National Operational Guidance Programme

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Title:	Subsurface, height, structures and confined spaces
Project Executive:	Steve Apter, Director of Safety and Assurance, LFB
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National Operational Guidance – Subsurface, height, structures and confined spaces first edition version one (ARCHIVED on 20-09-2017)

Introduction

National Operational Guidance is divided into three main activity categories: fires and firefighting, performing rescues and hazardous materials. All these activities take place in certain contexts. Some hazards apply to all activities but how they are controlled depends on the context of the incident.

This National Operational Guidance sets out the high-level knowledge, hazards and actions that should be considered in operations occurring subsurface, at height, in confined spaces and within/around collapsed or unstable structures. These are some of the most complex areas that fire and rescue services work in and include both geological and manmade structures.

Fire and rescue services frequently attend incidents that involve a combination of these contexts, where danger to operational crews and the public is significant. This guidance aims to promote and develop good practice and to support the development of safe systems of work to minimise the dangers faced by fire and rescue services in these environments. It also supports the development of intervention strategies and operational procedures.

This guidance specifically deals with potential hazards occurring subsurface, at height and in structural and confined space environments. It also suggests a number of potential control measures and links to other National Operational Guidance. Fire and rescue services can build on this guidance in line with their local risk assessment. This guidance may suggest further information to be considered when reviewing the hazard and control statement and the resulting guidance.

The guidance should be read in conjunction with other pieces of National Operational Guidance.

When reference is made to working with other agencies, please refer to the Joint Emergency Services Interoperability Principles (JESIP) Joint Doctrine for further information.

Relevant knowledge

To make an effective response, each fire and rescue service needs a consistent approach that forms the basis for common operational practices and supports interoperability between fire and rescue services, other emergency responders, infrastructure managers and users.

Fire and rescue service boundaries mean that different services may attend an incident. A joint approach is therefore essential. Understanding the typical hazards faced by incident commanders in these environments and adhering to the relevant control measures will ultimately lead to improved public and firefighter safety.

At an incident, the highest priority for fire and rescue services will always be the safety of the public and responders. Effective and informed action by responders can reduce hazards and help ensure the safety of the public and responders.

Large-scale incidents involving any structure during construction or in use are unusual, which makes it difficult for fire and rescue services to gain experience and test procedures, but the fundamental principles of operational response remain the same. All fire and rescue service personnel liaising with contractors or infrastructure managers should receive appropriate training in the skills and techniques required. It is also crucial that the statutory duties and limitations placed on the fire and rescue service, and those of the relevant duty holder, are examined and that those managing such projects understand this underpinning knowledge.

Although certain hazards will be common to all incidents, the environment in which they occur will vary. This is particularly the case during construction, where access and intervention will require specific strategies and procedures.

During an incident at a fully functioning structure, such as a road or rail tunnel, fire and rescue services may have the additional pressure of maintaining business continuity, especially where the incident has a significant impact and wide disruption is likely. From a fire and rescue service perspective, business continuity should be considered relative to the impact the incident has on the local community and economy. The most important consideration will always be the safety of emergency service personnel and the public.

At all incidents, it will be necessary to preserve the scene for investigation purposes both during and post-operation. Other organisations may have to carry out their own investigations. The police, British Transport Police, Office of Road and Rail, Rail Accident Investigation Branch, as well as local agencies, will all need to be considered when dealing with certain subsurface-related incidents.

Fire and rescue services will regularly work at height at incidents, along with general day-to-day activities that require personnel to take measures to protect themselves and others from the risk of falls. Working at height may be achieved safely using a variety of equipment and techniques.

Environments that require personnel to work at height can be found above and below ground, in urban and rural areas, in natural and manmade structures, and in both operational and non-operational scenarios.

For the purpose of this guidance, above-ground structures do not generally include buildings, unless the condition of the building requires the use of work at height equipment, such as when stairways and lifts have been compromised and aerial appliances, rope rescue or similar might be used to resolve the incident. Structures such as wind turbines and scaffolding will nearly always require specific work at height equipment.

Legislation clearly defines a confined space, and operating in these environments requires core and specialist skills, including techniques for working at height. Other areas that do not satisfy the specified risks for a confined space may be as challenging owing to varying degrees of difficulty in access and egress. Dealing with these environments will require similar skill sets and equipment as those for confined spaces.

Incidents involving underground structures may also require varied techniques and specialised equipment, including those needed for work at height and in confined spaces. In this guidance, underground structures may be referred to as subsurface or below-ground structures, depending on the context.

All or any of the above may involve a collapsed or unstable structure, and as such could include a combination of hazards.

Legislation

Civil Contingencies Act 2004

The Civil Contingencies Act 2004 (Contingency Planning) (Scotland) Regulations 2005

The Civil Contingencies Act 2004 (Contingency Planning) (Amendment) Regulations 2012 (The 2012 regulations)

Confined Spaces Regulations 1997

Confined Spaces Regulations (Northern Ireland) 1999 (The Regulations)

Control of Substances Hazardous to Health Regulations 2002

Corporate Manslaughter and Corporate Homicide Act 2007

Dangerous Substances and Explosive Atmospheres Regulations 2002

Dangerous Substances and Explosive Atmospheres Regulations 2002

The Environmental Damage (Prevention and Remediation) (England) Regulations 2015

The Environmental Damage (Prevention and Remediation) (England) (Amendment) Regulations 2015

The Environmental Damage (Prevention and Remediation) (Amendment) (Wales) Regulations 2015

Environmental Permitting (England and Wales) Regulations 2010

Fire (Scotland) Act 2005

Fire and Rescue Services (Emergencies) (England) Order 2007

Fire (Additional Function) Scotland Order 2005 [Scotland]

Fire and Rescue Services (Emergencies) (Wales) Order 2007

Fire and Rescue Services (Emergencies) (Northern Ireland) Order 2011

Fire and Rescue Services (Northern Ireland) Order 2006

Fire and Rescue Services Act 2004

Health and Safety (Consultation with Employees) Regulations 1996

Health and Safety at Work etc. Act 1974

Health and Safety at Work (Northern Ireland) Order 1978

Lifting Operations and Lifting Equipment Regulations (Northern Ireland) 1999

Lifting Operations and Lifting Equipment Regulations 1998

Management of Health and Safety at Work Regulations 1999

Management of Health and Safety at Work Regulations (Northern Ireland) 2000

Personal Protective Equipment at Work Regulations 1992

Personal Protective Equipment at Work Regulations (Northern Ireland) 1993

Police and Criminal Evidence Act 1984

Provision and Use of Work Equipment Regulations 1998

Safety Representatives and Safety Committees Regulations 1977

Work in Compressed Air Regulations 1996

Work in Compressed Air Regulations (Northern Ireland) 2004

Work at Height (Amendment) Regulations (Northern Ireland) 2007

Work at Height (Amendment) Regulations 2007

Work at Height Regulations (Northern Ireland) 2005

Work at Height Regulations 2005

Risk management plan

Each fire and rescue authority must develop a strategic direction through a risk management plan. To determine the extent of their firefighting and rescue capability, strategic managers will consider their statutory duties and the reasonably foreseeable risk in their areas.

Work to identify risk and prepare operational plans should consider all stakeholders, including local emergency planning groups, and the fire and rescue service risk management plan.

When developing risk management plans and strategies, fire and rescue services should also take into account any other organisations, either voluntary or for-profit, that provide rescue services in their area. They may include:

- Mountain rescue
- Cave rescue
- Mines Rescue Service
- Industry-related rescue teams

Responsibility of fire and rescue services

Fire and rescue services are responsible, under statutory legislation and regulations, for developing policies and procedures. They must also provide personnel with information, training, instruction and supervision on foreseeable hazards and the control measures used to prevent or limit risks arising from them.

This guidance aims to provide fire and rescue services with sufficient knowledge about the hazards that could be encountered by personnel attending incidents occurring subsurface, at height, in a confined space or a collapsed/unstable structural context. Fire and rescue services should ensure that their policies, procedures and training cover all hazards and control measures outlined in this guidance.

Hazard and control statement

Hazard	**Control measures**
Work at height	
Work at height environment	Situational awareness Establish appropriate cordon control Consider requesting specialist resources
Unguarded edges	Use appropriate work equipment Use a secondary system or build in redundancy Establish appropriate cordon controls Implement incident ground safety management
Fragile surface or ground conditions	Situational awareness Establish appropriate cordon controls Use appropriate work equipment Implement incident ground safety management
Failure of supporting structure	Establish appropriate cordon controls Implement incident ground safety management Assess and monitor structural integrity
Adverse weather conditions and microclimates	Access weather forecast information Minimise exposure to the working environment Monitor crews exposed to the working environment Consider welfare Wear appropriate personal protective equipment (PPE)
Unsecured items falling from height	Use essential items only Secure items used at height Establish appropriate cordon controls Implement incident ground safety management
Contaminated or damaged work at height equipment	Protect work at height equipment in use Manage, inspect and test equipment

Hazard	**Control measures**
Hazard	Control measures
Confined space	
Flammable or explosive atmosphere	Avoid entry Carry out atmospheric monitoring Consider ventilation Isolate or limit ignition sources Isolate or limit gases, liquids or other flowing materials Use intrinsically safe equipment Implement supervision arrangements Establish effective communications Maintain safe access and egress Wear appropriate personal protective equipment (PPE) and respiratory protective equipment (RPE)
Extremes of temperature or humidity	Avoid entry Consider ventilation Implement supervision arrangements Establish effective communications Maintain safe access and egress Limit working time Wear appropriate personal protective equipment (PPE) and respiratory protective equipment (RPE)
Irrespirable atmosphere	Avoid entry Carry out atmospheric monitoring Remove residual sludge or other deposits Isolate or limit gases, liquids or other flowing materials Consider ventilation Implement supervision arrangements Establish effective communications Maintain safe access and egress

Hazard	**Control measures**
	Wear appropriate personal protective equipment (PPE) and respiratory protective equipment (RPE)
Ingress of water or liquid	Avoid entry Isolate or limit liquids Implement supervision arrangements Establish effective communications Maintain safe access and egress
Free-flowing solids	Avoid entry Isolate or limit free-flowing materials Use appropriate work equipment Implement supervision arrangements Establish effective communications Maintain safe access and egress Wear appropriate personal protective equipment (PPE) and respiratory protective equipment (RPE)
Confined space working environment	Situational awareness Use safe person principles Establish appropriate cordon controls Identify alternative access/egress Consider using tag lines Have an effective recovery system Provide lighting
Ineffective communications	Deliver effective crew briefings Establish effective communication
Working at height in a confined space	Establish appropriate cordon controls Use appropriate work equipment Have an effective recovery system
Unstable natural or built environment	Consider shoring Implement supervision arrangements Have an effective recovery system

Hazard	Control measures
Biological hazards	Manage risk from biological hazards Manage risk from waterborne contaminants Have hygiene arrangements in place Establish firefighter decontamination Wear appropriate personal protective equipment (PPE) and respiratory protective equipment (RPE)
Chemical hazards	Have hygiene arrangements in place Establish firefighter decontamination Wear appropriate personal protective equipment (PPE) and respiratory protective equipment (RPE)
Electrical equipment and services	Isolate electric supply
Moving vehicles, plant and machinery	See National Operational Guidance: Industry
Hazard	**Control measures**
Above-ground structures	
Lightning	Consider stopping work
Sources of high-voltage electricity	See National Operational Guidance: Utilities and fuel
Sources of non-ionising radiation	Consider adherence to local restrictions and signage Manage risk from non-ionising radiation
Uncontrolled movement of machinery or structure	Isolate and lock out power supply
Restricted access and egress	Seek alternative routes Use appropriate work equipment
Ineffective communications	Deliver effective crew briefings Select and use appropriate communication equipment Maintain visibility with operators
Unstable natural or built environment	Consider shoring Assess and monitor structural integrity

Hazard	**Control measures**
	Implement incident ground safety management Establish appropriate cordon controls
Biological hazards	Manage risk from biological hazards
Hazard	**Control measures**
Underground structures	
Inaccurate situational awareness: Underground structures	Refer to Site-Specific Risk Information (SSRI) and emergency response plans Liaise with the responsible person Control room
Restricted access and egress: Underground structures	Maintain safe access and egress
Uncontrolled ventilation: Underground structures	Ventilation systems
Ineffective communications: Underground structures	Effective communications
Deep excavations	Cordon controls Supervision Consider shoring
Unstable natural or built environments	See Above-ground structures
Conditions in tunnels under construction	Apply specialist controls and intervention limits
Pressurised atmosphere work	Implement appropriate entry control procedures Incident ground safety management Implement decompression procedures
Ineffective intervention plan	Intervention plan: Underground structures
Hazard	Control measures
Collapsed or unstable structures	
Collapsed or unstable structures	Consider requesting structural engineers or specialist advice Use structural monitoring equipment

Hazard	Control measures
Internal collapse	Consider shoring Access weather forecast information
Structural defect or further collapse	Monitor structural integrity Consider shoring Access weather forecast information
Geological effects	Use geological monitoring equipment
Fire, heat and smoke	See National Operational Guidance: Fires and firefighting
Damaged utilities	See National Operational Guidance: Utilities and fuel
Heavy dust loads and airborne particulates	Wear appropriate personal protective equipment (PPE) and respiratory protective equipment (RPE)
Flying debris and shards	Establish appropriate cordon controls Limit access to inner cordon Use hard and soft protection Wear appropriate personal protective equipment (PPE) and respiratory protective equipment (RPE)
Ineffective communication	Deliver effective crew briefings Select and use appropriate communication equipment
Moving heavy and bulky items	See National Operational Guidance: Operations

Work at height

Introduction

Work at height covers all work activities where there is a possibility that a fall from a distance that is liable to cause injury could occur. The definition in the regulations states work at height is:

'(a) work in any place, including a place at or below ground level;

(b) obtaining access to or egress from such place while at work, except by a staircase in a permanent workplace, where, if measures required by these Regulations were not taken, a person could fall a distance liable to cause personal injury.'

This includes work above ground/floor level and areas where falls could occur from an edge or through an opening or fragile surface, or falls from ground level into an opening in a floor or a hole in the ground.

This is regardless of the work equipment being used, the time a person spends working or the height at which the work is performed. Fire and rescue services must be aware that any place of work could potentially include a work at height environment, depending on local conditions and circumstances.

Note: work at height does not include a slip or a trip on the level, as a fall from height has to involve a fall from one level to a lower level, nor does it include walking up and down a permanent staircase.

The primary function of the work at height regulations is to legally require employers, including the fire and rescue service, to ensure that all work at height is risk-assessed, properly planned, appropriately supervised and carried out in a manner that is, so far as is reasonably practicable, safe. The regulations state that plans should include planning for emergencies and rescue.

Examples of work at height include:

- All training or work where there is a risk of falling
- Using any ladder including roof ladders
- Working on an aerial appliance decking or platform
- Working on the roof of an appliance
- Rope rescue work and training
- Working in confined space
- Working on cliffs
- Working on tower cranes
- Firefighting and rescues on embankments, docks and quays
- Offshore firefighting
- Working on fixed structures
- Working close to an excavation area where someone could fall
- Working near a fragile surface
- Maintaining vehicles and property

Establishing safe systems of work

Fire and rescue service personnel should only work at height when absolutely necessary. Where there is a risk of falling from height, the hierarchy 'avoid, prevent, minimise' should be used:

- Avoid work at height where it's reasonably practicable to do so
- Where work at height cannot be avoided, prevent falls by using an existing safe place of work, such as a non-fragile roof with a permanent edge protection.

- Where risk cannot be eliminated, minimise the distance and consequences of a fall by using collective and personal protection

To reduce risk of injury or damage, personnel should always consider using alternative methods before committing to higher-risk options. For example, for access to a dangerous structure, they should consider using aerial appliances instead of rope-based or ladder systems.

When essential, work at height can be achieved in various ways.

Ladders

Ladders vary in length and are usually manufactured from aluminium using a riveted and trussed construction. Double or triple extensions are commonly used in the fire and rescue service.

Aerial appliances

- *Turntable ladder (TL):* A self-supporting and power-operated extension ladder mounted on a turntable. The ladder assembly is mounted on a self-propelled chassis above the rear axle. The ladder usually consists of a main ladder and three or four telescopic extensions.
- *Hydraulic platform (HP):* A platform attached to two or three booms, which are hinged together and assembled on a self-propelled chassis. The lower boom (or booms) pivots in a vertical plane, while the third takes the form of a hinged or telescopic extension arm at the upper end of the second boom.
- *Aerial ladder platform (ALP):* These appliances combine the principle features of turntable ladders (TL) and hydraulic platforms (HP) on a single appliance.

Working platforms

A working platform is any platform that can be used as a place of work or as a means of access to or egress from a place of work at height (aerial appliances fitted with a cage are deemed a working platform). Working platforms can also include any place of work on a scaffold, cradle, mobile platform, trestle, gangway, gantry or stairway.

All working platforms should be properly supported and provided with guard rails and barriers set at an appropriate height. Working platforms must be used in accordance with manufacturer's instructions.

Rope access and rope rescue

Rope access and rope rescue can be achieved using a variety of systems and with many types of equipment. Systems can be used in isolation or in conjunction with other work at height equipment, including working platforms and aerial appliances.

Specialist wire systems

In UK fire and rescue services, these systems are generally only used by nationally accredited urban search and rescue (USAR) teams or, in some cases, specialist rope rescue teams.

The line access and casualty extrication equipment (LACE) used by USAR teams usually involves wire winches, rather than fabric rope systems, in circumstances where there is an increased risk of damage such as in a collapsed structure or confined space environment.

Collective and personal protection

Collective protection is equipment that does not require the person working at height to act for it to be effective, i.e. collective protection offers effective protection to more than one person. Where practicable, collective fall protection should always take precedence over personal protective equipment (PPE). An example of collective protection is a guard rail.

When planning work, the safest practical option should be selected; however, fall arrest may be the only option in certain circumstances. Fall arrest systems are designed to halt the operator after they have fallen and slow their descent to a level where the kinetic energy created by the fall is gradually dissipated to reduce the risk of injury. Once the fall arrest system has been used, it may no longer be fit for further use (as in the case of personal fall arrest lanyards), so a pre-planned rescue system may also need to be set up to recover the stranded user.

Fall arrest systems commonly used in industry and fire and rescue services comprise a full-body fall arrest harness, a suitable anchor system and a fall arrest attachment. The fall arrest attachment may take the form of:

- Personal fall arrest lanyards
- Mobile fall arrest devices
- Retractable fall arrest block (inertia reel)

Some examples of where fall arrest may have to be deployed are:

- On fragile structures/surfaces
- Climbing a steel vertical ladder
- Climbing a latticework tower or mast
- Traversing along a latticework structure such as a crane jib

When fall arrest is used as a method of fall protection, the risk of falling remains. Continuous attachment to suitable anchor(s) must be maintained, and anchor position, potential fall distance, length of attachments and available clearance must be continually assessed.

Any work at height should include the provision for timely rescue and evacuation.

Whichever system or technique is selected, fire and rescue services and operational commanders must always carry out an analytical risk assessment, which relies on the experience and knowledge of the incident commander. In certain circumstances, the outcome of this risk assessment may be to withdraw temporarily until subject matter experts with appropriate knowledge and experience can assess the situation.

For more information, please refer to the HSE guidance for working at height.

Hazard – Work at height environment

Hazard	Control measures
Work at height environment	Situational awareness Establish appropriate cordon controls Consider requesting specialist resources

Hazard knowledge

A fire and rescue service may be required to attend and respond to a wide range of incidents at height involving a variety of environments, such as:

- Above and below ground
- The built environment, including buildings, buildings under construction and open structures
- Natural environments such as steep ground, rock faces, excavations or sink holes

Working at height can be complex and will require risk assessment, planning (which must include provision for emergency and rescue), provision of appropriate training and equipment and adequate supervision. Fire and rescue personnel must understand the significant hazards and risks associated with the physical environment when working at height, which may include:

- Environmental conditions
- Falling objects
- Fragile surfaces
- Equipment
- Foreseeable injuries and illness sustained when working at height
- Suspension intolerance (see HSE 'Evidence-based review of the current guidance on first aid measures for suspension trauma')
- Emergencies and rescue provision

Control measure – Situational awareness

Control measure knowledge.

Situational awareness is a person's perception and understanding of the situation they face. It includes their anticipation of what the situation might become, including the impact of their actions. For an incident commander, it is their perspective on the scene of operations. For further information on situational awareness see National Operational Guidance: Incident command.

At incidents that involve working at height there may be instances where the incident commander cannot observe all areas of the incident and may not initially have enough information to maintain situational awareness. It is essential for the incident commander to gather this information, so they can understand and interpret the situation and anticipate what is likely to happen next.

Various sources of information may be available:

- On-site personnel
- Tactical advisers
- Reconnaissance crews at the scene of operations
- Reconnaissance crews remote from the scene of operations, such as adjacent buildings/structures
- Unmanned aerial vehicles (UAVs/drones)

See National Operational Guidance: Incident command - Command skills.

Control measure – Establish appropriate cordon controls

Control measure knowledge

An inner cordon will be established to control the immediate scene of operations. The cordon must take into account the specific factors associated with working at height, such as:

- Almost any object falling from height may cause injury. Personal protective equipment (PPE) should be worn inside the cordon but may not be enough to protect personnel from injury.
- The wind can have a dramatic effect on how far objects travel: for example, a karabiner with a sling attached will travel a considerable distance because the sling acts like a sail in the wind. Even with no wind, some objects will naturally plane away from a structure.
- The height at which work is taking place can have an impact on how dropped objects behave, particularly if the wind is involved and if objects strike the structure on the way down, causing them to bounce outwards.
- There is a risk that equipment may be tampered with, for example, anchors could be vulnerable if set up and then left unattended.

A range of issues must therefore be taken into account when deciding on an appropriate cordon. The unique situation and circumstances of each incident will inform the incident commander's judgment about the size of a cordon and whether the minimum cordons recommended should be increased.

See National Operational Guidance: Incident command.

Tactical actions

Incident commanders should:

- Establish and control inner and outer cordons, taking into account items falling from height and wind conditions
- Secure any unattended fall prevention systems to ensure they cannot be interfered with

Control measure – Consider requesting specialist resources

Control measure knowledge

Some incidents that involve risks associated with falling from height may require actions that are beyond the capabilities of the initial response. In these circumstances incident commanders should be aware of the restrictions that available equipment and training place on their ability to take offensive action. In such circumstances technical rescue teams should be requested to attend the incident.

Strategic actions

Fire and rescue services should:

- Have arrangements for mobilising technical rescue teams to incidents involving risks of falling from height

Tactical actions

Incident commanders should:

- Request technical rescue teams to attend incidents involving risks of falling from height

Hazard – Unguarded edges

Hazard	Control measures
Unguarded edges	Use appropriate work equipment Use a secondary system or build in redundancy Establish appropriate cordon controls Implement incident ground safety management

Hazard knowledge

Firefighters responding to incidents may encounter unguarded edges around, for example, roofs, cliff edges, sink holes, docks and quarries. Guards around edges may have been severely damaged in an incident, as in the case of a serious fire in a high-rise building. The safety of crews in these situations should be of paramount importance to incident commanders.

An unguarded edge is generally defined as a floor, gallery, balcony, roof or area that people can access, and where there is no solid wall or raised rail of minimum 950mm high and no intermediate guard rail to offer protection from falling.

The work at height environment and the equipment and techniques used to overcome the inherent hazards will vary from incident to incident.

Most core work at height carried out by fire and rescue services will be on ladders and aerial appliances. Harness-based methods of fall protection, such as rope access and rescue techniques, are often used, while wire equipment is deployed by specialist fire and rescue teams where necessary.

Control measure – Use appropriate work equipment

Control measure knowledge

Where it is not possible to avoid working at height near an unguarded edge then it is essential that a safe system of work is established. Where possible, a temporary physical barrier should be erected to provide collective protection to operational personnel. When the work at height environment is above ground level, ladders (for short-duration tasks against stable structures) and mobile elevating working platforms (for long-duration tasks and unstable structures) can be used to prevent the need to work near or on the unguarded edge. Such equipment may not be practical when the work at height environment is at ground level; for example, working at the top of cliff edges, sink holes, docks or quarries. Risk assessment should always determine correct equipment selection and deployment.

In any operation, sufficient measures should be identified or established to provide collective and personal fall protection to minimise the distance and/or consequences of a fall. Practical examples of collective protection include safety nets and soft landing systems where present (such as air bags installed close to the level of the work). Personal protection can include using rope-based systems that fall into three categories: work restraint, fall arrest and work positioning.

It is important that incident commanders select the most appropriate equipment and, where necessary, consider using supplementary equipment to add protection to the initial equipment and systems. Using items that will reduce uncontrolled or unexpected movement should also be considered.

Appropriate pre-use equipment and system checks should be conducted prior personnel who will rely on work equipment for safety are deployed.

Strategic actions

Fire and rescue services should:

- Make appropriate work equipment available to prevent responders falling from height

Tactical actions

Incident commanders should:

- Select the most appropriate work at height equipment for the activities and hazards identified
- Use ladders for short duration tasks and request other equipment for longer-term activities
- Use appropriate collective and personal protection

Control measure – Use a secondary system or build in redundancy

Control measure knowledge

Using rope-based systems for access and rescue gives additional flexibility in certain operational environments but the same systems can be vulnerable to damage or failure. This can lead to catastrophic failure.

Poor selection of, or damage to, anchor systems, poor stowage/maintenance, incorrect system selection or operator errors can put personnel and casualties in danger. Using secondary systems to back up any possible system failure is therefore recommended and should be implemented wherever possible.

Redundancy should be built in to rope access and rope rescue systems, to act as a backup in case of failure. This can be done in many ways, but the most usual is to use a two-line system that starts at the anchors and works through the whole system to the operator and casualty.

Tactical actions

Incident commanders should:

- Implement pre-determined procedures and emergency arrangements at incidents involving working at height
- Use only personnel trained in the equipment and systems to advise or supervise work at height operations
- Ensure that work at height operating systems include an appropriate degree of redundancy

Control measure – Establish appropriate cordon controls

See Hazard – Work at height environment and National Operational Guidance: Incident command.

Control measure – Implement incident ground safety management

See National Operational Guidance: Incident command.

Hazard – Fragile surface or ground conditions

Hazard	Control measures
Fragile surface or ground conditions	Situational awareness Establish appropriate cordon controls Use appropriate work equipment Implement incident ground safety management

Hazard knowledge

The operating environment for work at height varies and can include:

- Roofs
- Cliff tops
- Unstable or collapsed structures
- Steep embankments

Rope access and rope rescue personnel must be aware of the physical condition of the surfaces they are working on. Roofs may be weak, embankments and cliff tops may be steep, slippery or have loose surface materials, and some built environments may be unstable and weaker than they first seem.

With this in mind, fire and rescue personnel must remember that while the equipment they use is regularly inspected, tested and maintained, the areas they traverse and attach to are not. These must be stringently examined and suitable precautions taken.

Control measure – Situational awareness

See National Operational Guidance: Incident command.

Control measure – Establish appropriate cordon controls

See Hazard – Work at height environment and National Operational Guidance: Incident command.

Control measure – Use appropriate work equipment

See Hazard – Unguarded edge.

Control measure – Implement incident ground safety management

See National Operational Guidance: Incident command - Ineffective safety management.

Hazard – Failure of supporting structure

Hazard	Control measures
Failure of supporting structure	Establish appropriate cordon controls Implement incident ground safety management Assess and monitor structural integrity

Hazard knowledge

Structures may fail for various reasons, such as insufficient strength to take the weight or force of a load, or possibly through secondary collapse. People may be affected directly if they stand or climb on the structure, or indirectly if they are attached to the structure with work at height equipment. Rescue loads and/or dynamic events apply additional forces. All aspects of the structure, the actions taken and the efforts made to distribute applied loads must therefore be considered.

An assessment of the structure must be made to determine whether it is safe to stand on, attach to, or whether other risks are present, such as the possibility of secondary collapse. This may be determined in a number of ways but primarily by those with training, knowledge and experience; these professionals could range from firefighters to structural engineers.

Control measure – Establish appropriate cordon controls

See Hazard – Work at height environment and National Operational Guidance: Incident command.

Control measure – Implement incident ground safety management

See National Operational Guidance: Incident command.

Control measure – Assess and monitor structural integrity

Control measure knowledge.

The suitability of any structure in supporting the use of work at height equipment must be considered. Structures that are not stable, or where there is doubt about structural integrity, should not be considered as platforms for working at height unless additional secondary systems are put in to place to add protection for the operators. For example, a combination of ladders and rope systems may be used to access fragile surfaces.

The suitability of a structure to support ladders and rope or line systems needs to be assessed, along with its ability to withstand forces created by rescue loads and dynamic events.

Fire and rescue services may attend incidents involving partially or fully collapsed structures. This not only includes buildings but also transport infrastructure such as rail or road bridges.

Collapses may occur without warning, so it is very important that the structure is assessed at the earliest opportunity. Assessment, which should continue throughout the incident, may be carried out at various levels, for example, by first responders, urban search and rescue (USAR) technicians or structural engineers. For more information on assessing structural collapse see National Operational Guidance: Fires in the built environment and Fires in buildings under construction or demolition.

When crews need to work in or near a damaged structure, it must be monitored. Monitoring should follow a risk assessment and implementation of control measures, and it should be continuous. Search and rescue responders should accompany personnel when monitoring the structure.

Monitoring is carried out at three levels:

- Initial: first responders
- Detailed: urban search and rescue (USAR) technicians
- Specialist: structural specialists

The urban search and rescue (USAR) capability includes personnel trained in monitoring collapsed structures with specialised equipment.

Tactical actions

Incident commanders should:

- Ensure that competent personnel assess and monitor the suitability of the structure for work at height activities
- Liaise with the urban search and rescue (USAR) tactical advisor or building engineers
- Ensure that all personnel are fully briefed on the current hazards, risks, control measures and tactical mode
- Ensure that minimum numbers of crew work in the hazard area and that emergency procedures are in place

Hazard – Adverse weather conditions and microclimates

Hazard	Control measures
Adverse weather conditions and microclimates	Access weather forecast information Minimise exposure to the working environment Monitor crews exposed to the working environment Consider welfare Wear appropriate personal protective equipment (PPE)

Hazard knowledge

Adverse weather conditions include extremes of heat and cold, rain, snow and wind. All these may affect the operational situation and personnel. It must be borne in mind that the effect of temperature relates to how hard a person is working, so while it may be extremely cold, physical activity will increase a person's core temperature. Factors such as rain and wind will have a further cooling effect.

Adverse weather conditions and microclimates can also affect an individual's ability to operate equipment, and may affect decision-making processes and morale.

In locations where it may normally be safe to work, strong wind and/or the presence of ice or snow may make it dangerous as personnel risk being blown over by the wind or sliding on ice near exposed edges.

Weather conditions not only affect personnel directly. Indirect consequences include smoke, dust or other hazardous materials blowing into working areas, and items being blown off edges and dropping from heights.

Personnel may be affected by microclimates. Working at height near tall structures can produce conditions that are surprisingly different from those in surrounding areas.

Lightning is a risk and can be unpredictable in some circumstances, with changes in weather taking place in very short periods of time.

Control measure – Access weather forecast information

Control measure knowledge

At incidents where working at height is involved, predicted weather conditions should be obtained and monitored as these can have a negative effect on operations and the health and safety of personnel.

Those undertaking work at height should access accurate weather forecasts from local and national sources. This information should be analysed along with consideration of any microclimate that could be produced by the specific location and topography of the working at height operation and form an integral part of the operational risk assessment and planning.

Strategic actions

Fire and rescue services should:

- Provide access to meteorological information (for example, the Met Office's FireMet in 'hazard manager') for predicting weather conditions
- Provide operational responders with appropriate clothing and personal protective equipment (PPE) that conforms to current regulations and European standards

Tactical actions

Incident commanders should:

- Request initial and periodic weather reports for the likely duration of the incident
- Consider the safety of personnel if lightning is a hazard, based on the incident ground risk assessment process

Control measure – Minimise exposure to the working environment

Control measure knowledge

Work at height operations, especially when using rope systems, are, by their nature, exposed and arduous. One way of mitigating these factors is to minimise exposure for operators. Where physical and psychological hazards cannot be fully eliminated, they should be reduced.

See National Operational Guidance: Operations and National Operational Guidance: Incident command.

Tactical actions

Incident commanders should:

- Consider the task, individual capabilities, load and environment (TILE) when undertaking manual tasks

- Rotate personnel undertaking arduous manual tasks and consider a relief strategy

Control measure – Monitor crews exposed to the working environment

Control measure knowledge

Crews should be monitored for the physical and psychological effects they may experience at an incident, which may be amplified by weather conditions, such as:

Physical effects

- Manual handling
- Incident-related risks such as exposed edges or working at height
- Extremes of temperature
- Weather
- Workload and physical effort such as when climbing structures

Psychological effects

- Exposure to height in adverse weather conditions, which can cause stress, anxiety and/or vertigo/dizziness

For further information on monitoring crews exposed to the working environment see National Operational Guidance: Operations.

Tactical actions

Incident commanders should:

- Monitor personnel exposed to extremes of temperature for signs and symptoms of heat stress or hypothermia
- Monitor personnel for signs of stress, anxiety, vertigo or dizziness while working at height

Control measure – Consider welfare

Control measure knowledge

Effective arrangements for welfare and physical wellbeing should be planned for and managed at incidents. Fire and rescue authorities support several key elements of the safe person principles. For further information, see National Operational Guidance: Operations and National Operational Guidance: Incident command.

The nature of working at height means that fatigue can be a risk; constant concentration may be required and the task may involve physical exertion. Fatigue can lead to reduced physical and mental capabilities and can affect a person's ability to function. Both physical and psychological risks may be present at the same time, and these need to be addressed.

Strategic actions

Fire and rescue services should:

- Provide adequate and appropriate health surveillance procedures to monitor the ongoing health of their operational personnel

Tactical actions

Incident commanders should:

- Consider relief and welfare arrangements to reduce the effects of stress and fatigue on themselves and others

Control measure – Wear appropriate personal protective equipment (PPE)

Control measure knowledge

Adverse weather conditions and microclimates likely to affect items of personal protective equipment (PPE) worn include:

Cold/warm weather

There is often a fine balance when deciding how much clothing should be worn for a task, and adjustments may need to be made periodically as crews work hard then become static. At an incident involving a tower crane operator on a wet and cold winter's day, for example, with the tower crane located on top of a high-rise structure, it would be unwise to wear the protective clothing necessary to keep warm when working at height immediately because the person will get warm while carrying the equipment and gaining initial access.

Where personnel will not be near exposed edges or will be working on a platform with handrails, it may usually be acceptable to work at height without personal protective equipment (PPE). However, PPE will sometimes be required because surfaces have iced up, potentially causing people to slide.

In warm weather, where too much clothing may prevent people maintaining a safe temperature, a balance will have to be struck depending on the task and the need for protection.

Windy conditions

If the wind is at a velocity that may create an additional risk to responders near an exposed edge, personal protective equipment (PPE) must be considered.

The Work at Height Regulations 2005 state that 'every employer shall ensure that work at height is carried out only when the weather conditions do not jeopardise the health and safety of persons involved in the work', but this does not apply where members of the police, fire, ambulance or other emergency services are acting in an emergency. However, consideration must always be given to the safety of professionals attending an incident.

Respiratory protection may need to be considered in situations where personnel are at risk from dust being blown into the area. Additional control measures may also need to be implemented as communications may be affected. National Operational Guidance: Operations.

See also National Operational Guidance: Operations.

Strategic actions

Fire and rescue services should:

- Ensure that work at height responders have access to appropriate personal protective equipment (PPE) depending on expected working conditions

Tactical actions

Incident commanders should:

- Select appropriate work at height personal protective equipment (PPE) considering the weather conditions and the duration of activity

Hazard – Unsecured items falling from height

Hazard	Control measures
Unsecured items falling from height	Use essential items only Secure items used at height Establish appropriate cordon controls Implement incident ground safety management

Hazard knowledge

Equipment used when working at height may fall a substantial distance if not properly handled and secured.

Any item of equipment that is allowed to fall could strike someone or something on its way to the ground or at ground level. This could lead to serious injury or death to personnel, other responders or the public, and has the potential to cause expensive damage to property and equipment.

Depending on the height and location of operations, additional factors must be considered – for example, the swirling wind dynamics found around high-rise buildings.

Control measure – Use essential items only

Control measure knowledge

At every work at height incident, personnel will have to make a choice about the equipment required. In nearly all cases that require work at height, all equipment will need to be carried manually or hauled by hand. This will mean that personnel will select the minimum amount of equipment to achieve the task, plus extra equipment to respond to any unexpected issues.

Tactical actions

Incident commanders should:

- Use only essential items when working at height to avoid the risk of objects falling

Control measure – Secure items used at height

Control measure knowledge

Every item used at height has the potential to fall; equipment should therefore be secured throughout the operation. Equipment being transported to the scene of operations or to a bridgehead area should always be secured.

The exposed and physical nature of rope access and rescue means that there is increased risk; good procurement, pre-planning and training will mitigate the level of these risks.

The use of loose equipment and objects should be limited and these should always be controlled using lanyards, a suitable tool bag or a separate supporting system if weighing more than 8kg. Toe boards, nets (debris/catch), sheeting and other guards should also be considered as control measures where present.

Tactical actions

Incident commanders should:

- Ensure that items taken and used at height are secured to reduce the risk of objects falling

Control measure – Establish appropriate cordon controls

Control measure knowledge

The location and environmental conditions such as wind at the incident will need to be considered when establishing an effective cordon around a work at height incident, as these factors could affect the movement of an unsecured item falling from height. The type and shape of structure can also have an effect on the way that items may fall, for example very tall buildings can create specific wind conditions that can make items move laterally further than may be expected.

See Hazard – Work at height environment and National Operational Guidance: Incident command.

Control measure – Implement incident ground safety management

See National Operational Guidance: Incident command.

Hazard – Contaminated or damaged work at height equipment

Hazard	Control measures
Contaminated or damaged work at height equipment	Protect work at height equipment in use Manage, inspect and test equipment

Hazard knowledge

Contaminated or damaged work at height equipment can present a significant hazard to operators relying on it to prevent injury caused by a fall.

Regulations require that a thorough examination of equipment and safety-critical parts is carried out by a competent person who must then complete a written report. For lifting equipment and any associated accessories used to lift people, this should be done:

- Before first use
- After assembly and before use at each location
- Regularly, while in service (at minimum 6 monthly intervals)
- Following exceptional circumstances

Contamination or damage will therefore normally occur when the equipment is being used or stored. Personnel must remain vigilant to anything that could present a risk to the integrity of the equipment and avoid putting it in a position that may cause contamination or damage.

Contamination may occur as a result of the location of the equipment, while damage is usually caused through misuse or exceeding working load limits.

Fire and rescue personnel should be aware at all times that they must try to preserve the equipment and that any damage or contamination must be reported.

If equipment is suspected of, or identified as, being compromised, it must be withdrawn, declared defective and managed under a strict quarantine procedure.

Equipment may be defective because of a known event or because of identified damage caused by use, misuse or poor storage. It may be that the equipment is contaminated and the substance and/or effects are unknown.

Quarantined equipment must undergo a thorough examination, where the competent person will decide whether the equipment can be reinstated or whether it should be permanently withdrawn and disposed of. Records must be amended to show the action taken.

Control measure – Protect work at height equipment in use

Control measure knowledge

Soft-textile type height safety equipment, including ropes and lanyards, is the most susceptible to damage from unprotected edges in the work at height environment.

Sharp or abrasive edges should be controlled using the following hierarchical approach:

- Remove (the hazard, where feasible)
- Avoid (the hazard)
- Protect (against the hazard)

After hazard removal, the best form of protection for textile equipment is to avoid contact completely. This can normally be achieved by using anchors and rigging configurations that completely avoid, or deviate from, edges or by using other equipment that holds the ropes away from the abrasive or sharp edge. Consideration must be given to the potential consequences of failure and shifts of positions. The access/rescue path of textile equipment must be fully assessed for potential hazards.

The following are examples of hazards that should be taken into account when protecting textile-type safety equipment:

- Sharp edges such as those found on steel work, cable trays, gratings, glass façades or composite panels
- Abrasive edges and surfaces such as coping stones, rock protrusions and corroded structures
- Trapping and cutting areas such as manhole covers, hatches or doorways
- Heat sources and the risk of melting from hot pipes, exhaust gases, lighting, etc.
- Corrosive substances such as chemical deposits or spillages
- Mechanical equipment, such as tools

Aside from personnel trying to avoid working where edges could compromise operational safety, the key control measure is to use supplementary equipment to protect the ropes when in contact with the edges in question: for example, rope-protecting edge rollers, tripods and cantilever frames.

Tactical actions

Incident commanders should:

- Use equipment and procedures to protect rope and other work at height equipment from damage when in use

Control measure – Manage, inspect and test equipment

See National Operational Guidance: Operations – Incident closure and handover – Preparing for redeployment

Confined spaces

Introduction

The Confined Spaces Regulations 1997 and devolved equivalents sets out the legal definition of what constitutes a confined space. However, identifying environments that fall within the legal definition is not always that easy, especially when confronted with a rapidly escalating or complex incident.

This guidance seeks to identify the common hazards found at incidents that may be considered confined spaces or incidents that have similar operational and environmental characteristics requiring the same control measures to be applied by attending crews. It deals with the environment rather than the specific risks described in the legal definition, though some headings will be similar.

Summary of a legal definition of a confined space

A confined space must have both of the following defining features:

a) It must be a space that is substantially (though not always entirely) enclosed

b) One or more of the specified risks must be present or reasonably foreseeable

The specified risks are:

1. Serious injury through fire or explosion
2. Loss of consciousness arising from increased body temperature
3. Loss of consciousness or asphyxiation arising from gas, fume, vapour or lack of oxygen
4. Drowning from an increase in the level of a liquid
5. Asphyxiation arising from a free-flowing solid or being unable to reach a respirable environment due to entrapment by a free-flowing solid

A confined space could be any space in which the above defining features are present.

Some confined spaces are fairly easy to identify, such as enclosures with limited openings, for example:

- Storage tanks and silos
- Drains and sewers

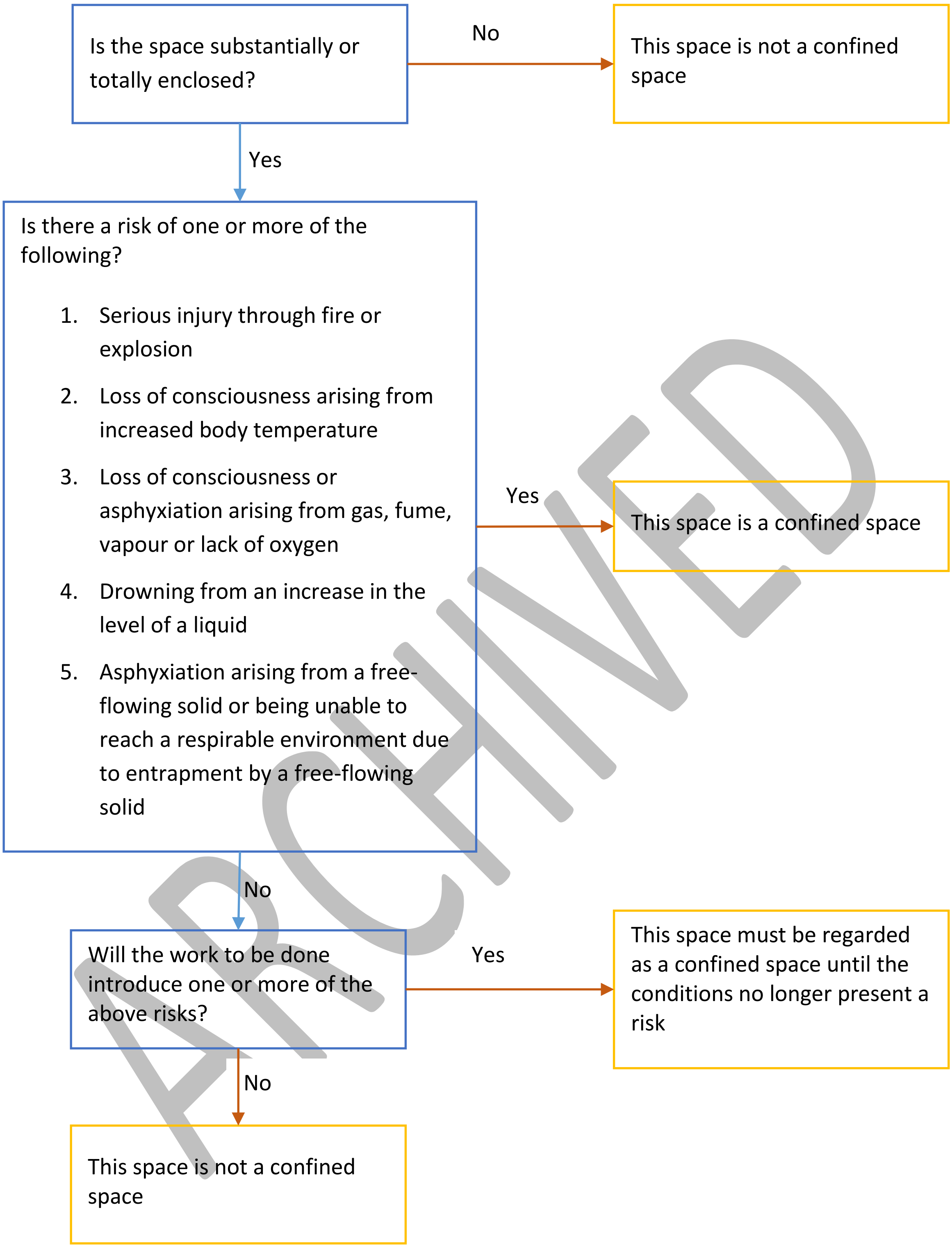
Others may be less obvious but can be equally dangerous, for example:

- Open-topped chambers and vats
- Ducting
- Trenches
- Unventilated or poorly ventilated compartments

It is not possible to provide an exhaustive list of confined spaces.

It is very important to recognise that some locations that are not considered confined spaces in normal use will become, and must be treated as, confined spaces if conditions worsen during an emergency. These include:

- Ship compartments
- Basements
- Tunnels



While at least one of the above five specified risks must be present or reasonably foreseeable for a space to be classified as confined, there are other associated hazards that may be encountered when working in confined spaces.

Hazard – Flammable or explosive atmosphere

Hazard	Control measures
Flammable or explosive atmosphere	Avoid entry Carry out atmospheric monitoring Consider ventilation Isolate or limit ignition sources Isolate or limit gases, liquids and other flowing materials Use intrinsically safe equipment Implement supervision arrangements Establish effective communications Maintain safe access and egress Wear appropriate personal protective equipment (PPE) and respiratory protective equipment (RPE)

Hazard knowledge

The legal definition of a confined space includes a specified risk of 'serious injury due to fire or explosion'. This can arise from a flammable or explosive atmosphere being present.

Fire and rescue personnel need to appreciate that confined spaces as defined by regulation present a unique and hazardous environment. Before entering such areas, they must apply a dynamic risk assessment and should only commit personnel who have received confined space training.

A risk of fire or explosion can arise from:

- Presence of flammable substances
- Excess oxygen in the atmosphere
- Presence of chemicals that can combust or spark in enriched (or, in some cases, normal) oxygen levels
- Ignition of combustible dusts (see Hazardous materials - Physical hazards)
- Leaks from adjoining plant or processes that have not been effectively isolated

Control measure – Avoid entry

Control measure knowledge

The regulations state:

'No person at work shall enter a confined space to carry out work for any purpose unless it is not reasonably practicable to achieve that purpose without such entry.' See also equivalent devolved legislation.

If objectives can be achieved without entering the confined space, the risk of injury to personnel and worsening of conditions (e.g. disturbance of sludge) in the confined space are significantly reduced. It is vital to assess the confined space to establish the risks presented by entry in comparison to the benefits of doing so.

All personnel should be aware of the limitations of their knowledge, training and equipment so they can assess the risk and make an informed tactical decision and intervention.

Strategic actions

Fire and rescue services should:

- Provide Site-Specific Risk Information (SSRI) on identified confined space risks

Tactical actions

Incident commanders should:

- Evaluate a range of options that avoid committing personnel to work in a confined space
- Commit personnel to work in a confined space only following a full risk assessment

Control measure – Carry out atmospheric monitoring

Control measure knowledge

Atmospheric monitoring should be undertaken whenever operations take place in a confined space. Before entry, the atmosphere within a confined space should be tested to check oxygen concentration and/or to check for the presence of hazardous gas, fume or vapour. Atmospheric testing should be carried out by competent personnel aware of the limitations of the equipment in use (e.g. a four-gas monitor may not have a sensor that detects ammonia)

Testing should be carried out where knowledge of the confined space indicates that the atmosphere might be contaminated or unsafe to breathe, or where any doubt exists as to the condition of the atmosphere. Testing should also be carried out if it is known that the atmosphere was previously contaminated and was ventilated as a consequence.

Where the atmosphere in the space may not be safe to breathe, and requires testing, the space should be constantly monitored, even when the atmosphere is initially found to be safe to breathe. Regular monitoring will be necessary to ensure that any change in the atmosphere while work is being carried out is identified. Where monitoring occurs, the results should be recorded. Testing and monitoring requirements should be defined by a competent confined space supervisor within the safe system of work.

This regular monitoring of the atmosphere in a confined space may be through on-site or fire service monitors used in a fixed location to protect a number of firefighters or, more commonly, through personal/portable monitors carried by individuals. Monitoring equipment should be maintained and recalibrated as required by the manufacturer, and designed to test for atmospheres that represent a hazard to fire and rescue service operations.

Commonly these are:

- High- or low-oxygen atmospheres
- Flammable/explosive atmospheres
- High carbon monoxide atmospheres
- Other gases that present a hazard – including hydrogen sulphide, ammonia and chlorine

Strategic actions

Fire and rescue services should:

- Provide suitable atmospheric monitoring equipment that is capable of being used in a confined space

Tactical actions

Incident commanders should:

- Carry out initial and continuous atmospheric monitoring and use the results to inform the incident plan

Control measure – Consider ventilation

Control measure knowledge

Ventilating a confined space can dramatically affect working conditions and the potential for casualties and rescuers to survive in a confined space. For ventilation to be effective, the specific confined space environment must be assessed to establish the appropriateness and potential success of any actions to be taken.

Tactical actions

Incident commanders should:

- Consider ventilating confined spaces to improve internal conditions
- Isolate or limit all ignition sources before ventilating a confined space where flammable gases are present

Control measure – Isolate or limit ignition sources

Control measure knowledge

Where gases are within flammable or explosive limits, any ignition source may cause combustion or explosion. Where inherent ignition sources are present and identified, isolating the ignition source will help to reduce the risk to casualties and rescuers.

Tactical actions

- Incident commanders should:
- Isolate or limit all ignition sources before ventilating a confined space where flammable gases are present

Control measure – Isolate or limit gases, liquids and other flowing materials

Control measure knowledge

When operating in a confined space, the ingress of gas, liquids or flowing materials will affect the environment, potentially causing a situation that may present additional hazards and pose a risk to those inside the confined space.

Personnel must be aware of the environment and any associated processes that may affect the confined space and take all appropriate actions to prevent the ingress of substances.

Tactical actions

Incident commanders should:

- Investigate the possibility of ingress from gas, liquids or flowing materials into the confined space
- Isolate the confined space from the ingress of gas, liquids or flowing materials before considering entry

Control measure – Use intrinsically safe equipment

Control measure knowledge

Any equipment that is not intrinsically safe can provide an ignition source for a gas within its flammable or explosive limits. This may cause combustion or explosion. The use of intrinsically safe equipment will preclude this.

In most confined spaces, it is impossible to classify the atmosphere present. For fire and rescue service operations, intrinsically safe equipment must meet the standards for use in Zone 0 under the ATEX directives.

Strategic actions

Fire and rescue services should:

- Ensure that intrinsically safe equipment is available to crews trained to work in confined spaces

Tactical actions

- Incident commanders should:
- Use only intrinsically safe equipment in confined spaces where there is a risk of a flammable or explosive atmosphere

Control measure – Implement supervision arrangements

Control measure knowledge

When working in a confined space, competent supervision must be in place to ensure that a suitable and sufficient risk assessment process is ongoing, that appropriate control measures are implemented, necessary safety precautions are in place, and hazards and risks are communicated to all those involved. For fire and rescue service operations, this role will be undertaken on behalf of the incident commander by a competent officer.

Incident commanders should apply the most appropriate level of breathing apparatus entry control procedure for a confined space incident.

Control measure – Establish effective communications

Control measure knowledge

An effective communication system must be in place and should enable communication between:

- All personnel working inside the confined space
- Personnel inside the confined space and those outside

An effective communication system should be in place to enable further resources to be requested in case of emergency. The equipment used for communication should take account of the other equipment, personal protective equipment (PPE) and respiratory protective equipment (RPE) that is used when working in confined spaces. Where there is a risk of flammable or potentially explosive atmospheres, all communication equipment that may be used in a confined space must also be protected so that it does not present a source of ignition.

Alternatives to normal communications should be considered, including dedicated urban search and rescue (USAR) capability and existing on-site systems (if functional). A leaky feeder system and deploy repeaters should be requested, if available.

Tactical actions

Incident commanders should:

- Ensure that the selected communications equipment will be effective in the confined space environment
- Conduct regular communication checks to ensure equipment continues to function
- Implement fallback procedures should there be a failure in the communications equipment

Control measure – Maintain safe access and egress

Control measure knowledge

Whenever entry is made to a confined space, the access/egress route should be maintained to ensure that all personnel working in the space are able to withdraw as quickly as possible should the need arise.

Where the size of openings to, or in, confined spaces is not sufficient, consideration should be given to increasing these. This should take account of the need to operate in personal protective equipment (PPE) and respiratory protective equipment (RPE) and to use associated equipment in the space.

Confined space supervisors can advise incident commanders of the hazards associated with restricted access/egress and operational requirements at incidents involving confined spaces.

Strategic actions

Fire and rescue services should:

- Ensure that confined space supervisors are deployed to any incident involving confined spaces

Tactical actions

Incident commanders should:

- Establish and maintain safe means of access to and egress from the confined space at all times
- Ensure that access and egress is appropriate for the operations being undertaken within the confined space
- Account for extended travel times in the incident plan and include contingencies for restricted access and egress

Control measure – Wear appropriate personal protective equipment (PPE) and respiratory protective equipment (RPE)

Control measure knowledge

Wherever possible, personnel should not work in a confined space if personal protective equipment (PPE) and respiratory protective equipment (RPE) is needed. However, it is accepted that this is rarely possible in fire and rescue service operations. Using PPE and RPE can make movement more difficult and add to the effects of high temperatures. Any PPE and RPE used should be suitable for a confined space.

The type of personal protective equipment (PPE) and respiratory protective equipment (RPE) provided will depend on the hazards identified, but might include safety lines, harnesses and suitable breathing apparatus (self-contained or constant flow airline). Account must be taken of foreseeable hazards that might arise and the need for emergency evacuation.

Tactical actions

Incident commanders should:

- Ensure that all personnel wear appropriate personal protective equipment (PPE) and respiratory protective equipment (RPE)

- Allocate sufficient personnel to support the use of PPE and RPE that has been implemented for confined space working

Hazard – Extremes of temperature or humidity

Hazard	**Control measures**
Extremes of temperature or humidity	Avoid entry Consider ventilation Implement supervision arrangements Establish effective communications Maintain safe access and egress Limit working time Wear appropriate personal protective equipment (PPE)

Hazard knowledge

The legislation refers to the specified risk of 'loss of consciousness arising from increased body temperature'. This could be the result of high atmospheric temperatures, humidity or a range of other factors.

Working in hot conditions can lead to a dangerous rise in core body temperature. This can be made worse by:

- Wearing personal protective equipment (PPE)
- Highly physical or strenuous work
- Working at a high work rate

In extreme cases, heatstroke and unconsciousness can result.

Excessive heat can occur where:

- Work is being carried out in hot conditions
- The confined space is exposed to a significant heat source
- Processes are being undertaken that generate significant amounts of residual heat

A slower heat build-up in the body can also cause heat stress. If action is not taken to cool the body, there is a risk of heatstroke and unconsciousness.

Control measure – Avoid entry

See Hazard – Flammable or explosive atmosphere.

Control measure – Consider ventilation

See Hazard – Flammable or explosive atmosphere.

Control measure – Implement supervision arrangements

See Hazard – Flammable or explosive atmosphere.

Control measure – Establish effective communications

See Hazard – Flammable or explosive atmosphere.

Control measure – Maintain safe access and egress

See Hazard – Flammable or explosive atmosphere.

Control measure – Limit working time

Control measure knowledge

Working in a confined space can be exhausting and is compounded by operating in high temperatures and in enclosed or restricted spaces that are commonly found in confined spaces. Extended travel times and/or possible arduous routes to the incident scene may also substantially reduce working time.

Strategic actions

Fire and rescue services should:

- Ensure that confined space supervisors are deployed to any incident involving confined spaces

Tactical actions

Incident commanders should:

- Enforce appropriate restrictions on the time crews can be committed to working in a confined space

Control measure – Wear appropriate personal protective equipment (PPE)

See Hazard – Flammable or explosive atmosphere.

Hazard – Irrespirable atmosphere

Hazard	Control measures
Irrespirable atmosphere	Avoid entry Carry out atmospheric monitoring

	Remove residual sludge or other deposits Isolate or limit gases, liquids and other flowing materials Consider ventilation Implement supervision arrangements Establish effective communications Maintain safe access and egress Wear appropriate personal protective equipment (PPE) and respiratory protective equipment (RPE)

Hazard knowledge

The legislation refers to the risk of 'loss of consciousness or asphyxiation arising from gas, fume, vapour or lack of oxygen'. This could arise from the hazard of an irrespirable atmosphere.

The presence of toxic gas, fumes or vapour can lead to asphyxia, unconsciousness and ultimately death.

This can occur because of:

- Previous processing or storage of contaminants in the space
- Sludge or other deposits
- Contaminants entering the space from ineffectively isolated areas or equipment in use
- Equipment/plant failure
- Naturally occurring biological processes producing toxic gases in poorly ventilated spaces
- Build-up in spaces such as sewers or manholes due to contaminated ground or leaks from behind vessel linings such as rubber, lead or brick
- Actions outside the space causing contaminants to enter a space

A lack of oxygen in the atmosphere may also lead to asphyxia or unconsciousness.

Oxygen deficiency can result from many processes and the storage of many different products, including:

- Purging confined spaces with an inert gas to remove flammable or toxic gas, fume, vapour or aerosols
- Naturally occurring biological or chemical processes consuming oxygen
- Transport or storage of wood pellets used as biofuel, which under certain circumstances can both consume oxygen and produce carbon monoxide gas
- Spaces left completely closed or poorly ventilated for extended periods

- Limestone chippings associated with drainage operations that can produce increased levels of carbon dioxide when they get wet
- Burning operations and work such as welding and grinding, which consume oxygen
- Displacement of air during pipe freezing
- The gradual depletion of oxygen as workers breathe in confined spaces and where provision of replacement air is inadequate
- Deliberate reductions in the oxygen level designed to inhibit fire, extend the shelf life of produce or reduce the effects of oxidation

Control measure – Avoid entry

See Hazard – Flammable or explosive atmosphere.

Control measure – Carry out atmospheric monitoring

See Hazard – Flammable or explosive atmosphere.

Control measure – Remove residual sludge or other deposits

Control measure knowledge

In certain confined space incidents, the fumes and gases created by a residual product may present a hazard as the actions of responding crews may disturb and release these fumes and gases. Removing sludge and other deposits may reduce the risk of uncontrolled release of fumes and gases.

Tactical actions

Incident commanders should:

- Identify the presence of residual sludge and other deposits before committing crews to a confined space
- Reduce the risk of fumes and gases from disturbed residual sludge and deposits in a confined space

Control measure – Isolate or limit gases, liquids and other flowing materials

See Hazard – Flammable or explosive atmosphere.

Control measure – Consider ventilation

See Hazard – Flammable or explosive atmosphere.

Control measure – Implement supervision arrangements

See Hazard – Flammable or explosive atmosphere.

Control measure – Establish effective communications

See Hazard – Flammable or explosive atmosphere.

Control measure – Maintain safe access and egress

See Hazard – Flammable or explosive atmosphere.

Control measure – Wear appropriate personal protective equipment (PPE) and respiratory protective equipment (RPE)

See Hazard – Flammable or explosive atmosphere.

Hazard – Ingress of water or liquid

Hazard	Control measures
Ingress of water or liquid	Avoid entry Isolate or limit liquids Implement supervision arrangements Establish effective communications Maintain safe access and egress

Hazard knowledge

The legislation refers to the risk of drowning from an increase in the level of a liquid. This could be a result of the hazard of ingress of water or liquids.

Liquids can flow into a confined space and lead to drowning; for example, the ingress of liquid when working in sewers or from other plant that has not been adequately isolated in an industrial situation.

The presence of a liquid can also lead to death, serious injury or an effect on health, depending on the nature of the liquid, such as its corrosiveness or toxicity. Drowning can occur in even a small depth of liquid.

Control measure – Avoid entry

See Hazard – Flammable or explosive atmosphere.

Control measure – Isolate or limit liquids

Control measure knowledge

See Hazard – Flammable or explosive atmosphere; Control measure – Isolate gases, liquids and other flowing materials.

In addition, the key control measure will be to isolate the flow of the particular liquid. This may be possible in industrial-type confined spaces such as vats and silos. However, in confined spaces affected by weather, water distribution or sewerage, it may not always be possible, so personnel should be extra vigilant and take extra precautions. Using appropriate submersible or other pumping equipment to remove liquid or reduce levels should also be considered. The level of liquid in the confined space should be continually monitored while crews are committed.

Strategic actions

Fire and rescue services should:

- Ensure that attending personnel are aware of the dangers presented by the inflow of liquids in confined space environments
- Ensure that those supervising confined space operations are able to recognise and inform attending crews of this hazard

Tactical actions

Incident commanders should:

- Consider using Met Office weather systems, such as Hazard Manager
- Identify the potential for liquids to enter confined spaces, including surface water
- Isolate all sources of liquid ingress to confined spaces where possible
- Implement suitable contingency arrangements where there is a risk of liquid ingress into a confined space

Control measure – Implement supervision arrangements

See Hazard – Flammable or explosive atmosphere.

Control measure – Establish effective communications

See Hazard – Flammable or explosive atmosphere.

Control measure – Maintain safe access and egress

See Hazard – Flammable or explosive atmosphere.

Hazard – Free-flowing solids

Hazard	Control measures
Free-flowing solids	Avoid entry Isolate or limit free-flowing materials Use appropriate work equipment

	Implement supervision arrangements Establish effective communications Maintain safe access and egress Wear appropriate personal protective equipment (PPE) and respiratory protective equipment (RPE)

Hazard knowledge

The legislation refers to the risk of asphyxiation arising from a free-flowing solid or being unable to reach a respirable environment due to being trapped by such a free-flowing solid. This could be due to the ingress of free-flowing solids.

Free-flowing solids have similar characteristics to liquids and can submerge a person, preventing breathing. These solids include grain, sugar, flour, sand, coal dust and other substances in powder or granular form, such as gravel or soil.

In a confined space, the risk is increased because there is no space for the material to flow away.

Some free-flowing solids may form combustible dust clouds when disturbed; this could present a risk of explosion, see Hazardous Materials – Physical Hazards.

Control measure – Avoid entry

See Hazard – Flammable or explosive atmosphere.

Control measure – Isolate or limit free-flowing materials

Control measure knowledge

See Hazard – Flammable or explosive atmosphere; Control measure – Isolate gases, liquids and other flowing materials.

In addition, the key control measure in this particular environment is to isolate the flow of the particular material into the space. In industrial-type confined spaces such as vats and silos there may be the option of shutting down the flow of materials into the space. In other situations, this may not be possible, but personnel may find they can remove the product from the space in question and eliminate the actual hazard.

Incident commanders should be aware that risks associated with free-flowing materials can include crusting of the upper surface, bridging of material and machinery, for example, a screw conveyor.

Tactical actions

Incident commanders should:

- Identify the potential for liquids to enter confined spaces, including surface water

- Where isolation or removal is possible, ensure that it occurs before personnel are committed to the space

Control measure – Use appropriate work equipment

See Hazard – Unguarded edges

Control measure – Implement supervision arrangements

See Hazard – Flammable or explosive atmosphere.

Control measure – Establish effective communications

See Hazard – Flammable or explosive atmosphere.

Control measure – Maintain safe access and egress

See Hazard – Flammable or explosive atmosphere.

Control measure – Wear appropriate personal protective equipment (PPE) and respiratory protective equipment (RPE)

See Hazard – Flammable or explosive atmosphere.

Hazard – Confined space working environment

Hazard	Control measures
Confined space working environment	Situational awareness Use safe person principles Establish appropriate cordon controls Identify alternative access/egress Consider using tag lines Have an effective recovery system Provide lighting

Hazard knowledge

Fire and rescue personnel should be aware that the physical environment of a confined space can take many forms and that a variety of techniques and skill sets are required to overcome the challenges they may present. No firefighter should enter a confined space unless they have been trained to do so and unless they fully understand the hazards these environments present. Challenges include difficult access and egress, restricted spaces, slopes, gradients, changing levels, narrow apertures, different types of surface and poor lighting.

Control measure – Situational awareness

Control measure knowledge

Because of the nature and severity of the risks faced while working in confined spaces, it is essential that the incident commander obtains as much information as possible before determining whether to deploy personnel.

All potential hazards within the confined space, as detailed in this guidance, should be identified and evaluated in accordance with the Confined Space Regulations to assess whether the benefit of entering outweighs the associated risks.

If the decision is made to deploy personnel, the risk assessment and safe system of work should be shared with all those deployed and the appropriate control measures should be applied.

See National Operational Guidance: Incident command - Command skills.

Control measure – Use safe person principles

Control measure knowledge

In line with safe person principles, only personnel who have received confined space training should be deployed in this environment, and they should only be deployed if they have the appropriate equipment, supervision and personal protective equipment. Adequate provision must also be made for the welfare of crews working in confined spaces.

A qualified confined space supervisor, where available, can advise incident commanders of the hazards associated with restricted access and egress and with the operational requirements at incidents involving confined spaces.

See National Operational Guidance: Operations - Health, safety and welfare.

Control measure – Establish appropriate cordon controls

Control measure knowledge

The entry point to a confined space is likely to sit within an already defined inner cordon, which will be under the control of the fire and rescue service.

See National Operational Guidance: Incident command - Establish appropriate cordon controls.

Control measure – Identify alternative access/egress

Control measure knowledge

Where the access and egress routes identified present intolerable risks to responding crews, an alternative route to and from the scene of operations should be sought.

Tactical actions

Incident commanders should:

- Identify the location of all suitable access and egress routes before committing crews to a confined space

Control measure – Consider using tag lines

Control measure knowledge

Tag lines can be attached to personnel or equipment in confined spaces to trace their location in an emergency or loss of communications. Tag lines should not be considered as a recovery system for crews operating in a confined space, but they are a useful physical locating method that can assist if a recovery does become necessary. Procedures and systems must be put in place to operate tag lines in a consistent and uniform way so that all teams in the environment work in the same manner.

Strategic action

Fire and rescue service should:

- Consider providing tag line systems to crews with confined space capability

Tactical actions

Incident commanders should:

- Implement a tag line system to assist in tracing and locating personnel working in confined spaces

Control measure – Have an effective recovery system

Control measure knowledge

The regulations state that no person at work shall enter or carry out work in a confined space unless there are suitable and sufficient arrangements for their rescue in an emergency, whether or not that arises from a specified risk. As a result, a recovery system should be in place for all personnel entering the area of risk.

Fire and rescue service personnel will encounter organisations working in confined spaces with recovery systems that range from simple and immediate systems to more extensive recovery and rescue provision. The water industry, for example, has simple two-person working systems through to full rescue teams on standby at main construction centres.

Depending on the level of access, recovery systems may involve using rope rescue equipment or dedicated confined space winching systems. An emergency team wearing appropriate respiratory protective equipment and associated equipment should also be available at all incidents except those with good access, adequate ventilation and low risks of a hazardous atmosphere.

Tactical actions

Incident commanders should:

- Establish what recovery systems have been employed before the fire and rescue service arrived

- Establish a recovery system for personnel deployed into confined space environments and ensure it is in place at all times
- Ensure that emergency arrangements are maintained and resourced for the duration of the incident

Control measure – Provide lighting

Control measure knowledge

Lighting is important at any scene of operations, and there are further considerations when selecting lighting for use in a confined space. Lighting should be intrinsically safe because of the potential for flammable atmospheres in confined space working. Even if the scene to be lit has been assessed using gas monitoring equipment and does not contain flammable gases, pockets of gas could still be released once operations have commenced, as in sewer environments, for example.

If it is assessed that there is no risk of a flammable atmosphere, consideration should be given to the heat that can be generated in a confined space if halogen bulbs are used for lighting. Ideally, light-emitting diodes (LED) or low-heat output lighting systems should be considered.

See National Operational Guidance: Operations - Health, safety and welfare.

Hazard – Ineffective communications

Hazard	Control measures
Ineffective communications	Deliver effective crew briefings Establish effective communications

Hazard knowledge

In some confined space environments, barriers and distances can be assumed to make normal communications ineffective. Communications may also fail during the course of the operation.

Control measure – Deliver effective crew briefings

See National Operational Guidance: Incident command.

Control measure – Establish effective communications

See Hazard – Flammable or explosive atmosphere.

Hazard – Working at height in a confined space

Hazard	Control measures
Working at height in a confined space	Establish appropriate cordon controls

	Use appropriate work equipment Have an effective recovery system

Hazard knowledge

Some confined spaces involve access to the area from above, using work at height access equipment. Support crews may be deployed in areas where there are unprotected edges and therefore a risk of falling.

Control measure – Establish appropriate cordon controls

See National Operational Guidance: Incident command.

Control measure – Use appropriate work equipment

See Hazard – Unguarded edges.

Control measure – Have an effective recovery system

See Hazard – Confined space working environment.

Hazard – Unstable natural or built environment

Hazard	Control measures
Unstable natural or built environment	Consider shoring Implement supervision arrangements Have an effective recovery system

Hazard knowledge

Fire and rescue services may be called to many varied environments that can be defined as confined spaces. These could include trenches, excavations and pits.

Personnel should be aware that some of these environments require additional resources and skills beyond the scope of the fire and rescue service.

The natural environment, such as a trench, excavation, pit, cliff or steep ground, or free-flowing solids, may be subject to instability for reasons such as:

- Excessive rainfall
- Vibration from nearby heavy plant or machinery
- Severe impact
- A load (e.g. crane/heavy plant) positioned too close to an edge

A serious risk of injury exists at incidents involving an unstable natural environment because soil can weigh more than 1.25 tonnes per cubic metre square. Even small collapses may be fatal. The risks to people include:

- Becoming trapped or buried
- Being crushed by the movement of soil and any subsequent loading
- Falling into a trench, pit or opening
- Drowning

Trenches and excavations are present in building works and utilities maintenance, and pits can be found in a variety of locations such as old mines or quarries, agricultural and industrial sites. An incident involving a trench or excavation may require shoring or the removal of soil, along with having to move heavy machinery/plant, etc.

Any unsupported trench or excavation may be subject to collapse and there are many factors that will influence stability, such as:

- Height of face
- Angle of face
- Type of soil
- Adjacent loading
- Vibration from nearby machinery or vehicles
- Water content
- Surface water
- Buried services or other obstructions
- Changes in soil type/make-up
- Previously worked-on ground
- Weather conditions
- Length of time the trench or excavation has been exposed

Loading at ground level adjacent to the trench increases the likelihood of unstable faces collapsing, as does vibration from machinery or vehicles; this area should be kept clear.

Other safe systems of work or procedures may be involved in rescue operations, such as those for confined spaces (a trench may collect flammable or toxic vapours or have an oxygen-deficient atmosphere) or safe working at height (for example, personal protective equipment (PPE) may be required for exposed edges). Access and egress may be difficult.

Control measure – Consider shoring

Control measure knowledge

Fire and rescue operations occur in many different environments. Some of these will be easily defined as confined spaces, whilst others may not be obvious. Personnel may find themselves having to manage an unstable confined space environment. This may be due to the structure the confined space is in or because of the type of product held in the confined space. Shoring up may be an option that allows an incident to be satisfactorily concluded. However, any shoring operation will need to be carried out by personnel with the full knowledge, training and equipment to carry out the task.

At collapsed structure incidents, it may be necessary to shore elements of the structure to provide sufficient protection from secondary collapse and enable search and rescue operations to proceed at reduced risk. Improvised shoring systems should only be considered if the risk of secondary collapse cannot be avoided or removed.

On-site plant, equipment or materials, propriety trench support equipment or materials suitable for use as trench or pit supports may be available, however, depending on the operational circumstance such equipment may have already failed and therefore a detailed risk assessment should be made prior to consideration of further use.

Depending on the type of environment, many different control measures may be or may become unstable, and actions taken by the emergency services may increase the chances of the ground becoming more unstable or increase the risks involved. There may be pressure to commit personnel before all control measures have been implemented, especially in the case of a live casualty trapped in a trench, for example. Other safe systems of work and procedures may have to be implemented, all of which could slow proceedings down.

Shoring can be described as temporary support to elements of a structure using metal or timber shoring systems and can be provided by urban search and rescue (USAR) teams.

Shoring provides:

- Temporary stability of structures/debris
- Sufficient protection from secondary collapse to enable search and/or rescue operations to proceed at reduced risk
- Support to vertical, horizontal or sloping surfaces

Strategic actions

Fire and rescue services should:

- Be aware of national resilience capabilities. This should include an understanding of the arrangements in the National Co-ordination Advisory Framework (NCAF), which should in turn ensure participation in mutual aid and access to resources, such as tactical advisors
- Consider providing local equipment and training to enable improvised shoring at incidents involving collapse or unstable environments

Tactical actions

Incident commanders should:

- Assess the structural stability of the working environment before committing crews to a confined space
- Request specialist tactical advice and resources to assist with shoring unstable working environments

Control measure – Implement supervision arrangements

See Hazard – Flammable or explosive atmosphere.

Control measure – Have an effective recovery system

See Hazard – Confined space working environment.

Hazard – Biological hazards

Hazard	Control measures
Biological hazards	Manage risk from biological hazards Manage risk from waterborne contaminants Have hygiene arrangements in place Establish firefighter decontamination Wear appropriate personal protective equipment (PPE) and respiratory protective equipment (RPE)

Hazard knowledge

Because there are many types of confined spaces, an equally wide range of biological hazards may be present in them. Some of these may be industrial or agricultural in nature, such as vats and silos used for a range of processes. In this instance, biological hazards may be bacterial, fungal or viral, relating to the specific process being undertaken inside the vessel.

Confined spaces such as sewers may contain raw sewage, sewage sludge or septic tank waste, which is a major source of harmful micro-organisms, including bacteria, viruses and parasites, which may result in a number of illnesses.

Common causes of contamination are by hand-to-mouth contact during eating, drinking and smoking, or by wiping the face with contaminated hands or gloves. Contamination can also occur through cuts or scratches.

Fire and rescue services must be aware of the additional risk to personnel from these potential contaminants and of the additional measures that will need to be taken following an incident, such as decontamination of personnel and equipment.

Control measure – Manage risk from biological hazards

See National Operational Guidance: Operations - Biological hazards.

Control measure – Manage risk from waterborne contaminants

See National Operational Guidance: Operations - Biological hazards.

Control measure – Have hygiene arrangements in place

See National Operational Guidance: Hazardous materials.

Control measure – Establish firefighter decontamination

See National Operational Guidance: Hazardous materials.

Control measure – Wear appropriate personal protective equipment (PPE) and respiratory protective equipment (RPE)

See Hazard – Flammable or explosive atmosphere.

Hazard – Chemical hazards

Hazard	Control measures
Chemical hazards	Have hygiene arrangements in place Establish firefighter decontamination Wear appropriate personal protective equipment (PPE) and respiratory protective equipment (RPE)

Hazard knowledge

Operating in confined spaces may expose responders to chemical hazards. For specific chemical hazards in premises, fire and rescue services should consider liaising with site staff to obtain existing procedures and decontamination plans.

Control measure – Have hygiene arrangements in place

See National Operational Guidance: Hazardous materials.

Control measure – Establish firefighter decontamination

See National Operational Guidance: Hazardous materials.

Control measure – Wear appropriate personal protective equipment (PPE) and respiratory protective equipment (RPE)

See Hazard – Flammable or explosive atmosphere.

Hazard – Electrical equipment and services

Hazard	Control measures
Electrical equipment and services	Isolate electricity supply

Hazard knowledge

In confined space environments, sources of electricity and electrical equipment may need to be managed. These may be items in their original serviceable condition that can be isolated easily, or they may have been damaged by the event that created the incident, for example, severed power cables or the workings of a machine that are exposed while it is still powered.

Control measure – Isolate electricity supply

Control measure knowledge

Isolating supplies may be possible. Where this is sensible, the appropriate supplier should be involved so disconnection can be confirmed. Incident commanders should also consider that, in certain circumstances, leaving some power systems on could be beneficial in resolving the incident.

At incidents where the confined spaces are in collapsed or unstable structures or environments, personnel should be aware of the possibility of exposed and live electrical services.

If it is deemed necessary to isolate the supply but security of isolation cannot be assured, consideration must be given to posting a safety officer who has been briefed to ensure the supply is not reconnected.

See National Operational Guidance: Utilities and fuel.

Hazard – Moving vehicles, plant and machinery

Hazard	Control measures
Moving vehicles, plant and machinery	See National Operational Guidance: Industry

Hazard knowledge

In some environments, moving vehicles, plant or machinery could strike rescuers.

Responding vehicles could also disturb the area around the scene of operations through vibration or additional weight. It is essential that the movement of vehicles, plant and machinery around rescue operations is strictly controlled.

See National Operational Guidance: Industrial and commercial; Hazard – Plant, machinery and robotics and Hazard – Presence of vehicles.

Above-ground structures

Introduction

Man-made above-ground structures can be divided into four classes: framed and unframed buildings (not included in this section of guidance), non-building structures and temporary structures.

Non-building and temporary structures

Non-building and temporary structures include scaffolding, temporary fairground rides and temporary stands. The technical operational difficulty presented by these structures will be similar to some of the structures outlined, but there may be additional problems for fire and rescue services. Depending on who has installed the structures, they may only be in the fire and rescue service area for a short time, the installation may be of dubious standard and/or fire and rescue service or other authorities may not have been given any notice. Fire and rescue services are likely to have little chance to actively pre-plan or familiarise their personnel with the structures.

A non-building structure has not been designed for continuous human occupancy. Non-building and temporary structures may be involved in any fire service activity and may present responding crews with unusual and unfamiliar hazards.

Some examples of non-building and temporary structures are set out below.

Masts, towers and pylons

The terms ‘mast’ and ‘tower’ are often used interchangeably. However, in structural engineering terms, a tower is a self-supporting or cantilevered structure, while a mast is held up by stays or guys. These are typically tall structures designed to support antennae for telecommunications and broadcasting, including television.

An electricity pylon is a tall structure, usually a steel lattice tower, used to support an overhead power line.

Wind turbines

A wind turbine is a device that converts the wind's kinetic energy into electrical power; the technical description of a wind turbine is an aerofoil-powered generator. Incidents that may require fire service attendance include rescuing workers or the generator catching fire.

Tower cranes

Tower cranes are a form of balance crane used in the construction of tall buildings. They are fixed to the ground on a concrete slab (and sometimes attached to the sides or top of structures).

Theme parks, Ferris wheels, piers, stadiums etc.

These structures are frequented by members of the public. They can include public access areas above, below and at ground level. They may also include areas with additional hazards, for example, they may be situated in or above water or have exceptionally restricted space.

Emergency intervention may also be affected by large numbers of casualties or trapped members of the public. For example, on some theme park rides, 40 or more people may be trapped in seat-belted or harnessed seats more than 20 metres in the air, possibly inverted or suspended.

Other generic structures

Other generic non-building structures that fire and rescue services may wish to plan for include statues, monuments, bridges, viaducts, aqueducts and transport infrastructure.

With incidents involving these forms of above-ground structures, a range of fire and rescue responses is possible. In general, the following are most likely to be appropriate:

- Aerial appliances
- Rope access and rescue teams
- Specialist urban search and rescue (USAR) teams

Because of the unique nature of above-ground structures, other agencies may become involved or lead in rescue intervention, for example:

- Helicopter search and rescue teams
- Private rescue teams specially employed to provide emergency rescue cover for a structure, for example, the London Eye
- Internal company volunteers who provide emergency cover, such as those at power generation companies

There may be a substantial delay in these agencies arriving and in most cases the fire and rescue service may be called on to attend in the first instance and then to assist.

Hazard – Lightning

Hazard	Control measures
Lightning	Consider stopping work

Hazard knowledge

Lightning is a risk and can be unpredictable in some circumstances, with changes in weather taking place in a very short period of time. Approximately 30 to 60 people are struck by lightning in the UK each year (5-10% receive fatal injuries) and, while there is a risk of lightning all year round, more people are killed in the summer months than at any other time of the year. Whenever thunder is heard, there is a risk of lightning and most people are struck before or after the peak of the storm. Lightning can injure a person in several ways:

- Direct strike
- Through the ground
- Through an object they are touching that has been struck
- From an object that has been struck (lightning can jump from a tall object to a person)
- Through being thrown by a strike, causing further injury

Symptoms can include:

- Cardiac arrest
- Brain injury
- Amnesia/confusion/difficulty in remembering events
- Personality changes (can be permanent)
- Perforated eardrums
- Eye injury
- Temporary paralysis
- Burns
- Numbness/tingling or weakness

Control measure – Consider stopping work

Control measure knowledge

The Work at Height Regulations provide an exemption from the requirements for working at height only when weather conditions do not jeopardise the health and safety of those involved in the work, but ceasing work must be considered if there is a risk of lightning strike.

Tactical actions

Incident commanders should:

- Consider using Met Office weather systems, including Hazard Manager
- Consider stopping activities where there is a risk of lightning strike

- Ensure personnel are sheltered and avoid open areas/high places where there is a risk of lightning strike

Hazard – Sources of high-voltage electricity

Hazard	Control measures
Sources of high-voltage electricity	See National Operational Guidance: Utilities and fuel

See National Operational Guidance: Utilities and fuel

Hazard – Sources of non-ionising radiation

Hazard	Control measures
Sources of non-ionising radiation	Consider adherence to local restrictions and signage Manage risk from non-ionising radiation

Hazard knowledge

Non-ionising radiation is radiation that does not cause changes to the molecular structure of living tissue, as is the case with ionising radiation such as gamma and X-rays. However, it can increase core body temperature, causing thermal damage to exposed sensitive body tissue such as the skin and eyes and localised limb heating. Its effects also focus on areas where there is a high water content and low blood flow, such as in the muscles and testes.

First responders may need to gain access and work near non-ionising sources of radiation such as radio frequency (RF) antennae that may be potentially hazardous to health. The antennae may be on freestanding masts or located on buildings.

Radio frequency (RF) is the term used to describe the part of the electromagnetic spectrum that can be used for radio communications. Electromagnetic waves emit from a power source, usually from an antenna that concentrates the energy in a beam or radiated pattern, and they usually lie in the infrared region.

Emissions present the greatest risk in the direction of the maximum gain from the antenna, which is generally to the front or within a sector. Many different types of antenna exist and it should be assumed that all unknown antennae are potentially hazardous. Non-ionising radiation affects the body in differing ways depending on wavelength, frequency and energy levels. The effects depend on:

- Distance from the source
- Time exposed
- Power level

Site owners must position antennae so that no member of public can be exposed to power levels in excess of those stipulated in the guidelines from the International Commission for Non-Ionising Radiation Protection, and employers are required to protect any workers or visitors to such sites. The telecoms industry categorises sites as ‘controlled’, ‘restricted’ and ‘general public’.

Controlled

This is a secure compound with access strictly controlled by the operator. Access is given only to those authorised, trained in radio frequency (RF) safety, wearing RF monitoring equipment or with established safe systems of work such as power isolation.

Restricted

These are controlled by a third-party provider and normally situated on building rooftops, lamp posts and other structures. Access is granted to non-operator third parties for maintenance. Antennae in restricted sites must be positioned so they are ‘occupationally safe by position’, with calculated exclusion zone warning signs at all access points.

General public

These occupy sites where it is reasonable to expect the public may gain access near the antennae, such as on rooftops or areas where members of the public carry out day-to-day activities.

Broadcasting installations operate at very high power levels, have strict controls, require a system of work to be in place and followed, and will have signage that identifies the radio frequency (RF) hazard. All visitors to these sites must have RF monitors or access will be declined.

The operation of surgical implants such as pacemakers and metallic implants such as pins or plates may be disrupted by radio frequency (RF) transmissions, causing them to heat up.

Many types of antenna are used:

Panel-shaped sector antenna (mobile phone communications)

Pole-shaped Omni antenna (mobile phone communications)

Control measure – Consider adherence to local restrictions and signage

Control measure knowledge

Most sites or structures that have non-ionising radiation hazards will have signage detailing the type of hazard, safe distances, emergency contact numbers and the site identification number. It may be possible to work safely near the radio frequency (RF) source as long as all local restrictions are followed.

Tactical actions

Incident commanders should:

- Observe and adhere to any warnings and local restrictions when working near to transmitting mast or towers

Control measure – Manage risk from non-ionising radiation

Control measure knowledge

It may be necessary to isolate the non-ionising radiation source so that responders can work safely. The information on the signage will normally need to be obtained to contact the responsible person to confirm isolation of the source.

If possible, the source of the non-ionising radiation should be avoided.

The effects of non-ionising radiation depend on the distance from the source, the time exposed and the power level. If there is no other choice but to be exposed to non-ionising radiation, the distance from the source must be as far as possible and the time exposed must be kept to a minimum.

Tactical actions

Incident commanders should:

- Establish and control appropriate cordons to keep personnel away from sources of non-ionising radiation
- Identify the responsible body and isolate the power to radio mast or tower before commencing operations

Hazard – Uncontrolled movement of machinery or structure

Hazard	**Control measures**
Uncontrolled movement of machinery or	Isolate and lock out power supply

structure	

Hazard knowledge

Some non-building and temporary structures will contain moving parts, such as wind turbines, while some structures are actually designed to move, such as tower cranes and roller coaster rides.

As well as the issue of power supplies or potential contaminants, any unexpected or uncontrolled movement could put fire service personnel at risk of entrapment.

Control measure – Isolate and lock out power supply

Control measure knowledge

Where possible, fire and rescue personnel attending incidents should seek to isolate any source of power or propulsion. A mechanical brake may also be included on certain moving parts to eliminate the risk of entrapment.

In many cases, information on how best to 'make safe' the installation will be available. Where this is not available, fire and rescue service personnel may find it necessary to withdraw and seek other assistance – from the operating company, for example.

In some cases, the movement of the structure may be a built-in safety design feature. For example, in the case of tower cranes, the rotation of the horizontal jib when not in use is generally set in 'free slew', allowing it to move with the changing wind direction; this reduces the wind's stress on the structure.

Tactical actions

Incident commanders should:

- Ensure that power supplies are isolated and locked out before commencing work on structures

Hazard – Restricted access and egress

Hazard	Control measures
Restricted access and egress	Seek alternative routes Use appropriate work equipment

Hazard knowledge

Access to areas of non-building and temporary structures may be difficult, as they are not designed for human occupancy. This presents a risk not only in gaining access to the scene of operations but also in maintaining safe egress routes for crews.

In some cases, the actual space within or on these structures is very limited, with the minimum room allowed for installation and maintenance. Casualties may actually be employees who, depending on their condition, may have the best information on specific mechanical and electrical issues.

Large numbers of casualties may be present, particularly in structures designed for public use, such as roller coaster and fairground rides.

Access to and egress from these structures may be via a single route, such as in wind turbines. In these cases, there is sometimes an escape hatch that can be used in conjunction with rope equipment for an emergency exit. Where an alternative emergency/escape route is not integral to the structure, incident commanders may need to rule out committing personnel.

Control measure – Seek alternative routes

Control measure knowledge

Incident commanders should use information gathering and scene assessment to identify whether there are alternative routes to access the scene of operations.

Tactical actions

Incident commanders should:

- Identify and evaluate all potential routes of access and egress before working on a structure
- Establish and maintain safe means of access and egress when working on structures

Control measure – Use appropriate work equipment

See Hazard – Unguarded edges.

Hazard – Ineffective communications

Hazard	Control measures
Ineffective communications	Deliver effective crew briefings Select and use appropriate communication equipment Maintain visibility with operators

Hazard knowledge

Communication with crews working on non-building and temporary structures may be ineffective because of distance, interference and barriers. If this may happen, incident commanders must ensure they make provisions to maintain communication. Where this is not possible, they must put in place procedures to withdraw teams if there is a communications failure.

Control measure – Deliver effective crew briefings

See National Operational Guidance: Incident command.

Control measure – Select and use appropriate communication equipment

Control measure knowledge

Communication systems should be appropriate for the environment in which they are used. Radio communications will not always be possible and the use of 'line' communications or line of sight, hand or whistle signals may be required.

Strategic actions

Fire and rescue services should:

- Ensure they have appropriate communications for all scenarios and environments

Tactical actions

Incident commanders should:

- Establish an effective system of communication considering distances and the working environment
- Conduct regular communication checks to ensure equipment continues to function
- Implement fall-back procedures should there be a failure in the communications equipment

Control measure – Maintain visibility with operators

Control measure knowledge

Where possible, line of sight between incident supervisors and operators should be maintained. In some circumstances, using hand or whistle signals will be appropriate. Where this is considered, all personnel must be aware of the system employed and there must be sufficient personnel for it to be effective.

Strategic actions

Fire and rescue services should:

- Ensure they have appropriate communications for all scenarios and environments

Tactical actions

Incident commanders should:

- Maintain visual contact with responders working on structures and use agreed hand or whistle signals

Hazard – Unstable natural or built environment

Hazard	Control measures
Unstable natural or built environment	Consider shoring Assess and monitor structural integrity Implement incident ground safety management Establish appropriate cordon controls

Hazard knowledge

Some non-building or temporary structures may become unstable due to a combination of causes that render the environment hazardous to fire crews operating within or nearby.

Where this occurs, alternative access and intervention methods should be considered in the first instance, such as using aerial appliances.

Control measure – Consider shoring

See Hazard – Unstable natural or built environment.

Control measure – Assess and monitor structural integrity

See Hazard – Unstable natural or built environment.

See Hazard – Failure of supporting structure.

Control measure – Implement incident ground safety management

See National Operational Guidance: Incident command.

Control measure – Establish appropriate cordon controls

See National Operational Guidance: Incident command.

Hazard – Biological hazards

Hazard	Control measures
Biological hazards	Manage risk from biological hazards

Hazard knowledge

Certain biological hazards associated with above-ground structures – for example, guano – can cause acute or chronic illness and should be considered when working on non-building structures, especially statues and open structures such as masts and pylons.

Control measure – Manage risk from biological hazards

See National Operational Guidance: Operations.

Underground structures

Introduction

An underground structure can be defined as:

'A natural or manmade structure, where all or part is below ground level or covered, where people can resort to for work or pleasure. This includes underpasses or associated shafts.'

Although some non-fire and rescue service organisations may use other definitions to satisfy their own requirements, this definition is the most appropriate as a basis for fire and rescue service risk assessments and planning.

Fire and rescue services attend incidents involving a variety of underground structures, particularly in tunnels, where the danger to operational personnel and the public is significant.

This guidance deals with the hazards present in the subsurface environment, providing a number of control measures and links to other National Operational Guidance.

Manmade subsurface structures vary greatly in depth, surface area and design. These often have restricted access and egress, poor or no lighting, the potential for extreme temperatures and complex and extensive topography.

Some structures are modern and well documented, while others are very old and have few or no plans. Some may come under heritage designation or be tourist attractions in their own right, while others may have no official public access.

The subsurface environment includes:

- Pedestrian areas
- Waterways
- Road and rail tunnels
- Utility provision
- Caves and potholes
- Mines
- Bunkers and underground storage facilities
- Military installations
- Basements
- Cellars
- Catacombs

- Vaults
- Cold stores
- Car parks

Such environments can be under construction, operational, disused or abandoned.

Various types of incident may occur in tunnel and underground infrastructure:

- Fire in infrastructure
- Fire in vehicles
- Collisions, including road traffic collisions or derailments
- People trapped on or in vehicles or machinery
- People lost or fallen into underground structure
- Flooding/inundation
- Hazardous materials (Hazmat)
- Explosions
- Collapse
- Aggressive acts involving any of the above.

Tunnels

Tunnels include those used for road, rail, waterway and pedestrian travel or for transporting goods and services. These may be in full operational use or disused, new or historic, and of varying size and complexity.

In general, tunnels used for pedestrian access do not present many incidents for fire and rescue services, unlike tunnels used for transport infrastructure systems, such as road and rail. A number of incidents in the UK and worldwide have occurred in or around a tunnel where the resolution of the incident has been led by fire and rescue services. These have included collisions and fires in road tunnels, derailments, fires in rail tunnels and fires in boats in waterway tunnels.

Where tunnels have public access, fire and rescue services will normally have prior knowledge and understanding of the hazards presented. There may be pre-planned arrangements for attendance and the actions to be taken in the event of an incident.

Tunnels under construction or renovation

This guidance focuses on the construction and operational use of existing tunnels, but much of the information may be relevant to disused or decommissioned tunnels.

Tunnels under renovation, restoration or construction can present challenging and unusual hazards. Fire and rescue services should ensure that all reasonable arrangements are made to liaise with those operating the tunnel system, and should review Site-Specific Risk Information (SSRI) and response plans so that they reflect the current situation.

As construction nears completion, it will be necessary to re-evaluate information previously collated and to work with infrastructure managers, tunnel user representatives, regulators and other multi-agency partners to ensure that the final emergency plan is validated. Plan validation should take place before commissioning exercises and the official opening, through exercises using the access and systems that are in place.

Many aspects of the construction of an underground structure fall outside the knowledge and skills of fire and rescue service personnel. It is recommended that fire and rescue services liaise with experts to ensure that proposals fulfil statutory duties, legal requirements and specific construction standards and that the services required to support a fire and rescue service incident are established.

Sewers and associated underground assets

Fire and rescue services may be called on to attend incidents in sewers and associated underground assets operated by a number of sewage or wastewater undertakers. Refer to National Operational Guidance: Utilities and fuel for further information about water and sewage services.

Some operations involving sewage systems will be subject to the Confined Space Regulations because they present one or more of the specified risks that define a confined space. These areas may present a number of other hazards, such as working at height and biological contamination.

Sewage or wastewater undertakers should have emergency procedures for their employees and subcontracted staff working in those environments. The assistance that fire and rescue services can provide will depend on the knowledge, training, skills and equipment of the individual services. It may be necessary to seek specialist assistance, such as urban search and rescue (USAR).

Operational mines

A mine is defined as:

'An excavation or system of excavations (including all excavations to which a common system of ventilation is provided) made for the purpose of, or in connection with, the extraction, wholly or substantially by means involving persons working below ground, of minerals (in their natural state or in solution or suspension); or mineral products.'

Depending on the type of incident at a mine, first responders may be limited in their ability to deal with the situation. It may be necessary to seek specialist assistance from teams skilled in rope rescue, confined space rescue, mine rescue or urban search and rescue.

Mines present various hazards, including:

- Complex layout
- Lengthy travel distances
- Vertical shafts, some hundreds of metres deep
- Totally dark environments
- Traverses and climbs

- Constricted and restricted passages and squeezes
- Static and running water (sometimes completely submerging the passageways)
- Mud and unstable rocks

The incident may also be affected by the impact of the weather on the environment below ground.

Fire and rescue services may need to provide equipment and personnel to assist specialist organisations, rather than directly use fire and rescue personnel to enter and operate as the primary rescuers.

The British Geological Survey (BGS) continually monitors the location and nature of active onshore mineral workings in the UK and publishes this information in its Directory of Mines and Quarries. A number of mines are used for other purposes such as tourism and storage of documents, computer records, wine and cheese.

Under the Mines Regulations 2014, the mine operator needs to make suitable arrangements for the escape and rescue of persons from the mine; this may include using safe havens in the mine. Arrangements for rescue may include using companies that provide specialist rescue training, trained rescue staff at mines, cave rescue teams in locations such as tourist mines and, in some instances, fire and rescue services.

Although large-scale coal mining operations have ceased in the UK, there may be hazards to people, livestock, property and the environment from:

- Collapse of mine entries and shallow coal mine workings (subsidence)
- Emissions of mine gases
- Incidents of spontaneous combustion
- Discharge of water from abandoned coal mines

The Coal Authority manages the effects of past coal mining, including subsidence damage claims that are not the responsibility of licensed coal mine operators. It deals with mine water pollution and other mining legacy issues.

Fire and rescue services need to be aware that they may be called to some mining-related surface incidents, such as partial collapse of a building or a person or animal falling into old mine workings. There may be oxygen-deficient atmospheres or gases that are toxic or explosive. Areas around the original collapse may be unstable and subject to collapse.

As large-scale incidents involving mine or mine surface hazards are infrequent, fire and rescue services should carry out joint exercises with the mine operator to acquire the skills and techniques required.

At all mine and mine surface incidents, it is important to consider the need to preserve the scene for investigation purposes, during and post-operation. Fire and rescue services need to be aware that other organisations may have to carry out their own investigations. The police, British Transport Police, Office of Road and Rail, Rail Accident Investigation Branch, Coal Authority, Health and Safety

Executive and utility companies, as well as local agencies, will all need to be considered when dealing with mine and mine surface-related incidents.

Caves and recreational underground environments

Depending on the type of incident at caves or recreational underground environments, first responders may be limited in their ability to deal with the situation. It may be necessary to seek specialist assistance from teams skilled in rope rescue, confined space rescue, cave rescue or urban search and rescue.

Attendance and intervention will often be led by attending cave rescue specialists, but there may be occasions when fire and rescue services have the ability and resources to intervene. For example, in the case of a person falling into a vertical entry point at the start of a cave system, the fire and rescue service personnel may have the rope rescue capability to immediately access and recover the casualty.

Abandoned mines and unfamiliar caves

Beneath the surface of the UK lie hundreds of miles of natural caves and abandoned but accessible mine workings and other tunnels. Each year, new caves or extensions to caves are discovered and old mines and passages in mines are rediscovered.

Almost all the caves and many of the disused mines occur in limestone areas, but all counties contain at least some disused mines that are accessed by people including recreational explorers, industrial historians and geologists.

Although the majority of those people have some knowledge and experience of these environments, it is an uncontrolled and unregulated pastime. As skills and understanding of the hazards vary widely, there is the potential for incidents to can become life-threatening.

Cave rescue

The British Cave Rescue Council (BCRC) is the body recognised by UK governments as providing the underground search and rescue service in caves and disused mines. It has a seat on the UK Search and Rescue Operators Group, where it meets regularly with other national search and rescue operators, including the Chief Fire Officers Association (CFOA).

The responsibility for inland rescue usually rests with the police under their general public order powers and responsibilities. However, if the police are unable to conduct searches or rescues in caves and disused mines, they will rely on the members of the BCRC.

BCRC members are also called on by the police to assist in animal rescues and occasionally to carry out other types of search to assist investigations.

The range of underground environments that may be accessed for recreational purposes is wide; some will have been formed by erosion within natural geological formations and others will have been created by mining or tunnelling operations. Many of the entry points to these sites will be in locations that are difficult to find and access and that may require approach by specialist vehicles or on foot over significant distances.

Fire and rescue services may need to provide equipment and personnel to assist specialist organisations, rather than directly use fire and rescue personnel to enter and operate as the primary rescuers.

The incident may also be affected by the impact of the weather on the environment below ground as cave systems may flood rapidly and with little warning.

Armed forces and civil protection underground structures

Many underground structures are part of, or have been developed by, military or civil protection organisations; some are still in operation while others have been decommissioned or sold on to private organisations. Some older sites have fallen into various states of disrepair or dereliction and others have since become accessible to members of the public.

The use of structures that are under military control is wide-ranging; they are not usually accessible by the general public or emergency services, as they are subject to security protocols.

Some of those in use are fully occupied, while others are remote stations that are only visited occasionally. Some are only visited by staff to check or maintain equipment or to assess the security of the site. Other sites provide resilience and have only occasional use, but there are usually procedures in place to ensure the safety of those who visit.

Underground armed forces or civilian protection structures have various uses including munition storage, command and control, equipment testing or accommodation. They may have several subsurface levels or be on one level with a single entrance or egress. They may have ventilation and heating systems, be fully self-contained, and have pedestrian or vehicle access.

The relevant Defence Fire Risk Management Organisation (DFRMO) may provide normal emergency response activities for all operational military establishments.

Structures may have been decommissioned and either sealed or handed to another organisation to maintain and run for other purposes. One use of such establishments is for historical education via a museum or historical society, such as the underground tunnels and command facilities at Dover. Others may be sold to private companies for a variety of purposes, such as document storage or housing of remote electronic equipment.

Structures in private or commercial use will be required to maintain a safe system of work for any working staff or visiting public and, depending on the use and levels of commercial security and sensitivity, will include notification and collaboration with local fire and rescue services.

Fire and rescue services should work with the establishment's management to provide additional assistance if required, to establish a structured response plan and arrange regular joint exercises and familiarisation of sites to ensure all partners have a clear understanding of the extent and limitations of their role and responsibilities.

Critical national infrastructure

Some subsurface environments may be used as a conduit for critical national infrastructure. An incident adjacent to these systems could have a potentially significant effect on the maintenance of essential services. Consideration should be given to the impact on:

- National transport networks, with local, national and international dependencies, principally involving road and rail use
- Telecommunications and power systems
- Water treatment systems
- Storage of significant items and use by industries
- Potential for widespread flooding resulting from the inundation of tunnels
- Tunnels being put to more than one use, for example a transport tunnel used to carry telecommunications cables, thereby compounding the community impact of a significant incident

Hazard – Inaccurate situational awareness: Underground structures

Hazard	Control measures
Inaccurate situational awareness: Underground structures	Refer to Site-Specific Risk Information (SSRI) and emergency response plans Liaise with responsible person: Underground structures Control room

Hazard knowledge

Incidents in underground structures may present significant challenges in gathering information and establishing accurate situational awareness. The seriousness of the incident in a tunnel or underground structure may not be immediately apparent and there is potential for the incident to rapidly escalate. Underground environments are varied and fire and rescue personnel may encounter a range of complex and unfamiliar conditions that may include:

- Long travel distances
- Complex workings and uncharted layouts
- Dead-end conditions
- Pressurised workings
- Complex and unfamiliar machinery
- Highly restricted working areas

Consideration should be given to the likely resource and time requirements to establish, initiate and maintain an effective intervention and the likely development of the incident during that time. Initial considerations should include:

- identifying appropriate bridgeheads or equipment staging areas
- Position of any ventilation outlets where the products of the incident may affect those on the surface or remote from the incident
- Direction of any mechanical forced ventilation, so that safe areas for members of the public and operational bridgeheads can be provided
- Gradient of any passageway allowing run off, liquid contamination or flowing fuel fire to spread, or the potential for inclined surface 'trench effect'.
- Method of containing run off or contaminated liquids, and their environmental impact
- Stability of the structure and its effect on the surface
- Risk of inundation of the infrastructure
- Identifying the possible spread of flood water and its predicted effects on the wider community.

Some infrastructures will contain large numbers of people, unfamiliar with their surroundings or emergency procedures. The responsibility for their evacuation in an emergency rests with the infrastructure managers, however fire and rescue services will undertake rescues of staff and/or members of the public where they are in imminent danger.

Incident commanders should attempt to identify the progress and success of managed evacuation. If it appears that people are, or may be, imminently exposed to harm then the situation becomes a rescue and the incident commander will take appropriate action.

Control measure – Refer to Site-Specific Risk Information (SSRI) and emergency response plans

Control measure knowledge

The planned operational response to underground incidents should be sufficient to allow relevant safe systems of work to be implemented.

During any construction process, it will be necessary to review the Site-Specific Risk Information (SSRI) and emergency response plans, so that any changes that will affect the existing risk information and guidance can be reflected throughout the project.

Pre-planning should be carried out jointly with other responder agencies that have knowledge of the environment, including volunteer rescue and leisure groups.

See National Operational Guidance: Operations - Risk information gathering

Strategic actions

Fire and rescue services should:

- Develop Site-Specific Risk Information (SSRI) and emergency response plans for underground environments in their area
- Provide operational personnel with risk information about identified underground environments
- Regularly exercise plans to ensure they are fit for purpose

Tactical actions

Incident commanders should:

- Refer to Site-Specific Risk Information (SSRI) and/or emergency response plan information relevant to underground environments
- Confirm the accuracy of the information about underground environments with the responsible person

Control measure – Liaise with responsible person: Underground structures

Control measure knowledge

Many aspects of underground structure construction are likely to fall outside the scope of fire and rescue service personnel knowledge and skills. It is the responsibility of experts to ensure that proposals meet statutory duties, legal requirements and standards set out for construction operations, and that services required to support a fire and rescue service intervention are put in place.

In the event of an incident, the fire and rescue service should seek expert advice from:

- The contractor
- The appropriate regulator
- The Health and Safety Executive (HSE)
- Regulatory bodies, such as the Office of Road and Rail

Strategic actions.

Fire and rescue services should:

- Develop arrangements and procedures for dealing with underground structure incidents with identified sources of expert advice or assistance
- Maintain the details of any expert adviser for underground structure incidents and know how to request their attendance

Tactical actions

Incident commanders should:

- Request expert advice or assistance based on the extent and urgency of the underground structure incident

- Ensure fire and rescue personnel work in accordance with agreed procedures that comply with contractor arrangements
- Liaise and work with on-site staff or the contractor's specialist teams where they are available
- Only use access lifts and transport approved for fire and rescue service purposes

Control measure – Control room

Control measure knowledge

Most tunnels will have control rooms with a range of features and information available to an incident commander. An understanding of the facilities afforded by infrastructure control rooms will assist in determining the means for managing an incident managed.

In some instances, there are protected control rooms within the infrastructure, providing facilities to assist in managing an incident. These may include facilities for fire and rescue service personnel to monitor progress of crews and the safe evacuation of the public. Alternatively, for widespread or complex infrastructure, a central control room may be provided. Both of these locations may provide a range of facilities for fire and rescue service use, including:

- Alternative access/egress routes
- Close circuit television (CCTV)
- Public address systems
- Ventilation systems
- Fire and rescue service telecommunications
- Incident ground plans
- Traffic management controls
- Ventilation controls
- REFUGE communications
- Some tunnel control rooms contain water inundation protection facilities, including tunnel portal door closers.

Strategic action

Fire and rescue services should:

- Identify the location of control rooms for subsurface infrastructure, as part of risk information gathering
- Ensure that fire and rescue personnel are aware of the capabilities of subsurface infrastructure control rooms

Tactical actions

Incident commanders should:

- Consider using the facilities available in the infrastructure control room to monitor the incident

Hazard – Restricted access and egress: Underground structures

Hazard	**Control measures**
Restricted access and egress: Underground structures	Maintain safe access and egress

Hazard knowledge

Fire and rescue service personnel need to consider the possibility of unusually complex access to and egress from the scene of operations. Considerations may include the need for additional and varied entry procedures and routes, extended travel times, various transportation methods to scenes of operations and using unfamiliar equipment.

Gaining access to the scene of operations in a safe and controlled way is a critical part of fire and rescue service operations. The means responders may use to access the infrastructure will vary depending on type, age and location. Some infrastructures may have facilities built in that accommodate fire and rescue service needs, such as:

- Hard standing areas for emergency vehicles
- Dedicated rendezvous points (RVPs) for emergency vehicles
- Fire and rescue service communications extended to cover the rendezvous points (RVPs), shafts, underground area or tunnels
- Premises information boxes or security standard boxes with plans, entry codes or keys
- Security doors providing an agreed method of fire and rescue service entry without unreasonable delay, normally using keys, entry codes or remote door release devices
- Firefighting stairs and lifts
- Ventilation system to protect firefighting access from contamination
- Firefighting lobbies
- Raised walkways

Control measure – Maintain safe access and egress

Control measure knowledge

Any incident involving underground structures, both natural and man-made, will require consideration of safe access and egress routes for committed personnel. Alternative means of making an entry should be considered and emergency arrangements put in place.

In addition to identifying the most appropriate access point, the precise location of the incident within the infrastructure must be found to:

- Identify the likely travel distances and working duration of crews
- Identify or anticipate any blockages that may affect access
- Factor in the likely fatiguing effects of extended travel distances and carrying equipment, including return journeys
- Determine the appropriate use of any vehicle that may be available and suitable for carrying personnel or equipment

Using lights, markers or barrier tape should be considered to indicate the extent of the inner cordon within complex structures, or where there are no distinguishing way finders or location indicators. Similarly, these items should be considered for indicating the door or level that leads to the way out along the route to the surface. This may be particularly important where the shaft is part of a larger surface building

Strategic actions

Fire and rescue services should:

- Establish a periodic review and amendment process to ensure the strict control and accuracy of fire and rescue service guidance. This will be an ongoing process to reflect construction advancement and the subsequent need to revise plans
- Assess the need to provide additional equipment and training for crews making an intervention below ground.
- Conduct regular site visits to ensure complete awareness of the site access point and access control system

Tactical actions

Incident commanders should:

- Identify the location of all potential access and egress routes to inform their incident plan
- Establish and maintain safe means of access to, and egress from, underground structures at all times

Hazard – Uncontrolled ventilation: Underground structures

Hazard	Control measures
Uncontrolled ventilation: Underground structures	Ventilation systems

Hazard knowledge

Underground structures, especially tunnels, may quickly be filled with poor quality air due to the impact of the incident or operational activities. Maintaining effective ventilation will be a key consideration for the incident commander.

The purpose of ventilation is normally for keeping the users of infrastructure comfortable, keeping equipment cool or assisting with the control of hot gasses or fumes. For the purposes of fire and rescue service operations, ventilation systems can be divided into two principal types:

- Natural: caused by the flow of air through the infrastructure's openings
- Mechanical: where a ventilation system serves a specific function, such as cooling, removing fumes or controlling smoke or fire

It should be noted that ventilation systems are more common in highway tunnels due to high concentration of contaminants. Rail transit tunnels may have ventilation systems in the stations or at intermediate fan shafts, but during normal operations rely mainly on the piston effect of the train pushing air through the tunnel to remove stagnant air. Some rail transit tunnels have emergency mechanical ventilation that only works in the event of a fire.

Mechanical ventilation system types

Tunnel ventilation systems can be categorised into four main types:

- Longitudinal ventilation
- Semi-transverse ventilation
- Full-transverse ventilation
- Single-point extraction.

If the ventilation is mechanical, it should normally be known whether it has been provided, designed and rated for fire and rescue service purposes. If it has been provided to control smoke or fumes in an emergency then the incident commander can have confidence that it will provide adequate protection for those evacuating the premises under the guidance of the infrastructure manager, and for responders being committed.

Where mechanical ventilation is uni-directional, or where pre-prepared plans define a default air flow direction, this creates a preferred entry point at the inlet end of the tunnel. Plans should then have responders committed in this direction.

Control measure – Ventilation systems

Control measure knowledge

Ventilation systems may assist in the control of the incident environment. Crews should be aware of the type, location, and operation of the control systems.

At incidents involving fire or hazardous materials, ventilation systems should not be turned off or re-configured until a risk assessment has been made and the full consequences of these actions to the public, firefighters and any fire development are known.

The design and topography of the infrastructure should be considered, including:

- The position of any ventilation outlets, where the products of the incident may affect those on the surface or remote from the incident
- The direction of any mechanical forced ventilation so that safe areas for members of the public and operational bridgeheads can be established
- Any 'piston' effect or other non-controlled air movement

In most circumstances emergency ventilation and evacuation procedures will be implemented before the arrival of the fire and rescue service, or other responders, either automatically or by the infrastructure manager

The positioning of air inlets outside the infrastructure should be identified to ensure that exhaust gases are not entering the ventilation system. Incident commanders should also consider the effect that the incident may have on the occupants, wider community and environment, such as the effects of any ventilation system exhaust carrying contaminates into the community.

If reasonably practicable the infrastructure manager should be advised of the intended tactical plan. It must be made clear that there should be no changes to any automatic ventilation or fire control systems settings, for the duration of the incident or until the incident commander requests such a change.

Strategic action

Fire and rescue services should:

- Include details of ventilation systems in risk information for underground structures and infrastructure

Tactical actions

Incident commanders should:

- Establish control over the operation of subsurface ventilation systems

Hazard – Ineffective communications: Underground structures

Hazard	Control measures

Ineffective communications: Underground structures	Effective communications

Hazard knowledge

Normal fire service radio telecommunications may be rendered ineffective when operating in subsurface environments and infrastructure.

Communications used for fire and rescue service purposes at an incident will be greatly enhanced by pre-planning and testing the range and extent of signals, including joint testing with other agencies and infrastructure managers.

In some circumstances limited installed infrastructure can support communications with existing fire and rescue service systems. For example, a relatively short tunnel that allows good, uninterrupted radio coverage in all reasonably foreseeable circumstances should not require the additional provision of a fire and rescue service 'leaky feeder'.

Fire and rescue services should take care when accepting the use of the infrastructure's own communication equipment, particularly if this is hard-wired telephone communications to a control point. The potential implications, including the loss of communication at a critical time, require careful examination.

In some circumstances, it may be beneficial for fire and rescue services to enter into local agreements with other responding agencies and organisations who can provide communications support.

Noise can also cause unnecessary harm and interfere with communication or emergency signals.

Communications with other agencies

Incidents involving tunnels and underground structures can present some significant challenges for communications infrastructure. There are no simple rules that can be applied and the communications problems found in individual locations need to be considered and overcome using operational fire and rescue service and multi-agency methods as well as the fixed systems supplied in many modern structures.

Historically, communications, both internal and external, have been identified as areas of weakness in post-incident investigations and debriefs. Therefore, fire and rescue service incident commanders should carefully consider their methodology for communicating with other responders, including:

- AIRWAVE radio system, using interagency radio channels
- The potential danger of reliance on mobile telephone networks
- Field telephones between emergency service control vehicles
- Runners if appropriate
- Inter-agency liaison officers
- Any mutually agreed method to overcome local difficulty

- Silver meetings to confirm the incident situation and inter-service communications structures and limitations.

Control measure – Effective communications

Control measure knowledge

Incident commanders should establish resilient telecommunications arrangements and carry out regular testing to confirm that contact has not been lost with crews operating in subsurface environments and infrastructure.

For incidents, particularly in older infrastructure, it may be appropriate to mobilise or request an attendance to more than one location. This will assist where:

- There is limited or no smoke ventilation or fire stopping
- There is limited or no effective communication system

The incident commander will need to consider establishing and maintaining:

- Communications with the tunnel operator
- Communications with fire control
- Using UHF radios, assign channels, and agree on call signs
- Communications with other agencies
- Communications within the subsurface environment

Strategic action

Fire and rescue services should:

- Ensure that they have resilient telecommunication arrangements for any subsurface environments and infrastructure identified as risks within their service area

Tactical actions

Incident commanders should:

- Establish and regularly monitor the effectiveness of communications with personnel operating in subsurface environments

Hazard – Deep excavations

Hazard	Control measures
Deep excavations	Cordon controls Supervision Consider shoring

Hazard knowledge

Fire and rescue personnel need to understand and consider the additional hazards presented within deep excavation workings. These include:

- Height-related risks
- Potential collapse of excavated sections and shoring equipment

A deep excavation in soil or rock is defined by the Health and Safety Executive (HSE) as being 4.5m deep (15ft).

Control measure – Cordon controls

See National Operational Guidance: Incident command – Ineffective organisation of the incident ground.

Control measure – Supervision

Control measure knowledge

Applying fire and rescue service cordon, sector and safety officer controls will ensure the correct levels of supervision during an incident. As operations are complex, the incident commander may wish to review the rank/role and specialist qualifications of those undertaking designated supervision tasks, to ensure appropriate management controls.

Safety officer supervision below ground should involve more than one person to ensure that hazardous activities are closely scrutinised and controlled. Communications between safety officers, the technical rescue team tactical advisor and the sector commander are of paramount importance

See National Operational Guidance: Incident command for further information.

Strategic actions

Fire and rescue services should:

- Ensure that information obtained from the contractor is shared with partner agencies

Tactical actions

Incident commanders should:

- Liaise with the responsible person, other responders and witnesses to gain an understanding of the incident
- Liaise with civil engineering specialists on-site and the tactical adviser from the fire and rescue service
- Ensure that all personnel are fully briefed on the current hazards, risks, control measures and tactical mode
- Ensure joint working with fire and rescue response crews, the technical rescue team and contractor specialists

Control measure – Consider shoring

Control measure knowledge

Shoring used during the construction of underground structures is of extremely high-grade concrete, steel interlocking sheeting or timber to meet the exacting standards set out in the Construction Design and Management (CDM) Regulations and Health and Safety Executive (HSE) guidance. The design and type of shoring will have been decided following engineering calculations that take into account geological conditions, stability of the ground, soil movement predictions and the depth of the excavation or workings. An inspection of the shoring will be conducted daily before work commences. When the factors mentioned above are adhered to, it is extremely unlikely that failure and collapse will occur. Once the shoring is in place, the area within the shored footprint will be excavated by mechanical means to prevent unnecessary hazard exposure to contractor staff.

If a structural failure does occur, resulting in a non-entrapment situation, the duty of care should be handed back to the responsible person on-site because the temporary emergency shoring used by the fire and rescue service to facilitate a rescue would not be suitable to replace the substantive structure.

In a structural failure involving an entrapment, the technical rescue team tactical advisor must consult with the contractor or civil engineer to determine the rescue strategy and the safe system of work that needs to be implemented. It should be noted that the equipment available to fire and rescue service personnel, even when national urban search and rescue (USAR) teams are in attendance, will have limited impact on larger structural failures and therefore co-operation with contractors and other external partners may be required.

Strategic actions

Fire and rescue services should:

- Liaise with the contractor and determine the rescue strategy for a collapse of the structure; this may include arrangements with third-party contractors, for example, providers of cranes
- Develop and issue tactical guidance and clearly identify the limitations of technical rescue team resources used to provide temporary emergency shoring

Tactical actions

Incident commanders should:

- Assess the structural stability of the working environment before committing fire and rescue service personnel
- Liaise with on-site specialist and rescue teams regarding structural stability and shoring capabilities
- Request specialist tactical advice and resources to assist with shoring unstable working environments

Hazard – Unstable natural or built environment

See Above-ground structures

Hazard – Conditions in tunnels under construction

Hazard	Control measures
Conditions in tunnels under construction	Apply specialist controls and intervention limits

Hazard knowledge

Fire and rescue service personnel need to consider the potentially limited intervention they can make at incidents in tunnels or other underground structures under construction. The need to wait for additional core and specialist resources will inevitably add pressure to crews and incident commanders to take action and this may increase the overall risk to personnel.

Control measure – Apply specialist controls and intervention limits

Control measure knowledge

The notification of any tunnel or underground structure project should be the starting point for engagement with the client, principal contractor and responders. This will enable the most hazardous phase of the project to be risk-assessed. The outcome of the risk assessment will inform the development of any special procedures, restrictions or limitations to be applied well before the construction phase commences. Risk assessment outcomes and plans must be confirmed in writing.

Special controls and procedures agreed must be recorded in the emergency plan and communicated to all partners so they can be implemented quickly and without confusion. Special controls, restrictions or limitations will need to be applied to dead-end conditions. These can be created when a tunnel-boring machine (TBM) commences boring and the services required to support a fire and rescue service intervention cannot be established for a period of time. In a fire situation, this would mean that the fire and rescue service could only make a limited intervention, as a charged line of delivery hose cannot be dragged for long distances.

A normal control measure applied during these circumstances is for the tunnel boring machine (TBM) to be provided with a water mist system to protect walkways, and a rear water curtain to protect the TBM crew who would remain on-board.

The hand-digging of cross-passages and the need to enter the cutting head of the tunnel boring machine both involve working in confined spaces. Such conditions will require the contractor to have special rescue teams available on scene when work is being carried out, as this responsibility cannot be discharged to the fire and rescue service. Although some fire and rescue service personnel are trained and equipped to work in confined spaces, technical rescue teams are not normally mobilised as part of the fire and rescue service first attendance and there will be a delay in intervention.

As the tunnel or underground structure reaches completion, the hazard and risk significantly reduces because the ‘as built’ environment will include all the design safety features that support an intervention.

Strategic actions

Fire and rescue services should:

- Conduct regular site visits to ensure complete awareness of the site access point and the access control system

Tactical actions

Incident commanders should:

- Access any operational information or Site-specific Risk Information (SSRI) and confirm its accuracy
- Establish and communicate limits of operation based on identified risks and available resources

Hazard –Pressurised atmosphere work

Hazard	**Control measures**
Pressurised atmosphere work	Implement appropriate entry control procedures Incident ground safety management Implement decompression procedures

Hazard Knowledge

Work in compressed air means work within any working chamber, airlock or decompression chamber that (in each case) is used for the compression or decompression of persons, including a medical lock used solely for treatment purposes, the pressure of which exceeds 0.15 bar. Access to a pressurised working will involve an air lock or a man lock.

Atmospheric pressure at sea level is fractionally above 1 bar pressure, pressure gauges are scaled to read zero at this at normal atmospheric pressure. In a pressurised atmosphere a reading of 1 bar refers to double that of atmospheric pressure. At 1 bar the equivalent volume of air at atmospheric pressure is halved, therefore inhaling the same volume of gas contains double the concentration of air.

Fires involving compressed air workings will involve an accelerated combustion process due to the richness of the oxygen in the pressurised atmosphere.

There are broadly two types of pressurised atmospheres workings, referred to here as ‘elevated pressures’ and ‘commercial workings’:

Elevated pressures

These are premises with a slightly elevated ambient pressure. They will include engineered features within structures to protect escape routes and/or to assist the emergency services in rendering assistance in terms of rescues or firefighting. Examples of these are where elevated pressures are created on protected staircases, crossover tunnels and commercial or medical 'clean areas'. As such engineered features are generally only a few Millibars above ambient pressure, they do not present any significant physiological effect on personnel entering the risk area or the duration of a self-contained breathing apparatus set.

Commercial workings

During construction, tunnels may be pressurised to prevent water ingress, particularly where they are bored under a river or in very wet strata. Regulations under the Health and Safety at Work etc. Act 1974 are in place in respect of persons employed in pressurised workings.

The Work in Compressed Air regulations 1996 apply to all people employed in tunnelling, pipe-jacking and shaft and caisson-sinking operations carried out in compressed air, including the use of tunnel boring or shaft excavating machinery and similar operations, as part of construction work.

The task of firefighting and rescuing persons employed in pressurised workings is principally the responsibility of the contractor on site. The fire and rescue service might respond to a call to pressurised workings and stand-by to give advice and provide back-up facilities as necessary. However, subject to any prior arrangement between the contractor and the fire and rescue authority, the contractor's responsibilities under the Health and Safety at Work etc. Act 1974 should make it unnecessary for the fire and rescue service to deal with an incident inside a pressurised commercial working.

Subject to prior agreement and arrangement, it might be reasonably foreseeable that fire and rescue authorities could be requested to provide some element of a contractor's emergency arrangements. Breathing apparatus (BA) command and control procedures appropriate to the risk should be established along with any minimum provisions for a safe system of work.

Health risks

When working in compressed air, the body's internal pressures balance to match the external pressure; therefore the amount of air inhaled at 1 bar pressure will be double that at atmospheric pressure.

Three types of health problem can be brought about by working in compressed air:

- Barotrauma: where a change in surrounding pressure causes direct damage to air-containing cavities in the body directly connected with the surrounding atmosphere, principally ears, sinuses and lungs
- Decompression illness: which predominantly occurs as a condition involving pain around the joints, or, more rarely, as a serious, potentially life-threatening condition that may affect the central nervous system, the heart or the lungs
- Dysbaric osteonecrosis: which is a long-term, chronic condition damaging the long bones, hip or shoulder joints.

Breathing apparatus

The working duration of self-contained breathing apparatus (SCBA) is significantly reduced by increased pressure. The balance of the exhale valve and diaphragm controlling the demand valve are likely to be affected by the increase in the external pressure. In addition, the stress and exertion of working in these environments is likely to increase breathing rates.

See also: The Work in Compressed Air Regulations 1996 and Work in Compressed Air Regulations (Northern Ireland) 2004

Control measure – Implement appropriate entry control procedures

Control measure knowledge

The elevated level of risk associated with working within a pressurised atmosphere will necessitate an appropriate level of command and control. Liaison with the responsible person at the scene will be of critical importance to the safe resolution of the incident. Entry control procedures should be based on a risk assessment of the potential for a lower working duration of self-contained breathing apparatus (SCBA) equipment.

Strategic actions.

Fire and rescue services should:

- Establish appropriate emergency arrangements at locations carrying out pressurised atmosphere work
- Gather information about the location and extent of pressurised atmosphere work and the location of the man lock door and air lock at the pressurised working chamber

Tactical actions

Incident commanders should:

- Identify and communicate any fire loading and accelerated combustion in the pressurised atmosphere
- Implement entry control and emergency arrangements based on the assessment of risk at incidents involving pressurised atmospheres
- Be aware that the use of breathing apparatus (BA) in a pressurised atmosphere may have an effect on the working duration of the BA set

Control measure – Incident ground safety management

See National Operational Guidance: Incident command for information on emergency evacuation and tactical withdrawal

Control measure – Implement decompression procedures

Control measure knowledge

To comply with Health and Safety Executive (HSE) legislation, the contractor in charge of the pressurised working operations is responsible for ensuring that medical resources for dealing with hyperbaric emergencies are provided on-site, and for formally notifying the local receiving hospitals of the fact that pressurised working is being carried out, before that work takes place.

Health and Safety Executive (HSE) legislation governs the use of, and control measures for using, compressed air, which also includes the need for decompression following a period of work or exposure in a compressed air environment.

Strategic actions

Fire and rescue services should:

- Gather information about the location and extent of pressurised atmosphere work and the location of the man lock door and air lock at the pressurised working chamber

Tactical actions

Incident commanders should:

- Ensure that on-site decompression facilities are adequate before committing crews into a pressurised atmosphere

Hazard – Ineffective intervention strategy

Hazard	Control measures
Ineffective intervention strategy	Intervention plan: Underground structures

Hazard knowledge

At known underground locations many of the risks and hazards will have been identified in advance and relevant control measures should form part of the agreed intervention strategy as part of any pre-planning process. However, incident commanders will need to devise and implement additional control measures where it is evident that any assumptions made as part of an intervention strategy can no longer be relied on.

The intervention strategy will normally establish hazard control by providing fire and rescue service facilities and one or more of the following methods:

- Activation of local or area wide automated fire/smoke ventilation and/or suppression systems, normally by the infrastructure manager, on discovery of an incident
- Liaison with infrastructure representatives and specialist fire and rescue service advisors to identify community impact

- Knowledge of the infrastructure evacuation strategy and information on its progress
- Discussion with the infrastructure manager confirming the extent to which any control has been implemented; this will assist the incident commander in identifying the safe working area for operations to take place within the infrastructure
- Use of established procedures for the type of infrastructure to establish appropriate safety measures (for example, road traffic or railway incident procedure) and to control traffic or machinery

Control measure – Intervention plan: Underground structures

Control measure knowledge

Confirmation should be sought from the infrastructure managers on the status and operation of systems used to protect members of the public, staff and firefighters, for example:

- Ventilation systems
- Pressurised escape area or intervention shafts
- Vehicle control systems (for example road traffic lights set to red at either end of tunnel)
- Current status of high voltage electricity.
- Use of any of the infrastructure manager's rescue or recovery teams
- Use of survivor reception centres and staff or customer support systems.
- Suitability of equipment to function in a tunnel or underground environment
- Communication facilities for subsurface operations

Strategic action

Fire and rescue services should:

- Develop pre-planned intervention strategies for underground environments identified as risk within the service area.

Tactical action

Incident commanders should:

- Risk-assess a range of intervention options before implementing the most appropriate strategy
- Co-ordinate the evacuation, ventilation, fixed installation and intervention strategies simultaneously

Collapsed or unstable structures

Introduction

Structural collapse can be caused in many ways: naturally (e.g. natural deterioration, earthquake, subsidence or flood water), accidentally (e.g. explosion, impact or fire), or by deliberate actions (e.g. terrorist attack or explosive device).

The possibility of collapse is also present in unstable structures. The reason for the instability could be due to one of the reasons above or could be the result of dereliction or bad workmanship.

When structures become unstable or collapse, the fire and rescue service is the best placed emergency service to respond. Individual services have the knowledge, skills, experience and equipment to deal with these environments and the UK fire and rescue service has a national network of trained urban search and rescue (USAR) operatives.

Urban search and rescue (USAR) teams are provided across the UK and are strategically located to ensure that response can be relatively rapid, co-ordinated and consistent. As part of this national network, some USAR personnel are designated as USAR tactical advisors and can be called on by the fire and rescue service to give advice on the resources available and how mobilising and tactical procedures can be used to resolve this type of incident.

Further information on the USAR capability can be found on the CFOA National Resilience website.

The issue for attending fire and rescue service personnel is that these environments are unpredictable. They are also labour intensive and arduous to work in.

Hazard – Collapsed or unstable structures

Hazard	Control measures
Collapsed or unstable structures	Consider requesting structural engineers or specialist advice Use structural monitoring equipment

Hazard knowledge

Collapse will often come without warning, leaving victims little or no time to escape. Experience of previous incidents has shown that such incidents rarely result in a total collapse. They often leave voids inside the structure, which can result in numerous casualties being trapped under large amounts of very heavy and often unstable debris. The emergency services are then faced with a complex rescue operation in one of the most hazardous environments imaginable.

There will inevitably be the risk of secondary collapse and falling debris, so monitoring structural integrity throughout the incident is of the upmost importance.

The construction of a building or structure provides some indication of the way it may collapse when subject to forces caused by fire, explosion, earthquake and so on. Structures of similar types when exposed to the same forces collapse in much the same way, and many common factors and hazards are present. Almost all types of damaged building could contain voids or spaces in which trapped people could survive for long periods of time. To understand where voids may be present, it is necessary to know the characteristics of various types of construction and the structure's likely behaviour in a collapse situation.

In considering these factors – hazards, structural damage and the location of voids – it is helpful to divide buildings and structures into four types:

- Framed buildings
- Unframed buildings
- Structures other than buildings
- Temporary structures

For further information, see the Building Research Establishment knowledge sheets.

Control measure – Consider requesting structural engineers or specialist advice

Control measure knowledge

Structural specialists can come from a variety of backgrounds and include urban search and rescue (USAR) tactical advisors, structural engineers, building control officers and demolition experts/engineers.

Most will have an in-depth knowledge of building construction; however, it should be remembered that their knowledge of collapsed and damaged buildings can vary greatly. Some may only be willing to confirm that a structure is unsafe; others will be able to offer more comprehensive advice and be able to assist in assessing and monitoring the situation.

Fire and rescue services should be aware of the national resources available to them, including urban search and rescue (USAR) tactical advisors and teams, and how they can request their attendance. Tactical advisors can give advice at varying levels, from phone contact to attendance at the scene for assessment.

Because these incident types are less common, fire and rescue personnel may not be familiar with the detailed assessment process used by urban search and rescue (USAR) personnel when dealing with collapsed or unstable structures.

Strategic actions

Fire and rescue services should:

- Establish arrangements with appropriate agencies to provide advice on the structural integrity of a building at a collapse
- Establish arrangements with appropriate agencies to provide on-scene structural monitoring equipment at a collapse

Tactical actions

Incident commanders should:

- Request the attendance of a structural engineer or seek specialist advice at incidents involving collapsed or unstable structures

Control measure – Use structural monitoring equipment

Control measure knowledge

An appropriate understanding of building design and construction materials and the size, severity and effects of the cause (natural, accidental or deliberate), both internally and externally, will help personnel identify and evaluate signs of partial or structural collapse.

Factors that may affect the structural integrity of a building include:

- Construction type
- Structural inadequacy, poor construction, illegal or non-engineered renovations/modifications
- Age of building
- Size and number of structural elements damaged/displaced
- Fire size, severity, location and number of fire-breached compartments
- Fire load applied to structural members
- Engineered timber, truss joists, nail plates
- Applied load increased as a result of water loading
- Cutting structural members during rescue operations/venting operations
- Weather extremes

Potential signs of collapse may include the following:

- Cracks in walls
- Sagging floors or floors deflecting from walls
- Displaced columns
- Dropping arches
- Bulging walls
- Buckling columns or beams
- Water or smoke that pushes through what appears to be a solid masonry wall
- Unusual noises coming from building or dwelling
- Fragmenting masonry or debris

Strategic actions

Fire and rescue services should:

- Establish arrangements with appropriate agencies to provide advice on the structural integrity of a building at a collapse
- Develop tactical guidance and support arrangements and procedures on the associated hazards and actions to be taken in, or where there is potential for, building collapse

Tactical actions

Incident commanders should:

- Consider requesting specialist monitoring equipment for unstable structures
- Assess and continuously monitor the buildings for signs of failing structural integrity

Hazard – Internal collapse

Hazard	**Control measures**
Internal collapse	Consider shoring Access weather forecast information

Hazard knowledge

Structural collapse can be caused in many ways: naturally (e.g. earthquake, subsidence or flood water), accidentally (e.g. explosion, impact or fire), and by deliberate actions (e.g. terrorist attack or explosive device). Often the collapse will come without warning, leaving victims little or no time to escape.

Experience of previous incidents has shown that such collapses rarely result in a total collapse and often leave voids inside the structure, which can result in numerous casualties being trapped under large amounts of very heavy and often unstable debris. The emergency services are then faced with a complex rescue operation in one of the most hazardous environments imaginable.

Any actions taken to locate, access and extricate victims may affect the stability of the structure, which will bring the risk of falling debris and secondary collapse. This can be mitigated to some degree by using shoring to support damaged/unstable parts of a structure and allow safe access to, and evacuation of, victims.

Control measure – Consider shoring

See Hazard – Unstable natural or built environment.

Control measure – Access weather forecast information

See Hazard – Adverse weather conditions and microclimates.

Hazard – Structural defect or further collapse

Hazard	Control measures
Structural defect or further collapse	Monitor structural integrity Consider shoring Access weather forecast information

Hazard knowledge

Most structural collapses occur because of a loss of stability: the basic shape and integrity of the structure is significantly changed through being subjected to a combination of forces. The newly altered structure/shape is then less capable of supporting the forces and loads imposed on it. The structure continues to change until it finds a new shape that is more stable. Structural collapse can follow a number of generic patterns, each with its own hazards and areas where survivors are likely to be found. Collapse patterns can be categorised as internal, external or total collapse.

Inherent design defects can cause weaknesses to parts of a structure, which may subsequently fail if stresses are applied, such as fire, abnormal weather conditions or abnormal loading by heavy machinery. A building under demolition or renovation may collapse if too many load-bearing walls or floors are removed without considering the effects on the other structural elements.

Equally, substandard materials used in construction or poor workmanship during the construction phase can result in a building that is substantially weaker than intended. This increases the likelihood of collapse should the building be exposed to additional forces.

Types of internal collapse

Pancake collapse

A failure in load-bearing walls or an upper floor fails and falls horizontally (or ‘pancakes’) onto the floor below. The added weight causes this floor, and subsequent floors, to fail and fall to a lower level (not always to ground level). Pancake collapse is sometimes referred to as progressive collapse and can be mistaken for total collapse.

Lean-to collapse

A supporting wall, column or beam fails at one end. Triangular voids are created beneath and can offer refuge for occupants.

V-shape collapse

Heavy loads from above cause a collapse at a given point of a floor level. The excess load causes the point to fail in the middle. This creates triangular voids that can act as safe havens.

Tent collapse

Structural supports fail near the outer walls but remain in situ on the interior load-bearing element.

External collapse

Types of collapse in this category include:

90° collapse

A wall falls outwards to a distance that is at least equal to its height. Debris will spread as the wall hits the ground.

Curtain fall collapse

Much like a curtain cut loose at the top; walls collapse straight down and create a rubble pile near the base of the wall.

Inward/outward collapse

Walls crack horizontally in the middle. The top half usually falls inwards and the lower half outwards.

Total collapse

This is the most severe form of structural failure and occurs when all the floors have collapsed to the ground or basement level and all walls have collapsed onto the floors.

Control measure – Monitor structural integrity

See Hazard – Failure of supporting structure.

Control measure – Consider shoring

See Hazard – Unstable natural or built environment.

Control measure – Access weather forecast information

See Hazard – Adverse weather conditions and microclimates.

Hazard – Geological effects

Hazard	Control measures
Geological effects	Use geological monitoring equipment

Hazard knowledge

Geological weakness may cause buildings to collapse through movement of the strata on which the foundations are laid, for example, earthquakes and subsidence. This movement can place excessive stress on a structure, overloading it and causing collapse. Alternatively, the ground on which the building is constructed may weaken to such an extent that it is unable to support the weight of the building. Liquefaction, where the water content in the soil increases to such an extent that the soil loses all cohesiveness and strength and the building literally sinks into the ground, is the most common form of failure.

Incident commanders should be aware of the impact that weather conditions can have on collapsed structures and consider accessing Met Office systems such as Hazard Manager.

Control measure – Use geological monitoring equipment

Control measure knowledge

There may be occasions when the unstable or collapsed structure may be affected by some form of geological movement. This is rare in the UK but similar types of ground movement within the substrata in and around the area of an unstable structure could occur.

The reasons for this movement may not be known and may not be noticeable, but the history of the initial cause of the structure's instability or collapse may indicate a need to be aware of potential ground movement. For example, in areas of known mining, the cause may be assigned to the collapse of old workings and therefore the possibility of further movement will need to be considered.

Urban search and rescue (USAR) tactical advisors will have some knowledge of the equipment available for monitoring ground movement, i.e. geological monitoring, but access to this type of highly specialist equipment will be limited. Some external specialists, such as Mines Rescue, will have access to or knowledge of geological monitoring equipment. It may be appropriate to consider using this type of equipment and service, especially in the case of protracted incidents, but it will take time to source and implement.

Strategic actions

Fire and rescue services should:

- Identify contacts who may be able to provide geological monitoring at incidents involving collapsed structures, such as urban search and rescue (USAR) tactical advisors and Mines Rescue

Tactical actions

Incident commanders should:

- Consider requesting geological monitoring equipment in consultation with urban search and rescue (USAR) tactical advisors

Hazard – Fire, heat and smoke

Hazard	Control measures
Fire, heat and smoke	See National Operational Guidance: Fires and firefighting

Hazard knowledge

Fire, heat and smoke are always a hazard to rescue operations but in unstable/collapsed structures the effect of even a small fire will be amplified. There are many reasons for this, which include:

- Restricted access and egress
- Reduced ability to get firefighting media or ventilation equipment to the scene
- The possibility that fire could weaken the structure further

Incident commanders must consider not committing personnel to the area if there is evidence of, or a risk of, fire, and should also consider withdrawing any personnel if a fire is suspected.

See National Operational Guidance: Fires and firefighting.

Hazard – Damaged utilities

Hazard	Control measures
Damaged utilities	See National Operational Guidance: Utilities and fuel.

Hazard knowledge

Gas, electricity and water services may be affected or damaged as a consequence of any structural collapse. This can create the potential for leaking gas, localised flooding and/or exposed electrical services. Isolating services must be considered in the early stages, along with liaising with the appropriate agencies to provide advice and assistance. Equal consideration should be given to the possible need to keep certain services functioning to aid in resolving the incident. The list of utilities will depend on the building; a hospital, for example, may have piped steam and/or oxygen. Unusual services such as these must be identified in the Site-Specific Risk Information (SSRI) and this must inform the incident commander's decision.

See National Operational Guidance: Utilities and fuel.

Hazard – Heavy dust loads and airborne particulates

Hazard	Control measures
Heavy dust loads and airborne particulates	Wear appropriate personal protective equipment (PPE) and respiratory protective equipment (RPE)

Hazard knowledge

Collapsed structure incidents will generate large quantities of dust as a result of the collapse and/or as a consequence of search and rescue operations undertaken and the associated equipment used. Such dust may be inherently carcinogenic or hazardous and have the potential to travel off-site, particularly in inclement weather conditions. The type and amount of such contaminants will inform the provision of appropriate personal protective equipment (PPE) and respiratory protective equipment (RPE). Consideration may also need to be given to people away from the incident who may be affected by dust plumes.

For more information on specific substances such as asbestos, silica etc. see NOGP – Hazardous Materials – Health Hazards

Control measure – Wear appropriate personal protective equipment (PPE) and respiratory protective equipment (RPE)

See National Operational Guidance: Operations.

Hazard – Flying debris and shards

Hazard	Control measures
Flying debris and shards	Establish appropriate cordon controls Limit access to inner cordon Use hard and soft protection Wear appropriate personal protective equipment (PPE) and respiratory protective equipment (RPE)

Hazard knowledge

Cutting equipment will be needed to create access to a collapsed structure. Such operations will produce debris, sparks and dust, which may create additional hazards if not appropriately managed. Damping-down techniques can be employed to reduce hazards of this nature, but all equipment must be appropriately guarded and used by suitably trained personnel wearing the appropriate personal protective equipment (PPE) or respiratory protective equipment (RPE).

Control measure – Establish appropriate cordon controls

See National Operational Guidance: Incident command.

Control measure – Limit access to inner cordon

Control measure knowledge

The nature of these environments will almost certainly limit the number of responding personnel in the inner cordon, but incident commanders will still have to consider how to achieve the task using the minimum number of personnel.

Other considerations will be the arduous nature of the tasks and the environment in which they are carried out. The need to relieve personnel regularly and the extended travel time to the scene of operations must therefore also be considered.

See National Operational Guidance: Incident command – Establish appropriate cordon controls.

Control measure – Use hard and soft protection

Control measure knowledge

Where flying debris and shards present a hazard to emergency responders working inside the inner cordon, a hierarchy of control measures should be considered. Where possible, responders should try to use or create 'hard' protection barriers. These may be in situ, for example, taking a specific access route to an unstable structure using elements that are structurally sound and avoiding higher risk routes. It may be possible to use equipment and shoring techniques to create hard protection, or to build temporary physical barriers that allow personnel to be isolated from the risk.

Alongside these hard protection methods, using cordons and appropriate personal protective equipment (PPE) will help to provide 'soft' levels of protection.

Both hard and soft methods of protection are forms of control measures in response to hazards and risks. As such, the choice of protection method must be the result of a risk assessment and should aim to provide the highest level of protection for those who may be exposed. It is also important to recognise that in these environments and at specific types of incident, the potential for dynamic change is high and the reassessment of control measures must be regular and frequent.

Tactical actions

Incident commanders should:

- Consider using hard and soft protection to protect crews from flying debris and shards

Control measure – Wear appropriate personal protective equipment (PPE) and respiratory protective equipment (RPE)

See National Operational Guidance: Operations.

Hazard – Ineffective communication

Hazard	Control measures
Ineffective communication	Deliver effective crew briefings Select and use appropriate communication equipment

See Hazard – Ineffective communications.

Control measure – Deliver effective crew briefings

See National Operational Guidance: Incident command.

Control measure – Select and use appropriate communication equipment

See Control measure: Select and use appropriate communications equipment

Hazard – Moving heavy and bulky items

Hazard	Control measures
Moving heavy and bulky items	See National Operational Guidance: Operations.

Hazard knowledge

Urban search and rescue (USAR) capabilities have access to resources, equipment and techniques that will reduce manual handling risks. Incident commanders should consider requesting specialist advice and resources through a USAR tactical advisor.

See National Operational Guidance: Operations.

Glossary

Term	Acronym	Description
Airlock		A compartment with controlled pressure and parallel sets of doors, to permit movement between areas at different pressures.
ATEX directive	ATEX	The ATEX directive consists of two EU directives describing what equipment and work environment is allowed in an environment with an explosive atmosphere. ATEX derives its name from the French title of the 94/9/EC directive: *Appareils destinés à être utilisés en **AT**mosphères **EX**plosives*.
Caisson		A large watertight chamber, open at the bottom, from which the water is kept out by air pressure and in which construction work may be carried out under water.
Coanda effect		The phenomena in which a jet flow attaches itself to a nearby surface and remains attached even when the surface curves away from the initial jet direction.
Compressed-air breathing apparatus	CABA	Sometimes referred to as a self-contained breathing apparatus (SCBA) or simply breathing apparatus (BA), CABA is a device worn by rescue workers, firefighters and others to provide breathable air in an irrespirable atmosphere.
Confined space supervisor		Confined space supervisors should be given responsibility to make sure that the necessary precautions are taken, to check safety at each stage; they may need to remain present while work is underway.
Civil Contingencies Act 2004 Category 1 responders	CCA Cat1	Category 1 responders are those organisations at the core of emergency response (e.g. emergency services or local authorities).
Civil Contingencies Act 2004 Category 2 responders	CCA Cat2	Category 2 responders are ‘co-operating bodies’ who, while less likely to be involved in the heart of planning work, will be heavily involved in incidents that affect their sector (e.g. Health and Safety Executive, transport and utility companies).
Fall protection		Prevention of an operative from going into free fall by way of a rigid barrier or similar protection method.
Fall prevention		Prevention of a fall arrest system user from colliding with the ground or structure in a free fall.

Fall arrest		Prevention of a fall arrest system user from colliding with the ground or structure in a free fall.
Fall mitigation		Reduction in the severity of the hazards and risk associated with fall protection.
Fall/work restraint		Personal fall protection system that restricts the travel of the user away from potentially hazardous areas.
Flashover		A flashover is the near-simultaneous ignition of most of the directly exposed combustible material in an enclosed area. When certain organic materials are heated, they undergo thermal decomposition and release flammable gases.
Work positioning		Fall protection system that enables the user to work while supported in tension or suspension in such a way that a fall is prevented.
Guano		Bird faeces.
Hazard Manager		A weather information interface provided by the Met Office. It provides a range of services to help authorities prepare for and respond to emergency incidents that are caused or influenced by the weather.
Infrastructure manager		An infrastructure manager is the person who is responsible for developing, maintaining, managing and/or operating an infrastructure.
Man lock		An airlock that allows workers to pass in and out of spaces with differing air pressures, especially one providing access to and from a tunnel, shaft, or caisson in which the air is compressed.
Personal protective equipment	PPE	Personal protective equipment includes items such as fire tunics, over-trousers, helmets, fire hoods, gloves and boots. Specialist personal protective equipment may be used for certain types of incident.
Pneumatic caisson		Pneumatic caissons are sealed at the top and filled with compressed air to keep water and mud out at depth. An airlock allows access to the chamber.
Respiratory protective equipment	RPE	Respiratory protective equipment includes breathing apparatus, particle masks and respirators.
Task, individual capabilities, load and environment	TILE	Considerations for manual work.
Technical rescue team		Technical rescue teams are those who employ specialist rescue tools and skills. These disciplines

		include rope rescue, swift-water rescue, confined space rescue, ski rescue, cave rescue, trench/excavation rescue, and building collapse rescue, among others.
Trench effect		The trench effect is a combination of circumstances that can rush a fire up an inclined surface. It depends on two well-understood but separate ideas: the Coanda effect from fluid dynamics and the flashover concept from fire dynamics.
Tunnel-boring machine	TBM	A machine used to excavate tunnels with a circular cross section through a variety of soil and rock strata.
Windage		The air resistance of a moving object, such as a vessel or a rotating machine part, or the force of the wind on a stationary object.

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Useful websites

CFOA National Resilience website: http://www.fireresilience.org.uk/

BS 6164:2011: Code of practice for health and safety in tunnelling in the construction industry: http://shop.bsigroup.com/ProductDetail/?pid=000000000030218916