# FIRE SERVICES EXAMINATIONS BOARD

# STUDY NOTE

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| EXAMINATION | SUB-OFFICERS EXAMINATION |
| PAPER | FIRE SAFETY, EDUCATION & ENFORCEMENT |
| SUBJECT | FIRE DEFENCE AND ALERTING SYSTEMS |
| ITEM | FIRE EXTINGUISHING SYSTEMS |
| STUDY NOTE No. | 2202 |

*INTRODUCTION TO THE STUDY NOTE*

*This study note has been prepared as the basis of study in connection with the qualifying examinations for promotion.*

*Candidates will be expected to demonstrate knowledge of the information contained in the study note and understand how it should be applied:*

*The 'References' made at the end of the Study Note are included for information only and candidates will not be expected to study these as part of the bibliography.*

FIRE EXTINGUISHING SYSTEMS

## 1 Introduction

Firefighting equipment forms an important part of the fire defence plans of buildings and premises and in the vast majority of cases will be required by legislation in workplaces and public buildings.

## 2. Categories

In general, the provision of firefighting equipment falls into two categories:

PORTABLE FIREFIGHTING EQUIPMENT; and

FIXED FIREFIGHTING SYSTEMS.

Where a fixed firefighting system is installed, there may still be a requirement for portable firefighting equipment to be provided for use by employees.

PORTABLE FIREFIGHTING EQUIPMENT

## 1. Classification of Fire

British Standard 4547 identifies the various categories of fire. These are as follows:

A - Fires involving solid materials, usually of an organic nature, in which combustion normally takes place with the formation of glowing embers;

B - Fires involving liquids or liquefiable solids;

C - Fires involving gasses;

D - Fires involving metals.

There is not a separate classification for "electrical fires". Such fires can be in any one of the four classes defined.

## 2. British Standard Codes of Practice for Portable Firefighting Equipment

There are a number of British Standards that set out the specification, installation, selection and maintenance requirements for portable firefighting equipment.

The British Standards address the ratings of extinguishers for Class A and Class B fires only, they do not provide ratings for extinguishers for fighting fires involving Class C and Class D.

Specialist advice for fighting such fires should be obtained from the manufacturers of firefighting equipment.

## 3. Firefighting Agents

The following tables give an idea of how some common extinguishing agents' function:

| Table 'A' - Water, AFFF and Foam | | | |
|---|---|---|---|
| **Agent** | **Function** | **Advantages** | **Restrictions** |
| Water | Cooling | Cheap and plentiful | Not suitable for metals, flammable liquids, gases or electrical equipment. |
| AFFF | Smothering and Limited Cooling | Relatively cheap. Easy to use. Also works well on flammable liquid fires. | Not suitable for metals, electrical equipment or gases. |
| Foam | Smothering and limited cooling. | Effectively blankets the fuel bed. | (as for AFFF) |

| Table 'B' - Inert Gases | | | |
|---|---|---|---|
| **Agent** | **Function** | **Advantages** | **Restrictions** |
| $CO^2$ | Smothering | Relatively cheap | Dangerous in the concentration that is required for extinction |
| $N^2$ | Smothering | | Ditto |
| Argon | Smothering | | Ditto |

| Table 'C' - Vaporising Liquids | | | |
|---|---|---|---|
| BCF(extinguishers) | Inhibits chemical reaction in flames to extinguish fire | Low concentration of 4.25% to 7% required | Not suitable for metal fires as it breaks down producing toxic products |

| Table 'D' - Dry Powders | | | |
|---|---|---|---|
| Agent | Function | Advantages | Restrictions |
| Sodium bicarbonate | Inhibition/ Smothering | Very effective on organic, oil and gas fires | Not suitable for metal fires |
| Potassium bicarbonate | Inhibition/ Smothering | Very effective on organic, oil and gas fires | Not suitable for metal fires |
| Potassium carbonate (Monnex) | Interference with combustion process | Monnex powder particles break down dramatically increasing the area of surface absorbing combustion gases and interrupting the chemical reaction. | Not suitable for metal fires |

| Table 'E' - Special Powders for Metal Powders | | | |
|---|---|---|---|
| Agent | Function | Advantages | Restrictions |
| Salt | Smothering | | Must be very dry |
| Ternary Eutectic Chloride | Smothering / Melts to form a crust, but must be evenly applied | Faster acting than salt | Very poisonous |
| Soda ash | Smothering | | |
| Sand | Smothering | | |

All the agents in Table 'E' above must be perfectly dry. Any moisture will explosively decompose if used on a metal fire thus releasing Hydrogen and Oxygen, which will result in an increase in the burning rate.

## 4. Calculating the Number of Extinguishers

The appropriate British Standard Code of Practice sets out various formulae to assist both the user and the fire officer in calculating the appropriate number and size of suitable fire extinguishers for dealing with Class 'A' or Class 'B' fires, or both. These formulae can account for inexperienced operators and other factors. The guidance within the Code of Practice should be followed when offering advice or checking that there is sufficient provision of firefighting equipment during inspections.

Extinguisher requirements for Class 'C' & 'D' fires and electrical risks cannot be calculated by means of simple formulae since all three types of risk require specialist types of extinguisher or extinguishing agent. The techniques for using these agents effectively mean that a very high degree of training is required for their use.

It should be noted that extinguishers filled with AFFF and de-ionised water complete with special discharge nozzles have been tested on electrical fires, and claims are made in this respect by manufacturers. Fire Officers, however, should exercise extreme caution when considering proposals to use these types of extinguishers as the tests only prove guidance resulting from ideal test conditions which may not always be the case in a real fire situation.

## 5. Maintenance

The importance of regular effective maintenance cannot be over stated when offering advice or carrying out routine inspections involving fire extinguishers.
Properly trained competent persons should carry out all recharging and maintenance. The appropriate British Standard Code of Practice sets out detailed minimum requirements for inspection, maintenance and testing.

In general, extinguishers should be inspected monthly, serviced and inspected annually and additional tests are essential as the extinguisher gets older. Extinguishers in frequent use may also need additional safety checks.

The extinguisher body should be inspected for signs of damage or corrosion and, if necessary, the extinguisher should be replaced if it shows signs of excessive damage. The cartridge should be weighed (and replaced if necessary) at least once every twelve months and every extinguisher should be fully serviced after use while being recharged.

The use of anti-freeze type additives is not recommended as a general rule, but some manufacturers have patent preparations, which are permissible for this purpose which will not cause danger to the operator or cause excessive corrosion of the extinguisher.

FIXED FIREFIGHTING SYSTEMS

## 1. General

Many premises in the Brigade area will be protected by fixed firefighting systems. Such systems may be connected to other fire defence systems such as alarms, detection and venting systems.

Fixed firefighting systems are highly desirable and effective, as they are immediately available and will normally have been designed to meet the particular risk in the premises concerned.

Sub Officers should be aware of systems in their area, the actions that need to be taken when attending an incident, and the broad fire safety dimension that such systems offer. This study note relates to the availability and general awareness of typical systems and their features.

## 2. British Standard Codes of Practice for Firefighting Systems

There are a number of British Standards for the specification, installation, selection and maintenance of firefighting systems. These standards are complex and lengthy. Advice of fire safety officers or other specialists should be obtained when faced with queries or questions about fixed installations.

## 3. Type of Medium Used

Extinguishing media currently available in fixed firefighting systems include:

(a) water;

(b) gases; eg carbon dioxide; nitrogen; argon and mixes such as Inergen';

(c) vaporising liquids; such as BCF and BTM;

(d) foams; and

(e) powders.

## 4. Choice of Medium

When engineers are selecting a fire-extinguishing agent for a fixed installation, a number of factors must be considered. Amongst the most important will be what effect the chosen medium will have on anyone exposed to it. The factors, which must be considered in this respect are its:

(a) toxicity;

(b) respiratory effects;

(c) electrical conductivity, and;

(d) impairment of vision, hearing and the risk of disorientation.

Another factor will be the effect the medium will have on the goods and equipment that the medium is exposed to. In addition to it being appropriate to the risk protected there should be no adverse effect on the goods or equipment protected. While this ideal situation is not always practical, a medium should be selected to be as close to this ideal as possible. Aspects to be borne in mind are:

(a) any corrosive properties or action of the medium;

(b) the possibility of cold shock upon sensitive equipment, and;

(c) the possibility of the contamination of equipment or materials or their subsequent degeneration due to any chemical action, etc.

These factors may also have a bearing on firefighting operations.

## 5. Firefighting Systems

This term is a very broad-based one and covers the full range of firefighting systems including:

(a) Hydrants and Dry and Wet Risers.

(b) Hose Reels.

(c) Foam Pouring Systems and Inlets.

(d) Sprinkler Systems.

(e) Drencher Systems.

(f) High - Pressure Water Spray Systems.

(g) Gas Flooding and Inerting Systems.

(h) Vaporising Liquid Systems.

(i) Dry Powder Systems.

There are other systems that have and are being developed which include variations on sprinkler and on gas systems, and those which are intended to replace Halon. Fixed systems may be further divided into automatic and manual systems.

A number of issues regarding these systems are appended below:

(a) Hydrants and Dry and Wet Risers

Where special provisions are made for firefighting on large premises or in a particularly large building, hydrant systems may be necessary and will usually fall into two categories, external and rising mains.

(i) External Hydrants

Hydrants with outlets suitable for fire service use should be installed on ring mains and sited not more than 70m from the entry to any building. In addition, no hydrant should be nearer than 6m to any building to ensure that it remains usable during a fire. Arrangements should be made for these to be suitably marked.

(ii) Rising Mains

A rising main consists essentially of a pipe installed vertically in a building with a fire service inlet or town main connection at the lower end and outlets valves at various levels throughout the building.
The outlet valves are usually sealed to prevent them from being used for purposes other than firefighting. A hose or a hose reel may be attached to the outlet valve.

There are two types of rising main: Wet Risers and Dry Risers:

1. Wet Riser

A wet riser is a pipe kept permanently charged with water, which is immediately available for use on any floor at which a hydrant outlet (sometimes known as a landing valve) is provided. The riser is connected to the main water supply of suitable capacity with a shut-off control valve installed. If the building height is such that the pressure in the main is insufficient, a booster pump will be necessary at suitable levels to ensure the maintenance of the required pressure and flow.

Where these pumps are employed, the landing valves must be fitted with a pressure regulator to ensure that the pressure head against the pumps is not transmitted to the hose.

A similar function to that of a wet riser is performed by what is known as a 'down-comer'. This, like a wet riser, is constructed of vertical piping (or falling main), but is supplied with water from a tank in the roof or at intermediate levels or, in the case of a falling main serving an area below ground or access level, the supply will be direct from the main water supply.

2. Dry riser

A dry riser is simply a vertical pipe, which is normally kept empty of water, fitted with outlets at various floor levels in the building. It is not connected to a water supply, but is charged when required by means of fire service pumps. In effect, it is a substitute for a line of hose, over which it has many advantages. It enables an upper floor level fire to be attacked by the fire brigade with a line of standard hose without the loss of time entailed in having to lay hose up through the building from the street. It obviates the risk of water damage, which might occur if a hose line burst in a part of the building not affected by fire.

A dry riser is charged through inlets at ground level, which are usually housed in external glass-fronted boxes.

Each box is normally identified by the words DRY RISER painted in red on the glass. Inlets may occasionally be found below pavement level in a box with a cover similar to that used for a hydrant.

An air valve is usually fitted at the highest point in the pipe to allow contained air to discharge to atmosphere when the riser is charged with water. Without such a provision, air in the riser might be compressed in the upper part of the pipe and prevent it being fully charged. The air valve, if fitted, is constructed to admit air to the pipe where it is drained after use and so prevent the creation of the partial vacuum, which would, result in pockets of water being trapped.

Dry risers are provided with a drain cock fitted beneath the inlets to enable the system to be drained after use. Additionally, where an outlet is fixed at a position below the inlet valves, a further drain valve is fitted at the lowest point of the riser.

(iii) Type to be used

The type of rising main to be installed in a building is generally determined by the height of the building. In buildings over 20 metres in height it is recommended that a dry rising fire main be installed, and in those above 60 metres, a wet riser is necessary because a brigade pump will not supply the necessary quantity of water pressure above this height. For operational reasons, however, the fire service may require dry or wet risers at levels lower than those quoted above.

The outlets from risers should be found in a firefighting staircase lobby, in an enclosed staircase forming part of an exit, or in a fire enclosure. They may be placed in a glazed cupboard, clearly marked in accordance with the appropriate British Standard.

Various methods are used to disguise and/or protect riser outlets from vandals. It is important therefore that the fire brigade is familiar with the siting of, and access to, rising main outlets in buildings within its area.

(b) Hose-Reels

The provision of Hose reels may well prove to be more appropriate and effective than portable firefighting equipment. An optimum hose length of 30 metres is desirable or the hose becomes unwieldy for the people who are to use it.

(c) Foam Pouring Systems and Inlets

(i) Foam Inlets

Small, low-expansion foam-pouring systems are frequently provided for fighting fires in basements and other areas containing oil-fired heating equipment.

The system consists of a number of foam pourers sited to give a rapid covering of foam over the expected area of involvement, a short pipe array and a connection outside the building to which is fitted a tapered orifice against which the foam making branch is held by hand. This is usually protected by a glass panel and marked with the words FOAM INLET together with an indication of the particular risk involved. The number of pourers or outlets should not exceed 3 for each inlet. If more than this number is required, additional inlets must be installed.

(ii) Low Expansion Foam Systems

There is a wider range of methods used for applying low expansion foams than for any other medium. This is because the property at risk varies enormously in size and complexity, and foam systems have had to follow suit. These methods vary from a simple pressure vessel containing a foam solution under gas pressure, and discharging when a fire on, for example, a dip-tank, causes a heat-sensitive sprinkler to operate, right up to a fully-fledged automatic foam generating system feeding a foam deluge system in an aircraft hanger.

(iii) Medium Expansion Foam Systems

Medium expansion foam systems are intended to provide protection, either indoors or outdoors, against spills of flammable liquids where the foam can be applied gently close to the risk, to build up rapidly and to give good vapour suppression.

(iv) High Expansion Foam Systems

High expansion foam systems dispense foam from a number of high expansion foam generators, to fill the volume within which fires (either Class 'A' or 'B') may occur at various levels. They are suitable for large volumes, cable tunnels, refrigerated rooms, basement areas, etc. Whilst mostly suitable for indoor use, high expansion foam can be used in outdoor areas where it is sheltered from the effects of the wind and rain.

(d) Sprinkler Systems

(i) Introduction

Sprinkler Systems are the most popular of automatic water based fixed firefighting systems.

Sprinklers play an important part in the fire engineering approach to fire protection in building design.

(ii) Legislation

The Building Regulations (The Building Standards (Scotland) Regulations) specifically make provisions for sprinklers in certain buildings such as a life risk in high multi-storey buildings, large unpartitioned areas in shops and commercial premises and buildings for industrial and storage use.

The installation of sprinklers allows buildings to be larger and closer to adjoining premises than would normally have been permitted.

(iii) Standards

A sprinkler system has to be properly designed and fitted to appropriate British Standards.

A certificate of conformity can be issued if the Loss Prevention Certification Board approves the installing company.

The standards comprise detailed system requirements and Fire Safety Officers and other specialists should deal with advice on their application and use.

(iv) General Description of a Sprinkler System

A grid of pipes covers all areas of the building to be protected with sprinkler heads fitted into them at regular intervals. Water from a tank via pumps or from the town main (if it can give enough flow) fills the pipes.

Each sprinkler head will open when it reaches a specific temperature and spray water on to a fire. The hot gases from a fire are usually enough to make it operate. Only the sprinklers over the fire open. The others remain closed. This limits any damage to areas where there is no fire and reduces the amount of water needed.

The sprinkler heads are spaced, generally on the ceiling, so that if one or more operate there is always sufficient flow of water. The flow is calculated so that there is always enough to control a fire taking into account the size and construction of the building and the goods stored in it or its use.

Sprinkler heads can be placed in enclosed roof spaces and into floor ducts to protect areas where a fire can start without being noticed. In a large warehouse sprinklers may be placed in the storage racks as well as at roof level.

At the point where the water enters the sprinkler system there is a valve. This can be used to shut off the system for maintenance. For safety reasons it is kept locked in the open position and only authorised persons should be able to close it. If a sprinkler head opens, waters flows through the valve and lets water into another pipe that causes a bell to ring. In this way the sprinkler system both controls the fire and gives an alarm using water, not electricity.

(v) Types of System

1. Wet Pipe

All pipes that lead from the water supplies through the various controlling valves to the sprinkler heads throughout the building are kept permanently filled with water.

These are the most common systems and are used in buildings where there is no risk of freezing. They are fast to react because water is always in the pipes above the sprinkler heads.

Wet systems are required for multi-storey or high rise buildings and for life safety.

2. Alternate Wet and Dry

This system is usually installed in premises that are without adequate artificial heating and where water in a wet system would be liable to freeze in cold weather. As the name suggests Alternate systems can have the pipes full of water for the summer and be drained down and filled with air (under pressure) for the winter.

3. Dry pipe

This system is provided where the temperature conditions are artificially maintained close to, or below freezing point, eg cold stores, or where the temperature is maintained above 70°C. The pipes are filled with air under pressure at all times and the water is held back by the control valve. When a sprinkler head opens the drop in air pressure opens the valve and water flows into the pipe work and on to the fire.

4. Pre - Action

This is a combination of a standard sprinkler system and an independent approved system of heat or smoke detectors installed in the same area as the sprinklers. Like dry pipe systems the pipes are filled with air but water is only let into the pipes when the detector operates. Pre-action systems are used to prevent accidental discharge of water from the sprinkler pipework following mechanical damage.

(vi) Sprinkler Heads

There are many different designs of sprinkler head.

They are designed to either apply the water to the fire in particular spray pattern or to fit in with the construction and décor of the ceiling eg flush pattern.

The actuation of the sprinkler system is generally governed by a 'seal' being broken by a rise in temperature at the sprinkler head allowing water to flow out of the pipework.

The 'seal', which is broken by a rise in temperature, may be divided into two categories:

1. those in which the operating medium is a fusible solder; and

2. those in which a bulb is ruptured by the expansion of a contained fluid.

In every case they must be of a type approved by the British Standard/Loss Prevention Council.

(vii) Some Questions and Answers about Sprinklers

1. Why are sprinklers important for life safety?

In a large, fast moving fire, people often do not know which way to go and may not be able to use hose reels or fire extinguishers.

Sprinklers are completely automatic. They work by themselves and can stop heat and smoke from trapping people.

2. How can we be sure sprinklers will work in a fire?

Most sprinkler systems are very simple. There are normally no moving parts to fail. The pipes are full of water, usually from the mains. The sprinklers over the fire burst open when they get hot and spray water on the fire. If there is water in the pipes the sprinklers will work.

3. What about water damage?

Reports of water damage from fires in buildings with sprinklers are often exaggerated. Only the sprinklers over a fire open. All the others stay shut. A sprinkler opening by accident is almost unheard of.

4. What about smoke?

Smoke damage is a major cause of loss in fires. Quick response sprinklers are now available that will attack a fire even earlier in its growth. Fast attack dramatically reduces the amount of smoke that a fire can produce.

5. Aren't sprinklers unsightly?

Modern sprinklers are specially designed to meet the needs of architects in offices, hotels, shops, hospitals and prestige buildings. In most buildings the public are usually unaware that sprinklers are fitted.

Miniature sprinklers are little bigger than a 50p piece and are neat and robust. They can be fitted with ceiling rosettes and painted to match any colour scheme.

Concealed sprinklers are recessed and covered by a flat plate flush with the ceiling. They are unobtrusive and almost invisible. Concealed sprinklers are ideal for clean areas, where there is restricted headroom or vandalism is a problem.

(e) Drencher Systems

While a sprinkler system protects a building from internal fire, drenchers are placed on roofs and over windows and external openings to protect the building from damage by exposure to a fire in adjacent premises.

A drencher system is comprised of water-heads somewhat similar to those of sprinklers; these may be sealed or unsealed (open-drenchers), but in the latter case the water is turned on manually. In a few instances drenchers may be controlled by quick-opening valves operated by loss of air pressure in a detector line system in a similar manner to high velocity water spray systems.

The controlling valves must be located in accessible positions on or near ground level but away from the adjacent fire risk. Protection from frost for the supply pipe and valves is essential. A padlocked or riveted strap must be used to secure the valves in the appropriate position. The position of each valve and the drenchers it controls must be clearly indicated by a wall plate.

Drenchers may be either open or sealed. Open drenchers are operated simultaneously by the opening of the main valve, while the sealed type is individually actuated in the same way as a sprinkler head. Sealed drenchers differ little from sprinkler heads except in the shape of the deflector plate. They normally operate on the alternate system, and are more economical in the use of water than open drenchers, since only those heads operate which are required, and the pressure in consequence is maintained more efficiently.

Drenchers are of three main types:

Roof drenchers.

Wall or curtain drenchers.

Window drenchers.

(i) Roof drenchers

Roof drenchers have a deflector rather similar to that of a sprinkler head. From the roof ridge they throw a curtain of water upwards which then runs down the roof. All parts of the roof and any skylights, windows or other openings must be protected.

(ii) Wall or curtain drenchers

Wall or curtain drenchers throw water to one side only of the outlet in the form of a flat curtain over those openings or portions of a building most likely to admit fire. A special use for this type of drencher is on the stage side of a theatre proscenium arch to protect the safety curtain.

(iii) Window drenchers

As their name implies, window drenchers are used to protect window openings. They are placed horizontally level with the top of the window providing a curtain of water to protect the glass. From the tail of the deflector, a jet is thrown inwards on to the glass near the top of the window, while two streams are directed at an angle of 45 degrees to the lower corners.

(f) <u>High - Pressure Water Spray Systems</u>

Water spray systems are intended primarily for use against flammable liquid fires. They may form part of a sprinkler system, eg for small flammable liquid risks in factories or storage, or they may form complete systems in there own right.

There are five main types of water spray systems:

(i) High Velocity Systems – for the extinction of fires in flammable liquids requiring rapid response and speedy fire control such as in oil cooled transformers.

(ii) Medium Velocity Systems – for dealing with fires involving water-immiscible liquids such as alcohol.

(iii) Deluge Systems for large flammable liquid spillage.

(iv) Deluge Systems for the protection of fuel storage tanks.

(v) Deluge/Water Spray Systems to protect apertures in fire resisting compartment walls.

The major difference between a water spray system or deluge system and a sprinkler system is in the operation of it. Where a sprinkler is designed to have a limited number of heads operating in the immediate area of a fire, water spray/deluge systems are intended to provide water over the entire area covered by the system on actuation. For this reason, they are limited in size and the water supply is therefore a critical factor in their design.

(g) Gas Flooding and Inerting Systems

Various gas flooding and inerting systems are available. These commonly use carbon dioxide, nitrogen, argon or a combination of gases.

Typical carbon dioxide systems will consist of a central storage tank or banks of cylinders where gas is stored under pressure, and a piping system conveys the gas to the point(s) of discharge.

Special nozzles are used to prevent the formation of dry ice as well as to assist in the even deployment of the gas itself.

Carbon dioxide systems are classed as:

(i) total flooding systems (manual or automatic);

(ii) local application systems (manual or automatic); or

(iii) manual hose-reel systems (manual only).

Total flooding is intended to provide an extinguishing concentration throughout the enclosure, while a local application system provides an extinguishing concentration at local points of risk. Manual hose-reel systems are intended to provide a local extinguishing concentration at any point where the discharge nozzle is directed.

(h) Vaporising Liquid Systems

The agents used in these systems are usually Halon or mixtures using Halon. These systems can cause severe reaction to persons who may be exposed to the vapours. Halon has been identified as a source of ozone depletion. Consequently, legislation requires that, except for a few ‘controlled systems’, all halon installations must be decommissioned by 31 December 2003.

(i) Dry Powder Systems

Fixed, mobile and portable systems using chemical powders as extinguishing agents have a wide application in the marine, aviation and transport industries.

Small fixed systems have been developed for use in kitchen extraction hoods and ducts where they have proved very effective in dealing with fire involving fatty deposits.

Large systems can be used to protect such risks as quench tanks as well as a range of risks where flammable liquids are sprayed, stored or mixed

Extinguishing powder systems have a number of advantages to offer in the form of cost, ease of maintenance, efficiency and reliability.

References

Fire Services Examinations Board
Fire Service College
British Automatic Sprinkler Association Limited