FIRE SERVICES EXAMINATIONS BOARD

STUDY NOTE

EXAMINATION	SUB-OFFICERS EXAMINATION
PAPER	FIRE SAFETY, EDUCATION & ENFORCEMENT
SUBJECT	FIRE DEFENCE AND ALERTING SYSTEMS
ITEM	FIRE DETECTION, ALARMS & TRANSMISSIONS SYSTEMS
STUDY NOTE No.	2201

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 DETECTION, ALARMS & TRANSMISSION SYSTEMS

1. Introduction

Fire detection and alarm systems include electrical systems that range from those comprising only one or two manual call points and sounders to complex networked systems that incorporate a large number of automatic fire detectors, manual call points and sounders, connected to numerous inter-communicating control and indicating panels.

They also include electrical systems that are capable of providing signals to initiate the operation of other fire protection systems and equipment (such as fire extinguishing systems, smoke control systems or automatic door release systems) or safety measures (such as shut down of air handling systems, closing of oil or gas valves, or grounding of lifts).

2. Need for a Fire Alarm System

The need for a fire alarm system in any specific building will normally be determined by the authority responsible for enforcing fire safety legislation in that building (eg The building control authority, fire authority, local authority, Health and Safety Executive) and/or by a fire risk assessment carried out by the owner, landlord, occupier(s) or employer(s) as appropriate.

In general, it is appropriate to install some form of electrical fire alarm system in virtually all buildings, other than very small premises that are relatively open-planned so that any fire can be detected by the occupants who will be able to warn others by word of mouth or simple mechanical devices such as hand operated bells.

Manually operated fire alarm systems are often sufficient to satisfy legislation in workplaces in which no one sleeps. Automatic fire detection is usually required by legislation to supplement the manual system in premises in which people sleep. Automatic fire detection might also be necessary to satisfy the requirements of legislation under the following circumstances:

(a) where the automatic fire detection forms part of a fire engineering solution:

(b) where fire protection systems, such as door closing facilities or smoke control systems, are to be operated automatically in the event of fire;

(c) where the low level of occupancy of a building, or part of a building, is such as to create the potential for fire to prejudice means of escape by occupants before they are aware of fire.

Automatic fire detection is also commonly used to protect property by ensuring the early attendance of the fire service, as a result of summoning the fire service by occupants of the building or by transmission of fire alarm signals to an alarm receiving centre (ARC) from where the fire service will be summoned.

The early detection by automatic means, and rapid summoning of the fire service, is also important in premises in which people cannot readily be evacuated immediately in the event of fire (eg Hospitals).

3. Categories of Systems

Fire alarm systems may be installed in buildings to satisfy one, or both, of two principal objectives, namely:

(a) The protection of life;

(b) The protection of property.

Because of the great variety of applications for systems, they are divided into a number of different categories, as follows:

3.1 Category M Systems

Category M systems are manually operated systems and, therefore, incorporate no automatic fire detectors.

3.2 Category L Systems

Category L systems are automatic fire detection systems intended for the protection of life. They are further sub-divided into five types:

(a) Category L1:

Systems installed throughout all areas of the building so as to offer the earliest possible warning of fire, and to achieve the longest available time for escape;

(b) Category L2:

Systems installed only in defined parts of the building. The objective of the system is identical to that of a Category L3 system, with the additional objective of affording early warning of fire in specified areas of high fire hazard level and/or high fire risk;

(c) Category L3:

Systems designed to give a warning of fire at an early enough stage to enable all occupants, other than possibly those in the room of fire origin, to escape safely before the escape routes are impassable owing to the presence of fire, smoke or toxic gases;

(d) Category L4:

Systems installed within those parts of the escape routes comprising circulation areas and circulation spaces, such as corridors and stairways, in order to enhance the safety of the occupants by providing warning of smoke within escape routes;

(e) Category L5:

Systems in which the protected area(s) and/or the location of detectors is designed to satisfy a specific safety objective (other than that of a Category L1, L2, L3 or L4 system). Often, the design is based on a fire risk assessment or forms part of a fire engineering solution. In such cases, the protection may be provided to compensate for some departure from normal guidance elsewhere or as part of the operating system for a fire protection system. Such a system could be as simple as one that incorporates a single fire detector in one room (in which an outbreak of fire would create undue risk to occupants, either in the room or elsewhere in the building), but the system could comprise of comprehensive detection throughout large areas of a building in which, for example, structural fire resistance is less than that normally specified for buildings of that type.

3.3 Category P Systems

Category P systems are automatic fire detection systems intended for the protection of property. They are sub-divided into two types:

(a) Category P1:

Systems throughout all areas of the building in order to offer the earliest possible warning of fire so as to minimize the time between ignition and the arrival of firefighters:

(b) Category P2:

Systems installed only in defined parts of the building in order to provide an early warning of fire in areas of high fire hazard level, or areas in which the risk to property or business continuity from fire is high. The areas of the building covered by such a system may be as few as one or more rooms, or as extensive as complete floors of the building.

Even in buildings with comprehensive fire detection, the provision of manual call points will still normally be of great value; people in the vicinity of a fire will normally be aware of the fire and be able to raise the alarm by use of a manually operated call point before it is detected automatically.

4. Actuation of other Fire Protection Systems or Safety Facilities

Any of the categories of systems previously identified may be used to actuate other fire protection systems or trigger safety facilities, whether for the purpose of life safety, property protection or a combination of the two.

5. Communication with the Fire Service

For a fire alarm to give maximum benefit, the fire service needs to be summoned as quickly as possible on every occasion that it operates, unless, in order to avoid false alarms being passed to the fire service, filtering arrangements are appropriate.

In occupied buildings, the primary means of summoning the fire service needs to comprise a call to the fire service using the 999(or 112) public emergency call system. This is the case even if there is a means for automatic transmission of alarms to an ARC, as an automatic system can fail at the time it is required to operate.

In the case of manually operated fire alarm systems, automatic transmission to an ARC is usually unnecessary. When the building is occupied, the system will not respond to fire; when the building is occupied, the call to the fire service from the occupants will suffice. Automatic means of transmission is only likely to be of benefit, as a secondary means of summoning the fire service, if factors such as the size or complexity of the building, or low level of occupancy, could result in a significant delay between the discovery of fire and summoning the fire service, thereby warranting the duplication of the call to the fire service (ie With calls made manually from the premises and automatically via an ARC).

Even in a Category L system, if the premises are unoccupied at certain times and the system incorporates automatic fire detection throughout a significant proportion of the premises, it can represent a missed opportunity, in respect of property protection, if no means of automatic transmission of alarm signals is provided.

In a Category P system, unless the premises are continuously occupied at all times, the objective of the property protection is unlikely to be satisfied unless the system incorporates means for automatic transmission of alarm signals to an ARC.

The reliability of the means for summoning the fire service, whether by manual or automatic means, always needs to be subject to consideration. There are four distinct means of connection between protected premises and ARCs. These are:

(a) Private wire - a dedicated and continuously monitored path via a telephone exchange;

(b) Omnibus circuits – each premises has a dedicated spur connection to a telephone exchange from where there is a single shared circuit to the ARC;

(c) ARC satellites – these are virtually unstaffed ARCs into which a large number of signals can be received and re-transmitted to an ARC which collects data from a number of satellites;

(d) Digital communications (DC) – this is a signaling device that is connected to an exchange telephone line. In the event of a fire signal operating at the premises, the DC dial up the ARC using the PSTN. A receiver at the ARC answers and a series of coded tones is sent by the DC, decoded by the ARC receiver and displayed at an operator's position for action.

If the services of a commercially operated ARC are used, it is necessary for the ARC to have a formal arrangement with the fire authority in whose area the protected premises are situated for rapid communication with the fire service by reliable means.

6. Audible Alarm Signals

It is essential that alarm signals are sufficient in nature and extent to warn all persons for whom the alarm signals are intended. In simple buildings, the alarm produced by a Category M or Category L system needs to be capable of alerting all occupants of a building regardless of their location. If people sleep in the building, the alarm signal needs to be sufficient to rouse them from their sleep.

In usually more complex buildings, a general alarm of the type described above may not be appropriate. For example, in hospitals and certain residential care premises in which occupants might need assistance to evacuate, the alarm system might not be intended to rouse people from sleep, and it might only be necessary for staff to be aware of the alarm signal. In some larger or more complex buildings, the extent of the area in which an evacuation signal is given might be restricted, at least initially.

In those areas in which audible signals are intended to alert occupants, the sound pressure level and frequency of alarm signals must be adequate to provide unambiguous warning of fire with particular care taken to ensure that it can be easily heard in small cellular spaces, such as cellular offices, toilets and plant rooms.

In order to prevent excessive sound pressure levels, which can cause disorientation or even damage to hearing, a larger number of quieter sounders is preferable to a very few loud sounders.

Once started, alarm signals generally need to continue until manually silenced by use of a silencing control.

Fire alarm sounders within a building should have similar sound characteristics, unless particular conditions, such as an area of high background noise, makes this impractical. The sounders should be distinctive in sound from the sounds of other alarm systems in the building. For example, a mixture of bells and electronic sounders should not be use in the same building as the fire alarm devices. The fire alarm sounders should be distinctive in sound.

A facility should be provided to enable silencing of alarm signals. The operation of the facility should:

(a) require a manual operation;

(b) cause an audible signal to be given at the control and indicating equipment;

(c) not cancel any visual signal of the alarm at the control equipment; sound any fire alarm sounders configured to that zone if, following silencing of the alarm sounders, a new zone goes into alarm, and normally should also resound those fire alarm sounders which were previously sounding;

(d) not prevent the correct operation of any control for starting or restarting the fire alarm sounders;

(e) not prevent the transmission of an alarm to an ARC.

Fire alarm sounders should not be used for purposes other than warning of fire, unless the response required is identical to that required in the event of fire (ie Immediate evacuation by use of all escape routes). However, as an established exception, the fire alarm signal may be used in schools to indicate the start or finish of pre-determined periods. The duration of such signals should not exceed five seconds.

7. Visual Alarm Signals

Visual alarm signals need to be used to supplement audible signals in situations in which the latter are likely to be ineffective, but normally ought not to be used on their own. Their use will principally be in areas with high ambient sound levels, where hearing protection is likely to be worn. However, they are sometimes used as the sole initial warning to staff in situations in which the disturbance of an audible warning is undesirable (eg Television and radio studios, cinemas, theatres and hospital operating theatres). Visual alarm signals may also be used as a means of giving warning of fire to people with impaired hearing.

The following should apply when visual alarm signals are to be installed:

(a) Visual alarm signals should be provided in areas where hearing protection is likely to be used under normal circumstances;

(b) Visual alarm devices should be sufficient in number and distribution to be readily visible from all normally accessible locations throughout the area in which they are provided under normal lighting levels;

(c) The visual alarm should flash at a rate of between 30 to 130 flashes per minute;

(d) The visual alarm should be clearly distinguishable from any other visual signal used in the premises, the colour red being preferred;

(e) The intensity of the output of the visual alarm devices should be sufficient to attract attention, but not so high as to cause difficulty with vision due to glare;

(f) Visual alarms should be mounted at a minimum height of 2.1m.

8. Fire Alarm Warnings for People with Impaired Hearing

Impairment of hearing does not mean that a person is completely insensitive to sound. Many people with severe impairment have sufficiently clear perception of some types of conventional audible alarm signals to require no special provision of warning of fire. In some situations there will be other people present who can alert those with impaired hearing to the need for evacuation, and in this case it might be necessary to put procedures in place that rely upon others to provide the necessary warning.

However, in circumstances such as:

(a) buildings with a significant number of occupants with impaired hearing;

(b) buildings in which one or more persons with impaired hearing work in relative isolation; or

(c) buildings in which one or more persons with impaired hearing tend to move around the building to a significant extent,

additional means of giving warning to those people with impaired hearing might be appropriate.

If the occupants in question tend to be located for a large proportion of their time within a limited area of the building, visual alarm signals complying with the above might be appropriate in that area (and associated toilets). If they sleep in the building, devices sensitive to touch, with or without visual alarm devices, might be considered. These devices, which may, for example, be placed under pillows or mattresses, may be wired into the fire alarm device circuits to be triggered by radio signals.

Alarm devices for the hearing impaired may be:

(a) Fixed - equipment which is usually fastened to a support or otherwise secured to a specific location (eg A fire alarm system control panel screwed to the wall);

(b) Movable - equipment which is not fixed equipment and which is not normally in operation while the location is changed (eg A local unit or controller which is placed on a table top and operates a vibrating pad in a bed); or

(c) Portable - equipment designed to be in operation whilst being carried (eg Radio pager).

9. Manually Operated Call Points

Manually operated call points should be:

(a) prominently sited at easily accessible, well illuminated and conspicuous positions free from potential obstruction;

(b) fixed at a height of 1.4m above finished floor level (a lower height is acceptable in circumstances where there is a high likelihood that the first person to raise the alarm of fire will be a wheelchair user);

(c) readily distinguishable from non-fire alarm call points;

(d) located on escape routes and, in particular, at all storey exits and all exits to open air (whether or not the exits are specifically designated fire exits) so that it is impossible to leave the storey or the building without passing a manually operated call point;

(e) identical, unless there is a special reason for differentiation;

(f) sited against a contrasting background to assist in easy recognition.

Sufficient call points need to be provided to minimize, to a reasonable extent, the delay between discovery of a fire and the sounding of the alarm. Where the hazard level is high and rapid development is anticipated, this delay needs to be commensurately shorter.

Manually operated call points can, if present in unsupervised areas, be subject to malicious operation. For this reason, they are not normally provided in, for example, public common areas of shopping complexes and certain public houses.

10. Principles of Automatic Fire Detection

An automatic fire detection system consists of point type detectors linked by a dedicated circuit to a control system and arranged to give a prescribed warning when fire is detected.

The function of fire detectors is to detect one or more changes in the protected environment indicating the development of a fire condition. They may operate:

(a) when the invisible products of combustion are being released;

(b) when smoke is being produced;

(c) when the temperature in the vicinity of the fire rises rapidly and reaches a predetermined figure;

(d) when flames develop.

The types of detector designed to operate at these stages are:

(a) Smoke

(b) Heat

(c) Flame

(d) Combustion gas

The choice of type of detector system has to be based on the type of risk to be protected, the circumstances surrounding that risk, reliability, robustness and, lastly, economics. In certain circumstances it is advantageous to have more than one type of detector in the same system.

11. Types of Detector and their Selection

11.1 Smoke Detectors

Point smoke detectors use one or more of the following principles:

(a) Ionisation chamber smoke detectors – detect smoke by the reduction it causes in the current that flows between electrodes in an ionization chamber within the detector.

(b) Optical smoke detectors – detect smoke by means of the light scatter that results from the presence of a small light source within the detector.

(c) Multi-sensor detectors – employ more than one sensor which can improve the efficiency of the detector over a wider range of fire characteristics. It can also bring about a significant potential for a reduction in the number of false alarms generated by the detector.

Ionisation chamber smoke detectors are particularly sensitive in the early stage of a fire when smoke contains small particles, such as are produced in rapidly burning flaming fires, but may be less sensitive to the larger particles found in optically dense smoke of similar mass, such as can result from smouldering fires, including those involving polyurethane foam, or overheated PVC.

Optical smoke detectors are sensitive to optically dense smoke, but are less sensitive to small particles found in clean burning fires that produce little visible smoke. One of the hazards on escape routes and stairways is visible smoke, which might obscure the visibility of route and exit signs. Optical smoke detectors are therefore well suited for use in escape routes because they detect visible smoke and might operate before the escape route becomes impassable.

In general, smoke detectors give appreciably faster response to most fires than heat detectors, but are more likely to give false alarms.

11.2 Heat Detectors

The detector system using heat detectors may be designed to respond when a fixed temperature is reached. The heat detector may also include a sensor that responds to the rate of rise of temperature. In this case, the detector responds when either the temperature rises at more than a certain rate, or when the fixed temperature is reached.

Heat detectors that operate only when the rate of rise of temperature is abnormal, but not when a fixed temperature is reached, ought not to be used as they can fail to detect a slowly developing fire.

Heat detectors are generally less sensitive to fires than all other types of detector, but can detect certain very clean burning fires, such as those involving certain flammable liquids (eg Alcohol) before a smoke or combustion gas detector. They are unlikely to respond to smouldering fires and, as a simple rule of thumb, will require the flames from a fire to reach about one-third of the distance to the ceiling before they will operate.

In view of their lack of sensitivity, heat detectors are not suitable for the protection of areas where warning of the presence of smoke is required or where a small fire would cause unacceptable damage.

11.3 Flame Detectors

As well as producing hot gases, fire releases radiant energy in the form of infra-red radiation, visible light and ultraviolet radiation. Flame detectors detect the infra-red and/or ultraviolet radiation that is emitted by flame. Detectors designed to recognize these use radiation-sensitive cells that "see" the fire either directly or thorough built-in lenses or reflectors.

Infra-red detectors are usually designed to respond to flame characteristics such as flicker, size, or more than one specific radiation frequency. Types intended for outdoor use can be designed to respond to special infra-red frequency bands that are not characteristic of solar radiation.

Ultraviolet flame detectors normally operate within wavelengths that the zone layer filters out of solar radiation. Hence, ultraviolet detectors do not normally respond to sunlight and may generally be used outdoors.

Because of their inability to detect smouldering fires, flame detectors ought not to be considered as general purpose detectors, and are normally used for specialized applications, such as detection of fire in plants handling or storing highly flammable liquids or gases.

11.4 Combustion Gas Detectors

Combustion gas type detectors respond to one or more of the gases produced by a fire. For example, carbon monoxide is produced when incomplete combustion occurs. These detectors will therefore be most sensitive to smouldering fires and fires in which the rate of burning is controlled by the supply of air.

Carbon Monoxide can spread by diffusion through certain forms of construction. In the event of fire, therefore, carbon monoxide detectors could operate at a considerable distance from the fire, and on floors other than the floor of origin. Care needs to be taken to ensure that this does not result in the provision of misleading information for firefighters or others responding to a fire signal.

12. Success or Failure of Operation

When a fire occurs in an area protected by an AFD, the fire will grow, probably slowly and irregularly at first, but then at an accelerating rate. Generally products of the fire will be transported to the detector and they will be 'checked' against the prevailing environment. When the detection system is sufficiently 'sure' that what it is detecting is not an 'environmental fluctuation' it will 'decide' that a fire exists and raise the alarm. All this appears straightforward but there are many ways in which an AFD system could fail. For example:

(a) Wind or draught fluctuations causing a false temperature reading.

(b) Obstructions to smoke travel, and heat or flame radiation preventing the detector from acting quickly enough.

(c) The detector may be unable to detect the products of that particular fire.

(d) A fault in the system may have made the detector inoperative.

(e) The system may be switched off for servicing (more strictly a maintenance system failure).

(f) The detector may be prone to false alarms, so that a genuine alarm may be ignored until a late investigation is made.

(g) In certain areas at certain times insects may trigger false alarms.

13. Control and Indicating Equipment

Except in the case of simple systems, all modern fire detection and alarm systems incorporate a control facility.

The control unit is the nerve centre of any system and is usually placed in a prominent position in a building to ensure that its signals will be easily seen and heard by the building's occupants, fire service etc.

It could be designed to perform all or any of the functions listed below:

(a) Automatically monitor and control the equipment in the system, such as the fire detection and fire alarm device circuits and the power supply to that equipment.

(b) Indicate fire and fault signals and their location.

(c) Provide manual control facilities for testing the circuit, triggering fire alarm signals, silencing audible fire warnings and resetting the system after a fire signal.

(d) Operate the alarm either throughout the building or in any particular sequence related to an evacuation plan for the building with manual override facilities as necessary.

(e) Transmit the signal to an ARC for onward transmission to the fire service or other interested parties (eg The keyholder, maintenance engineer).

(f) Indicate from which zone the signal is coming, not only at the main indicator panel but, if necessary, at repeater indicators throughout the premises (eg The gatehouse).

(g) Operate other equipment. (eg De-activation of door-holding devices, opening smoke ventilators).

(h) Operate fixed firefighting equipment.

This list is not comprehensive as designers are constantly adding to these functions.

Alternatively, in larger buildings, the control equipment may be dispersed around the building in key locations to meet staff and maintenance requirements. However, the indicating equipment, together with suitable manual control facilities, should be sited at an appropriate location for both staff and firefighters responding to a fire signal. This should normally comprise an area on the ground floor close to the entrance to the building likely to be used by the fire service, or a suitably sited, continuously staffed control room from which at least initial control of any fire incident, by staff and/or the fire service, will be implemented.

References

BS 5839 –1:2002
Fire Service Manual, Volume 3, Fire Safety – 'Fire Protection of Buildings'