

NEBOSH International General Certificate

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Element 5 | Fire Hazards and Control

Learning Outcomes

When you have worked through this element and answered the Revision Questions, you should be able to demonstrate understanding of the content through the application of knowledge to familiar and unfamiliar situations. In particular you should be able to:

- identify fire hazards and evaluate main fire risks in a workplace.
- explain the basic principles of fire prevention and the prevention of fire spread in buildings.
- identify the appropriate fire alarm system and fire-fighting equipment for a simple workplace.
- outline the requirements for an adequate and properly maintained means of escape for a simple workplace.
- outline the factors which should be considered when implementing a successful evacuation of a workplace in the event of a fire.

INTRODUCTION

In this element we will look at the basic principles of fire, the risks it presents in the workplace and the main measures that should be taken to minimise those risks. We shall consider measures for the prevention and control of fire, and for the safe evacuation of premises.

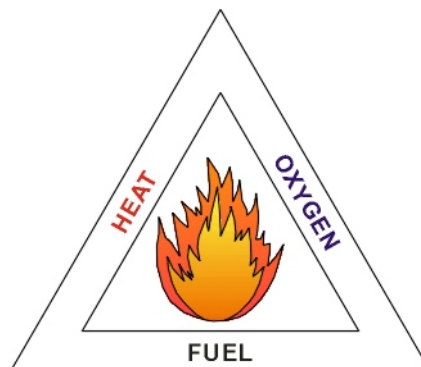
BASIC FIRE PRINCIPLES, HAZARDS AND RISKS IN THE WORKPLACE

Basic Principles of Fire

Fire is a rapid chemical process in which oxygen combines with another substance in the presence of a source of heat energy. The reaction of these elements is called **combustion**, and during the reaction, heat, light and flames are given off.

The Fire Triangle

Before a fire can start, three components have to be present in sufficient quantities. These form a structure known as the **fire triangle**. If one of these elements is removed, the fire will go out.



The Fire Triangle

Heat

Heat acts as the source of ignition and anything that gives off heat can start a fire. (Note that the source of ignition is not necessarily a flame, a spark or fire itself, but the heat they give off.)

It is important to be aware that the source of heat can not only be equipment and activities which, by design, involve the production of heat, but may also include a variety of other circumstances with which heat may not be expected at all. We could list a whole range of equipment which generate heat when in proper use, e.g. welding torches, blow-lamps, soldering irons, space heaters, hot plates, ovens, electric fires, light bulbs and electric irons. We could also include the use of matches and smoking. However, heat may also be produced as a by-product of other events, intended or not. As an example, grinding wheels can produce sparks, electrical equipment may be overloaded and then overheat, and static electricity or an electrical short circuit can cause sparking. Heat is also generated by friction, as when two pieces of metal rub together without lubrication.

Fuel

The fuel for a fire does not have to be a recognised fuel in the sense of petrol or gas. It may be any combustible material.

Most substances are combustible under the right circumstances although those circumstances vary for different materials, usually the temperature at which combustion takes place. Carbon or hydrocarbon based materials will burn readily at the sort of temperatures often generated in a workplace or domestic environment. They include solids

such as paper and wood, and gases such as petrol vapour, natural (town) gas or propane (bottled gas). However, other materials may also combust at relatively low temperatures.

The type of fuel is also important because different substances behave in different ways when they burn, e.g. the amount of flames or smoke they give off may depend upon the circumstances (temperature and air conditions) and because the means of extinguishing the fire may vary.

We shall consider the types of fuel in a little more detail later when looking at the way in which fires are normally classified.

Oxygen

The oxygen essential for combustion is usually supplied from the surrounding air. However, the naturally present oxygen may be enhanced by the presence of other sources of oxygen such as compressed air, the pure oxygen in gas cylinders used for welding, or by the combustion of peroxides, nitrates, and similar chemicals. (These chemicals give off oxygen as they burn, further aiding their own combustion. They are sometimes known as oxidising agents.)

Note that as the oxygen in an enclosed space is used up by the fire, so the fire will go out.

Classification of Fires

Fires are classified into five categories according to the fuel type. The classification also serves as a basis for identifying the means of extinguishing different types of fire:

- **Class A**
These are fires involving solid materials, normally of an organic nature, such as paper, wood, coal and natural fibres. These fires usually produce burning embers.
- **Class B**
These are fires involving flammable liquids or liquefied solids, such as petrol, oil, grease, fats and paint.
- **Class C**
These are fires involving gases or liquefied gases, such as methane, propane, and mains gas.
- **Class D**
These are fires where the fuel is a metal such as aluminium, sodium, potassium or magnesium.
- **Class F**
These are fires fuelled by cooking fats, as in the case of deep fat frying.

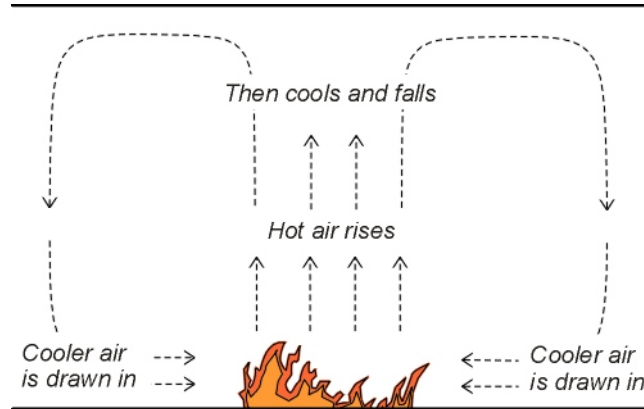
Methods of Heat Transmission and Fire Spread

Once a fire has started there are four methods by which it can spread: convection, conduction, radiation and direct burning.

Convection

Convection is the process whereby heat moves through a gas or liquid. When a gas or liquid, such as air or water, is heated it expands and becomes less dense. As a result it rises and cooler air or water is drawn in to replace it, creating a current.

Convection currents created in the air by fire are a major means of fire spread. They may carry burning materials through the air and into contact with other combustible materials and also, depending upon the intensity of the fire and the heat generated, create strong localised winds which may fan the flames and cause flare ups.

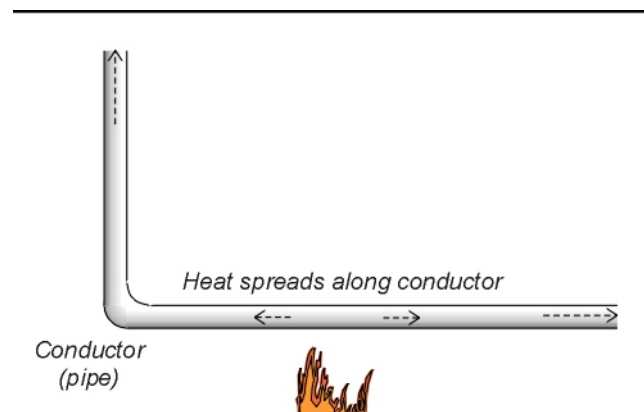


Convection Currents

Conduction

Heat may be transmitted through certain materials, known as conductors, without those materials themselves actually burning. This is particularly the case with metals. The heat generated by a fire (or any other process producing heat) may therefore be transferred to a separate location where it can act as a source of ignition.

This has important implications for many steel frame buildings which feature widespread use of metal within the structure of the building (e.g. steel girders) and the services which run through it, such as pipes and various types of ducting.



Conduction

Radiation

Radiation is the general term for the process by which energy is lost from a source without direct contact. Heat radiation refers to the process whereby the heat given off by hot objects passes through air and through certain types of transparent material such as glass. This radiant heat can in itself be sufficient to act as a source of ignition.

For example, radiators are an obvious source of heat and clothes which are left to dry too close to them may catch fire. Similarly, light bulbs give out heat (and in the case of certain

types of spot lights, a large amount of heat) and any fabrics or flammable materials which are too close may start to burn.

The intensity of radiant heat diminishes with the distance from its source. However, depending on the temperature of the source, heat transfer may take place over quite large distances. For example, a fire burning on one side of a street may be sufficient to cause materials on the other side of the street to ignite.

Direct Burning

This occurs where heat is transferred directly by contact from one substance to another. If a piece of paper catches alight then the heat (in the form of flames) can spread to the next piece of paper and then to the next until a whole area is on fire. Similarly, oil based paint on walls can spread fire, as can a pool or trail of flammable liquid.

Note that direct burning can take place across a gap where the wind conditions allow for flames to be fanned and thereby come into contact with other separate combustible materials. This fanning may be the result of simply opening a window or door, allowing more air into an enclosed space. Note, too, that localised winds are created by convection.

Common Causes and Consequences of Fires in Workplaces

Workplace fires start when the heat generated by a deliberate work process, or by accident, acts as a source of ignition on a combustible material. All such fires are preventable by appropriate safety precautions, as we discuss elsewhere. There is also an increasing incidence of arson which may account for a large proportion of all fires.

Once a fire has started it can spread quickly by means of all four methods of heat transfer. The most usual methods are through direct burning of the materials contained within the building and by convection. Hot gases and smoke can rise up staircases, lift shafts, vertical ducts and floor openings, and can be spread by convection currents under ceilings and other horizontal surfaces, through roof spaces, gaps between floors and false ceilings. Flying brands (particles of burning material) which are carried by the currents may ignite further combustible materials. As more materials are ignited and the heat intensifies, the volume of these gases and smoke grows and the speed of the convection currents increases, aiding the spread of the fire. Heat may also be spread by conduction through structural support materials (particularly steel girders), pipes and air conditioning ducts, and by both radiation and conduction through doors and other apparent barriers, allowing fire to move from one room to another.

Losses due to fire have an enormous cost (both financial and human) to industry and the community and yet most fires are preventable. Disruption to business in the form of loss of production, loss of plant and, sometimes, injury and loss of life can often be crippling. Even a minor fire involves disruption and a reduction in output which benefits no one (except the insurance company requesting higher premiums). Over 70% of businesses which have suffered a major fire either do not re-open or fail within three years of the loss.

Fire Risk Assessment

Prevention and control of fire spread is a high priority issue. This is nearly always reflected in legislation designed to cope specifically with this threat. Different countries tackle this in different ways (for example, through fire department inspectors and more recently the use of specific risk assessment for fire). Primary responsibility for workplace fire safety is placed on employers and those in control of workplaces. They must provide the measures necessary to prevent or control the risks from fire and, in particular, must ensure the following points:

- That the workplace is equipped with appropriate fire-fighting equipment, fire detectors and alarms and that any non-automatic fire-fighting equipment is easily accessible, simple to use and indicated by signs.
- That appropriate measures are taken for fire-fighting, the nomination and training of workers to implement those measures, and the arranging of contacts with external emergency services.
- That emergency routes are kept clear and comply with any rules or regulations relating to routes, doors and signs.
- That there is a suitable system of maintenance for fire precautions in relation to workplace procedures in general and to specific equipment and devices, which must be kept in good working order and repair.

These requirements may be enforced by local fire authority inspectors. The following basic points must be considered to fully assess the adequacy of any site fire precautions. Here we take a risk assessment based approach. These will be supplemented with any fire specific legislation in your own country.

Site Plan

A site plan is useful for identifying all principal sources of ignition; they should be clearly marked on the plan. The plan should show all electrical appliances, heating plant, site of hazardous processes, location of the electric mains switches and the main gas control valves. It should also show waste disposal areas and the location of fire extinguishers.

In premises where much of the work is carried out within a single area, it may be adequate to carry out the assessment of a building as a single unit. However, in most cases it will be necessary to subdivide the building into discrete areas or rooms. It is particularly important not to lose sight of the effects that adjacent work or storage areas, or some normally inaccessible areas, may have on the rest of the building, e.g. roof voids, boiler rooms or fuel storage.

Identification of Hazards and Assessment of the Level of Risk Each Presents

In all cases the assessment should consider how the risk may be minimised. This should take the form of a review of:

- General working policies, e.g. no smoking.
- Specific working practices, e.g. the removal of waste on a more frequent basis, reducing the use of flammable substances where alternatives are available, or using fixed electrical installations (as opposed to portable appliances).
- The physical condition of the premises, e.g. the sealing of any gaps around the pipe work running between rooms.

Identification of the Fire Control and Evacuation Measures

Although the main effort must be to reduce the likelihood of fire arising, consideration must be given to how a fire should be dealt with if the precautions are ineffective. This should cover the following points:

- Warning systems – alarms and detectors.
- Fire-fighting equipment.
- Evacuation procedures and escape routes, including signs and emergency lighting.
- Testing, maintenance and inspection procedures, including fire drills.

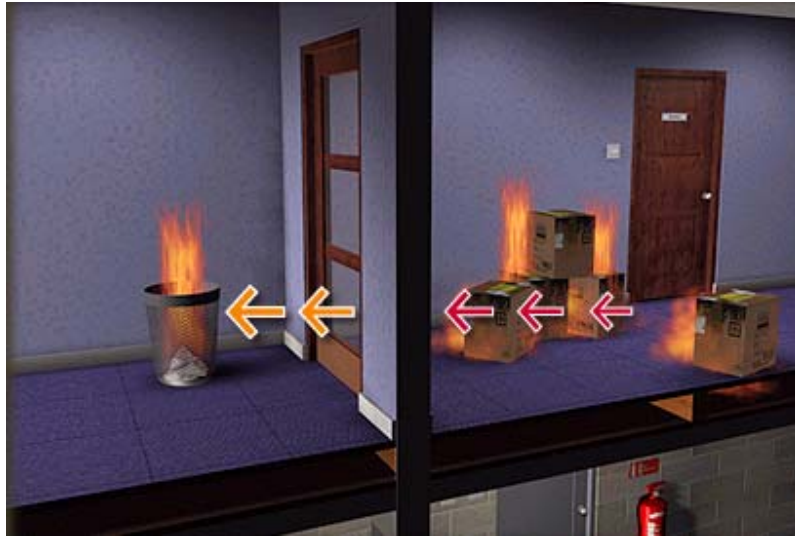
? Revision Questions

1. Explain briefly how each of the following might start a fire.
 - (i) Static electricity.
 - (ii) Friction.
 - (iii) Space heater.
2. What is likely to happen if you open a window to release the dense smoke in a room created by a fire?
3. Identify the fire classification of each of the following types of fire.
 - (i) Butane gas cylinders burning in the storage area of a garden centre.
 - (ii) Fire in the paint shop of a car manufacturer.
 - (iii) Fire in an office.
4. Identify the process of heat transmission/fire spread shown in the following photographs.
 - (i)



Source: Safe Practice “Fire Safety”

(ii)



Source: Safe Practice “Fire Safety”

(iii)



Source: Safe Practice “Fire Safety”

5. What additional method of heat transfer/fire spread is not illustrated by the photographs above?

(Suggested Answers are at the end of Unit IGC2.)

FIRE PREVENTION AND PREVENTION OF FIRE SPREAD

Control Measures to Minimise the Risk of Fire in A Workplace

Fire can start only when a source of ignition comes into contact with some combustible material. Fire prevention is based on two principles:

- Controlling potential sources of ignition.
- Controlling combustible materials.

If fire does break out it is important to prevent or minimise its spread.

The measures that may be taken in the workplace to prevent the outbreak of fire and control its spread overlap to some extent. They involve specific systems of work, general working practices (which we discuss here) and the structural design of buildings and the use of particular materials within buildings, which is considered elsewhere.

Central to these measures is the need to recognise the dangers of fire and to adopt safe working practices. Fire safety is therefore the responsibility of everyone in the workplace.

Use and Storage of Flammable and Combustible Materials

In order to reduce the possibility of fire, careful thought should be given to the introduction of flammable materials into the workplace. If they can be eliminated or their use limited, then the chances of fire occurring will be reduced.

When elimination or reduction is not possible, then proper management of the flammable materials is necessary.

All materials which present a risk of fire or explosion must be stored, transported and used correctly. This applies to solids (such as magnesium), liquids (such as petroleum and its derivatives, paints, solvents, etc.) and gases (such as hydrogen, liquefied petroleum gas (LPG), oxygen).

In use and when being handled in any way, flammable and combustible materials must be treated with great caution. Staff must be aware of the potential dangers for each type of material and the conditions under which they may ignite, and should be trained in the correct procedures to be applied. The containers used for flammable materials should be marked.

Storage areas for flammable and combustible materials should be:

- Detached, secure, single-storey, ventilated buildings of non-combustible construction, used for no other purpose.
- Separate from other parts of the premises.
- Accessible to firefighters.
- Large enough to allow clear spaces to be maintained around stacks of materials.
- Large enough so that sprinkler systems are not obstructed by stacking up the stored materials too high; there should be a space of at least 0.6 metre below sprinkler heads.

Control of Ignition Sources

Most fires in the workplace are caused by a lack of control over sources of ignition. These are always preventable by carefully designed working systems and practices.

Perhaps the most important practice to have been adopted in recent years has been that of “no smoking” policies. They have been in place for many years in areas where there is a particular fire risk, e.g. with flammable materials, but they have now been extended to many other work and public areas. Where smoking is permitted, sufficient metal ashtrays should be provided. Discarded cigarettes or matches have been responsible for many fires, resulting in considerable loss of life, injury and financial loss.

Systems of Work

Safe systems of work should be specific to the type of work and the equipment used.

Working with Hot Processes or Implements

Most workplaces employ some processes and equipment which by their very nature produce sufficient heat to act as a source of ignition in the right circumstances. However, good working practices can minimise the risk of fire. Examples include:

- All appliances and processes which produce heat or fire should be located or carried out a safe distance away from paper, wood and other combustible materials.
- Nothing should be placed or stored on heaters. Portable space heaters should be guarded and placed or fixed to prevent them being knocked over.
- Appliances such as soldering irons or pressing irons should be provided with stands to prevent them contacting work surfaces and surrounding materials when not in use. They should be switched off when not in use.
- Hot surfaces, such as boilers and associated pipe work, should be lagged to prevent radiant heat becoming a hazard.
- There should be fire watches during and after hot work.

Machinery

Poorly maintained machines may overheat or cause sparking and a planned maintenance programme is necessary in order to minimise creating a fire risk.

There should be regular inspections of all machinery and equipment, with checks on the proper lubrication of bearings and correct tensioning of drive belts to prevent friction and overheating.

Electrical Equipment and Systems

Inadequate safeguarding of electrical equipment and systems, along with inefficient maintenance, presents a considerable fire risk. Electrical faults (faulty earths, loose connections, short circuits) are the cause of many industrial fires.

All electrical equipment and systems should therefore be inspected and maintained on a regular schedule. This should include circuits being tested regularly to ensure that there are no faulty components or cables, especially in the roof of a building, and that plugs are not loose, sockets not worn or damaged, and cables not frayed or rubbing on the edges of benches.

Electrical equipment should always be switched off and unplugged when not in use as it can overheat. It is easy to lay a soldering iron down on the bench and then have it set material alight.

Good Housekeeping

The control of highly combustible materials and sources of ignition must be coupled with high standards of housekeeping to ensure that combustible materials in any form, but particularly waste, do not present a fire risk. This applies to all areas of work since waste

materials can accumulate in any circumstances and a build up of dust and dirt can easily provide the fuel for fire in the right circumstances.

The accumulation of process waste, contaminated rags, packing materials and other paper products, and general refuse and dust must be prevented. Oily, flammable and combustible rags are a particular problem in many workplaces as they are easily ignited and may even ignite spontaneously; they should be placed in metal containers with fitting lids.

Routine housekeeping should ensure that:

- Waste bins are emptied regularly so that there is no accumulation of combustible materials.
- Cupboards, lift-shafts, spaces beneath conveyors, stairs, benches and gratings are regularly cleaned and kept free of litter and rubbish.
- Safe disposal of all waste materials is arranged. "Unofficial" rubbish burning must be banned.

In addition, good housekeeping extends to other general "tidy" working practices which ensure that combustible materials do not come into contact with sources of heat. These include control of work clothing to ensure that items do not come loose and catch fire, and the general storage of clothing and paper away from any potential source of ignition.

At the end of a work period all equipment not required to operate should be switched off and portable equipment should be unplugged. If equipment is in use overnight it should be checked for safety. Other checks which should be made include ensuring that no cigarettes are left smouldering, fire doors and windows are closed and the premises are secured against intruders.

Precautions against arson should also include appropriate security to prevent unauthorised access to storage areas (both during and outside of work times) and the screening of new workers. Opportunities for fire-setting can be reduced further by keeping waste and rubbish to a minimum and out of reach.

Safe Storage and Use of Flammable Liquids

When flammable liquids are exposed to the atmosphere they give off flammable and toxic vapours. Correct storage and use are therefore essential to prevent accidental ignition or explosion and they should never be exposed to potential sources of ignition.

Non-flammable substances should be used instead wherever possible. When in use in the workplace, the quantity of flammable liquids should be minimised and contained in appropriate (usually metal) containers with secure lids. These must be correctly labelled. The need to decant highly flammable liquids from one container to another should be kept to the minimum, reducing the risk of spillages.

Preventive Structural Measures

Building design can be a significant factor in preventing both the outbreak and spread of fire. The main features which influence this are:

- The layout and construction of the building or the site premises.
- The materials with which buildings are constructed and those used in decoration and furnishings.

Preventive Structural Measures

Ideally, to reduce the risk of fire spread, high fire risk processes and the storage of highly combustible and flammable materials should be sited some distance away from other (particularly, occupied) buildings. Unfortunately, due to restricted space this is not always achievable. The main alternative is the enclosure of such activities within **fire-tight cells**. This principle can also be used within any building to prevent the spread of fire and smoke, with the building divided into compartments or cells using fire resistant materials.

There are essentially two types of fire compartment or cell, although both have the same effect in terms of design:

- Compartments which are designed to keep a fire **in** – applied to areas of high risk which are those where highly flammable materials are used, transported and stored, where toxic fumes are produced or where gas cylinders are used or stored.
- Compartments which are designed to keep a fire **out** – applied to high loss effect areas where essential records or documents are kept, or where essential equipment, plant or stock are located, and to fire-protected “place of safety” areas (see later).

The walls, floors and doors which form the boundary to a fire compartment must generally provide a 60 minute resistance to fire, but this may vary depending upon the level of risk within the compartment and may even be as much as six hours.

For the walls, floors and doors which subdivide fire compartments, the requirement is that they must generally provide a 30 minute resistance.

Fire doors, where fitted, should be clearly labelled “Fire Door – Keep Shut”. Nowadays self-closing fire doors are used in many buildings. They may be held open but will be automatically closed by a door release mechanism triggered by:

- The activation of a smoke-sensitive device on either side of the door.
- The activation of a fire alarm system incorporating automatic smoke detectors in the vicinity of the door.
- A fault in either of these systems or in the door release mechanism itself.

Where such mechanisms are provided it should be possible to release them manually. The doors should be labelled with the words “Automatic Fire Door – Keep Clear”.

A fire door will only perform its function if it is properly designed, installed, operated and maintained; failure may be fatal. A survey on 1,583 fire doors of various types (Factory Mutual International, 1990) produced an 18% failure rate, mostly attributable to poor maintenance and damage. The following table gives a summary of the causes of failure.

Causes of Fire Door Failure (FMI, 1990)

Type of Door	Main Failure Mechanism
Steel roller shutter	Incorrect spring tension or snagged chain
Horizontal sliding on inclined track	Blocked opening, damaged track or snagged cable
Horizontal sliding – counterweight	Damaged track, snagged cable or counterweight
Horizontal sliding – spring closure	Damaged track or spring tension
Swinging	Faulty closer, missing latch or binding on wall or floor
Vertical sliding	Blocked opening, damaged track or snagged cable

Additionally, some doors failed due to dirty, painted or unlubricated components.

If any services or ducting passes through a compartment wall, floor, ceiling or roof, then the joints around the services, etc. must be **fire stopped** to prevent the passage of fumes, smoke or gases.

Properties of Common Building Materials

The types of material used for both the structure and decoration of a building are a significant factor in the manner and rate of fire spread, affecting the safety of both the occupants and the building contents. There are many different types of building materials available and selecting which to employ depends on the specific use and circumstances of the building. It always involves a compromise between the various properties of the materials, mainly their combustibility, structural strength when subject to heat and the products of combustion (harmful or otherwise) – and, of course, their cost. We shall consider here the properties of the main types of building materials.

The most common materials used in construction and their application to different parts of a building are as follows:

Structure	Linings and Divisions	Services and Decoration
Bricks	Timber	Plastics (pipes, cables and coatings) Paint
Building blocks	Building boards	
Concrete	Insulation	
Stone	Glass	
Steel	Plaster (lime)	
Timber		

Steel Frames

Steel has a high strength/weight ratio and is used extensively as load-bearing, structural members such as columns, beams, portal frames and roofs, etc. It can also be used as “profiled” sheets or lightweight roof members (purlins).

Unprotected steel will rapidly lose its designed shape in a fire and also its structural strength; mild steel loses half its cold strength at about 550°C and high-tensile steel at about 400°C. A typical effect of this is that, for example, heating a steel cross-beam will cause it to expand, pushing vertical columns out and causing floor slabs to collapse onto the floor below which, not being strong enough to carry the extra load placed upon it, may itself collapse and hence lead to the whole building falling through.

Steel is also a very efficient conductor of heat and so extensive unprotected steelwork can be a significant cause of the spread of fire.

As a result of these weaknesses in the face of fire, steel is generally used in combination with concrete, where the concrete provides a measure of protection for the steel.

Reinforced Concrete Frames

Almost all concrete used for structural purposes is reinforced with steel rods. Their fire resistance is determined mainly by the protection offered by the concrete cover against an excessive rise in the temperature of the steel. This in turn depends on:

- The type of aggregate used – all concrete is likely to “spall” (break away) when hot, particularly when hit by a jet of fire or hot air, although the use of lightweight aggregate or aerated concrete can minimise this.
- The thickness of concrete over the reinforcing rods.

The fire resistance of reinforced concrete is good. In contrast to unprotected steel, structural concrete may deflect under fire conditions but does not normally collapse suddenly. Indeed, many structures have been able to be reinstated after severe fires.

Timber

Timber burns but in a predictable manner. If designed with an adequate factor of safety there can be a reasonable time lag before failure occurs, particularly if the timber is protected with plasterboard or other coverings. Applied heat will not cause expansion to stress the structure nor does wood collapse suddenly.

The fire resistance of timber depends on the “four Ts”:

- The **thickness** or cross-sectional area of the piece.
- The **tightness** of any joints involved – in general, the fewer joints the better.
- The **type** of wood – generally, denser timber has better resistance (the surface chars, but because conduction is poor the internal timber still performs structurally).
- Any **treatment** received, e.g. flame-retardant treatment is often applied to such materials as plywood or chipboard sheets.

For several years now the use of laminated timber members has been on the increase, simply due to the fact that it can be designed to almost any profile and has excellent fire resistant properties. Excess material (known as “sacrificial timber”) is often added to exposed beams and columns, providing a protective layer which is consumed by a fire before the structural core is attacked.

Bricks

There are three types of brick in common usage – fired clay, calcium silicate and concrete. Fired clay bricks usually respond better in a fire situation due to their composition (clay)

and the fact that during the manufacturing process they have already been exposed to very high temperatures and there will therefore be little reduction in their strength in any subsequent fire.

However, no distinction is made between the three types in classifying their behaviour in fire when incorporated as a wall. The key features which affect the fire resistance of a wall are:

- Its thickness.
- The applied rendering or plastering, especially if lightweight plaster is used.
- Whether the wall is load-bearing or not.
- The presence of perforations or cavities within the bricks.

Building Blocks

Blocks may be of clay or concrete:

- Clay blocks are usually hollow. The greater the thickness and the smaller the voids, the better the fire resistance. Spalling (blistering and exploding) is likely to occur on the face exposed to fire.
- Concrete blocks may be made of dense or lightweight aggregates and can be either solid or hollow.

Both types give high fire resistance (which can be improved by the application of plaster) with little risk of collapse, so they can be safely used for the walls of a fire compartment.

Building Boards

Boards are generally combustible but are not easily ignited. The main types are:

- Fibre building boards – either softboard (often called insulating board) which is non-compressed in manufacture or hardboard of both low and high density which, if tempered by impregnation with oils and resin, has high strength and water resistance and is not easily ignitable.
- Plaster boards which retard fire spread until the paper face burns away.
- Asbestos boards which have a high asbestos content and consequently have good fire-resistance properties (but the use of which is now forbidden in many countries due to the carcinogenic properties of asbestos).
- Asbestos cement sheets which have a low asbestos content and usually fail by shattering under fire.
- Plywood and block boards which offer variable fire resistance depending on the type of wood, thickness, treatment, etc.
- Plastic board of variable resistance depending on the surface treatment.

Building Slabs

Slabs are similar to building boards but are much thicker. "Wood-wool" slabs and compressed straw slabs are combustible and are often treated to give improved resistance. These are usually found as underlays for roofing materials.

Stone

Often used for cladding, the type of stone used in buildings is generally one of the following:

- Granite – which is likely to expand rapidly and shatter at 575°C, and has a risk of spalling (although this is reduced by the use of large blocks).

- Limestone – which is likely to spall if hit with a high temperature jet of fire or air.
- Sandstone – which generally comes between limestone and granite in behaviour, and is likely to shrink and crack.

Stone has a tendency to crack when subjected to continuous heat or to sudden cooling by a jet of air.

Glass

Glass is susceptible to breakage and cannot therefore be used as a barrier to fire. There are two exceptions to this – wired glass and copperlight glazing – which offer some fire resistance.

Other types of glazing are:

- Armour plate – toughened glass which is incapable of providing fire resistance and will not stand temperatures above 300°C.
- Double-glazing – two or even three sheets of glass which are mounted within a frame, but which are still likely to shatter in a fire and cannot therefore be considered fire-resistant.
- Glass blocks and glass lenses which are used for internal and external wall panels.

Fire resistant glazing is a recent development whereby glass incorporates clear intumescent (swelling) interlayers or laminates and which will provide fire resistance of up to 90 minutes.

Insulating Material

Most modern insulating materials are non-combustible but unfortunately in many older buildings combustible materials (such as sawdust) have been used. Their location in concealed spaces can aid fire spread considerably.

Lime (Plaster)

Lime is made by heating limestone (calcium carbonate) which is converted to quicklime (calcium oxide) and then slaked with water to make slaked lime (calcium hydroxide). Lime is a component of plaster and mortar. It is used for plastering internal walls and, if supported by lathing or expanded metal, has good fire resistance.

Paint

Most paints are flammable and a layer of many coats built up over years may be a fire risk. Flame-retardant paints and intumescent paints are also available. These bubble up to protect the timber beneath.

Plastics

There are two types of plastic:

- Thermosetting plastics, which are formed by the action of heat and compression – these will not soften and melt when involved in a fire, but will decompose.
- Thermoplastic plastics, which are moulded into the required shape by heating and on cooling remain in that shape – if involved in a fire they will melt and flow.

Plastics are used primarily in building services and surface fascias. The principal hazards they present in fires are the dripping of molten plastic and giving off products of incomplete combustion in the form of toxic smoke.

Protection of Openings and Voids

Ceiling and floor voids, as well as openings around pipe work and other services, can allow air to feed a fire as well as assisting in the spread of fire and smoke. Debris should not be allowed to accumulate in voids. When necessary such openings should be bonded or fire-stopped with non-combustible material.

Ventilation ducts and gaps around doors must have the facility to be stopped in the event of a fire. This can be achieved by the use of baffles, self-closing doors and intumescent material which expands when subject to heat thereby sealing the opening.



Revision Questions

6. How might you minimise the risk of fire in a woodworking area?
7. What precautions should be taken when using flammable liquids?
8. Describe the effects of fire on an unprotected steel beam.
9. Upon what does the fire resistance of each of the following building materials depend?
 - (i) Timber.
 - (ii) Reinforced concrete.
 - (iii) Brick walls.
10. Describe how flame retardant paint protects covered timber.

(Suggested Answers are at the end of Unit IGC2.)

FIRE ALARM AND FIRE-FIGHTING EQUIPMENT

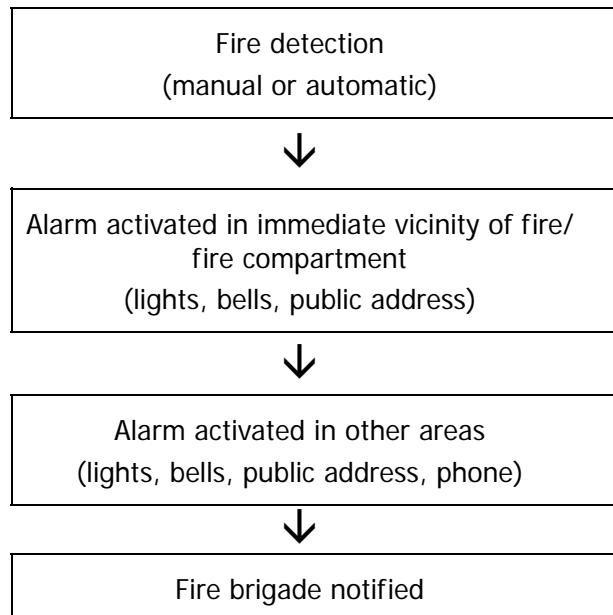
All workplaces must have arrangements for:

- Sounding an alarm in the event of fire.
- Fighting the fire.

Fire Detection and Alarm Systems

There are many systems for raising an alarm on detecting an outbreak of fire, ranging from simple hand bells (or even just shouting) to sophisticated electronically-triggered systems. However, whatever system is employed, all staff must know how to raise an alarm on discovering fire and what to do when the fire alarm sounds.

The general principles of an alarm system are shown below.



Fire Alarm System

Depending on the size and layout of the premises and upon the type of fire hazard faced, the alarm system activated on detection of a fire may proceed in stages (as shown above and described below) or may cover all the stages at once.

In order to avoid unnecessary disturbance in hospitals and other large installations it may be preferable to restrict an initial alarm to the locality in which it arises (zoning) or restrict it to a small number of responsible personnel. A general alarm would then be sounded only if it was considered desirable. Such restricted alarm systems must have a control point which is under continuous and competent watch during the whole time the premises are occupied. An over-riding switch should also be provided to enable the responsible person to raise a general alarm for complete evacuation. If an alarm is to be restricted it will also be necessary to have some additional means of summoning fire-fighting staff to the affected area.

The alarm signal itself is usually a bell or siren sounded loudly throughout the buildings and premises affected. It must be clearly audible to all staff in those buildings and premises, which means that careful thought must be given to the siting of alarm bells or sirens, e.g.

fitting fire doors to a building cuts down the distances over which call bells are heard and may mean additional bells must be fitted or noise levels raised. In some circumstances, audible devices on their own may not be sufficient to act as clear signals and emergency lighting patterns may be required. Further, to comply with the requirements of disability discrimination legislation it may be necessary to use lights or vibrating devices in addition to bells and sirens. Recognising the alarm signal will be an important part of staff training in relation to fire precautions.

All equipment and systems used for fire detection and for raising an alarm (even the basic manual devices described below) must be maintained and tested regularly and the results recorded. Any faults discovered must be rectified and the system rechecked.

Manual Systems

Manual systems are suitable for small workplaces and involve the use of the following basic devices:

- Rotary gongs – which are sounded by turning a handle around the rim of the gong.
- Hand strikers, e.g. iron triangles suspended from a wall accompanied by a metal bar which is used to strike the triangle manually.
- Hand bells.
- Whistles.
- Air-horns.

These devices are normally located on the walls of corridors, entrance halls and staircase landings, etc., where they are readily available to anyone who may have to raise an alarm.

While these types of manual systems provide for an alarm over a limited area, operation of one of them is rarely adequate to give a general alarm throughout the premises. Also, as a person is required to operate them, a continuous alarm cannot be guaranteed for as long as may be necessary.

In order to raise a more general alarm it is also possible to use facilities which may already be installed in a building for other purposes, e.g. a telephone or public address system. With automatic telephone systems, arrangements can be made for a particular dialling code to be reserved for reporting a fire to a person responsible for calling the fire service and sounding the general alarm. Alternatively it can be arranged that use of the code automatically sounds the general alarm.

Manual/Electric Systems

These are systems which, although set in motion manually, operate as part of an electrical alarm circuit. When an alarm call point is activated, the alarm signal is automatically sounded throughout the premises (or a particular part of them). The alarm system may also sound an alarm outside the building and possibly relay an alert to the fire service.

The call points in a manual/electric system are usually small red wall-mounted boxes which are designed to operate either automatically when the glass front is broken or when the glass front is broken and a button pressed. Most available models are designed to operate immediately the glass front is broken.

Automatic Fire Alarms

Usually mounted on ceilings or in air ducts, an automatic fire detector identifies one or more physical changes in the protected environment which indicate an outbreak of fire. All such systems will sound an alarm within the affected area, as well as outside the building and direct to the fire service. Many will also be linked to containment and/or extinguishing

devices, such as activating automatic door releases, closing down ventilation or air conditioning plant, or activating sprinkler systems.

Fire may be detected in one of three main ways:

- By sensing the presence of **smoke** or **other fumes** (often invisible) given off by combustion.
- By detecting the presence of **flame** and a degree of illumination.
- By sensing **heat** – an actual temperature or the rate of a rise in temperature.

There are different types of detector for each of these three conditions.

- **Smoke Detectors**

There are two types of automatic smoke/fumes detector.

- **Ionisation** devices, which are sensitive in the early stages of a fire when smoke particles are small, but their sensitivity tends to drop as particles grow in size. Remember that the detector may mistake dust for smoke, resulting in a false alarm.
- **Optical** devices, which are effective in situations where there is dense smoke (i.e. large particles) which obscures or changes the normal levels of light in the protected area.

- **Radiation Detectors**

The flame of a fire emits visible light, also ultra-violet and infra-red radiation. Flame detectors operate on the basis of sensing the presence of these forms of radiation.

They are capable of rapid detection because of the almost instantaneous transmission of radiation to the detector head. However, their effectiveness depends on the detector having a clear “view” of all parts of the protected area.

- **Heat Detectors**

There are two main types of automatic heat sensors:

- **Fusion**, where special alloys melt and either break or make a circuit and sound an alarm, with the alloys requiring replacement after each time the detector operates.
- **Expansion**, where a contained metal, air or liquid sensor expands to create a circuit and sound the alarm. They usually reset themselves after operation when the conditions have cooled.

Heat detectors may be designed to operate at a pre-selected temperature (“fixed-temperature” type) or on a rapid rise in temperature (“rate-of-rise” type) or both. With both types, but more particularly with fixed-temperature ones, “thermal lag” has to be considered when choosing the operating temperature. This is the difference in temperature between that at the sensor itself and that at the source of the fire at the point when the sensor is triggered, which could be quite great depending on the distance between the two and the intensity of the fire.

Not all detectors will be equally sensitive in every possible situation and in some cases a combination of different detectors may be required. Smoke and heat detectors are suitable for most buildings. However, particular types of building and particular fire hazards may make specialised detectors more effective. For example, radiation detectors are particularly useful for high-roofed buildings (such as warehouses) and in situations where clean-

burning flammable liquids are kept, and laser beam infra-red detectors may be used where there are tall compartments or long cable tunnels.

Other factors to be considered in determining the type of detectors used include:

- The **conditions in the area to be protected** – a more robust detector is necessary, say, in an industrial setting than is required for hotel purposes. Dusty or damp atmospheres will affect some detectors more than others.
- The **sensitivity required** – it would not be sensible to install a smoke detector set at high sensitivity in a normally crowded hotel bar (or similar conditions) because of false alarms caused by cigarette smoke.
- The **availability of suitable locations** – the detectors should be located so they are in the best possible position to perform their function.
- The **potential for false alarms** – false alarms can happen for many reasons and are often unavoidable (e.g. dust may be mistaken for smoke by smoke detectors or strong sunlight can be reflected from windows or puddles which can be mistaken for a flame by ultra-violet radiation detectors). The choice of detection system should take account of the potential for such false indications in the particular circumstances.

Portable Fire-Fighting Equipment

The main types of portable fire-fighting equipment are fire extinguishers. These are appliances designed to be carried to the point of the fire and operated by hand. They contain an extinguishing agent which is expelled by internal pressure on operating the release mechanism and can be directed by means of a horn or tube onto the fire. The pressure may be by compression within the extinguisher or may be the result of a chemical reaction or release of gas from a cartridge, triggered by the operation of the extinguisher.

The correct type of extinguisher should be available for the risk it is going to protect against, with the type of extinguishing agent clearly marked. Extinguishers must also be well maintained and be sited in an easily seen and reached position, usually by an escape route. To ensure that these conditions are always met there are a number of important requirements relating to fire extinguishers, many of which are included in a fire risk assessment.

Marking

In most countries portable appliances must be coloured red and display a distinguishing coloured label, usually on its collar, to identify the type of extinguishing agent contained. These are as follows:

Water	–	Red
Chemical foam	–	Cream
Carbon dioxide	–	Black
Dry powder	–	Blue
Halon (vaporising liquid)	–	Green

In addition, each appliance has to have the date of its last inspection marked on it.

Siting

The location should be clearly marked and should not be further than 30 metres from the next location. The number of locations should be determined by a risk assessment and would normally be a minimum of two locations on any floor. Depending on the circumstances, there are likely to be one or two 9-litre water extinguishers at each location.

The siting of extinguishers should make them readily visible on escape routes and placed close, but not too close, to the point of any potential fire risk.

The extinguishers should be properly mounted, sited to avoid temperatures beyond their operating range and protected from corrosive environments.

If necessary more than one extinguisher should be provided in each location to enable different types of fire to be extinguished. Many locations therefore have water extinguishers, along with carbon dioxide or dry powder extinguishers which should be used in the case of electrical fires.

Maintenance

Regular inspections and examinations must be carried out by a suitably qualified technician. The requirements vary for different types of extinguisher. Here are some typical requirements (the actual detailed requirements may vary between countries):

- **Water Extinguishers**

Stored-pressure extinguishers must be checked to ensure that the pressure is correct, that the hoses and nozzles are not blocked and there is no corrosion. They should be discharged annually.

Gas-cartridge extinguishers should be opened annually and the working parts and contents checked. The gas cartridge should be weighed to check for losses and the sealing washer examined. They should be discharged every five years.

- **Foam Extinguishers**

These should be opened annually and checked to ensure that no clogging has occurred and all the working parts are in good order. Gas cartridges should be weighed and losses in excess of 10% will require replacement. The extinguisher, if pre-mixed, should be discharged every two years or, if the compound is kept separate, every four years.

All foam extinguishers must be thoroughly washed out after discharging.

- **Dry Powder Extinguishers**

Examination should be once a year for all the features covered for the other extinguishers. With the gas cartridge type, which can be opened, the powder should be checked to ensure it has not caked. They should be discharged every five years.

- **Carbon Dioxide Extinguishers**

The contents should be checked by weighing or by gamma ray to ensure there is no loss. The working parts should be examined and the horn checked for freedom of movement. Every 10 years, or when discharged, the cylinder should be hydraulically tested. After 20 years the test should be every five years.

- **Vaporising Liquid Extinguishers**

Annual working order checks are required by weighing the contents. The extinguishers should be checked by discharge every five years.

Training

The ability to carry out fire-fighting with portable extinguishers may not only control the rate at which a fire spreads, thereby giving those precious few moments which mean the difference between a person escaping or becoming a victim, but often reduces fire damage

to a lower level than would have been the case if the fire had proceeded without being checked. It is therefore very important that all personnel are familiar with the available fire-fighting equipment and are able to use it correctly.

The following points form a general scheme for training in the use of fire-fighting equipment:

- General understanding of how extinguishers and other appliances operate.
- The importance of using the correct extinguisher for different classes of fire (which should not be a problem as only the correct type of extinguisher should be available for use in any particular situation). Staff should be aware that using the wrong type of extinguishing agent on a fire may increase its intensity.
- Recognition of whether the extinguisher has to be used in the upright position or in the upside-down position.
- Practice in the use of different extinguishers. This can be done with or without a practice fire, although dealing with a live fire is obviously the better method. Opportunities for training may arise during the inspection process – when appliances are being tested or discharged. (Training in using carbon dioxide extinguishers is particularly important as they can be frightening to use – they start off with a bang and the horn gets freezing and can cause the skin to stick to it, pulling the skin off if you try to remove your hand.)
- When to and when not to tackle a fire. If the fire is small and does not involve the building structure, then portable extinguishers can usually be used. It must be understood that extinguishers can only provide a “first-aid” treatment for small fires and evacuating the building must take priority over fighting a fire if the conditions demand it. A means of escape must always be maintained.
- When to leave a fire that has not been extinguished. As a general rule, once two extinguishers have been discharged, the fire requires the fire service. There should be no delay in calling the fire services, but immediate fire-fighting action from a properly trained employee can avert a more serious fire spreading throughout the whole building. When leaving a fire, all doors and windows should be closed if possible to help contain the fire.

Other Types of Fire-Fighting Equipment

- **Fire Blankets**

These are portable fire-fighting devices designed to smother small, contained fires. There are different types of fire blankets suitable for different types of fire – lightweight ones suitable for Class B and occasionally small Class A fires, and heavy duty blankets for industrial use, including those that can be used for Class D fires. They are especially useful in a kitchen for extinguishing deep fat frying pan fires and other types of small fat and oil fires (Class F).

When using a fire blanket, the corners must be turned towards you so that you do not get burnt as the blanket is laid over the fire. It should be kept in place until all the heat has been removed.

- **Hose Reels**

These are very effective as a first line of attack against Class A fires.

Reels should be located near exits, stairways or lobbies and arranged so that no part of the building is beyond the reach of the jet (6 metres). If the hose reel is fitted into a recessed installation the doors, whether glazed or not, should bear the words “FIRE

HOSE REEL". The hose has a shut-off nozzle and the supply is via a control valve at the connection to the main, which must be opened before the reel is pulled out. Some reels operate this valve automatically as the hose is rolled out.

Reel installations have a number of advantages:

- Only the required length of hose has to be run out.
- The hose is light and only one person is required to operate it.
- The lack of back pressure from the nozzle makes it easy for persons of limited strength to handle it.
- The control of the water at the nozzle of a hose reel will limit water damage.

- **Automatic Sprinklers**

There are several different types of sprinkler system but essentially they all involve fixed pipe work in the ceiling of each part of the protected building. The pipe work is connected via control valves to a water supply and sprinklers are spaced at intervals along the pipe work so that the discharge patterns overlap and leave no part unprotected. They are activated by automatic fire detectors.

The quantity of water discharged is designed to at least control any fire in the protected area, if not to extinguish it.

- **Drenchers**

These are designed to provide a coverage of water over areas of a building or structure which could be damaged by radiant heat from a fire close by. Normally adequate spacing limits the radiation hazard and therefore only vulnerable areas need be covered, such as unprotected doors and windows.

- **Hydrants and Foam Inlets**

These are provided on the outside of buildings to allow the fire service easy access to a supply of water or foam close to a potential fire hazard, with the type of extinguishing agent being appropriate to the type of hazard.

Extinguishing Media

Extinguishing a fire is based on removing one or more sides of the fire triangle.

- **Removing the Fuel**

Extinction by this process is known as **starvation**. This can be achieved by taking the fuel away from the fire, taking the fire away from the fuel and/or reducing the quantity or bulk of fuel available. So materials may be moved away from the fire (to a distance sufficient to ensure that they will not be ignited by any continuing radiant heat) or a gas supply may be turned off.

- **Removing the Oxygen**

Extinction by this process is known as **smothering**. This can be achieved by either allowing the fire to consume all the available oxygen, whilst preventing the inward flow of any more oxygen, or adding an inert gas to the mixture. The most usual method of smothering is by use of a blanket of foam or a fire blanket.

- **Removing the Heat**

Extinction by this process is known as **cooling**. Cooling with water is the most common means of fighting a fire and this has a dual effect in terms of absorbing heat and thereby reducing the heat input into the fire, and reducing the oxygen input through the blanketing effect of the steam produced.

Although water is the most common medium used to fight fires, it is by no means the only or the most suitable substance. Indeed, using water on certain types of fire can make the situation worse.

The main types of extinguishing media are described below and you should note their application to the classification of different types of fire.

Water

Water applied as a pressurised jet or a spray is the most effective means of extinguishing Class A fires, and may under certain circumstances also be used as a spray on Class B fires involving liquids and liquefied solids which are miscible (capable of mixing) with water, such as methanol, acetone and acetic acid. Whilst ineffective on Class C fires themselves (those involving gases), water may be used to cool leaking containers.

It must never be used on fires involving electricity, as the current can flow up the stream of water, nor on non-miscible liquid fires as only a cupful of water can cause the whole fire to erupt into a conflagration.

Foam

Foam is a special mixture which forms a smothering blanket over the fire, cutting off the supply of oxygen. It can be used on Class A and B fires (although there are some restrictions in its use on Class B fires since certain types of foam break down in contact with alcohols).

Using foam as an extinguishing agent demands considerable skill when dealing with anything but very small scale liquid fires, since the procedure is to start at the rear and to lay a blanket of foam across the surface of the liquid.

Dry Chemical Powder

The powder is sprayed as a cloud over the fire, again acting to smother the supply of oxygen. It can be used on Class B fires and on small liquefied gas fires (within Class C). Specialised dry powders using inert substances are also used on Class D fires, where they form a crust over the burning metal and thus exclude the oxygen.

Dry powders are also effective on fires involving electricity.

While dry powder extinguishers are effective against Class A fires, they are very messy and are not necessarily the method of choice.

Vaporising Liquids

When applied to a fire these agents produce a heavy vapour which extinguishes the fire by excluding oxygen. They are safe to use on Class A and B fires and are particularly effective on fires involving live electrical equipment, since they interfere with electrical combustion reactions.

Carbon Dioxide Gas

This works by means of smothering the supply of oxygen. It is effective on Class B fires and also for electrical fires as the gas can enter the inside of the equipment.

Extinguishing Agents and Fire Classification

Fire Class	Description	Examples	Extinguishing Agents
A	Solid materials usually of organic origin (containing carbon based compounds)	Wood, paper, fibres, rubber	Water Foams
B	Flammable liquids and liquefied solids	Those miscible with water (capable of being mixed)	Dry powder Specialist foam CO ₂ Lightweight fire blankets for small fires
		Those immiscible with water	Dry powder Foam Lightweight fire blankets for small fires
C	Gases and liquefied gases	Natural gas, liquefied petroleum gases (butane, propane)	Turn off the supply Liquid spills may be controlled by dry powder
D	Flammable metals	Potassium, sodium, magnesium, titanium	Inert dry powder Dry sand Heavy-duty fire blankets
F	High temperature cooking oils	-	Specialist 'wet chemical' Damp blanket (minor fire only)

Note that the above table expresses the best rule for the primary use of extinguishing agents for the various classes of fire.

Also note that there are no effective means of extinguishing gas fires (Class C). The correct procedure is to shut off the supply (i.e. remove the fuel from the fire) before extinguishing any residual flames.



Revision Questions

11. What are the limitations of manual alarm systems and how may they be overcome?
12. Identify the three ways in which fire may be detected and state the types of automatic detector associated with each.
13. State the colour coding requirements for portable fire extinguishers.
14. Outline the main points to be covered in training in the use of fire extinguishers.
15. Identify the three ways of extinguishing a fire.
16. Identify the classes of fire for which each of the following extinguishing agents/devices are suitable.
 - (i) Water.
 - (ii) Carbon dioxide gas.
 - (iii) Dry powder.
 - (iv) Foam.
 - (v) Fire blankets.

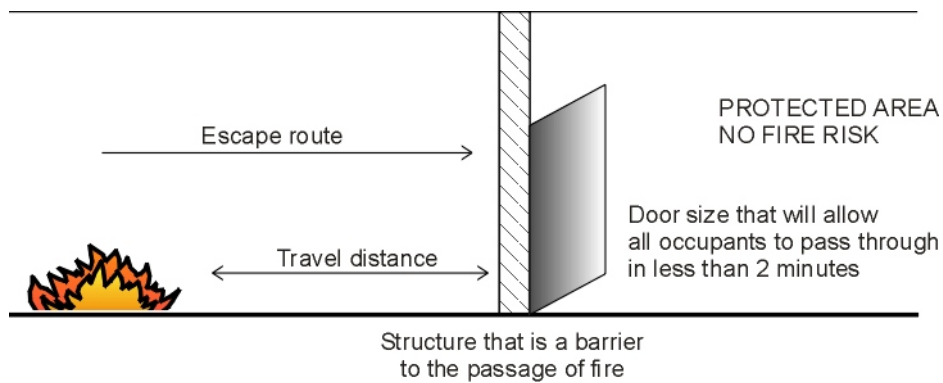
(Suggested Answers are at the end of Unit IGC2.)

MEANS OF ESCAPE

Requirements

Irrespective of the level of risk associated with premises, suitable means of escape must be provided. The general principle to be adopted is that, except in very small premises or those presenting low fire risk, there should be alternative means of escape so that in the event of fire, people present can turn their back on the flames and escape to a place of safety.

An escape route provides the means by which people in any given area can reach a place of safety – a protected area where there is no fire risk, or the risk is considerably reduced. This place of safety will be an assembly area or muster point under the evacuation procedure.



Fire Escape Route

Legislation or best practice places a number of very specific requirements on escape routes. The details may well vary depending upon which part of the world we are talking about. However, the basic idea remains the same – getting people out of a building safely, the escape route being protected for long enough to get everyone out. Below we consider the escape route requirements enforced in the UK. These are good principles to use anywhere because they are based on times rather than on strict distances.

Travel Distances

If escape times are to be kept to a minimum, some limit must be placed on the travel distance. Where there is more than one escape route then the maximum escape times and the subsequent distance of the escape route should be:

- For high risk areas – one minute or 12 - 25 metres.
- For normal risk areas – three minutes or 18 - 45 metres.
- For low risk areas – five minutes or 45 - 60 metres.

The times given take into account the time taken to respond to the alarm and to close down equipment. Where all people affected may be considered to be familiar with the building and with the evacuation procedure, the further distances may be acceptable.

Stairs

From the upper floors, escape should be by stairs – the use of lifts and escalators is forbidden since these may well be disabled by fire. Therefore the same conditions as apply to passageways and doors, as set out below, apply to stairs in buildings.

Note, too, that a protected stairway may serve as a place of relative safety and may therefore form an assembly point (see later).

Passageways

The escape route should be as straight as possible, clear of obstruction and free of materials which could pose a fire hazard.

A checklist for escape routes would include the following points:

- Corridors should be at least 1 metre wide, and 1.2 metres is required for wheelchair users.
- Corridor walls should not be decorated with heavy flock wallpaper, carpet material or other combustible materials.
- Large notice boards should not be located along escape routes. Although a limited number of smaller boards are acceptable, they should be maintained regularly to minimise the amount of loose paper.
- Escape routes should be kept clear of portable heaters, gas cylinders and electrical appliances such as photocopiers, shredders and microwave cookers, vending and games machines. Furniture should be kept to a minimum.

Doorways

Escape routes should have no doorways or openings which would restrict the flow of people. In short, there should be no bottlenecks:

- Doors on escape routes should open in the direction of travel if more than 50 people have to pass through, if it is at the bottom of a stairway or if it leads into an assembly point. Otherwise people may get trapped by the weight of people pushing forward behind them.
- Doorways should be a minimum of 0.75 metres wide, although as a general rule a width of over 1 metre is desirable. This is equivalent to 40 people passing through every minute and is acceptable as an escape route.

We have seen that fire doors are crucial to fire protection in buildings because they provide permissible openings between fire compartments. They are also an integral part of the means of escape. They have two functions:

- **Smoke control doors** serve a life-saving function in that they prevent the spread of smoke in the immediate vicinity of the fire and also protect more distant escape routes. Such doors do not have to have any specified fire resistance, but they should be of substantial construction. They must be capable of preventing all smoke intrusion at ambient temperatures and of only allowing limited amounts of smoke through at medium temperatures.

Protection against cold smoke must be by flexible edge seals and not intumescent strips because the latter will not operate in time and smoke seals depending on rebated frames are unreliable because the door may warp.

- **Fire doors** themselves are required to meet the same conditions as smoke control doors, as well as having 20 minutes fire resistance (integrity) and both flexible seals and intumescent ones.

Fire doors create obstructions in corridors and there is a risk of injury as people try to get through them. They must be easy to open (although with automatic closure devices). Glass panel doors should be wired to provide suitable fire resistance and to demonstrate their presence to people who might otherwise not be aware of a plain glass panel in an emergency.

All types of fire door must be kept closed at all times. Because they are an obstruction, in some buildings where there is a poor understanding of the risks presented by fire, it is not uncommon to see them propped open. Safety officers should be vigilant to the appearance of wedges and especially the bad habit of propping fire doors open with fire extinguishers. Many fire doors are fitted with magnetic catches linked to the fire detection system which hold the door open in normal use, but which close automatically when the alarm is sounded.

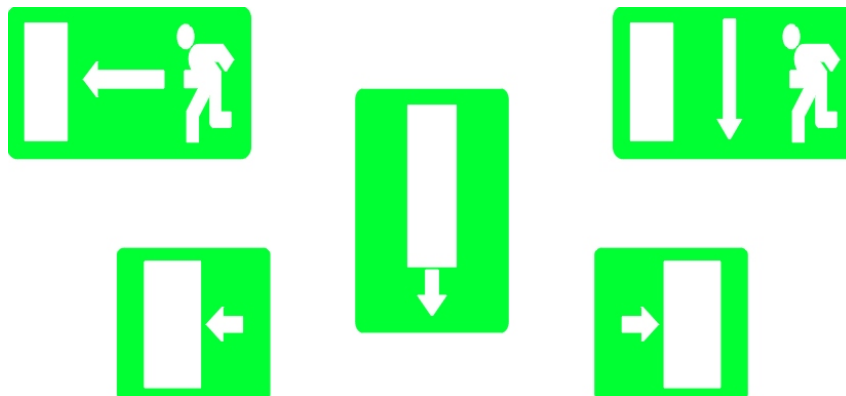
Emergency Lighting

Emergency lighting, which operates even though the main lighting circuits may have been shut down, should be provided so that fire exit signs are visible and to illuminate changes in direction or floor level. It will also be required in large open plan areas or where it is necessary to close down hazardous processes. Such lighting may be provided in the form of “borrowed light” from outside street lamps, and this is acceptable.

Not all premises require such installations. In small businesses of low or normal fire risk a supply of torches may be adequate, providing staff are familiar with the floor layout and the torches are maintained.

Exit and Directional Signs

Escape routes must be identified clearly – this is particularly true where sites are open to public access. The public may not be familiar with the layout of the building and so need more direction. The following “running man” type symbols are common throughout Europe and many other parts of the world. They use a rectangular green background with white lettering and white pictogram to indicate the escape route.



Emergency Exit/Escape Route Signs

The signs should be visible from any point within the floor area. They should be placed above escape doors, between 2 and 2.5 metres above floor level, or if this is not possible, beside the door. If the door is at right angles to the escape route, a hanging sign with directional arrows should be used.

For obvious reasons all emergency exit and escape route signs should be illuminated. Continuous operation should be incorporated in the emergency lighting systems by using both lamps external to the sign and lamps incorporated within the sign. Some signs are

self-powered, using a radioactive source which has a limited range of about 25 metres. These also have a definite useful life and will require replacement. Remember that an excess of signs may lead to confusion, and if there are doors or routes which could pose a danger in an emergency, they should be marked clearly.

Assembly Points

Escape routes lead to an assembly point. This will usually be a place of safety outside the building in the open air, away from any further danger from the fire. However, it may also be a place of comparative or relative safety, in a fire-protected area such as a secure staircase or corridor. Where this is the case the following conditions must apply:

- It should be accessible from each location in the area which it serves.
- It should, in itself, have a continuous escape route to the open air.
- It should be protected from the fire by fire-resisting construction which provides protection for a minimum of 30 minutes and be protected from smoke and gases by fire doors.
- It should be finished with non-hazardous materials.
- It should be ventilated.
- It should be free of fire risks itself within the structure, which excludes such locations as boiler rooms and kitchens, or proximity to refuse chutes, etc.

Assembly points must be designated for every area of the premises and their location and the escape route to them clearly displayed.

EVACUATION OF THE WORKPLACE

Emergency Evacuation Procedures

Should it become necessary to evacuate the premises there should be a pre-arranged plan which will enable all workers to leave safely and quickly. The aim of any evacuation procedure will be to enable all people on the premises to leave as quickly as possible along designated escape routes and report to their designated assembly point for a roll call and further instructions.

It is very important that every employee should be familiar with the evacuation procedure and the escape routes to be used, no matter where they happen to be in the building at the time. They should also know of alternative routes should their own be impassable. All staff should therefore be given specific instructions about what to do in the event of a fire – this is usually done as part of a worker's induction training. There must also be written instructions, prominently displayed, to ensure that casual visitors are also aware of the requirements. These instructions should be precise and relate directly to the particular workplace in question.

Any evacuation must be orderly and conducted in such a manner that the escape facilities, e.g. the capacity of escape routes – can handle the numbers of people using them. In addition, where there is a great number of people present, the procedure should also aim to prevent panic as this will slow evacuation and may cost lives.

A massed crowd will cause congestion and is likely to slow the flow. One method of avoiding this is **zoned evacuation**, where evacuation takes place by one compartment or floor at a time. The compartments must be evacuated in sequence, with the one at highest risk leaving first. (This approach has implications for sounding an alarm throughout the whole premises, as this would imply that the whole premises should react together and at once.)

Fire Marshals

Whatever the number of workers it is vital that responsibility for action in the event of fire is assigned to specific people. All premises should have designated and trained fire marshals or fire wardens who are responsible for the following actions:

- Ensuring all members of staff (and other persons on the premises, including the general public in the case of shops and public buildings) leave by the designated escape route.
- Searching all areas, including toilets, to ensure that the area is clear.
- Ensuring that fire escape routes are kept open and clear at all times.
- Ensuring all doors and windows are closed on leaving the area.
- Conducting the roll call at the assembly area.
- Meeting the fire service on arrival and informing them of all relevant details.

In addition, premises with a large number of occupants or where there is a high fire risk may have trained personnel who will carry out first aid and firefighting. They will also have a nominated senior person, e.g. a safety officer or senior manager, who is responsible for all aspects of fire safety including training, overseeing of fire contracts (such as for equipment maintenance) and record-keeping.

Deputies should be nominated to take over all these responsibilities when the marshal/warden or senior person is absent.

Fire Drills

Having specific staff responsible for particular actions in the event of fire is not sufficient. All staff must be aware of and be trained in using the correct procedure to follow in the event of fire.

Fire drills are practice evacuations and should take place at least once a year and preferably once every six months. More frequent drills may be held in areas of high risk. Records should be kept indicating the date, evacuation time, number of participants, etc. Any problems apparent should be analysed and resolved.

Roll Call

On evacuation, a roll call of all those reaching the designated assembly point must be held in order to establish that complete evacuation of the premises has occurred. The roll call will be conducted by fire marshals using a register of everyone who is on the premises – including staff, visitors, contractors, etc. The register must therefore be updated continually to reflect the comings and goings in the workplace. This is a management responsibility. Many workplaces may do this roll call electronically – if they have some form of site security access system which automatically records when individuals enter/leave the building. The system may then be able to print out an exception list of who is apparently unaccounted for.

If anyone is not accounted for in the roll call the fire officer in charge must be notified as soon as the fire services arrive. In the case of premises where there is random public access (shops, etc.), it may be necessary for the fire services to undertake a search.

Provisions for the Infirm and Disabled

Staff with hearing or other physical disabilities must be accommodated within an evacuation plan. Plans must therefore be in place to assist people in wheelchairs who cannot use stairs if a lift is inactivated (and in most escape plans, lifts and escalators are not appropriate as escape routes). Provision must also be made for the needs of other groups with limited mobility, such as children and elderly people.



Revision Questions

17. State the escape times and distances for:
 - (i) High fire risk areas.
 - (ii) Normal fire risk areas.
 - (iii) Low fire risk areas.
18. What is the purpose of signs used on escape routes?
19. Outline the main requirements for an escape route.
20. What areas may be used as assembly points?
21. List the actions for which fire marshals/wardens are responsible when an evacuation takes place.
22. What should take place at an assembly point following an evacuation?

(Suggested Answers are at the end of Unit IGC2.)

SUMMARY

Fire is caused by the interaction of three elements, known as the fire triangle: heat, fuel and oxygen. The fire triangle is fundamental to understanding the prevention, control and extinction of fire.

Fire spreads by means of direct burning, heat radiation, conduction and convection.

Fires are classified into five categories based on the fuel type. This classification is fundamental to identifying the means by which each type of fire may be extinguished.

Fire prevention is based on controlling the use and storage of combustible materials, particularly those which are flammable, and on minimising the risk associated with potential sources of ignition. This is mainly through safe working practices and good maintenance procedures. The design of buildings and the types of materials used in their construction are also crucial to the prevention and control of fire.

All premises must have effective systems to detect fire and raise an alarm, which may be manual or automatic.

All premises must also have effective facilities for fighting a fire. Different extinguishing media are appropriate for different types of fire and it is important that the correct one is applied. Fire-fighting equipment may be fixed or portable. The main portable devices are hand-held fire extinguishers and detailed requirements apply regarding their marking, siting and maintenance. Staff require training in their use.

All premises must have evacuation plans in place in the event of fire and the plans must be understood by all occupants. Evacuation takes place by means of designated escape routes leading to fire-protected assembly points where a roll call will be held.