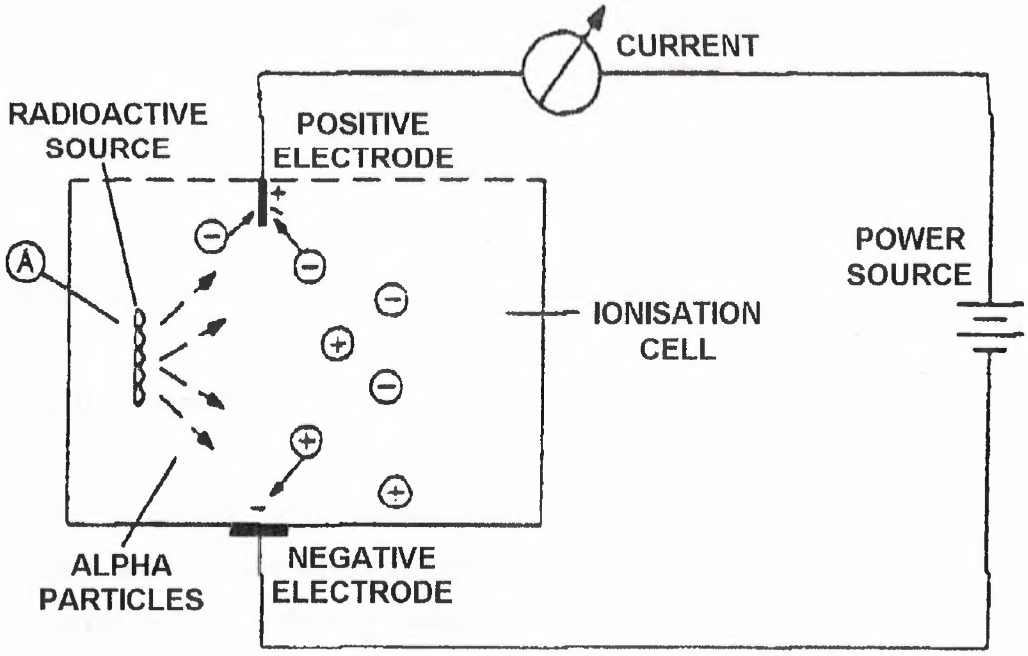
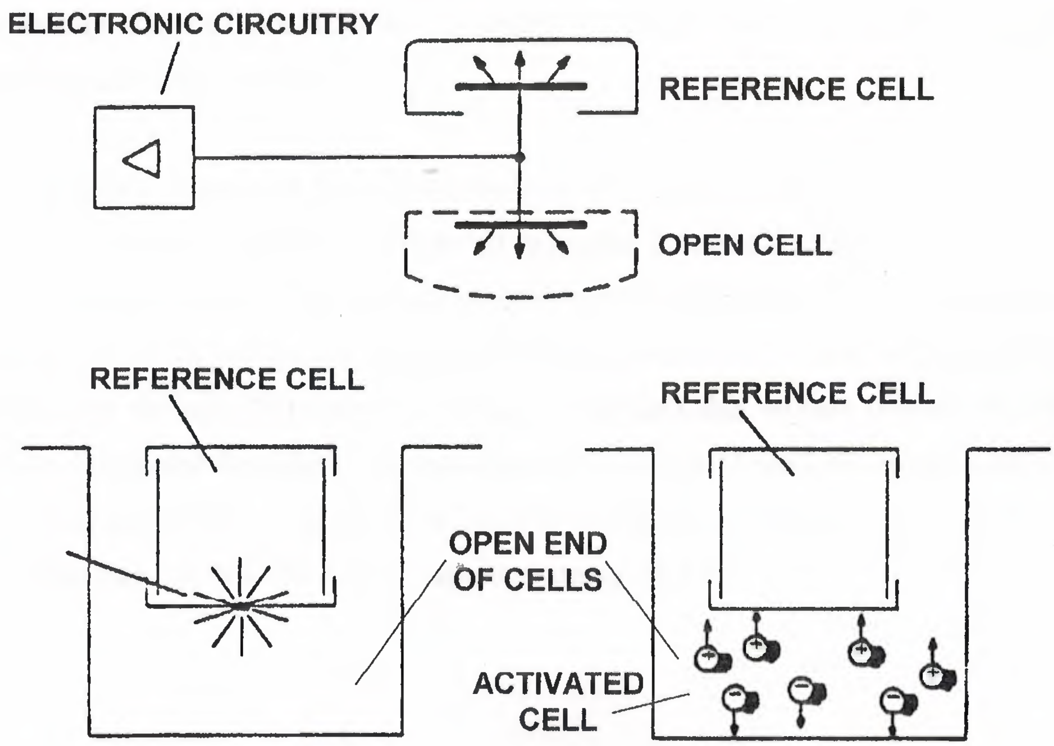


Figure 3.1. Basic working principle of ionization smoke detector



Figures 3.2, 3 and 4. Double cell detection principle and the method of detection

Open cell on the other hand is effected by the weather conditions and the room conditions. The difference in the two cells gives the room conditions. The smoke and gas in case of a fire enters the open cell. Depending upon the density of the gas and smoke the current will decrease, as the ions colliding with gas and smoke particles will increase weight of ions. (fig. 3.4)

The voltage between reference and open cells will also change this change is followed by a MOSFET. Triggering at a specific level gives warning [4,10].

3.2.1 Electrical structure

Sensors are connected to the central control unit with 17 – 28 V DC. (fig. 3.5) Terminals 1 and 6 are the inputs of positive and negative supplies. Terminals 2 and 5 are connected to 1 and 6 through sensors printed board and supply energy to the next sensor or to the end of line resistance. When the sensor is energized sensing and reference cells energies are controlled by ZD3 and R5 resistor. The connection between the sensing and reference cells are connected to type Mosfet's high resistive (G) gate and to bipolar transistor TR1.

The fresh air is connected through the chain of R4, R9, R6 resistors by the help of R9 the cut in voltage of MOSFET is adjusted to a value less than 3 volts. When the smoke enters the open cell (fig 3.6) the gate resistance of TR1 decrease if the gate voltage of TR1 reaches cut in voltage the resistance falls to several ohms from several mega ohms. The current through TR1 forms a voltage on R2 and this voltage triggers the SCR (Silicon Controlled Rectifier). Through diode DZ and R3-R4 the LED operates and cuts the conduction of TR1. A parallel warning ED is connected between the terminals 2 and 4 and this way it is possible to have remote warning. [4,5,10]

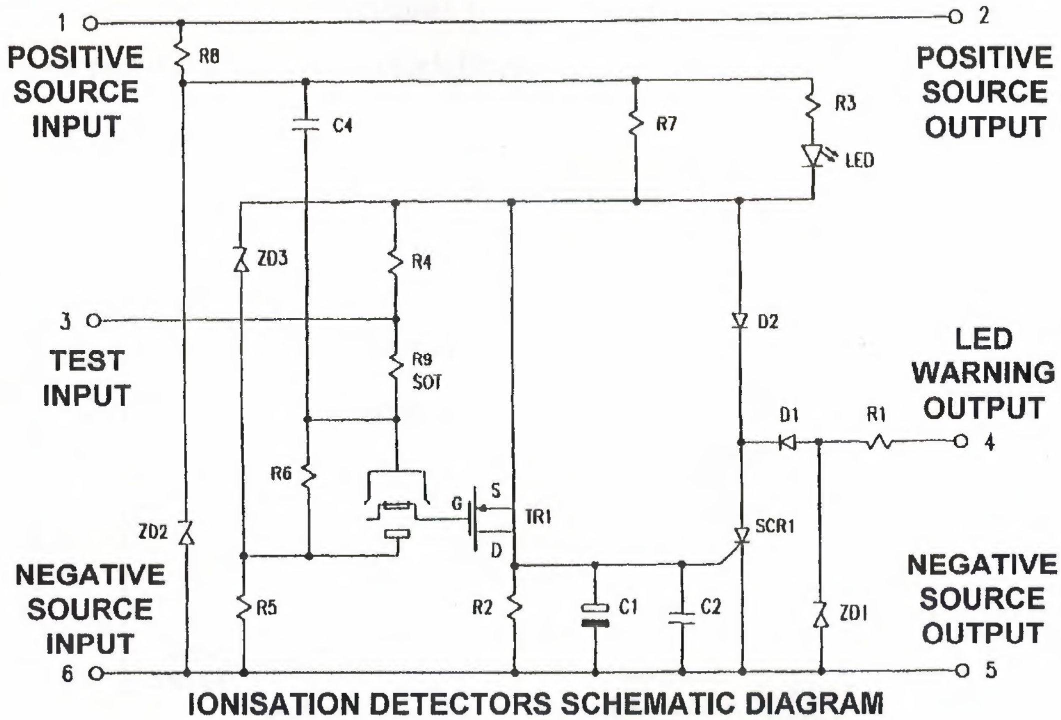


Figure 3.5. Ionisation smoke detector circuit diagram

It is possible to obtain a current less than 80 mA from terminal 4. D1 provides the opportunity to connect parallel LED's for more than one sensors.

When a potential is connected to terminals 2 and 3 and increased slowly in case of smoke entering the ionizing cell equal valued MOSFET gate experiences a difference in its resistance. This gives the opportunity to test the sensor.

An element is used in the circuit to provide protection for the reverse connection of the sensor.

ZD2 diode protects the device for reverse connection. If reverse connection is done a current passes through diode ZDZ and resistance R8 so the sensor cannot be connected reverse.

Capacitor C4 protects the device from high discharges. Connecting through R7 and R3 even if LED has a fault sends a warning signal to the panel. ZD1 protects the line from the changes that may occur in the parallel warning line. DZ protects the sensor from the effects that may come from terminal 4. C1 prevents the ununiform changes of ionizing unit. C2 prevents the SCR from high frequences. [4,5,10]

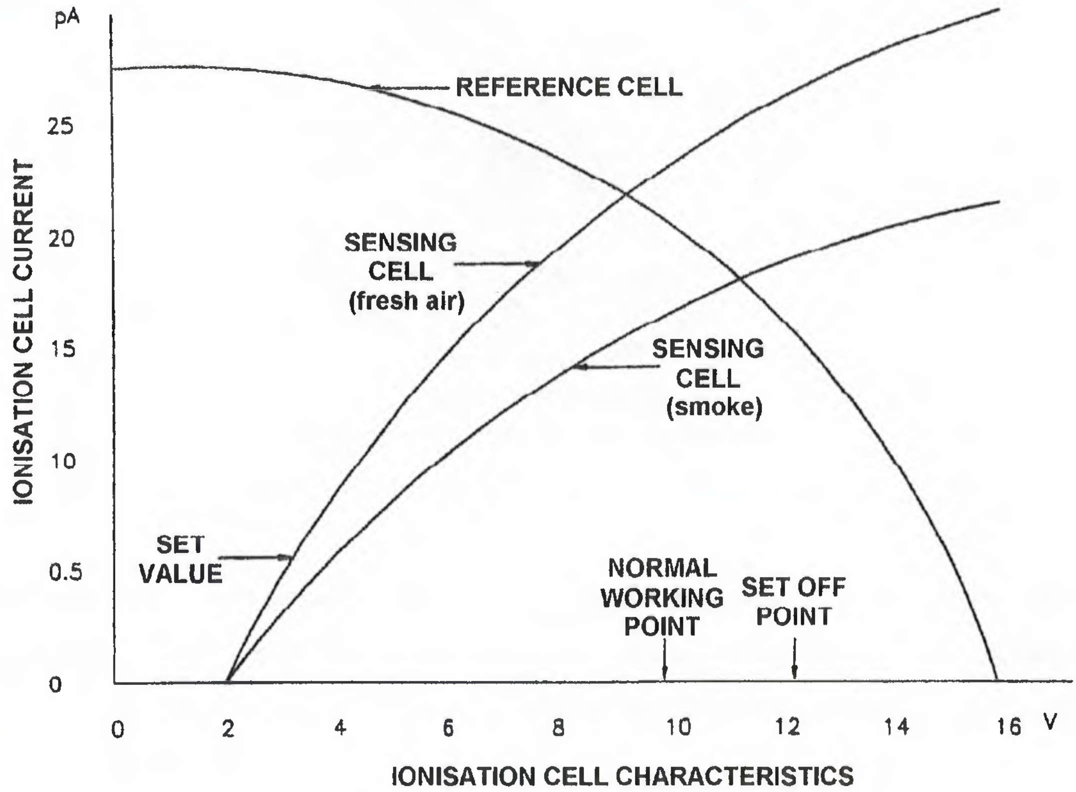


Figure 3.6. Ionisation cell characteristics

The fire warning signal is send to control panel through the line current. The line resistance and the impedance are constant. The line current increases while alarm signal is present. This increase is sensed by the panel and it activates the necessary functions.

3.2.2. Mechanical Structure

The ionizing smoke sensor is seperated into two parts as the sensor head and the sensor base. (fig 3.7,3.8) The sensing line connection is done by the clemences at the sensor base and the sensor base can be connected to anywhere. The sensor had is screwed to this base.

3.2.3. Usage

It is used to sense the fires that develop slowly and the smoke cannot be observed.
e.g. paper, wood, sentetic products, etc.

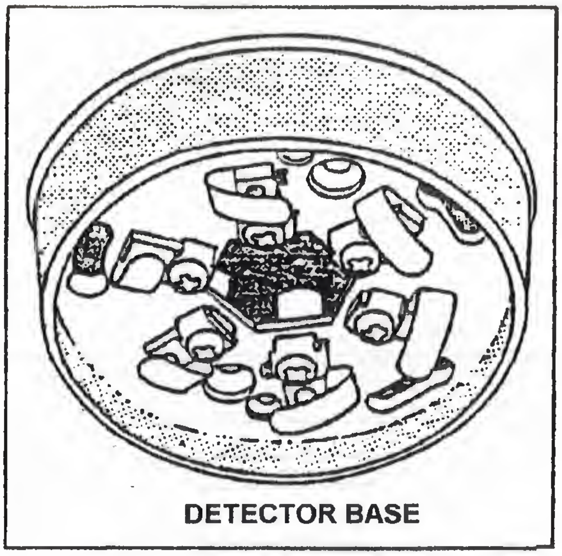


Figure 3.7. Ionisation detector mounting base

Ionizing sensor cannot sense products like PVC while they burn. They cannot be used to sense fires of alcohol and other liquids. Automatic smoke sensors provide the sensing of the fire in the shortest possible time. Usually the smoke sensors sense the fire earlier than heat sensors.

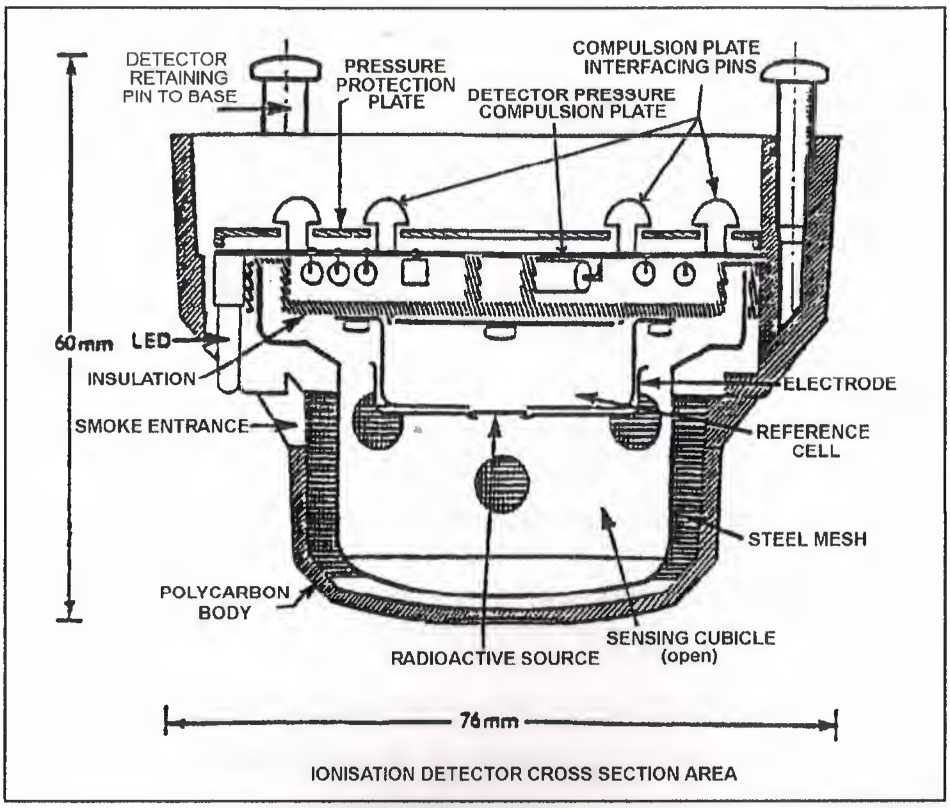


Figure 3.8. Cross section of the ionization detector

The distance of sensor from fire is one of the most important parameters in design.

3.2.4. Configuration

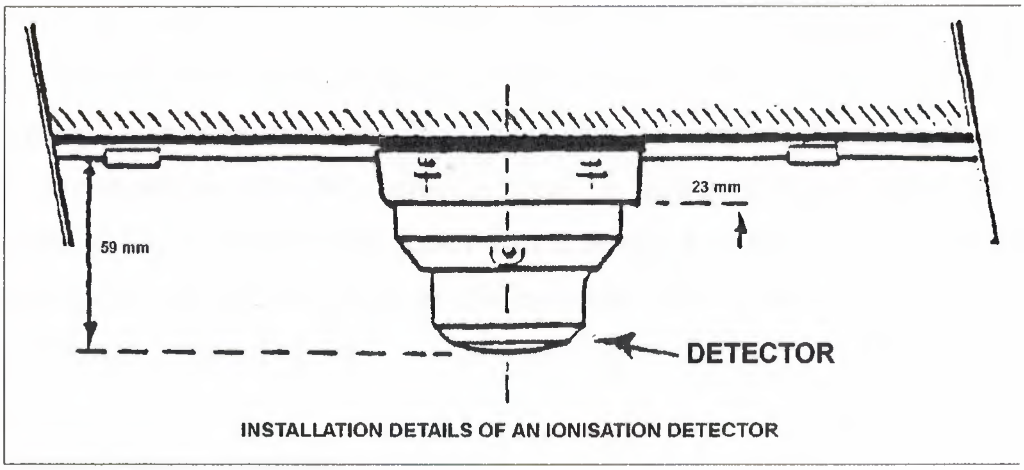


Figure 3.9. Mounting details of an ionization smoke detector

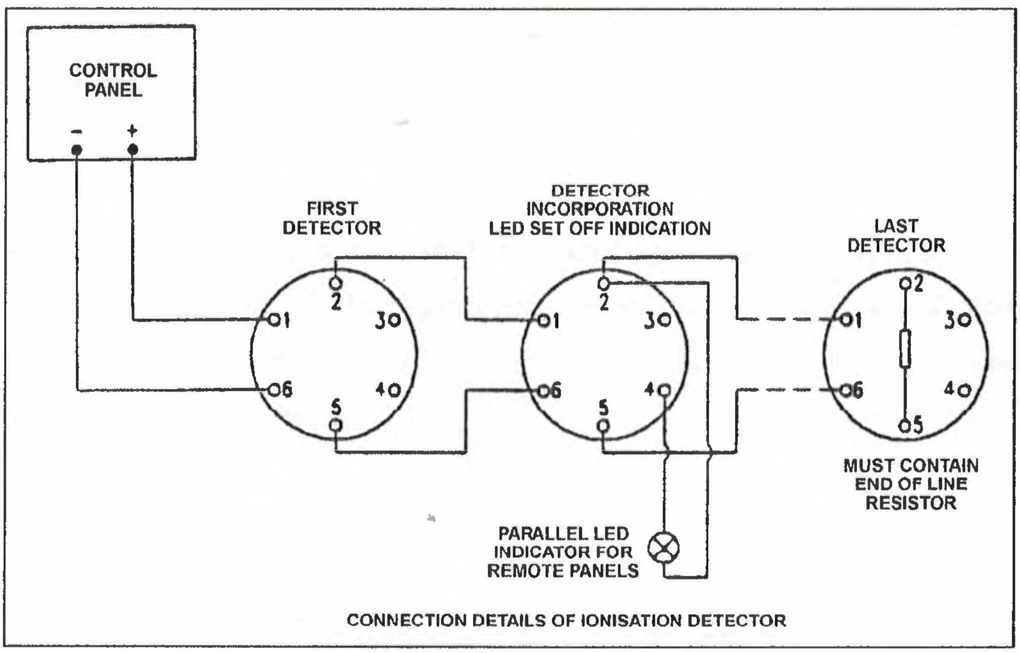


Figure 3.10. Electrical connections of the ionization smoke detectors

The ionizing smoke sensors are connect in series as seen in fig. 3.10. The beginning of line is connected to the panel and last is connected to a end of line resistor. The two wire system is installed by 2 x 1.5mm^2 NYY cable.

3.2.5. Installation

The distance of the sensor to any point depends on the height of the room. The maximum ground area to be controlled is $100m^2$ in any case. Nevetheless the distance between two sensors should not be greater than 12 meters. From this statement we can deduce that the height of the room plays a great role in sensing the fire. This is the reason why the sensors should be placed more close in rooms having a height of above 10m. Care should be taken for rooms less than 3m high as cigarette smoke can cause false alarms. The basement of the sensor should be mounted directly to the ceiling. The sensing unit is 70mm below ceiling by this mounting (fig 3.9). This distance should not be greater than 130mm. [4,5,10]

3.3. Optical Smoke Detectors

They contain light emitting LED Lens system and silicon photocell. (fig. 3.11) The light coming from LED is directed by the lens system. The photocell is placed to the darkest area of the sensing unit so under normal conditions light coming from LED does not reach photocell.

When smoke enters the unit it, prevents the directed light by lens and reflects them this way they fall onto photocell. The light coming from LED is in various intensity and frequency. In this time the second signal is evaluated when smoke is sensed in second signal a fire warning is given. [4,5,10]

3.3.1. Electrical Structure

The sensor is connected to the control unit by two wire system that carries 17 and 28 volts. (fig 3.13) Terminal number 1 and 6 are used for positive and negative supply connections. Terminals numbered 2 and 5 are connected to 1 and 6 through the printed circuit boards and they are used to connect the next sensor or end of line resistor. The energy control unit of the sensors is supplied through UPS and power supply. The frequency of the pulses supplied by LED driving unit is controlled by the oscilator circuit. The LED driving unit causes the LED to be on in 8 second intervals when there is no smoke no light falls on photocell, but when there is a smoke it reflects the light on photocell, under this condition the ON period of LED decrease to turn on the LED each second. If the light still falls on the photocell in this interval the warning circuit is energized. (fig 3.14) The SCR is energized and LED is on continuously and sensor is in continuous operation period (fig. 3.15).

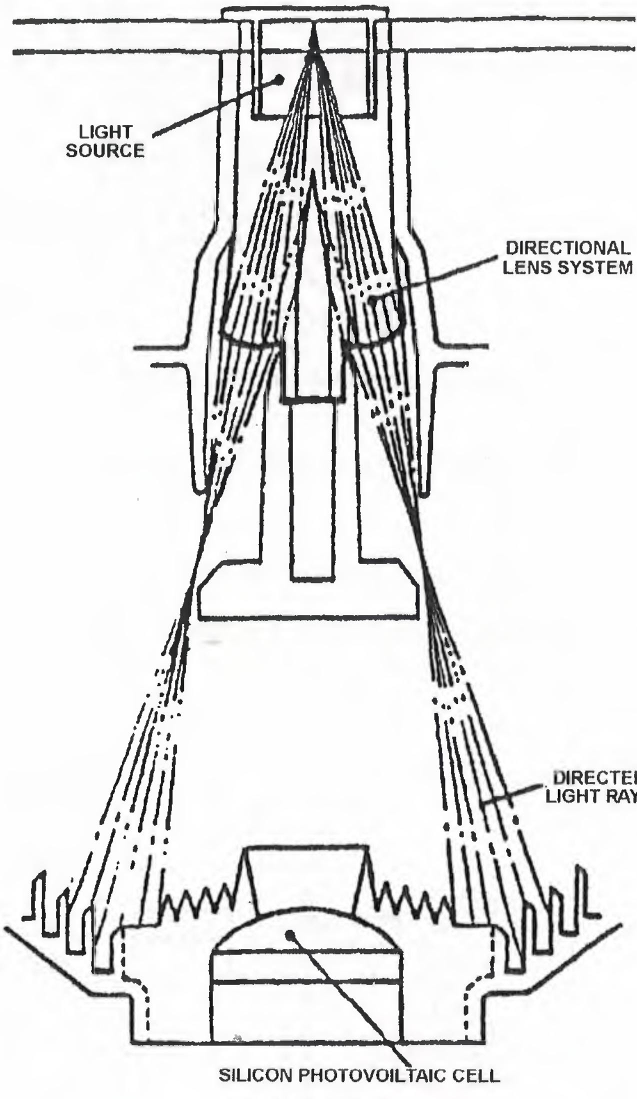


Figure 3.11. Optical transmission and detection arrangement of an optical smoke detector

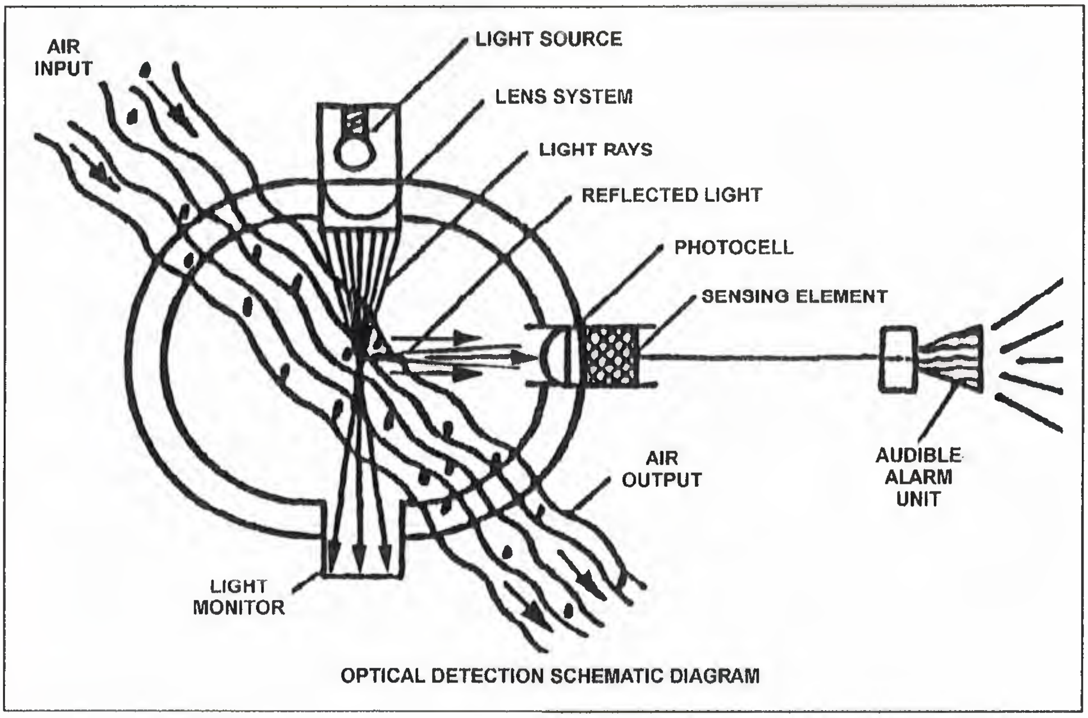


Figure 3.12. Schematic diagram of the detection principles of an optical smoke detector

This increase in current is sensed by the control panel and performs the functions that was programmed. The external warning LED can be connected between terminals 2 and 4 (fig. 3.19)

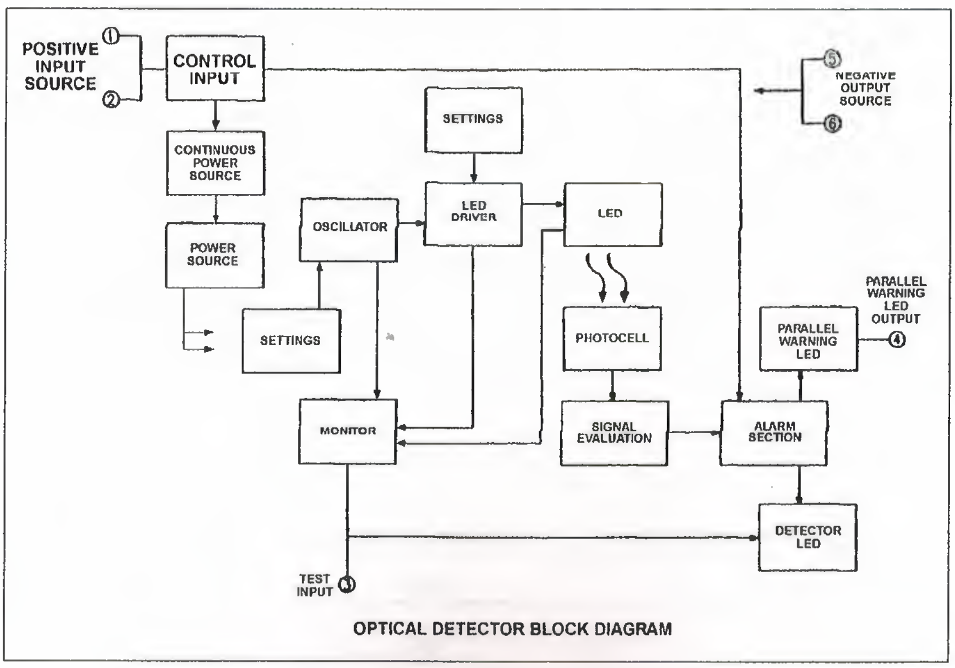


Figure 3.13. Block diagram of the optical smoke detector

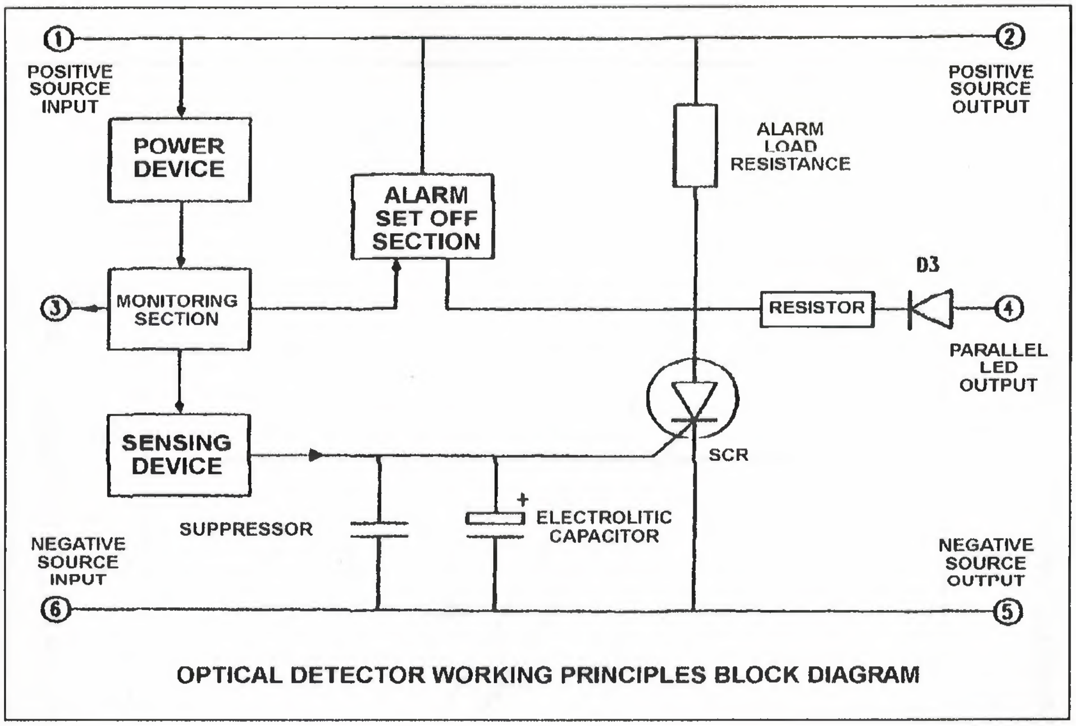


Figure 3.14. Working principles block diagram of an optical smoke detector

It is necessary to turn of the power supply to operate the sensor again as seen in fig. 3.13. The LED circuit is followed by a circuit to catch any fault. If a fault is sensed sends warning in 32 second intervals to both the sensor and the LED. Terminal no.3 provides input for test signal.

For an excellent and cooperative system it is necessary to take care to variation of the voltage of the source the control panel impedance and end of line resistance. If sensor is operating continuously the operating current should be 50 mA. In case of alarm a 510 Ohm series resistance and a 2V SCR is in operation. These are the conditions for minimum sensor current. In case of warning and normal conditions the following table is valid.

Feeding Voltage V	*Normal Condition* mA	*Alarm Oprerating Current* mA	
28	50	66	
24	50	58	18
50	43		

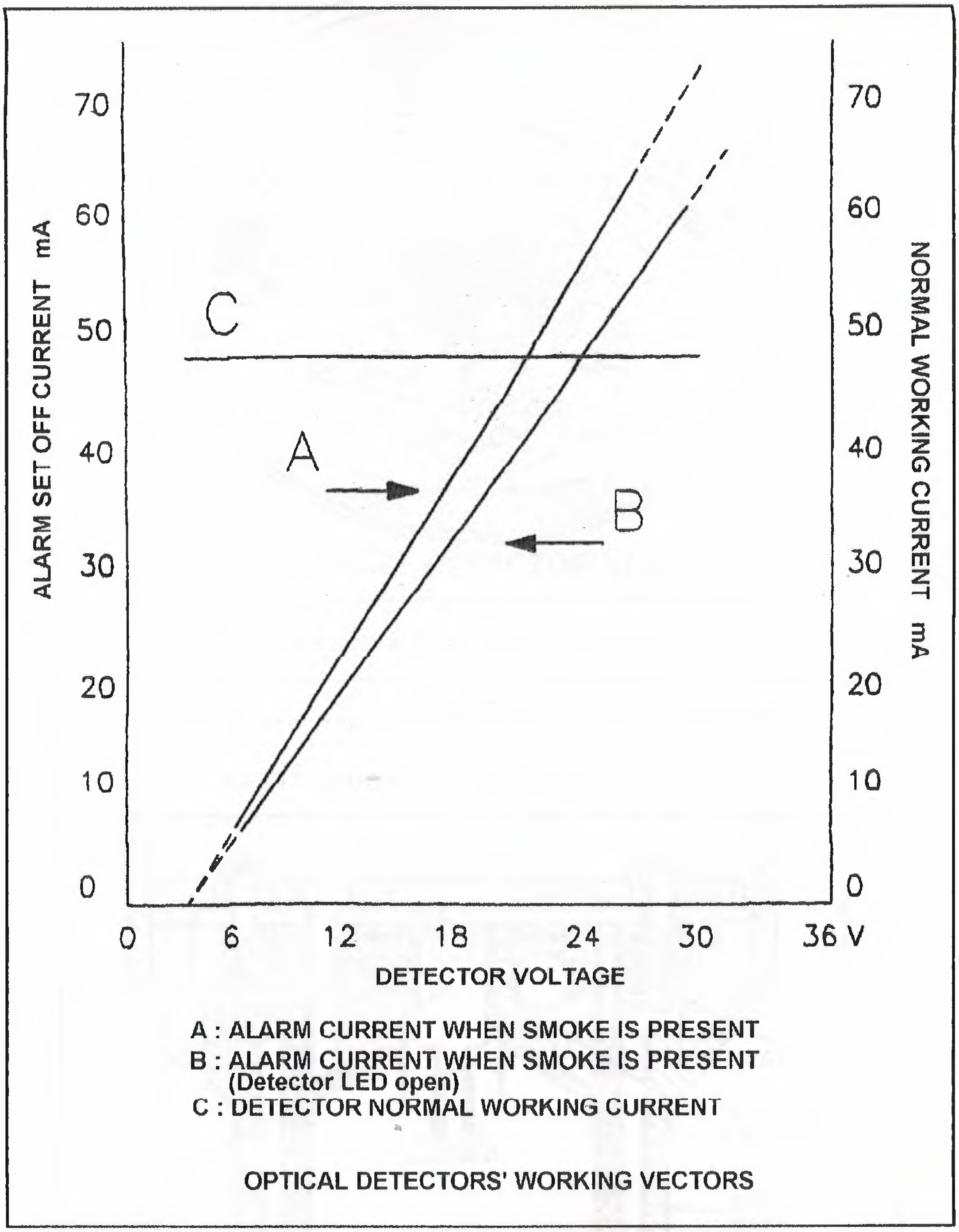


Figure 3.15. Vectors showing the optical detectors' working characteristics

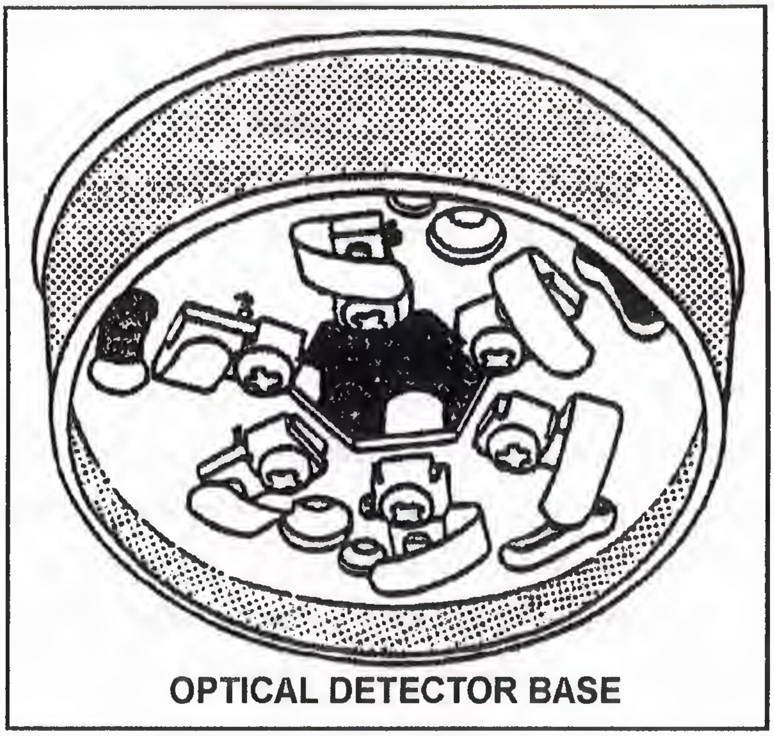


Figure 3.16. Mounting Base of the optical smoke detector

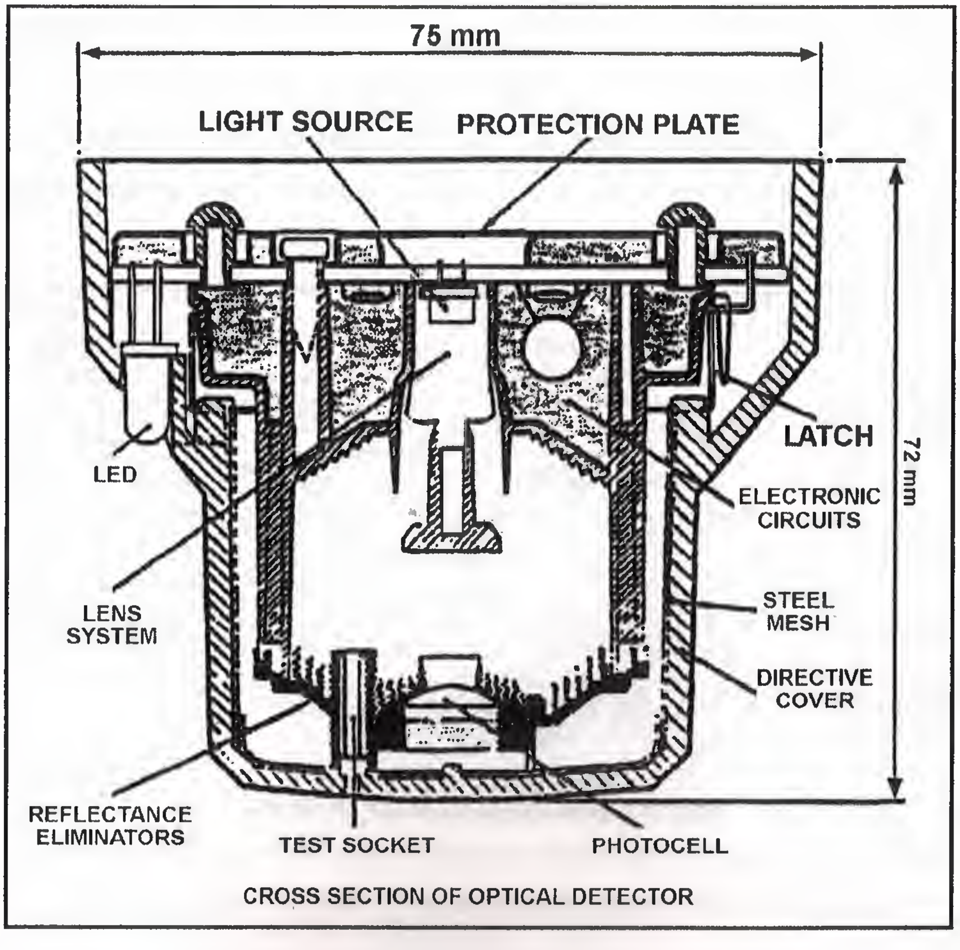


Figure 3.17. Cross section area of the optical smoke detector

3.3.2. Mechanical Structure

The optical smoke sensor is composed of two parts the base and the sensor. (fig. 3.16) The sensing line mounting is done with the clips present on the base. The base can be mounted any place desired. The sensor is screwed on it.

3.3.3. Usage

The time required to sense a fire depends upon many factors like the type of material, shape of room and the dimentions, the ventilation ratio etc. It was found experimentally that it is possible to sense 6% of grey smoke in each meter with these sensors. These sensors can be used to sense various type of fire. It is best used in the fires caused 250°C and above heat as a result of burning plastic material. It is not adviced to use them in nonsmoke fire. [4,6]

3.3.4. Configuration

They are connected to the control panel by two lines as seen in fig. 3.19. End of line resistance is present. The two lines are 2 x 1.5 mm^2 NYY cables. [5,8,10]

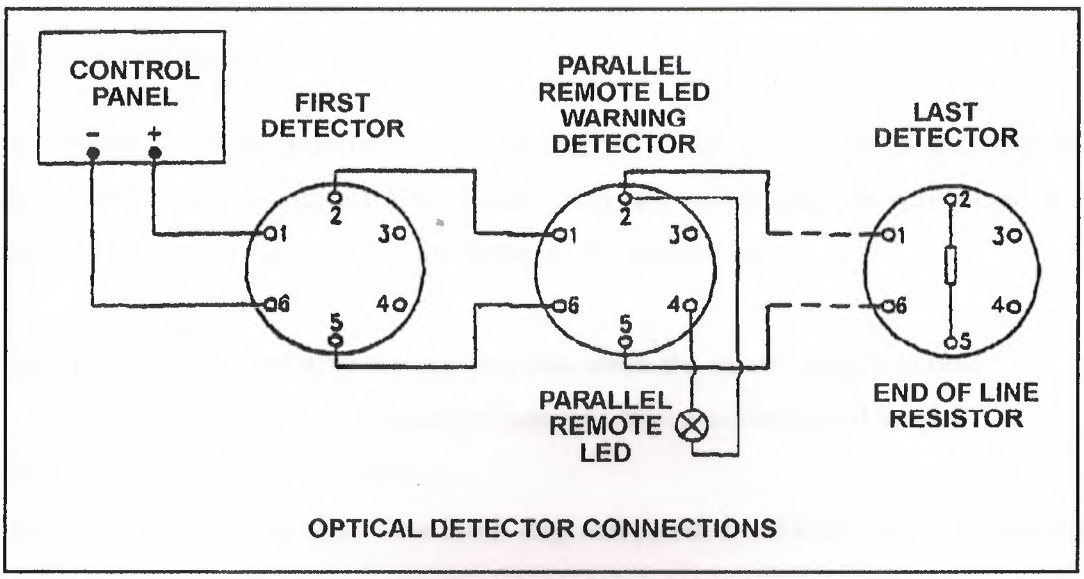


Figure 3.19. Mounting base connections of the optical smoke detectors

3.3.5. Installation of Optical Detectors

They should be mounted directly to the ceiling. In this position sensing unit is 80mm below the ceiling this distance should not be above 150mm. They should not be mounted vertically and inside the ceiling. They should not be mounted upside down. The distance between a sensor and a wall should not be less than 500mm. The height of the room is very important for sensing the fire. The optical sensors should be placed more frequently in places where height of the room is above 12m. [4,6]

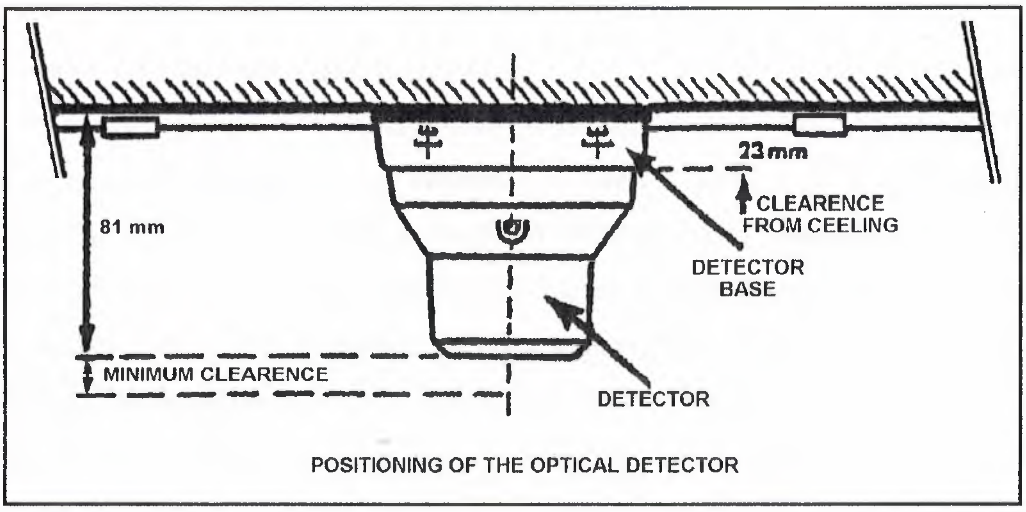


Figure 3.18. Mounting position of the optical smoke detectors

3.4. Heat Detectors

Heat detectors are that type of sensor they respond to the heat within their environment. Smoke or ionization will not affect them. They are robust and can whithstand to fire blazes. They are seperated into 3 according to the sensitivity.

Class 1 – The most sensitive sensors they can sense the small changes in heat. They give warning when the heat gets above a determined level.

Class 2 – Less sensitive than class 1.

Class 3 – Less sensitive than class 2 but they can be used in kitchens etc. as their upper limit is high. [4,5,10]

3.4.1. Electrical and Mechanical Structure

The heat sensors has similar couple of negative resistive constant thermistors. One of the thermistor is outside to form a good heat contact. So it is effected easily by the variation of heat in the medium. The other thermistor is isolated in equilibrium both has same value if heat varies outer has different (less) resistive value than the isolated. Both values are followed and in case of any change above set value warning is given fig. 3.20. If a slow variation is present then this can be observed by a series connected resistor to the isolated thermistor.

3.4.2. Usage, Configuration and Installation

The heat increase element is very important in class 1 sensors. When the sensor is energized the voltage is regulated through R3, ZD4 and TR1 transistor, and a stable voltage is obtained. This voltage is applied on the main thermistor through R5, R6, R7. Under normal condition incontinuous medium temperature the source will supply less current then the dissippated. For this reason the collector current of TR3 and voltage at collector is low. If the source current gets above dissippated then FET is triggered. Triggering SCI through ZD5 and this cause a warning signal LED 1 is on through R1, R10 and D1. (fig. 3.21)

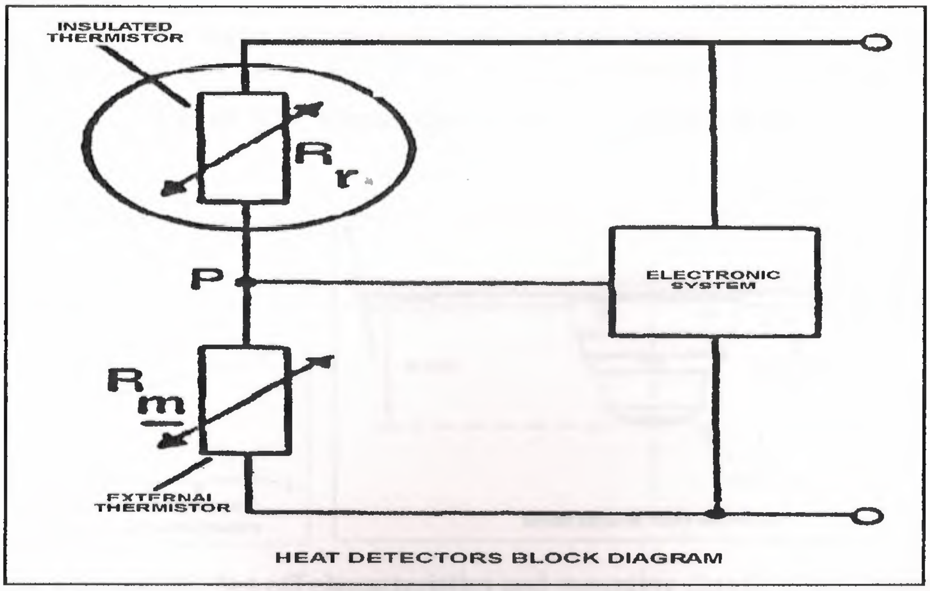


Figure 3.20. Block diagram showing the electrical structure of the heat detectors

The control unit should supply the sensor a voltage between 5-24 V DC. A parallel warning LED could be connected between terminals 2 and 4 whose current should not exceed 80 mA. If the voltage allplied to the sensor is temporarily off the sensor is reset and ready to sense. C1 C2 are protecting SCR from outer conditions. ZD6 and ZD7 are protecting sensor from variations in supply side. In case of alarm a voltage drop on 510 serial resistor and 2 V SCR should be considered. The structure, configuration and installation of the sensors are represented in schematic diagrams.

If fig. 3.21 (a) and 3.21 (b) the current and voltage readings are given.

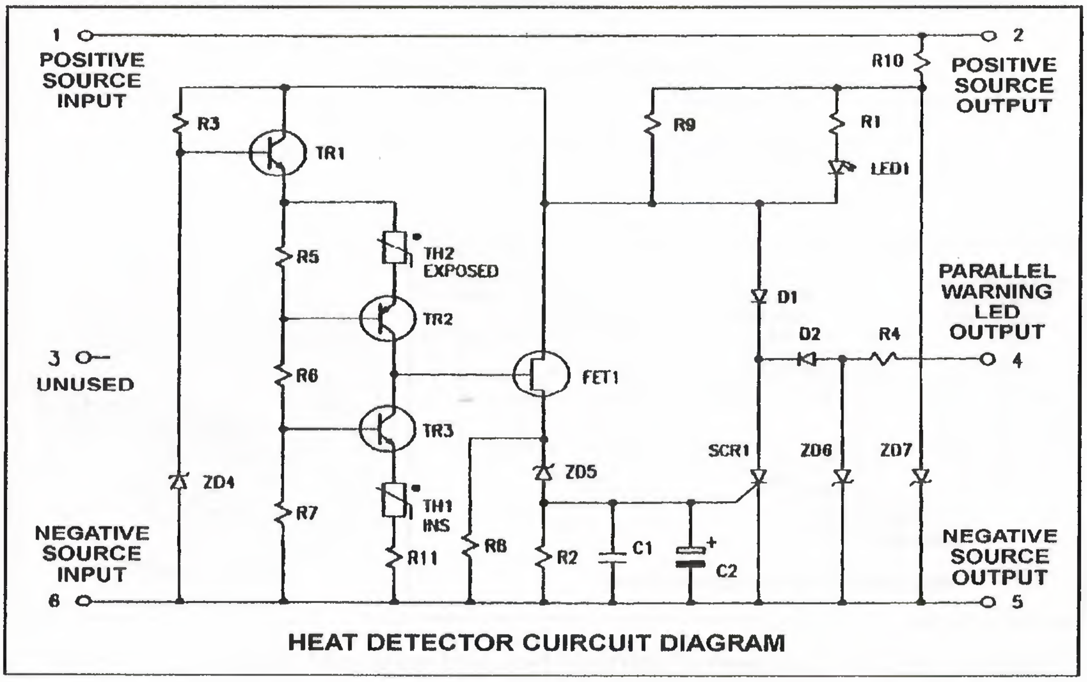


Figure 3.21. Circuit diagram of the heat detectors

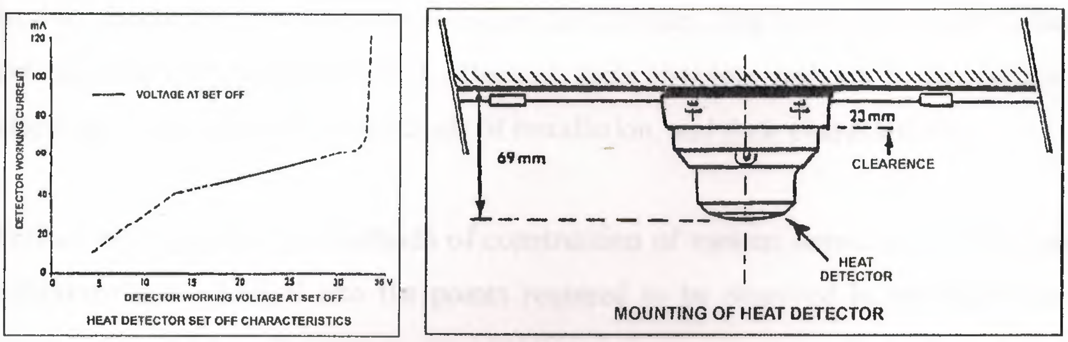


Figure 3.22 and 23. Set off characteristics and mounting details of heat detectors

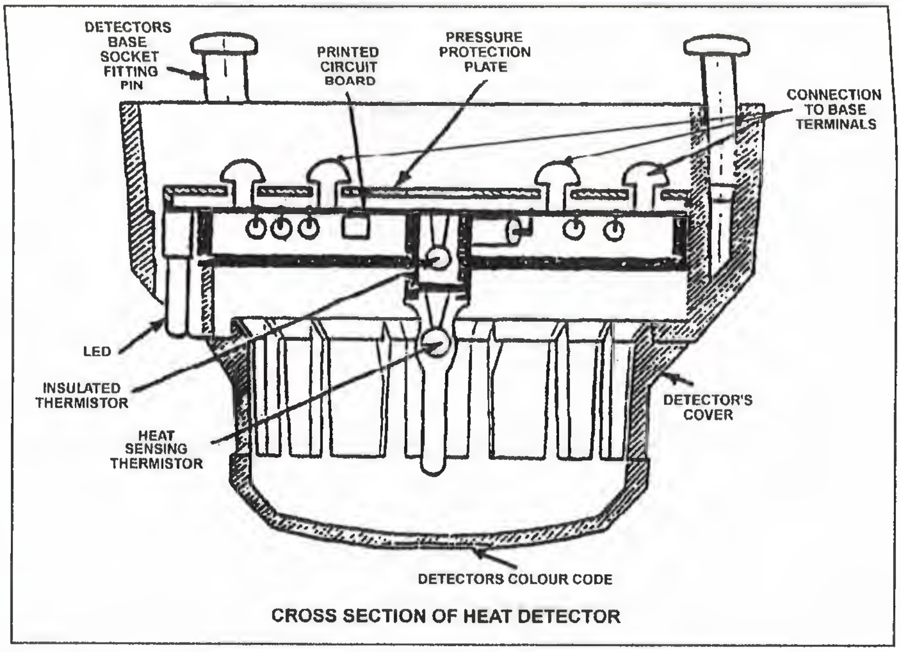


Figure 3.24. Cross section are of a heat detector

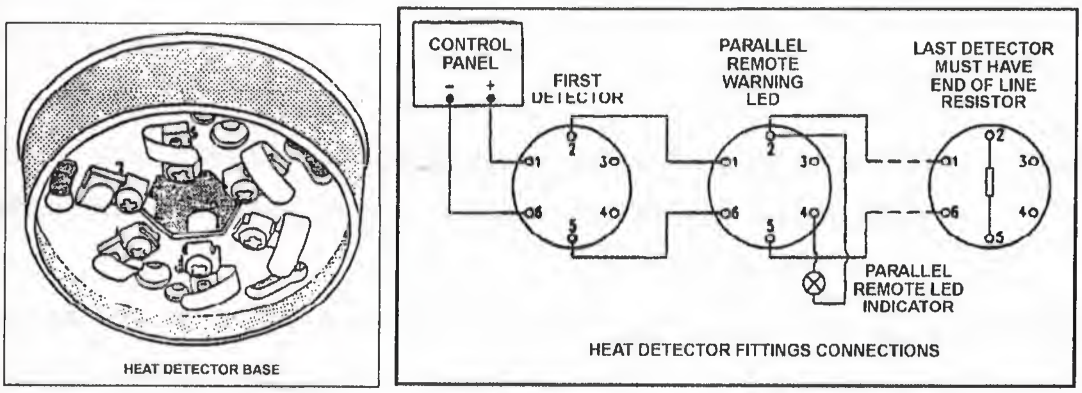


Figure 3.25 and 26. Mounting base and electrical connections of heat detectors

3.4. Summary

In this Chapter we discussed the fire detection devices, like ionization smoke detectors, optical smoke detectors and heat detectors, their structure relevant to mechanical and electrical composition, their methods of installation. and their characteristics.

Further we discussed the methods of construction of various detectors and their usage. Additionally we looked into the points required to be observed in installation and in their configuration.

CHAPTER 4

4. FIRE CONTROL PANEL

4.1. Overview

This chapter projects the developed work introduced by the author based on designing a fire control panel.

The Fire detect and alarm systems control panel is composed of fire warning and control equipment.

Detectors are the devices that sense the differences in various conditions and send related signals.

Control panel evaluates the control signals coming from the detectors and it operates with a two wired system. After evaluation it sends variable control signals.

The warning and control devices are the devices to be controlled by the variable signals from the control panel.

Three conditions can be present after evaluation of the signals from the panel detectors.

1- YAVUS has no fault.
2- YAVUS has a fault.
3- YAVUS is warning.

1- If YAVUS has no fault there is no difference in the levels of smoke or heat at the medium that is controlled.

2- If YAVUS has a fault there should be something wrong with the detectors, detector cables or with the control panel. (Open cct. or short cct.) This is indicated on the control panel with the LED's and sound warning.
Warning system is shut down and the fault is corrected.

3- If YAVUS is warning there should be a fire in one of the mediums that are controlled by the system under this condition.

Monitoring conditions

- Indicates the place of fire with LED.
- The warning devices are operated
- The fire extinguisher system at the place of fine is operated.
- The eritical doors that should be closed are operated.
- The ventilation is shut down.
- The smoke collecting canal system is operated.
- The machines in the fire medium are shut down.
- The police and fire departments are warned.

All these functions can be performed with a delay. [1,3,7,8,10]

4.2. Units in the Control Panel

These units are the boards that has LED's to inform the operation. EACH has different task and combination of these tasks constitude the main board of the control panel. These units follow the sensing devices activates the warning system and performs some other control operations. [1,3,7]

It can be grouped under three main headings:

1. CPU
2. I/O ports
3. Warning system

4.2.1. Central Processing Unit

Central Processing Unit (CPU) is the heart of the panel. It evaluates the whole of data passed through it. After the analysis either it carries out a transaction, or evaluates the given data and based on the data and the evaluation issues instruction to the required substation or peripheral for action as necessary. The Unit controls and directs the operation.

It keeps the information about the panel configuration and the operation data in ROM.

The control module shows the state of the system to the operator by LED's and lets the various operation to be performed by the switches mounted on itself.
One of the duties of the control unit is to indicate any fault on the panel and earthing.
It has some inputs enabling remote control.

1- Monitoring / Communication Units.

It is also called the addressing unit. It informs the user the digital addresses of all the parallel devices by LEDs.

2- Operation Unit.

Follows the sensing units and manual warning switches and informs the operator by the LED's corresponding to mediums.

3- Indication Unit.

Controls the warning devices and activates them in presence of fire.

The Devices on a Control Panel are:

1- LED to indicate state of the sensing line.

- LED's for each fire sensing zone.
- LED for sensing line.
- LED for alarm.
- LED showing that extinguisher is operating.

4.2.2. I/O Ports

Input and output ports are the interfacing devices that connects the peripherals of the system in order to facilitate the necessary communication and required control actions. Generally they consist of:

- 22OV AC line input
- 24 V DC line input
- Spare battery input
- Sensing line input
- Warning line output
- Control line output
- Extinguisher line output

3- General Control Buttons.

- System turn off button
- System reset button
- System on-off button
- Night-Day button
- Delay button

4- LED's indicating faults on energy and battery feeding.

4.2.3. Visual Warning System

It is very important to select the cables for the installation. The cables should send signals rapidly and minimize the losses. The cables of the fire systems are generally installed together with the electrical instullation cables and therefore can be effected by the electrical noise. Therefore the fire system cables should be noise immuned.

The best cables for this purpose are the JY(S+)Y cables manifuctured under VDE0815 standarts.

They are manufactured from pure on soldered electrolytic copper and isolated by thermoplastic material. Polyester bands are wound on lines twisted two by two. Soldered monitoring wire is added and polyester laminated aluminium foil is wrapped before red PVC outer wrapping. [3,4,5,6,7,8,10]

J-Y(st)Y Type cables for outer conditions.

Black polymer material is wrapped against water and sun light. (-10/+80°C)

J-Y(st)Y-105/cable that bears 105°C

Outer wrapping is special termovin material. (-40 °C/+105 °C).

SIF (st) Y silicon.

The conductor is multiwired and the isolation is silicon, aliminium wrapped termovin material against heat.

(-60 °C/+200 °C)

LIY (st) Y

Multiwired, soldered, PVC isolated.

Aliminium wrapped, foiled wire, thermoplast outer shield cable.

N-Y (st) M

NYM type single wire PVC isolated, aliminium wrapped, PVC outer wrapping.

4.3. Summary

In this chapter a developed work introduced by the author based on designing a fire control panel, which is composed of a fire detection and alarm system control panel, fire warning and control equipment.

It also discussed how the detectors sense the differences in various conditions and send related signals to the control panel for evaluation and taking the necessary actions based on this evaluation.

CHAPTER 5

5. DESIGN PRINCIPLES

5.1. Overview

This chapter generally covers the general principles of the design characteristics and the selection criteria of the detectors. It analyses the smoke propagation and the methods that can be adopted in different situations. It also investigates the area and space suitability of various sensors. The study is extended to the fire risk factor of various buildings and confined spaces. In the study room factors, ventilation effects, distance of the detectors and irregular conditions are also considered.

5.2. Divisions

In order to indicate the specific place of fire.

- These should not be a multi zone. Each zone should be separate.
- Living rooms, offices and fire exits should not be considered in the same area.
- The detectors designed for Danger zones and the detectors that are less sensitive should not be considered together.
- If non addressed sensing devices are used the limit for number of sensors is 25.
- Addressed sensors have a limit of number of sensors is 50.

The zoning should be placed in the memory. Special detectors should be placed to operate the warning system rapidly.

5.3. Selection of the Detectors

- For Hotels smoke and toxic sensors should be considered for life saving. Smoke sensors are preventing false alarms. In special places like the kitchen the smoke sensors may cause false alarm.

5.3.1. Smoke sensors

Smoke sensors are suitable to protect the people living in buildings as they can sense the toxic gases and smoke immidiatelly.

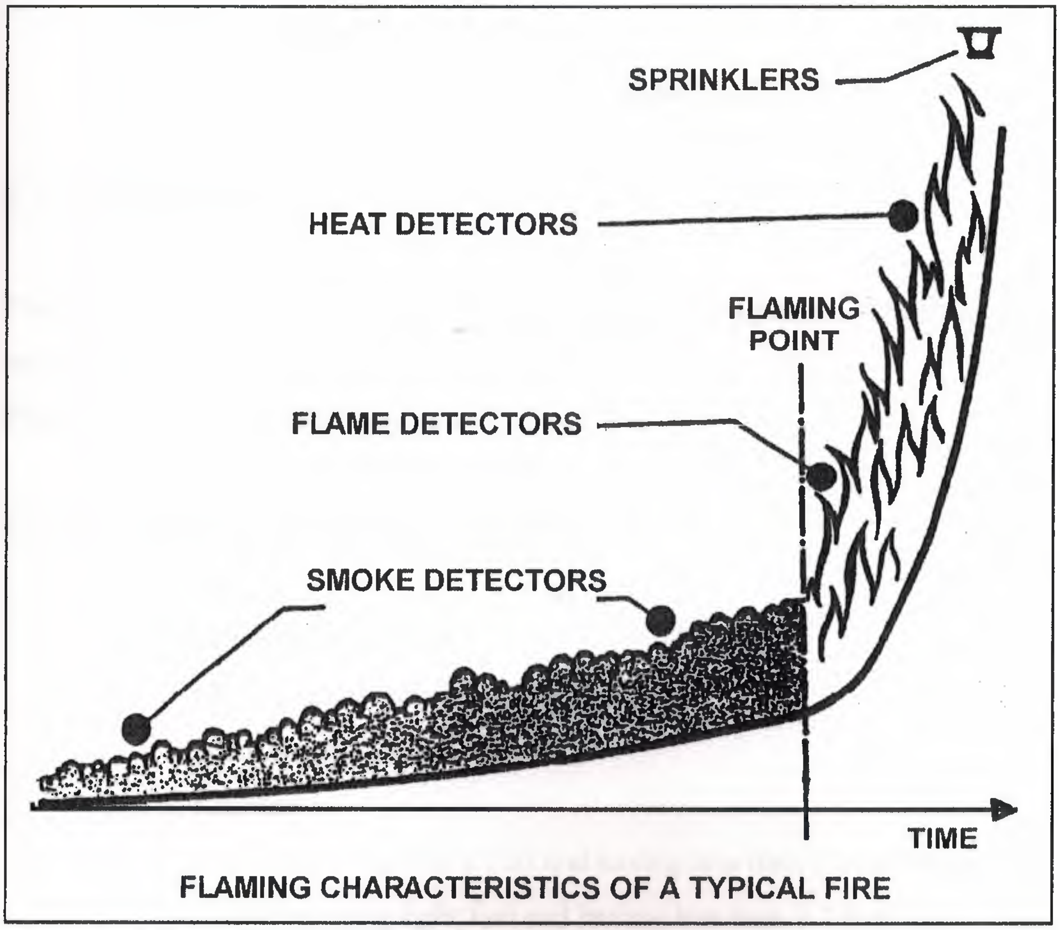


Figure 5.1. Typical characteristics of the propagation of a fire

But,

- When humidity is % 95
- Ventilation reaches 4.5 m/s.

- Under dirty, wet conditions
- Over dust

Is present then sensitivity is very less.

In Hotels under the following conditions smoke detectors are not suitable.

- If height of the mechanical workshop is above 3.65m
- Kitchens
- Restaurants having above 4.6m height
- Areas having oper decorative fire
- Garrages and parking areas.
- Conference rooms having 2.7m height and less

5.3.2. Heat Detectors

They have the ability to sense increasing and fixed temperature. They are used in the areas where smoke detectors cannot be used.
They are less sensitive than smoke detectors.

They are adviced for the following conditions.

- Humidity above % 95
- Fire expected without smoke
- Dirty and rusty areas
- Kitchens
- Platforms using heavy fuel and having less than 6.8. m height
- Platforms using light fuel and having less than 2.7 m height
- Equipment having burners
- Parking areas

They are not suitable for areas having above 6.8 m high.

5.4. Testing

It is adviced to have a fire test for areas having problems while placing the detectors.

5.5. Protection Considerations

Fig. 5.2 is for a room that has no ventilation. The heating effect of the fire forces the smoke to go up. When smoke reaches the cuiling distributes circularly and cools a little bit. The density drops height of the room increase.

The detectors area is inversely proportional to its sensitivity.

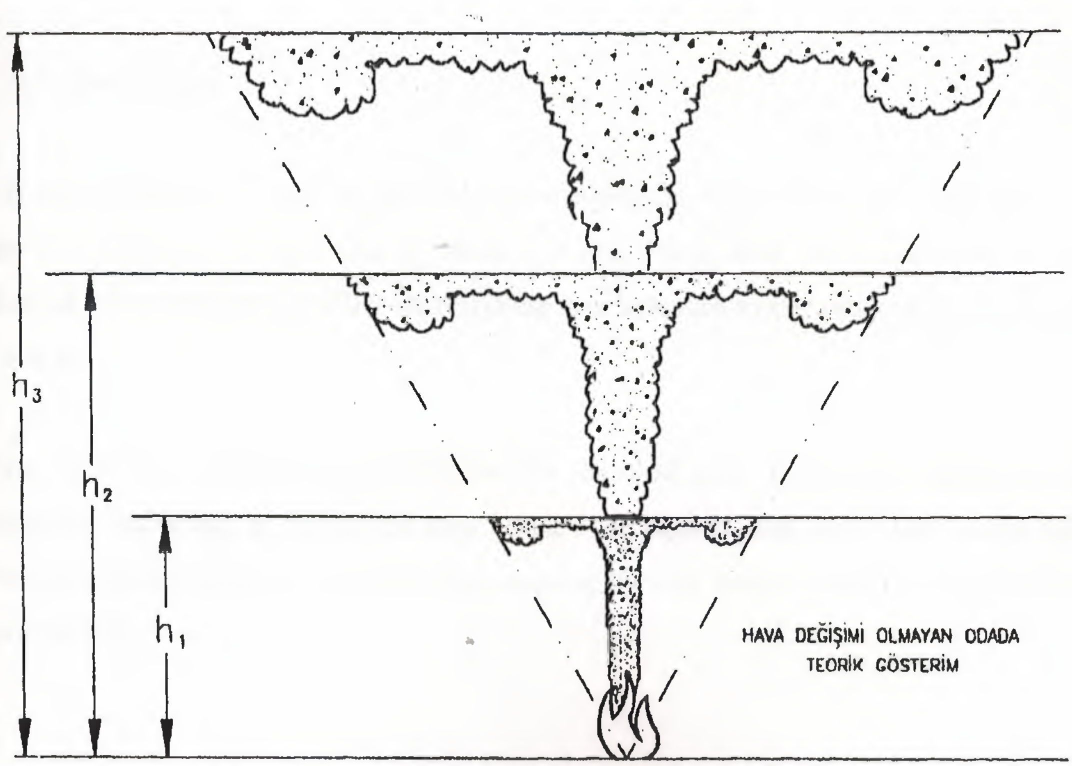


Figure 5.2. Typical smoke propagation relevant to the height of the room

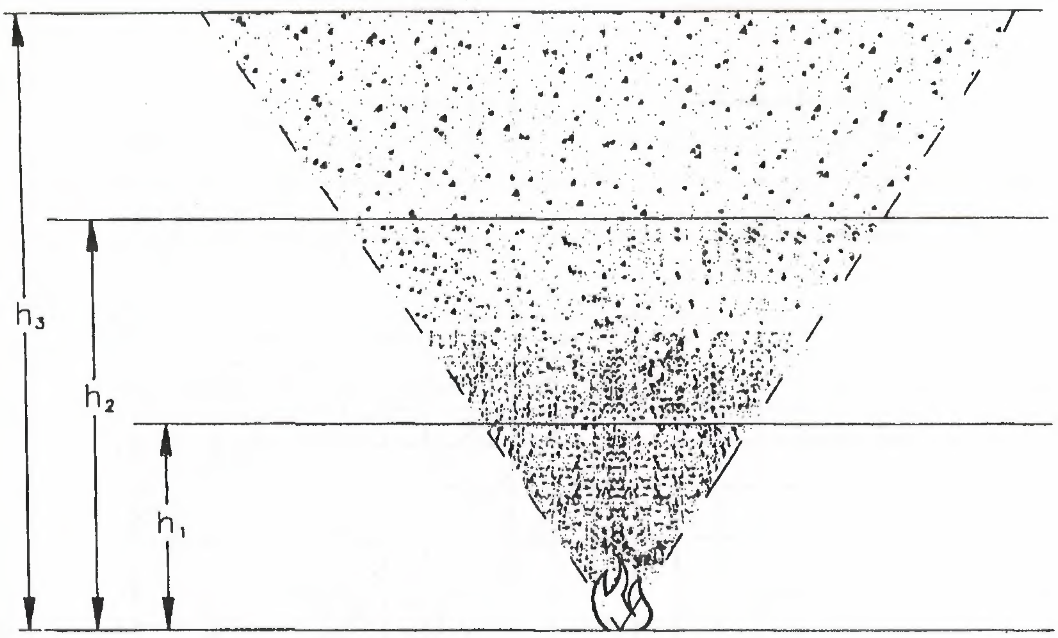


Figure 5.3. Theoretical propagation of the smoke relevant to the height of the room

5. 5.1. Risk Factor

It is very important to consider the risk factor when the size of the area is selected. As a rule the response time of a smoke detector is faster than their counterparts. If the area covered by a detector is smaller its response time relevant to the progression of the fire is quicker.

Figure 5.4. is a graphical representation for the evaluation of the risk factors of the detectors. According to this graph area 1 bears the highest and area 3 the lowest risks. The evaluation graph can be used in determining the risk factor which is suitable for the selected area.

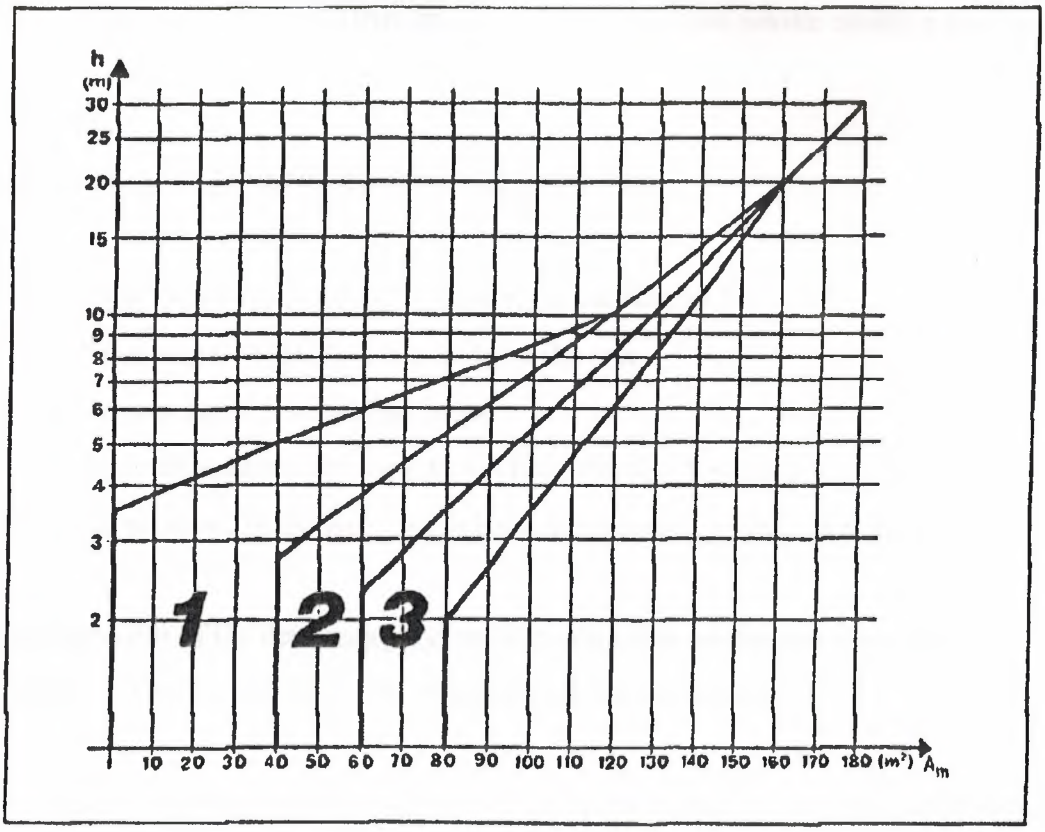


Figure 5.4. Determination of the controllable are relevant to the fire risk factor

Area 1 can be selected under the following conditions:

- Where the escape routes are likely to receive more than 10% of the total population of the building
- If the area or part of the area has a high fire risk value
- If the building contains valuable commodity, masterpieces, etc.
- If the building is dangerous and has the signs of collapsing
- In the event of a fire if there are more than 50% smoke emitting products in the area
- In the case of a fire if there are more than 20% toxic smoke emitting products in the area

Area 2 can be selected under the following conditions:

- If there are people at the area and the escape routes are limited
- If the commodity in the area has a high value
- If the area or part of the area has a high fire risk value

- In the case of a fire if there are more than 20% toxic smoke emitting products in the area

Area 3 can be selected under the following conditions:

- If the area has no direct relation to endanger human life
- If there are no valuable commodity in the area
- If the area has a low fire risk value
- If the commodity in the area do not have flaming tendencies
- If the products in the area do not have the potential to emit of toxic gasses

The arrangement of the detectors plays an important role on the cost and efficiency of the system. Therefore the following points should be considered

- The selected detectors should be able to operate either by the heat radiation or smoke emission in the event of a fire
- The selected detectors should be suitable for the environmental factors relevant to the determined area
- The detectors should be maintained and tested regularly

In mounting of the detectors the conditions of the area should be considered rather than the appearance. It may be necessary to compromise between the selection and the aesthetic and decorative appearance of the environment.

In Hotels the maximum coverage area ($80m^2$) of a smoke detector must conform with the existing rules and norms as appended below[26]:

- The escape positions of people subjected to dangers
- The possibility of maximum destruction of the valuable items
- The potential of fire risk
- The quantity of the toxic gas releasing products
- Fire partitions

For general hotel applications low sensitivity detectors are used. Where there are areas that do not conform with the typical applications the surveillance area should be narrowed. Rooms that are more than 3m high the number of the detectors should be increased to offset these conditions.

5.5.2. Room Height

The distance between the detector and the floor of a room increases with the height of the room. In such cases the condensation of the smoke becomes weaker but more uniform at high levels. That is why the number of the detectors are related to the height of the room. In such cases the response time relevant to the detection of the smoke will be increased and a small delay will occur in setting off the detector. This is due to the small size of the area of the smoke at the break point.

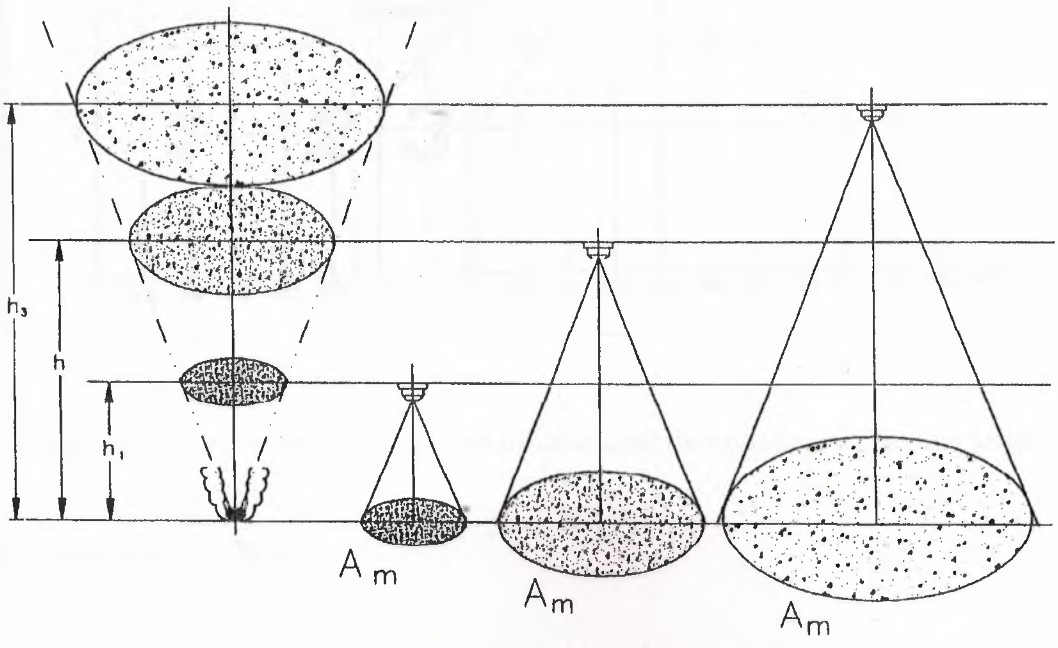


Figure 5.5. Area covered by the smoke detector relevant to the different room heights

Example in selection of A_m in a monitored area

Height of the room = 3.5 m

Risk area = 2

Based on these details, from the graph of risks, figure 5.6., it will be seen that the resultant values will fall between 54 – 78 A_m.

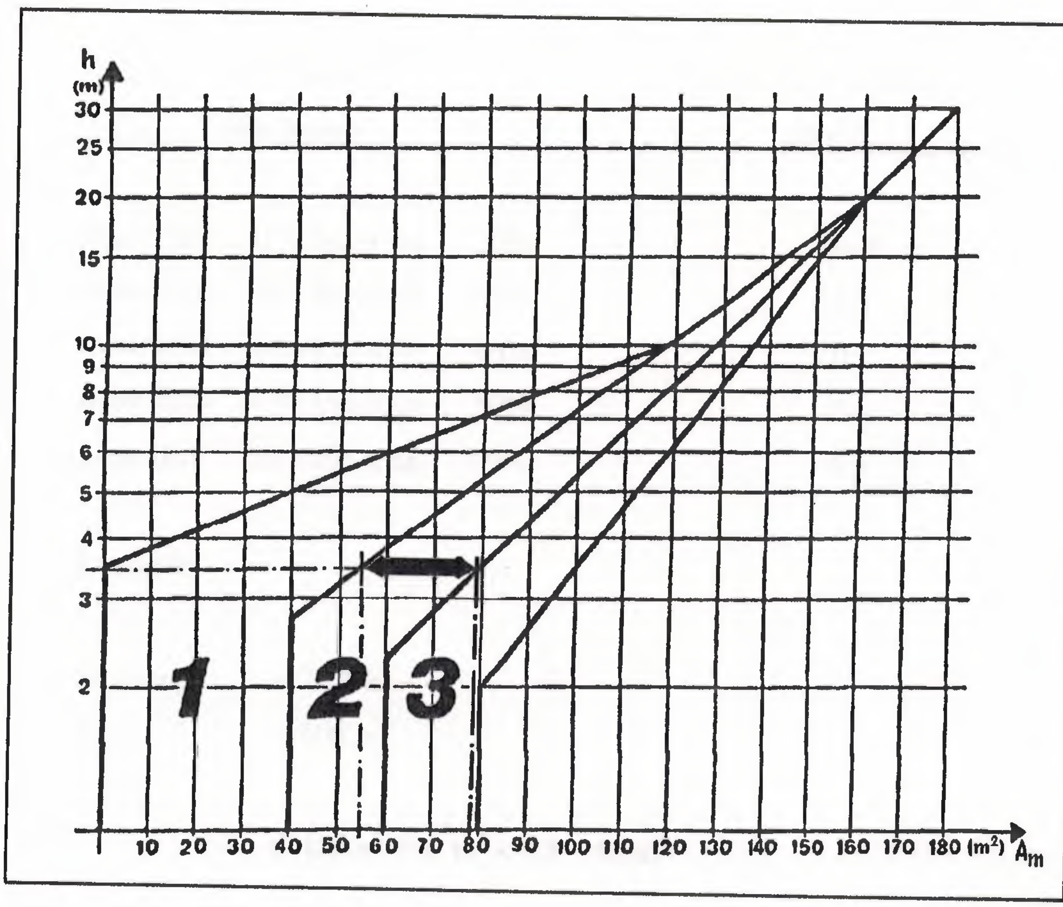


Figure 5.6. Determination of the controllable area through the risk factors graph

5.5.3. Ventilation Effects

In ventilated rooms the propagation of the smoke is degraded. Because of the frequent change of the air in the room the density altitude of the smoke will be lowered.

Such degradation will reduce the sensitivity of the sampled air. To overcome this problem the sensing density of the smoke can be compromised by reducing the area covered by the detector in that area.

In order to determine the reduction in the concerned area the following A_m constants can be taken into consideration. To find the reduced area, the monitored area simply can be calculated with the given constants as below:

Air Change (per hour)			Reducing Constant (for A_m)
more than	10% less than	20%	0.9
more than	20% less than	30%	0.8
more than	30% less than	40%	0.7
more than	40% less than	50%	0.6
more than	50% less than	60%	0.5

Example:

air change = 25 p/h

A_m = 100 m^2

Solution: $100\ m^2 \times 0.8 = 80\ m^2$

5.6. Distance Between Detectors

The maximum distance between the detectors and the walls is a function of the monitored area (A_m).

In principle, each detector controls a circular area as shown in fig. 5.7. and this area should not be exceeded. Therefore the maximum distance between the detectors is governed by this area.

The distance between the detectors can be taken at a point that nor the diameter or the area of the circle is exceeded.

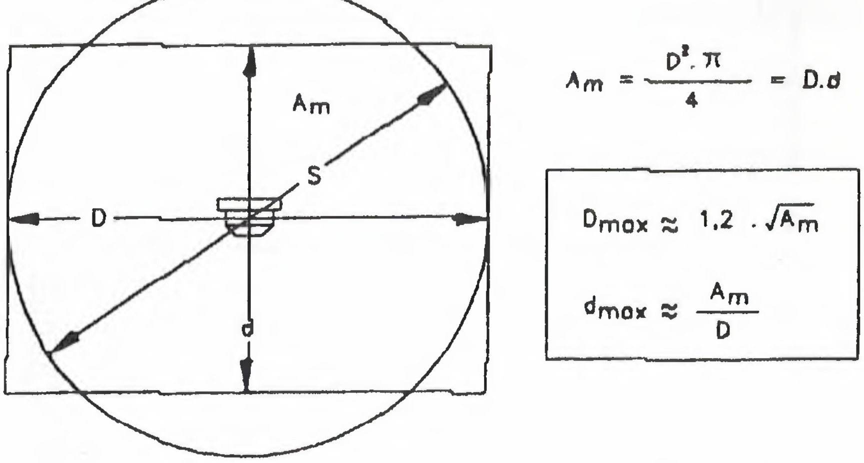


Figure 5.7. Area of circular controlled area should equal to the rectangle area as shown above.

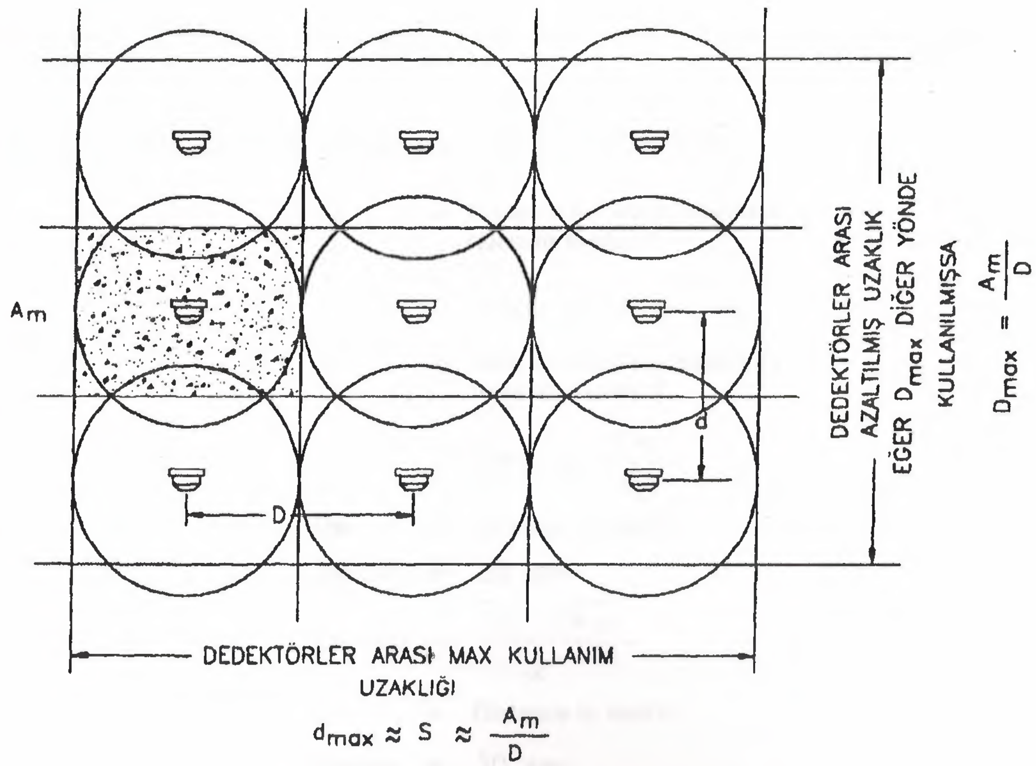


Figure 5.8. Maximum distance between the detectors

The distance of the detectors are measured from the walls. The corners are ignored.

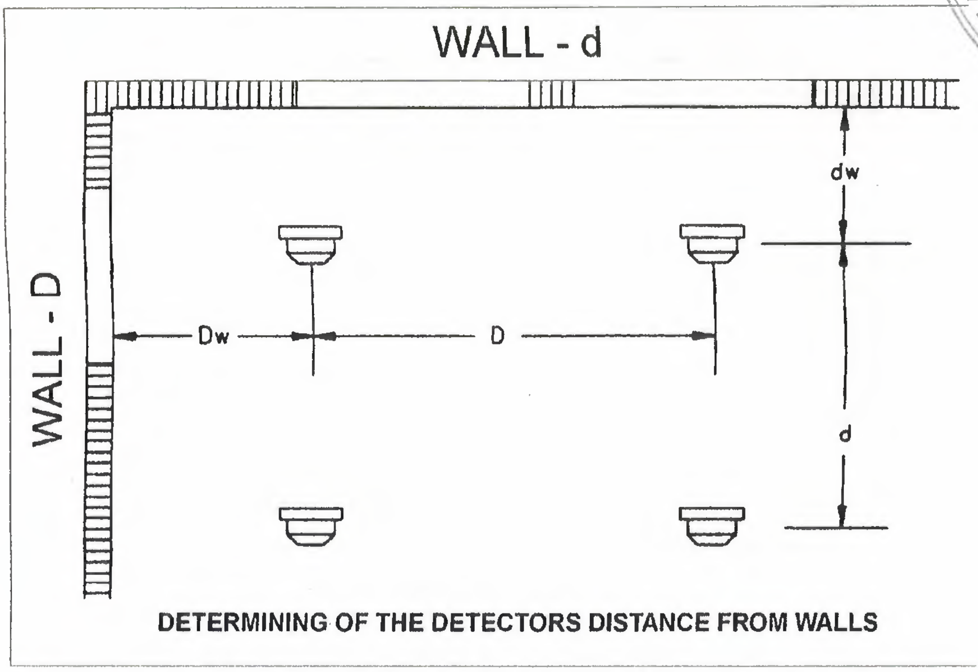


Figure 5.9. Schematic diagram showing detectors' distance from adjacent walls.

Examples of calculation of distances of detectors from walls:

D = **Distance between detectors relevant to side D**

$$D_{max} = 1,2 \cdot \sqrt{A_m}$$

d = **Distance between detectors relevant to side d**

$$d_{max} = \frac{A_m}{D}$$

Dw = **Distance to wall D**

$$Dw_{min} = 30 \text{ cm}$$

$$Dw_{max} = \frac{1,2 \cdot \sqrt{A_m}}{2}$$

dw = **Distance to wall d**

$$dw_{min} = 30 \text{ cm}$$

$$dw_{max} = \frac{A_m}{2D}$$

DETERMINATION OF THE DISTANCE OF THE DETECTORS TO WALLS

General arrangement of the detectors would be as shown in the following schematic diagram. (fig. 5.10.)

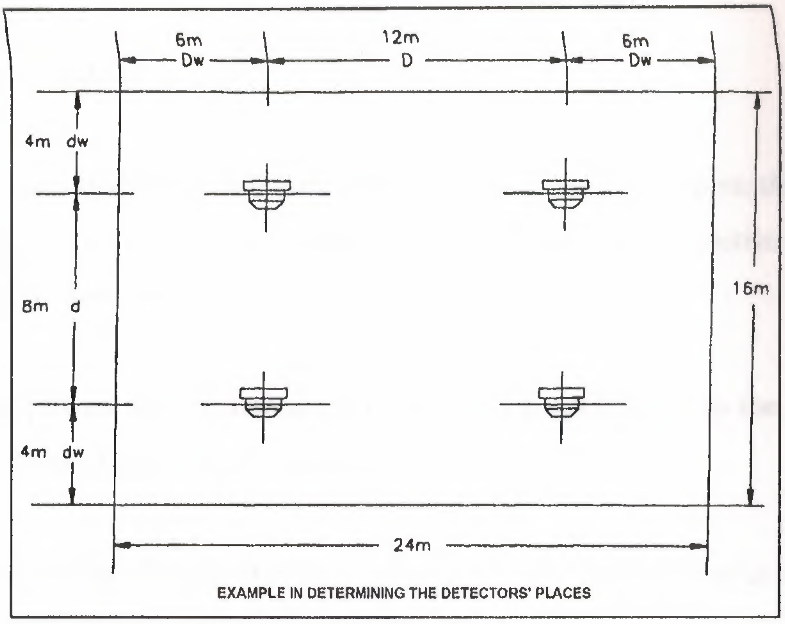


Figure 5.10. Determination of the distances of the detectors from walls

Another examples in calculation of distances of the detectors from walls:

$$\text{Area of the Room} = 24 \times 16 = 384 \ m^2$$

$$A_m \ (\text{Chosen}) = 100 \ m^2$$

$$D = D_{max} = 1{,}2 \ . \sqrt{A_m}$$

$$= 1.2 \ . \sqrt{100} = \underline{\underline{12m}}$$

$$d_{max} = \frac{A_m}{D} = \frac{100}{12} = \underline{\underline{8.33m}}$$

$$= 8m \ (\text{Chosen})$$

$$Dw_{max} = \frac{1{,}2 \ . \sqrt{A_m}}{2}$$

$$= \frac{1.2 \ . \sqrt{100}}{2} = \underline{\underline{6m}}$$

$$Dw = 6m$$

$$dw_{max} = \frac{A_m}{2D} = \frac{100}{2 \cdot 12} = \underline{\underline{4.16m}}$$

$$dw = 4m \ (\text{Chosen})$$

DETERMINATION OF THE DETECTORS PLACES

5.6. Irregular Conditions

There are certain conditions that sometimes may necessitate to mount the detectors on the hotel or guest room walls. Detectors sometimes adds to the decorative appearance or it may be easy to work on the installation wiring on the wall.

But tests have proved that in such detectors there is a small delay in the response time and also has certain disadvantages as shown below:

- Smoke may be obstructed to reach the detector by the furniture in the vicinity
- The detector cannot monitor the most critical area
- The detectors can be damaged through the movement of the furniture or through the cleaning of the area.

If such installation is unavoidable than the fire department officials should be consulted. Figure 5.11 shows the arrangement of such detectors.

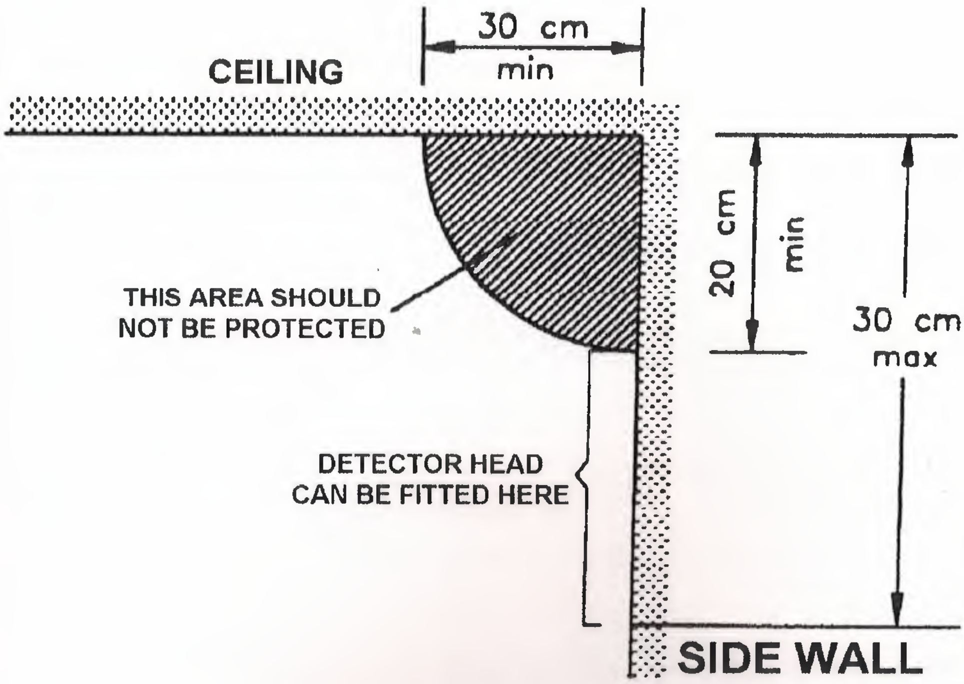


Figure 5.11. Mounting procedures of the detectors on a wall

5.7. Summary

In this chapter we covered the general principles of the design characteristics and the selection criteria of the detectors. We analysed the smoke propagation and the methods that can be adopted in different situations. We also looked at the area and space suitability of various sensors. We extended our investigations to the fire risk factor of various buildings and confined spaces, the room factors, ventilation effects, distance of the detectors and irregular conditions.

CHAPTER 6

6. ANALYSIS OF FIRE RISKS

6.1. Overview

This chapter presents an indepth analysis of fire risks in general. The structures of the hotels that have different characteristics from the other buildings have been taken as an example in this instance. Further the large hotel complexes will be compared with other industrial centres. The complexes under scrutiny have heating and cooling systems, annexes, work shops, computing centres, etc.

The customers in the hotels are not the only occupants of the rooms but there are also workers, bar tenders, disco staff, restaurant and ballroom attendants, etc. Therefore it has a high level of responsibility to look after the safety and security of these parties.

Because of high population and high value materials the risks are also high especially in protection of human life and their possessions. Another aspect is that the contents of the building have flammable characteristics. Therefore necessary steps are required to be taken to reduce the losses to the minimum in case of a fire brake.

6.2. Fire Risks in Hotels

The level of fire risks can be established by the amount and nature of contents and structural conditions of a building. The term "Fire potential" describes the energy created by burning materials in a fire.

In hotels the fire potential can be categorised under "low" or "medium" risks. Depending on the construction of a building their fire potential differs from one another. It is an accepted principle that generally older buildings have higher fire potential.

It should not be forgotten that temporary partitioning, new decorations (including new carpets and curtains) increases the fire potential.

Although there are no fire regulatory bodies in our country to take the initiation in establishing and regulating the fire risks it is the responsibility of the chief engineer of the hotels to take over such initiation and apply precautionary measures to reduce the fire risks in the hotel that he is responsible for.

6.3. Fire Risk Considerations

The fire risks are the result of the sources that are likely to flame and presence of materials that have the possibility of fire. In hotels such possibilities exists everywhere. These areas are indicated as follows:

6.3.1. General Areas

Generally the fires are set off because of the following reasons:

- **Electrical faults :** Distribution boards, motors, transformers, heaters, lighting equipment, short circuits and overloads.
- **Maintenance work :** Welding, soldering, heating, flame used in de-freezing the pipe-work and painting works.
- **Insufficient cleaning :** The dirt and grease accumulated in the air conditioning trunking system, air change systems, ironing rooms, storage rooms, kitchens and laundry rooms, etc.
- **Sabotage :** Intentional fire created by unsatisfied personnel or customers.
- **Carelessness :** Forgetting to switch off electrical equipment, using flammable materials in cleaning and painting, smoking.
- **Temporary decorations**
- **Synchronous ignitions :** During carpet cleaning, etc.
- **Modifications**
- **Lightning**

6.3.2. Customers Rooms

In these areas the main reasons for braking out of a fire are as follows:

- **Smoking in bed in a careless manner**
- **Usage of faulty electrical equipment :** Electrical blanket, iron, shavers, hair dryer, etc.
- **Carelessness :** Forgetting to switch off the electrical equipment when leaving the room, etc.

6.4. Reasons for Fire Breaks

The following table shows a statistical summary of the fires set off at the hotels. The data is obtained from the NFPA which is prepared over a period of one year.

Table 6.1. Fire breaks in hotels and their reasons

Reasons for the Fire Breakout	**Percentage of Hotel Fires**	
	360 Hotels, open throughout the year	**127 Hotels, open seasonally**
• **Cigarettes**		
In beds	13 %	8 %
Other places	22 %	21 %
• **Electric**		
Installation	15 %	16 %
Motors and hand tools	4 %	5 %
Heating and cooking equipment	8 %	9 %
• **Arson**	13 %	13 %
• **Heating System**		

Faulty oil heaters	3 %	4 %
Chimney	3 %	2 %
Faulty gas heaters	2 %	1 %
Faulty coal heaters	1 %	-
Miscellaneous	1 %	2 %
• **Cooking equipment**		
Oil, grease and waste accumulated in the cooking hoods	7 %	5 %
• **Other reasons**		
Sparks, sudden blazes, faulty gas installation	8 %	14 %

As it will be seen from the table smoking is the most severe element in breaking the fires, second comes electrically originated fires.

The following table shows the regions where the fire generally starts:

Table 6.2. Reasons for Hotel fires and their source of origin percentages

Location of Fires	*Percentage of Hotel Fires*	
	360 Hotels, open throughout the year	**127 Hotels, open seasonally**
Service Areas	%	%
Kitchens	10	13
Heating systems	9	7
Storage areas	10	5
Corridors, stairs	6	3

Personnel areas	2	8
Ironing and laundering rooms	3	2
Technical rooms	3	2
Lift shafts	1	--
Offices	4	2
Guest Areas		
Guest rooms	23	10
Bars	4	6
Lobbies	3	7
Toilets	3	2
Restaurants	2	2
Sitting and meeting places	2	3
Other	17	28

6.5. A matter of Life and Death

Beyond the provisions of the standards and regulations it is the conscious responsibility of the hotel administration to protect the personnel and the guests that they happen to be in the vicinity of the hotel building. The fame of the hotel depends on the relevant precautions taken against the fire breaks. Even one outbreak of a fire is sufficient to dent the image of the hotel.

There are many locations of the hotel are continuously functional. E.g.:

- Bed rooms
- Lobby and common areas
- Ballrooms
- Service areas

- Restaurant, bar, disco
- Personnel areas
- Workshops
- Escape routes
- Pools, saunas
- Shops
- Technical units
- Kitchens
- Launderette etc.

IT should be noted that in many cases, people who gathered at these areas are alien to these environments and they can easily be scared or panic under fire outbreaks. Improper alarms or alarms caused by blundering actions may create panic and injuries or even death driven circumstances.

In the evaluation of the situation the guests of the hotel are also to be observed. Generally the guests are not familiar with the environment, such as the place of the fire exits, fire exit stairs and the alarm signal patterns.

The guests that are staying in the hotel have different characteristics from their physical build and age. Therefore it should be observed that these guests most of the time are sleeping or under the influence of drugs that were taken for sleeping purposes.

In general, the guests of the hotel they cannot be trained for a fire drill, but only the procedures of the hotel relevant to the fire breakout are drawn to their attention. It will be a safety factor to assume of the fact that the notices displayed in a hotel room will not be read by the guests.

Additional to the different approaches and behaviour many nationalities, facing the language problems are very common. The importance of such factors comes forward under the evacuation and emergency conditions.

On the other hand the personnel of the hotel must be trained relevant to the following matters continuously:

- Knowledge about the risks of fire.
- The place of fire manual, emergency buttons, escape routes, fire exits, location of the fire fighting equipment.
- Extinguishing or suppression of small fires.
- Evacuation and rescue topics.

6.5. Summary

In this chapter we presented an indepth analysis of fire risks in general, taking the structures of the hotels that have different characteristics from the other buildings have been taken as an example. Further the large hotel complexes have been compared with other industrial centres. The complexes under scrutiny had heating and cooling systems, annexes, work shops, computing centres, etc.

In the analysis the customers in the hotels were not the only occupants of the rooms but there were also workers, bar tenders, disco staff, restaurant and ballroom attendants, etc. Therefore from the point of analysis it had a high level of responsibility to look after the safety and security by the parties concerned.

Because of high population and high value materials the risks were also high especially in protection of human life and their possessions. Another aspect is that the contents of the building had flammable characteristics. Therefore we looked into the necessary steps that were required to be taken in order to reduce the losses to a minimum in case of a fire brake.

CHAPTER 7

7. PROTECTION MEASURES AGAINST FIRE

7.1. Overview

It is possible to prevent the fire before it can happen by taking certain passive and active measures. This section will study such measures and recommend certain precaution that it is possible to be taken administratively or otherwise. SAuch protection measures cover perception, c ombating and evacuation. There are other measures that can be taken at managerial levels, such as: Engineering precautions, training of the personnel to combat small scale fire, placing warning signs at various places of the building, carrying out periodical inspections, assigning and maintainin dedicated escaping routes, preparing detailed plans under emergency conditions. It will also help to select the building materials that they are fire resistant and cannot emit toxic gasses under fire.

This chapter describes some protection measures that may be taken against fire risk in order to minimise the dangers on human life, personal possessions and on properties.

7.2. Protection Measures

Protection measures against fire can be grouped under two headings

1. Passive measures
2. Active measures

Passive measures are those measures that are taken after the happening of a fire, which are the measures taken to determine the structural strength of the building; the active measures are those measures that take into considerations the prevention of starting of the fire and the prevention of the spread of smoke.

7.2.1. Passive Measures

Passive protection measures have a significant place in the general protection concept. Passive measures covers the structure of the building, methods of construction and the materials used to sustain to a fire.

The main passive protection measures relevant to constructional methods are summarised as follows:

- Dividing the building into fire protected compartments.
- Selection of the materials used in the construction to have characteristics of prevention from collapsing of the building.
- Materials used to have the characteristics to minimise the spreading of the fire.
- Fire resistant exit paths, lifts and stare case designs.
- Selection of materials to minimise the effects of fire.
- Selection of materials that will prevent the creation of toxic gasses.

For those buildings that are under construction most of these measures should have been determined by the prevailing standards.

It should be noted that in accordance with the prevailing standards most of these measures should have been taken earlier for the existing buildings. For those buildings which do not incorporate such measures, it will not be possible to update them without going into intensive modifications.

For those buildings that do not have adequate passive protection measures, in the preparation of fire protection policy for the building, such deficiency should taken into consideration.

7.2.2. Active Measures

In a building where all the passive measures are considered does not mean that it does not necessitate for the active protecting measures not to be taken. Active protection methods mainly are considered under 4 sections. These sections are outlined below:

7.2.3. Administrative Measures

- A responsible person must be appointed for all operations.
- Training of the personnel (prevention and intervention)
- Preparation of the plans for alarm and emergency conditions.
- Periodical maintenance of the fire fighting equipment
- Keeping clear and without any obstruction of the escape routes and emergency exits.
- Usage of fire resistant decoration, furniture and coverings.

7.2.4. Perceptive Measures

- Auto detection system
- Manual emergency buttons
- Auto signal communication (Fire Brigade)

7.2.5. Fire Combating Measures

- Keeping in hand of the mobile extinguishers
- Hydrant hoses
- Water sprays
- Dry extinguishers (for certain areas)
- Smoke extraction systems
- Automatic fire isolation systems
- Automatic Fire Brigade Warning System
- Emergency telephone system

7.2.6. Evacuation Measures

- Indication of escape routes
- Usage of dependable oral announcement and visual indication evacuation equipment

- Emergency lighting system
- Pressurisation of stair cases and stair evacuation routes

7.3. Management Measures

In a Hotel probable fire risk areas should be regularly inspected and a list of the hazardous areas should be prepared and necessary precautions should be taken immediately. In coordination with the Local Fire Brigade emergency plans, which is one of the important policies should be prepared.

7.3.1. Engineering Services

The chief engineer of the hotel must be responsible for the inspection in the conformity of the fire fighting equipment with the standards and where there are inconsistencies, recommend what measures that are required to achieve such conformity to the management of the hotel.

7.3.2. Training of Personnel

In accordance with a pre-planned program the hotel management should organise fire drills at regular periods in the course of training the hotel personnel. The Trainings indicated below are compulsory:

- Usage and operation of the mobile extinguishers and internal building fire hoses.
- Procedures for reporting and knowledge of fire policy of the building
- Knowledge on escape routes and fire exits
- Knowledge in evacuation and rescue operations and training in rescue of handicapped persons
- Training in operation of emergency fire pumps and generators, including the knowledge to stop these equipments

All personnel should be instructed to carry out the following operations:

- All escape routes positively to be cleared from any obstruction
- Storage localities, installation conditions, blanket storages, electrical rooms, etc., are to be kept closed or locked.
- Administration to be informed immediately on the case dof iscovery of dangers

7.3.3. Warning Signs

As it is not possible to train the hotel guests, similar to the training given to the staff, for emergency cases, warning signs should be prepared and placed in different languages. Such signs should be placed in guest rooms, common places, exit routes, and where they are appropriate.

The warning signs should conform with the relevant standards and should incorporate the following minimum information:

- Information about what to be done when a fire is noticed
- Basic precaution to prevent spreading of fire
- Clear instructions of what to do fire alarms are set off
- Details of fire exits and escape routes

It should be observed that the warning signs are written on rigid plates that cannot be tampered instead of hardboards or paper based material that can be removed or destroyed.

Even if they are rarely read by the guests these signs should be placed at the appropriate places and their contents should be clear and precise.

Warning plates should be placed at the interior face of the entrance room's door where it can be easily noticed.

7.3.4. Emergency Instructions

Plates that contain such instructions should be placed in every room of the hotel. Appearance and contents are very important should be such a way that it is very important to draw attention.

7.3.5. Periodical Inspections

With the help of the section supervisors the chief engineer of the hotel must make sure that the following conditions are fulfilled:

- All the fire extinguishers are in place in operational condition
- All mobile extinguishers are in the right place
- All connections to auxiliary water reserves are in reachable places
- All fire hoses are in place and are in order
- Inspection of fire drills that are carried out every month
- Fire system and emergency fire equipment are maintained by relevant specialist firms
- Fire fighting equipment to be placed where paint, furniture, flammable solvents etc., are stored and "No Smoking" signs are placed
- All chimney hoods are protected by automatic fire extinguishing systems and maintained at least once in 3 months
- Oil filters to be cleaned at least once a week

7.3.6. Escape Routes

It is the responsibility of the hotel management to observe that the following matters are performed:

- All fire doors are in working order, unlocked and free from obstructions
- All tables, chairs, rubbish, waste paper, dirty bed linens, etc., are kept away from the fire exits and these doors are not locked at all times
- All service areas are free from rubbish

7.3.7. Plans for Emergency Conditions

In many countries, it is the requirement of the law that certified fire alarms and evacuation plans are held in the building. These plans should contain the detailed procedures and the duties of the appointed fire officers in the case of a fire break.

For the countries that such requirements are not protected by the law, it is the responsibility of the hotel management to enforce similar appropriate plans for the hotel. The plans that are prepared in coordination with the section leaders, locally authorised persons and the fire brigade officers are to be reviewed regularly and revised if necessary at the regular meetings.

In order to reduce the fire risk of the hotel decorations and furniture should be made of fire resistant materials.

7.4. Perception

The fire system of building should be installed with addressable analogue sensing detectors and must have remote connections with the local Fire Fighting Team and the Fire Brigade.

7.5. Intervention

In order to minimise all kinds of losses to the building, all interventions and fire fighting measures should be taken immediately after the outbreak of the fire.

7.6. Summary

It is possible to prevent the fire before it can happen by taking certain passive and active measures. This section will study such measures and recommend certain precaution that it is possible to be taken administratively or otherwise. SAuch protection measures cover perception, c ombating and evacuation. There are other measures that can be taken at managerial levels, such as: Engineering precautions, training of the personnel to combat small scale fire, placing warning signs at various places of the building, carrying out periodical inspections, assigning and maintainin dedicated escaping routes, preparing detailed plans under emergency conditions. It will also help to select the building materials that they are fire resistant and cannot emit toxic gasses under fire.

This chapter describes some protection measures that may be taken against fire risk in order to minimise the dangers on human life, personal possessions and on properties.

CHAPTER 8

8. FIRE FIGHTING EQUIPMENT

8.1. Overview

In this chapter the fire fighting equipment, their characteristics and usage have been introduced. Their conventional application methods examined and certain methods that may improve their effectiveness and usage are recommend.

Further the sensors, outstations, analyzing devices, and the algorithm, software reqirements for the setup and their application within the system is overviewed. Brief information about the requirement of such devices are explained.

The chapter initially explains the necessity for the description of the components and gives their address details and functions lists. Subsequently it incorporates the conditions and the steps required to be taken as how the system will detect and warn the users and the occupants of the building.

8.2. Equipment

When a fire breaks there are considerable number of equipment and methods of applications to extinguish them. The equipment that considered in this chapter are:

1. Portable fire extinguishers
2. Hydrant cabins
3. Automatic sprinkler systems
4. Dry fire extinguishers
5. Foam extinguishers
6. Smoke extractrion systems
7. Equipment for auto-start
8. Emergency telephone contact system

8.2.1. Portable Fire Extinguishers

The portable fire extinguishers are very effective to extinguish small scale fire outbreaks. These extinguishers should be placed in every corner of the building, at the exit routes, preferably where the emergency fire buttons are located. They should be placed in such a way that it can be accessed by anyone who wishes to used it in emergency cases. In the event of the removal of these extinguishers from their position an alarm device should implemented to warn the fire watchers through their monitoring systems. A small micro switch placed at a suitable place at the back of the extinguisher will do the trick. Such arrangement not only is useful in emergency cases but also a protection against the theft of the item.

8.2.2. Hydrant Cabins

It is very effective in fire fighting system for use by the fire brigade in large scale fire outbreaks. Such hydrant cabins should be installed at suitable places in sufficient quantity around the building.

In certain cases the hydrant cabins incorporate the sprinkler system pipe-work also. The pipe-work of the sprinkler system incorporate a flow switch, which sets off the fire alarms when water is drawn form the pipe-work.

8.2.3. Automatic Sprinkler System

The system is very effective in suppressing the local fire when started. That's why their usage is very common. When a sprinkler head is activated the mimic diagram on the panel should indicate the offended head.

8.2.4. Dry Fire Extinguishers

In specialised areas, i.e. computer rooms, telephone communication centres etc., usage of wet fire extinguishing equipment may damage the such equipment therefore in these areas CO_2 fire extinguishers must be used.

Other dry fire extinguishers like, potassium bicarbonate, mono-ammonium phosphate generally are used in the kitchens. The nozzle of the equipment is pointed at directly where the fire may or broke out.

8.2.5. Foam Extinguishers

Generally the usage of such extinguishers are very common in the hotels. These fire extinguishers should be used only in certain special risky areas, i.e. kitchens, and the person who noticed the fire should activate it. The selection of the foam should be made according to the materials in question.

8.2.6. Smoke Extraction Systems

The smoke that is created by the fire, not only limits the distance of the vision but also endangers the fire fighting. Additionally it is very dangerous for all living beings. In hotels smoke presents a more dangerous situation than the fire itself.

In such cases the automatic smoke extract fans should be started automatically and fresh air to be provided to the areas that fire is not present in order to sustain human life in that vicinity. It should be noted that fresh air increases the fire flames therefore supply of fresh air should be avoided from these areas. The fire fighting officers should be able to control the smoke extract system manually also. This necessitates all sectional air paths to be controlled from the master fire room and a visual display unit maintained to indicate all actions taken and their responses.

8.2.7. Automatic Start of Fire Prevention Equipment

Additional to the other fire fighting systems, the fire prevention system should be able to start automatically in case of a fire break. The following items represent the minimal systems that should be controlled by the Automatic Fire Prevention System.

- All lifts should be grounded and stopped except the fire lift.

- All air supply systems should be stopped.
- All fire doors should be shut off
- The fire pumps should be started but prevented to stop until manual intervention

8.2.8. Emergency Telephone System

The emergency telephone systems are very effective in a fire fighting situation. They are installed for the use only by the fire fighters and are placed at strategic points in the building.

8.3. Evacuation Measures

Additional to the precautions mentioned earlier the following measures proved to be beneficial in fire fighting and in many countries their usage are enforced.

8.4. Indication of the Escape Routes

In many countries there are provisions in the law as how to indicate the escape routes in an establishment. In fire it is very important (where smoke becomes a hazard and obstructs the vision) that they should be noticed and seen by the observers.

8.5. Public Address Systems

Public address systems work in conjunction with the fire sensing equipment and in case of fire they commence to announce messages in order to prevent panic and confusion and eliminate any misunderstanding in an evacuation process at the related floor level.

8.6. Emergency Lighting

Emergency lighting are installed in hotels so that they are switched on in case of power failures. These emergency lights are placed in the vicinity of service areas, fire exits and escape routes. Under normal usage they are fed from the mains but in case of power failure or under fire conditions their source of power automatically are switched to batteries or emergency generators. They are equipped to work in both cases.

In many countries the procedures of the emergency lightings are set out by the related standards.

8.7. Application and Software Requirements

8.7.1. Unit Spread Sheets

The configuration the software for each unit is based on the lists that are attached at the end of this project. You can think about these lists as a mathematical explanation for the theory. With aid of this table it is possible to see the architectural structure of the units and the examine their functions.

8.7.2 Computer Software

The software of the system is specifically prepared for the functions of the units. It is prepared for the purpose to interface the control system with the units. First, the program makes sure that all the detectors on the line are interrogated with a toll function one by one in order to specify their location and their addresses that are relevant to the point on the screen and are functional. The last, warning commands and the expected return signals are designated. A translation relevant to communication program adopted in the system is appended to this project as an example.

8.7.3. Schematics

It will be possible to get a better comprehension and clear understanding off all the details given so far relevant to the program lists earlier in corporation with the schematic diagram of the system that is appended to this project.

The hotel is comprised of five main buildings and one annexe. At all places detectors are installed according to the types required for the local area. There are fire warning buttons in all escape routes. A sprinkler system has been installed in the building incorporating an on screen fire location detection arrangement.

When a fire warning signal is received the PA system is activated for the predetermined fire announcement at the local area only where the fire alarm is set off. Additionally at that area all the fire doors are closed and the smoke fans are started for the extraction of the smoke automatically.

In general there are 3500 warning and control points in the vicinity of the hotel building, which are connected to five fire units that has the facilities to work independently in case of a communication failure with the main system. Additionally it is possible to monitor all the events through the central computer of the building.

8.8. Summary

In this chapter we discussed the fire fighting equipment, their characteristics and usage. We mentioned about:

1. Portable fire extinguishers
2. Hydrant cabins
3. Automatic sprinkler systems
4. Dry fire extinguishers
5. Foam extinguishers
6. Smoke extractrion systems
7. Equipment for auto-start
8. Emergency telephone contact system

We highlighted their conventional application methods, examined certain new methods that may add effectiveness and usage on the conventional methods and expressed our views and recommendations as to how they can be improved.

Further we discussed the application of the sensors, outstations, analyzing devices, their algorithm and software reqirements that are required in setting up the required system. Brief information about the requirement of such devices, the description of their components, their address details and functions lists. Subsequently we incorporated the conditions and the steps that are required to be taken as how the system will detect and warn the users and the occupants of the building.

CONCLUSION

In our age fire detection and warning systems are upgraded themselves to a point that their functions are addressable and analogue. Because of these systems early warning messages can be obtained so that fire fighting team can intervene and stop a possible fire outbreak. In order to bring the level of false alarms to the minimum and increase their dependability they can be adjusted to suit any circumstances and environment.

The recent improvements and applications of these systems they can sample the air and determine a fire breakout before it can happen and set off an alarm to that effect. Such improvements increase their speed in sending the necessary information and reliability, which is extremely pleasing.

The recent approach to their local applications is receiving attention and the importance that they deserve.

In the light of these applications fire detection and warning systems this dissertation will shed light to those who are interested to learn about the subject in all points.

Fire detection and warning systems, from their detectors to their control centres and the warning elements, all are introduced in a technical approach and looking at it from this point of view how to make up of a plan relevant to the system is conveyed. Adding to the subject the hotels as the application area it gives to the project a special dimension. The start off point of the project begins with a theory and ends up with an application in a hotel which will narrow the gap a little bit that exists in our country.

In chapter 1 the author presented the fire propagation in buildings, the combustion materials and their calorific value in a fire, the methods of determining the fire load in building, the toxidity values produced in a fire, spreading and movement characteristics of fire and smoke. It has also introduced the devices that used in protection from fire that will be discussed later on in detail.

In chapter 2 the author discussed the currently available conventional systems that are commonly used in many buildings and their addressing possibilities. We highlighted the differences of digital and analogue addressing concepts. He introduced the wireless warning systems, their methods of communication and the places that they are used. Here the author also discussed the air sampling methods and how they are used in early warning systems.

In chapter 3 the author discussed the fire detection devices, like ionization smoke detectors, optical smoke detectors and heat detectors, their structure relevant to mechanical and electrical composition, their methods of installation. and their characteristics.

Further the author discussed the methods of construction of various detectors and their usage. Additionally we looked into the points required to be observed in installation and in their configuration.

In chapter 4 the author introduced his methods on designing a fire control panel, which is composed of a fire detection and alarm system control panel, fire warning and control equipment.

He also discussed how the detectors sense the differences in various conditions and send related signals to the control panel for evaluation and taking the necessary actions based on this evaluation.

In chapter 5 the author covered the general principles of the design characteristics and the selection criteria of the detectors. He analysed the smoke propagation and the methods that can be adopted in different situations. Then looked at the area and space suitability of various sensors and subsequently he extended his investigations to cover the fire risk factor of various buildings and confined spaces, the room factors, ventilation effects, distance of the detectors and irregular conditions.

In chapter 6 the author presented an indepth analysis of fire risks in general, taking the structures of the hotels that have different characteristics from the other buildings have been taken as an example. Further the large hotel complexes have been compared with other industrial centres. The complexes under scrutiny had heating and cooling systems, annexes, work shops, computing centres, etc.

In this chapter the outline of the analysis included the customers in the hotels, the occupants of the rooms, the workers, bar tenders, disco staff, restaurant and ballroom attendants, etc., all are considered. Therefore from the point of analysis it had a high level of responsibility to be looked after relevant to the safety and security.

Because of high population and high value materials, the risks were also high especially in protection of human life and their possessions. Another aspect is that the contents of the building had flammable characteristics. Therefore he looked into the necessary steps that were required to be taken in order to reduce the losses to a minimum in case of a fire brake.

In chapter 7 the author has presented that it is possible to prevent a fire before it can happen by taking certain passive and active measures and recommended certain precaution that it is possible to implement administratively or otherwise. Such protection measures cover perception, combating and evacuation. There are other measures that can be taken at managerial levels, such as: Engineering precautions, training of the personnel to combat small scale fire, placing warning signs at various places of the building, carrying out periodical inspections, assigning and maintainin dedicated escaping routes, preparing detailed plans under emergency conditions that will help in selecting the building materials that have fire resistant and cannot emit toxic gasses charachteristics under fire.

In chapter 8 the author discussed the fire fighting equipment, their characteristics and their usage. In this chapter he highlighted the conventional application methods, examined certain new methods that may add effectiveness and usage on the conventional methods and expressed his views and recommendations as to how they can be improved.

In chapter 9 the author discussed the application of the sensors, outstations, analyzing devices, their algorithm and software reqirements that are required in setting up the required system. Brief information about the requirement of such devices, the description of their components, their address details and functions lists were given. Subsequently he incorporated the conditions and the steps that are required to be taken as how the system will detect and warn the users and the occupants of the building in case of fire.

The aim of this operation is to search for the new developments in fire fighting equipment and develop certain new measures so that the installers search for new methods of fire alarms themselves before they carry out their installation regardless of the existing conventional methods in order to improve the fire alarm systems.

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