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# GUIDELINES FOR PREVENTION, DETECTION AND CONTROL OF FIRE IN ARCHIVES AND LIBRARIES

NATIONAL ARCHIVES OF INDIA
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Conservation of Archives and Library Materials
School of Archival Studies

# GUIDELINES FOR PREVENTION, DETECTION AND CONTROL OF FIRE IN ARCHIVES AND LIBRARIES

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## PREFACE

Fire is one of the major causes of destruction of our cultural heritage preserved in the form of records, manuscripts and books. This hazard can be caused by people and processes either directly or indirectly, out of ignorance or due to carelessness. National Archives of India, being one of the major repositories of public and private archival collections, is particularly alive to this difficult problem of fire. An attempt has therefore, been made to compile useful information regarding prevention, detection and control of fire with particular reference to archives, manuscript repositories and libraries, so that it provides guidance for fire safe storage, and adoption of necessary fire protection measures in archival repositories and libraries.

I am sure that information contained in this monograph, will help an institution to analyse the fire hazards embodied in the existing building and various operations carried out therein, so as to plan and implement measures for providing adequate protection for valuable collection of records, manuscripts, books and other associated materials. The monograph will also be useful for the trainees of the School of Archival Studies as it covers an important aspect of their training Syllabus.

I am thankful to Shri V.V. Talwar, Senior Fellow, School of Archival Studies for collecting all relevant information/data/illustrations on the subject and presenting the same in a very lucid form.

NEW DELHI

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## INTRODUCTION

Over the years devastating fires have occurred in all parts of the world and have caused great loss to life and valuable property including records. Unless timely preventive measures are taken, this calamity will continue to create havoc. Government Departments and various authorities of Metropolitan cities have recognised this hazard and have brought out rules and regulations regarding fire protection and fire-fighting requirements. The Bureau of Indian Standards has classified fires in the following categories according to the nature of materials on fire:—

| | |
|---|---|
| Class A Fires . . . | Fires involving solid combustible materials like wood, paper, textile, plastic, rubber etc. |
| Class B Fires . . . | Fires involving flammable liquids like oil, grease, petrol, paint, varnish, thinner etc. |
| Class C Fires . . . | Fires involving gaseous substances under pressure like liquefied petroleum gas. |
| Class D Fires . . . | Fires involving metals like magnesium, aluminium, lithium, zinc, sodium, pottasium etc. |
| Class E Fires . . . | Fires in live electrical equipments like generators, transformers etc. |

Most fires develop in four distinct stages viz. incipient, smouldering, flame and heat. When fire is in the first stage, no visible smoke, flame or significant heat is developed, but combustion particles are generated by chemical decomposition, which rise to the ceiling. When it reaches the second stage, the quantity of combustion particles increases and they become visible in the form of "smoke". At this stage, there is still no flame or significant heat development. When it reaches the next stage, the point of ignition occurs and flames start. The visible smoke decreases and the heat level increases. When it reaches the fourth stage, large amounts of heat, flame, smoke and toxic gases are produced. Usually the transition from the flame to the heat stage develops very quickly.

Fire is a process of combustion, and is an exothermic reaction which results in the release of heat energy. The process involves four basic needs for a fire to occur. These are fuel, oxygen, heat and chain reaction. Keeping in view these four basic needs fire extinguishers therefore, work on the following

four principles viz. (i) Blanketing and cooling (ii) Cooling and drenching (iii) Blanketing and excluding oxygen and (iv) Depleting oxygen.

In Archives, libraries, museums and other allied institutions, the collections mainly comprise combustible materials and hence these institutions are easily prone to fire hazards. Therefore, provision of a Fire Protection System in these institutions is of vital importance since such a system primarily aims at preventing the inception of fire. However, when fire occurs, the most immediate task is to detect, confine and then extinguish it.

# CHAPTER 1

## FIRE PREVENTION

An occupied building with the presence of a large number of people provides more chances for the outbreak of fire, since any of its occupants could perform a careless or malicious act that may result in fire. Type of building, nature of the materials stored therein, electrical and mechanical fittings and appliances installed are also a potential hazard since misuse, faulty construction and sub-standard installations can cause fire. Accumulation of combustible waste material frequently provides ready means for spread of fire. Special functions and requirements of the building and proximity and nature of buildings located in the neighbourhood are also taken into consideration for fire prevention measures. All buildings should satisfy certain requirements which contribute individually or collectively to the safety of life and property from fire, smoke and fumes and panic arising from these causes. The Bureau of Indian Standards has brought out National Building Code of India 1983 which serves as an excellent guide for such purpose.

Besides traditional paper records, manuscripts and books, archives and libraries also preserve records on magnetic tape, photographic, micrographic and other special media that are particularly susceptible to fire and/or water damage. They are, therefore, in the category of extra hazard occupancy.

For provision of adequate fire protection and to minimise the risk of fire hazard, the following considerations should be kept in view while planning a building for an archives or a Library, or making alterations in an existing building.

### Fire Separation

While planning the lay-out of the building, care should be taken to leave sufficient open space around the building so as to minimise the possibility of spread of fire from and to neighbouring buildings since the building gets exposed to heat which is radiated horizontally by flames from the windows of a burning neighbouring building. High buildings also get exposed to drift of hot gases and flame when fire occurs in a lower building. The Indian Standard IS: 1643-1988 "Code of Practice for Fire Safety of Buildings (General): Exposure Hazard" covers requirements regarding spacing of buildings.

When exposed to fire, the internal temperature of the stacks or the interior face of the stack door should not exceed 175°C so that paper records do not get charred or ignited. Minimum distance recommended between front, back and side walls of opposite buildings is 9 metres, 6 metres and 6 metres respectively.

If there is no provision of sufficient space, then the exterior walls of the archives or library should be of masonry or other adequately fire resistive construction wherein care has to be taken that the doors, windows or other openings do not face the adjacent buildings.

When opening in an exposed wall is necessary, then provision should be made to prevent transmission of heat or flames from a nearby fire and this could be done by providing fire windows with wired glass or electro-copper glazing in place of ordinary glass, fire doors, outside automatic sprinklers, automatic fire shutters or a combination of all these. Roof coverings should also be given due consideration.

The degree of protection to be provided depends upon the distance from the neighbouring building and the comparative hazard of their occupancy and the resulting hazard of radiant and convected heat.

**Hazard of occupancy**

Hazard of occupancy is determined and depends on the nature of contents, processes and operations carried out in the building. One of these factors or all three combined may result in starting and spreading of fire, smoke and gases and even the danger of explosion. No doubt these factors determine the type and scale of fire extinguishing installations.

Hazard of Occupancy could be classified under three major categories:—

(i) *Light hazard occupancy.*—They contain relatively small amount of combustibles. Office buildings, schools, churches etc. come under this category.

(ii) *Ordinary hazard Occupancy.*—In this case, average severity of fire is anticipated. Department stores, warehouses, manufacturing buildings etc. come under this category.

(iii) *Extra hazard occupancy.*—Extra severe incipient fire may be anticipated here because of the character and quantity of combustibles. Wood-working shops, textile and paper mills, archives and libraries, warehouses storing inflammable liquids and gases belong to this category.

When the building is used for more than one type of occupancy, it should conform to the requirements of the most hazardous of the occupancies. An archives, in addition to housing records may also have a library, microfilms, magnetic tapes, motion picture films etc. that provide ample fuel and may contribute to a serious fire, even in the absence of other combustibles. It may also have work rooms, bindery and reprographic room where various types of manually and electrically operated equipments are used besides having research and reading rooms and even an assembly hall.

Paper has an ignition temperature of approximately 235°C, and fuel load in records or library stacks ranges from 45 to 60 kgms per linear metre of shelf space. Paper and wood have a caloric value of 16-20 MJ/Kgm. (7000-8000 Btu/lb.) Exterior and interior finish materials also contribute fire load. Other factors like ventilation systems, building shape, degree of openness and amount of compartmentation also affect the fire load. Fire load is a guide to develop and provide adequate fire protection.

Work within records storage areas is normally limited to placing records in, retrieving records from, or removing records from storage. Additional operations can introduce ignition hazard and are inappropriate in records storage areas.

Other fire risks in the records storage areas can be reduced by (i) Prohibiting the use of portable space heaters, lights on extension cords, hot plates, duplicating devices, welding torches and other such ignition sources. (ii) Prohibiting the storage of oils, paints and other inflammables in or near the record storage areas. (iii) Switching on the lights only when required and switching off the electric supply to the records storage areas after the office is closed.

**Maximum height**

The building should be restricted in its height above the ground level depending upon the nature of its occupancy and the type of construction. The maximum permissible height is

also related to the width of the street fronting the building or the floor area ratio (FAR), the local fire regulations and fire fighting facilities available.

**Means of access**

Adequate passage-ways and clearances should be provided around the building for fire fighting vehicles. The width at the main entrance should not be less than 4.5 metres with an overhead clearance of 5 metres.

**General principles of fire safe building**

(i) *Type of Construction*

By virtue of their contents archives and libraries have high fire load grading and hence fire resistive buildings should be designed and constructed for archives and libraries as per Indian Standards given below:

(a) IS: 2663-1977 "Recommendations relating to Primary Elements in the Design of Buildings for Archives".

(b) IS: 1553-1976 "Code of Practice relating to Primary Elements in the Design of Library Buildings".

(c) IS: 1641-1988 "Code of Practice for Fire Safety of Buildings (General): General Principles and Fire Grading" and

(d) IS: 1642-1988 "Code of Practice for Fire Safety of Buildings (General): Materials and Details of Construction".

The buildings should have structural stability, and capacity to withstand fires of specified intensity and duration without failure. Besides it should have resistance to collapse, to flame penetration and to excessive temperature rise on unexposed face. It is desirable that the fire load should be less than the structural fire resistance of the building.

Common high fire resistive components that should be taken care of, are masonry load bearing walls, reinforced concrete or protected steel columns and poured or precast concrete floors and roofs. Fire ratings are available for most of these components and also for doors, windows etc. Depending upon the total fire load and the expected security against outside fire exposure, the fire resistant rating should not be less than 2 hours.

Special care should also be taken about the "Interior finish" used in the building for aesthetic and/or acoustical purposes. All surface finishes must have low flame spread and should not generate toxic smoke and fumes. The flame spread rating of almost all surfaces can be improved by treating them with approved fire retardants.

Good quality fire-resistant material for interior decoration, panelling, furnishing, partitioning and false ceiling is now available for use. Therefore, it is advisable that seasoned hard wood which is chemically treated by impregnation for fire retardance should be used. Expertise is also available to provide fire resistant coatings for flame proofing of existing wooden structures, thermocole, fibre glass, upholstery and electrical cables.

In many archives and libraries, the "stack area" i.e. the part of the building where records and books are housed, is only a shell and called "stack area". The metal stacks kept in that area are self supporting, and extend through several floors of the building. The stack floors are merely platforms of cement concrete or metal gangways. Such an arrangement permits a rapid un-interrupted upward flow of air, heat, smoke and flames. In new archival or library buildings or in major renovation of existing buildings, this type of stack should be avoided. Floors should be of conventional building construction with appropriate fire resistive ratings and shelves/stacks installed thereon as ordinary furniture.

A significant feature of the stack area is the 'Shelving Arrangements' which could be of two types as indicated below:—

(i) *Open-type shelving.*—In this type of arrangement, records contained in file folders are tied between wooden boards or kept in various types of open or closed carton boxes and these are in turn placed on open shelves. Books and volumes are supported between metallic book ends. Rows of records and books face each other and loose ends of the papers or folders are amenable to quicker ignition.

(ii) *Mobile Shelving.*—The practice of mounting books/record racks on tracks is now being adopted in new library or archives construction. To gain access to a particular shelf, racks are moved manually or by a motor drive which is another potential ignition source. This arrangement can result in fires of excessive duration

and calls for a greater mandatory need of an automatic fire extinguishing system in all mobile stacks.

Yet another feature to be kept in mind is the metal containers, where records are housed in closed metal file cabinets, transfer boxes etc. so that no loose papers are around. As for metal containers there would not be any significant fire development from most ignition sources.

(ii) *Compartmentation/Fire Confinement*

For localising and quick extinguishment of fire, the respective floor areas should be divided into smaller compartments, the volume of each being not more than 1000 $m^3$. The compartments should be separated from one another by non-conducting "Fire Walls" with openings fitted with fire-resisting doors for segregation of risks. All ducts running from one compartment to another should be provided with automatic dampers to achieve complete isolation from the affected area.

All partitions must extend from the floor to the ceiling. Any opening required for passage through the partitions must be fitted with a self-closing fire/smoke check door. Glazing used in partitions and doors should be of safety glass (6.5 mm thick) of approved quality.

(iii) *Smoke Control and Ventilation*

Smoke and hot gases generated by a fire seriously impair fire fighting operations since they reduce visibility and cause suffocation. Therefore, arrangements should be made with the provision of "fire-ventilation" to induce heat, smoke and gases to leave the building as quickly as possible. Pre-fabricated vents that are designed to open automatically at pre-determined temperatures and/or smoke concentration, should be installed for this purpose. As for basement, it should be separately vented. Protected vents with cross-sectional area not less than 2.5% of the floor area, spread evenly round the perimeter of the basement, should be provided.

(iv) *Exit and Evacuation*

Exit facilities play an important part in securing safety of life and property from fire. An exit can be a doorway, corridor or passageway to a stair-case which provides access to the street or to a refuge area. An exit can also be a horizontal exit leading to an adjoining building at the same level. Lifts and escala-

tors are not to be considered as exits and must not be used as a means of escape during a fire emergency.

To enable Fire Services Personnel to reach the upper floors with minimum delay, one of the lifts should be designated as "Fire Lift" which should have arrangements to switch over to an alternate source of electric supply in the event of failure of normal power supply.

The number and width of the exits i.e. exit doors and stairways depends upon the occupant load and fire hazard. It has been estimated that a 70 cm (28") wide door allows 60 persons and a stairway of 56 cm (22") 45 persons to escape downwards per minutes. Location of the exit should be at such points that a person need not to have to cover more than 30-45 metres to reach an exit.

All Archives and library buildings having an area of more than 500 $M^2$ on each floor should have a minimum of two stair-cases made of incombustible material, which should be arranged in such a way that possibility of blocking both the stair-cases is minimised at the time of fire. One of the stair-cases should be on the outer wall of the building where adequate "refuge area" has to be provided. The stair-case should be ventilated to atmosphere at each landing. Exit doors leading to stairs should have the capacity to withstand fire and smoke for the intended period of time as stipulated in National Building Code. Revolving doors are not to be used as exit doors.

No stove or combustion heater should be located under or immediately at the foot of the stairs as it will block escape of the occupants of the building. All areas of hazardous occupancy like boiler room, transformers, refrigeration or central heating plant etc. should not be located directly under or adjacent to exits. All such rooms should be effectively cut off from other parts of the building by a separation wall with vents to the outer air.

Exits should be marked by a readily visible sign. Exits and paths of travel to reach them should be provided with adequate illumination. Stairs should be properly illuminated and be connected to a stand-by electric supply.

For control of panic, an orderly exit drill practice should be held at regular intervals.

(v) *Water Supply*

Adequate supply of water in the form of underground or overhead water storage tanks should be provided with arrangements for replenishmtnt as well as delivery with necessary pressure at various floors. The number, location and spacing of hydrants and size of the water-mains also require planning to cover all the risk areas. Fire pumps should have the provision of alternate source of electric supply.

(vi) *Drainage*

On each floor it is essential to make provision for drainage of water used as fire extinguisher. Suitable arrangements must be made to prevent water used during fire fighting etc. at each landing, from entering the lift shafts.

(vii) *Electrical Installations*

(a) To reduce the risk of electrical fires, all electrical wiring and equipment should be installed and maintained as per Indian Electricity Act or the Indian Standard IS: 1646-1982 "Code of Practice for Fire Safety of Buildings (General)—Electrical Installations".

Conduit wiring is a must for all power and lighting circuits. Separate circuits for water pumps, fire pumps, lifts, stair-case and corridor lighting should be provided directly from the main switch panel. These circuits must be laid in separate conduits so that fire in one circuit does not affect the others. Main switches should be provided outside the security area so that power could be switched off in an emergency. A master control electrical switch for each floor should be located on the ground floor for easy emergency switch off.

Stair-case and corridor lighting should also be connected to an alternate source of supply. Provision for emergency lights at strategic places should also be made.

Water mains, telephone lines, intercom lines, fire detection installation lines etc. must not be laid in the same ducts/shafts with electric cables.

(b) Electrical wiring and equipment should not be overloaded. Temporary and make-shift wiring should be avoided. Only workshop braided and armoured flexible wire and standard plugs and sockets suitable for the intended electric load, should be used.

Electric wiring should be checked periodically as high temperature tends to weaken insulation after some time.

(c) All electrical equipments, particularly portable electric tools should be earthed. Electric shock control device against failure of earth connection and circuit breaker to guard against short circuit, should be provided on all circuits. Tampering and blocking of circuit breakers, use of wrong fuses or by-passing of fuses should be prohibited. Electric Distribution Board, switches and plug points should not be obstructed.

(d) To avoid over-heating, exhibition cases should have ventilation and if possible, the light fittings should be outside the case.

(e) *Air-Conditioning*: It is highly advisable to use individual air conditioning or space heating systems for each floor. However, if central air conditioning or space heating systems are used, then care should be taken to provide automatic fire dampers for each floor in the common ducting system. Fire dampers should be located in conditioned aid ducts and return air ducts of each compartment on every floor. All ducts should be of substantial gauge metal and all insulation used should be of non-combustible type. Air ducts for each floor must be separate and in no way inter-connected with the ducting of any other floor.

Arrangements should also be made so that the Air Handling Unit of the A.C. System switches off automatically when the automatic fire alarm operates. A study of the Indian Standard IS: 659-1964 "Safety Code for Air Conditioning" will be helpful in this connection.

(f) Excessive heat generated by friction in bearings of equipment can also cause a fire. Preventive maintenance and adequate lubrication can avert occurrence of such fires. Open flame heating equipment, welding and cutting operations are other fire hazards to guard against. Sources of intense heat, such as spot lights should have adequate insulation and should be kept away from easily ignitable material.

(viii) *Lightning Protection*

Since lightning is a possible fire hazard, necessary measures should be incorporated in the building for protection against damage by lightning.

(ix) *Good-House-Keeping*

(a) Carelessly discarded cigarettes, pipe embers and cigars are a major source of fire. Smoking in areas where records/ books and other combustible materials are housed, should be strictly prohibited, and in other areas, proper care should be taken for the disposal of cigarette butts etc. Metallic, glass or ceramic ash trays containing a little sand or water should be used, to put out the cigarette completely. It is not safe to throw pieces of paper into an ash tray. A burning cigarette should not be left on an ash tray because it can fall off and set fire to paper, carpet, upholstery etc

(b) Fires are also caused by spontaneous combustion in piles of decaying organic matter where the heat of fermentation cannot escape due to blanketing effect of the material and poor ventilation. Such material should, therefore, be disposed off and ventilation/exhaust system should be augmented.

(c) Concentration of sun's rays can also cause a fire, and hence due care should be taken to avoid such a concentration.

(d) Flammable, explosive or highly combustible substances should not be stored in large quantities, particularly in poorly ventiated rooms and confined spaces. Moreover, storing of such materials without a valid license is a major offence.

To eliminate fire hazards, a good house-keeping both inside and outside the building, should be strictly maintained. Areas under and around the stack rooms, store rooms, lunch rooms, heater rooms, A.C. rooms and workshop require special attention.

The steps outlined above, if implemented properly, will go a long way in preventing fires and thus conserve the nation's wealth and heritage.

**Fire Protection in Existing Buildings**

For Fire protection in existing buildings it will be desirable to evaluate existing and potential fire hazards and the following fire preventive steps should be taken:

1. To improve structural soundness of the building.
2. To arrange for compartmentation of holdings.
3 To improve means of egress.

4. To check electrical equipments and electrical wiring insulation.

   Prevention of overloading of circuits.

   Provision of emergency lights at strategic places.

   Switching off electrical supply to the stack areas after the working hours.

5. To improve ventilation.

6. To augment water supply.

7. To give fire retardant treatment to drapes, curtains and partitions.

8. To provide fire detection and alarm system and first-aid fire extinguishing equipment.

9. To provide lightning protection.

10. To provide good house-keeping.

CHAPTER 2

## FIRE DETECTION

Most fires develop in four distinct stages viz. incipient, smouldering, flame and heat and detectors are available to detect a fire in each of these stages.

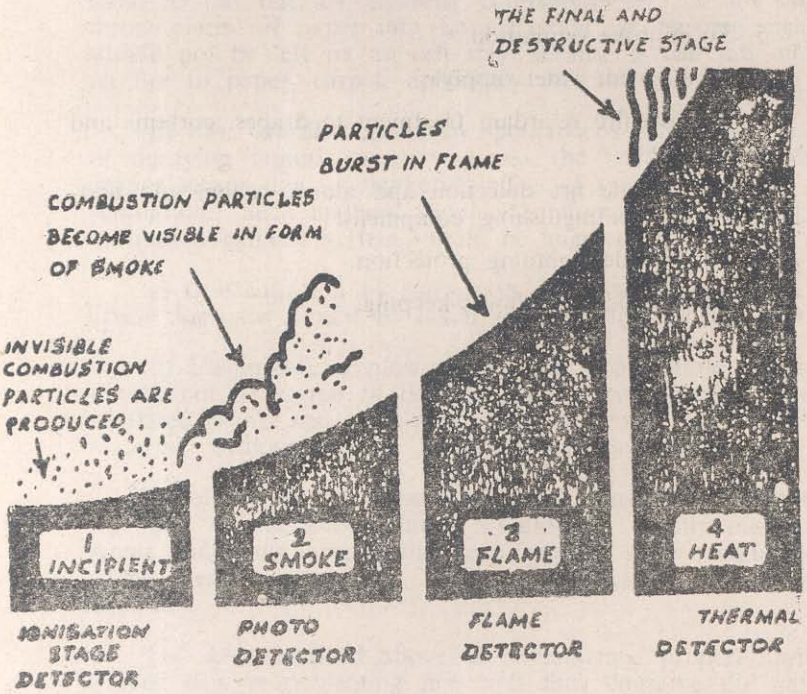



Fig. 1

Losses would be reduced if each developing fire were detected in time and extinguished. A detector has therefore, to serve two functions viz. (i) to give an early warning to the building occupants, and (ii) to start the extinguishing process.

Each automatic fire detecting system requires a sensor, which observes a physically measurable quantity. This quantity must undergo measurable variation in the vicinity of detectors when a fire begins. Smoke density, air temperature or flame radiation is used for this purpose. The sensing element in the detector is coupled to a decision making device which sounds the alarm if there is appreciable difference as compared to a pre-determined value. A detector thus both detects and signals. No single detector is suitable for universal application. Various types of detectors are, therefore, knit into a co-ordinated system to meet the desired performance parameters.

**Smoke Detectors**

Smoke detectors respond to the particles of combustion, both invisible and visible, which occur in the incipient or second smouldering fire phase. A conventional smoke detector operates on a light principle depending upon the absorption or scattering of visible light by the combustion product. They are referred to as "Optical or Photo-electric Smoke Detectors" (fig. 2) and are of two types:

Optical Smoke Detector.

Fig. 2

(i) *Beam type photo-electric detector.*—This detector works on the reduction of light principle. A beam of light is directed at a photo-cell. Rising smoke tends to obscure the beam, decreasing light transmission and sounding an alarm. (Fig. 3)


Fig. 3

The detecting system consists of a light source and associated lens system to collect the light into a near parallel beam and a light sensor with an associated lens system to focus the light beam on to the sensor which may consist of a photo-transistor or a photo-voltaic cell. With the introduction of smoke into the path of the light beam, the amount of light at the receiver will be reduced and by arranging an electronic circuit to sense the reduction in light falling on the photo-sensor, an alarm is sounded at a predetermined level of light reduction, and

(ii) *Reflected beam type photo-electric detector.*—In this system, a beam of light is used in a chamber with the photo-cell being normally in darkness. When visible smoke particles enter the chamber, they scatter the light and reflect it on to the cell, causing a change in electric conductivity, which results in an alarm.

In this arrangement, a light beam is produced by a light source which is usually a filament lamp or a light emitting diode and a focusing lens. This beam is transmitted across the chamber to a focus point above the sensor (Fig. 4) or an opaque light shielding element is provided (Fig. 5) to keep the sensor in dark. If smoke enters the detecting chamber, the light from the light source is scattered by the smoke particles and a portion of the scattered light falls on the photo sensor, causing in the process a change in its electrical characteristics which signals an alarm when a predetermined level of light illuminates the photo sensor.

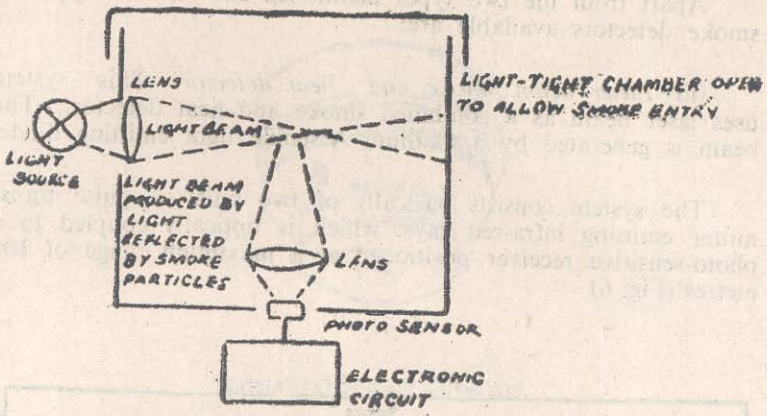



Fig. 4

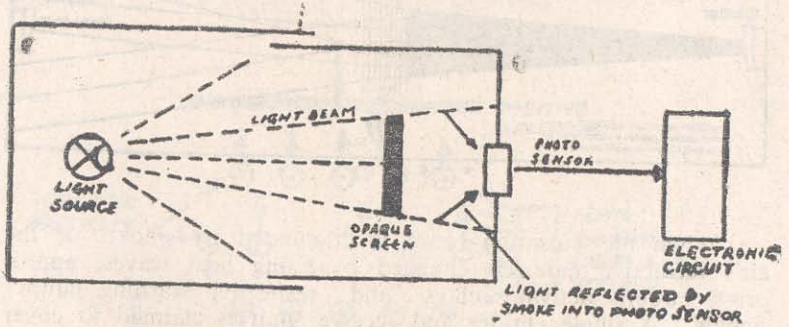



Fig. 5

This detector is also sensitive to voltage variations, dirt on lamp or lens and to insects which are attracted to the light.

Apart from the two types mentioned above, other types of smoke detectors available are:

(iii) *Laser beam smoke and heat detector.*—This system uses laser beam as a combined smoke and heat detector. The beam is generated by a Gallium Arsenide light emitting diode.

The system consists basically of two units—a pulse transmitter emitting infra-red rays, which is optically coupled to a photo-sensitive receiver positioned at a maximum range of 100 metres (Fig. 6).

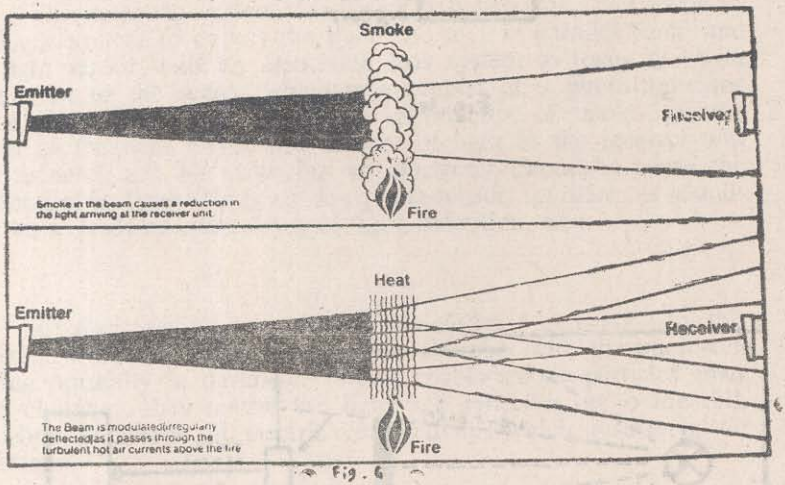
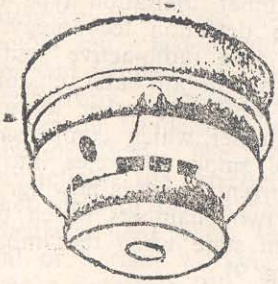



Fig. 6

When the pulsating beam is attenuated by smoke, or the air's refractive index is changed by rising heat waves, appropriate circuits activate relays and respective warning lamps/signals. A single emitter and receiver unit is claimed to cover half a million cubic feet (18000 cubic metres) under varying environmental conditions at high ceiling levels of upto 46 m (150 ft) above the fire.

(iv) *Ionisation chamber smoke detectors.*—They depend upon the effect of the combustion products both visible and invisible, on the ionisation currents within the detector (Fig. 7).



**Ionisation Smoke Detector**

Fig.7

The system consists of a chamber with positive and negative plates and a minute amount of radio-active material that ionises air in the chamber. The potential difference between the two plates causes ions to move across the chamber, setting up a small current. When smoke particles from incipient fires, enter the chamber they cling to masses of moving ions. This slows down the ion movement and increases the voltage necessary for the ions to make contact. This voltage imbalance triggers an alarm (Fig. 8).

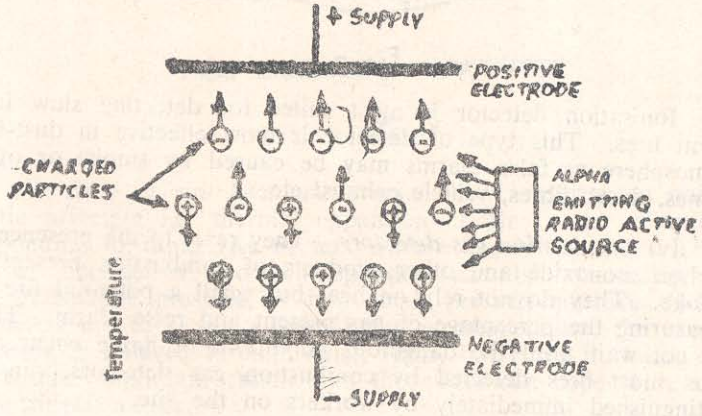
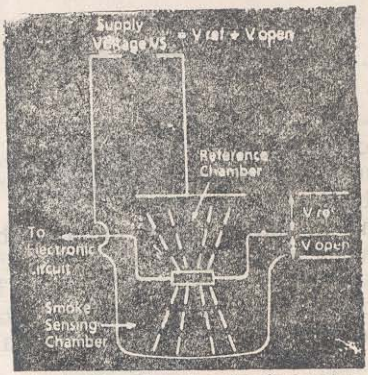



Fig. 8

The "dual chamber ionisation type detector" is the most advanced in smoke detection technology. It contains a dual sided high surface area radio-active source. One side of the surface ionises the air in an outer chamber which is exposed to the atmosphere, while the other ionises the air in a semi-sealed reference chamber which compensates for environmental changes. Ingress of smoke particles into the outer chamber reduces the small current which is flowing. This results in imbalance between the two chambers which causes the detector to change to the alarm state when the imbalance exceeds a predetermined limit (Fig. 9).




**Ionisation Chamber Configuration**

Fig. 9

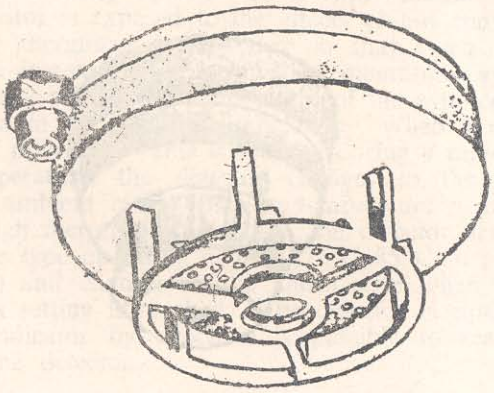
Ionisation detector is most suited for detecting slow incipient fires. This type of detector is most effective in dust-free atmosphere as false alarms may be caused by smoke or other fumes, dusts, fibres, vehicle exhaust etc.

(v) *Combustion gas detectors.*—They react to the presence of carbon monoxide and other products of combustion present in smoke. They do not rely on heat but smell a potential fire by measuring the percentage of gas present and raise alarm. They do not wait until the dangerous conditions of flame occur and thus most fires detected by combustion gas detectors, can be extinguished immediately by workers on the site.

**Thermal Detectors**

(i) *Fixed temperature heat detectors.*—They detect the heat of a fire (4th stage). They are based on a bimetallic element,

made of two metals that have different coefficients of expansion. Due to heat, the element bends to close the circuit and initiate the alarm. The detectors self restore automatically after an operation when the ambient temperature falls below the operating temperature. Alternatively, a thermal detector may use a fuse which melts at a certain temperature releasing an arm to close a circuit and raise an alarm. The fixed temperature heat detectors are sufficiently reliable for detection of that fire which is characterised by either rapid or slow increase in ambient temperature, and are particularly used where smoke or fumes produced by an industrial or normal working process cause unwanted alarm from smoke detectors (Fig. 10).



Fixed Temperature type Heat detector

Fig. 10

(ii) *Rate of rise heat detectors.*—They operate on pneumatic principle i.e. thermal expansion of air in the chamber, responding to rapid rise in temperature caused by fire. They use an enclosed vented hemi-spherical chamber containing air at atmospheric pressure, with a small pressure-sensitive diaphragm on the top. At a normal rise in temperature, the excess pressure is relieved through small vents, but rapid heat rise deflects the diaphragm faster than the vents can cope with and thus triggers an alarm.

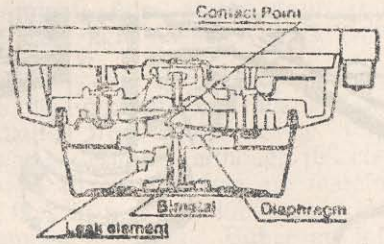
Heat sensitive detectors are also known as "point" or "Spot" detectors as they cover a limited area of hot gas layer immediately adjacent to it. As such, these detectors should be so mounted

that their heat sensitive elements are positioned not less than 25 mm and not more than 150 mm below the ceiling. The degree of cover provided by heat sensitive detectors falls sharply as their height above the floor level increases. Generally heat sensitive detectors are not very effective where roof height exceeds 9 metres.

(iii) *Rate of rise cum fixed temperature heat detectors.*— They have the unique 2-in-1 function of using the rate of rise method and independently functioning fixed temperature method for a double standard protection by using only one detector (Fig. 11).

Combined Rate of Rise and Fixed Temperature Detector
Fig. 11

The fixed temperature function is effected by a bimetallic strip whereas the rate of rise temperature is effected by rapid expansion of air inside the chamber which elevates the contact point, thereby establishing a short-circuit and triggering the alarm signal. In instances where the ambient temperature increases at a slow rate, air is leaked through the leak element to compensate for normal fluctuations, but when the rise in temperature continues, the bimetallic disc operates at a pre-determined fixed temperature to initiate fire condition (Fig. 12).




(iv) *Fully electronic combined fixed temperature/rate of rise detectors.*—They operate on a twin thermistor principle. One thermistor is exposed to the effects of hot convected gases, the second thermistor is insulated so that when the ambient temperature increases, the thermistor temperature, and therefore, resistance lags behind the temperature of the exposed thermistor, This results in an electrical imbalance. When a certain combination of thermistor value is reached during a rapid increase in room temperature, the detector changes to the alarm state. When the ambient rate of rise in temperature is insufficient to cause enough thermistor imbalance, the detector acts as a fixed temperature type operating at 60°C/72°C/85°C (depending upon the setting) and changes to the alarm state when the required temperature setting is reached. The detector is equipped with a response indicator by which it is possible to readily identify the alarming detector.

This detector is ideally suited to locations where high sensitivity is required and where smoke detectors may be unsuitable. For example, where there is risk of fire which produces little smoke in its initial stages or where there are adverse environmental conditions, this detector could be opted for.

(v) *Line type heat detectors or firewire sensing units.*—They are continuous small diameter tubes providing heat sensitivity throughout their length and conveying warning of overheating to a central control point. When exposed to the heat of a fire, air inside the tube expands, and sends a pressure wave to a diaphragm at the end, thereby triggering an alarm. Or, the tube may contain a central electrode core separated from the outside sheath by a glass semi-conductor sleeve. At normal temperatures a small current flows from the inner core to the sheath. Increased temperature at any point in the tube strengthens the flow of current and sounds an alarm.

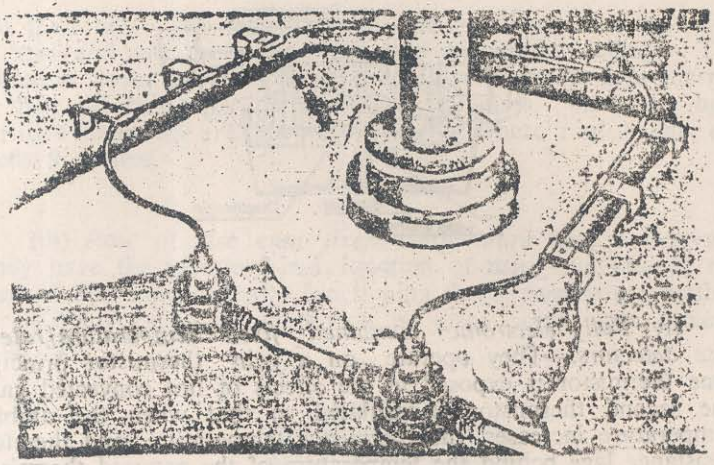


Fig. 13

This is an inexpensive detector which can be run along the ceiling and is sensitive to the effect produced by heated gases along any portion of the detector line.

(vi) *Eutectic salt line type detector.*—It consists of a pliant metal tubing containing a eutectic salt in which a wire is embedded. At a pre-selected temperature, the salt will melt and create a short circuit between the internal wire and the outside tubing, thereby triggering an alarm. This type of detector is used to guard against fires in jet engines and conveyor belt systems.

(vii) *Bulb detection system.*—This is a mechanical system and avoids the use of electricity. Some fire extinguishers are fitted with heat sensitive (68°C/57°C) glass bulb sprinkler heads which function as heat detectors-cum-discharge heads.

Thermal detectors can only detect the heat of a fire which has reached the fourth stage. They are generally used along with smoke detectors.

**Flame Detector**

It responds to the optical radiant energy of combustibles. A flame fire detector senses light from flames. To avoid false alarms from other light sources, it is set to detect the typical

flicker of flame. Or, there may be a few seconds delay before the alarm, to eliminate false alarms from transient flickering light sources like flash light or head lights.

The combustion is not always accompanied by flame and this fact restricts the application of flame detectors. Another factor is that radiation from flames travels in straight lines and a clear line of sight is desirable, although reflected radiation may actuate a detector. Flame detectors are therefore, used mainly to guard against fires in fuel and lubricant drips and to supplement heat and smoke detectors. Either an infra-red or ultra-violet detector can be used to sense the flame.

(i) *Infra-red type flame detector.*—It senses a portion of the radiant IR energy of flames without loss of time. It is often used in operations requiring extremely fast response e.g. in areas where flammable liquids are stored or used.

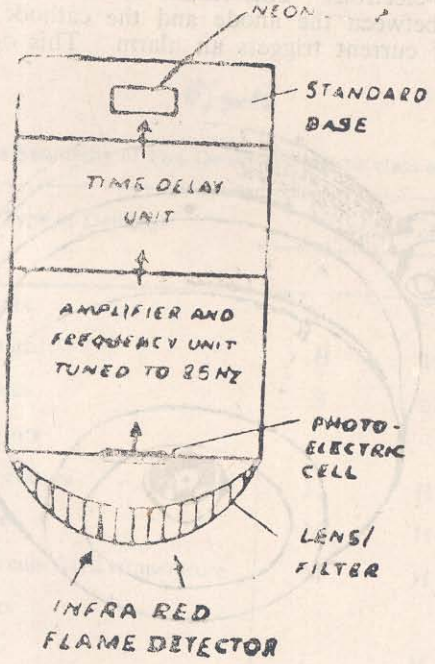
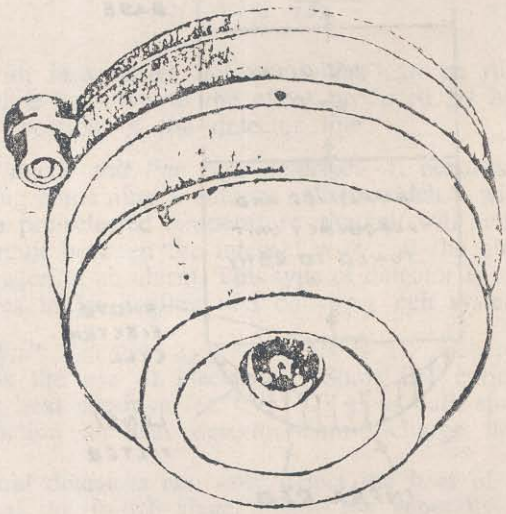



Fig. 14

Flame has a characteristic flicker frequency of about 25 Hz and this fact has to be kept in mind while triggering an alarm. Flickering radiation from flame reaches the detector lense/filter unit, which allows only infra-red rays to pass and be focused upon the cell. The signal from the cell goes into the selective amplifier which is tuned to 25 Hz., then into a time delay unit (to minimise incidence of false alarms, fire has to be present for a pre-determined period) and to finally trigger the alarm circuits.

(ii) *Ultra-violet flame detector.*—It reacts only to actual flame. It does not respond to glowing embers or incandescent radiation (i.e. infra-red radiation) and ordinary illumination.

The ultra-violet detector has an anode and a cathode facing each other and is filled with argon. In case of a fast flaming fire that gives off ultra-violet radiation, the cathode starts to emit photo-electrons. This results in an increase in the current flowing between the anode and the cathode. This additional flow of current triggers an alarm. This detector is used



Ultra violet Flame Detector

Fig. 15

in areas where fast burning flammable materials are stored. Spectral response is from 1700 to 2600 Au (Fig. 15 and 16).

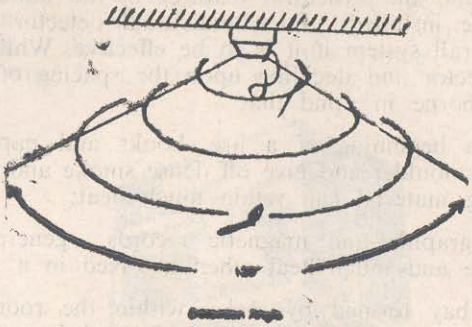


Fig. 16

**Relative Sensitivity of Fire Detectors vis-a-vis class of Fire**

| Type of Detector | Class of Fire | | |
|---|---|---|---|
| | A | B | C |
| 1. Smoke Detectors | | | |
| (a) Particulate matter | H | H | M |
| (b) Visible smoke | H | L | M |
| 2. Thermal Detectors | | | |
| (a) Fixed temperature | L | H | L |
| (b) Rate of rise | M | H | L |
| (c) Rate of rise cum fixed temperature | M | H | L |
| 3. Flame Detectors | | | |
| (a) Ultra Violet | L | H | H |
| (b) Infra red | L | H | L |

**Selection of Detectors for Libraries and Archives**

A fire detection system should not be an individual thermal, smoke or flame detection system but a combination of

various types in an integrated system depending upon the materials stored in a building, the activities and processes being carried out there and the structural features of the building where they are to be installed. Each individual detector must be part of an overall system if it is to be effective. While selecting a suitable detector and deciding upon the spacing of detectors, it should be borne in mind that—

(a) in the beginning of a fire, books and paper records only smoulder and give off dense smoke and the smouldering material can retain much heat;

(b) photographic and magnetic records generate dense smoke and much heat when involved in a fire;

(c) each bay formed by racks, within the room/compartment where books/records are stored is to be treated as a separate compartment for spacing of detectors, where the gap between ceiling and rack is less than 230 mm;

(d) the direction in which smoke and hot gases travel from a fire in books/records depends upon the normal air current within the storage space; the air currents in turn depend upon the existence of any air handling or air-conditioning system.

Because of the facts stated in (a) to (d) above, smoke (ionisation type) and heat (rate of rise cum fixed temperature) detectors are recommended for use in a library or an archives, installed as per Indian Standard IS: 2189-1988 "Code of practice for installation of automatic fire alarm system using heat sensitive type fire detectors".

The following are the general guidelines for siting of detectors.

1. Each portion of the building should be covered and each effectively enclosed space should be considered separately for this purpose in accordance with the limits of spacing laid down by the manufacturer of detectors.

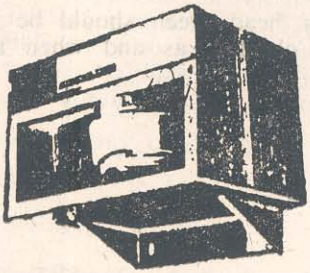
2. Rooms divided into sections by walls, partitions or storage racks reaching within 230 mm of the ceiling, should have detectors for each section or passageway.

3. If the ceiling is intersected by beams more than 25 cm in depth, each bay formed by successive beams in the

ceiling should be treated as a separate compartment and detectors should be installed in each compartment.

4. Stair-cases should be covered by detectors on each floor.

5. Hoists, elevators and similar openings, windows, doors, ventilators and inlet ducts of an air-conditioning system, electrical panels, false ceiling etc. should be covered by a detector (Fig. 17).



Air Duct Detector

Fig. 17

6. If the building is provided with mechanical ventilation system and such system results in more than 10 air changes per hour, significant dilution of the smoke will take place and a definite air flow pattern may be established. In such a case additional detectors become necessary to cover the ventilation inlet and exhaust openings.

7. No automatic detector shall be necessary in any room or portion of the building which is equipped with an approved installation of automatic sprinklers.

The number of detectors required for a given area depends upon the type of building construction area contents and method of their storage, air movement, ceiling obstruction etc. In general, the greater the number of detectors, the greater and better is the coverage provided, as the time and distance to be covered by the products of combustion will be proportionately reduced. In any case, detector spacing should not exceed the limit laid down by the manufacturer.

**'Detector Maintenance'**

Every detector must be regularly inspected and maintained. Alarm relay contacts should also be checked at regular intervals for proper operation. This can be done by applying heat to a thermal detector or inducing smoke directly into a smoke or ionisation detector. One or two detectors covering different storage areas should be checked every month and a record be maintained.

Every detector head-screen should be inspected for dust accumulation and cleaned, as and when required.

## CHAPTER 3

## FIRE ALARM SYSTEMS

The detectors installed must be part of an overall system if they are to be effective. These automatic detectors are linked to sounders and other equipments for automatic transmission and indication without manual intervention. The alarm sounded is both visual and audible and also indicates the danger zone. The personnel trained to handle first-aid fire fighting equipment should respond as per specific disaster control procedure.

A fire alarm system may consist of:

1. Spot Indicator/Remote Indicator.
2. External Acoustic Alarm.

(i) *Spot Indicator/Remote Indicator.*—It is used in conjunction with smoke/heat detectors which are concealed or located in enclosed areas i.e. above false ceiling or in closed cabinets or inside electrical panels etc. When any of these detectors is activated, its exact location is pinpointed by the help of these indicators which are mounted at easily visible points near a particular detector (Spot Indicator) or at the Central Control Panel (Remote Indicator).

(ii) *External Acoustic Alarm.*—It produces a modulating or continuous sound along with a blinking or steady visual indication which is familiar to all the occupants of the building concerned.

(iii) *Water-flow Alarms.*—Where a records centre is protected by an automatic sprinkler system, provision can be made of a waterflow alarm that transmits a signal to the Central Control Panel on the fusing (opening) of one or more sprinklers. With the use of "on-off" sprinkler heads, each head operates individually at a pre-determined temperature, and when the temperature drops below the pre-determined temperature, the head shuts off. Each head works "On-off", independently depending upon the fire situation in its immediate area. No separate detection system is required. However, the sprinkler discharge would not necessarily extinguish fire that is concealed under the shelves or inside mobile shelving but it can definitely remove heat, and slow down further spread of fire. The technology of the "On-off" heads is new and its long term reliability is still to be established.

(iv) *Manually Operated Electric Fire Alarm System (MOEFA SYSTEM) "Manual Call Point (Pill Box)* In addition to Automatic Fire Alarm System, arrangement should also be made for 'Manually operated electrical fire alarm system' with one or more call boxes located at each floor and accessible to all occupants of the floor without having to travel more than 22.5 metres. In this system braking of glass is effected by which an emergency signal is sounded as well as transmitted to the Control Panel for immediate warning/alarm (Fig. 18).


Manual Push Button Station

Fig 18

The Control Panel is designed to accept signals from all types of Automatic Detectors and/or Manual Actuators. Once the signal is received, an audio-visual alarm comes on. This pinpoints the area of distress. External hooters can also be actuated by the Panel. The system also contain provisions for testing of circuits and for the operation of auxiliary services.

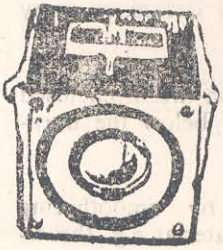
In addition to producing audio-visual alarm, detectors can also be linked to automatic door release system to control the spread of fire, to automatic vents for exhaust of smoke, to switch off the Air Handling Unit of the Air Conditioning Plant, and to start automatic water sprinklers or other extinguishing medium to extinguish the fire. The detectors can also be linked to the local Fire Brigade where the name of the building appears as an indicator.

The alarm system should be maintained in good working order with tests at intervals not exceeding one month.

The automatic fire detection and alarm system and the manually operated electrical fire alarm system should operate on batteries of adequate capacity, continuously trickkle-charged *in-situ* from the electric mains.

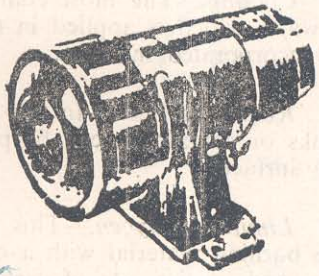
(v) *Electric Hooters & Public Address System.*—The electronic hooters are installed at strategic points to raise the audible alarm. By providing a two channel (hooter channel & voice channel) amplifier the hooters can also be used as speakers in Public Address System. Normally, the amplifier is kept in hooter channel so that in case of fire, the hooters start sounding the alarm tone. They can have different tones for fire, alert, evacuate etc. as per the specifications.

If it is felt to give verbal instructions, then the amplifier is switched over to the voice channel to give necessary instructions on the microphone of the amplifier to guide the persons to safety. (Fig. 19 and 20).



Electronic Hooter

Fig. 19



Electrical Siren

Fig. 20

CHAPTER 4

# FIRE CONTROL

## 1. Principles of Fire Control

A fire is a combustion process intense enough to emit heat and light. The process has four basic needs—heat, fuel, oxygen and a chain reaction. The control of fire, therefore, involves the control of above four factors—Heat can be taken away by cooling, fuel can be removed to cooler environment, oxygen can be taken away by excluding the air, and the chemical reaction of flame fire can be interrupted by inhibiting rapid oxidation of fuel.

*Cooling.*—The most common cooling or extinguishing agent is water which is applied in the form of a solid stream or spray or incorporated in foam.

*Removing Fuel.*—In this case, liquid fuels on fire in enclosed tanks or containers, can be pumped away from below the burning surface.

*Limiting Oxygen.*—This can be achieved by smoothering the burning material with a non-combustible material e.g. throwing sand on fire, use of carbon dioxide or inert gas or covering with a chemical or mechanical foam.

*Interrupting Chemical Reaction.*—This can be effected by the use of dry chemical powder (DCP) or halogenated hydrocarbons (Halon) fire extinguishers.

A fire can thus be attacked from four different angles. Since a fire is usually composed of more than one source of fuel, it has to be controlled by several different types of extinguishers.

## 2. Fire Extinguishers

Fire extinguishers are classified to indicate the class of fire they are specifically meant to handle.

| *Class of Extinguisher* | *Identification* |
|---|---|
| 1. Class A Extinguishers are for ordinary combustibles such as wood, paper, plastics and textiles where a quenching-cooling effect is required. |   A triangle containing the letter 'A' |
| 2. Class B Extinguishers are for flammable liquid fires such as oil, gasoline, paint, varnish, thinner and grease where oxygen exclusion or flame interrupting effect is essential. |   A square containing the letter 'B' |
| 3. Class C Extinguishers are for fires involving gaseous substance under pressure like liquefied petroleum gas. |   A cle containing the letter 'C'. |
| 4. Class D Extinguishers are for fires involving metals like magnesium, potassium, sodium, powdered aluminium, zinc etc. |   A five-pointed star containing the letter 'D'. |
| 5. Class E Extinguishers are for fires involving live electrical wiring, equipment, generators, transformers etc. |   A rectangle containing the letter 'E'. |

Equipment used to control and extinguish fire is of two types—Portable and Fixed.

**A. Portable Fire Extinguishers**

They are first-aid devices provided for immediate use on fires in their incipiency and are effective only at that stage. They are the first line of defence and must be easily accessible and promptly used.

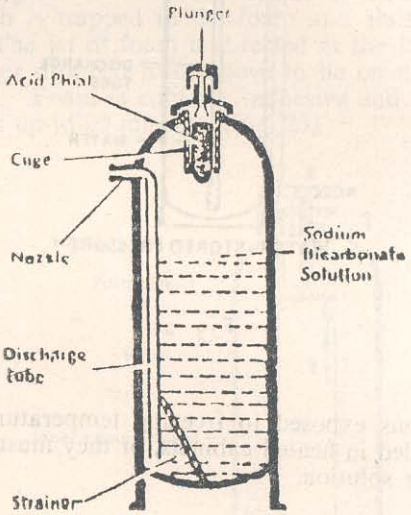
They are sufficiently small in size and light in weight and hence can be carried by hand. Larger models, however, are mounted on two wheeled chassis (trolley mounted) that could be moved by hand towards the fire. They also have a length of hose to extend the range of the appliance. All hand extinguishers are operated either by pumping action or by air or gas pressure in the upper part of the extinguisher which forces the extinguishing medium out through the nozzle.

(i) *Portable Water Type Fire Extinguishers.*—Water expelling fire extinguishers are used mainly in class A fires involving ordinary combustible materials like wood, paper, textiles, plastics etc. which are put out by the cooling action of water. Besides, water when applied to the burning material, is converted into steam which reduces the percentage of available oxygen. Water expelling type extinguishers should not be used on fire involving electrical equipment without de-energising them or on flammable liquid fires.

The simplest equipment is the use of water buckets. In other water type of fire extinguishers, water is released in the form of a jet by means of gas pressure in the upper part of the container. The gas pressure is induced by chemical reaction or by mechanical means. The various types of water expelling extinguishers are: (i) Soda acid type, (ii) Gas pressure type and (iii) Constant air pressure type.

(a) *Soda Acid Type Extinguishers* (*IS*: 934-1976).—They tain a gless phial of acid (sulphuric acid) suspended over a solu-

tion of sodium bicarbonate as shown in Fig. 21. When the plunger is struck, it breaks the acid phial. The acid and sodium bicarbonate solution react together to release carbon dioxide gas which generates pressure and forces the water out of the nozzle of the extinguisher in the form of a jet.




Soda acid type

Fig. 21

(b) *Gas Pressure Type Extinguisher* (*IS*: 940-1976.—This type of extinguisher has an outer container filled with water. A gas cartridge filled with carbon dioxide under pressure forms the inner compartment. When the cartridge is pierced, carbon dioxide is released under pressure into the body of the extinguisher driving water out through the discharge tube.

(c) *Constant Air Pressure Type Extinguishers* (*IS*: 6234—1986).—This type of air pressure extinguisher is filled with water and dry air is introduced till the desired pressure is built up. The container is then hermetically sealed. While actuating, safety pin is withdrawn and valve lever is depressed resulting in a jet of water through the hose (Fig. 22).

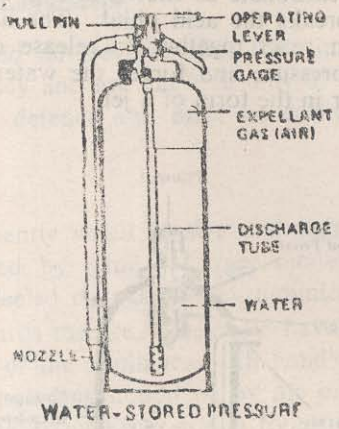



Fig 2

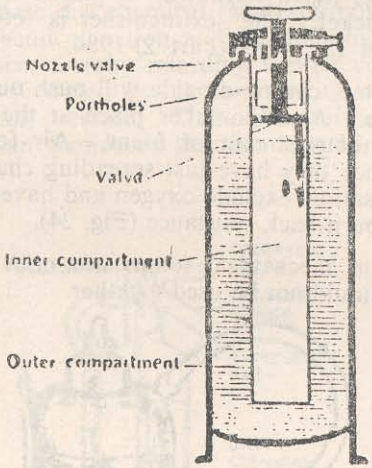
In locations exposed to freezing temperatures, extinguishers must be installed in heated cabinets, or they must be charged with a non-freezing solution.

At the time of using water extinguishers, the jet of water is directed at the base of fire, attacking vertically the spreading fire at its lowest point and following it up. At the end, hot spots are searched and extinguished.

In the case of all water extinguishers, it is important to inspect the nozzle frequently for deposits that may prevent discharge.

(ii) *Foam Type Fire Extinguishers.*—Portable extinguishers expelling foam are best suited to put out class 'B' fires involving flammable liquids like organic solvents, petroleum products, grease, varnish, paints, thinners etc., especially when flammable liquid is in definite shape by volume, for example, in a barrel, tank, tray or pit. The foam expelled by actuating the extinguisher forms a blanket over the surface of the liquid on fire and cuts out the contact of the burning liquid with air, thus extinguishing the fire as well as preventing re-ignition. However, these extinguishers are not to be used in the case of electrical fires. Portable chemical foam type extinguisher is covered by Indian Standard IS: 933-1976.

The extinguisher consists essentially of two containers. The outer container holds a solution of sodium bi-carbonate to which a foaming agent and stabilizer are added. The inner container contains a solution of aluminium sulphate. When operated, the solutions would intermix and produce foam which is expelled from the extinguisher. Carbon dioxide is also evolved in the reaction, which is trapped in the foam and assists in extinguishing the fire. The jet of foam is directed at the far inside edge of the container or dropped from above to lie on the surface of the burning liquid. Foam is cohesive, adhesive and free flowing and does not break up to 20 minutes. (Fig. 23)




Foam Type Extinguisher

Fig 23

In addition to chemical foam described above, foam can also be produced in three ways as indicated below:

(a) *Mechanical or air generated foam.*—Here foam is produced by the mechanical action of adding proper amount of liquid concentrate into a water stream and then introducing and mixing air into water concentrate solution. The extinguisher is covered by Indian Standard IS: 10204-1982.

(b) *Protein foam.*—Protein type concentrates with some additives are used in 3 or 6% strength in water for covering vertical surfaces with an insulating blanket to aid in confining the fire. The foam is applied through foam nozzles. The extinguisher is covered by Indian Standard IS: 4989 (Part 1)—1985.

(c) *Synthetic foam.*—Synthetic foam is referred to as "aqueous fluorinated film forming foam" (AFFF). It consists of a fluorinated surfactant (surface active agent) and a foam stabilizer. A 9 litre extinguisher is supplied with 540 ml of 6% AFFF concentrate, carbon dioxide gas cartridge, nylon hose with a plastic foam branch and wall bracket. The extinguisher is covered by Indian Standard IS: 4989 (Part 2)-1984.

When operated, carbon dioxide will push out the foam liquid through the hose. Aeration takes place at the end of the hose forming a continuous stream of foam. Air foams possess low viscosity and hence they have fast spreading characteristics. They halt fuel vapourisation, exclude oxygen and have rapid fire knockdown and good burn-back resistance (Fig. 24).

Chemical and mechanical foams are not compatible with each other and should not be used together.

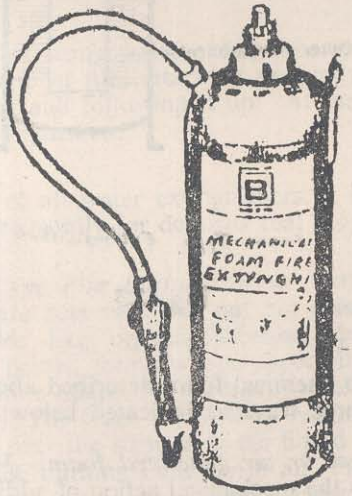
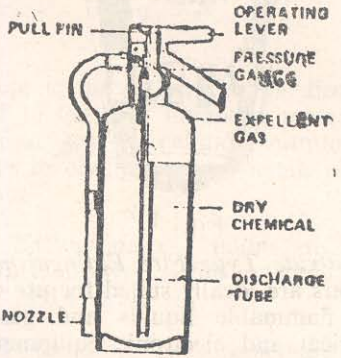



Fig. 24

(iii) *Dry Chemical Powder Fire Extinguishers.*—They are suitable for tackling class 'B', 'C' and 'E' fires involving inflammable liquid running fires, gaseous fires and electrical fires, where deposition of powder on the equipment involved is not objectionable. They are also known as "Magic Broom" for fire sweeping as they are very instantaneous and swift in action. Its all purpose capacity makes DCP extinguishers a premier fire fighting facility.

The chemical powders employed are sodium or potassium bicarbonate base. These chemicals extinguish fire by positive displacement of air from the seat of fire, arresting chain reaction and decomposition of dry powder into carbon dioxide. Ammonium phosphate base dry chemical (Multi-purpose) powder extinguishes fire by chemical action and by adhering to and coating the burning surface, thereby retarding further combustion. Propellant action is provided by carbon dioxide/nitrogen gas cartridge or stored air pressure. These extinguishers are manufactured as per Indian Standards specifications IS: 2171-1985 (Fig. 25).




RY CHEMICAL–STORED PRESSURE

Fig. 25

Modular Automatic Dry Chemical Powder Fire Extinguishers of different capacities, fitted with heat sensitive glass bulb sprinkler heads (57°C/68°C) which function as heat detector cum discharge head, pressure indicator, arrangement for fixing to the ceiling, charged with dry chemical powder, pressurised with nitrogen to cover varying areas, are available for installation.

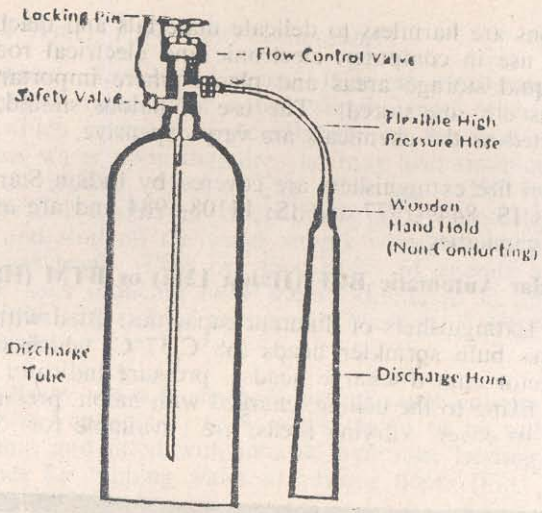
*Dry Powder Type Fire Extinguishers.*—Dry powder type fire extinguishers are suitable for tackling class 'D' fires (Metal fires). The most commonly used powder agent is a graphite-organo phosphate compound. When applied to a metal fire, the phosphate material generates vapours that blanket and smother the flames, and graphite being a good conductor of heat, cools the metal below its ignition temperature. The extinguisher contains carbon dioxide gas cartridge or stored air pressure to discharge the powder.

The dry powder used should conform to Indian Standard Specifications IS: 4308-1982. A sand bucket is the most elementary form of dry powder fire extinguisher (Fig. 26).


Fig. 26

(iv) *Carbon Dioxide Type Fire Extinguishers.*—Carbon dioxide fire extinguishers are ideally suited for use on class B, C and E fires involving flammable liquids and gases, and also on sophisticated electrical and electronic equipment. Carbon dioxide is not combustible and does not react with most substances. It does not leave a residue and this property is of great importance.

The common type of portable fire extinguisher is covered by Indian Standard Specification IS: 2878-1986. Carbon Dioxide is retained in the cylinder as a liquid under pressure. It is put to operation by removing the safety pin and starting the discharge device. Carbon dioxide is delivered with great velocity by means of discharge horn (Fig. 27). The gas being heavier than air, displaces the air around the fire. It blankets the fire, thus reducing the oxygen supply needed to continue combustion.




Carbon dioxide fire extinguisher

Fig. 2.7

It has to be kept in mind that Carbon dioxide extinguishers should not be used in (a) fires involving materials that contain their own supply of oxygen e.g. cellulose nitrate, potassium chlorate etc. and (b) fires involving reactive metals like sodium, potassium and magnesium.

(v) *Halon Fire Extinguishers.*—Halons are halogenated compounds which are very effective as fire extinguishers and are suitable for class A,B,C and E fires.

Halon 1211 (Bromochloro difluoromethane, B.C.F.) is a liquid stored under pressure and when discharged, it quickly vapourises. Halon 1301 (Bromo tri-fluoromethane, B.T.M.) is a liquefied gas that disperses immediately in the fire area.

Halons extinguish fire by inhibiting the chemical reaction of fuel and oxygen. Halons do not reduce visibility when operated, and hence do not impede evacuation activities. No clean up is required after the system is operated. In concentrations normally required for extinguishing fire, it is non-suffocating and low in toxicity. Their fire fighting ability is 2-3 times better than carbon dioxide.

Halons are harmless to delicate materials and machinery and ideal for use in computer, electronic and electrical rooms, flammable liquid storage areas and places where important records, microfilms etc. are stored. The use of halons should, however, be restricted as the chemicals are very expensive.

Halon fire extinguishers are covered by Indian Standard Specifications IS: 8449-1977 and IS: 11108-1984 and are available in different capacities.

**A. Modular Automatic BCF (Halon 121I) or BTM (Halon 1301)**

Fire Extinguishers of different capacities, fitted with heat sensitive glass bulb sprinkler heads (68°C/57°C) which function as heat detector cum discharge heads, pressure indicator, arrangement for fixing to the ceiling, charged with halon, pressurised with nitrogen, to cover varying areas, are available for installation (Fig. 28).

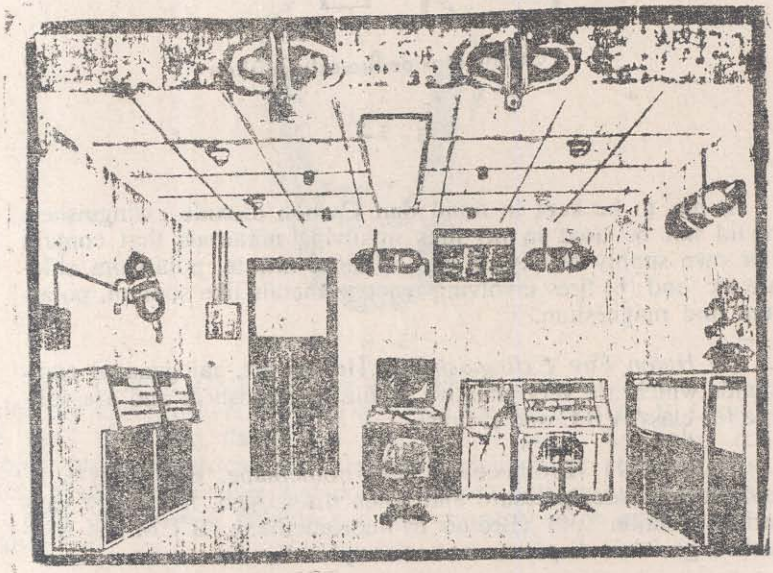


Fig. 28

**B. Fixed Fire Extinguishing Systems**

These include water equipment (automatic spriklers, hydrants, hose pipes etc.) and special pipe systems for Dry Chemical Powder, Foam, Carbon Dioxide and Halon.

(i) *Fixed Water Type Fire Installations*

(a) *Automatic Sprinkler System.*—It is an arrangement of piping, sprinklers, connected water supply and other related equipments which operates automatically by the heat of fire and discharges water upon that fire and may also simultaneously give automatic audible alarm. The "On and Off" sprinkler heads now available, operate individually at a pre-determined temperature and shut off the water supply when the temperature falls below that level. They are then ready to operate again if fire re-ignites thus reducing total water discharge in any fire event and minimising risk of unnecessary wetting of records and library materials.

(b) *Wet Riser.*—It is a charged vertical water column inside a building, with connection to a water main or an automatic stationary pump and fitted with internal hydrants, landing valves and hose pipes for tapping water at various floors (Fig. 29).

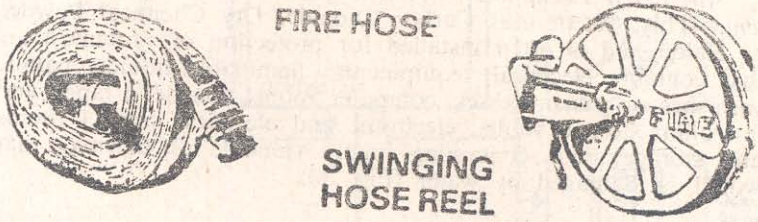



Fig. 29

For high rise buildings the pump provided should be of multi-stage types so that it can maintain the pressure of water on each floor. A stand-by pump of equal capacity should also be provided on an alternative source of electric supply.

The Wet Riser Installations should conform to Indian Standard Specifications IS: 3844-1966 "Code of Practice for installation of internal fire hydrants in multi-storey buildings".

(c) *Dry Riser.*—It is a vertical water main inside a building (not normally connected to a water main or an automatic stationary pump) with an inlet at street level through which water can be pumped by fire service pumps to hydrant outlets or hose pipes at various floors.

The wet riser and dry riser systems are linked to an underground static water storage tank with capacity specified for the

building concerned, with arrangements for replenishment by main or alternate source of water supply.

(d) *Down Comer.*—It is a 'Wet Riser' fed from an overhead tank installed on the building.

(e) *Static Water Storage Tank.*—A satisfactory supply of water for the purpose of fire fighting should always be available in the form of an underground water storage tank with a capacity ranging from 50,000—100,000 litres as specified for the building, with arrangements for replenishment by main or alternate source of supply.

For more details of fixed water requirements and installations, a reference be made to National Building Code of India (1983), part IV, or Indian Standard IS: 9668-1980 'Code of practice for provision and maintenance of water supplies for fire fighting'.

(ii) *Fixed Local and Flood Type Fire Extinguishing System.*—This system uses Carbon Dioxide, Dry Chemical Powder or Halon and is often installed for protection of rooms/areas that contain electrical equipment, flammable liquids, paints, varnishes or gas processes, computer rooms, magnetic tape and microfilm storage vaults, electronic and electrical control rooms and storage areas containing highly valuable documents that would be damaged by water (Fig. 30).

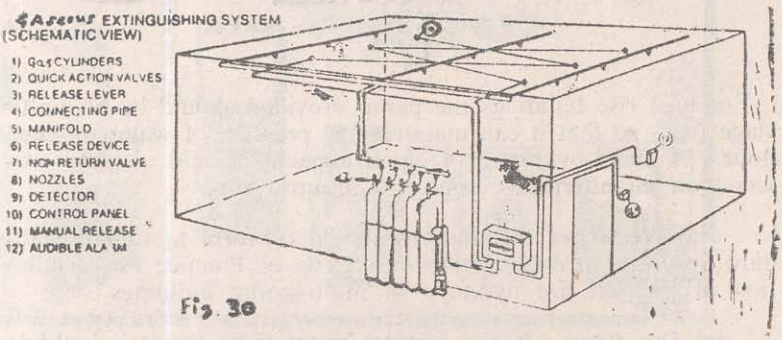



Fig. 30

The extinguishing system consists of a supply of extinguishing medium, detection and activation devices responding to smoke, flame and/or heat and one or more discharge nozzels. Automatic shut down of the ventilation system, closing of doors, provision of local or remote alarm and other auxiliary features can be made to tailor the capability of the system to the need of the user. (Fig. 31).

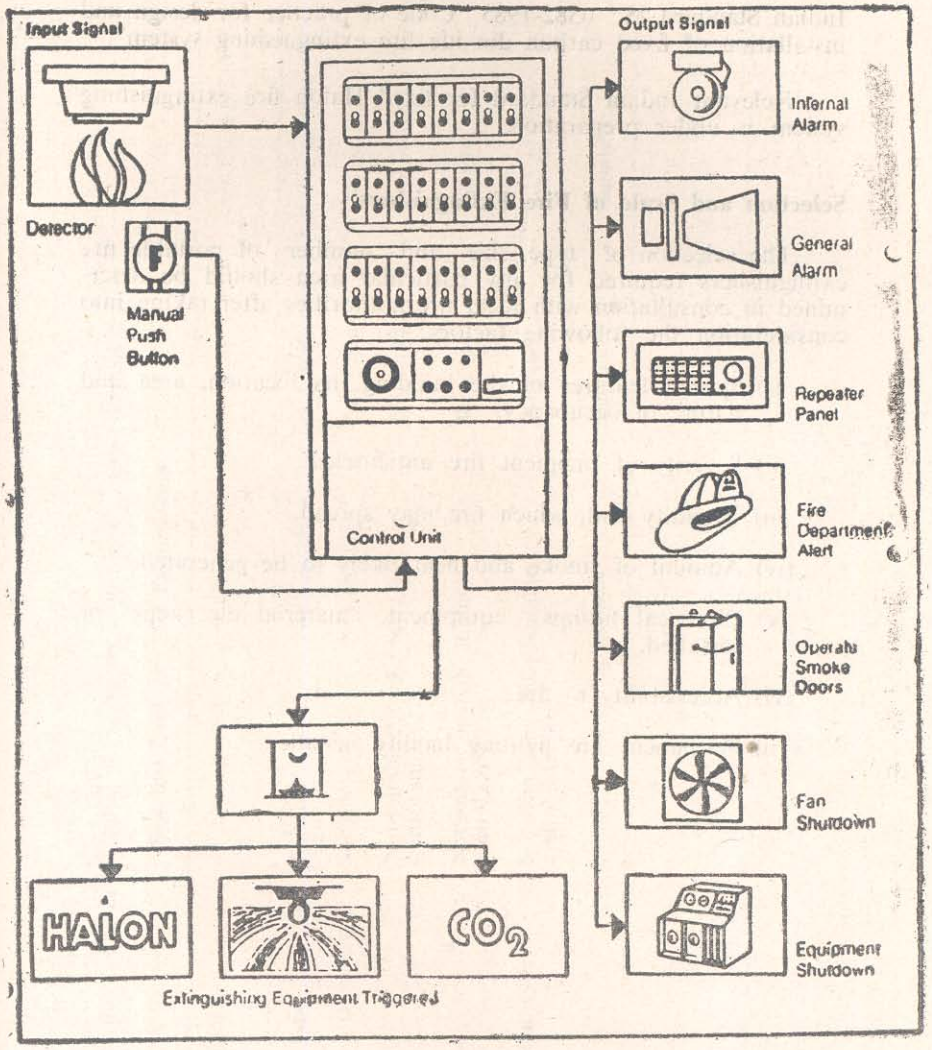

Input Signal
Output Signal
Detector
Manual Push Button
Control Unit
Internal Alarm
General Alarm
Repeater Panel
Fire Department Alert
Operate Smoke Doors
Fan Shutdown
Equipment Shutdown
HALON
$CO_2$
Extinguishing Equipment Triggered

Fig. 31

Fixed carbon dioxide fire extinguishing system is covered by Indian Standard IS: 6382-1985 "Code of practice for design and installation of fixed carbon dioxide fire extinguishing system".

Relevant Indian Standard for fixed Halon fire extinguishing system is under preparation.

**Selection and Scale of Fire Extinguishers**

The selection of type, size and number of portable fire extinguishers required for any particular area should be determined in consultation with local fire authorities after taking into consideration the following factors:—

(i) Special features of the building, its location, area and nature of occupancy.

(ii) Severity of incipient fire anticipated.

(iii) Rapidity with which fire may spread.

(iv) Amount of smoke and heat likely to be generated.

(v) Electrical fittings, equipment, material etc. kept or installed.

(vi) Accessibility to fire.

(vii) Permanent fire fighting facility installed.

The following table is intended to serve as a guide in this respect :

**Selection Guide for Fire Extinguishers**

| Sr. No. | Extinguisher | Class A Fire | Class B Fire | Class C Fire | Class E Fire |
|---|---|---|---|---|---|
| 1. | Soda Acid Type | Suitable | Not suitable | Not suitable | Not suitable |
| | Water-Carbon Dioxide type | Suitable | Not suitable | Not suitable | Not suitable |
| 2. | Foam Type | Not suitable but will control small fires. | Suitable | Not suitable | Not suitable |
| 3. | Dry Chemical | Not suitable but will control small fires. | Suitable | Suitable | Suitable |
| 4. | Carbon Dioxide Type | Not suitable but will control small fire. | Suitable | Suitable | Suitable |
| 5. | Halon Type | Suitable | Suitable | Suitable | Suitable |

**Type of Fire Risk and Scale of Fire Extinguishing Equipment**

| Type of Fire Risk (Class of Fire) | Extinguishing medium and relevant Indian Standard | Scale of Equipment Minimum Recommended |
|---|---|---|
| 1 | 2 | 3 |
| | **Water** | |
| **1. Class A Fire** | | |
| Fire involving ordinary combustible materials like wood, paper, textiles, rubber, plastics etc. | Soda Acid Type IS : 934-1976<br>Gas Pressure Type IS : 940-1976 | For every 600 Sq. metre floor area or part-one 9 litre capacity. |
| Low and medium fire load. | Constant Air Pressure Type IS: 6234-1971 | Maximum 4 Nos. per floor or room, should not be required to travel more than 15 mt. to reach any extinguisher. |
| High and special fire load. | Do. | Do.<br>*Extra Provision*<br>For every 100 sq. mt. floor area or part-one 4.5 Kgm. Carbon Dioxide Minimum 2 nos. per room.<br>Should not be required to travel more than 10 mt. to reach any extinguisher. |
| **2. Class B Fire** | | |
| Fire involving flammable liquids like oils, solvents, petroleum products, paints, varnishes. | Foam Type IS: 933-1976<br>AFF Foam IS: 10204-1982<br>Carbon Dioxide IS: 2878-1986<br>Dry Chemical Powder IS: 2171-1976 | For every 50 Sq. mt. Floor area or part-2 nos. 9 litre foam, 4.5 Kgm. Carbon Dioxide or 5 Kg. Dry Chemical Powder. |
| Storage and handling in small quantities. | IS: 4308-1982 | Should not be required to travel more than 10 mt. in the area of storage to reach any extinguisher. |
| Bulk storage other than in tank form. | Do. | Do.<br>Minimum 3 nos. per room. |

| 1 | 2 | 3 |
|---|---|---|
| 3. **Class C Fire**<br>Fire involving gaseous substances under pressure | Carbon Dioxide Type IS: 2878-1986<br>Dry Chemical Powder IS: 2171-1976<br>IS: 4308-1982 | For every 100 sq. mt. floor area or part—2 nos. 6 kgm. Carbon Dioxide or 10 kgms. Dry Chemical powder extinguishers.<br>Minimum 3 nos. per room. Should not be required to travel more than 10 mt. to reach any extinguisher. |
| 4. **Class D Fire**<br>Fire involving metals like magnesium, aluminium, zinc , sodium, potassium etc. where the burning metal is reactive to water and which require special extinguishing media or technique. | Dry Chemical Powder IS: 2171-1976<br>IS: 4308-1982 | For every 50 qs. mt . floor area or part—2 nos. 5 kgm. special Dry powder extinguisher.<br>Minimum 3 nos. per room. Should not be required to travel more than 10 metres to reach any extinguisher. |
| 5. **Mixed Occupancy**<br>Electrical equipment, generators, transformers etc. | Carbon Dioxide type IS: 2878-1986<br>Dry Chemical Powder type IS: 2171-1976<br>Halon-1211 (BCF) IS: 8449-1977 | For every 100 Sq mt. floor area or part—one 6 kgm. Carbon Dioxide or 10 kgm. Dry Chemical Powder extinguisher or 5 kgm. Halon 1211.<br>Minimum two nos. for every location.<br>Should not be required to travel more than 10 mt. to reach an extinguisher. |

### 3. Requirements under Delhi Fire Prevention and Fire Safety Rules, 1987.

The minimum standards for fire prevention and fire safety measures specified for buildings or premises shall be according to the provision made in building bye-laws notified in 1983 or as may be amended from time to time thereafter, relating to the following matters:

1. Means of access.
2. Underground/overhead water statis tanks.
3. Automatic sprinkler systems.
4. First-aid hose reels.
5. Fire extinguishers of ISI Certification Mark.
6. Compartmentation.
7. Automatic fire detection and alarm system/manually operated electrical fire alarm system.
8. Public address system.
9. Illuminated exit-way marking signs.
10. Alternate source of electric supply.
11. Fife lift with Fire-man switch.
12. Wet Riser, Down Comer system.

### 4. Fire Control Measures in an Archives or a Library.

For control of fire in an archives or a library, provision is to be made for both detection and extinguishment. While these are separate functions they may be consolidated into one continuous fire protection system to detect a fire, sound an alarm and set off the automatic extinguishing devices. As already stated, Ionisation Type Smoke Detectors and Rate of Rise cum fixed temperature Heat Detectors are recommended for use in a library or an archives.

Early warning detection systems provide an opportunity for occupants to take immediate action with portable fire extinguishers before advanced stage of fire develops to activate the automatic fire suppression systems. Library, archives and manuscript repositories should therefore, be equipped with both fixed

and portable fire control systems and extinguishers which may be automatic or manually operated. Since an archives or a library, besides housing paper records, manuscripts and books also stores records on magnetic tape, photographic, micrographic and other special media susceptible to fire and use divers, types of electrical equipments for duplication and restoration of records, special care should be taken so that all types of fire risk that may co-exist, are adequately covered. Local fire authority should also be consulted in this connection.

Among the "fixed fire control systems" the following are recommended:

I. *Water Extinguishment.*—For this type of extinguishment, provision has to be made of (i) Fire hydrant outlets outside the building, easily approachable and strategically located all around the building. (ii) Wet Riser/Down Comer System with outlet at each floor and (iii) Underground/overhead water storage tank of sufficient capacity with arrangements for replenishment.

B. "*Automatic Sprinkler System*".—The automatic wet-pipe sprinkler system is the most effective, reliable and economic means of controlling fire in an archives or a library. Although the system is opposed by archivists and librarians because of their concern regarding damage to be caused by water, the following factor should dispel such misgivings:

1. Wet records can be recovered while burnt records are not recoverable.

2. Each sprinkler operates individually depending upon the fire situation in its immediate area, at a predetermined temperature with automatic off system when the temperature goes down, thus eliminating unnecessary damage. Sprinklers thus use minimum rather than maximum of water.

3. Sprinklers actuated in early stages of a fire, can localise a fire and prevent it from spreading. However, to minimise risk of accidental working of the sprinkler, a higher temperature rating of 120-150°C is used instead of the normal 57-72°C for the sprinkler heads.

4. There is also an arrangement for water flow alarm which eliminates the possibility of a sprinkler operating un-detected.

II. *Gaseous Extinguishment.*—This system has the potential for the least damage without leaving any residue. Special fixed systems using Halon 1301 (Bromotrifluoromethane, BTM) or Carbon Dioxide gas can provide the required protection for areas where specially valuable contents would be irrepairably damaged by water. This system can be automatically activated by a suitable early warning detection system.

Halon 1301 is a liquified gas stored under pressure which disperses immediately in the fire area and extinguishes fire by inhibiting the chemical reaction of fuel and oxygen while carbon dioxide extinguishes fire by reducing oxygen content of air below combustion support level. The process involves filling the entire protected area/volume with a specific concentration of gas. Openings not required for pressure venting must be closed at the time of discharge so as to avoid loss of gas during the soaking period. In order to avoid hazard to life, ample warning and time must be given prior to discharge so that occupants can escape from the area to be flooded. Provision has to be made for safely exhausting the atmosphere after the soaking period and fire extinguishment. Since gases do not damage the records, books, manuscripts, microfilms and other electrical equipment, no clean up is required.

Halon 1301 systems are relatively expensive and their use is limited to protection of high value collections in modest sized spaces. In order to avoid false alarm and discharge of gas, two detectors are used to trigger the alarm and release the gas.

Halon 1301 being a flame inhibitor, is not effective at normal concentrations against a smouldering fire. Rapid fire growth would, however, be inhibited, and complete extinguishment is achieved by the use of water.

III. *'Dry Chemical Powder System'.*—This system leaves powdery deposit on all exposed treated surfaces and hence requires clean up. The 'High Expansion Foam Systems' on the other hand cause wetting or low water damage to all the collections in the room and that requires immediate and extensive salvage operations.

**Portable Fire Extinguishers**

Portable fire extinguishers of appropriate types and sizes, wall-mounted or trolley-mounted should be provided and maintained throughout the building. To meet fire hazard from

various sources in an archives or library the following types of portable fire extinguishers will be required:

| | |
|---|---|
| 1. Fire in paper, wood, cloth and plastic materials storage areas. | Water Extinguishers<br>1. Soda Acid Type<br>2. Gas/Air Pressure Type.<br>3. Water Buckets. |
| For small Fires | Carbon Dioxide Extinguishers<br>Halon 1211 (BCF) |
| 2. Fire in | |
| (i) Volatile flammable liquids, solvents etc. | Carbon Dioxide Extinguishers<br>Dry Chemical Powder Extinguishers<br>Halon 1211 (BCF) Extinguisher<br>Sand Buckets |
| (ii) Gaseous substances under pressure and shed for repair and preservation of documents. | Do. |
| 3. Fire in Electrical Equipment Microfilm Storage Areas Basements | Carbon Dioxide Extinguishers<br>Halon 1211 Extinguishers<br>Dry Chemical Powder Extinguishers. |

A general guide to the scale of their use is on pages 55 to 57. Fire Extinguishers should be distributed in accordance with Indian Standard IS: 2190-1979 "Code of practice for selection, installation and maintenance of portable first-aid fire extinguishers". Local fire authority should also be consulted. The type of extinguishers provided should be of trigger action type in which the flow can be started and stopped by the operator.

**Location of Portable Fire Extinguishers**

(i) The extinguishers should be placed in conspicuous position and should be readily accessible for immediate use. They should be wall-mounted or kept on stand and not on floor.

(ii) Portable fire extinguishers are to be generally placed at a place nearest to the exits or stair landing or normal routes of escape.

(iii) Extinguishers of proper type should be located at a particular area depending upon the class of fire hazard anticipated because of the nature of occupancy.

(iv) If extinguishers intended for different classes of fire are required to be grouped, their intended use should be marked

conspicuously to ensure choice of proper extinguishers at the time of fire without any confusion.

(v) Framed plan showing the location of fire extinguishers, means of access etc. should be displayed suitably so that all can understand how to get at the first-aid fire fighting equipment during an emergency.

**Inspection, Maintenance and Testing of Portable Fire Extinguishers**

(i) Portable extinguishers should be maintained in a fully charged and operable condition, and should be kept in their designated places at all times when they are not being used.

(ii) At regular intervals, not more than one year apart, or when specifically indicated by an inspection, extinguishers should be thoroughly examined and/or recharged or repaired to ensure operability and safety, or replaced as needed.

(iii) Extinguishers taken away for recharging should be replaced by spare extinguishers during the period they are being recharged.

(iv) Each extinguisher should have a durable tag securely attached, to show the maintenance or recharge date and the signatures of the person who performs this service.

(v) Performance tests on each extinguisher should be carried out by trained personnel.

**Fire fighting teams**

Fire fighting teams recruited from the staff working at the concerned location, offer the advantage in the sense that they can be in action quickly because they have an exact knowledge about the locality and the site. Such teams should be formed at every site, with one leader for each floor. These teams should be adequately trained in first-aid fire fighting operations. Re-training from time to time would also be necessary. Practice drills for fire fighting should be conducted at least once in two months. In addition, care must be taken to ensure that all personnels on each floor are suitably informed about (i) raising an alarm in case of fire (ii) conduct in the event of fire and disaster (iii) safeuargding of property against fire (iv) orderly evacuation (v) use of stairs instead of lifts and (vi) location of fire extinguishers and hydrants.

**Alarm and patrol service**

(i) An early warning system (hooters, sirens, electric alarm etc.) which would alert all the concerned people immediately on the sighting of a fire should be organised.

(ii) An effective communication system should be established to enable immediate contact with the officer-in-charge of fire safety and the local fire-brigade on the sighting of a fire.

(iii) Important telephone numbers and residential addresses of the Head of the Department, Administrative Officer, Officer responsible for fire safety, local fire brigade etc. should be prominently displayed near each telephone and near the main entrance of the building.

(iv) Security guards should provide round the clock patrol service and be suitably trained in raising alarm, notifying all concerned and starting first-aid fire fighting operations immediately on discovery of a fire.

(v) Effective supervision including surprise checks should be arranged to keep the security guards on patrol service, constantly alert and all alarm and communication systems in working order.

# CHAPTER 5

## CARE OF FIRE AND WATER DAMAGED RECORDS

Although all modern libraries and archival institutions make necessary arrangements for fire prevention, detection and extinguishment, yet accidents do happen and a sizeable collection gets destroyed or damaged by fire. Since water is the chief fire extinguishing agent, the problem of rehabilitating burnt, charred, wet and water soaked books and documents arises after a fire has been extinguished and that calls for quick action.

### Treatment of burnt and charred documents

In many cases there may be papers which are completely burnt and reduced to bits. Attempts at restoration of such papers are futile. However, it is desirable that such material is properly screened and all charred sheets that are in tact, are salvaged. These may be undecipherable to the unaided eye, yet could be scientifically treated and examined for bringing out the text.

Charred paper is very brittle and a very careful handling is necessary for separating and placing each sheet in a separate cover. After such placement, it is essential that no pressure is deployed on such covers, otherwise the papers which are intact, may fall into pieces. The covers containing these papers may then be held fast at three ends and placed flat in a document or transfer box.

Deciphering of charred documents needs considerable expertise and the method used depends upon the type of ink of the writing. Aniline inks are decomposed and leave no trace on paper. Carbonaceous inks and iron-gall inks on the other hand, leave sufficient residue to prepare a photo copy of the text with the help of infra-red radiation or other processes. If it is not possible to transfer these documents to the specialised Laboratory immediately, they should be kept in the repository as a separate collection.

Partially charred documents and documents which are damaged and yellowed due to high temperature, should be segregated and kept in separate covers for the purpose of restoration.

**Treatment of water soaked and wet documents**

Documents that have been rendered wet as a sequal to fire extinguishing operation, are likely to suffer damage due to rotting, attack of mildew or fungus, blocking of sheets and running of ink. Hence they need to be treated as soon as possible.

As a first step, it is desirable to prevent damage by fungus or bacterial agents. For this, documents may be sprayed with 10% solution of thymol in methylated spirit. As a further precaution, the room where these documents are kept may likewise, be sprayed with this solution to destroy the spores in the air.

Before taking up the treatment, the mass of completely soaked documents may be separated from only damp or slightly wet documents. Excess water of soaked documents is allowed to drip away and wet papers carefully separated from one another using dull paper knives, if necessary. These sheets may then be kept individually between white blotters and pressed lightly. Blotting paper may be changed as often as necessary. When fairly dry, they may be ironed by placing then below a dry blotter or cloth. Alternately, the separated wet sheets may be spread on white blotter in a well-ventilated room for natural drying. Air-circulation may be augmented by electric fans. The temperature of the room may be raised to 30-40°C by using heat convectors. For speedy drying, a constant air flow is very necessary and should be maintained round the clock. After separating and drying, the sheets should be fumigated and repaired wherever necessary, before storage.

In case of wet volumes, the binding may be removed after draining the excess water and the wet sheets separated and treated as above. If the sheets have excess water, no attempt should be made to separate them till they dry to a safe handling stage. The volumes may be rebound later. If the volumes are only damp, the sheets may be interleaved with blotting paper or newspaper cuttings to facilitate free air circulation within the sheets. After drying, the volumes should be fumigated before storage.

The leather bound volumes may need fungicidal treatment in which 1% solution of orthophenyl phenol in methylated spirit is applied with a brush and this is followed by an application of leather preservative dressing.

While handling the wet documents, it is desirable:—

(i) that the sheets are separated only after they are placed on waxed paper, oiled paper or polythene sheet for support,

(ii) that the soaked books and papers are not mechanically pressed.

(iii) that coloured blotting paper or docket cover is not used with wet materials, and

(iv) that the documents are not dried by direct exposure to heat or sun.

If some mud or dirt sticks to the papers, it can be removed by washing the documents in luke warm water (35-45°C) or by slight scraping after the documents have been dried. The use of detergents or bleaching chemicals for this purpose is not desirable.

Blocking of papers into a dry mass can be prevented by timely treatment. Yet there may be cases where such dried mass may have to be humidified or dampened by keeping the material in between damp blotters and then the sheets carefully separated.

In case of papers soiled with fungi, fungus growth may be removed gently with dry cotton and the papers be fumigated.

**Damage to Writing**

As a sequel to contact with water, the writings may bleed or get washed. The extent of damage to writings depends upon the type of ink. It may be possible to reconstruct the smudged and faded writing, but scientific aids such as the use of ultra-violet rays is necessary. As in the case of deciphering of charred documents, these documents are to be handled in a properly equipped laboratory.

## CHAPTER 6

## SELECT BIBLIOGRAPHY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## APPENDIX

## LIST OF FIRMS DEALING IN FIRE PROTECTION SERVICES

1. M/s Vijay Fire Protection System (P) Ltd.,
   Pragati House, R. No. 508
   5th Floor, 47 Nehru Place
   New Delhi - 110 019.

2. M/s Security and Fire Equipment
   19 F, Basant Lok
   Vasant Vihar
   New Delhi - 110 057

3. M/s Kohbers Fire Care (P) Ltd.
   214 Hemkunt Towers,
   Nehru Place
   New Delhi - 110 019

4. M/s Matronic India (P) Ltd.
   41/1 Ashok Nagar
   Delhi - 18

5. M/s Anand Brothers (P) Ltd.
   2150/4 West Patel Nagar
   New Delhi - 110 008.

6. M/s Ahluwalia Fire Protection Engineers
   10450, East Park Road
   New Delhi - 110 005

7. M/s Aquatech
   36, FIEE, Okhla Industrial Estate
   Phase II, New Delhi - 20

8. M/s Firetech Industries
   100/2, Nahar Seth Industrial Estate
   L.B.S. Road, Bhandup (West)
   Bombay - 400 078.

9. M/s Zenith Fire Services
   15, Vadhani Industrial Estate
   L.B.S. Marg, Ghatkopar (West)
   Bombay - 400 086

10. M/s Shanti Fire Protection Services
F-20, Shopping Centre I,
Mansarover Garden, New Delhi - 15

11. M/s Fire Remedy Appliances,
B-38 Ansal Chambers
13, Bhikaji Cama Place,
New Delhi - 66

12. M/s Mollimer Suppliers (Regd.)
168, Ajmeri Gate
Delhi-6

13. M/s New Age Industries
J6/151, Rajauri Garden Ext.
New Delhi - 27

14. M/s Ace Turnkey Fire Protection (P) Ltd.
202, Laxmi Bhawan
Nehru Place
New Delhi - 19

15. M/s Everguard Corporation
N-138 Greater Kailash I
New Delhi - 48

16. M/s Asiatic Fire Shield
33/18, East Patel Nagar
New Delhi - 8

17. M/s Spack Engineers & Consultants,
A-87, Malviya Nagar
New Delhi - 17

18. M/s Fire Cool Engineers
Y-1, Green Park (Main)
New Delhi - 16

19. M/s Styluss Fire Protection Engineers
B-2/34, Azad Apartments
Sri Aurobindo Marg
New Delhi

20. M/s Techofab Engg. Ltd.
502, Eros Apartments
56, Nehru Place
New Delhi - 19

21. M/s Jainex Fire Protection and
Safety Engineers
17, Arun Chambers
Tardeo, Bombay - 400 034

22. M/s FEMACK
A-227, Defence Colony
New Delhi - 27

23. M/s Radiant Fire Protection Engineers
Parekkh Market
39, Kennedy Bridge
Bombay.

24. M/s Fire Safety Devices
31, Neelam Chowk
Faridabad.

25. M/s Capital Fire Engineers
27, Gole Market
New Delhi - 1

26. M/s GENELEC Limited
11, Commercial Centre
Basant Lok, Vasant Vihar
New Delhi - 57

27. M/s FYRPROTEK Engg. Consultants
AG-1/145 A, Vikas Puri
New Delhi - 18

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# ERRATA

| S. No. | Page | Line | For | Read |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| 1. | (v) | 17,18 | Pottasium | Potassium |
| 2. | 5 | 16 | and called "stack area." | delete |
| 3. | 9 | 17 | aid | air |
| 4. | 10 | 21 | ventiated | ventilated |
| 5. | 17 | Fig. 8 | temperature | delete |
| 6. | 24 | 3 | lense | lens |
| 7. | 30 | 7 | braking | breaking |
| 8. | 30 | 14 | contain | contains |
| 9. | 31 | 3 | trickkle | trickle |
| 10. | 32 | 15 | smoothering | smothering |
| 11. | 33 | under diagram C | cle | circle |
| 12. | 34 | last | tain | contain |
| 13. | 34 | last | gless | glass |
| 14. | 38 | 8 | fluorinated | delete |
| 15. | 48 | under class B Fire Line 2 | pains | paints |
| 16. | 50 | 7 | statis | static |
| 17. | 50 | 17 | Fife | Fire |
| 18. | 53 | 16 | and shed | used |
| 19. | 53 | 22 | 55 to 57 | 48 to 49 |
| 20. | 54 | 36 | safeuarding | safeguarding |
| 21. | 59 | 14 | *Berkshira*, | *Berkshire*, |
| 22. | 60 | 6 | *Bughee*, | *Bugbee*, |
| 23. | 60 | 10 | Maurices | Maurice |
| 24. | 63 | 9 | Parekkh | Parekh |

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