Safety at Scenes of Fire and Related Incidents

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Front cover: a petrol vapour explosion severely damaged this public house in Deptford, London, and made investigation very hazardous.

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Introduction

The investigation of fires and similar incidents, such as gas explosions, is inherently dirty and often hazardous. Every person involved in such activities should aim to minimise the risks while performing as full an examination as possible. There will be occasions when risks are too great to be overcome; if an incident cannot be investigated without an unacceptable level of risk to the people involved, the scene should remain unexamined. *No fire investigation is worth serious injury or death.* Such circumstances are rarely encountered by most workers in this field but it is important to be able to recognise the hazards involved and assess the degree of risk.

This document has been written primarily for the use of forensic scientists working in the Fire Investigation Unit (FIU) of the Metropolitan Police Forensic Science Laboratory. This includes both permanent staff and those on temporary attachments. It is intended to form part of the Laboratory safety manual and, as such, to be used by any members of staff whose duties take them into this kind of environment.

It is also designed to be of use to other scene examiners, whether forensic scientists or not, in public or private sectors. This includes police and civilian scenes of crime officers, fire service officers and anyone whose work leads them into fire damaged places. For this reason, it has been prepared as far as possible in general terms, without detailed reference to FIU practices unless these are unavoidable.

J. W. Munday

May 1994

1 The Law Relating to Safety at Work

The most important piece of legislation which relates to people working at scenes of fire and the like is of course the Health and Safety at Work, etc. Act 1974 (HSWA). This act unified the earlier piecemeal safety provisions in specified industries or premises and provided a framework for the application of new regulations (for example COSHH, Electricity at Work etc). The most important provision of the HSWA was to place a requirement on employees to play an important part in their own welfare. For example, where an employer was obliged to provide certain facilities or prevent certain practices, there was an equal obligation on the workforce to use the facilities or desist from the activities to protect both themselves and others.

Part I of the Act expresses this as follows:

Section 2(1): 'It shall be the duty of every employer to ensure, so far as is reasonably practicable, the health, safety and welfare at work of all his employees.'

Section 7(a): 'It shall be the duty of every employee while at work to take reasonable care for the health and safety of himself and of other persons who may be affected by his acts or omissions at work.'

Note the wording of 7(a); the reference to 'other persons who may be affected...' is clearly applicable to many of the activities involved in fire investigation. The concept will recur many times in this document. There are two other pieces of the HSWA which it is relevant to quote at this stage:

Section 1(3): 'For the purposes of this Part [of the Act] risks arising out of or in connection with the activities of persons at work shall be treated as including risks attributable to the manner of conducting an undertaking, the plant or substances used for the purposes of an undertaking and the condition of premises so used or any part of them.'

Section 7(b): 'It shall be the duty of every employee while at work, as regards any duty or requirement imposed on his employer or any other person [under this Act]...to co-operate with him so far as is necessary to enable that duty or requirement to be performed or complied with.'

In plain language, this means that an investigator at a fire scene (in the capacities of both employee and employer's representative) has exactly the same duties and responsibilities in terms of health and safety as at the office (or normal workplace) or in the laboratory.

Implications of the HSWA

There are two major implications. Firstly, as the employer's representative or agent at the fire scene, the investigator has certain powers which must be used wisely. Secondly, he or she (hereafter referred to as 'he' for sake of simplicity) must consider not only his duties and obligations as an employee under the Act but the responsibilities incurred through his presence by his employer and modify his actions accordingly. To sum up: once a scene has been handed to the investigator to examine, he is in charge. He can therefore make decisions as to what may be done safely and make changes, or cause them to be made, to diminish risks. Equally, provided that the employer's safety policy is adequately formulated and the employee suitably trained, he will be liable if something goes wrong and an injury results. It is important to remember that the HSWA can be and is enforced by the criminal courts.

The only general exemption from the provisions of the Act is for members of HM Armed Forces, to whom other regulations apply. Many people believe that there are exemptions for specific occupations, for example, police officers and firefighters. This is not the case. There may be circumstances in which the interpretation of the law is affected by the known hazards of a particular profession, but the Act nonetheless applies. In such cases, the interpretation will usually turn on the phrases 'reasonably practicable' and 'reasonable care' in the extracts above.

Application of the HSWA

Having considered the background and legal requirements, we can now look at the practical steps which can be taken to ensure the health and safety of the fire scene examiner. There are areas of particular concern which will be covered in detail, whilst other more general scene safety points which are covered elsewhere will be dealt with more briefly.

2 Protective Clothing

The most basic step which can be taken to protect an investigator from many of the adverse effects of a fire scene is the provision and use of appropriate protective clothing. There are many ideas as to what constitutes the best combination of garments, almost as many as there are fire investigators! Every selection has both advantages and disadvantages but it is usually possible to arrive at a comfortable and practical compromise suitable for most scenes.

Experience suggests that a bare minimum of protective clothing would include a one-piece overall or boiler suit of strong construction (disposable paper suits are rarely adequate), a pair of boots with steel toecaps and puncture resistant midsoles, a protective helmet and a pair of stout gloves. In addition, a waterproof jacket and overtrousers are very useful, since an abnormally high proportion of examinations seem to take place in the rain or beneath man-made waterfalls. The boots and gloves should also be as waterproof as possible. It is not usually practical to work in waterproofs all the time as perspiration cannot escape. For many 'dry' scenes, leather industrial safety boots are more comfortable than the reinforced Wellington.

A standard site helmet normally offers adequate head protection, although these leave the nape exposed and investigators should always be aware of this limitation when bending down. Safety helmets are only designed to deflect and absorb minor impacts, not a half-full domestic water tank or a chimney stack. Moreover, a helmet which has been subjected to a substantial impact will be weakened and must be replaced. Helmets should also be replaced routinely every three years or so. Gloves are a major problem for fire investigators. It is difficult to achieve the right blend of strength, puncture resistance, flexibility, 'feel' and water resistance. Many types are in use, probably the best at present being heavy gauntlets of cotton backed PVC.

More specialised clothing may be needed on occasion. For example, lighter and more flexible gloves are useful for fine examination of items found in debris, inspection of bodies or packaging tasks. Latex or vinyl surgical gloves are normally the best choice, although they are readily cut or torn so great care should be taken; wearing two pairs of gloves to provide an extra layer is sometimes helpful as protection still exists if the outer glove is punctured.

Dust can be a problem and dust-filter face masks should be available. These should not be confused with particle filters suitable for asbestos protection which will be mentioned later. Working in very unpleasant or noxious atmospheres can be made safe by a cartridge-type respirator, which will normally include a dust filter. This only applies if the oxygen content of the air is at normal levels. If conditions are worse than this, only staff trained in and equipped with breathing apparatus (BA) equipment should proceed. BA equipment is available in many different forms designed for various hazards. Advice should be sought from the Fire Service, who may be able to escort an untrained person using a linked BA. This would only be done in a genuine emergency. A fuller discussion of particle and asphyxia risks appears later in this document.

Eye protection is very important at fire scenes. The main risks arise from dry, dusty environments with many airborne particles and from the fragments and chippings generated during excavation or cutting away. (Lachrymatory or corrosive substances could be present; these will be discussed later.) Goggles and full-face visors should be available. Visors can be preferable for protection against larger fragments (for example, when using a pickaxe or hammer on masonry) while goggles give better protection against finer particles but are more prone to misting-up during strenuous activity.

It is generally better to put on the basic protective clothing *including the helmet* before entering any fire scene. It is much easier to remove unnecessary items after a preliminary assessment than to try to justify the compensation claim later! Of course, information is often available in advance concerning the condition of the building etc, and an estimate of the degree of protection required may be based on this and an external inspection of the premises. However, if there is any doubt as to the accuracy of the information, it is essential to err on the side of caution.

A good, all-round view of the scene establishes major hazards, including unstable brickwork, suspended timbers, exposed services and, in this case, a large quantity of residual flammable liquid.

3 Approaching and Viewing the Scene

In many smaller fires, a direct inspection of the damaged area from outside may not be possible (for example, a fire in a room within a house). However, even in these cases, an appraisal of the exterior of the building and its approaches can reveal many potential hazards from masonry, tiles, glass etc. At larger scenes, it is important to walk around as much of the affected area as possible at a sensible distance. The purpose of this is to note its size, construction and peculiarities and to visualise potential hazards. Where a very large venue (for example, a warehouse or factory) is involved, a nearby high vantage point can be most useful. The view from a neighbouring roof, or a Fire Service hydraulic platform, can help to assess much of the internal damage.

Points to look for at this stage are signs of collapse or distortion of structural steelwork, cracked brickwork or cladding, suspended weights, actual movement, broken glass, impeded access routes and notification of other hazards, for example, HazChem markings. All of these will be discussed in more detail.

If the Fire Service is still in attendance, the approaches to the scene may be congested with vehicles, hoses laid on the ground and other items of equipment lying about. Smoke venting may still be in progress; this often involves breaking out windows or knocking holes in roof coverings, so that falling debris is a potential hazard. Similar problems occur if damage control teams, scaffolding or demolition contractors or boarding up services are on scene. It is wise to contact the person in charge of such activities at the earliest opportunity to discuss a safe approach to the premises.

If it is suspected that activities of terrorists or action groups are involved the fire investigator should be aware of the possible use of incendiary devices and take particular care in case 'live' devices are still present in the debris or in undamaged parts of the building.

4 Assessment of Building Safety

Many factors are involved in deciding whether it is safe to enter a building and conduct a full (and possibly lengthy) investigation. Other options may include making only a partial examination, returning later when modifications have been made, or refusing to attempt any investigation of the scene. Personal observations will play a large part, but the advice (or even instructions) of those more knowledgeable in a specific area of expertise is also important. If firefighting is still in progress when the investigator arrives at the scene, it is important to remember that the Fire Service has total control of the incident until the fire is declared extinguished. Any approaches to them concerning possible access to the scene should be made to the senior officer or the staff of any Control Vehicle present.

At most large scenes there will be a number of people offering opinions, sometimes contradictory, on safety matters. All advice should be considered seriously but in the absence of a legally enforceable prohibition the final decision is that of the investigator. This must be taken in light of the earlier remarks concerning the implications of such decisions, especially their effects on others. The following may be regarded as giving sound advice within their own areas of expertise.

Fire Brigade Safety Officer

At many scenes, considerable numbers of Fire Service personnel are involved during firefighting and related operations. It is important that a close check is kept on the position and activities of fire crews and that the building is carefully observed for signs of collapse or sudden involvement of previously unaffected areas. For this reason there is a nominated Safety Officer who will remain outside the premises. This person is usually a middle-ranking officer with wide experience in the behaviour of structures under fire conditions. If firefighting operations are still continuing, this officer must be consulted before any attempt is made to enter. His decision is final; although he will generally be as helpful as possible to anyone with a legitimate interest, and may offer guidance as to potential dangers, he is responsible for the safety of anyone allowed in at this point and will probably err towards caution.

Borough Surveyor

In any case where unsound building structures are reported by the Fire Service or other persons, such as members of the public who notice falling masonry, a surveyor employed by the local authority will attend the scene. This official is known by various titles, including borough, district or county surveyor, structural engineer or building control officer. His function is to ensure the safety of the public and to achieve this he can order shoring-up of, demolition of or prevention of access to any part(s) of a structure he considers dangerous. Although he is not technically responsible when private property on wholly private land is involved, any form of public access to the area usually justifies his involvement. In most cases the surveyor is sympathetic to the fire investigator's viewpoint and will attempt to ensure that 'making safe' operations are done so as to cause minimum hindrance to the examination, provided that good liaison is established at an early stage. He is a specialist in building and structural safety and is generally pleased to give advice. In practice, a site meeting with the surveyor will often result in limited access for the purpose of investigation being permitted, even to a building which has been declared unsafe, so long as certain safeguards are met.

Other specialists

Other persons present may have specialist knowledge concerning structural safety and their advice should be considered. Health and Safety Executive (HSE) inspectors can be involved, for example, where fires affect industrial premises or processes or in storage facilities subject to specific legislation. These inspectors have a great breadth of experience which can prove most valuable. They also have the legal power to forbid certain actions which they consider dangerous, including the access to and examination of fire scenes. Again, suitable consultation and liaison will normally result in a workable compromise.

Contractors engaged in demolition or shoring and scaffolding work are usually helpful. Most of the larger and more reputable companies have staff with experience in dealing with many kinds of dangerous structures. They may be able to suggest different approaches to a problem involving an unsafe area. Demolition workers in particular, if approached at an early stage, can help a great deal by directing their work so as to minimise the subsequent clearance of rubble by the investigator.

In summary, it is important to establish which (if any) of the persons present at a scene have useful specialist knowledge and to consider their advice before proceeding. The final decision, in the absence of absolute prohibition, is that of the investigator and so he must himself be able to assess the risks involved . The remainder of this document deals with the identification of such risks.

5 The Examination of Building Structures

A gross examination of the structure and fabric of a building can give useful information about the development of the fire itself as well as the potential hazards. The simplest approach is to consider the various levels and features of a building.

Roofs

Roof structures and coverings are extremely diverse, but all share some common features, chiefly (a) being somewhere above head level under normal circumstances and (b) tending to be affected seriously by a well-developed fire. This ensures that a roof will present a greater hazard from falling debris than for any other reason. Coverings range from clay or concrete tiles widely used in south east England, through traditional slates and thatch to the large-span light coverings encountered in many larger commercial premises. These include corrugated asbestos or mineral cement sheet, tiles of similar material, various polymers in sheets or panels and synthetic composites. There are also the so-called 'continuous' surfaces used on flat roofs (that is, less than 10% slope) such as bitumen/felt and asphalt over wooden panels, sheet metal, or concrete decking.

The various stone and ceramic tiles are heavy and therefore likely to cause serious damage or injury when falling from roof height. Slates are thin and sharp edged as well as heavy; they can cause severe wounds or, in extreme cases, amputation. Although the lighter coverings present less of a hazard in themselves, they are usually interspersed with windows (roof lights) of wired glass held in place by metal glazing bars. The roof lights and bars are heavy, sharp, not normally well secured and therefore extremely dangerous.

The best way of dealing with any insecure roof structure is to avoid the area directly beneath. This is often impossible to achieve. The loose pieces can sometimes be removed or dislodged in a controlled manner. It is particularly important to keep a close watch on loose roofing in windy weather and be prepared to withdraw from the scene.

This large country house was gutted by fire, leaving the external walls unsupported…

Walls

Most residential and older commercial buildings in the UK still have traditional brick or stone walls. Although these generally resist the fire itself very well, they are likely to be damaged and weakened by other effects such as the collapse of internal floors or the expansion and contraction of metal structural members.

In general, if inner floor joists remain intact, the roof is fairly stable and there is no evidence of distorted metal components, then the walls are unlikely to fall. This will be the case in most house fires unless there has been a long delay or some other problem encountered in firefighting.

Many modern residences, both houses and flats, have concrete walls. These are of two types, poured on site or precast panels. Both are constructed around a tensioned steel mesh or rods. Panels are normally then hung on a steel framework using clamps or bolts, whereas the poured concrete walls are made between formers which are then removed to leave a free-standing structure. Again, both types are relatively resistant to the effects of fire and failure will normally occur only if the steelwork is disrupted by heat.

…and as cooling took place the weakened walls collapsed onto the forecourt.

Timber framed buildings are the norm in many countries and are becoming more common in the UK. These often have an external brick cladding but this is more cosmetic than structural. Burning to the wooden framework can cause collapse of the brick wall, often as a complete 'leaf'. The internal lining of such walls is usually 10mm or 13mm plasterboard or mineral cement board. There is often an infill of mineral wool or other insulation in the cavity. Although the notional fire resistance of the lining is sufficient to comply with regulations, it is relatively easy for flames to breach it and reach the timber. If this happens, the whole premises can become involved in the fire very quickly and there is great danger of subsequent collapse. This may happen a considerable time after the fire is put out if the brick cladding is stressed or subjected to impacts.

Other types of walls which are encountered include those of many larger commercial premises, which have a steel frame similar to that described above but are finished with an infill of low-density building blocks or a cladding of asbestos or mineral cement board or metal sheeting. Older warehouses and aircraft hangars are often of this construction. Again, heat distortion of the frame may result in insecure infill blocks or cladding. Since these are likely to be heavy and/or sharp, the exterior of the building should be carefully inspected for any such damage.

A further hazard involves the openings in walls. Doors, windows, and the like in loadbearing walls are normally surmounted by lintels, often of heavy concrete, steel girders or large baulks of timber. Bricks and masonry on either side of the opening must be checked for cracks which could allow the lintel to fall. This is especially important if a steel joist or reinforcing is involved, due to the effects of expansion.

Floors and ceilings

Floors, and the associated ceilings where present, are probably the most frequent source of injury and embarrassment to the unwary fire investigator. The most common floor construction in use in this country is the traditional suspended wooden floor of boards on joists. These are present in virtually all older dwellings, most older public and commercial buildings and many modern houses. Whilst wood retains a great deal of strength when only partially burnt, it is weak and brittle when charred almost through. In the later stages of many fires, holes are burnt through the boards; then burning to the joists occurs with consequent weakening; and finally the joists can burn through and collapse.

Clearly, great care is needed when a floor has been affected to any degree by fire, whether from above or below. The floor is often covered by debris and its condition is not readily visible. In this case, cautious clearance of the debris is required to establish the degree of burning present. Upper floors can often be checked more easily by viewing from beneath, although care is needed if loose debris is present overhead. If the floorboards are holed or largely missing but the joists are reasonably intact, it is usually possible to cross the floor using crawling boards or ladder sections laid across (not along) the joists. Great care is needed; if a joist shows a tendency to ‘give’ unduly, or cracking is heard, the area should be avoided. Even a floor too badly damaged in this way for crawling can be examined if a ladder is erected from below through the gaps between joists. Some newer premises have floors of plywood or chipboard laid on the joists. For safety purposes, plywood should be treated in the same way as floorboards.

Chipboard, however, loses strength rapidly when wet and such floors should be treated with great caution if any water has been used in the area, even if no fire damage is visible.

The ceilings most often used with these timber floors are older style lath and plaster or more modern plasterboard. Either will protect the joists against fire damage from below for a limited time. Plaster tends to collapse when heated or made wet, for example by firefighting. Generally, the pieces are small and not particularly hazardous when they fall, but decorative mouldings and cornices are usually much more substantial. Plasterboard can also fall as complete sheets. In addition, water can be trapped above ceilings, causing a tell-tale bulge. A sudden collapse is then possible, releasing a large quantity of water and debris onto the unwary.

Many other buildings, especially of recent construction, have concrete floors/ceilings. These take the form of a single or double thickness deck, with appropriate decorative facings on either side. Major structural damage to these is unlikely except in the very worst of fires.

Checking for safety is much the same as for concrete walls; danger signs are severe spalling with colour changes, disruption of structural steel and cracked supports.

A few buildings have stone floors. Since these cannot be laid as large span sections, they are either built directly onto the ground or foundations, or on a substantial framework. Heating and rapid cooling of the stone may produce cracking and above ground level such floors should be treated with the same caution as stone staircases (see below).

Staircases

In general, stairs are particularly strong and well-built parts of a structure. However, in many fires the staircase is among the worst damaged parts of a building. This is mainly a result of the ‘chimney effect’ by which fire spread from lower to upper storeys occurs via the stairwell. During this process the staircase itself is subjected to very high radiant heat levels and considerable direct flame impingement, especially towards the top. Many staircases are made of wood and such extreme heating can obviously cause severe disruption and even collapse of the

The stone stairs of this hotel in Bayswater, London, failed suddenly many hours after the fire was extinguished. A fire investigator was standing on the upper landing and fell, but fortunately suffered only minor fractures timbers. ‘Open plan’ or ‘open tread’ stairs are extremely susceptible to this type of damage as the flames can reach all the surfaces.

It is usually possible to make a visual safety assessment of a burnt staircase, looking for holes burnt through treads and risers, sagging of the central or outer ends of steps and severe charring to the underside (especially the framework). Stairs which abut a solid wall are almost always firmly fixed and it may be possible to ascend a damaged flight by keeping very close to the wall. This should not be attempted if walls have been disturbed (for example, by explosion or collapse). If in any doubt, it is better to pitch a ladder spanning the suspect area. Where damage is very severe, it is better to place the ladder on the outside of the building.

Concrete stairs, like floors, are much less likely to be severely damaged by fire. The diagnostic features described for concrete floors and walls may be applied. In larger buildings, concrete stairs are often used on escape routes and are therefore well protected from fire spread.

Stone stairs are less common, being restricted to large old buildings in the main. These present a special problem. When heated strongly and then cooled quickly, for example by water jets, they frequently break up and collapse. The collapse can occur some considerable time after the heating; the fire may be extinguished and the building quite cool and apparently safe to enter. Special precautions are therefore required when approaching stone stairs. Firstly, no-one should enter the area beneath such a staircase until the stability has been thoroughly checked. Secondly, the stairs should be thoroughly tested with a long pole or using a similar method. Thirdly, any ascent or descent attempted after such testing must be close to the wall; free-standing stairs should not be climbed. The best advice is to avoid such staircases altogether and pitch a ladder where necessary.

Miscellaneous

There are several structural features of buildings which result in specific hazards after fires.

Chimneys can be left free-standing after collapse of the surroundings and are often seen to be swaying. They are very dangerous and should be made safe by demolition or shoring before work begins. Where floor

A large warehouse housed a printing works with heavy presses on the upper floor. Fire caused the steel roof structure to fail under its design load and caused deformation of the steel floor supports, allowing the machinery to hang into the area beneath.

collapse has occurred, it is common in older premises for fireplaces to remain in position on walls above ground level. These usually have a heavy stone or concrete hearth projecting into the air. It is dangerous to work beneath these as they have been known to fall some time after the fire.

Highly glazed buildings, typically office blocks and flats, demand special care in the initial approach. Where glass is still in place in damaged areas of the structure, large areas should be taped or marked off and access strictly controlled. This is particularly important in windy weather. Consideration should be given to the safe removal of potentially dangerous glass, the whole area being cleared while this is done.

Basements and cellars are prone to waterlogging and to retention of asphyxiant gases. Both these subjects will be dealt with later.

Other structural components may cause safety problems and each case must be treated on its merits. It is not possible to give guidance for every eventuality and the common sense and training of the investigator must be relied upon.

The '500 °C Rule'

A useful guide in assessing building safety is to remember that structural steel loses about half its strength at 500°C. In effect, this is the whole of its overload factor (safety margin) and therefore any additional load placed upon it at this stage is likely to cause collapse. Above about 630°C, it is incapable of bearing any more than its own weight and will fail under design loads (such as provided by concrete floors).

As a guide to whether parts of the building have reached these temperatures, at around 500°C any glass present will soften and slump and aluminium alloy fittings may begin to soften; by the time 650°C is reached, most aluminium alloys will melt and run freely and glass will mould around objects onto which it falls.

6 After-effects of Firefighting

Whatever the size of a fire, both the combustion products and any residual extinguishing materials may present a significant hazard. This section will describe the potential risks and suggest some ways to deal with them. Again, circumstances will vary with each incident and a common sense approach must be used.

Water

The main hazard of a waterlogged scene is the investigator's inability to see the floor and therefore assess the risks of walking on it. Even a shallow layer of dirty water can conceal major changes in floor level, steps, holes, low obstructions (for example, pallets) etc. These present an obvious potential cause of stumbling or falling. Basements and cellars cause particular problems; if water comes part way up the stairs it is often impossible to assess its depth, and hence the number of concealed steps. An unwary descent will result in a wetting at best, or a slip and possible drowning at worst. Excess water should be drained off wherever possible. It may be necessary to dig run-off channels or holes. Small submersible pumps, often available from the Fire Service, can clear water to a depth of about 25mm.

Another problem associated with large amounts of water is the possibility of back-flushing a foul drain or sewer. In this case, contaminated water could enter the boots or clothing. Various pathogenic organisms could be present, including the causative agent of Weil's Disease (leptospirosis). This is dealt with in greater detail in the section on 'Biological hazards'. Whilst the odour of such effluent would normally be recognised, it is good practice not to allow water to touch the unprotected hands or face in any case.

Leaking tanks and heating systems may carry a risk of Legionnaire's Disease if mists or sprays of contaminated water are inhaled. This is covered in the 'Airborne agents' section.

Foam

Fires are occasionally extinguished using foam. If this remains behind it can cause some problems. Low-expansion foams, which are simply water plus detergent, can usually be hosed away without difficulty. High-expansion foams, on the other hand, are often fluoroprotein based and very stable. These are difficult to clear and specialist help should be sought from the Fire Service. In both cases, movement through the foam is physically restricted and vision almost nil. As with water, obstacles and changes in floor level cannot be seen; a person falling into deep foam could easily be lost for long enough to suffocate.

Asphyxiant gases

Some gases such as carbon monoxide (CO) and carbon dioxide (CO_2) are produced during the fire, together with other noxious materials. This production is linked with a depletion in the oxygen content of the air. In addition, carbon dioxide and various halon gases are sometimes used in extinguishing fires. These are most commonly encountered as portable extinguishers or in fixed, automatic systems protecting such areas as computer rooms, switchgear, process plant and controllers etc. If such a system has operated, the oxygen may not be depleted but the adverse effects of the gas are still considerable. The best way of dealing with any suspected build-up of asphyxiants or low oxygen levels is of course thorough and sustained ventilation. Again, basements and other enclosed areas will present a special difficulty and specialist assistance may be needed.

Breathing apparatus can be considered if adequate specialist knowledge or guidance is available; ordinary respirator masks are not adequate protection against most asphyxiant gases or depleted oxygen. The use of this type of device against noxious vapours and combustion products will be considered later.

Dry powder

Generally found only in portable extinguishers, dry powder presents no serious risk to health. If a large amount has been used, irritation may be caused to the eyes and nose. Normal protective clothing, including dust mask and goggles, should alleviate the problem.

7 Industrial Processes and Stored Materials

Many commercial and industrial scenes present unfamiliar hazards to the fire investigator in consequence of the nature of the materials involved in the fire and/or the work being carried out. It is clearly impractical to address every possibility in this document. Each case must therefore be dealt with on its merits within the following guidelines. Further information is in the section covering 'Chemical hazards'.

Processes

Premises or areas in which unfamiliar or complex industrial processes are carried out should only be entered with professional help and advice. Any COSHH assessments which are available should be noted. The best source of general information will usually be a member of the management or workforce concerned, but on occasion this will be impossible. Suitable advice must then be sought from persons engaged in similar work, or from the Health and Safety Executive (factory inspector).

Stored materials

Information (including any COSHH assessments available) should be sought concerning the nature of any precursors, intermediates or products which may be involved or of any stored bulk goods (for example, in mixed use warehouses). Most of this will come from the operators of the site but if, for any reason, they cannot be questioned advice may have to be sought from elsewhere. The local factory inspector may have first-hand knowledge and the requirements of the Fire Precautions Act 1971 may mean that an inspection has been carried out by the Fire Service. Another useful source of very general information is the HazChem codes and other warnings, often around the main entrance to the premises.

Of course, where illicit manufacturing or processing (for example, of drugs of abuse) is being carried out, there is little chance that such information will be readily available. Advice must be sought from specialists skilled in the examination of these scenes, such as forensic drug analysts.

Bulk storage of flammable liquids poses particular problems, especially if there is leakage or escape of vapours. An obvious risk is that of ignition and the precautions outlined for mains gas and LPG (liquefied petroleum gas) (see 'Services') should be applied. A further hazard from vapours is that of inhalation, which can be mitigated by adequate respiratory protection and ventilation of the area.

The investigator must be aware of any potentially noxious materials or combustion products and take the necessary action to protect against them. A cartridge respirator may be useful if the oxygen concentration is adequate. It is worth noting that the Fire Service can provide specially trained and equipped personnel to advise on and deal with chemical hazards if requested.

8 Practical Precautions

Demolition and making safe

As already mentioned, partial demolition or shoring up of a structure may be required before it is safe to examine. In such cases it is essential for the investigator to liaise with the surveyor and contractor responsible. The person in charge of these operations must give express permission before the scene is approached by anyone other than the contractor's employees or sub-contractors. Failure to obtain such permission could leave the investigator in a legally vulnerable position, should an accident occur.

Hazards and escape routes

It is important that any potential hazards, once identified, should be clearly visible to any persons with a legitimate interest in the investigation. Similarly, the route(s) available for retreat from the scene in the event of an emergency should be apparent from both within and outside the building. Where either of these requirements are likely to cause problems (for example, concealed hazards, blocked escape routes), consideration should be given to marking with appropriate signs, incident tape etc. This may fit in well with scene preservation criteria such as marked entry routes.

Access

In the initial stages of viewing the scene, the investigator should consider what equipment is likely to be needed and how close it is reasonable to bring, for example, vehicles carrying tools. Obviously, bulky and heavy items should be moved by hand as short a distance as possible. It must also be possible to move the equipment to the area needed without further disrupting or damaging doorways, walls etc. If this is not possible, now is the time to consider modifying the scene to make it so.

Within the building, it is important to have enough room to work safely with the necessary numbers of people present. If space is restricted, numbers must be limited as accidents occur more easily in crowded conditions. In very confined spaces, there may be space for only one person at a time; if so, a second must remain as close as possible to render assistance if needed.

In larger buildings and those where some structural disruption has occurred, it is advisable to locate alternative exits in case the original entrance should become blocked or otherwise unavailable. It may also be necessary to consider whether certain spaces should be kept clear for rescue work in the event of an investigator being injured or trapped. Such events are fortunately rare and careful adherence to this safety code will minimise their likelihood.

Visibility

For safety and efficiency, fire scenes are best examined in full daylight and attendance should be postponed if possible until this is available. However, it is clear that on some occasions such ideal circumstances do not prevail. Dark areas of premises, fading winter daylight and night time examinations where delay cannot be permitted are all examples of poor visibility. In these cases, the only realistic alternative is adequate and comprehensive floodlighting.

Portable handlamps, although very useful for close examination and inspecting dark corners, are entirely inadequate for viewing the whole scene in context and for hazard appraisal. On occasion, smoke and steam from continuing firefighting operations may also obscure the view. Additional lighting will rarely overcome this and the best course of action is usually to withdraw and allow the Fire Service to ventilate the premises.

First Aid

All scene examiners should be familiar with the provisions of the Health and Safety (First Aid) Regulations 1981 and the amended Approved Codes of Practice, together with currently accepted procedures for emergency treatment. The investigator should have ready access to a first aid kit at all times (these are carried in each of the FIU vans and in all other police vehicles).

9 Services

The vast majority of premises in industrialised countries are supplied with one or more types of energy supply, water and some means of removing waste materials. All of these can present risks to the investigator in the aftermath of a fire or explosion.

Mains gas

In the UK mainland, the gas supply network operated by British Gas supplies only 'natural gas' which is almost entirely methane. It is normal Fire Service procedure to shut off the stop valve on the incoming supply pipe on arrival at the fire or as soon as possible thereafter. Should this valve be inaccessible for any reason, the supply authority is usually summoned to isolate the incoming pipe at a remote location (usually under the roadway outside). Where an installation has been disrupted and gas escaping from the mains supply has ignited, flaring often occurs. In these cases, the gas will be allowed to burn until the supply is disconnected in order to prevent potentially explosive gas levels building up.

In most fires, turning off the stop valve will prevent further gas escape from the 'carcase' (fixed piping within the building) and the meter, even though these may be badly damaged. After many fires, the supply authority will have attended in order to remove the meter, cap internal pipes etc. Should the distinctive odour of 'gas' become apparent during an investigation, the stop valve should first be checked to ensure it is off. (In fact the odour has been deliberately added as an aid to the detection of gas.) If the odour persists for more than a few minutes, the supply pipe is probably leaking and the local emergency gas service must be called at once. The obvious major hazard of a gas leak involves ignition sources which may start a fire or explosion.

To minimise the risk, therefore, some simple steps can be taken pending isolation. Firstly, all ignition sources must be removed; as well as the obvious cigarettes and matches, electrical equipment, internal combustion engines (for example, generators) and high temperature surfaces are such potential hazards. However, operating electrical switches may cause sparks. This must be considered when deciding whether to switch off.

'No Smoking' signs should be prominently displayed at every entrance to the scene or at the perimeter of an established cordon around it and strictly enforced. Suitable signs are carried on the Fire Investigation Unit (FIU) vans. If possible, all personnel should be withdrawn until the supply is disconnected.

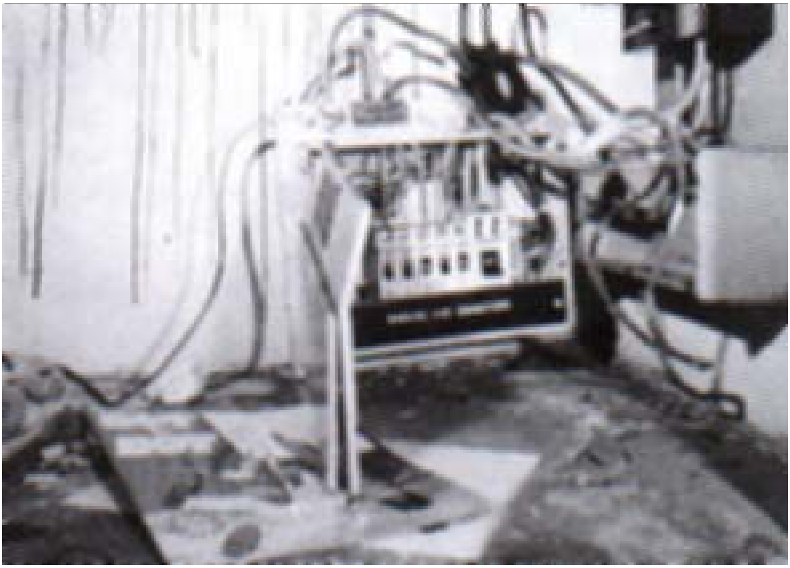
Liquefied petroleum gas (LPG)

Several flammable gases, refined from natural sources, are sold as forms of LPG. These include butane, propane and mixtures of these with other gases in smaller proportions. LPG is so-called because it is stored as a liquid under pressure in cylinders (bottles) or larger tanks. It is widely used both by consumers wishing to burn gas but remote from the mains supplies and by those requiring a portable gas source. The larger fixed installations are often unfamiliar to the Fire Service (except in those parts of the country where this is the normal supply type) and the stop valve may therefore be left open more often than with mains gas. Hazards associated with leakage are similar to those of 'natural gas' although the gas is more dense than air and can therefore pool at low level. Special ventilation measures may then be needed. Otherwise, precautions should be identical to those for methane. The supply company may not have an emergency service facility close by and local contractors may have to be used.

In addition, there is a specific risk associated with strong heating of a pressurised container of LPG. If the safety venting system fails or is inadequate, internal pressure can rupture the heat-weakened container wall, releasing a cloud of gas which can readily ignite and even explode. Such a situation, known as a 'Boiling Liquid Expanding Vapour Explosion' or BLEVE, is extremely dangerous. No investigator should attempt to approach any LPG fuelled installation or appliance until the fire has been extinguished and the tank or cylinder cooled.

Other cylinder gases

Many types of gas are supplied under pressure in metal cylinders for industrial, medical and domestic use. Some of them are flammable



When ensuring that the electrical supply system is disconnected, unorthodox wiring such as this illegal meter by-pass can cause confusion. Sometimes the main switch or company fuse itself has been by-passed and the installation is still live.

Some assist burning, others are inert. Some even act as effective fire extinguishing agents. However, when heated strongly as in a fire, any of them can explode due to the high pressures generated inside. If the contents are flammable, a BLEVE may result while release of combustion supporters such as oxygen or compressed air can lead to a catastrophic increase in fire intensity. Firefighters normally remove any cylinders from the vicinity of the fire and cool them with water; if possible, they will be vented to atmosphere. In the unlikely event of an investigator finding a hot or distorted cylinder inside the scene, the Fire Service should be recalled at once and all personnel withdrawn until the situation is dealt with.

Electricity

Most occupied premises in this country are supplied with mains electricity. The Electricity at Work Regulations 1989 deal with the safe use of electricity in the course of employment, encompassing both the supply normally present in a building and any other supply introduced for the purpose of undertaking the investigation (eg lighting, cutting tools). The FIU has developed an internal Code of Practice for safe working at scenes within the provisions of these regulations (published separately). It is mandatory for any person within the FIU, or for anyone working under the direct supervision of such a person, to comply with this Code. It is strongly recommended that other investigators, whether in the public or private sectors, develop their own Code of Practice along similar lines and have it validated by a qualified electrical engineer or nominated representative of the supply authority. If in doubt, consult the Institution of Electrical Engineers.

Supplies to buildings may be single- or three-phase AC mains or power from a local generating set. In the UK, mains supplies are nominally 240V rms phase to earth and 415V rms phase to phase. Generators may supply any AC or DC voltage to the customer's requirements, but the most common are 240V or 110-120V AC and 12V DC. The same safety procedures apply in all cases and the remainder of this section is subject to the provisions of the FIU internal Code of Practice. Firstly, the state of the main isolator switch should be checked. Firefighters often switch this off when they attend, but it may have been missed or even reset after the fire.

If it is not possible to tell whether it is off for any reason, the main fuse may need to be removed. In any case, the wiring should then be checked for zero supply voltage. Exposed metalwork, for example, plumbing pipes and structural steel, should also be checked; in older installations the earthing paths may result in a damaged or wrongly connected input cable imparting a voltage to these components.

Before work commences in industrial premises ensure, where appropriate, that all phases of the supply are isolated and be conscious that some sites may have more than one electrical intake.

A very serious risk is that of accidental penetration of the main input cable. Although normally armour sheathed, vigorous excavation can cause it to be broken by tools like picks and shovels. If the path and condition of this cable cannot readily be seen, the supply authority should be asked to disconnect the cable at its junction outside the building. This action is often requested by the Fire Service.

On occasion it may be necessary to reconnect the supply to part of the building wiring in order to test a piece of equipment in situ or a hypothesis about the electrical system. Any such work must be done only in strict compliance with the Code of Practice, the investigator having taken steps to ensure that only the desired circuit(s) become live by removing fuses or supply connections from all the others or other suitable means. This practice should not be adopted routinely and, if there is any doubt, technical assistance should be obtained. In any case, this is always a last resort.

Water

(See also 'after effects of firefighting')

The presence of large amounts of standing or running water at a scene is often more inconvenient than hazardous. However, certain risks are involved; the danger of obscuring the floor and concealing changes in level has already been mentioned. Wet surfaces are also likely to be slippery, particularly if tiles or similar smooth finishes are involved. This can obviously cause falls which may lead to injury. Running water from a fractured pipe, overflowing tank or burst central heating system, invariably falls precisely on the area which the investigator needs to examine in detail! Clearly, this can lead to chills and other problems associated with exposure to cold, wet conditions. It also makes concentration difficult and therefore dangerous mistakes are more likely.

Domestic premises usually have a readily located stopcock, although after a fire this may be difficult to operate. In many commercial buildings, any isolation of the water supply will have to be carried out by the supply authority. This will often involve disconnecting pipes outside the premises. A request for their attendance may have been made by the Fire Service; if not, emergency call out numbers are readily available in most areas. Drainage of the accumulated water has already been discussed.

Drains

The main risk occurs when fire has damaged lead, ceramic or PVC soil pipes allowing liquid and solid excreta or other waste (such as kitchen or hospital residues) to escape. Care should be taken to wear adequate protective clothing, including waterproofs where necessary, to conform with the general precautions concerning biological hazards (see later) and avoid using or allowing others to use toilets and sinks in the building. The possibility of the drains having been backflushed by firefighting water should be considered, as already discussed.

Waste disposal

Solid waste, such as kitchen refuse, is usually only present in a building in relatively small amounts for example, pedal bins or waste paper baskets, and perhaps in larger amounts in dustbins outside. However, every investigator will encounter some scenes where the usual standards of cleanliness simply do not apply. The examination of these, as in those cases where contents of bins need to be checked, must be conducted with a full awareness of the proper level of protection against biological hazards, including being aware of the dangers of hypodermic syringes and needles. This will be addressed in a later section. On occasion, building collapse will expose the interior of rubbish chutes. These should be treated in the same way.

10 Vehicles

There are extra safety considerations involved in the examination of fire-damaged vehicles. Most of the following relates to road vehicles, although some points will be relevant when dealing with aircraft, ships etc. However, the investigation of fires involving non-road transport is a specialist subject and it is advisable to seek further guidance from suitable texts or practitioners in this field.

Fuels and lubricants

Apart from the obvious risks associated with ignition of leaking or residual fuel, which are covered under 'Stored materials' and 'Services', contact with liquid fuels, oils and greases can cause dermatitis. In addition, inhalation of fuel vapours can be very hazardous, especially if working in an enclosed space. Adequate skin and breathing protection should be used and the area kept ventilated.

Fluoroelastomers

In many modern engines and transmission systems there are oil seals, O-rings and other sealing components manufactured from synthetic polymers containing fluorine. If these decompose under high temperature conditions, in a fire or certain types of mechanical failure, hydrogen fluoride gas may be produced. This will immediately react with any available water (including moisture in the air or in the respiratory tract) to produce hydrofluoric acid, which is a highly corrosive and toxic material. This acid is extremely dangerous by contact and inhalation and it is therefore imperative to use adequate protective clothing (and respiratory protection where necessary). Any suspected exposure must be reported to a hospital or medical practitioner without delay and suitable first aid treatment given immediately. In practice, if such components have been flushed with large amounts of firefighting water, the risk is likely to be minimal but care should always be taken. If any parts of the vehicle or protective clothing are thought to be contaminated with hydrofluoric acid, expert advice should be sought as to disposal methods.

Gas filled dampers

These are most often encountered as dampers on supporting struts, such as on hatchbacks and tilt-cab supports, although they are sometimes found as suspension components, more commonly on high performance vehicles.

Although the greatest risk from these dampers is that of explosion whilst the fire is in progress, it is possible for them to fail explosively after the fire if the metal parts have been affected by heat. Care should be taken when moving or disconnecting such components.

Crash and impact protection

Many modern cars and some other vehicles are fitted with a variety of devices intended to protect the occupants in the event of a road accident. If these have not been activated, they can present potential risks when examining the vehicle.

Air bags are intended to inflate rapidly when required. This is accomplished by using a small charge of sodium azide which decomposes explosively. Should the investigator unwittingly trigger the device, he could be pushed by the expanding bag into danger; if the bag itself is already cut or torn, the sudden release of gas can have similar effects as well as violently propelling small objects. Sodium azide is also highly toxic as a solid and reacts with water to give the highly corrosive sodium hydroxide.

Cable systems fitted to some vehicles are intended to pull the engine block away from the passenger compartment in an impact. Some of these use pre-tensioned cables which will part violently if cut through, for example, when removing body parts for access using hydraulic or disc cutters.

Some convertible (open-top) cars are now being fitted with auto-erect roll protection, comprising a roll bar or cage which is activated instantaneously and with considerable force when a given angle of roll or pitch is exceeded. The investigator should take this into account when deciding on the best approach to jacking or rolling a vehicle to gain access to the underside.

The unitary construction of many modern cars can result in sudden failure of the structure if stressed members have been cut, for example during rescue attempts. There may also be sharp edges and corners as a result of these activities.

It is important for the investigator to be aware of the systems in use in the vehicle being examined; close liaison with the manufacturer or dealer may be required.

Electrical systems

Most vehicle electrical systems operate on low voltage DC (usually in the range 6-24V), but with the potential for very high current flows. Although the low voltage means that serious shocks are unlikely, the heating effect of very high currents can cause severe burns as well as such effects as welding tools to metal parts. The precautions needed are much the same as when dealing with mains electricity (see 'Services').

There are also high voltages associated with the spark ignition systems of petrol and LPG engines. These can deliver a painful shock but the current is too low to cause serious harm. In any event, these circuits are only live when the engine is running and are therefore unlikely to affect the investigator.

Most batteries fitted to vehicles are of the lead-acid type; in the rare event that such a battery is severely disrupted by the fire, sulphuric acid is likely to escape. This is fairly concentrated, although likely to have been diluted by firefighting water. Normal precautions for dealing with corrosive liquids should be applied.

11 Other People at the Scene

At almost every fire scene, various people are present with a legitimate interest in, and some rights of access to, the area of interest. There is usually another group with no legitimate concern, but unlimited interest in the proceedings. The latter will be excluded from consideration here, as they should be from the scene; the most effective way to accomplish this is a uniformed police presence. If an investigator cannot arrange this, then adequate roping or taping off with signs indicating the danger of entry should be placed at a suitable distance from the scene. Those persons allowed access must also be kept safe; as already made clear, in the absence of a Fire Service safety officer (if the brigade has withdrawn) or an inspector from the HSE, much of the responsibility for the safety of others falls upon the investigator. He should ensure:

(a) that no-one enters without adequate protective clothing;

(b) that people with little experience of fire scenes (for example, lawyers, witnesses, undertakers, press) are escorted at all times;

(c) that other specialists are warned of specific hazards present in or around their area of interest; and

(d) at large scenes, where individuals could be out of sight and hearing, that an effective logging in and out system is set up. (This is often done by a police officer at the main entrance.)

Other specialists working independently assume much of the responsibility for their own safety. However, they should be left in no doubt as to what is considered permissible behaviour and if they persist in potentially dangerous conduct should be asked to desist and/or sign a disclaimer. A refusal leaves the investigator with no choice but to leave the scene himself and report the matter to the HSE.

12 Safe Working Practices

The processes of gaining access to, clearing and reconstructing the fire damaged scene present a number of risks associated with the use of tools and equipment and the movement of the contents.

Access aids

The most important mechanical aids to access are ladders, although scaffolding, crawling boards and building props may also be needed from time to time. Demolition or repair contractors will normally be responsible for the erection of scaffolding or for propping up (for example, with 'Acrow' jacks), on the instructions of a surveyor. They are required to perform these tasks to a secure standard and the surveyor will normally inspect the work on completion. It is therefore reasonable to assume that such installations are safe to use.

Great care should still be taken when ascending, descending or working from scaffolds; ladders must be used to move between levels, only firmly fixed boards may be used as working platforms and the possibility of tools or other items being dropped from a height must always be considered. If jacks or other building props have been installed, it is important not to knock into them or to disturb the base or top section in any way.

Crawling boards (or scaffold boards) are useful for bridging holes in floors etc. The two most important factors in using these safely are that the board itself will bear the load and that the structure on which it rests is stable. The investigator must therefore ensure that only a board intended for this purpose is used, it is in good repair with no major cracks or splits and it is supported at intervals of not less than 1.2m; he must also be satisfied that the structural members (for example, joists) are strong and secure enough to support the additional load. This may include the body weight of one or more scene examiners and potentially a wheelbarrow full of debris.

Ladders are used in all manner of shapes and sizes. Steps, often useful for checking fuseboxes etc, must be fully opened, braced and on a firm, level footing. Roof ladders must only be climbed if hooked over the pitch. Straight and extension ladders must be:

(a) on a firm, level footing (which can be dug out or built up if necessary);

(b) at an angle of approximately 30° to the vertical;

(c) firmly supported and preferably tied at the upper end;

(d) braced by a fixed, heavy object or second person at the foot (the second person is obligatory if the ladder is not tied at the top).

It is important not to over-reach when working from a ladder and to remember that extending a heavy object may cause the ladder to slip sideways.

To climb a ladder, it is much better to grasp the rounds (rungs) firmly with the hands and use a hand over hand action than to hold the stiles (sides). Descent should be by the same method. It is dangerous to attempt to descend with the back to the ladder. Ladders should not normally be used as crawling aids for bridging horizontally; they are not designed to carry loads in this orientation.

Clearing debris

In the initial assessment of the scene, it is important to address the quantity of debris needing to be removed and the best way of taking it out. It is tempting, and sometimes possible, to throw debris out of a window so long as great care is taken to ensure that no-one outside the scene can be struck by it. This may require limiting access to certain areas. In larger premises, it is usually possible to find an area which will not need later excavation into which to throw debris; again, care is needed as other persons may wish to enter this area and taping off may be worth consideration. If there are holes in the floor, it may be possible to push debris through; where another storey is beneath, access to it will need to be prohibited during the clearance.

Use of hand tools

Generally, the hazard from these falls into two categories: 'impact' damage to the investigator or others (such as stabbing, cutting, crushing) and 'postural' damage limited to the tool user. The former is often a result of using a tool in a confined space, at an awkward angle or position or simply choosing the wrong tool for the task. Most such injuries can therefore be avoided by taking some simple precautions, such as: not allowing overcrowding in the work area; taking time to consider the problem and changing the approach if necessary; ensuring that tools are used only for their designed purpose and therefore changing implements when required. An important consideration when using tools with a cutting edge is to keep the whole of the body behind it, not cutting towards the user.

The second group, typified by back strains, pulled muscles etc, are the result of holding or using the tool wrongly or, again, using the wrong one for the job. Many such problems arise from physical peculiarities of the scene itself, such as uneven debris on the floor, limited access or changing angles of attack as excavation progresses. To minimise such problems, the scene must be thoroughly assessed and work planned to take place in the most efficient way. Under most circumstances this will also be the safest. An early indication of likely 'postural' injury is often a general perception that the work is awkward or uncomfortable; this is a danger sign and the method should be adjusted.

Use of power tools

It is relatively rare for an investigator to resort to power tools during scene clearance. However, many fire scene examiners carry, or have access to, such equipment. Examples include light cutting tools, drills, and lighting. These obviously need a power source, usually a portable generator or transformed mains supply. The electrical safety of such equipment and its supply falls within the provisions of the Electricity at Work Regulations, which have already been discussed. The safe use of the tool itself is largely a matter of common sense, familiarity with the maker's instructions and training. The same considerations apply as for hand tools; the working area must be clear, posture good and cutting edges away from the user. If abrasive cutting discs are used, these must only be fitted or removed by a person familiar with the equipment and trained under the provisions of the Abrasive Wheels Regulations. It is an offence under the HSWA for an untrained person to do this.

The two main risks associated with floodlights are the high temperatures often reached by the casing or other accessible parts and the potential for explosive failure of the bulb if water falls on it. Both of these can usually be avoided by careful siting.

13 Particulate Materials

Inhalation of any fine particles is a potential hazard and steps should be taken to prevent it. Dust has already been mentioned in general terms; prolonged or repeated exposure to finely divided concrete, stone, plaster etc could lead to lung disorders. Even finely divided charred wood may not be innocuous. Various toxic and carcinogenic chemicals, resulting from decomposition of materials in the fire, are likely to be present on the particle surfaces and can therefore find their way into the body. Protection against all these dusts can normally be afforded by use of an appropriate respirator, conforming to BS 2091 and selected for use according to the recommendations of BS 4275. The combination of gas cartridge mask and prefilter issued to FIU staff is suitable for this purpose. Of course, any mask must be fitted correctly and worn throughout the exposure period.

Asbestos

Exposure to asbestos fibres is hazardous. If inhaled, they may lodge in the airways and lungs, causing serious diseases at a later date. There are three main types of asbestos, commonly known as blue, brown and white. Fire investigators are recommended to consult specialist texts concerning the recognition of these materials.

In some industrial buildings, older style flats and system-built housing, asbestos lagging and insulation can still be found, often composed of the much more dangerous 'blue' or 'brown' fibres. This should be treated with extreme care and expert advice must be sought immediately. In the first instance, the local Environmental Health Officer can be approached. It should not be touched or disturbed in any way and will continue to shed fibres even when wet. These can be transferred via clothing or hands to the face and inhaled. If the asbestos appears loose or dusty it should not be approached. Removal of such asbestos is a skilled exercise, carried out by specially equipped contractors. Their advice, or that of the Environmental Health Officer, must be heeded.

Most of the asbestos encountered at fire scenes is in the form of asbestos cement, in which the least harmful type of fibres are firmly bonded in a cement matrix. When this breaks up, unless it is actually powdered, very few fibres are released into the air. Sometimes asbestos board is found. This is a highly compressed form with an inert facing material on either side. Little or no escape of fibres occurs unless the board is violently penetrated, for example by cutting or drilling. Release of asbestos from both board and cement is greatly inhibited if they are wet, as is usually the case after a fire. Further damping down can normally be organised if necessary.

If the presence of airborne asbestos fibres is suspected but work cannot be stopped for some reason, it must only continue when :

(a) all unnecessary personnel have been excluded from the area and

(b) remaining persons are wearing breathing protection which at least complies with BS 2091 and has HSE Asbestos Regulations approval. (The respirators issued to FIU staff fulfil these criteria.)

14 Chemical Hazards

It is not possible to list here all the chemicals, including mixtures and common household preparations, which it is possible to encounter at scenes of fire. There are broadly speaking two potential risks; inhalation of gases, fumes or dusts and direct contact with corrosive, noxious or harmful materials (especially liquids). In addition, there is a possibility of flammable liquids and/or vapours being present and therefore an ignition risk. This can be precluded by adopting the safety precautions described for mains gas and LPG.

Inhalation

If the presence of harmful gases or fumes is suspected, a suitable gas cartridge respirator complying with BS 2091 must be worn. Examples are combustion products, pesticide residues, solvent vapours and industrial feedstock. Note that this advice only applies if the oxygen level is normal; in oxygen-depleted environments, specialist advice must be sought as already discussed. Where the gases also have a lachrymatory effect, close-fitting eye protection will be needed.

Direct contact

Normal protective clothing, including waterproofs, will prevent injury from most of the common water-miscible chemicals. Again, eye protection is important. Many of the solvents encountered, however, will penetrate the normal protective clothing and specialist advice must be sought if such a liquid is suspected. A particular problem is the use of fluorinated rubber seals in some vehicle and engineering applications; these can be decomposed by heat to produce highly corrosive hydrofluoric acid. It is important to remember that even commonly encountered liquids (such as petrol and paraffin) can cause dermatitis and therefore the normal handling precautions must be observed. In an industrial or commercial setting, there should already be a COSHH assessment for any chemical present on site; this will give the investigator guidance on how best to handle the risk. The Fire Service operates a system for the safe containment, dispersal or disposal (as appropriate) of chemical spillages and their advice should be sought if there is any doubt as to the materials involved.

15 Biological Hazards

Again, there are far too many individual risks posed by bacteria, viruses, fungi etc to list them all. It is possible to list the various means of transmission and deal with the most serious hazard and the best method of control. Generally, protection depends on good standards of hygiene, especially washing of hands and not eating, drinking or smoking in contaminated areas. All scene examiners should have up to date immunisation against tetanus and hepatitis-B.

Blood and body fluids

Although HIV is rightly considered to be a major danger, hepatitis-B is far more prevalent, more persistent and just as serious. Current guidance within the Metropolitan Police Forensic Science Laboratory is to treat all such fluids as potentially hepatitis-B infected and to adopt control measures to reduce risk to a safe minimum. Compliance will also protect against other blood-borne organisms. This involves a number of actions on the part of the investigator:

(a) all open wounds must be covered with waterproof (not washable) adhesive plasters;

(b) waterproof disposable gloves must be worn;

(c) where possible, disposable overalls and plastic overshoes should be worn. If these are inadequate (due to the rigours of the scene), cloth overalls must be laundered and footwear cleaned immediately afterwards;

(d) if dried blood or other fluids are present, or aerosols could be formed, breathing protection must be worn (see under 'Particulate materials');

(e) after exposure, all disposable clothing must be placed in a suitable container and sealed, while other items (for example, boots) must be thoroughly washed in a 1% hypochlorite solution (or domestic bleach diluted 1:10 with water) or other approved disinfectant.

Puncture wounds from potentially contaminated items, such as syringe needles and weapons, should be given first aid treatment and medical assistance sought at once.

Waterborne diseases

Leptospirosis has already been mentioned. Also known as Weil's Disease, this is a form of hepatitis transmitted from infected rats via their urine. The bacteria can be present in contaminated or untreated water. There are numerous other pathogens possibly present in dirty water. Provided the same general instructions are followed as for blood, that is, to protect against hepatitis-B, there should be little chance of infection.

However, it is not always obvious when contaminated water is present and the disposable clothing may not be in use, although open wounds must be covered and gloves used at all times. If it is thought that exposure may have occurred, all wounds should be swabbed with disinfectant immediately. Any flu-like symptoms which develop must be reported to a GP or hospital emergency department at once. If left untreated, Weil's disease has a 50% mortality rate.

Airborne agents

These include bacteria, fungal spores and various allergens, together with mists or aerosols of contaminated fluids (see above). The Legionella bacteria which can cause Legionnaire's Disease may be inspired in water sprays or mists from contaminated sources. Breathing protection as described under 'Particulate materials' should be worn when necessary.

Parasites and infestations

In many scenes, there are parts which are less heat damaged and in which parasitic organisms and pests such as cockroaches could survive. There is also a possibility of coming into contact with these from clothing and victims. Good personal hygiene is the best safeguard against infestations; wearing of adequate protective clothing, followed by bathing or showering, will normally suffice. If an infestation persists, medical advice should be sought.

Animals

Domestic pets, livestock and vermin (for example, rats, mice) may be encountered. These will often be distressed by the fire and subsequent activities and may be aggressive. Any bites or scratches inflicted by them should be given appropriate first aid treatment and medical advice obtained.

Handling fatalities

Where dead bodies of humans or animals are examined or moved, the precautions required for blood and body fluids must be observed. In addition, care is required in lifting or removing victims as they are often heavy and awkwardly positioned. This can result in unexpected strain on the investigator's back or limbs leading to injury.

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