FIRE SERVICES EXAMINATIONS BOARD

STUDY NOTE

EXAMINATION	STATION OFFICERS' EXAMINATION
PAPER	OPERATIONS
SUBJECT	FIREFIGHTING AND RESCUE INCIDENTS
ITEM	OPERATIONAL INCIDENTS IN TUNNELS & SIMILAR STRUCTURES
STUDY NOTE No.	3106

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.

OPERATIONAL INCIDENTS IN TUNNELS AND SIMILAR STRUCTURES

1. Exclusions

This study note is concerned with fires and other incidents in road or rail tunnels and similar structures, including underpasses.

Pressurised workings underground and mines are excluded from the study note.

Although all or part of the guidance may apply to the Channel Tunnel, this tunnel is a specific and special risk that has standing orders and instructions on operational procedures issued by the brigades involved. It is therefore not specifically included.

The guidance that follows is not intended to cover incidents in EVERY underground structure but provides a framework for good practice that potential Station Officers should be aware of.

Any reference to fire prevention or fire safety matters in this guidance should be seen as an aide memoir only and not regarded as comprehensive guidance on the subject.

PART ONE - PRE-PLANNING FOR OPERATIONAL INCIDENTS

1. Introduction

Although there are exceptions, underground tunnels and similar structures are normally designed and used for transportation, mineral excavation, car parking and storage purposes.

The structures are often quite old and, as a result, neither designed nor built with ideal standards of fire protection and fire safety incorporated. The characteristics of each tunnel or structure will vary greatly; a tunnel may be nothing more than a short horizontal tube cutting through a hill, or it may be a vast underground complex with many tunnels, access points, and service and customer facilities.

Tunnels under construction, railway tunnels, both those with underground passenger stations and those without, and road tunnels will give rise to different problems. Tunnels under construction, for example, present unique difficulties because of their constantly changing nature. A common feature, however, is that a fire in the structure is likely to pose the fire service special hazards and a range of logistical and other operational problems.

The fire services have long recognised that pre-planning for tunnel and underground structure incidents must be as effective and comprehensible as possible. The wide variation in local factors and tunnel characteristics mean that each contingency plan must be tailored to fit specific circumstances. The following guidance notes should therefore be seen as general indicators of a range of planning considerations for preparing or reviewing local plans.

2. The Risk

It is important to consider carefully the location and structural characteristics of the tunnel or underground complex, such as its depth, dimensions, construction, ventilation, drainage and the potential risk posed by the tunnel's contents or the nature of its traffic. Consideration should also be given to the provision of communications.

In new structures, a significant contribution to reducing the risk can be achieved by asking operators to build in facilities not readily available or achievable in existing tunnels.

It may be possible to minimise a risk by re-routing or re-scheduling the transport of hazardous loads.

The risk underground must be kept to a minimum. Areas to consider include:

(a) Site management's knowledge of fire loads, ignition sources, fire detection and suppression equipment;

(b) Site management's knowledge of materials stored or used and their hazards and properties;

(c) Site arrangements for environmental monitoring or surveillance;

(d) The level of training undertaken by the operator's workforce and the priority given to safety; and

(e) The arrangements to prevent unauthorised access and malicious ignition.

The fire brigade may also be involved in:

(a) Enforcing of agreed safety standards. Operators are expected to follow the Code of Practice for Safety in Tunneling in the Construction industry;

(b) Surveys and inspections to identify possible risk areas;

(c) Suggesting improvements and keeping operators informed of technical advances;

(d) Training of site work-force, observing at fire drills; and

(e) Liaison with on-site firefighting teams and an ongoing programme of realistic training exercises to test operational procedures.

3. Risk Management

Risk Management has grown in importance for economic and statutory reasons, and is today seen as an integral part of overall fire protection.

Local authority fire brigades have an important contribution to make to risk management underground and although each underground risk will be specific there can be a common strategy:

(a) Identify the risk or risks;

(b) Determine the precautions required;

(c) Establish systems of fire prevention;

(d) Maintain them on a day-to-day basis; and

(e) Prepare an operational plan.

Under the Control of Substances Hazardous to Health Regulations, fire authorities are required to adopt a scheme for controlling the exposure of fire brigade personnel to any substance "hazardous to health".

The fire service can be of help by considering fire precautions. For example, a store containing flammables underground would not be considered ideal but it may be essential and unavoidable. However, questions that should be asked include:

(a) Could alternative materials be used?

(b) Could the stock held be reduced?

(c) Could access to the store be restricted? and

(d) To reduce movement into the store, could daily used stocks be stored in smaller amounts in a separate store?

Whilst every effort should be to reduce the possibility of fire breaking out, there are occasions when the need for extra vigilance and proper control must be recognised.

The more obvious of these are:

(a) Tunnels under construction;

(b) New storage; processes; or use of materials and equipment;

(c) New management or large influx of staff;

(d) The presence of contractors; and

(e) Modifications or renovations in progress.

Proper risk assessment should identify areas of concern. Steps should be taken to ensure that management remove the risk or upgrade the protective measures while the risk exists.

4. Access for Fire Appliances and Personnel

The best means of access to a tunnel entrance should be determined. Appliances attending may be required at both ends of the tunnel that may be a special risk in an otherwise low risk area.

The following points regarding access to underground structures may assist with individual contingency plans:

(a) In very large underground risks there may be numerous access points, including staircases; lifts and escalators.

(b) There may also be ramp-ways, suitable for pedestrian and vehicular access.

(c) In very large underground complexes rubber tyred vehicles or narrow gauge railways are sometimes employed.

(d) Vehicles used to transport firefighters into a tunnel should remain available for their immediate egress.

(e) It is possible that in both rail and road tunnels, the owners may assist by providing a wheeled or tracked trolley for use in conveying equipment to a forward point.

(f) Fire service appliances will not normally enter tunnels except where road or rail tunnels have vehicle access tunnels alongside.

(g) Four-wheel drive vehicles cannot be driven over rail tracks and many tunnels are too small to enter.

(h) It may be possible to adapt a vehicle for use inside a tunnel to assist in the movement of equipment and personnel. In some instances, tunnel operators may assist with the provision of underground transport facilities.

Safe working practices must be followed particularly in smoke filled environments, where passengers are likely to be trapped.

5. Water Supplies

To ensure water supplies are available below ground there will have to be a good supply at the surface level. Pre-planning should include:

(a) The quantity of water that may be required;

(b) The quantity of water available;

(c) Static supplies;

(d) The availability at all times of these supplies;

(e) The distance from the risk;

(f) Any water relay that may be required;

(g) Hard standing for pumps;

(h) Adaptors to these supplies for fire brigade equipment;

(i) The pressure-fed supplies available;

(j) Their location and marker plates;

(k) The flow rates and pressures;

(l) Booster pumps for these supplies;

(m) Their compatibility with fire brigade equipment; and

(n) A full survey of surrounding water supplies and access for fire brigade use.

6. Ventilation

Entering an underground structure where a fire has occurred is extremely hazardous and any measures that will reduce this hazard should be considered. The distance from surface level to the floor affected may be considerable and bridgeheads may be an essential part of the plan. Additional precautions which can be pre-planned for underground structures, though not road tunnels, include:

(a) Break-in panels to assist ventilation; and

(b) External openings for fire brigade smoke extraction units.

An efficient ventilation system is essential. Flashover conditions may occur with disastrous consequences for firefighting operations. The location of air shafts and their likely effect on the fire should be borne in mind.

7. Communications

The structure of communications systems between crews underground and from surface level to underground will require thorough investigation.

There are many types of communications systems available on the market. The decision on which to choose will depend on the type of underground structure in question.

The first thing to decide is the communications structure that is likely to be used and who is to be in the scheme.

It will be an advantage if it has flexibility of use so that as many control points as may be used can have access to the system.

The installation of leaky feeders so that they are laid ready for use is an inexpensive means of providing a well-proven form of communication underground. The installation of a line communications system could also be considered.

It is important to consider during pre-planning, the tunnel's location and surrounding topography, bearing in mind that mountainous or hilly terrain can pose specific communication problems.

The establishment of effective communications within the tunnel can often be a pre-requisite to successful operations, and it is vital that this aspect is given a high priority as it is recognised that each tunnel or similar complex is practically unique in terms of its structure.

The continuation training of all personnel in communications procedures and equipment is vital.

At large or protracted tunnel incidents the need for inter-service liaison between all emergency services and the compatibility of communications equipment should be addressed.

8. Transportation of Personnel and Equipment

Pre-planning should include consideration of how personnel and equipment will be transported to the scene of the fire or incident within the tunnel, bearing in mind the importance of speed of attack.

It may be possible to use underground transport if conditions permit and the use of such transport is likely to prove effective.

A large scale breathing apparatus operation involving deep penetration and prolonged duration will require the transportation of large amounts of equipment. An evaluation of whether existing brigade equipment is adequate for the potential risks involved is essential.

9. Training

Where underground risks exist, localised training must be considered. The close co-operation of the operator of the risk, possibly by nominating a liaison officer, would greatly assist in this training.

An ongoing programme of realistic exercises carried out with other emergency services is essential. Consideration should be given to liaison with on-site firefighting teams and inter service training sessions for both parties.

As well as on site training and exercises the following training methods may be considered necessary:

(a) Floor plan exercises at station level;

(b) Local station drills and lectures; and

(c) Risk assessment visits.

10. On-Site Exercises

It is good practice for Brigades to consider the merits of refining their contingency plans and familiarising front-line crews with a tunnel's layout by means of regular on-site exercises. The effectiveness of the brigade's communications can be established at such exercises.

At cross-boundary tunnels it may be beneficial for the exercises to be held jointly with the neighbouring brigades.

11. Conclusions

Measures taken to ensure the smooth running and safe operation of any underground structure will have a direct bearing on any firefighting operations. Consequently only by close co-operation between the tunnel operator and the local authority fire brigade can a reliable and effective contingency plan be drawn up.

The steps to be taken must take into account all eventualities, including all practical measures and procedures that will cope with the worst possible scenario. The roles of other emergency services will also be relevant.

High temperatures, poor access, congestion, long travel distances below ground and poor communications are all factors which will put a heavy strain on command and control, operational procedures and firefighting crews. Steps can be taken prior to any incident that will reduce these difficulties. For example:

(a) Packs carried on appliances showing site plans, rendezvous points, fixed installations etc; and

(b) Identification of key personnel from all parties. (Tabards).

Exercises will highlight deficiencies, and a comprehensive package of measures that will be of positive value can be drawn up and implemented in plans. Some of these measures have been discussed. Others include:

(a) Determining the level of first attendance appliances and special appliances;

(b) Location of control points and appliance positioning;

(c) The control over services, including electricity, gas and water supplies, and the location and access to these controls;

(d) Whether equipment should be safe for use in a flammable atmosphere;

(e) Salvage operations, identification of high value goods or equipment; essential salvage requirements; and stages of salvage operations;

(f) The provision of drainage for firefighting, water, sprinklers, etc;

(g) Collection points for equipment, - assembling specialist equipment, technical advice, etc and

(h) Inter service liaison between police, ambulance service and local authority, including combined training exercises.

Fire brigade responsibilities include:

(a) Set up a working party to review innovations and techniques that may be used at underground incidents;

(b) Establish an officer to provide liaison between all interested parties;

(c) Prepare instructions and technical advice within a comprehensive operational order;

(d) Set up visits and inspections on a regular training programme for all first attendance crews and officers;

(e) Ensure that the whereabouts of specialist equipment is known and that it is readily available at all times;

(f) Regularly inspect equipment and vehicles provided for brigade use; and

(g) Consider calling on specialist advice or equipment for some incidents.

In some underground structures an on-site fire brigade may form part of the work force. This means that personnel will be available not only to carry out any first aid firefighting to a high standard, but also to assist the local authority fire brigade in all stages of operations. The degree of support they can offer will depend on good liaison and a full understanding of each other's procedures.

They will be familiar with the risk and the fixed installations provided. They will have a day to day knowledge of storage and personnel, access points and routes to follow. They could prove invaluable to the fire brigade and every effort should be made to establish a good working relationship.

If there are special procedures peculiar to the particular structure they should be formalised within operational guidance that can be clearly understood by all.

The procedures to be used should be practiced by all parties likely to be involved at any incident. All information within any pre-planning document must be regularly checked for accuracy ensuring that it is kept up to date and relevant.

PART TWO - OPERATIONAL TACTICS

1. Reconnaissance

Each contingency plan should stress the need for the officer-in-charge to take full account of pre-planning and to gather as much information as possible both on route and upon arrival at the scene. Before committing crews in a tunnel a message will need to be sent requesting the stopping of all traffic and the isolation of power supplies in the affected tunnel(s).

Officers in charge should also bear in mind, however, the potential danger of the isolation of power resulting in passengers being trapped underground and should ensure that this occurs only if operational circumstances make it unavoidable.

The need for an early reconnaissance and careful determination of operational tactics should be emphasised, along with a requirement for brigade control to be kept abreast of information received and operational developments. This is important given the time, which may be required to mobilise additional resources to remote locations.

There may be a problem in actually reaching the seat of the fire. Staircases could provide access but they are not always available or require long travel distances below ground.

Low level access points could be considered. At any low level opening a tunnel may be designed to allow personnel and equipment to reach a central point within the structure. The early use of fixed firefighting protection and ventilation systems may assist.

2. Command and Control

Strict command and control is important at tunnel fires, given that development and incident progression cannot always be easily or reliably predicted.

The importance of controlling all entry into the tunnel should be stressed and consideration should be given to the merits of nominating selected personnel as safety officers for this purpose.

In protracted and deep-seated tunnel incidents, strict control should be maintained on everyone entering the tunnel. Records should be kept at the entrance of anybody passing entry control.

A breathing apparatus entry control point can be sited within the tunnel if the prevalent environmental and air conditions permit. If so, it is essential that environmental monitoring at this location is continuous.

If there is any doubt about the quality of the environmental conditions then officers in charge should require breathing apparatus to be started up. Communications between entry points should be maintained with particular emphasis placed on firefighters entering with breathing apparatus.

There will be a need for inter service liaison between emergency services and a main control point.

3. Firefighting Methods

Firefighting methods will obviously depend upon the circumstances pertaining at the time of the incident.

There are a number of factors, however, that can be considered both during the pre-planning stage and subsequently at the scene of an incident.

The first consideration at an incident is the nature of the fire. During pre-planning it might be possible, in certain circumstances, to identify in advance the type and range of substances which are transported through the tunnel and which might, therefore, be involved in an incident.

The nature of an incident will determine the appropriate firefighting media.
Officers in charge will need to consider the varied conventional and high expansion foam options, taking into account their likely effectiveness and the associated problems of maintaining a continuous attack upon a fire with the respective media.

Water is normally the most effective and readily available media for firefighting, and consideration should be given to the merits of advancing behind a water screen towards the source of the fire.

The location and type of water supplies will also need to be established. If it is anticipated that a special extinguishing media will be required, then pre-planning should include consideration of whether sufficient quantities will be available to mount and sustain an effective attack upon a major fire.

The siting of appliances in order to ensure the effective and speedy deployment of equipment and extinguishing media will require consideration, as will the availability of special appliances, foam tenders, emergency rescue tenders and their positioning at any incident.

The appropriate and safe deployment of personnel is of primary importance. Brigades should consider deployment strategy during pre-planning, taking into account the minimum number of firefighters likely to be required in order to undertake the following functions:

(a) Forward firefighting and rescue;

(b) Support duties concerned primarily with sustaining firefighting and rescue; and

(c) Relief and emergency breathing apparatus crews.

During operations it may be necessary, on occasions, to consider the use of non-fire service personnel. However, it should be borne in mind that they are not fire service trained and will not react in the same way as firefighters. The safety of such personnel should be considered at all times.

It is essential that all personnel entering the tunnel should clearly understand the evacuation signal, which is to be used.

Where non-fire service personnel are utilised, it may prove beneficial to involve them in training sessions at the risk with fire brigade staff to ensure that procedures are fully understood and that uniformity and standardisation of evacuation is maintained.

The length and depth of the tunnel may require special evacuation signals to be used.

The feasibility of using helicopters for reconnaissance purposes and the transporting of personnel to the fireground area should also be considered.

4. Breathing Apparatus

(a) Type of Breathing Apparatus

The task of selecting the appropriate type of breathing apparatus set used may prove difficult. This will depend on many factors. The likely working duration expected at an incident will give some guidance on possible choices. The following notes provide an indication of the options available:

(i) Self-contained compressed air apparatus is a preferable choice for use in incidents below ground whenever the available working duration is sufficient to permit firefighters to travel to and from the working area, to undertake their tasks and to return to breathing apparatus entry control in good time.

(ii) A limitation in the use of this type of apparatus occurs due to its open-circuit mode of operation. Where the duration available from conventional cylinders including ultra-lightweight types is likely to be inadequate, consideration should be given to the use of larger capacity cylinders of composite construction.

(iii) A combination of compressed air breathing apparatus and airlines may be a possibility and the airline equipment could be portable on trolleys. Manoeuvrability may be difficult but if space below ground is adequate it may be possible to use this method to reach the seat of a fire. The problems of airline equipment including limitations of use should be borne in mind. The maximum penetration achievable with airline equipment is unlikely to exceed 60 metres. Users should be alert to the possibility of debris falling on and crushing airlines.

(iv) Long duration closed circuit oxygen breathing apparatus with a working duration of two hours may be considered where deep penetration is necessary. This type of apparatus has certain advantages in its length of duration and safety benefits arising from the ability to extend the duration during entrapment. The disadvantages include initial cost and servicing, the temperature of breathable oxygen, which may be as high as $40^{o}C$, additional training required for firefighting personnel and the availability and cost of spare equipment.

(b) Emergency back-up facilities

In situations where deep penetration is necessary beyond the point where breathing apparatus wearers may be able to exit to safe air on foot within the limits of the set being worn, a 'back-up' supply of air or oxygen is necessary.

An option is the provision of 'safe haven' transport fitted with on-board respiratory protection capable of supporting crews with expired breathing apparatus sets.

Standard 'man-rider' rail cars used in the mining industry are capable of adaptation to provide up to three hours of on-board air for a large number of personnel. This particular method has for example been employed in the construction of the Channel Tunnel. Brigades should also be aware that at some sites to which they might be called, Health and Safety Executive Regulations may require the use of a "Self Rescuer".

(c) Quantity of Apparatus/Weight of Attack

It is for each brigade to determine the appropriate PDA in respect of each known risk, and to decide the number of sets which should be immediately available. Back-up facilities and the availability of additional sets should be known and located at stations adjacent or near the risk. The total number of sets required to deal effectively with any tunnel incident should allow for a reserve of sufficient quantity to cater for on-scene servicing and maintenance whilst still maintaining a full strike capability. It may be necessary to bear in mind the following:

(i) Total number of sets required to address the training need whilst maintaining full operational readiness; and

(ii) Defective equipment off the run for servicing.

(d) Clothing

In most instances full firefighting uniform will suffice. A difficulty may be experienced, due to high levels of heat and humidity frequently found in tunnel incidents, which will considerably reduce the working time of breathing apparatus crews and result in rapid fatigue.

To combat this problem the use of lightweight, highly breathable coveralls, which will allow a movement of air within the clothing, may alleviate hot travel and working conditions and reduce the fatigue effect on wearers.

However, it should be borne in mind that such clothing will not enhance protection from radiated heat. Such protection in proximity to a fire can only be obtained by the use of clothing of appreciable bulk and with the kind of thermal insulation associated with conventional tunics.

Furthermore, lightweight clothing will not afford as much protection to wearers from flashover conditions as normal fire uniforms. Lightweight leather footwear instead of rubber fire boots may reduce energy demands over long distances.

(e) Servicing - Spares

Large numbers of spare cylinders and equipment such as servicing tools, batteries, hand lamps, facemasks, distress signal units and maintenance gear may be required at tunnel incidents. It is likely that this list will vary considerably with each individual risk. Brigades may also wish to liaise with owners of a tunnel complex who may hold spares in the vicinity of the entrance to long tunnels. In this event the possible problems of theft, vandalism and access for maintenance and servicing will need to be addressed. The benefits of transportable servicing facilities including cylinder replenishment should also be considered.

(f) Servicing of apparatus

It is felt that the ideal location for set servicing would be out of the environment of the tunnel. However, if the incident dictates, servicing points may have to be set up within the tunnel itself. Platforms and airshafts are potential sites for these areas.

(g) Guidelines and Ancillary Equipment

In long tunnel incidents, it is possible that disorientation could take place. Therefore, the use of guidelines, hose indicators and permanent high visibility wall exit markers should be considered. Difficulty may be experienced in locating tie off points.

Due to the complexity of incidents in underground structures the use of automatic distress signal units by breathing apparatus wearers may increase their safety.

(h) Breathing Apparatus Wearing

It will be essential that starting up of breathing apparatus is adequately planned and monitored and that a team entering an underground structure continually monitor the environment with portable equipment (if available) to ensure that 'start up' is commenced in 'safe air' conditions.

(Note: The terms "safe air" and "fresh air" are synonymous and "safe air" can be defined as "an atmosphere that will not cause respiratory discomfort or injury".)

The officer-in-charge should order breathing apparatus to be started up if any doubt exist about environmental and air conditions.

Unless there are exceptional circumstances, for example, where there is a risk to life, the breathing apparatus wearers should proceed to an environment where a "safe air" breathing apparatus entry control point can be established.

This may be a bridgehead or forward control position. It is imperative that communications equipment is introduced between the breathing apparatus wearers and the breathing apparatus entry control point and that communications safety procedures are initiated immediately loss of communications occurs.

(i) Breathing Apparatus Teams

The length and complexity of the tunnel and the likely workload of the team should determine the size of a breathing apparatus team.

Where appropriate, it may be desirable for an additional wearer to be allocated to the team to enable the team leader/safety officer to concentrate on his responsibility for wear planning.

(j) Fitness

Fitness is an important factor in all firefighting operations and particularly so with breathing apparatus wearers. There should be an understanding, however, that extended duration breathing apparatus crews will generally face a greater demand than normal duration breathing apparatus work. It is considered, therefore, that additional training with particular emphasis on fitness, set familarisation and working and wearing demands should be given to personnel who will be required to wear extended duration breathing apparatus.

If, during an incident, such crews need to be re-committed, great care is needed in the evaluation of the task to be performed and the ability of the crew to perform it.

(k) Bridgehead/Forward Control/Breathing Apparatus Entry Control

A point may be reached during an incident where it will become necessary to don facemasks and start up sets. At this point, the officer-in-charge should consider implementing forward control breathing apparatus entry control procedures. This decision and the positioning of bridgeheads, forward control and breathing apparatus entry control points requires careful consideration and a number of important factors should be taken into account:

(i) The safety of personnel working ahead of the bridgehead;

(ii) The distance from the main entrance of the tunnel to the bridgehead;

(iii) The availability of relief crews for the first breathing apparatus teams;

(iv) The immediate operational considerations;

(v) Communication between the bridgehead/forward control and breathing apparatus controls;

(vi) Emergency breathing apparatus teams; and

(vii) The dangerous effect of relocating a breathing apparatus entry control from which breathing apparatus teams entered, because of changing conditions such as environment.

It must be remembered that breathing apparatus wearers calculate their working duration based on their cylinder pressure contents at the time of entry. If the breathing apparatus control point is relocated or initiated remote from the start up point, the breathing apparatus wearers' travel distance is increased and their working duration may not provide sufficient air supply for them safely to reach fresh air.

(l) Physiological Condition of Breathing Apparatus Wearers

It is essential that refreshments in the form of fluids are made available for breathing apparatus wearers and that the condition of crews is closely monitored at the bridgehead.

Particular problems occurring in personnel at this type of incident are that of heat stress, exhaustion and de-hydration. Safety Officers should look for signs of these occurring.

PART THREE - COMMUNICATIONS

1. Introduction

The information below supplements that already given in section 7 of PART 1.

Radio communications that facilitate normal routine and incident operations are not easily achieved below ground or in man-made environments. As a consequence special techniques and procedures may have to be employed.

The effectiveness of all forms of fire brigade communications can, with the co-operation of the site owners/operators, be tested by means of operational trial. For road or rail tunnels this trial should be conducted with vehicles or trains in tunnels. Once the effectiveness of any facilities has been evaluated, contingency plans for dealing with incidents that might occur at the risk can be formulated and recommendations for improving communications can be made.

2. Technical Effects of Underground Communications: Radio

For all practical purposes there is no penetration of the surface by any of the frequencies used in normal above-surface communications. These frequencies will only propagate through air and through thin walls. Other media such as rock, brick or water absorbs the energy very quickly.

Where successful communications from above ground to below ground (at VHF and UHF) occur this is generally due to reflections of waves through entrances and from parts of the structure that are above ground rather than by "penetration" through the ground. Such penetration is possible by transmission of magnetic waves at low frequencies.

VHF main scheme radio is unlikely to penetrate an underground structure by more than a few metres. Appliances that are driven into road tunnels or into service roads beneath large shopping or housing complexes are unlikely to be able to contact mobilising controls using normal aerial arrangements.

Similar limitations are likely to exist for brigade and commercial paging systems and mobile telephones.

3. Incident Pre-Planning

Where any special arrangements have been made or special facilities provided to provide communications at any underground or sub-surface risk premises, detailed information on the use of the facilities should be available to all operational personnel who might attend operational incidents at those premises. Suitable signs erected at the risk premises and aides memoirs, as appropriate may supplement this information.

Every opportunity should be taken to familiarise operational personnel with communications facilities at sub-surface risks, and to train and exercise them in their use. This activity is considered essential when considering operational procedures specific to the risk in question.

Where attendance to a sub-surface risk is likely to involve personnel from more than one brigade, or indeed from another agency, technical information, training and familiarisation should be made available to all personnel who might attend an incident.

The adequacy of communications in sub-surface premises should be continually reviewed in the light of changing circumstances, new developments and changing operational procedures. Whenever exercises are held the opportunity to review the performance of the communications system should be taken. Where another agency is responsible for the maintenance of the equipment such exercises should be used as an opportunity to monitor the performance of the system.

4. Summary

There are a number of techniques for overcoming communications in sub-surface risks. There are no simple rules which can be applied and the communications problems of each risk need to be separately assessed, both from the point of view of the operational requirement and from the technical viewpoint.

The fixed equipment to be provided at the tunnel complex to facilitate communications must perform reliably after long periods of inactivity. It should therefore be self-checking with automatic fault reporting to a point which is continuously staffed.

All equipment failures should be reported to the brigade as soon as possible, to enable pre-planning of alternative communications arrangements, if required.

References

Technical Bulletin 1/1993