Title:	Fires and firefighting
Project Executive:	CFO Tom Capeling, Tyne and Wear FRS
Synopsis:	This guidance covers all phases of a fire incident – locating the fire, extinguishing the fire, preventing damage from fire and/or firefighting operations and fire investigation. Firefighting activity is for fires in the built environment (including compartment firefighting) and the open environment (including small to medium outdoor fires).
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National Operational Guidance – Fires and firefighting third edition version one (ARCHIVED on 20-09-17)

Introduction

This section of the guidance sets out the hazard knowledge and control measures that should be considered in relation to fires and firefighting. The aim is to integrate the knowledge, understanding and actions required to support the appropriate, safe and efficient resolution of any incident involving fire.

Fires and firefighting guidance should be read in conjunction with the information contained at www.ukfrs.com; this provides information on the aims and intended use of the guidance. It should also be read alongside other related National Operational Guidance (NOG) where appropriate.

This guidance has not been developed in isolation; there are many existing points of reference, including scientific papers, technical reference books, reports and earlier guidance. Some of these remain valid sources of information; for example, the Fire Service Manual, Volume 2: Hydraulics, Pumps and Water Supplies and British Standards for Classification of Fires.

Legislative requirements

There are numerous pieces of legislation that have an impact on fire and rescue services as they pursue their fundamental duties; much of this has been considered when compiling this guidance.

- Fire and Rescue Services Act 2004
- Fire (Scotland) Act 2005
- Fire and Rescue Services (Northern Ireland) Order 2006
- Civil Contingencies Act 2004
- Civil Contingencies Act 2004 (Contingency Planning) (Amendment) Regulations 2011
- The Civil Contingencies Act 2004 (Contingency Planning) (Scotland) Regulations 2005
- Dangerous Substances and Explosive Atmospheres Regulations 2002
- Dangerous Substances and Explosive Atmospheres Regulations (Northern Ireland) 2003
- The Confined Spaces Regulations 1997
- Confined Spaces Regulations (Northern Ireland) 1999
- The Work at Height Regulations 2005
- Work at Height Regulations (Northern Ireland) 2005
- Police and Criminal Evidence Act 1984
- The Police and Criminal Evidence (Northern Ireland) Order 1989
- Water Act 2003

Risk management plan

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

Work to identify risk and prepare operational plans should be carried out with all stakeholders in mind, including local emergency planning groups and the fire and rescue service's risk management plan.

Responsibilities of fire and rescue services

Fire and rescue services are responsible, under legislation and regulations, for developing policies and procedures and for providing their personnel with information, instruction, training and supervision about foreseeable hazards and the control measures used to prevent or limit the risks arising from them.

Hazard and control statement

Hazard	Control measures
Inaccurate situational awareness	Local knowledge and incident orientation Refer to Operational Risk Information: Fires Liaise with the responsible person: Fires Scene survey Consider using thermal imaging or scanning Building systems and facilities Consider using closed-circuit television (CCTV) Consider making a forcible entry
Insufficient resources	Appropriate deployment of resources Additional resources Specialist resources and advisers Water and extinguishing media management and planning
Fire and thermal radiation	Appropriate speed and weight of intervention Eliminate ignition sources Select an appropriate firefighting method Select an appropriate firefighting media • Foam delivery Select the appropriate firefighting technique • Direct firefighting • Gas cooling • Firebreaks and fuel breaks • Cutting away • Controlled burning • Damping down and turning over Select appropriate firefighting equipment • Portable fire extinguishers • Flow rates

Hazard	Control measures
	• Hose • Branches and nozzles • Monitors Wear personal protective equipment (PPE) Consider wearing respiratory protection equipment (RPE)
Flashover, backdraught and fire gas ignition	Understand signs and symptoms of flashover Understand signs and symptoms of backdraught Gas cooling Consider employing tactical ventilation Wear personal protective equipment (PPE)
Uncontrolled ventilation	Consider employing tactical ventilation
Smoke and fire gases	Avoid smoke plumes Consider employing tactical ventilation Wear personal protective equipment (PPE) Consider wearing respiratory protection equipment (RPE) Employ safe navigation techniques
Live utilities	Consider isolating utilities
Fires involving flammables, explosives and combustible dusts	See National Operational Guidance: Hazardous Materials – Physical hazards (to follow)
Preventable damage	Planning Use on-site salvage plans or expertise Tactical planning – Damage control Removal of valuables Protection of valuables Close doors Minimal use of firefighting media Mitigation

Hazard	Control measures
Failure to conduct fire investigation	Secure the scene Preserve evidence Undertake the appropriate level of investigation Establish cause Liaise with and hand over to other statutory bodies Consider using closed-circuit television (CCTV) Cutting away Consider using thermal imaging or scanning Personal protective equipment (PPE) Consider wearing respiratory protection equipment (RPE) Writing reports for fire investigations Attendance at coroner's court (or equivalent) Highlight trends Support future learning Identify failures in fire safety measures

Hazard – Inaccurate situational awareness

Hazard	Control measures
Inaccurate situational awareness	Local knowledge and incident orientation Refer to Operational Risk Information: Fires Liaise with the responsible person: Fires Scene survey Consider using thermal imaging or scanning Building systems and facilities Consider using closed-circuit television (CCTV) Consider making a forcible entry

Hazard knowledge

In exercising their statutory duties and powers under the relevant and current legislation, fire and rescue services will encounter, and should expect to deal with, fires of various types (as detailed in BS EN 2: 1992 - Classification of fires) and sizes, in a wide range of locations, environments and contexts.

In any fire situation, regardless of size or type, the fundamental factor for all fire and rescue services will be locating the fire. This may be establishing the location of the incident or the potentially more complex task of finding the fire in a building, structure or vessel.

Locating a fire will depend on many competing factors and pressures but, in simple terms, it relies on gathering information, sharing intelligence, reconnaissance and, above all, effective communication and liaison between individuals, teams and other agencies/responsible authorities. Further information can be found in the Joint Emergency Services Interoperability Principles (JESIP), joint decision making model.

From the moment the incident commander and firefighters are notified and mobilised to a fire, information, both factual and predictive, will begin to flow. It is essential for the incident commander to ensure that everyone adopts an approach that enables them to manage the information they receive methodically, so they assimilate the data and begin to assess what can often be a complex, dynamic and chaotic situation.

At any incidents involving fire, information will present itself to the incident commander and firefighters from multiple sources, in numerous forms and not necessarily in an entirely expected order. Some of this will be factual information and some largely predictive information.

- Factual information can be defined as accurate data from sources such as:
  - Prior knowledge, including information from pre-incident planning Site-Specific Risk Information (SSRI), tactical plans, business fire safety and site visits/inspections. See National Operational Guidance: Operations for further information.
  - Reliable sources, such as information from a responsible person, the owner/occupier of a building, a building engineer or other agencies
  - Directly observed information – time of day, temperature, weather conditions, signs and symptoms of flashover or backdraught.
  - Topography

The incident commander and firefighters will, in most situations, rely heavily on fire control rooms as their primary source of factual information. This information will be vital and will support the initial assessment and evaluation of what is likely to be encountered on arrival.

Assessing and evaluating an incident will often be the key determining factor in the overall success or failure of a firefighting operation. It is therefore important that the information gained at this stage as part of the dynamic risk assessment (DRA) is used carefully to build a picture of the situation, identify the respective hazards, determine the immediate priorities, actions and subsequently the tactics (offensive or defensive), to ultimately establish the resources that may be required to bring the fire under control as safely as possible.

Especially when responding to an incident involving fire, at a very early stage the incident commander will need to consider their priorities, with the primary objective always being to save lives. This should include keeping firefighters safe as well as performing rescues. The remaining priorities will normally include preventing surrounding risks or buildings being exposed, containing the fire in a specific area and, of course, extinguishing the fire.

With the exception of saving lives, these tactical priorities do not take particular precedence or follow a hierarchy, and it may be that in carrying out any one of them, the others are dealt with simultaneously. For example, a rapid intervention with limited resources may bring the fire under control quickly. This will in turn support containment, reduce likely spread and lead to the fire being extinguished.

Interpreting data and information from the various sources available will allow crews to identify, negotiate and establish safe approach, and access and egress to and from the proximity of the fire for attending resources.

Reference to the historical knowledge, intelligence, risk information and data gathered by a fire and rescue service and during pre-planning events such as site visits will also be vital.

See National Operational Guidance: Operations for further information.

By the time the incident commander and firefighters arrive at an incident they will have begun to formulate a basic initial plan. However, once in attendance on the fire ground, they will be in a better position to collect further predictive information and verify the facts to help locate the fire. This may come from interviewing and interrogating a range of data sets including:

- The original caller – See National Operational Guidance: Operations for information on call handling and mobilising
- The responsible person – National Operational Guidance: Operations for further information
- An appointed competent person
- Casualties, the public and bystanders – See National Operational Guidance: Incident Command
- Information gathered from fire and rescue service personnel and other emergency responders. See National Operational Guidance: Incident command for information on briefing and debriefing
- Interrogation of systems and technologies including fire detection and fire protection systems – See National Operational Guidance: Fires in the built environment for further information
- Mobile data systems

The incident commander and firefighters may also consider using a variety of skills, knowledge and items of fire and rescue service equipment, individually or in combination, to identify the exact location of a fire, including:

- A scene survey of the area or building to give a visual and sensory appreciation of all immediate priorities and hazards

- Thermal scanning of the structure, building or immediate area to highlight hotspots or help identify the position or extent of fire or to locate casualties
- Interrogation of building systems, such as automatic fire alarm (AFA) systems and CCTV, that may assist in identifying the exact location of the fire

As well as gathering all available information and possessing the necessary professional firefighting skills, knowledge and equipment, it is important that firefighters make effective use of the simple information that may be presented to them in a fire situation. Identifying, understanding and reading the key information available through human senses (sight, sound, smell, and touch) are vital skills that may help firefighters to identify the location of a fire in any environment.

For example, when dealing with a fire in the open environment, a firefighter may be able to use all of their senses to help locate the fire; they may be able to see the fire itself or the fire gases or smoke being given off.

This may also help to give an immediate indication of the size or extent of the fire or help in identifying key hazards such as flashover or backdraught and their inherent signs and symptoms.

The ability of firefighters to interpret smoke, including its volume, velocity, colour, density, movement and behaviour, can be useful predictive information. Sometimes even the smell from a distance can give clues to what may be involved; for example, burning foodstuffs, overheating electrical equipment, burning wood or paper have fairly distinctive odours.

Direct observation will often provide good predictive information about a fire. However, this should always be considered alongside more accurate factual information about the building and the incident. For example, visible flames can indicate where a fire is and its intensity, but in isolation this may not tell the entire story. Equally, flaming combustion, blackened windows or smoke coming from a window may seem to indicate that a fire is contained in a specific room but it is possible that it could be spreading through unseen structural voids that exist in many buildings, including timber-framed buildings.

It may not always be possible to pinpoint the location of a fire solely from an exterior view; from the information gained during the scene survey alone or where it is not possible to undertake a full scene survey. It may therefore be necessary to commit firefighters to a fire situation to provide internal reconnaissance.

In these circumstances, crews should be specifically tasked and given a clear briefing that allows them to operate safely and effectively. Inside a building they can use direct observation and senses to feed factual and predictive information to the incident commander who will be in a position outside a building or remote from the immediate fire zone.

Where the prevailing conditions of the fire or smoke limit visibility, firefighters can look, listen or feel for indicators such as changes in temperature (radiant heat), or the light from the flicker of a flame from a specific direction that may lead them to the seat of fire. Other simple signs and symptoms like the distortion of superficial parts of a structure, blistered surface finishes or smoke percolating through gaps may help find the fire.

The skills, knowledge and experience of the incident commander and firefighters are vital to the successful execution of any fire attack or suppression plan. However, emergency fire vehicles, equipment and resources will also be integral to supporting any attack.

To assist in locating the fire, thermal imaging equipment is particularly effective; handheld devices can assist firefighters in pinpointing the location of a fire. It can be used both internally and externally to scan a structure or area of a fire. Thermal imaging equipment has the additional benefit of enhancing overall firefighter safety as well as being a valuable item that breathing apparatus (BA) search and rescue teams can use to locate casualties.

Most police helicopters, including those operated by the National Police Air Service (NPAS), have thermal imaging equipment. This may be something that fire and rescue services can explore as part of local liaison and interoperability. Some service may have access to drones or unmanned aerial vehicles with live video and infra-red capabilities. The facility is particularly effective at large-scale fires, such as wildfire events, which have the potential to spread and cover large geographical areas.

By considering some of these simple measures and developing them further in local procedures, fire and rescue services can ensure that firefighters are in a position to quickly assess and evaluate the situation, make an informed judgement about the location of the fire and begin to find out what is burning (type of fire) and the extent to which the fire has spread (physics of combustion).

This will subsequently enable them to make clear decisions about the overall priorities, tactics and plans needed to intervene and extinguish the fire, including the firefighting method and the type of firefighting media to deal with the situation in the safest, most appropriate and efficient manner, preventing, limiting and minimising damage from fire and firefighting operations.

Control measure – Local knowledge and incident orientation

Control measure knowledge

Pre-planning is the process of gathering and recording information that could be critical for fire and rescue service personnel making life-saving decisions at a fire. Pre-incident plans generally include information that will be used by decision makers at a fire. Property and lives can be saved when the incident commander has access to this critical information about the building and its contents.

Pre-fire planning is essential. A detailed pre-plan can help the incident commander determine the appropriate tactics to adopt when tackling a fire and how best to deploy firefighters and equipment at the incident scene. See National Operational Guidance: Operations for further information about pre-planning.

A detailed pre-fire plan provides a range of information such as the design and construction materials of buildings along with their facilities and systems. One of the most critical pieces of information a pre-plan can offer is the presence of hazardous materials, including the type and quantity and their location in the building. Ideally, pre-incident plans will list any materials located at a site so they can easily be found.

Historically, plans, diagrams and associated information have been paper-based and filed on fire and rescue service vehicles, with a crew member having to search through files to find the relevant plan and information for the building where the incident occurred. Today, most fire and rescue services have mobile computers or data systems in at least some of their vehicles, which can store pre-plans and other information

Technology aside, comprehensive knowledge of a firefighter's station ground is the primary requisite for successful firefighting, with the information gained growing with time and through attendance at fires on the ground. They should be familiar with the location of hydrants, supplementary and/or secondary water supplies that would help firefighting in both urban and rural areas.

Fire and rescue service personnel should try to learn as much as possible about any special industrial processes or industries in the area, so they are aware of the conditions they will meet if they are called to a fire at these premises and of any precautions they should take.

Enquiries before a fire will tell them if the police or other responsible person (or appointed competent person) holds keys to certain classes of premises. They should also make contact with appropriate individuals, such as the occupiers of large premises and officers in charge of industrial or private fire services. Good liaison with these people will foster the co-operation essential for smooth working should fire and rescue services be called to a fire at these premises.

See National Operational Guidance: Operations - Time of alert to time of attendance

Control measure – Refer to Operational Risk Information: Fires

Control measure knowledge

Every fire and rescue service must assess the hazards and risks in their area, with site-specific risk plans established for locations where hazards and risks are significant. A site-specific assessment includes information relating to pre-planning firefighting tactics.

See National Operational Guidance: Operations – Information gathering

Control measure – Liaise with the responsible person: Fires

Control measure knowledge

Buildings

Many types of premises, such as industrial or commercial buildings, should have a responsible person who will be accountable for aspects of the site under their control. See National Operational Guidance: Operations for further information.

Open environment

Fires in all other areas of land should have a responsible person appointed. Examples of those who can be considered responsible persons for areas of open land include:

- Government authorities
- Local authorities
- Forestry Commission
- Private land owners (farmers, individuals, organisations)

For further information see National Operational Guidance: Operations – Risk Information Gathering

Control measure – Scene survey

Control measure knowledge

For an incident commander to formulate a safe and effective operational plan, a high level of situational awareness should be achieved. A full scene survey of the fireground at the earliest opportunity can help to establish the location and extent of a fire, along with safe access and egress points and routes or designated rendezvous point (RVP) for the incident.

The incident commander may nominate another suitably qualified member(s) of personnel to carry out the task if it would be safer and more effective to do so, especially since, at some large incident sites, a full scene survey could be a prolonged activity. Details such as further life risk, fire development or alternative access routes must be relayed to the incident commander and all relevant personnel.

Fire and rescue service commanders may need to carry out a scene survey repeatedly during prolonged fire incidents to provide the most recent information from the incident ground for incident command personnel to adapt their plan as necessary.

Employing other resources to provide aerial survey could be considered, such as:

- Police helicopters or other aircraft
- Unmanned aerial vehicle or drones
- Aerial appliances

See National Operational Guidance: Incident Command – Situational awareness

Strategic actions

Fire and rescue services should:

- Provide incident commanders with development to support the gaining of situational awareness through scene survey

Tactical actions

Incident commanders should:

- Identify the location of the fire, materials involved and any potential for flashover or backdraught
- Consider potential causes of fire e.g. deliberate or accidental ignition and illegal activities
- Monitor and assess fire development for signs and symptoms of fire spread and rapid escalation

Control measure – Consider using thermal imaging or scanning

Control measure knowledge

Thermal imaging cameras (TIC) and other thermal scanning equipment are devices that form an image using emitted infrared radiation as opposed to normal visible radiation. They gather information when normal observation may be inhibited due to smoke or lack of lighting. They also provide the option to search for specific points of interest such as casualties or seats of fire, which may not be obviously visible through the normal spectrum. In some situations, firespread may not be visible to the naked eye, but may be detected using TICs.

The range of thermal image cameras available is wide and they have varying specifications. However, many cameras have a numerical and colour gradient temperature scale, which may assist crews attempting to locate a fire and any causalities or for thermal scanning of a building.

The heat energy radiated from the objects in the form of infrared waves is picked up by the TIC, which is then able to identify the energy differences from the objects being scanned and convert the readings into visual images. The image displayed is therefore based on temperature differential.

Images may be displayed in black and white or in a colour range. The TIC manufacturer's information should be referred to for descriptions of how higher or hotter temperatures will be displayed on their equipment.

TICs are available in different sizes and as an integral part of a number of different resources:

- Hand-held
- Helmet-mounted
- Emergency fire vehicle-mounted
- Self-contained
- Remote-controlled
- Aircraft-mounted (helicopter, drone and aeroplane)

Thermal imaging equipment can offer considerable benefits to incident commanders during the information gathering stage of an incident, including:

- Establishing possible seats of fire
- Establishing the extent of firespread
- Establishing internal fire conditions and assessing the need for defensive or offensive action
- Searching for casualties inside a structure
- Wider search for casualties (during road traffic collisions, aircraft crashes, railway incidents, incidents in the open)
- Improved search capability during low light or low visibility
- Locating the seat of fire in large fuel supplies (for example in landfill or waste management centres)

- Locating hot spots, bullseyes, small areas of combustion or heating
- Establishing heat spread to adjacent hazards and fuel supplies
- Establishing sources of overheating in electrical or mechanical scenarios (for example lighting chokes, vehicle brakes)
- Establishing compromises or weaknesses in fire resistance
- Locating hot spots in cylinders, vessels or pipework
- Recording images and videos, which can assist subsequent investigations or debriefs
- Assisting the incident commander via video link to command and control units

Operators of thermal imaging cameras should be aware that:

- The equipment may not be intrinsically safe, limiting its use in some hazardous environments
- Some surfaces can reflect or absorb infra-red radiation, causing images to be misleading to an operator. For example, the devices often depict areas of the same temperature in the same shade or colour. This can obscure some hazards such as pits, surface liquid or unsafe ground which may be dangerous for operators in that area
- Equipment using a different spectrum should not be relied on as a total replacement for normal vision. Standard service procedures for moving in smoke and darkness must be maintained and great care should be taken to ensure that personnel remain safe because battery power may be lost rapidly with little warning
- Images displayed on the devices are computerised images created from the sensor equipment. Allowances should therefore be made for alterations to the actual size and distances involved for the objects on display
- Images may be misleading as sensors may not differentiate between the heat of a fire versus the reflected heat from the sun on surfaces such as glass or polished metal. Well-insulated structures (e.g. sandwich panelled premises) do not readily allow for the passage of infrared radiation. Using a TIC may therefore indicate weaknesses in a structure but may not give any indication as to the conditions within it.

A video developed by Greater Manchester Fire and Rescue Service shows the use of thermal scanning as part of its future firefighting techniques programme.

Strategic actions

Fire and rescue services should:

- Develop tactical guidance and support arrangements for the actions to take, and hazards associated, with the use of thermal image cameras
- Consider using thermal image cameras with video link facilities
- Ensure all personnel receive information, instruction and training in the use and limitations of thermal imaging equipment

Tactical actions

Incident commanders should:

- Consider using thermal imaging equipment for scanning when carrying out a scene survey

Control measure – Building systems and facilities

See National Operational Guidance: Fires in the built environment and the Building Research Establishment knowledge sheets for further information.

Control measure – Consider using closed-circuit television (CCTV)

Control measure knowledge

Closed-circuit television (CCTV) systems are found in many different forms with various degrees of capability. Although the type of system and its overall purpose will vary, they are mainly used to ensure the safety and security of premises, people and property.

Many city centres,-motorway and road networks, individual buildings (commercial and domestic), public vehicles and even emergency fire vehicles are equipped with cameras linked to networks or recording facilities. All of them may provide valuable information for the fire and rescue service from both an operational and investigative perspective.

Systems are often monitored by a dedicated CCTV control room, which can be a useful source of information to help an incident commander build a picture of what has occurred and what is currently going on in areas that may be remote from where fire and rescue service personnel are operating.

These dedicated CCTV control rooms may be located in individual premises or sometimes remotely at other locations. They often have the capability to broadcast live or recorded imagery to multiple networked receivers who may be on a fire ground or at a remote location.

Dedicated CCTV control rooms are often able to adjust the views of individual cameras. For larger incidents or in areas with difficult or dangerous terrain such as wildfire incidents, it may be appropriate to use CCTV equipment attached to aerial vehicles such as helicopters, fixed-wing aircraft or remotely piloted aircraft

Some CCTV may be able to provide imagery in radiation spectrums, including infrared, which could provide helpful data during incidents with poor lighting or obscured visibility.

Note: CCTV systems fitted to fire and rescue service vehicles can be useful in protecting fire and rescue service employees who may sometimes be subjected to verbal abuse, physical attacks or road traffic collisions.

Strategic actions

Fire and rescue services should:

- Make appropriate arrangements with CCTV system operators where necessary and, according to identified risks, to assist with operations, incident command structures and interoperability
- Develop tactical guidance and support arrangements for the hazards and actions to be taken into consideration when using CCTV systems at operational incidents
- Following the assessment of risk in the fire and rescue service area, consider using vehicle and personnel mounted cameras

Tactical actions

Incident commanders should:

- Access CCTV images to support situational awareness if available and timely

Control measure – Consider making a forcible entry

Control measure knowledge

Incident commanders should consider the type of construction, possible entry points and the types of securing devices present and establish the most appropriate equipment and techniques for the specific situation. Selecting the right tool and techniques can save valuable time, could save lives and may also assist in mitigating any damage.

In most fire situations, the level of urgency and the method of entry will, to a great degree, depend on the time-critical nature of events. For example, if rapid entry is needed to save a life or prevent more serious damage or firespread, crews may not have the opportunity to limit any damage.

However, when the situation appears less urgent, firefighters can take more time and potentially select a less invasive technique to minimise or prevent any unnecessary damage. For example, the activation of an automatic fire alarm in a closed business in the middle of the night is much less likely to be a life-threatening situation than a call where people are reportedly in distress or trapped.

A huge range, and countless variations, of elements such as doors, windows, locks and security devices may be encountered depending on the type of premises. Firefighters should be familiar with the common styles of windows, doors, locks and security devices in their local area and with those that may be unique to certain types of premises, such as police custody suites, prisons and detention centres, hospitals or secure units.

The optimum time to build knowledge and understanding of unique sites and specific components is during Site-Specific Risk Information (SSRI) and pre-incident planning visits in compliance with current legislation. Arranging tours or inspections of buildings under construction and renovation is also an excellent way to learn about building construction and examine different security devices.

See National Operational Guidance: Operations - Risk Information Gathering

Incident commanders will need to evaluate all the information presented before deciding on a course of action. This includes:

- Confirming that firefighters are at the correct address or location: where it is not obvious, it is important to check and establish that the address or location is correct and that crews are forcing entry to the correct premises, room or compartment
- Considering implementing defensive firefighting actions before making a forcible entry
- Establishing the severity and level of urgency related to the incident. For example, where flames and smoke are visible and people reported missing, trapped or in distress, the methods of forcing entry may cause damage that requires more expensive repairs to doors, windows or parts of the structure
- Selecting the safest and simplest method of gaining entry. When considering how to make entry, the objective should be balanced with the severity or urgency of the emergency. Crews should generally attempt to enter with the least damage in the shortest amount of time.
- Before forcing entry, a simple rule is 'try before you pry'. Always check doors and windows to confirm that forcible entry is actually required. An unlocked door requires no force; a window that can be opened does not need to be broken. Taking a few seconds to check could save several minutes of effort and unnecessary property damage.
- Checking for alternative means of entry or entry points can also ensure that crews are not spending time working on a locked door when, for example, a nearby window provides easy access to the same room
- Selecting the most appropriate tools and equipment to effect entry
- Consider the creation of an access/entry point where one did not previously exist to reduce the travel distance for BA wearers to exit a hazard area. Consideration should be given to the equipment and time required to create a new opening and the structural integrity of the building.

In most circumstances, personnel should:

- Select the point of entry and the method of gaining entry as part of the initial incident plan.
- Ensure that the efforts of different crews are properly co-ordinated for safe, effective operations. For example, all actions taken to force entry should be co-ordinated with breathing apparatus teams and firefighters to ensure that firefighting, safety and/or covering jets are in place and ready to advance before forcing access.
- Consider whether the action of forcing an opening to a building or compartment will create a flow path that allows air to enter the structure. This could contribute to an increase in fire development that may lead to events including flashover or backdraught.
- Consider that making an opening at the wrong location could undermine a well-planned fire intervention and impact on the overall ventilation strategy
- Consider entry as part of a ventilation strategy and ensure it is co-ordinated with the overall tactical plan

Strategic actions

Fire and rescue services should:

- Develop tactical guidance and support and mitigation arrangements for forcible entry by service personnel into areas and buildings
- Develop processes for letting absent occupiers, owners and responsible persons know that forcible entry has been made.
- Provide crews with information, instruction and training in effective methods of making forcible entry
- Make arrangements for securing property where forcible entry has been made

Tactical actions

Incident commanders should:

- Gain access to premises, causing minimal damage while having regard to the urgency of the situation
- Consider cutting away to access the seat of the fire, hidden voids and compartments

Hazard – Insufficient resources

Hazard	Control measures
Insufficient resources	Appropriate deployment of resources Additional resources Specialist resources and advisors Water and extinguishing media management and planning

Hazard knowledge

The deployment of resources at an incident involving fire will be key to the success or failure of subsequent firefighting strategy and operations.

Any failure to mobilise sufficient personnel, equipment, specialist skills and other agencies to a fire incident may result in delayed operational intervention, increased fire development and reduced firefighter safety. Attempting to extinguish a fire with insufficient media available could result in the incident plan being only partially successful and the risk of reignition. As part of an initial plan, incident commanders should consider those resources available and whether there is an opportunity to save life or prevent the incident escalating.

In some cases, resources such as firefighting media may be critical to a specific type of fire and may need to be considered for a particular risk as part of pre-incident planning, including site visits, Site-

Specific Risk Information, tactical plans and foam plans. For example, a fire in a flammable liquid storage facility may require large quantities of foam and associated equipment to apply it effectively.

Fire and rescue services should consider special factors such as the requirement for large volumes of specific extinguishing media and make the necessary contingency or resilience arrangements to obtain them when required.

At large-scale incidents, fire and rescue services and the incident commander may need to consider additional resources that may be required as part of a protracted deployment. These may include fuel supplies for emergency fire vehicles and equipment, particularly for firefighting pumps that may remain in position for days or even weeks at a time.

See National Operational Guidance: Operations for further information.

Commanders should be aware that any congestion on the fire ground can lead to delays in important resources arriving and the likely impact on any fire development. It may also obstruct the passage of vehicles from other agencies, particularly ambulance service vehicles, where efficient arrival and departure may be key to achieving good patient outcomes.

Control measure – Appropriate deployment of resources

Control measure knowledge

The uncontrolled arrival and deployment of emergency fire vehicles and crews on the fireground may lead to poor vehicle positioning and insufficient accounting for personnel deployed at the scene. In an explosion, a sudden worsening of fire conditions or structural collapse, failure to follow proper deployment protocol may lead to injury, damage and a delay in locating or failing to locate affected personnel.

Vehicle drivers and commanders need to be aware of the appropriate cordon and safety distances applicable to hazardous materials, the likely development of fire and the nature of building collapse for different types of structure. Other significant hazards and risks include:

- Members of the public who may be distressed, excitable or unaware of the nature of the emergency
- The operational imperative, which may place moral pressure on crews, or the imperative to act in a way that is directed at satisfying that need rather than the operational needs of that particular incident
- The working environment~~,~~ which may include available light, distance to the scene of operations, terrain and conditions underfoot
- Remote locations, which may lead to poor radio communications, increased workloads on firefighters, difficulties with water supplies and increased attendance times

When deploying resources to the fireground, incident commanders should be aware of the strategic disposition of resources in their service and release or withhold from deployment any resources that are not needed or have become surplus to requirements.

At larger incidents, commanders should consider nominating a rendezvous point (RVP) for emergency fire vehicles to attend before arrival at the incident. At major incidents a strategic holding area (SHA) or tactical holding area (THA) may be necessary, where resources may be held for longer periods, and where welfare arrangements are in place and dedicated enhanced logistical support available.

For further guidance see National Operational Guidance: Operations – Time of alert to time of attendance

Strategic actions

Fire and rescue services should:

- Develop tactical guidance and support arrangements for the hazards and actions to be taken when considering the appropriate deployment of resources
- Consider and implement National Operational Guidance: Incident command

Tactical actions

Incident commanders should:

- Anticipate the effects of fire development, thermal radiation, collapse and other hazards when positioning vehicles
- Consider using a rendezvous point (RVP), marshalling area or strategic holding areas (SHA)

Control measure – Additional resources

Control measure knowledge

Incident commanders should be aware of the type, number and disposition of emergency fire vehicles and personnel in their own and in nearby surrounding service areas, and should have a working knowledge of the responsibilities and capabilities of other blue light and non-blue light services they may call on for assistance.

All personnel should have a thorough knowledge of the capabilities of special emergency fire vehicles to ensure they select the correct type for the needs of the incident. They should also be aware of those that could be requested to help minimise the number of pumping appliances and personnel needed to deal with that particular incident. Their knowledge of the risks on their fire ground will be backed by regular visits and deployment planning, enabling them to assess the additional resources required at an incident involving fire.

Incident commanders should begin assessing the need for additional resources as soon as they are mobilised to an incident, based on the number of calls received, information received by fire control, visual indications en route and knowledge gained on visits and through pre-planning, which may give indications of what may be required.

Strategic actions

Fire and rescue services should:

- Ensure relevant information on the availability of service resources is made available to operational and fire control personnel

Tactical actions

Incident commanders should:

- Ensure sufficient resources are available to maintain a sustained firefighting attack
- Request sufficient resources to implement the incident plan and support contingency plans
- Request special appliances if they can reduce the numbers of personnel and fire appliances committed to the incident

Control measure – Specialist resources and advisers

Control measure knowledge

A number and variety of specialist resources can be made available to the fire and rescue service during emergency situations.

When planning a firefighting strategy, fire and rescues services should consider the potential contribution of specialist crews, not only in extinguishing the fire, but also in improving safety and efficiency on the fire ground. Examples may include animal rescue units for controlling the movement of animals at a fire involving livestock accommodation, or a technical rescue team shoring up an unstable structure to improve access on the fireground. These considerations should form part of the pre-planning stage when crews are familiarising themselves with the risks on their fireground.

Fire and rescue services should arrange and maintain specialist capabilities according to the identified risks within the area of the service. Specialist resources may include:

- Inter-agency liaison
- Aerial fire appliances
- Water supply and management (including high volume pumps)
- Bulk foam
- Bulk dry powder
- Cutting extinguisher firefighting
- Marine firefighting
- Water rescue and flooding (including under water search and recovery)
- Wildland firefighting
- Technical rescue (including USAR teams)
- Extended duration breathing apparatus (BA)
- Animal rescue

- Fire safety and investigation
- Hazardous materials (including hazardous material advisers and incident response units)
- Rope rescue and line working

All operational and control staff should be familiar with the capabilities, limitations and expected time of arrival of the specialist crews in their service area, and have a working knowledge of those in surrounding services that may be called on for cross-border assistance.

Strategic actions

Fire and rescue services should:

- Ensure relevant information for all available service specialist resources (including those resources used by neighbouring and partner agencies) is made available to all personnel
- Make arrangements with neighbouring fire and rescue services and partner agencies on the shared use, procurement and/or availability of specialist resources
- Where necessary, include recommended specialist resources in site specific risk information (SSRI)
- Where possible, invite specialist crews to accompany them on visits to sites with special risks to plan their own specialist operations should an incident occur

Tactical actions

Incident commanders should:

- Consider requesting aerial or special appliances to reduce risk and demand on resources
- Consider requesting tactical advisers and personnel to establish functional roles

Control measure – Water and extinguishing media management and planning

Control measure knowledge

From the smallest to the largest incident, it is vital that early consideration is given to developing, managing and planning water and extinguishing media supplies for firefighting.

The purpose of an extinguishing media plan should be to supply enough media for a fire to be fully extinguished; this should include an appropriate level of resilience, including identifying a secondary supply that can be used should the primary supply fail.

Water supplies and their method of delivery to the fireground will vary depending on the size of incident but may include:

- Portable systems including backpacks, buckets, etc.
- Tanks and pump supply from emergency fire vehicles
- Continuous supply from water mains through hydrants
- Open water supplies: for example, rivers, lakes, ponds or swimming pools

In achieving suitable and sufficient water plans for any incident, sufficient physical resources should be available at the incident to deliver of water from the source to the emergency fire vehicles and from the emergency fire vehicles to the scene of fire.

A competent pump operator is essential if a water plan is to be successful. Failure of the continuous delivery of water to the fire ground can create serious hazards for frontline firefighting teams.

In normal circumstances, only fire and rescue service pumps and fire and rescue service hose should be used to deal with the incident. However, certain incident types may result in crews using other systems to support firefighting operations. For example, when firefighting on a ship, the use of on-board firefighting pumps and pipelines may be used in place of pumping emergency fire vehicles.

Estimation of water requirements

The flow rate required to deal with a particular risk and the period of time for which that flow rate must be sustained depend on many factors, including:

- The extent to which the fire is likely to have spread before firefighting starts
- The size of the building or area at risk
- The fire loading
- Environmental factors – the possibility that nearby watercourses may become contaminated
- The construction of the building – materials and compartmentation, etc.
- The need to protect adjacent risks

There are many factors to be considered, particularly with a large or protracted use of water. It may be difficult to estimate the exact quantity of water likely to be required but this should be established by incident commanders as part of their incident plan and risk assessment. For larger incidents, it may be necessary to allocate responsibility for formulating a tactical water plan to a functional water officer.

Refer to the National guidance document on provision of water for firefighting, published by the Local Government Association and Water UK in January 2007 for further information.

Distribution of water supplies

Water undertakers obtain their water from three main sources:

- River intakes
- Impounding reservoirs, containing water collected from high ground, streams and general rainfall
- Underground sources, such as wells, boreholes and springs

When establishing a water plan using hydrants, it is important that the incident commander or water officer is aware of these district metered areas through liaison with local water company specialists. This will enable them to maximise the amount of water available in the area of the incident, helping to maintain an adequate supply and ensure that the supply is not overrun, causing damage to the main. For further information on district metered areas see Section 4.2 of Fire Service

Manual, Volume 1, Fire Service Technology, Equipment and Media: Hydraulics, Pumps and Water Supplies

Supplying water to the fireground

There are two fundamental methods of conveying water from distant sources to a fireground:

- Using water tenders or water carriers to maintain a shuttle from the supply source
- Relaying water over the distance using pumps and hoses

When determining which might be the most appropriate strategy, incident commanders should consider:

- The additional quantity of water needed and the time that it will be required
- The location and size of the source(s), factoring in the time of year and the distance from the fire
- The resources and equipment available
- The time required to set up operations

Emergency fire vehicles – tank supply

With the increasing diversity in modern emergency fire vehicle design, there is no standard tank size. A traditional water tender ladder or water tender typically has a tank size of 1,800 litres; however modern appliances may carry significantly different volumes of water.

Water relay

A water relay comprises a number of pumps spaced at intervals along a route between a water source and the point where the water is required.

There are two types of water relays commonly referred to and used:

- Closed-circuit water relay, in which the water is pumped through hose direct from one pump to the next
- Open-circuit water relay, in which water is pumped through hoses through portable dams placed between pumps

The principal advantage of the open-circuit water relay is that, should there be a failure of the base pump (the first pump in the water relay set into open water supply or hydrant supply); the relay can continue to maintain a flow of water to the fire.

When determining which might be the most appropriate strategy the incident commander should consider the effect on local infrastructure (i.e. the disruption to the local transport network caused by hose lines with limited crossing points.) This will be particularly prevalent where high volume pumps are used.

Water carrying or water shuttle

Water carrying or water shuttle is achieved by using a number of water tenders to collect water from the source and deliver it to the tank of an emergency fire vehicle or into a temporary open dam.

Alternatively, bulk water carriers can be used to transport water from a water source some distance from the fire scene to the fire ground and deliver it to the tank of an emergency fire vehicle or into a temporary open dam.

The advantages of using water carriers instead of a large number of conventional water tenders are:

- Fewer numbers of emergency fire vehicles are required at the incident
- Fewer personnel are required
- Total time taken to mobilise emergency fire vehicles is usually reduced
- Fewer numbers of water carrying journeys are required
- Emergency fire vehicles are not committed simply to carry water
- Operating costs for the incident are reduced

Refer to the firefighting equipment knowledge sheets for information on:

- Hose layers
- High volume pumping (HVP) units

Strategic actions

Fire and rescue services should:

- Develop a water management strategy in liaison with all relevant stakeholders for the identified risks in their area
- Develop tactical guidance and support arrangements for the hazards and actions to be taken for the supply of water for firefighting purposes

Tactical actions

Incident commanders should:

- Secure sufficient extinguishing media for the duration of the incident, so that the fire can be fully extinguished
- Develop and organise a water management strategy or nominate a functional water officer
- Identify a secondary water supply that can be made available should the primary water supply fail
- Consider the need for water relay or high volume pumping operations

Hazard – Fire and thermal radiation

Hazard	**Control measures**
Fire and thermal radiation	Appropriate speed and weight of intervention Eliminate ignition sources

Hazard	**Control measures**
	Select an appropriate firefighting method Select an appropriate firefighting media • Foam delivery Select the appropriate firefighting technique • Direct firefighting • Gas cooling • Firebreaks and fuel breaks • Cutting away • Controlled burning • Damping down and turning over Select appropriate firefighting equipment • Portable fire extinguishers • Flow rates • Hose • Branches and nozzles • Monitors Wear personal protective equipment (PPE) Consider wearing respiratory protection equipment (RPE)

Hazard knowledge

Type of fire

Having established the location of a fire, the incident commander and firefighters will need to give early consideration to the type of fire they are confronted with. Identifying the type of fire is critical as it will help form the basis of an initial incident plan or strategy and clarify decisions on the method for extinguishing the fire, the type of media needed and how best to apply it.

To accurately identify the type of fire, it is imperative that firefighters possess a sound fundamental understanding of the physics and chemistry of combustion, including areas such as:

- Physics of combustion
    - States of matter and energy, density, heat transmission and temperature
- Chemistry of combustion
    - Atoms and molecules, elements, compounds and mixtures, pyrolysis and flammable range

This knowledge, combined with experience, will enable firefighters to understand the relationship between the types of combustion, phases of fire and the products of combustion (smoke) and how these are likely to interact in a fire situation. They will then be able to make effective judgements and/or decisions to ensure that any fire is appropriately, safely and efficiently extinguished.

In simple terms, firefighters should have an understanding of what a fire is and the conditions required for it to start (ignite) and grow (develop) so that they can tackle and extinguish the fire and be safe and effective in their role.

Fire is the result of a chemical reaction called combustion. Combustion is a chemical reaction between oxygen and a fuel source that produces chemical energy in the form of heat and light.

To understand the process of combustion and the subsequent behaviour of a fire, firefighters need to have a basic understanding of the elements required for combustion to occur. In the first instance, a combustible fuel must be present, along with oxygen in sufficient quantities and a source of ignition.

This is commonly represented by the 'triangle of fire'. For many years, this simple triangle of fire (oxygen, fuel and heat) has been used to illustrate our basic understanding of fire. While it remains useful, from a technical perspective, there is a fourth component in the chemical chain reaction, which is extremely important for fire suppression and extinguishment.

The three elements of oxygen, fuel and heat need to be sufficiently balanced for combustion to occur. They must then continue to interact in such a way that they create a self-supporting chemical chain reaction to maintain the combustion process. This is described as the fire tetrahedron. Each component of the tetrahedron must be in place for self-sustaining combustion to continue.

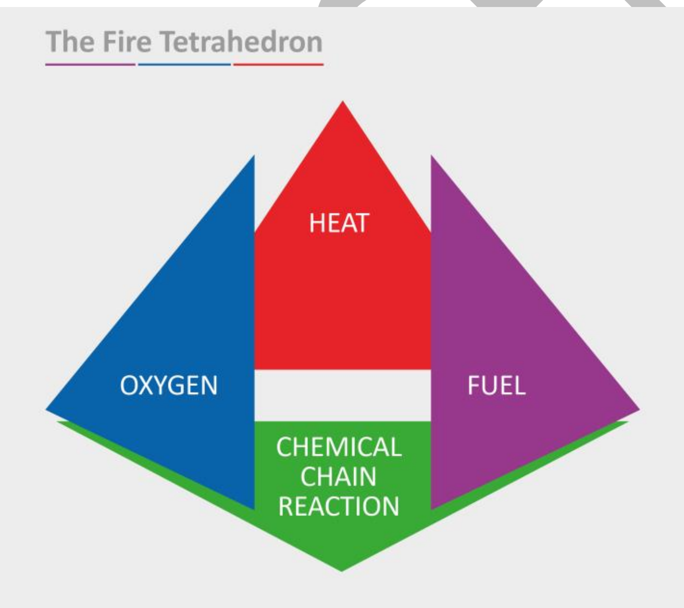

Figure 1: The fire tetrahedron

A fire will typically develop in four clearly defined phases (or stages). By being able to easily recognise these different phases (or stages) through observation of signs and symptoms and/or use of their senses, a firefighter will better understand the method, tactics and techniques that may need to be employed to deal with the respective phases.

Incipient phase

An accidental fire normally begins with an incipient phase during its early stages. This stage of fire growth may occur very slowly but in some instances could proceed quite quickly.

Growth phase

The growth phase incorporates fairly rapid fire development, depending on an adequate availability of fuel, heat and oxygen (fire triangle). This stage normally concludes in flashover unless restricted by a lack of any of fuel, heat or oxygen.

Fully developed phase

The fully developed stage represents a period of burning where the maximum heat is released (termed 'steady state' fire) and flames fill the compartment or area. This is usually a period where the majority of the energy in the fire load is released.

Decay phase

The decay stage follows the fully developed fire. During this period, much of the energy in the fire load continues to be released but to a lesser degree as the burning rate decreases.

Time/temperature curve – the phases of fire development

A time temperature curve demonstrates the phases of fire and shows the demarcation between each stage of fire development. During the incipient phase of a fire, which will be an upward curve, the time can vary depending on the type of fuel, the size of the compartment and the amount of oxygen supplying the fire. Flashover may occur at the end of the growth phase and the start of the free-burning (or fully developed) stage. Backdraught can occur in the smouldering (or decay) phase.

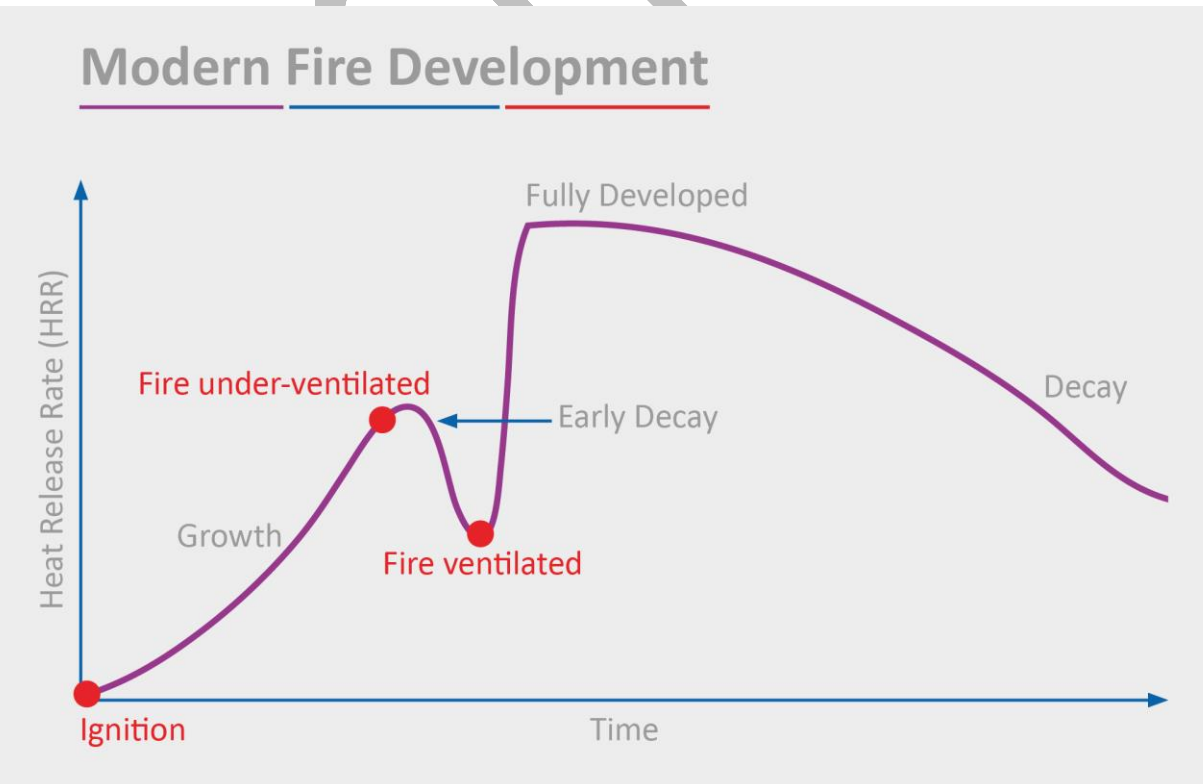

Figure 2: Fire Development curve

The type of fire encountered by firefighters varies enormously, both in terms of what is involved and its size. However, by having good knowledge and giving consideration to the classifications of fire (as detailed in BS EN 2: 1992 - Classification of fires) firefighters can anticipate or make very early judgements on the most appropriate extinguishing media.

BS EN 2: 1992 - Classification of fires broadly identifies classes or groups based on the physical properties of the material/s actually burning:

- Class A fires: fires involving ordinary combustible materials, such as wood, cloth or paper
- Class B fires: fires involving flammable liquids, greases and gases
- Class C fires: fires involving gases
- Class D fires: fires involving combustible metals, such as magnesium, titanium or sodium
- Class F fires: fires in combustible cooking fuels such as vegetable or animal fats

Electrical fires are not considered a class of fire on their own and may better be described as fires involving electricity. Once the source of electricity is isolated and any residual current dissipated or earthed, a fire can be classified and treated as one of the primary classes.

Although this standard that sets out the types of fire that may be encountered is based on the material or substance type, many incidents attended by firefighters are likely to involve a combination of material or some of these groups in isolation. For example, a well-developed fire in a take-away or restaurant may potentially involve a combination of all of the substances identified in each of the classes A–F.

One of the tasks for the incident commander and firefighters will be to identify the primary material group involved in the fire, including the amount of fire loading, how it is stored and the form in which it is found. For example, large structural timbers may behave differently when burning, compared to timber shavings exposed in a fire of the same intensity.

The process of identifying the fundamental material or substance group involved will be critical to the subsequent decision-making process. It will help to ensure that the overall method of intervention and extinguishment selected is appropriate and is the most efficient way of dealing with the fire.

The method of extinguishing a fire is based on interrupting one or more of the essential elements in the combustion process. With flaming combustion, the fire may be extinguished by reducing temperature (cooling), eliminating fuel or oxygen (starving or smothering), or by stopping the uninhibited chemical chain reaction. If a fire is in the smouldering mode of combustion, only three options exist: reducing the temperature, eliminating fuel or eliminating oxygen.

Once the type of fire is clearly identified and the incident commander and crews have selected an effective method and approach to putting the fire out, they will need to consider selecting the most appropriate extinguishing media to achieve the objective. This may include:

- Water
- Foam
- Dry powder

- Carbon dioxide
- Blanketing
- Beating out
- Controlled burn
- Allow to burn out

The method for extinguishing the fire and the type of firefighting media selected will influence the way the media is applied and the choice of firefighting techniques.

Water is usually the default media type because of its abundance and its rapid impact on the chemical process of combustion. Techniques and equipment can include simple hose lines and branches.

More complex media may require more complex techniques of application because of lack of availability, insufficient amounts being available or the manner in which they need to be produced, such as producing foam.

Identifying the type of fire, selecting an appropriate method to extinguish it along with appropriate media and the most appropriate techniques and equipment to apply it are frequently decisions taken simultaneously without any significant delay on the speed or timeliness of an initial intervention.

This may also depend on the type of incident as there may be an opportunity for initial intervention to contain the fire so that crews can perform the immediate life-saving rescue of casualties. It may then be possible to withdraw to consider the safest and most efficient, method, media, techniques and equipment, such as a major foam application or allowing the fire to burn out.

By determining what is involved (the type of fire) at the earliest opportunity, subsequent decisions for the fire and rescue service personnel on firefighting method, appropriate firefighting media and the techniques of application can become natural and intuitive processes.

Extent of fire

Locating a fire, its type and overall extent are critical steps in the initial stages of any incident. The information and intelligence established by the incident commander and crews at this early stage will set the foundation for implementing a basic plan to bring the situation under relative control.

Where the situation expands, for example in a large developing fire, the initial incident plan may need to be revised as more factual and predictive information is obtained or where more resources become involved and the incident command structure grows.

Protecting life and preventing deaths and injuries at a fire are clearly the primary objective for fire and rescue services in any fire situation, whether this is to protect members of the public, ensure the safety of firefighters, or minimise the social and environmental impacts of fire.

For further information, see National Operational Guidance: Incident command – Safety Management

Often the best way to protect lives and minimise damage is simply to extinguish the fire quickly. However, the ability to contain, gain overall control (surrounding the fire) and extinguish a fire will vary enormously and depend on many factors including the type of fire and its broad environment. For example:

- A fire in a high-rise building may be complex with regard to access, egress and the number of resources required to deal safely with the situation.
- A wildfire incident may cover a wide geographical area and require the deployment of significant resources from a fire and rescue service or numerous fire and rescue services over a period of weeks

Even in the simplest of circumstances, fire and rescue services will need to consider the best way to achieve timely intervention and the correct speed and weight of intervention for a given incident (context of operations) and ensure the appropriate deployment of resources to deal with the fire in a safe and effective manner.

The speed and weight of intervention in any organisation will largely depend on the capacity of a fire and rescue service to deliver crews, emergency fire vehicles, equipment and media to an incident ground to control, contain and extinguish a fire.

It is imperative that the incident commander and firefighters have a good knowledge of the number and range of resources that they have at their disposal and carefully consider what they may need to deal with fires that they may encounter in their service areas.

During the initial assessment and evaluation of a fire, the incident commander will have considered the level of risk, the resources they require and how quickly they will need them – the speed and weight of intervention to have an impact on the fire. The initial incident plan will also depend on the available or responding resources being assembled in a considered manner. For example, if a delay occurs for whatever reason, the fire could grow and spread rapidly, affecting firefighters, casualties or members of the public.

If the fire develops rapidly or is too large for the initial attendance, the incident commander will need to exercise their operational judgement and determine the actions that can be taken safely with the resources at hand, for example, whether the crews should continue with an offensive strategy, limit their actions to protecting surrounding exposures or wait for the fire to burn out.

One of the most crucial decisions that an incident commander will have to make during firefighting operations is whether it is necessary to attack a fire internally or externally. To some degree, this will be influenced by the environment in which the fire has occurred, largely dictating whether the incident commander adopts an offensive or defensive firefighting strategy.

In deciding the most appropriate fire attack, incident commanders will need to look at the various factors and consider the following:

- Risk versus potential benefits
- Whether it is safe to commit firefighters to an area or structure
- Whether there are any obvious casualties or lives at immediate risk
- Whether the size, type or intensity of the fire limits or prohibits entry
- Whether there are sufficient resources in attendance to undertake a safe and effective intervention (personnel and emergency fire vehicles)

- The nature of the building construction
- Whether there are adequate water supplies available to sustain an attack
- Additional hazards and their location in relation to the area on fire
- Access points and maintaining egress points
- Fire safety features in a building
- Information from a responsible person
- Specialist advice

An objective for all fire and rescue services, their incident commanders and firefighters, is to protect property. In some situations it will result in the incident commander having to exercise operational judgement by making difficult decisions such as sacrificing property to save life or, with a fire in a derelict structure, focusing resources on protecting surrounding buildings or risks to infrastructure.

A-priority for an incident commander and firefighters will be to prevent the fire from spreading. This will depend on the level of risk and how far the fire has already spread. For example:

- In a domestic dwelling, if the fire is confined to a single room, the aim should be to prevent it spreading to neighbouring rooms or compartments
- In a high-rise structure, if multiple flats or apartments are already involved, the incident commander may decide to focus on containing the fire to a single floor.
- If a fire has spread substantially through a building or geographical area, it may be necessary to focus on protecting and limiting firespread to the neighbouring structures, high-risk areas, critical equipment or infrastructure

Incident commanders should use all the factual and predictive information at their disposal to anticipate, look ahead and identify a point at which crews can intervene safely with an appropriate firefighting method and suitable firefighting media. For example, they should:

- Look for, capitalise on or seek to create, natural gaps, breaks or separations between buildings to minimise the effect of radiated heat. See National Operational Guidance: Fires in the Built Environment for further information.
- In a wildfire situation, use the information to predict the path and/or head of the fire and identify a safe point to intervene and create a firebreak by removing the fuel to starve the fire, either by cutting or burning away sources of fuel. See National Operational Guidance: Wildfires (to follow)
- A fire involving flammable liquid will usually require the use of foam as the primary extinguishing agent. The crews will aim to lay a blanket of foam over the surface area or the pooling fuel to prevent ignition or to smother the fire by preventing the vapour of the substance mixing with the air and source of heat.

Preventing or limiting firespread in all instances is vital. It is worth considering the use of thermal imaging cameras, which can play a valuable role in helping to identify sources of heat and potentially highlight any areas of unseen firespread through structural voids such as roof space. They can be deployed externally during the scene survey or internally by breathing apparatus teams. In addition, they may act as a key control measure to help crews remain safe in this context.

Dealing with a fire will invariably result in firefighters engaging in a range of activities or tactics, employing a number of different methods, techniques, extinguishing media or items of equipment to complete the respective tasks that may be necessary to extinguish the fire.

The suppression of the fire will usually be accomplished through removing one of the elements of the fire tetrahedron to stop the process of combustion.

The fire will essentially be extinguished by cooling, starving or smothering with firefighting media, or through a combination of those methods, which inherently or by design will inhibit or interfere with the chemical chain reaction that is combustion.

Other methods such as using a fire blanket (smothering), creating firebreaks (starving) or beating out the fire can be very effective ways to suppress and extinguish the fire. It is also possible that the incident commander or firefighters may undertake controlled burns to remove fuel sources from an advancing fire, such as cutting away timbers of a roof structure to limit or prevent spread.

Alternatively, an incident commander may simply choose to focus on protecting surrounding exposures or risks and let the fire burn out, effectively starving the fire of the fuel element of the fire tetrahedron. The firefighting media selected will be a direct result of the initial assessment and evaluation carried out by the incident commander once they have identified the type of fire they are likely to be dealing with. There are four main categories of media:

- Water
- Foam
- Carbon dioxide (CO_2)
- Dry powder

Fire and rescue services will usually be able to choose from a range of firefighting methods and media to support extinguishing the many different types or classes of fire they may encounter. However, the emergency fire vehicles, equipment and techniques employed by most fire and rescue services will more often than not revolve around water as the most frequently used extinguishing agent.

Water is generally accepted to be the most effective firefighting media because it is the cheapest, most efficient and readily available media for extinguishing fires of a general nature. It is used by fire and rescue services for the majority of fires, although the techniques of application can differ.

Water is the most common fire-extinguishing agent because it has a range of physical and chemical properties and can be found in a range of sources – hydrants, lakes, ponds, streams, rivers, sea, even swimming pools. It is non-toxic and, in comparison with other types of media, due to its unique chemical composition, has a high specific heat capacity and high latent heat of vaporisation.

Fire loading

The level of fire loading, and its reaction to the building or structure in which it is located during any incident involving fire, will have an impact on the decision-making process and incident plan.

Therefore, it is important to consider the impact that the nature, amount, and orientation of the fire loading will have on a fire situation.

The nature and diversity of the substances and materials that will be encountered in contemporary buildings (sandwich panels, timber framed, steel portal framed, etc.) will have an impact on the process of combustion and may produce energy, achieving peak temperatures and heat release rate at a faster rate than in conventional buildings.

See National Operational Guidance: Fires in the Built Environment

And: Building Research Establishment knowledge sheets

This is important from a firefighting perspective, as this can mean that firefighters may encounter rapid fire development conditions at an incident whilst the structure is simultaneously deteriorating in stability and integrity.

An assessment of the fire load, its location with regard to ignition sources and the likelihood of any firespread should be considered at an early stage as part of a dynamic risk assessment.

Items involved in fire

Any fire can have the potential to involve sealed metal objects which, when heated, can pose an explosion and/or projectile hazard. These sealed metal objects can vary in size, use and construction and are all subject to the laws of pressure and heat

The following lists a few examples of sealed metal objects:

- Batteries
- Aerosols
- Domestic radiators (with valves closed)
- Central heating boilers http://www.hse.gov.uk/services/localgovernment/boilers.htm
- Vehicle airbag inflators
- Electrical transformers www.hse.gov.uk/pubns/indg372.pdf

Additionally, emergency service personnel should be made aware of the more obscure sealed metal objects which may have a potential to cause harm, when heated. These objects include welded box sections in the construction of vehicles and skips and sealed metal objects used in building construction.

Fires in vehicles pose a variety of hazards to firefighters due to the number of potential materials and inbuilt systems involved and the location of the vehicle in proximity to other hazards e.g. buildings, other vehicles, open dry land and members of the public. Fires in vehicles can develop rapidly, producing high heat release rates which can have an effect on surrounding structures. Examples of vehicle fire hazards include:

- Plastic or composite fuel tanks (running fuel fire risk)
- Compressed gas struts
- Compressed gas airbag inflators

- Pyrotechnic gas generators (Sodium Azide)
- Magnesium components
- Petroleum and alternative fuel (LPG, electricity, hybrid, biofuels)
- Hydrofluoric Acid
- Air conditioning systems

Contain, control or extinguish

Having identified the type of fire and its location, varying degrees of dynamic activity will take place as fire and rescue services and other responders begin to build a picture of what they are faced with in a particular scenario.

The process of information gathering will be intensive at this stage, but diligence will support the development of the approach, tactics and techniques required to extinguish the fire safely and efficiently.

During this period it is critical that the incident commander and firefighters ascertain the overall extent of the fire, including the phase of development, how it is behaving and the likelihood of firespread.

Many factors may affect the development and extent of a fire in any given situation. In the first instance, it is important to note the impact of the location of the fire and its interaction with the environment in which it has occurred, such as a wildfire in the open environment or a fire in the built environment, a vehicle or a vessel.

Although the fundamental principles related to the physics and chemistry of combustion are broadly the same with any fire, its behaviour and development may vary significantly depending on the environment in which it occurs. For example, a fire in the open environment will be strongly affected by the overall meteorological conditions and the geography and topography of a wide area. The ambient temperature and time of day combined with the angle or gradient of a slope will have a dramatic effect on the pre-heating of fuels and consequently on the likelihood of firespread.

One of the primary effects of a fire in the built environment will be the impact of compartment boundaries (ceilings, floors and walls) and openings (doors, windows and hatches) on a fire's development and behaviour. See National Operational Guidance: Fires in the built environment and the Building Research Establishment knowledge sheets for further information.

To understand and establish the likely extent of a fire and how it can spread, firefighters should have a fundamental knowledge of the physics of combustion. In simple terms, this states that fires can spread or grow through the transmission of heat in four fundamental ways:

- Direct contact
- Conduction
- Convection
- Radiation

An understanding of the theories of convection, conduction and radiation, combined with a good basic knowledge of what fire is (combustion) and the typical phases of fire, will enable an incident commander to predict the likely pattern of firespread in a given scenario.

Firefighters will also need to know how fire behaves. There are many factors that can affect a fire's behaviour in a given situation. These include the materials or substances involved, the fire loading, ventilation, wind and other meteorological conditions and the size of the building or area.

Having a good knowledge of the key fire phenomena such as flashover, backdraught and fire gas ignition, and how they can occur, is a requirement for all firefighters. Even more important is their ability to interpret the key behavioural indicators that are the step and transient events that lead to a fire.

By understanding how a fire behaves, firefighters will be safer and more effective at predicting the potential extent of any fire, limiting its spread and subsequently selecting the most appropriate time and method to be used to intervene and suppress and extinguish the fire.

The extent and development of a fire will be heavily influenced by the degree of ventilation to the compartment or area involved. In its most fundamental form, ventilation can be defined as the amount of air available to the fire; this is clearly linked to the chemical process that is combustion:

- A ventilation-controlled fire occurs when there is not enough air to support the complete combustion process of the fuel in a fire compartment
- A fuel-controlled fire is where there are adequate amounts of air but not enough fuel to support the combustion process of the fuel in the fire compartment

The impact of ventilation, whether pre-existing such as through open doors or windows, through the effect of building design and systems such as heating, ventilation and air conditioning (HVAC), or where it is used as an intervention technique by firefighters, will have an effect on the state of the fire and can also assist in making the conditions more acceptable for casualties, occupants and firefighters. Where ventilation is used as an offensive intervention tactic, incident commanders should ensure that there is a clear ventilation strategy to prevent unplanned or unwanted outcomes.

The extent of a fire and its likely development will also be acutely influenced by what is actually involved, such as materials, substances or processes. Ascertaining information about the type of fuel and the amount of material present – the fire loading – along with how long a fire has been burning, should therefore always be considered by the incident commander and crews before deciding on the appropriate intervention and whether to adopt an offensive or defensive approach.

The level of fire loading will, given adequate ventilation, help an incident commander to predict the likely extent and severity of firespread that may be experienced during firefighting operations.

Problems of high fire loading may be worsened by poor housekeeping, by lack of site management by owners and occupiers, or by emerging issues such as hoarding in domestic properties; these factors increase the potential for rapid firespread or unusual fire development.

Most of this information can be acquired from various sources, including the responsible person, but incident commander and firefighter knowledge, judgement and situational awareness, and their ability to read and interpret key fire behaviour indicators (including the signs and symptoms of phenomena such as flashover and backdraught), are vital.

Once the incident commander and firefighters have an understanding of where the fire is, what is involved and to what extent it is involved, they will then be in a position to make a more accurate assessment of the resources that will need to be deployed. As the picture becomes clearer, they will be able to predict any additional resources required, taking into account the necessary speed and weight of intervention. This will allow crews to begin the process of containing, controlling and extinguishing the fire in a safe, appropriate and effective manner.

Control measure – Appropriate speed and weight of intervention

Control measure knowledge

Committing crews to offensive operations requires the adoption of a safe system of work that reduces the risks to firefighters to a level as low as is reasonably practicable. If an incident commander has insufficient personnel present to introduce such a system of work, they may have to adopt defensive tactics until further resources arrive, or until they are reasonably certain that further resources will arrive imminently.

Rescue operations must be the subject of a dynamic risk assessment, balancing the benefits in terms of saveable life against the risk to firefighters.

See National Operational Guidance: Incident Command

Where signs and symptoms suggest the likelihood of a backdraught, consideration should be given to employing defensive firefighting tactics until further resources, or special equipment such as cutting extinguisher or positive pressure ventilation, can be brought to the incident. Incident commanders must ensure they have considered the likely outcome of ventilating a compartment before opening it up for firefighting.

Incident commanders must assess the growth stage of the fire when deciding to commit crews to offensive operations. If rapid intervention with a sufficient application rate of firefighting media can be made, a flashover may be forestalled. However, compartment size, the presence of fire and fire gas spread in voids, fire loading and poor application rates may make this tactic untenable.

At high-rise fires or wildfires, fire may be wind-driven. The effect of high wind speeds on a fire may prevent rapid intervention and, particularly in the case of high-rise fires, require incident commanders to adopt specific tactics to prevent uncontrolled firespread and injury to firefighters. These tactics are likely to require a large number of resources be assembled before committing to offensive firefighting.

When fighting fires in the open, the incident commander should deploy firefighters with due regard for the likely effect of topographical features on firespread. Although wind direction and the presence or absence of vegetation are the key factors in firespread, other features may produce unexpected changes in fire behaviour leading to crews being overtaken. Fires tend to spread more quickly uphill, due to preheating of fuel, and more slowly downhill. Underlying root structures and soil types may cause fire to spread unseen, and the relative moisture content of different types of vegetation may produce unexpected patterns of firespread.

See National Operational Guidance: Wildfires

See National Operational Guidance: Incident command – Command decision-making

Strategic actions

Fire and rescue services should:

- Develop tactical guidance and support arrangements for the hazards and actions to be taken when considering the appropriate speed of intervention
- Consider and implement National Operational Guidance: Incident command
- Ensure all incident commanders receive information, instruction and training in command decision making

Tactical actions

- Adopt the most appropriate speed and weight of intervention to limit fire development
- Consider an initial incident plan to prevent fire spread, rapid or significant escalation of the incident
- Protect the surrounding environment from thermal radiation and fire spread

Control measure – Eliminate ignition sources

Control measure knowledge

From the smallest to the largest incident, the incident commander and firefighters need to be aware of, and take notice of, possible ignition sources that could create additional hazards.

Although eliminating ignition sources may not be an immediate priority in a fire situation because the fire is already burning, firefighters should be aware of the potential for additional ignition sources and their potential to start events such as fire gas ignitions in areas that may be remote from the initial seat of fire.

At incidents where there may be a release of gases or other flammable atmospheres because features such as storage vessels, tanks or pipework may fail or be damaged, incident commanders should consider this a concern and identify it in the incident dynamic or analytical risk assessments (DRA or ARA) and incident plan.

The amount of energy required to ignite a mixture of air and flammable gas or vapour (including smoke) is called the minimum ignition energy (MIE) and depends on the characteristics of the gas or vapour, concentration in air, type of oxidant, temperature and pressure.

An ignition source can be defined as a form of energy that, when added to a flammable mixture, is sufficient for the combustion process to start; an ignition source with energy greater than the minimum ignition energy (MIE) for a particular mixture is sufficient for a fire or explosion to occur. Generally, the energy required to ignite a flammable gas or vapour mixture is relatively low, though some low-energy ignition sources may not be incendiary enough for all flammable mixtures.

Ignition sources include:

- Open flames
- General firefighting operations, including cutting

- Frictional sparks and localised heating
- Impact sparks
- Sparks from electrical equipment
- Electrostatic discharge
- Vehicles
- Use of cigarettes or matches
- Hot surfaces
- Electrical equipment and lighting
- Hot processes
- Exothermic runaway reactions (water applied to reactive metals such as sodium and potassium)
- Heating equipment

It is often challenging for crews to identify and eliminate every ignition source at an operational incident. The first option for ensuring safety is therefore usually to prevent flammable gas or vapour mixtures being released or formed. All foreseeable ignition sources should also be identified and effective control measures taken.

In industrial premises, depending on the ignition sensitivity of the materials handled, the types of equipment involved and the process parameters (such as temperature and pressure), incident commanders should consult with on-site process safety professionals or the responsible person to address safety issues and provide recommendations to aid the safe resolution of the incident.

Strategic actions

Fire and rescue services should:

- Develop tactical guidance and support arrangements for the hazards and actions to be taken in eliminating ignition sources

Tactical actions

Incident commanders should:

- Extinguish the fire and eliminate all ignition sources
- Develop and communicate an incident plan to all personnel
- Deal with any immediate fire risk and provide a means of extinguishing fires during the incident
- Control ignition sources that cannot be eliminated as far as reasonably practicable
- Use the appropriate extinguishing method, techniques, media and equipment
- Ensure that crews are briefed on all firefighting activities and provide regular updates on progress

- Consider removing fuel from any source of ignition

Control measure – Select an appropriate firefighting method

Control measure knowledge

The fire tetrahedron identifies the four components needed for burning to take place. To extinguish a fire it is largely a matter of depriving the fire of one or more of these factors, so methods of extinguishing fire can be classified in terms of removing these factors.

All fires can be extinguished by cooling, smothering, starving or by interrupting the combustion process to extinguish the fire.

- Cooling: limiting temperature by increasing the rate at which heat is lost from the burning material
- Smothering: limiting oxygen by preventing air from reaching the seat of the fire to allow the combustion process to reduce the oxygen content in the confined atmosphere until it extinguishes itself
- Starving: limiting fuel by removing potential fuel from the vicinity of the fire, removing the fire from the mass of combustible materials or by dividing the burning material into smaller fires that can be extinguished more easily

Interrupting: inhibiting the chemical chain reaction by applying extinguishing media to the fire that inhibit the chemical chain reaction at the molecular level).

Cooling

One of the most common methods of extinguishing a fire is by cooling with water. This process depends on cooling the fuel to a point where it does not produce sufficient vapour to burn, with the reduction in temperature dependent on the application of an adequate flow of water to establish a negative heat balance. For example, if the rate at which heat is generated by combustion is lower than the rate at which it is lost from the burning material, burning will not continue.

To extinguish a fire by cooling, the rate at which heat energy is lost from the burning material must be increased by removing some of the heat energy. This reduces the temperature of the burning mass, reducing the heat release rate. Eventually, the rate at which heat is lost from the fire may be greater than the rate of heat production and the fire will die away.

When water is applied media, it undergoes changes as it absorbs heat from the fire:

- Its temperature will rise
- It may evaporate (boil)
- It may react chemically with the burning material

To achieve maximum effect, the quantity of heat energy absorbed should be as great as possible. The properties of a good cooling agent are therefore:

- High specific heat capacity (thermal capacity)
- High latent heat of vaporisation

- High heat of decomposition

Water is a good cooling agent because of its high thermal capacity and latent heat of vaporisation. This, combined with the fact it is available in large quantities, makes it by far the most widely useful fire extinguishing agent.

The role of decomposition is insignificant in the case of water but very relevant with certain substances, such as carbon dioxide, that absorb heat in this way.

Smothering

If the oxygen supply to the burning material can be sufficiently reduced, burning will cease. The general procedure is to prevent fresh air from reaching the seat of the fire, allowing the combustion to reduce the oxygen content in the confined atmosphere until it extinguishes itself, for example by:

- Snuffing out candles
- Smothering a pan with a fire blanket
- Wrapping a person in a fire blanket
- Applying a blanket of foam over the burning surface, thus separating the fuel from the air

Smothering can also be achieved by removing the oxygen in the atmosphere, thus extinguishing the fire, for example, by:

- Introducing carbon dioxide (CO_2) to the immediate vicinity of the fire
- Introducing an inert gas to the immediate vicinity of the fire, such as through systems installed to protect computer server rooms

Starvation

In some cases, a fire can be extinguished simply by removing the fuel source. This may be accomplished in a number of ways, such as stopping the flow of liquid or gaseous fuel, removing solid fuel in the path of the fire or allowing the fire to burn until all of the fuel is consumed.

Fires can be starved of fuel by removing potential fuel from the vicinity of the fire, for example:

- Back burning forestry fires
- Draining fuel from burning oil tanks
- Removing cargo from a ship's hold
- Creating firebreaks in peat, heathland and forest fires
- Removing vehicles in the proximity of the fire
- Creating firebreaks in thatch roofs
- Removing tyres not affected by the fire from a tyre dump

Interrupting the combustion process

Dry powder, Bromochlorodifluoromethane (BCF) and other halon extinguishers work by releasing atoms that interrupt the chemical chain reaction. They also create an inert gas barrier.

Strategic actions

Fire and rescue services should:

- Develop tactical guidance and support arrangements for the hazards that may be encountered and the actions to be taken when selecting an appropriate firefighting method

Tactical actions

Incident commanders should:

- Select an appropriate firefighting method (i.e. cooling, smothering, starving, interrupting)
- Consider the impact of the extinguishing method on the fire, personnel, property and environment

Control measure – Select appropriate firefighting media

Control measure knowledge

There are many different types of firefighting media and many different ways in which to apply them, depending on the nature of the incident encountered.

The media chosen for a given type of fire will depend on the nature of the materials involved and the size and intensity of the fire.

When applied to a fire, the extinguishing media undergoes changes as it absorbs heat from the fire:

- Its temperature will rise
- It may evaporate
- It may chemically decompose
- It may react chemically with the burning material

To achieve maximum effect, the quantity of heat energy absorbed when these changes occur should be as large as possible.

Water

Water is the cheapest, most efficient and readily available way of extinguishing fires of a general nature. With a high latent heat of vaporisation, it takes about six times as much heat to convert a given mass of water at its boiling point into steam as that required to raise the temperature of the same amount of water to boiling point. The most efficient use of this media is where as much water as possible is converted into steam. The smothering effect of the steam produced at the seat of the fire is thought to play a part in assisting the extinguishing process.

Submerging the burning materials in water can be effective, particularly when considering cooling the remnants of fire. This can be achieved using a variety of container types, sizes and methods, such as buckets, large refuse skips and improvised methods. Consideration will need to be given to containing the resultant contaminated water.

There are occasions when water in any form is not effective and occasions when it is dangerous to use, particularly where there are materials that react unfavourably with water, potentially with explosive effects. Examples include magnesium, aluminium, lithium, potassium, sodium and other combinations of these substances; they are commonly used in manufacturing processes. It is important that specific sites that may store or use these materials are identified and emergency responders are made aware of the associated hazards, control measures and planning arrangements.

Foam

Firefighting foams have been developed primarily to deal with the hazards posed by liquid fuel fires. Although water is used for most incidents, it is generally ineffective against fires involving liquid fuels. This is because the density of water is greater than that of most flammable liquids so when applied it quickly sinks below their surfaces.

Finished foams consist of bubbles produced from a combination of foam concentrate and water that has been mixed with air. These air-filled bubbles form a blanket that floats on the surface of flammable liquids, knocking down and extinguishing fires by:

- Excluding air (oxygen) from the fuel surface
- Separating the flames from the fuel surface
- Restricting the release of flammable vapour from the surface of the fuel
- Forming a radiant heat barrier which can help to reduce heat feedback from flames to the fuel and hence reduce the production of flammable vapour
- Cooling the fuel surface and any metal surfaces as the foam solution drains out of the foam blanket; this process also produces steam which dilutes the oxygen around the fire

A variety of foam concentrates can be categorised into two main groups: protein or synthetic-based, depending on the chemicals used in their production. The characteristics of each concentrate and the finished foam they produce vary, making them suitable for some applications and unsuitable for others.

The main properties of firefighting foams include:

- Expansion: the amount of finished foam produced from a foam solution when it is passed through foam-making equipment
- Stability: the ability of the finished foam to retain its liquid content and to maintain the number, size and shape of its bubbles; in other words, its ability to remain intact
- Fluidity: the ability of the finished foam to be projected onto, and to flow across, the liquid to be extinguished or protected
- Contamination resistance: the ability of the finished foam to resist contamination by the liquid to which it is applied
- Sealing and resealing: the ability of the foam blanket to reseal should breaks occur, and its ability to seal against hot and irregular shaped objects
- Knockdown and extinction: the ability of the finished foam to control and extinguish fires

- Burn-back resistance: the ability of the finished foam, once formed on the fuel, to stay intact when subjected to heat and/or flame

The most common foam in use is in a compressed air foam system, which can be carried in combination with traditional water appliances. The foam attacks all three sides of the fire triangle simultaneously; the foam blankets the fuel, thereby reducing the fuel's capacity to seek out a source of oxygen and adheres to ceilings and walls, more readily aiding rapid reduction in heat. Also, the opaque surface of the foam, as it adheres to walls and ceilings, shields the fuel source from radiant energy.

Compressed air foam systems can deliver a range of useful foam consistencies, labelled from type 1 (very dry) to type 5 (wet), which are controlled by the air-to-solution ratios and, to a lesser extent, by the concentrate-to-water percentage. Types 1 and 2 foams have long drain times, meaning the bubbles do not burst and give up their water quickly. Wet foams, such as types 4 and 5, drain more quickly in the presence of heat.

Compressed air foam systems can produce a wide range of foam qualities or foam types, providing the most appropriate foam response to individual fire situations. This gives the incident commander the advantage of tailoring the best foam type to the tactical use and fire problem at hand. Generally, the environmental effects of foams are considered in terms of their toxicity and their biodegradability. It is the total volume of the foam concentrate that is released into the environment that is of concern; it does not matter by how much it has been diluted. See National Operational Guidance: Environmental protection for further information.

Fire and rescue services also use foam for other purposes in addition to firefighting. See National Operational Guidance: Hazardous materials (to follow)

Dry chemical powders

The basis of most dry powder extinguishers is sodium bicarbonate. With the addition of a metallic stearate as a waterproofing agent, it is widely used as an extinguishing agent in portable extinguishers and for larger application. Dry powder is very effective at extinguishing flame (rapid knockdown), and is particularly valuable in tackling a fire involving an incident in which clothes have been soaked in flammable liquid and ignited.

Dry chemical powders are expelled from containers by gas pressure and directed at the fire in a concentrated cloud through specially designed nozzles. Dry chemical powders are also tested for their compatibility with foam because early powders tended to break down foam. The two can complement each other at fires where foam is the standard extinguishing agent.

Ternary eutectic chloride powders have been developed for some metal fires. This type of foam melts, and then flows to form a crust over the burning metal, effectively sealing it from the surrounding atmosphere and isolating the fire.

Some burning materials, such as metals that cannot be extinguished by water, may be dealt with by using dry earth, dry sand, soda ash or limestone, all of which act as smothering agents.

Carbon dioxide, vaporising liquids and inert gases

Halons (halogenated hydrocarbons) vaporise rapidly when released from their pressurised container. The vapours are heavier than air, but when drawn into the flames, they inhibit the chain reactions and suppress flaming. Halons have now been largely replaced with inert gases or fine water mists because of environmental concerns.

At normal temperatures, Carbon dioxide (CO_2) is a gas 1.5 times as dense as air. It is easily liquefied and bottled in a portable cylinder where it is contained under approximately 51 bars pressure. When discharged, cold CO_2 vapour and some solid CO_2 are expelled from the horn, which rapidly cools in the process. The solid quickly turns to gas, and some of the liquid CO_2 evaporates to maintain the pressure in the cylinder. The gas, however, extinguishes by smothering, effectively reducing the oxygen content of the air. About 20 to 30% is necessary to cause complete extinction, depending on the nature of the burning material.

Carbon dioxide is quick and clean, electrically non-conductive, non-toxic and non-corrosive. It is however an asphyxiate at the concentrations necessary to extinguish a fire. The operation of total flooding CO_2 systems requires prior evacuation of all personnel.

Another fire extinguishing method is blanketing, which deprives the fire of oxygen. This is especially useful if someone's clothes are burning. For dealing with fires such as cooking fat fryers, the best method is to smother the fire with a fire resisting blanket.

Small fires in textile materials may often be extinguished by beating them out, or by rolling and screwing up the material tightly to exclude the air. Beating is also the method normally employed to extinguish heath, crop and similar fires in rural areas when water is not readily available.

See also National Operational Guidance: Environmental protection – Fire water run-off

Strategic actions

Fire and rescue services should:

- Develop tactical guidance and support arrangements for the hazards that may be encountered and actions to be taken when selecting appropriate firefighting media
- Identify specific firefighting media from site-specific risk information (SSRI)
- Ensure sufficient stocks and/or supplies of firefighting media are made available at incidents within the area of the fire and rescue service
- Where necessary, make contingency arrangements with neighbouring services regarding using bulk media supplies for firefighting purposes

Tactical actions

Incident commanders should:

- Select appropriate firefighting media (e.g. water, foam, dry powder, CO_2)
- Monitor the effect of the media on the fire to ensure that the anticipated outcome is achieved

Control measure – Foam delivery

Control measure knowledge

When using foam to fight a fire, consideration should be given to the technique and equipment for delivery. In general, foam is made by mixing a foam concentrate with water to create a foam solution and then aspirated through some form of equipment. The mixing can be done as a premix solution in which the foam concentrate is introduced into the water stream at an earlier stage, usually by some form of induction or injection equipment, or mixing can take place in the foam-making equipment as it is aspirated. This type of foam-making equipment is fitted with a means of picking up foam concentrate through a length of tube, known as self-inducing.

Two main types of foam equipment are described here:

- Foam-making equipment (foam-making branches, foam-making generators, etc.)
- Foam concentrate induction and injection equipment (inline inductors, etc.)

The primary aspirating foam-making equipment used by fire services can be divided into the following main categories:

- LX (low-expansion foam) handheld foam-making branches
- LX handheld hose reel foam unit
- LX foam generators
- LX foam monitors
- MX (medium-expansion foam) handheld foam-making branches
- LX and MX handheld water branch attachments
- MX foam pourers
- HX (high-expansion foam) generators

Refer to the Firefighting equipment knowledge sheets for information on foam-making equipment

See also: National Operational Guidance: Environmental protection.

Strategic actions

Fire and rescue services should:

- Develop a foam media firefighting strategy in conjunction with site-specific risk information, the community risk register, the national risk register and consultation with local emergency planning groups, the environment agencies, neighbouring services and national resilience capabilities. Further information can be referenced at Logistic operations for emergency supplies - Publications - GOV.UK
- Develop tactical guidance and support arrangements for the hazards and actions to be taken when using foam and associated equipment for firefighting purposes

Tactical actions

Incident commanders should:

- Consider using foam as an extinguishing media and adopt the appropriate application technique
- Be aware that foam can obscure surface hazards (e.g. holes, kerbs)

Select the appropriate firefighting technique

Applying the appropriate firefighting media will, in the majority of fires, involve various techniques or combinations of techniques, equipment and activities undertaken by crews, many of which will occur simultaneously.

The most effective means of extinguishing a fire will be a direct attack, using hose lines and branches to apply water or other firefighting media in a jet, spray or other form directly to the seat of fire.

Alternatively, submerging burning materials in water can be effective, particularly when considering disposing of remnants of fire and containing contaminated water. Burning materials can be submersed using a variety of container types, sizes and methods, for example, buckets, large refuse containers and locally improvised methods.

There may be situations where gas cooling may be more conducive to controlling the fire. This technique will normally be most effective in a compartment firefighting situations, where crews can apply the technique to reduce the risk of flashover or fire gas ignition etc., or during the decay phase where the risk of backdraught is more prevalent.

The technique of gas cooling involves crews controlling the flow rates by directing short pulses of water spray toward the ceiling or roof area of a room or compartment. The aim is to remove the heat from the fire gases in the atmosphere, and to delay and prevent any potential reaction flashover and provide safe access and egress for crews to extinguish the seat of fire.

There are many other application techniques that will support in extinguishing the fire using various types of extinguishing media. The advancement and development of new technologies is something that fire and rescue services should consider. For example, water misting or cutting extinguisher systems provide an innovative option in fire attack plans and support improving firefighter safety in dealing with compartment fires.

In addition, media such as foam, dry powder and carbon dioxide (CO_2) may have specific techniques of application. Although the production of foam will largely rely on an adequate and secure supply of water, its application may vary depending on the type of foam and how it is provided, whether from dedicated foam systems such as Compressed Air Foam Systems (CAFS) or supplied from drums or bulk foam stocks such as IBC containers.

The application of dry powders and CO_2 will generally be provided from some form of 'hard body' extinguisher, which may vary in size and capability depending on the risk.

Fire and rescue service personnel should ensure that appropriate techniques and applications are used, appropriate to the type of media chosen. They will need to monitor the impact of the techniques to ensure the safety of crews and to ensure the fire is brought under control and eventually extinguished.

Ventilation has a key role in the containment, control and extinguishing of any fire. It is important that the incident commander and firefighters take this into account and adopt a co-ordinated approach that complements the various firefighting methods, media and application techniques and supports the overall incident strategy and fire attack plan.

For example, if the type of fire dictates that dry powder or CO_2 is the most appropriate extinguishing media, crews will need to be aware of the negative impact that forced ventilation such as the use of Positive Pressure Ventilation (PPV) may have on dispersing the firefighting media before it has a chance to suppress the seat of fire.

By containing and attempting to control a fire at the earliest opportunity, the incident commander and firefighters minimise the chances of firespread, reduce the level of risk to casualties, members of the public and, to some degree, minimise the exposure to risk for firefighters.

Early, safe intervention at any fire will also help to prevent or limit any potential damage that may occur should the fire continue to develop unchecked.

Likewise, during any firefighting operations, the incident commander and firefighters should consider the impact firefighting operations may have on the building and its contents. They should pay attention to minimise or prevent damage caused by firefighting operations.

Control measure – Direct firefighting

Control measure knowledge

Direct firefighting is a means of extinguishing a fire, sometimes after the fire gases have been suppressed using gas cooling techniques and/or compartment boundaries have been cooled using indirect methods. However, firefighters should not become overly focused on, or distracted by, gas cooling techniques when the direct application of firefighting media is required to extinguish the fire.

Direct firefighting has the potential to generate large amounts of steam, as it involves applying a controlled amount of water directly to the seat of the fire. Firefighters should consider taking measures to ensure they are protected from steam burns and the increased heat in the fire compartment. For example, they could adopt defensive/safe positions behind substantial available cover (doors/walls) or use tactical ventilation.

Straight stream direct attack

A constant flow straight stream attack (jet) on the fire is traditionally the most common form of fire attack. In situations where a high-flow rate is required to overcome a high-energy fire, the direct attack is sometimes the only method that will achieve effective suppression and rapid knock down of the flame front.

Strategic actions

Fire and rescue services should:

- Develop tactical guidance and support arrangements for the hazards that may be encountered and the actions to be taken whilst adopting direct firefighting tactics

Tactical actions

Incident commanders should:

- Select an appropriate firefighting technique (e.g. direct firefighting, firebreaks, controlled burn)
- Consider direct cooling as the most effective method of extinguishment
- Put safety jets in place to protect firefighting teams and maintain safe access and egress
- Put covering jets in place to prevent fire spread and protect surrounding risks
- Establish communications to coordinate internal and external firefighting operations
- Protect personnel from steam produced by direct firefighting, using ventilation and personal protective equipment (PPE)

Control measure – Gas cooling

Control measure knowledge

Gas cooling is the approach of directing variable bursts or 'sweeps' of water-fog into the hot gas layer

Essentially, this involves the distribution of finely divided water droplets into the hot gas layer using a short 'burst and pause' (or pulsing) action at the branch nozzle as a means of reducing the temperature in the fire gases to a point where the threat of an impending flashover is limited or avoided. This technique can also be used where the hot gas layer is igniting and threatening to develop into a full compartmental flashover.

In either situation, an adequate flow rate (litres per minute) and an optimum spray pattern must be available at the branch.

It is extremely important to understand that gas cooling is predominantly a means of reducing the likelihood of flashover and should not be considered as a technique for dealing with either a fast developing or post-flashover fire. In such cases a solid stream (jet) directed at the fuel base becomes the dominant technique for fire suppression.

To fully understand the effects of gas cooling, it is essential to understand what the intervention is trying to control. Once it is understood that combustion can take place within the fire gases and how and why it occurs, firefighters are more prepared to intervene effectively.

Combustion is a chemical reaction that results in heat and light being produced. The fact that it is a chemical reaction means that new chemical substances are generated. Many chemical reactions generate heat but critically a combustion reaction will also produce light. The elements essential to the initiation of a combustion reaction are sometimes described in terms of the fire triangle; an ignition source or sufficient heat together with fuel and a supporter of combustion all have to be present.

Supporter of combustion

In its simplest form, combustion is a sequence of exothermic oxidation reactions, which means that energy (heat and light) is generated as the fuel source is broken down and an oxidant is added. This oxidant is the supporter of combustion. Under normal circumstances, the oxidant is most likely to be the oxygen in air.

A number of different factors can have a significant impact on the danger and intensity of a reaction within the fire gases:

- Stoichiometric mixture (ideal mixture)
- Flammable limits
- Flash point
- Fire point
- Auto-ignition temperature
- Ventilation

Intervention

When water evaporates it expands to water vapour (steam); this can be anywhere within the ratio range of 1,700:1 and 3,400:1 depending on the temperature. When restricted to a compartment, this can have significant benefits but it also carries some risks, for example; the expansion can lead to a significant increase in pressure in the compartment.

However, when properly applied, the contraction of the fire gases can be greater than the amount of water vapour formed. The result should be a noticeable rise in the smoke layer (previously referred to as the neutral plane) in the fire compartment. This benefits effective application as the over-pressure area will rise with the smoke layer (previously referred to as the neutral plane); firefighters should not be subjected to a wave of hot fire gases and visibility will improve.

Incident commanders should be aware of:

- The most appropriate firefighting media, for example, water and foam
- The most appropriate weight of intervention (litres per minute), for example, firefighting jets and hose reels
- The most appropriate method of firefighting, for example, smothering, starvation and cooling (indirect or direct cooling)
- Contingency plans that are formulated, implemented and communicated to ensure the safety of committed personnel in the risk area, for example, committing a supporting firefighting team

Strategic actions

Fire and rescue services should:

- Provide appropriate equipment and media to enable effective gas cooling tactics to be implemented

- Develop tactical guidance and support arrangements for the hazards that may be encountered and the actions to be taken when considering gas cooling tactics for fires in buildings

Tactical actions

Incident commanders should:

- Use appropriate gas cooling techniques and equipment for the internal conditions identified

Control measure – Firebreaks and fuel breaks

Control measure knowledge

A firebreak can be implemented to present an obstacle to the spread of fire; this tactic can be useful in waste, roof (particularly thatch) and wildfires. If a firebreak is to be effective, it should be a sufficient distance from the fire to ensure that the break can be completed before the fire reaches that point. A firebreak can be complemented by using extinguishing media to further resist the spread of fire in a particular direction.

A fuel break is an existing, planned change or discontinuity in fuel that will reduce the likelihood of combustion, fire intensity and/or the rate of firespread.

In preventing firespread, the position of separating walls and other firebreaks that could help with checking the spread of fire should be considered. In modern buildings with fire-resisting floors, horizontal fire travel is more usual, while in older buildings the spread of fire tends to be in a more vertical direction.

See National Operational Guidance: Wildfire

See National Operational Guidance: Environmental protection

Strategic actions

Fire and rescue services should:

- Develop tactical guidance and support arrangements for the hazards that may be encountered and the actions to be taken when implementing a firebreak system
- Consult and liaise with relevant people and/or agencies to obtain advice and support on firebreak information in identified areas of land and specific buildings
- Produce site specific risk information (SSRI) on appropriate firebreaks

Tactical actions

Incident commanders should:

- Consider creating a firebreak to prevent firespread, also considering the time required to implement
- Monitor the effectiveness of any firebreak and communicate any breach to all personnel

Control measure – Cutting away

Control measure knowledge

During firefighting and salvage operations, crews may need to cut away elements of a structure, removing surface coverings such as flooring, skirting, roofing members and partitions to ensure that all hot spots have been exposed and the fire has been fully extinguished.

Various techniques and methods of cutting away may be required to assist in locating a fire. For example, at chimney/hearth fires, in voids or between floors may require significant cutting away actions to locate the fire and enable adequate extinguishing media to be applied.

Crews involved in cutting away should be aware of the type of building involved and the construction methods likely to be encountered. Cutting away even small areas may have an impact on the entire structure and care should be taken to ensure that the wider structure remains safe at all times. This can be particularly relevant in timber-framed structures where one element weakened through fire or fire and rescue service intervention could have a detrimental effect on the entire building's strength. Incident commanders should ensure that nominated safety officers and/or specialist advice are used where appropriate.

Crews should try to ensure that, as far as practicable, cutting away any parts of a structure or property is done in the most effective manner, minimising property damage and allowing easy repair.

Strategic actions

Fire and rescue services should:

- Develop tactical guidance and support arrangements for the hazards that may be encountered and the actions to be taken when considering cutting away coverings and structures to locate fires and firespread
- Develop local arrangements to ensure that during operational incidents relevant building structural integrity is assessed by suitably qualified individuals

Tactical actions

Incident commanders should:

- Undertake cutting away to locate and extinguish fire, considering the risk of weakening structure

Control measure – Controlled burning

Control measure knowledge

Controlled burning is a defensive operational tactic to prohibit or restrict the use of extinguishing media on fires to allow the combustion process to continue uninhibited. UK law does not require fire and rescue services to extinguish fires. A controlled burning strategy may warrant consideration in certain circumstances, including protecting the environment, where the benefit from offensive firefighting does not outweigh the risks, or where available resources and media are insufficient to successfully resolve the incident.

This operational strategy can be employed to limit damage to the environment when it is not possible to contain polluted fire water, as it can minimise the risk to public drinking water supplies from fire water runoff. It may also benefit air quality through improved combustion and dispersion of airborne pollutants. It can be employed in conjunction with firebreaks as a firefighting technique when responding to fires in areas such as moorlands or heathlands.

It is essential to understand that this strategy may have adverse effects, such as hazardous gaseous by-products to form or increase. The balance of potential water and airborne impacts is one of the factors that should be taken into account before implementing the strategy. See Section 3.7, Environmental Protection Handbook.

Controlled burn considered	**Controlled burn likely to be inappropriate**
Life or health is not at risk or a controlled burn will reduce risk to people	Life or health is at immediate risk or a controlled burn will increase risk to people
There is little chance of extinguishing the fire	There is a high chance of extinguishing the fire with minimal health or environmental impacts
Fighting the fire with other techniques could cause a significant risk to firefighters	The fire is likely to spread widely or to high-hazard areas
Property is beyond salvage	Important or valuable buildings are involved
Fire conditions, weather conditions and/or the local landscape are appropriate for minimising air quality impacts	Fire conditions, weather conditions and/or the local landscape are inappropriate
Fire water run-off could damage an area of high environmental sensitivity or value	Drainage from the site leads to an area of low environmental sensitivity or fire water is not polluting
Fire water run-off could affect drinking water sources or sewage treatment works	Fire water can be contained on-site or off-site

Incident commanders will decide whether to allow a controlled burn. Wherever possible, they should take specialist advice from hazardous materials advisers (HMA), environment agency staff, owners/occupiers and public health bodies. The decision should be communicated as appropriate, including to the public via the media if necessary.

A controlled burn strategy may be considered at any time during an incident. At incidents where it is expected that the fire will burn for some time it may be appropriate to use both controlled burn and extinguishing tactics. For example, using a controlled burn in the initial stages of an intense fire may result in lower concentrations and better dispersion of pollutants because of the high combustion temperatures as well as reduced run-off.

The technique of introducing an accelerated control burn, which may include the use of fire service positive pressure ventilation fans (PPV), can help to increase temperature and therefore decrease the combustion time.

However, with both controlled burn and an accelerated controlled burn, as the fire dies back and begins to smoulder, the pollutant levels in the smoke plume may increase, resulting in reduced dispersion of pollutants and lowering of the smoke plume and contents in the atmosphere. At this point an extinguish strategy could be used. Such a strategy would also give more time for firewater containment measures to be put in place.

Controlled burn strategies may apply to industrial or commercial premises processing or storing polluting substances but can also be useful to limit the effects of fires involving:

- Agricultural premises, for example barns or BASIS (Registration) Ltd stores
- Transport by road, rail, air or sea or hazardous and/or environmentally damaging materials in significant quantities

For sites falling under the Control of Major Accident Hazard Regulations 1999 (COMAH), The Environmental Permitting (England and Wales) Regulations 2010 and other relevant environmental legislation, fire and rescue services should liaise with site occupiers and environment agencies to establish situations where considering a controlled burn may be required as part of:

- An industry protection scheme such as the BASIS (Registration) Ltd scheme for agrochemical stores
- An incident response plan at a site regulated by environment agencies
- An environmental management system or as part of the risk management plan as an agreed environmentally best option

Certain buildings have a particularly high value, not just in rebuilding costs but also because of their architectural, cultural, historical or strategic significance. Although it is unlikely that a building of this type would be used to store significant quantities of hazardous or polluting substances, the health and environmental benefits of a controlled burn must be weighed against the value of the building when they do.

The decision to adopt a controlled burn strategy should be made following consultation with relevant agencies, for example:

- Environmental agencies
- Nature conservation bodies
- Public health organisations
- Local authority
- Highway agencies

See National Operational Guidance: Environmental protection

Strategic actions

Fire and rescue services should:

- Develop tactical guidance and support arrangements for the hazards that may be encountered and the actions to be taken for controlled burning
- Ensure that a controlled burn strategy takes into account both the event and post-event phase of an incident
- Make appropriate arrangements for mitigating pollution and informing the relevant environmental agency and, where necessary, the local population. Liaise with the appropriate agencies to establish air and water monitoring arrangements, both on and off site where necessary
- Identify pre-determined sites where a controlled burn strategy may be appropriate

Tactical actions

Incident commanders should:

- Consider a controlled burn strategy and communicate this to personnel and relevant authorities

Control measure – Damping down and turning over

Control measure knowledge

Most fires are likely to produce debris under which small pockets of fire can continue to smoulder for some time. Turning over ensures that all faces of a burning material have been fully extinguished. This debris can contain useful information on the possible cause of the fire, so firefighters should try not to disturb it more than necessary before investigations into the fire's cause are complete.

The nature of the fire and the substances involved should be noted. Firefighters should recall that toxic vapours or liquids may be a greater source of danger at this stage in operations than the firefighting.

If possible and appropriate, the debris should be removed to an open space. Alternatively, a small clearing should be made and the debris methodically turned over into it, working from one end to the other.

In large industrial premises, where a lot of turning over has to be done, it may be possible, after gaining permission from the management and assessing the risk, to get assistance from drivers of forklift trucks.

Any baled goods, such as rolls of paper or cotton, should not be opened. If it is suspected that a bale may be on fire internally, it should be moved to the open air where it can be opened safely.

Even after a fire has apparently been extinguished, pockets of fire, flying brands, bullseyes or other possible causes of re-ignition may remain.

Burning materials can linger in various places, many not immediately obvious. For example, dust may become ignited and burn slowly in a trail from one compartment to another, setting it alight some time after the main fire has been extinguished. Bullseyes may linger for long periods, often in unlikely positions, and cause a later recurrence.

Strategic actions

Fire and rescue services should:

- Develop tactical guidance and support arrangements for the hazards that may be encountered and the actions to be taken when turning over and damping down

Tactical actions

Incident commanders should:

- Ensure all fire is extinguished by damping down and/or turning over

Select appropriate firefighting equipment

Once an incident commander has established what they are dealing with and selected the method of extinguishing the fire and type of firefighting media to be used, the crews will need to focus on transferring the media to the fire ground and onto the fire itself.

This can be achieved using a range of equipment in a number of ways, for example:

- Extinguishers: Stored pressure, gas cartridge
- Portable systems: Buckets, backpacks, and portable misting systems
- Emergency fire vehicles and pumps e.g. Tank supplies, portable pumps, hose layers, High Volume Pumps (HVPs)
- Hose: Hose reels, delivery hose, suction hose
- Branches: Smooth-bore, hand-controlled, foam-making
- Monitors: Ground monitors, water towers
- Foam delivery equipment: Inductors, applicators, branches

The range of delivery equipment for transporting firefighting media to the incident ground, such as water relay and water shuttle or carrying, in which the water can be transferred from remote supplies over long distances, may require many of these resources to be deployed or used either in isolation or in various combinations.

Control measure – Portable fire extinguishers

Control measure knowledge

A fire extinguisher is an active fire protection device used to extinguish or control small fires, often in emergency situations. A fire extinguisher is described by its contents:

See: Fire and thermal radiation hazard knowledge

At present these use:

Type		BS EN 3 colour code	Suitable for use on fire classes (brackets denote sometimes applicable)					
Water		Signal red	**A**					
Foam		Red with a cream panel above the operating instructions	**A**	**B**				
Dry powder		Red with a blue panel above the operating instructions	**(A)**	**B**	**C**		**Electrical**	
Carbon Dioxide **CO^2**		Red with a black panel above the operating instructions		**B**			**Electrical**	
Wet Chemical		Red with a canary yellow panel above the operating instructions	**A**	**(B)**				**F**
Class D Powder		Red with a blue panel above the operating instructions				**D**		
Halon 1211/BCF		No longer in general use	**A**	**B**			**Electrical**	

Extinguishers conforming to British Standard BS EN3 range from approximately 2kg to 20kg, the latter being considered the maximum a person can satisfactorily carry and use effectively.

Before selecting a fire extinguisher as an appropriate media:

- If using a self-aspirating foam extinguisher on a contained fire, direct the foam against a vertical surface such as a wall or side of the container if possible
- On a running fuel fire, ensure that the foam from a foam extinguisher falls gently onto the surface to build up the blanket and, if possible, make a break between the already burning liquid and that not yet ignited
- When using a powder extinguisher, be aware that although most powders are of minimal toxicity, some can be dangerous if inhaled for some time. If discharging a powder extinguisher in a confined space, personnel should ensure adequate ventilation is present when conditions permit or use respiratory protection equipment (RPE)
- Be aware that while powder extinguishers can suppress a fire, they do not normally form an inert atmosphere and will rapidly settle out once application stops. Firefighters must always be aware of re-ignition, especially on class B fires, and be ready to begin powder application again or use another suitable medium
- Realise that a powder extinguisher is not good at penetrating hidden spaces and may cause damage to delicate machinery. It also tends to obscure visibility in confined spaces

Refer to the Firefighting equipment knowledge sheets for information on portable fire extinguishers

Strategic actions

Fire and rescue services should:

- Develop tactical guidance and support arrangements for the hazards that may be encountered and the actions to be taken when using portable fire extinguishers

Tactical actions

Incident commanders should:

- Consider using an appropriate fire extinguisher type to tackle small fires

Control measure – Flow rates

Control measure knowledge

At its simplest, the flow rate is the amount of extinguishing media being applied to a fire at any one time, referred to in litres per minute (L/min).

Required flow rate may be simply viewed as the amount of firefighting media required to control and ultimately extinguish a fire. This introduces many variables; more precisely two flow rates need to be considered:

- Critical flow-rate (CFR): typically this would be the absolute minimum amount of firefighting media flow needed to fully suppress a fire at any given level of involvement
- Tactical flow-rate (TFR): the target flow for a primary attack hose line or lines

The actual critical flow rate is dynamic; it is directly related to the phase of the fire and this may be unknown. It also has no built-in safety factor. More relevant is the tactical flow rate, which more accurately represents the flow rates required by firefighters to deal with a given fire in a known compartment.

The concept of firefighting flow rate requirements can be based theoretically in matching the flow of firefighting media against known rates of heat release in compartment fires (measured in megawatts or MW).

It can also be empirically based on fire loads, in established floor space, against the flow of firefighting media needed to suppress fires during their growth or decay stages. The latter is generally a defensive application.

It is recognised that flow rate i.e. the amount of firefighting media, extinguishes fire, not pressure.

Relying on pressure alone as the basis to deliver firefighting media does not provide information on the litres per minute being delivered and may be insufficient to prevent fire growth and spread.

The mathematical calculations for the amount of water required to extinguish a given fire are relatively complex. However, as a fire ground rule of thumb for fires from 50 to 600m^2, the following calculation could be considered:

Optimum flow rate (L/min) = fire area (m^2) x 5

For example, in a situation with a fire in an open plan flat measuring 90 m^2

Optimum flow = $90m^2$ x 5 = 450 L/min

This shows that an estimated flow rate of >450 L/min would be required as a minimum to extinguish the fire.

Flow meters

A flow meter is a device that measures the amount of water passing a given point at any time. Vehicles can be equipped with flow meters for each delivery, giving the pump operator information to manage water more effectively. In summary, flow meters provide the knowledge that firefighters require to operate more safely and effectively. Flow meters automatically measure the flow rate when pumping and can also measure the cumulative flow from delivery.

Strategic actions

Fire and rescue services should:

- Develop tactical guidance and support arrangements for the hazards that may be encountered and the actions to be taken when calculating flow rates for effective firefighting
- In considering the environmental impact, provide appropriate equipment, systems and processes to enable personnel to monitor the amount of applied firefighting media

Tactical actions

Incident commanders should:

- Select appropriate firefighting equipment (extinguisher, hose reel, main jet, cutting extinguisher)
- Select appropriate firefighting equipment based on risk assessment and required weight of intervention

Control measure – Hose

Control measure knowledge

Hose may be divided into two main groups:

- Delivery hose, used where the water passing through it is at a greater pressure than the atmosphere
- Suction hose, used where the water passing through it may be at pressures either below or above that of the atmosphere

Refer to the Firefighting equipment knowledge sheets for information on firefighting hose

Strategic actions

Fire and rescue services should:

- Develop a firefighting hose equipment strategy incorporating, for example, site-specific risk information, the community risk register, the national risk register and consultation with local emergency planning groups, the environment agencies, neighbouring services and national resilience capabilities. Further information can be seen in Logistic operations for emergency supplies - Publications - GOV.UK
- Develop tactical guidance and support arrangements for the hazards that may be encountered and the actions to be taken for the adequate supply of water via hose and associated equipment for firefighting purposes
- Ensure all personnel understand the flow rate capabilities of available fire service equipment

Refer to the Firefighting equipment knowledge sheets for information on the care of firefighting hose

Tactical actions

Incident commanders should:

- Select appropriate hose and branches based on risk assessment and identified flow rates

Control measure – Branches and nozzles

Control measure knowledge

A branch pipe, or branch as it is normally referred to, is used at the delivery end of a hose line to increase velocity and to provide an effective firefighting stream.

Branches are divided into three principal classes:

- Those that yield a stream in the form of a jet, which cannot be controlled by the operator
- Those that provide for some form of control by shutting off the jet, adjusting the flow rate, altering its shape or size, or changing its character, such as converting it into a spray
- Those which are used exclusively as hose reels

Special equipment, such as cutting extinguisher firefighting equipment may be used to achieve a rapid intervention at a fire before the start of offensive operations. This type of equipment may be used to reduce temperature, the rate of burning and the speed of firespread, before firefighters enter a compartment, or while waiting for further resources to arrive.

Refer to the Firefighting equipment knowledge sheets for information on branches

Strategic actions

Fire and rescue services should:

- Develop tactical guidance and support arrangements for the hazards that may be encountered and actions to be taken when selecting and using the appropriate branches and nozzles for firefighting

- Procure, or make arrangements to provide, appropriate equipment capable of providing safe systems of work for all foreseeable circumstances

Tactical actions

Incident commanders should:

- Select appropriate hose and branches based on risk assessment and identified flow rates

Control measure – Monitors

Control measure knowledge

Monitors can be fixed or portable, manual or remote controlled, and can in general be used with water or foam, although in specific circumstances monitors may be designed for other types of firefighting media.

Fixed monitors are found wherever there are substantial class B fire risks while mobile or portable monitors are often used aboard emergency fire vehicles or to protect multiple risks by moving the monitors around a site.

Nearly all industrial fire hazards are candidates for monitor protection, but some of the more common applications are:

- Refineries
- Fuel distribution depots
- Chemical plants
- Warehouses
- Helicopter landing pads
- Aircraft hangars
- Loading jetties
- Process plants
- Industrial process areas
- Shipping
- Vehicle-mounted

Monitors may also be used in areas of risk, for example, an area identified as being at risk of structural collapse (either internally or externally) or in irrespirable or explosive atmospheres, or to free up firefighting personnel. A monitor can be positioned to apply firefighting media and left in position indefinitely without the need for firefighters to be present.

Refer to the Firefighting equipment knowledge sheets for information on monitors.

Strategic actions

Fire and rescue services should:

- Procure or make arrangements to provide appropriate equipment capable of providing safe systems of work for reasonably foreseeable risks
- Develop tactical guidance and support arrangements for the hazards that may be encountered and the actions to be taken when using monitors
- Consider the use of fixed monitors as part of any site pre-planning

Tactical actions

Incident commanders should:

- Consider using monitors to release personnel and minimise deployment in hazard areas

Control measure – Wear personal protective equipment (PPE)

Control measure knowledge

Personal protective equipment (PPE) for firefighting purposes is a key requirement for fire and rescue services.

Further information can be found in National Operational Guidance: Operations – Health, safety and welfare.

Strategic actions

Fire and rescue services must:

- Ensure that the types of personal protective equipment (PPE) used comply with relevant standards and meet the requirements of their risk assessment for fires and firefighting

Tactical actions

Incident commanders should:

- Ensure that appropriate firefighting PPE is worn by all personnel as identified in service risk assessment
- Consider the need for additional PPE where compatible with firefighting PPE (e.g. high visibility, eye protection)

Control measure – Consider wearing respiratory protection equipment (RPE)

Control measure knowledge

Respiratory protection equipment (RPE) is a key requirement for fires and firefighting.

See National Operational Guidance: Operations

Strategic actions

Fire and rescue services must:

- Ensure that the types of respiratory protection equipment (RPE) used comply with the relevant standards and meet the requirements of their risk assessment for fires and firefighting

Tactical actions

Incident commanders should:

- Ensure that appropriate respiratory protection equipment (RPE) is worn by all personnel as identified in service risk assessment

Hazard – Flashover, backdraught and fire gas ignition

Hazard	Control measures
Flashover, backdraught and fire gas ignition	Understand signs and symptoms of flashover Understand signs and symptoms of backdraught Gas cooling Consider employing tactical ventilation Wear personal protective equipment (PPE)

Hazard knowledge

Firefighters need an adequate understanding of the development of fires in ventilated and fuel controlled states, so they can recognise any potential fire development conditions. Tactics such as venting and indirect and direct application of water can then be used more effectively and safely.

A flashover is the stage where the total thermal radiation from the fire plume, hot gases and hot compartment boundaries causes all exposed combustible surfaces to pyrolyse (release flammable gases) and ignite when there is adequate ventilation. This sudden and sustained transition of a growing fire to a fully developed fire is known as a flashover.

All firefighters should be aware of the phenomenon termed *backdraught*. A backdraught is sudden and fierce and may occur at any stage during enclosed firefighting operations. Tragically, this type of event has killed firefighters in the past.

A backdraught is where limited ventilation can lead to a fire in a compartment producing fire gases containing significant proportions of partial combustion products and unburnt pyrolysis products (pyrolysates). If these accumulate, the admission of air when an opening is made to the compartment can lead to a sudden deflagration. This deflagration moving through the compartment and out of the opening is a backdraught. The force of a backdraught has the potential to damage building elements resulting in an unstable structure.

Fire gas ignitions occur when gases from a compartment fire have leaked into an adjacent compartment and mixed with the air within this additional area. This mixture may then fall within the appropriate flammable limits that, if ignited, will create an increase in pressure either with or without explosive force. Where this process occurs it is not necessary for an opening to be opened for such ignition to take place. If an explosive force is experienced, this is commonly termed a 'smoke explosion'. Where an ignition occurs with much less pressure, the term 'flash fire' is more appropriate.

Fire and rescue service personnel should be aware that the above phenomena are not mutually exclusive and all could be present at the same incident.

Control measure – Understand signs and symptoms of flashover

Control measure knowledge

The previous section provides a scientific description of events that firefighters may encounter but most importantly firefighters should be able recognise and understand the following signs.

Signs of room flashover include:

- High heat conditions or flaming combustion overhead
- The existence of ghosting tongues of flame
- A lack of water droplets falling back to the floor following a short burst fog pattern being directed at the ceiling
- A sudden lowering of the smoke layer (previously referred to as the neutral plane)
- The sound of breaking glass as windows or glazing begin to fail from exposure to heat, possibly causing a visible rise in the smoke layer (previously referred to as the neutral plane)
- A change in smoke issuing from a window (seen from the exterior), with increasing velocity, as if issuing under pressure, and a darkening of smoke colour towards black
- The sudden appearance of light-coloured smoke (pyrolysis) from low-level items being subjected to high heat flux from the hot gas layer

This video demonstrates the phenomenon of flashover.

Where it is necessary to use a combination of direct and indirect firefighting techniques and gas cooling, firefighters should take care at all times to ensure that direct firefighting jets/sprays do not impact negatively on the conditions or on firefighting teams as they move through a structure when deployed for internal firefighting operations.

Summary of key fire behaviour indicators

	Fire behaviour indicator	**Hazard information**
1	Slow-moving light-coloured smoke issuing from an opening	Early-stage fire development or smoke issuing some distance from the fire compartment
2	Fast-moving darkening smoke issuing from an opening	Impending flashover

	Fire behaviour indicator	Hazard information
3	Heavily darkened or heat-crazed windows	Under-ventilated fire conditions threatening backdraught or smoke explosion
4	Pulsing (in and out) darkened smoke movements around closed doors and windows	Fire development heading towards backdraught
5	Very hot doors or windows (feel with back of the hand)	Under-ventilated fire conditions threatening backdraught, smoke explosion or thermal runaway (flashover)
6	Sudden reversal of smoke issuing from an opening, causing smoke to head back into the compartment/building	The fire is rapidly developing and in need of more oxygen (impending flashover or backdraught), or a gusting wind-driven fire event is occurring
7	A rapid lowering of the smoke layer (previously referred to as the neutral plane)	Impending flashover
8	A rising of the smoke layer (previously referred to as the neutral plane)	A vent opening may have occurred at another location in the compartment/building
9	Turbulence or rising and falling (bouncing) in the smoke layer (previously referred to as the neutral plane)	Rapid fire development may be occurring
10	Heat radiating down from the smoke layer (previously referred to as the neutral plane)	Impending flashover
11	Detached 'ghosting' tongues of flame moving around the fire compartment	Impending flashover
12	Flaming combustion seen near the ceiling or at the smoke interface	Impending flashover
13	Smoke seen issuing from closed windows, doors or roof eaves, as if under pressure	Under-ventilated fire and impending backdraught

Strategic actions

Fire and rescue services should:

- Provide information, instruction and training to ensure all personnel are aware of the indications, safety measures and actions to take for potential flashover events
- Develop tactical guidance and support arrangements to ensure the safety of personnel when dealing with potential flashover events

- Maintain systems and processes to acquire and act on operational information on the occurrence of flashover events at operational incidents
- Share operational information and organisational learning on flashover events with relevant stakeholders

Tactical actions

Incident commanders should:

- Where flashover conditions are suspected, consider external direct firefighting techniques
- Consider employing a combination of direct firefighting and gas cooling to control conditions
- Carry out self-protection, door entry and compartment firefighting in line with procedures and training

Control measure – Understand signs and symptoms of backdraught

Control measure knowledge

All firefighters need an adequate understanding of the development of fires in ventilation-controlled and under-ventilated states, so they can recognise potential backdraught conditions. Tactics such as venting and/or the indirect and direct application of water can then be used more effectively and safely.

Signs of backdraught include:

- Fires in tightly closed compartments, especially in energy efficient buildings
- Dark oily deposits and condensation running down the inside of windows
- Windows, doors and door handles that are hot to touch (back of the hand)
- Rattling sounds or smoke pulsating around openings
- Smoke being drawn back into openings and large air movements (draughts) seen heading into openings as the fire searches for more oxygen
- Ghosting tongues of flame seen in the compartment
- Turbulence in the smoke layer (previously referred to as the neutral plane), sometimes seen to 'bounce' up and down
- Whistling and roaring sounds, sometimes denoting high-velocity air flowing in or gases burning off in the compartment, preceding a backdraught event
- A change in fire conditions, with fast-moving smoke seen from the exterior to exit at high velocity, as if under pressure, and a steady darkening of smoke colour

This video demonstrates the phenomenon of backdraught

Strategic actions

Fire and rescue services should:

- Ensure all personnel receive information, instruction and training in the indications, safety measures and actions to take for potential backdraught events
- Develop tactical guidance and support arrangements to ensure the safety of personnel when dealing with potential backdraught events
- Maintain systems and processes to acquire and act on operational information on the occurrence of backdraught events at operational incidents
- Share operational information and organisational learning on backdraught events with relevant stakeholders

Tactical actions

Incident commanders should:

- Where backdraught conditions are suspected, apply media and ventilate before interior deployment

Control measure – Gas cooling

See Hazard - Fire and thermal radiation

Control measure – Consider employing tactical ventilation

See Hazard - Uncontrolled ventilation

Control measure – Wear personal protective equipment (PPE)

Control measure knowledge

Fire service personnel should be aware that in the event of flashover, structural firefighting PPE on its own is unlikely to provide adequate protection to the wearer.

See National Operational Guidance: Operations

Hazard – Uncontrolled ventilation

Hazard	**Control measures**
Uncontrolled ventilation	Consider employing tactical ventilation

Hazard knowledge

The rate of development of any fire is directly linked to the supply of oxygen available to it. Establishing control over ventilation should form a key part of the overall incident plan.

Incident commanders should be aware that any increase in the supply of oxygen to a fire will accelerate the development of the fire. Experience has shown that where ventilation is not properly controlled or coordinated, firefighter safety has been compromised and serious consequences have followed.

Ventilation is one factor amongst the many tactical considerations that the incident commander will need to consider and implement as part of their overall incident plan. When planned and performed correctly ventilation can contribute to, and assist in, saving lives, improving firefighting conditions to support firefighter safety and reducing damage to property.

The incident commander must balance the benefits of controlled and coordinated tactical ventilation, in line with their service policy and training, with the hazards associated with accelerated fire growth and the introduction of oxygen into under-ventilated fire compartments.

Various natural or mechanical phenomena are associated with ventilation as well as being inherently linked to fire development, which can have an impact on any planned ventilation strategy. It is important that firefighters and incident commanders have an awareness of these phenomena and the potential impact when developing an overall ventilation and firefighting strategy, including:

- Wind-driven fires
- Coandă effect (see figure 3)
- Piston effect
- Trench effect (see figure 4)
- Stack effect (see figure 5)
- Dust explosions

Wind-driven fires

The term 'wind-driven fire' has no formal definition under ISO or in UK fire and rescue service manuals. It is, however, becoming the standard generic term for fires that may also be referred to as forced-draft, wind-assisted, force-vented or blowtorched.

A wind-driven fire may be described as one where external wind (or ventilation-forced) pressure causes strong air movements, affecting the severity of fire spread.

Fires can be affected by wind pressure and high-velocity air movements. The impact can be experienced in open fires or wildfires, while in buildings the greatest impact is usually experienced with fires in high-rise structures. Where windows have failed through exposure to heat, allowing external wind to affect the speed and direction of fire development, firefighters located in the flow path between the air inlet and air outlet are potentially in great danger, as temperature layering balances out across all levels, floor to ceiling.

Coandă effect

The 'Coandă effect' (see figure 4 and 5) is described as the tendency of a stream of fluid or gas to stay attached to a nearby surface rather than follow a straight line in its original direction. In firefighting terms, this is the tendency of a fast-moving stream of air to deflect to nearby surfaces. The airstream's static pressure tends to decrease, which causes a pressure difference between the wall and areas far from the wall. This bends the stream towards the surface and tends to keep it attached to that surface.

The Coandă effect will influence hot gases escaping from compartments involved in fire. The effects of convection, fire compartment pressurisation and the wind will cause smoke and hot gases to be expelled from an external opening and usually move vertically. In some instances, the Coandă effect also influences downward fire spread.

The Coandă effect will encourage the venting products of combustion to be drawn back towards the face of the building, which will generate fire spread to other compartments or areas of the structure.

While this effect is commonly considered to occur at high-rise incidents, the same effect is often responsible for the spread of fire from ground floor compartments to upper levels when uncontrolled ventilation occurs.

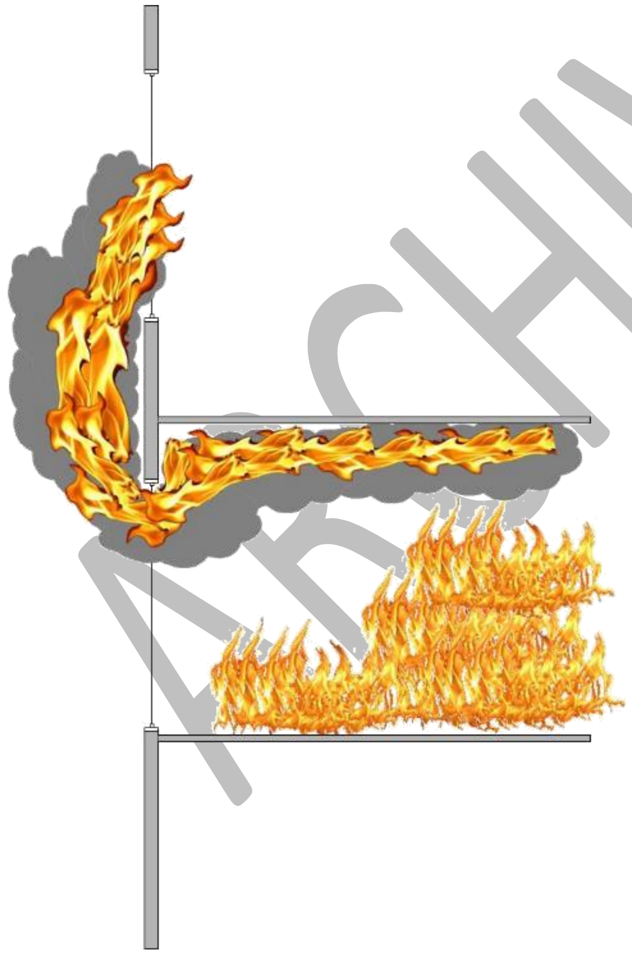

Figure 3: Coandă effect

Source: Building Research Establishment

Figure 4: Post-fire damage illustrating the result of the Coandă effect

Source: Building Research Establishment

Piston effect

The ‘piston effect’ is a phenomenon that creates a potentially large movement of air in a shaft or tunnel when an object moves in the enclosure. The effect is more pronounced when the object’s sides are close to the enclosure walls and if the object moves at speed.

For example, a train, when moving in an unrestricted location, displaces air around it except in the direction of the ground. If the same train enters a tunnel, the displaced air is confined by the tunnel walls. An area of higher pressure is created in front of the train as well as around the sides. Behind the train, an area of lower pressure is created, which is filled by the pressurised air escaping from around the sides of the train and equalised by the flow of air from all sides of the area of low pressure.

As the train exits a tunnel, into an underground station for example, the pressure wave, or movement of air felt by passengers standing on the platform, is the pressure front created by the moving train. This effect is similar to the operation of a mechanical piston in an engine or pump, hence the term ‘piston effect’.

The same effect and impacts can be created by the movement of a lift in a lift shaft. The piston effect can influence the movement of air not only close to the lift shaft but also in the wider area of the building or structure. These air movements will affect the ventilation flow paths throughout the structure and can induce undesirable air movement in relation to wind-driven fires, blowtorch effect, flashover, backdraught or fire gas ignitions.

Incident commanders and fire crews should be aware of, and manage, these flow paths to minimise the hazards that may be experienced during a fire where there is the potential for sudden and rapid fire growth.

Trench effect

The 'trench effect' is a phenomenon that can produce a developing fire plume that accelerates up an inclined surface. It is influenced by two separate physical effects, the Coandă effect and flashover.

The trench effect can occur when a fire develops on or close to an inclined surface (approximately 25°). The flames deflect towards the surface (Coandă effect) and heat the combustible materials further up the incline. These materials will begin to be heated, leading to pyrolysis and subsequent ignition. Rapid fire development continues towards the top of the inclined slope until the fuel is depleted.

The trench effect can be exacerbated by flow paths in buildings and structures as well as by prevailing climatic conditions. The piston effect can also intensify the trench effect, for example, the King's Cross fire in London (1987). Further reading on this is contained in the Department of Transport: Investigation into the King's Cross Underground Fire.

Figure 5: Diagram of the trench effect

Source: Building Research Establishment

Stack effect

The 'stack effect' (see Figure 7) is the movement of air into and out of buildings, structures and chimneys and is driven by buoyancy. Buoyancy occurs because of a contrast between external and internal air density caused by temperature and moisture differences. The result is either a positive or negative buoyancy force. The greater the thermal difference and height of the structure, the greater the buoyancy force (stack effect).

Buildings are invariably constructed with provision for natural ventilation. Generally, air in the building is warmer than the external air temperature. This warmer air rises up through the building and exits through open windows, ventilation openings and through other forms of leakage. The rising warm air creates an area of lower pressure in the lower section of the building, allowing cooler external air to be drawn in through open doors, windows or other ventilation openings.

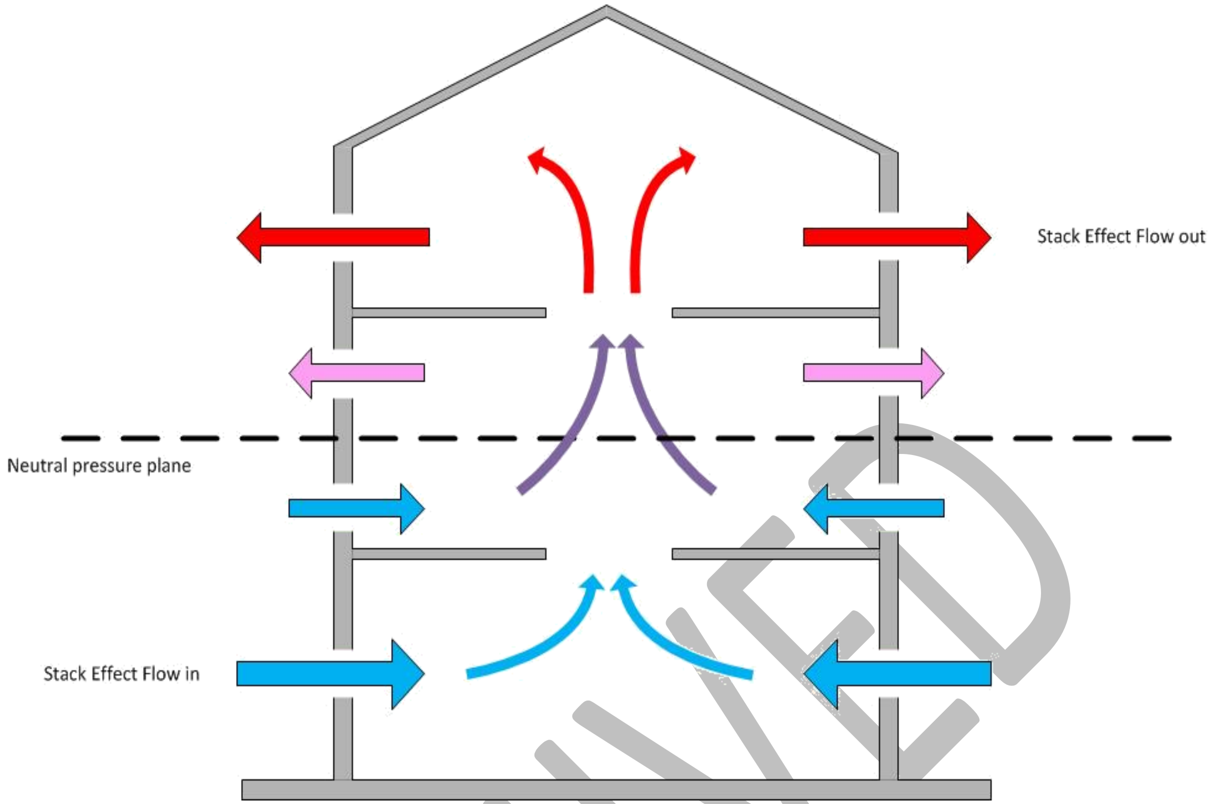

Figure 6: Diagram of the stack effect

Source: Building Research Establishment

Control measure – Consider employing tactical ventilation

Control measure knowledge

Ventilation is one factor amongst the many tactical considerations that the incident commander will need to consider and implement as part of their overall incident plan. When planned and performed correctly ventilation can contribute to, and assist in, saving lives, improving firefighting conditions to support firefighter safety and reducing damage to property.

In simple terms ventilation can be defined as:

> *'The removal of heated air, smoke or other airborne contaminants from a structure or other location and their replacement with a supply of cooler, cleaner air'*

In fundamental terms ventilation is something that will occur naturally as part of the fire development/decay process. It will have an impact on the development of a fire both pre- and post-arrival of firefighting crews at an incident scene, where they may encounter or be presented with fires in various phases of development. However, ventilation is also a valuable tactical intervention tool/option that fire and rescue services and incident commanders should consider as part of any overall firefighting strategy.

Historically, the traditional approach to ventilation focused heavily on ventilating after the fire to clear residual smoke and heat from buildings or structures. The subject of ventilation has however seen significant research and development over a number of years with new techniques and technologies becoming available to help improve the understanding and application of ventilation tactics.

When applied and managed correctly, ventilation can provide significant beneficial effects to any firefighting strategy by:

- Replenishing oxygen and reducing carbon monoxide levels
- Controlling temperature and humidity
- Removing moisture, dust and other airborne contaminants
- Improving visibility and aiding navigation

Tactical ventilation is a planned intervention that requires the co-ordination of fire and rescue services to open up buildings and structures to release the products of combustion and can be defined as:

> *'The planned and systematic removal of heat and smoke from the structure on fire and their replacement with a supply of fresher air to allow other firefighting priorities.'*

As part of an overall firefighting strategy, incident commanders should always have a clear and informed objective before commencing any form of ventilation activity. This will ensure that the full range of benefits of ventilating can be realised including:

- Improving conditions for the survivability of building occupants
- Improving conditions for firefighters to enter and search
- Reducing the potential for rapid fire development (flashover, backdraught, fire gas ignition)
- Restricting fire and smoke damage to property

In broad terms ventilation can be separated into two basic types:

Natural ventilation

This is the process of supplying and removing air through a structure or space without using mechanical systems. In firefighting terms this refers to managing the flow of air (flow paths) into and out of a structure or location, using the prevailing atmospheric conditions such as wind strength, speed and direction via structural openings such as windows, doors and vents, to clear any smoke or hot fire gases.

Forced ventilation

This is the process of using fans, blowers or other mechanical means or devices to assist in creating, redirecting and managing the air flow into and out of a structure or location so that heat, smoke and fire gases are forced out.

In both instances, additional factors related to climatic and atmospheric conditions such as temperature and pressure will have an impact on the relative success of any ventilation process.

Type of forced ventilation	Considerations
Positive pressure ventilation (PPV)	This is achieved by forcing air into a building using a fan. Using the fan will increase the pressure inside the building relative to atmospheric pressure. The most appropriate tactic for PPV will depend on whether the inlet vent is also being used for access/egress. If the fan has to be placed further back because of operations at the entrance to a building, the fan may be less efficient. The efficiency of smoke clearance will depend on a whole range of factors including the wind direction and strength, the size, type and number of fans, the proportion of the fan's air that enters the building (fan performance), the relative sizes of inlet and outlet vents, the size of the compartment to be cleared and the temperature of the fire gases (smoke) in the compartment. Firefighters should always be aware of the potential risk of increasing the level of carbon monoxide (CO) in other areas of a building when ventilating, either when directing/forcing fire gases through a premise or, in particular, where using petrol driven PPV fans. Firefighters should ensure that fans are positioned to prevent any build-up of CO.
Negative pressure ventilation (NPV)	Negative pressure ventilation refers to extracting the hot air and gases from the outlet vent. This will reduce the pressure inside the building relative to atmospheric pressure. This can be achieved by fans or water sprays.
Heating, ventilation and air conditioning (HVAC) and Fire Engineered systems	These systems are often engineered into buildings so that, in the event of a fire, they can be operated to ventilate public areas and support safe evacuation as well as improve conditions for responding firefighters. These systems are normally automatic but can also be operated by a manual override.
Powered smoke and heat exhaust systems	These systems are generally operated automatically and are likely to be operating before the arrival of firefighters. They can also be operated manually but this will need careful consideration by incident commanders as part of the firefighting and ventilation tactical strategy.

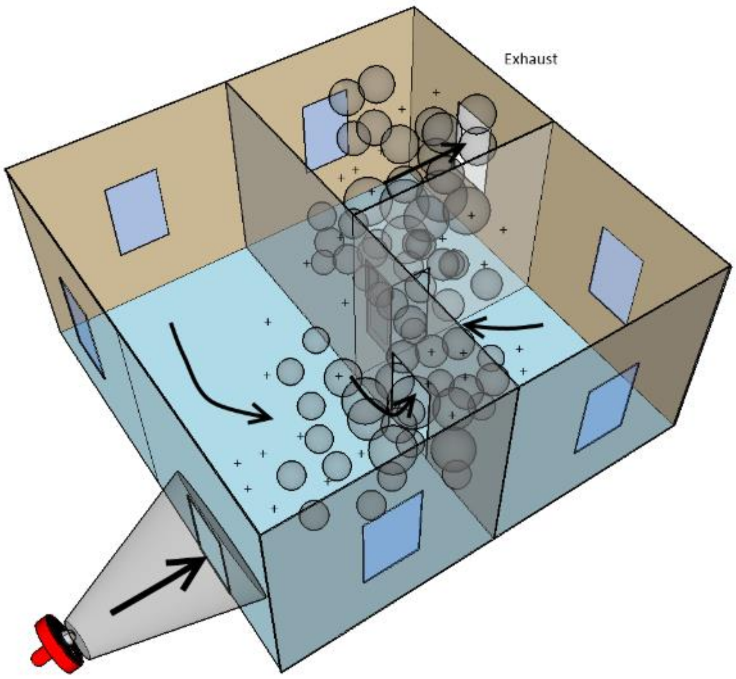

Figure 7: Positive pressure ventilation

Source: Building Research Establishment

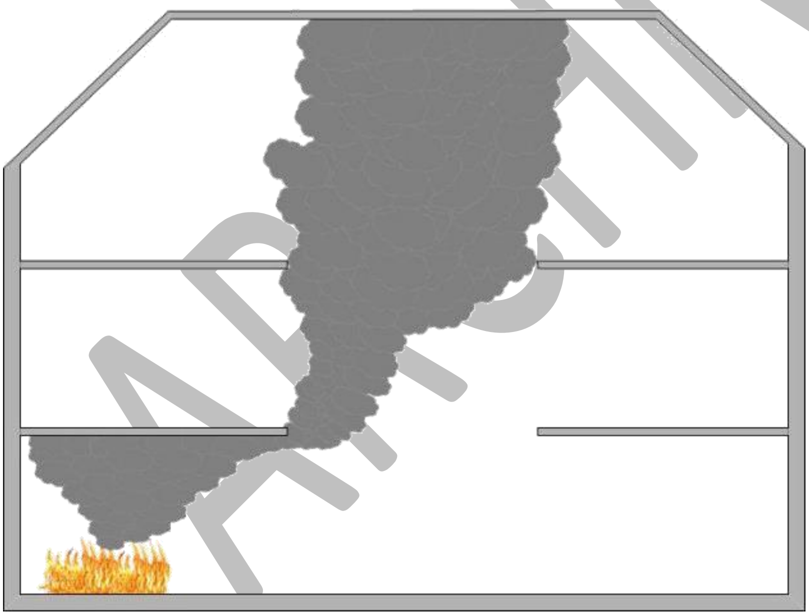

Figure 8: Heating, ventilation and air conditioning system in an atrium

Source: Building Research Establishment

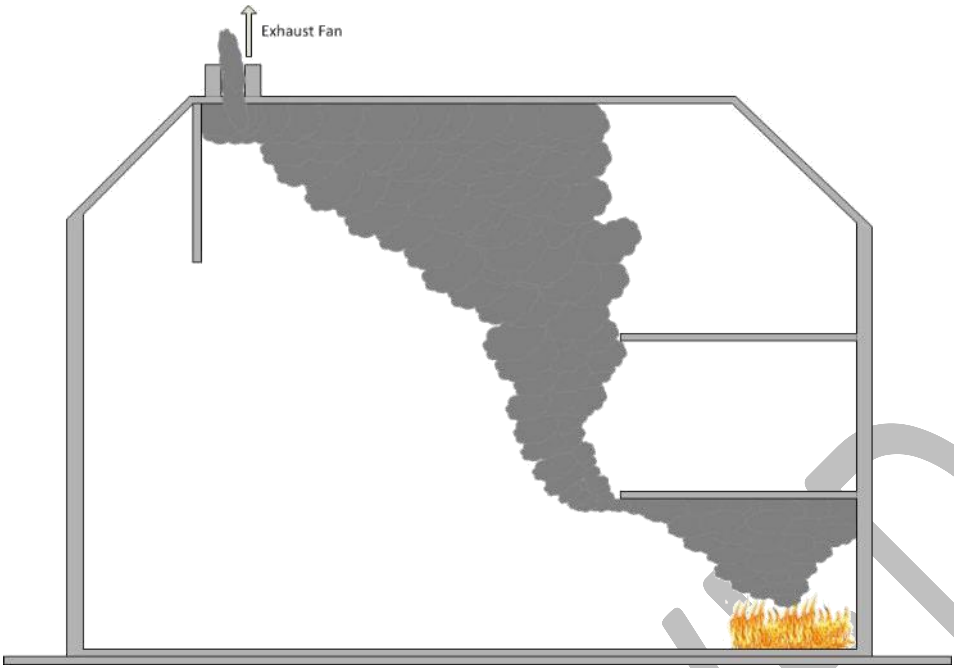

Figure 9: Heating, ventilation and air conditioning system

Source: Building Research Establishment

The success of any ventilation plan or strategy will to a greater degree depend on the techniques employed to effectively plan and manage where air will enter a building, structure or location (inlet vent) and where hot gases and smoke will leave a building, structure or location (outlet vent), including the route that they will take (flow path).

Fire service personnel should be aware that creating a vent in a previously under-ventilated compartment can increase the risk of creating a backdraught.

In broad terms, two basic techniques may be considered, which present both barriers and enablers to the ventilation process:

- Vertical (or top) ventilation: making an opening at high level to take advantage of the natural characteristics of hot gases and smoke – for example, buoyancy – allowing them to escape
- Horizontal (or cross) ventilation: making openings in external walls using doors and windows to aid removal of hot fire gases and smoke

Both of these techniques can be employed using natural or forced means of ventilation.

Strategy

The ventilation strategy implemented at any fire will be affected by a whole range of factors but in broad terms, the strategy should initially be based around either one or a combination of the following:

- Offensive ventilation: close to the fire to have a direct effect on the fire itself, to limit fire spread and to make conditions safer for firefighters

- Defensive ventilation: away from the fire, or after the fire, to remove heat and smoke, particularly to improve access and escape routes and to control flow paths to areas of the building not affected by the fire

Whatever strategy is adopted, an incident commander should always consider the benefits, impact and effects of ventilation in relation to the situation. Many factors will influence an incident commander's decision in this context, including any priority rescues, the presence of hazardous materials, processes or conditions and the effects of any pre-existing ventilation, as well as the design and layout of the building or compartment, climatic conditions and how these may affect any tactical ventilation activities.

It is also important to consider the impact that fire loading will have on ventilation activity in a fire situation. The nature and diversity of the substances and materials that may be encountered in buildings can have an impact on the process of combustion and fire development, which may increase the likelihood for peak temperatures to be reached at a faster rate. This is important from a firefighting perspective, as this can mean that firefighters may be more likely to encounter rapid fire development conditions at an incident.

Fire and rescue services should consider the benefit of information gathering in pre-planning activities and on arrival. This may prove to be of great value in formulating the ventilation strategy as well as any overall firefighting strategy. These information sources may include:

- Site-specific risk information
- Local knowledge
- On-site plans
- On-site responsible person (or appointed competent person)
- Scene surveys
- Fire protection plans and operational information
- Building management and monitoring systems, for example HVAC, CCTV and fire-engineered systems

Once an incident commander has gathered any initial information, a critical decision must be made in developing a plan of attack: whether or not ventilation is to be used or appropriate.

Where an incident commander decides that ventilation activities are not to be used, they may choose to contain or isolate the heat and smoke in the fire compartment (anti- ventilation). For example, this can be achieved simply by closing doors or windows to unaffected routes and protect other areas of a building or structure. This tactic may enable occupants to escape via unaffected routes and limit further damage and limit rapid fire escalation.

Conversely, where the incident commander decides that ventilation or an appropriate tactic is to be used, it is generally most effective when considered or integrated in the early stages of firefighting activity. This allows efficient search and rescue operations to be undertaken and improves the working environment for firefighters.

The incident commander should be aware that any uncontrolled or unplanned movement of smoke and hot fire gases can increase the potential for fire spread. The decision to use or commence tactical ventilation activities must be part of an overall strategy and should invariably be undertaken with a simultaneous combined fire attack or suppression plan. Ensure that the appropriate firefighting media is available, including any supporting media such as covering jets for external fire spread.

Locating the fire

For an incident commander, the process of locating a fire is critical in formulating a robust, safe and effective ventilation strategy. The following factors should be considered:

- Be aware that the location of the fire may be clearly evident on arrival, but it is possible that the fire has developed in unseen areas or that it may not be visible at all. It is vital to identify any routes of potential fire development and any flow paths that may be created, taking into account the impact on firefighting operations and their potential to create or intensify undetected fire development.
- In the majority of incidents, ventilation should only be used when a fire has been located and an assessment of the likely impact of ventilation has been taken into account. However, in circumstances where the location of the seat of fire is difficult for crews to establish, tactical ventilation may be used to clear adjacent compartments, corridors or staircases etc. to assist firefighters in identifying the seat of fire, maintaining safe access and egress routes to and from a risk area and also mitigating or reducing the potential for phenomena such as fire gas ignition.
- In many instances, fire crews will be able to use their human senses, professional judgement and experience to locate the fire. However, monitoring systems such as automatic fire detection systems or CCTV along with thermal scanning with thermal imaging equipment may assist with this process.

When planning and developing any ventilation strategy it is vital that due consideration be given to the impact that any unplanned or poorly considered ventilation can have. This can happen in a number of ways and may be as a result of one or more of the following:

- Self-ventilation caused by fire damage to the building or structure
- Fire crews carrying out inadvertent and uncontrolled ventilation, such as unplanned opening of vents, doors, windows
- Failure to take the creation of new flow paths into account when carrying out firefighting operations
- The effect of automatic ventilation systems (HVAC or powered heat and exhaust systems)
- Air movement created by the movement of lift machinery, stock or vehicles
- Air movement created by fire crews or escaping occupants opening internal and external doors and other openings
- Changes in wind speed and direction

The safety of firefighting crews and any building occupants is vital when forming a ventilation strategy and it is important that the impact and effects of the ventilation/fire conditions process are constantly monitored and reassessed and, where appropriate, tactics are adjusted accordingly.

The incident commander should make the safety of fire crews and any building occupants the primary concern when formulating and implementing a ventilation strategy. The benefits and effects of any planned ventilation must be considered together with:

- Location of the fire
- Location of any occupants, and protection of escape routes
- Access routes for fire crews to fire compartments
- Internal/external layout and design of the structure; including any fire engineered solutions
- Likely fire dynamics and development
- Natural ventilation, local topography that may affect wind effects and pressure differentials
- Effect of HVAC systems incorporating smoke control, sprinklers and design features such as atria and smoke curtains (see figure 9)
- Impact of natural fire phenomena on fire development/conditions, for example Coandă, stack, trench, piston effects or wind-driven fire
- Potential for a dust explosion:
    - Give due consideration to the possibility of dust explosion when determining the overall incident plan, as well as the ventilation strategy, if an incident occurs in a compartment, building or other structure
    - Identify any potential dust explosion risks as part of information-gathering in the initial stages of an incident
    - Pre-planning may have identified this as a potential hazard – it can be reasonably expected that control measures in any industrial processes will be in place and adequately maintained
    - Take the potential for a dust explosion into account in the ventilation strategy – ensure that any ventilation activities do not create movement of air that may agitate dust particles to the extent where an explosion occurs

The Incident commander should re-assess any actions to ensure that safety is maintained and that any planned ventilation activities are supporting the overall incident plan, considering relevant factors including:

- Wind direction, strength
- Whether ventilation is appropriate and/or the correct ventilation tactics
- Whether effective communications are firmly established
- The need to withdraw firefighters whilst ventilation takes place
- Location of outlet vents – ideally downwind and at a high level

- Whether external covering jets are in place
- Whether an inlet vent is created and kept clear (ideally as soon as possible following creation of the outlet vent)
- The requirement to constantly monitor the effects of ventilation

Figure 10: Smoke curtain

Source: Building Research Establishment

Figure 11: Smoke and heat exhaust ventilation system

Source: Building Research Establishment

Post-fire considerations

Consider:

- Using ventilation post-fire to assist in clearing any smoke and other airborne particles as part of the salvage activities.

- Ensuring that bullseyes (hot spots) are identified and fully extinguished before the fire scene is handed over – turning over and damping down will assist in identifying such areas.
- Noting the movement of any items and passing details to a fire investigation officer if in attendance
- Advising the fire investigation officer or other agencies of any ventilation activities undertaken during firefighting operations, as this may have some relevance to the subsequent fire investigation in respect of fire development and post-fire indications

Strategic actions

Fire and rescue services should:

- Produce policy guidance for the operational use of offensive or defensive positive pressure ventilation for fires in buildings
- Develop tactical guidance and support arrangements on the hazards and actions to be taken for the ventilation of fire gases in buildings
- Provide crews with information, instruction and training in ventilation techniques and tactics

Tactical actions

Incident commanders should:

- Provide appropriate ventilation for any smoke and fire gases
- Consider using tactical ventilation to improve conditions and maintain access and egress routes
- Monitor the effect of the wind on fire, smoke and fire gases
- Consider the flow path of smoke and hot gases from controlled and uncontrolled ventilation
- Put covering jets in place prior to the creation of exhaust vents

Hazard – Smoke and fire gases

Hazard	**Control measures**
Smoke and fire gases	Avoid smoke plumes Consider employing tactical ventilation Wear personal protective equipment (PPE) Consider wearing respiratory protective equipment (RPE) Employ safe navigation techniques

Hazard knowledge

Smoke is generally a mixture of fine solid particles, droplets of water and other liquids, and gases given off by the materials involved in the fire. The most important toxic product in any fire is carbon monoxide, which is produced by all organic materials when they burn. However, tests have shown that a 'cocktail' of nearly a hundred gases can be detected by specialised equipment. In addition to producing smoke, fire can reduce oxygen levels, either by consuming the oxygen or by displacing it with other gases. Heat is also a respiratory hazard, as superheated gases burn the respiratory tract.

Smoke is made of:

- **Particles:** unburned, partially burned, and completely burned substances
- **Vapours:** fog-like droplets of liquid that can poison if inhaled or absorbed through the skin, such as benzene, formaldehyde and other volatile organic compounds
- **Toxic gases:** carbon monoxide (CO) can be deadly, even in small quantities. Hydrogen cyanide results from burning plastics and interferes with cellular respiration

Regulation 7(5) of the Control of Substances Hazardous to Health Regulations (COSHH) sets out clear requirements for the control of carcinogenic and mutagenic substances, including a requirement that exposure be reduced to as low as is reasonably practicable.

Working in smoke and darkness reduces visibility and the effectiveness of other sensory perceptions, making navigation difficult even in relatively simple environments. When committed to a building there is a strong possibility that firefighters will encounter conditions limiting visibility and affecting their key human senses. For example, when deployed to locate a fire internally in a structure, firefighters wearing breathing apparatus (BA) will often rely on touch and hearing as their primary senses; their sense of smell will be lost and their visual sense impaired when working in smoke and darkness.

Smoke, steam and fire gases can increase the distance electricity can jump and may result in arcing between sources, affecting firefighter safety.

See National Operational Guidance: Utilities and fuel

Control measure – Avoid smoke plumes

Control measure knowledge

Where possible, contact with smoke plumes should be avoided by selecting upwind approach routes and adopting defensive firefighting techniques. Avoiding contact with smoke and fire gases will reduce the need for respiratory protective equipment (RPE) and post-incident decontamination.

See National Operational Guidance: Environmental Protection – Smoke plumes

Strategic actions

Fire and rescue services should:

- Ensure that all crews are aware of the risk to health presented by working in smoke and fire gases

Tactical actions

Incident commanders should:

- Adopt an upwind approach to smoke plumes and fire gases, and to avoid where possible
- Consider the effects of wind on smoke and fire gases when positioning firefighting personnel and appliances
- Advise relevant agencies if a smoke plume presents a risk to the safety of the public

Control measure – Consider employing tactical ventilation

See Uncontrolled ventilation

Control measure – Wear personal protective equipment (PPE)

See Fire and thermal radiation

Control measure – Consider wearing respiratory protection equipment (RPE)

See Fire and thermal radiation

Control measure – Employ safe navigation techniques

Control measure knowledge

The presence of smoke and fire gases will reduce visibility and the effectiveness of sensory perception, which will complicate the process of navigation even in relatively simple environments. Teams deployed in breathing apparatus (BA) should adopt procedures as trained and maintain close contact between personnel. (See Breathing Apparatus Foundation – to be published). In large or complex structures, additional measures may need to be implemented to ensure that fire crews can safely navigate to and from the scene of operations and maintain safe access and egress at all times.

Strategic actions

Fire and rescue services should:

- Ensure all crews are trained in safe navigation techniques to be used in smoke and darkness

Tactical actions

Incident commanders should:

- Brief crews committed into the hazard area on the safe navigation techniques to be adopted

Hazard – Live utilities

Hazard	Control measures
Live utilities	Consider isolating utilities

Hazard knowledge

At operational incidents, live utility services present a number of significant hazards to firefighter safety and to the effective resolution of the incident. Gas, oil and solid fuels have the potential to accelerate the development of the fire, potentially suddenly and with little or no warning. Renewable energy generators can continue to supply live electricity after incoming mains supply has been isolated and therefore continue to present a risk of electrocution.

Utilities include:

- Electricity and renewable energy generation (such as solar, wind and water)
- Gas
- Water
- Domestic heating oil
- Solid fuel or biomass

See National Operational Guidance: Utilities and fuel

Identifying and isolating utilities should be made a priority to:

- Support firefighter safety
- Reduce further damage to the property
- Prevent the uncontrolled release of flammable or toxic gas
- Reduce the possibility of electrocution
- Reduce the possibility of further ignition sources and firespread

The location of utility points can vary enormously and should be ascertained by the incident commander or nominated safety officer at an early stage of the incident.

Significant hazards may exist where fire has started inside underground utility distribution ducting. Fire development and subsequent firespread can lead to pressurisation of the underground system, which can cause pavement level inspection covers to be blown off with an explosive effect. Additionally, fire can travel significant distances underground, spread to buildings and affect other utilities such as high-voltage electricity, gas and water. Underground cable fires can produce large volumes of carbon monoxide and other toxic gases which can travel to nearby premises.

Control measure – Consider isolating utilities

Control measure knowledge

The decision to isolate the utility should be balanced with the need for that utility, which may or may not assist firefighters. For example, isolating the electrical supply that fire-engineered solutions rely on, such as smoke extraction, may be a detrimental rather than a positive action.

It is an incident command decision whether or not to isolate the utilities in a building. This should be documented in the dynamic and analytical risk assessments, stating what has and has not been isolated. This should be kept as part of the incident risk assessment and decision-making log.

Strategic actions

Fire and rescue services should:

- Make appropriate arrangements with utility suppliers for representatives to attend at incidents
- Develop tactical guidance and support arrangements for the hazards that may be encountered and the actions to be taken to isolate utility supplies

Tactical actions

Incident commanders should:

- Identify any sources of renewable energy generation such as photovoltaic panels or wind power
- Isolate utilities that may affect fire development and secure them against reconnection
- Consider isolating the electricity supply to reduce the risk of electrocution
- Inform the National Inter-agency Liaison Officer (NILO), police and utility provider where illegal extraction of utilities is evident
- Establish an exclusion zone around inspection covers, where the fire involves underground services

Hazard – Fires involving flammables, explosives and combustible dusts

See National Operational Guidance: Physical Hazards for incidents involving substances that are likely to present a physical hazard when involved in a fire situation.

Hazard – Preventable damage

Hazard	**Control measures**
Preventable damage	Planning Use on-site salvage plans or expertise

	Tactical planning – Damage control Removal of valuables Protection of valuables Close doors Minimal use of firefighting media Mitigation

Hazard knowledge

Fire and rescue services are under legal, economic and moral obligation to take reasonable steps to limit damage, reduce losses and protect the environment as a result of their actions at fires and other incidents.

At certain premises they are likely to attend, such as heritage sites or important national infrastructure sites, the owners will view salvaging the contents as the highest priority, and far more important than extinguishing any fire.

The economic effect of fires on businesses can be catastrophic. The efforts of the attending fire and rescue service can make the difference between a company going out of business or continuing to trade. Successful damage prevention and mitigation will reduce the recovery phase following an incident.

In a domestic fire, personal items such as photographs will often be irreplaceable and of enormous value to the occupier even though they may have little or no financial value.

Damage can occur at locations remote from the main scene of operations and consideration should be given to water runoff and smoke travel.

Fire and rescue services should be mindful that damage control may be a high priority and should have the flexibility to divert appropriate resources from other operational priorities to address this.

Fire and rescue services should be aware of the potential conflict between mitigating damage caused by their actions against saving life and maintaining firefighter safety. Equally, at some incidents, the most effective action to limit damage will be to quickly extinguish the fire.

In most cases, damage control will take place at fires in buildings. However, there may be other incidents when fire and rescue services will be required to implement damage control plans. Indeed, current legislation relates specifically to road traffic collisions and other emergencies. For example, it might be appropriate to implement damage control at a Hazardous Materials incident involving a goods lorry by moving the contents of the trailer to a place of relative safety or containing spilled contents for subsequent recovery.

Preventing damage begins with planning, in particular at locations where both the fabric and contents of a building are irreplaceable. Once an incident has occurred, preventing and mitigating damage can take place at any stage, including occurring at the same time as firefighting operations.

Preventing damage and harm to the environment is addressed in National Operational Guidance: Environmental protection.

At the conclusion of an incident, fire and rescue services have an obligation to hand responsibility for a location or premises and any recovered or salvaged items to the responsible person or to ensure their security until they can be moved to a place of ultimate safety. Preventing and mitigating damage control will be best achieved if it is considered at the earliest stages of an incident, and its place in the overall plan for an incident is communicated to and understood by all.

Damage can be caused by:

- Direct fire damage
- Firefighting methods
- Firefighting media
- Smoke damage
- Collapsed structure
- Exposure of contents to elements
- Breaches of security
- Economic losses: buildings, vehicles, contents, etc.

It is also important to consider the impact of damage control actions on fire investigations.

Control measure – Planning

Control measure knowledge

At heritage sites or premises of national significance, where the fabric of the building or the contents are irreplaceable, preventing and mitigating damage will be greatly enhanced where appropriate emergency plans have been developed and are used. Individual emergency salvage plans will be different for each location but as a minimum they should contain the following:

- Plans of the premises
- Priority items and/or areas for damage control or salvage
- Level of support to be provided by on-site specialists and specialist or dedicated equipment

See National Operational Guidance: Operations – Risk Information gathering

Strategic actions

Fire and rescue services should:

- Liaise with developers, owners, occupiers and responsible persons of specifically identified buildings, premises and land to develop damage control tactical plans
- Record salvage plans as part of the Site-Specific Risk Information
- Consider training and exercising with on-site specialists
- Consider mobilising specialist crews and emergency vehicles on predetermined attendances

Control measure – Use on-site salvage plans or expertise

Control measure knowledge

For a salvage or disaster plan to be implemented, attending crews need to be aware of its existence. If a salvage plan exists, the attending crew should liaise and work closely with the responsible person, either on-site or remotely, to ensure that salvage or disaster plans are implemented appropriately.

If an incident commander considers an area too dangerous to allow non-fire and rescue service personnel to implement their salvage or disaster plans (for example in the presence of a developing fire or heavy smoke logging), they should deny them access to that area. They should consider recording the decision in the incident command log or analytical risk assessment and the reasons supporting it.

Strategic actions

Fire and rescue services should:

- Liaise with developers, owners, occupiers and responsible persons of specifically identified buildings, premises and land to make appropriate arrangements for access by the fire and rescue service to salvage plans and/or site expertise
- Consider systems such as mobile data terminals or hard copy documents to ensure that attending crews are aware of the presence of on-site salvage or disaster plans

Tactical actions

Incident commanders should:

- Use available on-site salvage plans and expertise to inform an incident damage control plan

Control measure – Tactical planning – Damage control

Control measure knowledge

At premises without salvage or disaster plans, or where these plans are not available, incident commanders should develop a damage control plan.

Damage control can be categorised into three phases of operations:

- Phase 1 includes work undertaken at the same time as firefighting. This is usually the most important phase if significant damage is to be prevented.
- Phase 2 is aimed at mitigating the damage that has already occurred and preventing further deterioration
- Phase 3 deals with preventing subsequent damage or losses including removing and temporarily storing items

Incident commanders are expected to consider each phase of operations when formulating the damage control plan and ensure that it is fully integrated with the overall incident plan.

There is no clear demarcation between each phase of operations. They will overlap as the incident progresses and consideration should be given to prioritising damage control, working away from the area of highest risk outwards to other areas. This may be across floors and could include adjoining property.

The effectiveness of damage control activities is directly proportionate to the following:

- The speed and skill with which they are carried out. Incident commanders should aim to resource and implement damage control plans at the earliest opportunity.
- The implementation of safe systems of work. All staff involved in damage control should be aware of the hazards, should be fully briefed on how conditions may change and appreciate how their work fits in with the overall plan to resolve the incident.
- Effective communication. Incident commanders should be aware of the actions of damage control crews and these crews should be aware of the impact of their actions on the successful resolution of the overall incident.

Strategic actions

Fire and rescue services should:

- Develop tactical planning arrangements that incident commanders can adopt to limit damage during any fire incident
- Develop tactical guidance and support arrangements for the hazards that may be encountered and the actions to be taken when implementing a damage control strategy

Tactical actions

Incident commanders should:

- Implement a damage control plan where no on-site pre-planning is available
- Consider implementing a functional damage control sector at complex, large incidents

Control measure – Removal of valuables

Control measure knowledge

When valuable items, artefacts or stock are removed from a hazard zone and secured safely, it is important that they are subsequently not lost, damaged or stolen. Consideration should be given to the time of year and prevailing weather conditions.

See National Operational Guidance: Operations - Closing stages

Strategic actions

Fire and rescue services should:

- Develop tactical guidance and support arrangements for the actions to take and associated hazards when removing valuables from risk areas

Tactical actions

Incident commanders should:

- Move valuable items to an appropriate place of safety in liaison with the responsible person
- Consider completing an inventory of all items removed to a safe location
- Hand over responsibility for scene security, and the items removed, to the responsible person or the police

Control measure – Protection of valuables

Control measure knowledge

Where it is not possible to remove valuables because of their size, weight or quantity, damage can be prevented and reduced by lifting, moving, raising or covering items.

Sheeting can be used to protect from water and dirt damage. Where more than one sheet is used, they should be overlapped in such a way as to allow water and debris to run off. Care should be taken when removing sheeting so as not to damage valuables underneath. Sheets should be folded inwards and water and debris carefully disposed of outside the premises.

Where valuables sit directly on the floor, lift them onto blocks or place sheeting to minimise damage from water runoff. Where carpets or floor coverings cannot be rolled up and removed, cover them with sheeting to minimise damage caused by the movement of personnel and equipment

Strategic actions

Fire and rescue services should:

- Develop tactical guidance and support arrangements for the actions to take and associated hazards when protecting valuables in at risk areas

Tactical actions

Incident commanders should:

- Move, cover or raise valuable items to protect from damage

Control measure – Close doors

Control measure knowledge

Smoke travelling through a building can cause significant damage to property. Closing doors can slow the movement of smoke throughout a site and reduce associated damage. Progress of firefighting personnel in a building can have a significant impact on smoke and fire spread.

For further information, see National Operational Guidance: Fires in the built environment - Consider employing tactical ventilation strategy.

Strategic actions

Fire and rescue services should:

- Develop tactical guidance and support arrangements for the actions to take and associated hazards when considering the need to minimise air flow, fire development and smoke travel by the closing of doors

Tactical actions

Incident commanders should:

- Close doors to prevent smoke and fire gas travel whilst maintaining access, egress and ventilation
- Consider leaving unopened doors closed to prevent the unnecessary spread of smoke and fire gas

Control measure – Minimal use of firefighting media

Control measure knowledge

Incident commanders should understand the importance of balancing the competing needs of providing a sufficient weight of intervention to extinguish a fire against the damage that could be caused by firefighting water runoff. The aim should be to use the minimum amount of extinguishing media required to extinguish the fire without compromising firefighter safety.

Water is very heavy – 1,000 litres or one cubic metre weighs one tonne. The weight of this can have a significant impact on the stability of any structure, building or vessel. For example:

- Where a roof is involved in fire and the roof timbers burn through to the degree where they cannot support the weight of the roof covering, the roof will collapse to the floor below and the weight of the roof structure and firefighting water will impose a load that may be too heavy for the floor to support and cause further collapse. See National Operational Guidance: Fires in the built environment – partial and structural collapse.
- If water is lying on a lath and plaster or boarded ceiling it can put a strain on the fixings of the laths to the joists and the keying of the plaster to the laths
- In churches and cathedrals, fan-vaulted ceilings have conoids in the roof spaces, which can fill with water and fail catastrophically. Some cathedrals have a weak panel fitted that will fail when water fills the conoid to avoid collapse, but this is not a commonplace feature, so care should be taken to avoid filling them with water.

See National Operational Guidance: Transport - Stability of the vessel

Strategic actions

Fire and rescue services should:

- Liaise and make appropriate arrangements with owners, occupiers and responsible persons to provide appropriate systems and processes that enable personnel to take appropriate steps to minimise damage and work safely whilst firefighting
- Develop tactical guidance and support arrangements for the actions to take and associated hazards regarding the minimal use of firefighting media

Tactical actions

Incident commanders should:

- Use the minimum extinguishing media required, considering the appropriate weight of intervention

Control measure – Mitigation

Control measure knowledge

At every incident, there is a risk that the actions taken by fire and rescue services to resolve the incident may cause loss and damage that exceeds the loss or damage caused by the original emergency. Fire rescue services have a legal responsibility to take reasonable steps to limit and reduce losses as a result of their actions. Incident commanders should balance the competing demands of preventing and mitigating damage against the need to save lives and maintain crew safety.

Operational tactics that might be employed to limit the damage caused by firefighting media include:

- Diverting or channelling water runoff; this can be improvised by rolling salvage sheets to create a trough
- Damming doorways to prevent water runoff entering unaffected rooms or parts of a premises
- Running hose up the outside of the building
- Inspecting dry rising mains leaks
- Replacing burst lengths of hose as quickly as possible
- Isolating sprinklers; this should be balanced against the need to ensure that a fire is appropriately contained and will not redevelop
- Using sheeting to protect contents from the elements and any firefighting water run-off, i.e. contaminated water

Strategic actions

Fire and rescue services should:

- Assist owners, occupiers and responsible persons in developing plans to limit damage to property

- Develop tactical guidance and support arrangements for the actions to take and associated hazards regarding mitigation of damage due to firefighting actions, tactics and activities

Tactical actions

Incident commanders should:

- Employ measures to limit any preventable damage caused by firefighting operations
- Consider adjoining areas when mitigating damage due to fire, smoke and extinguishing media

Hazard – Failure to conduct fire investigation

Hazard	**Control measures**
Failure to conduct fire investigation	Secure the scene Preserve evidence Undertake the appropriate level of investigation Establish cause Liaise with and hand over to other statutory bodies Consider using closed-circuit television (CCTV) Cutting away Consider using thermal imaging or scanning Personal protective equipment (PPE) Consider wearing respiratory protection equipment (RPE) Writing reports for fire investigations Attendance at coroner’s court (or equivalent) Highlight trends Support future learning Identify failures in fire safety measures

Hazard knowledge

Conducting an investigation should always be at the forefront of an incident commander’s mind, both during the dynamic phases of an incident and during the post-incident activity.

It is important that firefighters have a basic knowledge and understanding of the need to preserve any evidence at a fire scene as far as reasonably possible, particularly where they have any early suspicions as to the cause of the fire during the course of their duties extinguishing the fire. It is therefore important that they have a fundamental awareness of the powers available to them to support their role in the investigative process.

UK legislation affords authorised firefighters the power to enter premises for the purpose of investigating the cause and development of a fire and, where necessary, to seize and remove material.

Incident commanders should have a basic understanding of the need to investigate and understand the causes of fire and the behaviour of people, buildings and materials, and how this can inform future learning and in developing fire and rescue service policies and campaigns to reduce risk to firefighters and the community.

Fire scene investigation is a complex and specialist area of a fire and rescue service's work. However, it is the responsibility of all responders to support the investigative process and understand the main reasons for fire investigation:

- To contribute to national statistics through accurate reporting on the Incident Recording System (IRS)
- To help to prevent similar fires from occurring through identifying fire trends
- To enable better targeting of enforcement and advisory fire safety resources through understanding the effects of fire on buildings
- To assist with advising and educating both junior and juvenile fire setters
- To assist in the prosecution of offenders
- To assist the coroners' courts
- To assess the effect of fire on fixed firefighting and detection systems in buildings and its effect on other building services
- To assess the effect of fire and rescue service intervention

To ensure that the correct level of investigation is instigated or undertaken by the appropriate person, firefighters understand that there are different levels of fire investigation and know who would generally carry out each of them.

Every fire investigation should be carried out with five fundamental objectives in mind:

- If the fire is due to some dangerous industrial process or operation, to allow the fire authority to provide advice on safety measures to prevent re-occurrence and support potential legal action
- If due to faulty storage, carelessness, neglect or a design fault, to bring the cause to light, thus avoiding the possibility of a re-occurrence and supporting potential legal action
- If the fire has been deliberately started, to identify physical and/or interpretative material, advise the police accordingly and produce reports for police and criminal justice procedures
- To collect statistics on all manner of causes, to provide information
- To assist in completing fire research reports where a death has occurred due to fire

When undertaking fire investigation, it is the responsibility of the fire investigator to ensure that the investigative process follows a logical framework and that all fire investigations are approached without presumption of the origin, cause or responsibility for the incident until the scientific method has yielded a provable hypothesis.

This is achieved by following a series of logical steps:

- Step one: recognises that a problem exists in the case of fire investigation where a fire or explosion has occurred
- Step two: defines the problem, which involves identifying the cause of the fire or explosion
- Step three: the scene is examined and facts are collected; this will require collecting data and gathering information from witnesses
- Step four: the data is analysed; this analysis is based on the knowledge, training and experience of the investigator and if the investigating officer lacks the necessary skills or training they must seek assistance
- Step five: the investigator produces a hypothesis or hypotheses based on an analysis of the data
- Step six: the investigator tests the hypothesis to ensure it can withstand examination, possibly in a court of law
- Step seven: the investigator selects a final hypothesis

For effective and methodical data gathering, consider using a log book, which could take the form of a contemporaneous notebook that the fire investigator can refer to when providing evidence in a court of law.

During the investigation the investigator should consider an individual's right to confidentiality, understand the needs of individuals including their culture, religious beliefs, ethnic origin, sexuality, disability or lifestyle, have regard to vulnerable adults and children, and have respect for the professional ethics of others. This is particularly important when working as part of a multi-agency investigation.

Investigating a fire scene is inherently dangerous. Every person involved in the activity should aim to minimise the risk involved while performing as full an investigation as possible. Even post-fire, incident commanders should consider the following factors to minimise risk:

- Identify the hazards, and assess and record the risks at the scene and establish the appropriate control measures (including personal protective equipment (PPE) and respiratory protective equipment (RPE))
- Identify the type, location, extent and circumstances of the incident; identify and evaluate available information
- Identify which specialists and other agencies need to be involved

To aid this process, a risk assessment must be carried out by the investigating officer at all fire investigations

Control measure – Secure the scene

Control measure knowledge

Best practice in multi-agency working strongly advocates joint operational considerations to achieve a common outcome. The security of the fire scene and preserving evidence in it are of concern to both the fire and rescue service and the police. This is especially the case in relation to preserving physical evidence from the actions and tactics of fire and rescue service personnel at the scene.

Additional considerations:

- Physical evidence including glass broken before the fire, papers and/or flammable material piled in the scene, petrol cans or other containers with strong odours
- Sources of information, which may include:
    - CCTV on the emergency fire vehicles
    - Local CCTV
    - Fire/burglar alarm systems at the scene, including any remote, offsite recording systems
    - Mobile phone recordings made by eye witnesses (video or conversations), potentially downloaded to local news sites or social media feeds

Incident commanders should achieve scene security and evidence preservation by establishing and maintaining the use of an incident control system:

Confirm	• Use contemporaneous notes – decision logs that note command decisions and plans for preserving/securing evidence at the scene Confirm: • All factual information relating to the incident • Whether or not life has been confirmed extinct if there is a deceased person at the scene • Age, gender, name and contact details of the deceased, victims, witnesses and agencies (utilities, etc.) in attendance • Information recorded by the entry control operative, if required • Entry route and tactical methods used to effect entry • Doors and windows open or broken at the time of the incident • Emergency fire vehicle call signs – helping to establish whose CCTV was best placed to record the incident
Cordon	• The aim of a cordon is to keep the public out and maintain control within the cordon • A cordon should start as large as is physically possible until such time as resources can be released from a scene and the cordon reduced

	• Physical evidence may be present within the cordon; the police crime scene investigators will search within the cordon to ensure that any potential evidence is recovered • Other agencies may wish the cordon to be of a specific configuration; incident commanders should liaise with them on the cordon
Secure	• Only authorised personnel should enter the scene • A clear common approach path must be used for all authorised personnel to protect physical evidence and prevent cross-contamination at the scene
Control	• Windows and apertures that provide a vantage point to see into the scene should be covered where possible to prevent direct observation • Physical evidence noted on arrival (broken window or remains of a petrol bomb, etc.) should be documented and the police informed • Incident commanders should ensure that crews are aware that statements may be required • Requests to allow occupiers or others to enter a property should be considered carefully if there are any doubts about the cause. If allowed, the person must be accompanied and supervised and the actions/people/locations recorded. • The decision to leave identified physical evidence at the scene should be carefully considered. If it is essential to move anything, a record should be kept with reasons/implications explained. Care is needed where insurance claims will be made as the property may transfer ownership to the insurance company.

Strategic actions

Fire and rescue services should:

- Consult with other emergency services and partner agencies, develop tactical guidance and support arrangements for the actions to take on securing a scene for investigative purposes

Tactical actions

The incident commander should:

- Secure the scene to ensure evidence is preserved post-incident
- Hand over responsibility for scene security and removed items to the responsible person
- Consider moving physical evidence to a safe place, away from the effects of the fire or firefighting
- Delegate to, or consult with, a police crime scene investigator or fire investigator responsible for collecting physical evidence

- Make a note of any issues relating to the cordon or physical evidence in the decision log for incident command and future investigation purposes

Control measure – Preserve evidence

Control measure knowledge

By its very nature fire can destroy or significantly alter structures, vehicles and objects. Fire is sometimes used specifically and criminally for the purpose of destroying forensic evidence.

With every passing minute, key evidence may be lost before the fire and rescue service arrives. On arrival at the scene, it is therefore important that incident commanders and firefighters consider their firefighting tactics and actions to ensure, wherever possible, that evidence is protected and preserved and the scene is not contaminated by the activities of the responding crews.

Evidence can take many forms, from broken glass at the point of entry to twisted or scrunched paper used as an initiating fuel or fingerprints left on items damaged at, or brought into, a fire scene.

In some instances, fire may be used to destroy vehicles, machinery, documentation or stock in commercial premises. The way in which the fire was started or the presence of multiple seats of fire can be seen as potential evidence.

Even in cases where there is no suggestion of arson, it may be necessary to investigate the cause of the fire for public fire protection reasons. In the same manner as at an arson scene, it is important that the accident scenes are preserved as completely as possible.

Once in attendance, the fire and rescue service can ensure that as much evidence as possible is preserved by identifying potential evidence and taking steps to preserve or retrieve it where there is potential for it to be lost during the course of the fire and operations.

Preserving evidence through the positioning and choice of cordons, access routes, firefighting media, equipment and tactics employed should be considered at the earliest stage. For example, it may be possible to avoid entering a building through a route where there are signs of forced entry that has not been accounted for.

Specific techniques, such as tactical ventilation or using cutting extinguisher systems, should also be assessed for their impact on evidence before use. Where it is not possible to avoid damaging evidence, it is good practice to record as much as possible beforehand and to note the subsequent effect of equipment or tactics.

Any forensic precautions adopted, and the requirement to save evidence that would otherwise be lost to the fire, should be communicated very clearly to the attending crews.

The police crime scene investigators and fire investigators can provide scene preservation advice at the scene or by telephone.

Consideration should also be given to avoiding contamination of the scene by personnel or by introducing materials that may be identified as potential evidence by others, such as:

- Personal protective equipment (PPE), gloves, cigarettes, drink bottles and other consumables used by fire and rescue service personnel should not be dropped at the scene or in the cordon area. These materials are called contamination transfer and may indicate poor scene management procedures.

- Particular care is needed when using petrol and other flammable liquids. There is a potential for contamination transfer between different incidents or areas of the same incident (for example through residues on boots) or through direct contamination when refuelling generators, etc.
- If the attending crews have attended a road traffic collision immediately before a suspect fire scene, ignitable liquids (petrol or diesel) may have contaminated boots or firefighting PPE, which could be transferred into the fire scene later

Any contaminated transfer creates false evidence that could waste significant time and resources to identify, recover and process forensically during the key phase of an investigation.

DNA evidence is robust and can withstand heat, soot contamination and water. However, in many cases, it may not be immediately apparent where the DNA evidence has come from.

Any blood injuries to an authorised person that occur within the inner cordon (not only the scene) should be noted and brought to the attention of the relevant agency, particularly in a police-led investigation.

Fingerprints can withstand the effects of indirect heat and water contamination; fingerprints will remain on objects such as bottles, containers and papers even when covered with soot. Authorised personnel entering the fire scene should therefore avoid touching or moving items with bare hands. Items should not be moved or handled until a police crime scene investigator or fire investigator has assessed these items in situ.

Damping down operations can damage potential evidence at a fire scene. Therefore, damping down operations should be managed and controlled to address hot spots using the least physically intrusive methods possible to cool specific areas. For example, a hose reel, with the branch set to spray, using the lowest pressure possible, should be used to gently cool the targeted hot spot.

Strategic actions

Fire and rescue services should:

- Develop tactical guidance and support arrangements for the actions to take to preserve evidence at the scene of an incident, in consultation with partner emergency services and agencies

Tactical actions

Incident commanders should:

- Consider the preservation of evidence when developing incident plan and selecting tactics
- Incorporate a forensic evidence plan with the incident log, noting points that raise suspicion (e.g. broken windows or doors, trails of papers, fuel cans or containers out of context)
- Make crews aware of known or likely areas of interest and outline measures taken or required to minimise further loss

- Ensure any dials, valves and controls are, where possible, left as found and their relevant positions noted
- Isolate utilities externally wherever possible
- Manage the use of any ignitable liquids used in the inner cordon and at the fire scene
- Record tactics used and ensure that tools used are available for forensic inspection
- Minimise cross-contamination from previous incidents or between areas of incident.
- Notify police crime scene investigators or fire investigators if crews have recently attended other incidents (e.g. road traffic collision)
- Ensure that all authorised personnel entering the scene wear gloves
- Ensure that any blood injuries are recorded and reported to eliminate potential DNA cross-contamination

Control measure – Undertake the appropriate level of investigation

Control measure knowledge

The range of incidents attended by fire and rescue services is diverse in nature and extent. An assessment of the incident dictates the nature of response deployed to bring it to a safe conclusion, either at the time of call (by reference to predetermined attendances) or through specific requests made from the fireground.

In a similar way, the scenes encountered by post-fire investigators range in their size and complexity and a 'one size fits all' approach will not be sufficient.

This requires a means for fire and rescue services to plan for, and respond to, a wide range of investigation scenes.

Levels of fire investigation

There are three levels of investigation:

- Level one: basic fire investigations
- Level two: intermediate fire and explosion (non-terrorist) investigations
- Level three: advanced fire and explosion (including terrorist) investigations

Level one: basic fire investigations

This category refers to what is considered typical fire investigation, generally carried out for completing the Incident Recording System (IRS). In the absence of any earlier indicators, it is also a chance to assess the fire for suspicious or unusual features that may be of interest to other agencies, or offer chances for future learning. This will usually be completed by the attending incident commander and not require the use of specialist fire investigation knowledge or equipment.

Level two: intermediate fire and explosion (non-terrorist) investigations

In general terms, this is an investigation that requires a greater degree of knowledge or control than level one, but that can be managed by use of internal resources. Typically, these investigations will be carried out by a specialist fire investigation team comprising experienced fire officers from the local fire and rescue service.

Level three: advanced fire and explosion (including terrorist) investigations.

In broad terms, due to its complexity or seriousness, this investigation requires the involvement of additional resources, either of a specialist nature (forensic scientist or product specialist) or of a neutral party to oversee or carry out the investigation (for example where there may be a claim or criticism of the host service). At level three, there will almost always be a multi-agency investigation, which will usually involve specialist fire investigation team members.

Most fire and rescue services have two types of investigators; operational crews and a specialist fire investigation team (either full-time or as a bolt-on role for officers in the flexible duty system). The latter work on both level two and level three scenes and will act in accordance with their organisational remit and personal competence.

Other considerations

As well as identifying the level, there will be other areas to consider in how to approach an investigation, including the interest, powers and role of other agencies.

Powers of entry

UK legislation grants powers to investigate fires. Knowledge of the systems to use the powers available in the Act, and how to adopt them, are beneficial in ensuring clarity and legitimacy.

Strategic actions

Fire and rescue services should:

- Develop tactical guidance and support arrangements for the actions to take in carrying out fire investigation, in consultation with partner emergency services and agencies,
- Develop systems and processes to enable sharing relevant information related to the occurrence of fires of special interest

Tactical actions

Incident commanders should:

- Undertake a fire investigation at a level appropriate to the circumstances of the incident
- Record statements from relevant people as soon as practicable to assist the investigation process
- Recognise the need for, and adopt a structured approach to, managing the differing complexities and requirements in conducting fire investigations
- Recognise other considerations that may influence the resourcing of an investigation
- Adopt arrangements to ensure that the expectations of UK legislation for fire investigation are met
- Have arrangements to ensure compliance with the powers of entry granted by UK legislation

- Ensure that personnel recognise their organisational remit and personal competence and do not exceed them
- Ensure that statements from relevant people are recorded as soon as practicable to assist in the investigation process

Control measure – Establish cause

Control measure knowledge

Once a fire has been extinguished, identifying the cause will need to be considered. Ideally, it would be possible to reliably identify the exact cause for each fire attended. However, by its very nature, a fire scene is one in which valuable evidence can easily and quickly be lost to the effects of the fire or firefighting operations. As a result, there will be times when the cause can be confidently established, others where it is possible to identify a limited number of possible causes, and other situations where no reliable assessment can be made because of the degree of damage or the inability to enter unsafe premises.

The cause should be considered as a combination of circumstances that result in the fire. Establishing the cause will include looking for potential ignition sources, a means that would explain how the fire started and developed, and any acts or omissions that may have contributed to this. The evidence should demonstrate that all the ingredients were present and an explanation offered for how they relate to each other. For example, the presence of an ignition source such as matches is not proof they were responsible for a fire.

Initial assessment

Before any activity begins, an early assessment is essential to consider the level of investigation required and the associated level of proof needed to establish the cause. In addition, thought should be given to who else may have an interest and who has primacy for the scene. Where there are indications that a fire is suspicious at the start of the investigation, or at any point during the investigation, this information should be passed to the police and the appropriate processes followed.

Scientific method

Using the scientific method is generally recommended as the approach to investigating the cause of a fire. With this method, the investigation findings can be presented logically and objectively, including stating any gaps or uncertainty in the evidence. This is described in various ways but the core elements are:

- Observing an event, for example, the fire scene
- Defining the problem – the cause of the fire
- Collecting data and evidence – physical and verbal
- Formulating a hypothesis – what does the evidence suggest to be the most likely cause of the fire, including ignition source, materials involved and any human factors?
- Testing the hypothesis and revising if necessary – is the evidence available all consistent with the hypothesis and does it allow other possible causes to be discounted?

- Selecting a final hypothesis – set out the believed cause and supporting evidence, and any limitations or inconsistencies

This is a scalable approach and the amount of time and resources committed to an individual incident will be in line with the expected purpose of the investigation of the cause.

Standard of proof

For most incidents where the only requirement is to complete the Incident Recording System (IRS), it is sufficient for the 'most likely' cause to be assessed. This will not usually require detailed notes or supporting evidence to be collated, although it may be good practice to do so. It should be noted that while the IRS does not explicitly require more than an assessment of the cause, there is benefit in achieving the greatest degree of confidence possible about the cause of all fires, as the subsequent data will directly inform service activity through analysis and intelligence work. As such, consideration should be given to ensuring clear guidance on the expectations of crews and the standard of origin and cause investigation required to support the ability of the fire and rescue service to target resources effectively.

Where the cause of a fire is being sought as part of a formal investigation or another agency's investigation, the standard of proof required should be confirmed at the outset. Most commonly, this is where the evidence must be beyond reasonable doubt, as employed in criminal cases and some coroners' inquests, or based on the balance of probability (more likely to be true than not) for civil cases and most coroners' inquests.

Locating the origin of the fire

The first requirement in establishing the cause will usually be to identify an area of interest (or radius of error as it is sometimes known) that is believed to contain the origin of the fire. The area of interest will be larger than the believed actual point of origin, to allow for the discovery of associated evidence and, as its name suggests, some scope for error in the initial assessment.

In most cases, the affected area of fire damage is relatively small and so the possible seat of the fire may be fairly obvious and localised. However, where the fire has affected a greater area, a logical method should be adopted to assist in narrowing down the scene to a specific area of interest. For example, the initial assessment might involve a walk around the scene to observe the damage.

This stage should not involve the disturbance of material. Generally, the process adopted will be to conduct an external and then internal viewing, noting the effects of the fire or other salient features such as signs of forced entry or possible evidence. This can also be a good opportunity to formulate a risk assessment.

Considerations for establishing an area of interest

There are a number of ways in which the investigator can identify the area of interest. These should be used to provide information that is consistent in identifying where the fire started and how it spread. If not, the evidence may have been moved at some point during the fire or firefighting, or it may have been misinterpreted. Either way, an explanation should be sought for any inconsistency or a different hypothesis considered.

'Post-fire indicators' is the general term used to describe the different clues or effects the fire leaves behind on a structure or contents within. This can relate to damage caused by direct burning (flame) heat, smoke or a combination of these. These clues can help the investigator identify the potential origin of the fire, its development and the location of items at the scene.

Another approach is to identify the lowest and most severe area of burning as this will typically indicate the point of origin. However, this will not always be the case and the context of the fire should be considered. For example, one area may have burnt for longer because crews were unable to reach and extinguish it, or there was a higher fuel loading in one location or liquid or dropping material/embers may have spread the fire to a lower level.

Witness evidence can also be helpful in confirming the origin (and cause) of a fire but the investigator should always ensure that the physical evidence matches the verbal information as it is sometimes possible for witnesses to be deliberately or unintentionally misleading.

When assessing the post-fire indicators, time should be taken to ensure any activity that might have affected the scene before the investigation is known. This can include actions by members of the public, the fire and rescue service and other first responders. The choice and application of various firefighting techniques may also influence or alter the expected post-fire indicators.

Excavating the area of interest

Once the area of interest has been established, the next step is to try to identify the cause of the fire. This should include identifying any potential sources of ignition, the materials or means by which a fire took hold and developed, and the mechanism by which it happened.

Excavating an area can be a time-consuming process and the degree of care needed will need to be assessed with reference to the level of proof required, the resources available and the type of evidence being sought. For example, retrieving small or fragile items intact will require greater care in excavation than a large, solid item. The way in which items are handled, retrieved and preserved will also be determined by the nature of the investigation.

It is important to be aware of items that are unusual or out of context (for example, a can of petrol may be expected in a shed but is less likely in a lounge). What is not present can also sometimes be of value and should be noted.

There are a number of readily available lists of typical causes of fire but the investigator must always follow the evidence and be mindful that new types of fire are regularly found and that knowledge of fire constantly changes and expands.

Checking the hypothesis

Once all the evidence has been identified and recorded (if appropriate), the investigator should review it to ensure it is consistent with the identified cause. If not, the information should be checked and further investigation undertaken or a new hypothesis developed, as necessary.

One way to check the physical evidence is by recreating the scene. This can be useful for larger fires. It allows the room to be cleared of all items, and then the major or important items put back in the location in which they were believed to have been during the fire. From this the investigator can check the post-fire indicators against the structure, that moveable items correlate, and that the fire development can be explained by the evidence.

Resources and tools

There are a number of resources and tools that the investigator may find of use. These include using dogs or bespoke equipment that can help to indicate the presence of possible accelerants.

In addition, a range of small tools and personal protective equipment (PPE) will be required and, for larger incidents, specialist access, lighting and other equipment may also be necessary.

Reference sources

A range of good reference sources is available to those required to establish the cause of a fire. These include specialist fire investigation publications covering peer-reviewed books and articles, online sources and communities.

It is also useful to stay up- to-date with related areas such as new products, construction materials/designs and human behaviour, and to understand how these could lead to fires.

Strategic actions

Fire and rescue services should:

- Develop tactical guidance and support arrangements for the actions to take to establish the cause of fire, in consultation with partner emergency services and agencies
- Ensure that personnel have an understanding of relevant legal issues
- Ensure that investigators have a good knowledge of fire science and keep up-to-date with developments in buildings, products and human behaviour that may influence the ways in which fires are caused or develop
- Ensure that those responsible for carrying out investigations are familiar with the scientific method and with different standards of evidence, and are able to use them appropriately based on the nature of the investigation

Tactical actions

Incident commanders should:

- Use appropriate post-incident investigation techniques to establish the cause of the fire
- Ensure that good scene and evidence control and preservation practices are adopted at all stages of an incident
- Ensure that appropriate techniques are adopted to identify the area of origin and investigate possible causes

Control measure – Liaise with and hand over to other statutory bodies

Control measure knowledge

The investigation of a fire can involve a wide range of people or organisations, including those with a statutory duty.

Statutory bodies are organisations set up by the government to consider evidence and make judgments in a relevant field of activity. For fires, the police and the Health and Safety Executive

(HSE) may be those most commonly encountered and both of these may pursue criminal prosecutions based on their findings. Other agencies such as the Rail Accident Investigation Branch (RAIB), Marine Accident Investigation Branch (MAIB) or Air Accidents Investigation Branch (AAIB) may be less frequently involved and undertake investigations where the aim is to learn lessons and not to apportion blame.

During the course of an incident, it may be necessary for the fire and rescue service to liaise with other agencies and hand over responsibility for the fire scene and/or investigation (see JESIP). To achieve this successfully will require pre-planning and good scene and/or investigation management practices.

While many of the organisations involved in a fire investigation will be interested in the origin and cause of a fire, this will not always be the case. The type of information they wish to collect and how they wish to use it will vary significantly. Knowledge of this is helpful to fire and rescues services and the individual investigators.

The police

The police are responsible for investigating suspected crimes, which includes activity related to fires believed to be suspicious or deliberate. Identifying the cause of the fire will usually be a necessary and important part of their investigation but their primary aim will then be to identify those responsible for the offence(s).

There is a longstanding difference between the number of deliberate fires recorded by fire and rescue services and the number of arsons recorded by the police.

It would be unreasonable for the police to attend every deliberate fire or incident where an accidental cause cannot be established. As such, it is sensible to consider a structured agreement between fire and rescue services and the police, and sometimes the Crown Prosecution Service. This type of agreement is known as a memorandum of understanding (MoU). This sets out strategic aims and interests and may also include a service level agreement outlining different incident types and how they will be investigated. This can range from immediate joint responses to a fatal fire through to using analytical approaches to identify trends of small fires that would not normally warrant a scene attendance.

A second tier of decision-making will also often take place at the scene, where an appraisal may be made of scene safety, resources required and the likelihood of securing sufficient evidence before committing to an investigation of the scene.

The police have an additional role as the investigative body for the coroner or procurator fiscal all fire-related fatalities will fall within the coroner's or procurator fiscal's remit.

Health and Safety Executive (HSE)

The Health and Safety Executive (HSE) is the national independent watchdog for work-related health, safety and illness. The organisation is an independent regulator acting in the public interest to reduce work-related death and serious injury in all UK workplaces.

The fire investigator is most likely to encounter the HSE where they have an interest in a fire related to a potential breach of health and safety requirements in a workplace at a fire attended by fire and rescue services.

Investigating a fire and rescue service

In rare cases the police and/or Health and Safety Executive (HSE) may be required to investigate the actions of a fire and rescue service itself, after the fire and rescue service has attended an incident. Whether or not the fire and rescue service under investigation is required to assist with fire investigation will depend on the nature of the enquiries.

However, it may be prudent to anticipate this and ensure that arrangements exist where independent fire investigators (whether appointed by the fire and rescue service or by the police or HSE) can be requested and given access to the facilities they require. This may also be useful where there is the potential for a conflict of interest (real or perceived) to exist if the service investigated the fire, for example, a re-ignition.

Multi-agency investigations

Certain investigations may require a number of agencies to work together for all or part of it. Where possible, a lead agency will have overall responsibility, although this may not always be straightforward as roles may change during different phases of the investigation.

Time should be taken at the start to ensure a clear appreciation of each agency's role, legal powers and duties, resource commitment and what they are seeking to prove or disprove. Arrangements for areas such as information sharing, administration, media briefings, team updates and so on can also be agreed at this stage. In certain cases it may be necessary to draw up formal written memoranda of understanding (MoUs) for an individual fire investigation to ensure clarity and agreement on the key areas.

As well as organisational interests, it is important to establish the competencies/areas of specialist knowledge of the individual personnel forming part of the team and the role they will play in the investigation.

Other agencies may also be involved for a limited time to perform specific tasks without being part of the investigation. The nature of their involvement, details of personnel and any impact on evidential material should be recorded.

Powers of entry in relation to working with the police

Where fire and rescue services are requested to provide assistance to the police in investigating a fire scene, there should be clear local guidance and procedures for arrangements regarding powers of entry.

Handover arrangements

The handover phase of an investigation may take place directly at the scene or at a later stage, once all the scene work has been completed.

The requirements for handing over a scene will be influenced significantly by the type of investigation to be conducted. Where a statutory body is taking over, an appropriate level of formality should be employed and all reasonable efforts taken to avoid any breaks in maintaining the security of the scene as this could compromise the use of any evidence recovered after the initial period to be used.

For non-statutory agencies, local protocols or an assessment of each incident on its own merits will determine the extent to which the fire and rescue service can assist with an on-site handover or maintenance of scene security. Most commonly, this category includes investigators employed by, or acting on behalf of, insurers.

When the party taking over the scene does not have a statutory role, the fire and rescue service should be able to satisfy itself that it is the appropriate body or person to take responsibility for the scene.

The physical transfer of the scene between agencies, notably at the conclusion of fire and rescue service operations, is an important stage. It is very easy for scene management practices to be reduced or lapse during the transition. The fire and rescue service may be keen to remove any equipment still deployed and have a last walk round the scene. The organisation taking over may want to view the scene, either escorted by the fire and rescue service or not. Good cordon and scene management will limit the potential for valuable evidence to be lost or compromised.

The nature of a handover will be influenced by the fire scene or the nature of the investigation and may range from a formal and documented handover to a verbal briefing.

Consideration should be given to providing information on the incident history (the fire and actions of the fire and rescue service, members of the public or other first responders), facts relevant to the investigation (methodology and actions taken so far), safety issues (possibly including risk assessment findings) and other issues that may have had an impact on the scene or be of relevance to the investigation (e.g. witness details).

For formal handovers, it may be useful to record the names and signatures of the responsible individuals from each agency.

It is important to remember that, where a scene is handed back to the owner or occupier, some of these considerations on providing information should be observed.

Handing over the scene or investigation may not be the end of fire and rescue service involvement and the fire and rescue service may continue to play a supporting role. In this case, fire and rescue service personnel should make themselves familiar with the working protocols of the lead agency.

Liaison

Scene-based liaison will often tie in to existing local protocols and incident management systems, particularly with statutory partners who will be familiar with this type of working.

Maintaining liaison away from the scene can be more difficult and the principle of providing single or named points of contact can ensure efficient and appropriate practices. This can be particularly important when managing the exchange or submission of documents, other evidence or where interviews may be requested. Too many informal contacts can compromise the organisations or evidence and result in no one having a full knowledge of the investigation.

Where the details of other parties are not known at the time, it can be useful to have a general contact point for initial enquires that can be readily accessed, for example, through the fire and rescue service website.

In all cases, a managed approach to liaison can ensure that the investigation is progressed effectively; each agency can track their involvement and actions, with decisions set out and explained at a later stage if required.

Consideration should be given to having clear protocols for formal and informal liaison processes. Informal processes are particularly open to misinterpretation, where one party may feel they had an 'off the record' conversation only for it to be used subsequently and attributed to them as evidential material.

Record keeping

Good record keeping is important in any investigation.

Decision logs can also be used to maintain a record of the decisions taken and the rationale for them. Recording not only the evidential material but also the process followed can be very important for formal investigations. Without it, the evidence may be challenged or deemed inadmissible if not secured in accordance with recognised practice or local agreements.

If the fire and rescue service seizes evidence, this should comply with the appropriate standards for its collection, handling and storage.

Strategic actions

Fire and rescue services should:

- Develop tactical guidance and support arrangements for the actions to take to hand over responsibility for a fire scene and/or investigation, in consultation with partner emergency services and agencies,

Tactical actions

Incident commanders should:

- Cooperate with multi-agency incident investigations or hand over to the relevant authority
- Be aware of the agencies, and their roles, that may be encountered during the course of a fire investigation
- Reference any available memorandum of understanding (MoU) (and service level agreement) for key partners such as the police
- Reference available bespoke MoUs in complex or significant multi-agency investigations
- Consider and identify arrangements for using powers of entry and make arrangements for their use
- Ensure appropriate arrangements are in place for handing over a fire scene
- Consider using single points of contact or a named team to maintain ongoing liaison and support, with associated guidance on formal or informal liaison arrangements

Control measure – Consider using closed-circuit television (CCTV)

For control measure detail, refer to the hazard - Unlocated fire.

Control measure – Cutting away

For control measure detail, refer to the hazard - Unlocated fire

Control measure – Consider using thermal imaging or scanning

For control measure detail, refer to the hazard - Unlocated fire.

Control measure – Personal protective equipment (PPE)

For control measure detail, refer to the hazard - Unlocated fire.

Control measure – Consider wearing respiratory protection equipment (RPE)

For control measure detail, refer to the hazard - Unlocated fire.

Control measure – Writing reports for fire investigations

Control measure knowledge

Report writing in relation to the circumstances of a fire, its physical appearance and spread is a key aspect in gathering information and intelligence on a fire incident.

It is important that reports are accurate, clear and unbiased as they will support further research, formal investigation and/or statistical content.

Legislation, such as the Criminal Procedures and Investigation Act 1996 and the Criminal Justice Act 2003 should be referred to regarding the legal standpoint for official report writing and note taking. This includes the need to:

- Record the information as soon as practicable
- Retain the information in its original and complete format
- Reveal the information when requested
- Review the information for accuracy, procedural applications and assessment of corporate or operational risks and threats

Reports can consist of:

- Informal contemporaneous notes:
    - Made at the time of an incident or event, or as soon as practicable, whilst the facts of the situation are still fresh in the mind of the person making the record
    - Where operationally practicable, notes and records should be written in ink
    - Consider creating a permanent record of other notes - for example dry-wipe breathing apparatus (BA) entry control boards can be photographed
    - Notes have a legal significance in that they can capture more detail than a person may recall at a later date

- Formally structured data gathering documents
    - Notes made on unofficial materials or papers should be transcribed onto an official form of record as soon as practicable after the event. The original form of the note must be retained and disclosed if required.
- Contemporaneous note books, as issued to officers
- Sketch plans, diagrams and photographs
    - Can include the layout of a building or compartment, positions of people, vehicles or sectors, and are considered to be equivalent to a written record or note
    - The storage and movement of digital images and media is subject to legislation such as the Data Protection Act 1998, the Freedom of Information Act 2000 and the Human Rights Act 1998

All types of records should be signed and dated by the person creating them so as to enable their use within a formal legal context if required.

Strategic actions

Fire and rescue services should:

- Develop guidance and support arrangements for the actions to take to record relevant information to support the investigation of a fire, in compliance with relevant legislation and following consultation with partner emergency services and agencies

Tactical actions

Incident commanders should:

Regardless of the use of the report or the nature of the content, consider recording key data, including:

- Initial incident information: date, time, location, weather conditions, observations of the incident scene and surroundings, access method and route, details of non-fire and rescue service personnel present
- Description of the incident: smoke patterns, colour and intensity of smoke, broken or insecure doors or windows, method of entry, tactics employed
- Incident-specific details: area or point of origin, what materials were burning, suspicious factors, difficulties or problems with firefighting, condition of consumer units and switches, actions taken to isolate utilities, smoke detector locations and operation, fire or burglar alarm systems and any activation zones
- Evidence of a criminal act: establishing the cause of the fire and whether accidental, deliberate or not known
- Opinion: this could be from a fire service specialist fire investigator or from an independent fire investigator, expert witness or scientist

- Statements: usually an electronic template document developed by a fire and rescue service that should be based only on objective and personal recollection of events, not on opinions and unfounded conclusions
- Sketch plans and diagrams: may be required in the event of a fatality, complex or serious incident where it would benefit the investigation or debriefing
- Photographs: can be used to document evidence of fire behaviour, firespread, fire safety issues or specific features such as insecure or broken doors or windows

Control measure – Attendance at coroner's court (or equivalent)

Control measure knowledge

Note: For ease of publication the terms 'coroner', 'coroner's court' and 'inquest' have been used in this control measure. However, it is recognised that other terminology is used outside of England and Wales; the equivalent of these terms should be applied where appropriate (e.g. procurator fiscal).

Fire and rescue service personnel may be called to give evidence at an inquest into the death of an individual. The aim of an inquest is to establish the means, cause and circumstances of a person's death. The coroner is also lawfully charged to identify measures to prevent future deaths in similar circumstances.

The aim of the inquest is not to apportion blame or to attack the behaviours or actions of key personnel such as the emergency services, but to understand the situation leading up to the event the actions of first responders and the conditions in which the deceased may have been found.

Fire and rescue service personnel are seen as professional witnesses. Their role is to assist the inquest in understanding the situation that the fire and rescue service faced on arrival at an incident and to explain their professional observations, actions and outcomes.

The fire and rescue service witness could be presenting evidence as:

- An officer in charge or firefighter directly involved in the incident
- The fire investigation officer who has investigated the cause, spread and outcome of the incident

The coroner will take the fire and rescue service witness through their statement and/or report made in relation to the incident. An inquest is a fact-finding process and it is not necessary to remember exactly what was said at a specific time during a dynamic incident. The coroner will give the fire and rescue service witness the opportunity to add, confirm or change their statement. This may be followed with more specific questions or requests for clarification on key points of a technical or professional nature from the coroner or others in court, including family members of the deceased.

Fire and rescue service witnesses should avoid using technical or working jargon and seek to present evidence in an unambiguous and simple manner. If a witness is asked a question that they cannot give a full or factual answer to, the coroner may direct them not to answer the question and instead seek to resolve the issue through open discussion with the family members in court.

The aim of the fire and rescue service witness should always be to impart their knowledge and observations from the incident in a clear and informative manner and to add clarity to the inquest's understanding of the incident. The inquest is not necessarily concerned with the specific and individual technical aspects of the activities of any one firefighter during a dynamic incident.

Refer to the Ministry of Justice, Guide to Coroners Services for details on the inquest process in England and Wales.

Refer to information and booklets available on the Crown Office & Procurator Fiscal Service for details on the inquest process in Scotland.

Refer to the publication Working with the Coroners Service for Northern Ireland

Strategic actions

Fire and rescue services should:

- Develop guidance and support arrangements for the actions to take to enable personnel to provide evidence in a court of law, in compliance with relevant legislation and following consultation with partner emergency services and agencies

Tactical actions

- Before attending the inquest witnesses should:
    - Ensure they have copies of their statement and/or any report previously provided to the coroner
    - Review their statement to ensure the contents are accurate. They should check dates, times and key facts in the statement.
    - Consider discussing the statement and/or report with an experienced fire investigation officer to gain an understanding of the types of questions that may be asked by the coroner and/or family members of the deceased
- When giving evidence at the inquest witnesses should:
    - Remember they are not on trial but are there to assist the court in understanding the circumstances of the incident
    - Be prepared to discuss their professional observations and immediate actions on arriving at the scene so that the coroner has a clear understanding of the physical condition of the incident
    - Be able to explain how, as a fire investigation officer, they arrived at their stated hypothesis for the cause of the fire and spread
    - Refrain from drifting from their relevant areas of professional knowledge
    - Answer the questions in a factual manner; the coroner will oversee the inquest and manage the impact on the family members

Control measure – Highlight trends

Control measure knowledge

A trend can be considered to be a number of fires that exhibit one or more features in common. This may be geographical, physical or related to other circumstances under which they occur. Trends can be identified in relation to both accidental and deliberate fires but will generally only comprise one or the other.

Failure to identify trends at the earliest possible stage can risk the possibility of the number or severity of fires increasing so early identification is important. This is particularly true of deliberate fires where a series of small fires may reflect someone's growing confidence in using fire before attempting something more serious.

Accidental fires trends may relate to new products or changes in the way existing products are used. Whatever the reason, fire investigation can be of assistance in confirming the presence of the trend and establishing its cause or common features and collecting the evidence required to influence a solution.

Identifying trends

Trends can be identified through deviations in the expected patterns or frequency of existing events or by the emergence of new events. This includes the outcome of a fire, such as an unexplained increase in the number of injuries or size of fires.

Trends may first be identified by using analytical methods or software to interrogate the Incident Recording System (IRS). However, where desktop analysis identifies the presence of a trend, it may have insufficient information to provide a sufficient explanation or find a root cause.

The collection of additional information from the fire scene is one way in which this gap can be bridged. Once the key features of the trend have been identified, arrangements can be made to ensure that any future incidents matching it are appropriately investigated. Depending on the level of information, this may be suitable for operational crews or the specialist fire investigation team to collect. Consideration may be given to collecting information through a bespoke template where the nature of the information required is known (e.g. the make and model of a potentially faulty product).

An alternative means of identifying trends is through direct observations by an individual or crew at fire scenes. In this case, using analysis can help to supplement the initial information and identify the presence and size or scope of a wider trend. The key features can then be communicated and a fire investigation used to collect further data.

In either event, the role of a fire investigation will be to provide good quality and objective data from fires meeting the trend pattern. This may require the use of specialist fire investigation teams to attend fires outside their normal scope if the nature of the evidence required is difficult to collect or must comply with evidential standards.

The aim will be, as far as possible, to establish the root cause; the fire investigation may help to explain not only the specific cause but to identify any contributory factors, including behavioural elements.

External liaison and information

Good liaison with other fire and rescue services and other organisations will help to establish whether the trend is localised or being seen in other areas. The liaison can take place through existing groups and communication networks (general or specialist) or established specifically for the trend depending on the nature of the issue. For example, with deliberate fires, close liaison with the police and other agencies that maintain relevant data will be important; they may have additional knowledge about individuals or activities.

Monitoring

Identifying and researching a trend should provide a means by which targeted interventions can be taken.

Once action has been taken, the impact on the trend should be monitored both remotely and through attendance at scenes. Care will also be required to ensure that the problem has been addressed and not just displaced. Again, effective use of analysis and fire investigation will help to confirm this.

Strategic actions

Fire and rescue services should:

- Develop guidance, processes and support arrangements for the actions to take to highlight and take appropriate action to reduce fire trends, In consultation with partner emergency services and agencies

Tactical actions

Incident commanders should:

- Use agreed systems to actively identify and define trends
- Consult and liaise with relevant departments, agencies and partners to ensure early communication of identified trends and to share appropriate information
- Use operational crews and specialist fire investigation teams to assist with collecting objective and detailed data from fire scenes to identify, research and/or confirm the cessation of a trend

Control measure – Support future learning

Control measure knowledge

Following a fire, many agencies may take an interest in attending and investigating one or more aspects of the circumstances. It is important that each agency has a clear understanding of its own and others' focus.

While it is acknowledged that other organisations are interested in public and responders' safety, fire and rescue services are unique in routinely attending fire incidents and in being able to capture evidence directly from the scene. In this respect, fire and rescue services may be considered to have one or more of the following unique roles:

- Learning from fires to improve public safety
- Learning from fires to improve the safety of fire and rescue service personnel or others involved during or post-fire activities
- Duties under the Regulatory Reform (Fire Safety) Order 2005

This refers to organisational interest and is not the same as on those occasions where a fire and rescue service provides resources to assist another agency with its aim.

In pursuit of their statutory role to prevent fires, fire and rescue services should actively look for individual incidents or trends where lessons may be learnt. In practical terms, all fires should be assessed for any learning opportunities. Alternatively, prior knowledge (for example, external reports or internal analysis) may provide an automatic trigger for closer scrutiny of specific incident types.

Collecting information

Fire and rescue services, by virtue of their extensive network of stations and attendance at fires, can collect valuable information from a large number of real fires. Combined with knowledge of fires and the behaviour of property, products and people, fire and rescue services are well placed to gather good quality evidence quickly, either through operational crews or specialist fire investigation personnel.

Fire investigation can play an important part in supporting future learning by providing a structured and objective approach to identifying and capturing evidence. This approach should ensure that it withstands scrutiny in its future application and is fit for purpose.

For most incidents, the main focus of the fire investigation is to identify the specific origin and cause of a fire. However, fire investigation techniques and knowledge are also ideal for collecting information to support wider future learning. These include using the scientific method, reading post-fire indicators, interviewing witnesses and knowledge of the fire behaviour of buildings, products and people, the interaction between these and how they may have contributed to the outcome (positively or negatively).

As an example, new methods of construction are continually being developed and will have undergone testing in accordance with the relevant standards. However, a difference in their expected performance in a fire may occur during the construction phase of building when not all the fire safety features are in place or due to their interaction with other products. Fire investigation can identify any deviation from expectations and seek to explain the reason.

Once the opportunity for future learning has been identified, careful and early consideration should be given to the type and format of information required. This may include quantitative and qualitative data. Specific areas of interest or the standard to which they need to be collected should be agreed and stated. This needs to be communicated to the fire investigator. The use of audio, visual or written techniques may be employed at the scene for capturing raw evidence and later adapted for presentational or analytical purposes. Failure to collect the right type or quality of data can severely impair the ability to achieve a successful outcome.

Any changes to or flaws in the original data requirements should be communicated to the fire investigator with an explanation of the rationale. Equally, the fire investigator should communicate any significant findings at an early stage if it is possible they may affect the request. It should also be identified whether information from the scene will be sufficient on its own or require further research, including, in some cases, using partial or full-scale testing

The environment in which the information will be used is important as this may also have its own rules regarding ethics, storage and data protection, etc.

Learning outcomes may be of assistance to fire and rescue services across their span of prevention and operational activity. This may be at local level or in the context of the wider fire and rescue service.

Fire and rescue services may also provide information to a range of external partners. This could be to assist with the partner's objectives or those of the fire and rescue service. Examples of different uses include lobbying, media campaigns, academic research or discussions with partners including trade and professional bodies or individual companies. This can result in changes in the law or guidance documents, can influence technical standards, inform product development, support consumer initiatives and generate new knowledge for academic study.

Away from the scene, the fire investigation community has a well-established network both in the UK and beyond. It also has links to other sectors or organisations and these can be employed to provide additional information on known issues or to see whether others have experienced anything similar.

It is also worth noting that the UK legislation provides powers of entry to support future learning. Consideration should also be given to having an appropriate policy relating to removing items from the fire scene in support of future learning. Failure to do so could compromise any insurance claim, leave the fire and rescue service open to challenge and compromise the evidential value of an item.

Strategic actions

Fire and rescue services should:

- Develop guidance, processes and support arrangements for the actions to take to support future learning for internal and external stakeholders, in compliance with relevant legislation and following consultation with partner emergency services and agencies

Tactical actions

Incident commanders should:

- Formally document any outcomes that may have an effect on future practice, process and/or procedure and share this information with the relevant fire and rescue service departments
- Consult and liaise with specialist fire investigation teams and personnel to ensure all incident investigative outcomes are included as part of any operational debriefing process
- Follow-up action points from learning outcomes to ensure learning has been or is being appropriately embedded

Control measure – Identify failures in fire safety measures

Control measure knowledge

Fire safety measures are found in many buildings (either as a means to satisfy legal requirements or as a discretionary measure) and comprise both physical and management elements. Their ability to protect the occupants, building and contents relies on the correct selection, design, management and maintenance of the measures both individually and in combination.

When a fire occurs in a building with fire safety measures, the opportunity to assess the measures in place and the effectiveness of their performance is something that should be given early consideration.

Additionally, where the premises fall within the scope of the Regulatory Reform (Fire Safety) Order 2005, fire and rescue services have a statutory role to consider whether the arrangements were appropriate and in line with the risk assessment, following which a prosecution may be initiated.

Fire and firefighting operations can destroy or significantly alter items to the extent that it the original contents of the room are not immediately obvious. Fire investigation can aid this by collecting evidence that can help with understanding the pre-fire and during-fire conditions, fire development and the influence of fire safety measures from the physical evidence.

Where this is completed as part of a possible prosecution, specialist fire investigators should be considered, to comply with investigative practice and evidence collections standards. In this case, the fire investigation process will need to fall within the management of the wider investigation team from the earliest stage.

Specific areas of significance

The fire investigation can then help the wider assessment or investigation to understand whether the fire safety arrangements were appropriate, whether they worked and, if not, what defect act or omission would explain why the fire developed and provide evidence to support this. When assessing the performance of fire safety measures, note should be paid to features that have worked well or better than expected, as this will be of interest for future learning.

Identifying the origin of the fire will usually be an important part of an investigation to consider the fire safety measures. It will confirm where it started, without which it will be difficult to understand how the fire developed or spread and how this links to the relevant fire safety measures and the sequence in which active systems operated.

The cause of the fire may or may not be important when considering fire safety issues as, depending on the nature of the business, the risk of a small fire occurring may be inherent or accepted. Generally, fire safety measures will be designed to allow people to escape in a fire and not necessarily to prevent a fire occurring in the first place.

However, where possible it is good practice to establish the cause as this may inform future practice at the premises or more widely. It may also identify items that should not be present or are unusual (not consistent with stated business or building use) and in turn suggest further lines of enquiry.

Post-fire indicators will be of assistance in a number of other areas of specific relevance to fire safety measures:

- Building structure: identify the methods of construction and materials. This may be for the whole premises or in the fire-affected area/s. In heavily damaged properties, it may even be necessary to look for clues that help confirm the internal layout.
- Compartmentation: assess the type and rating of any fire safety compartmentation and any breaches or areas where the appropriate standard has been compromised. Poor maintenance or building work may have left compartments breached, and evidence of firespread (and direction) through these may be established by the fire investigation.
- Fire doors: fire investigation can help identify the type of door, markings or rating identifiers, its position during the fire and the location (height) and direction of any fire or smoke travel
- Other fixed fire safety measures: fire investigation techniques will usually enable the presence, location and condition (including switch and lever positions if relevant) of other fixed measures such as lighting, signage, etc. to be identified
- Portable fire safety measures: the location, make/model and condition of portable fire safety measures, such as fire extinguishers.

Other opportunities

- Document or specific item retrieval: fire investigation techniques may help to locate and safely retrieve important small or fragile items from the fire debris
- Intelligent systems: while retrieving or reading records from intelligent fire safety systems will normally be done by a specialist, it will be useful for these results to be provided to the fire investigator for cross-reference with the physical findings
- Witnesses: the fire investigation may include or require the need for witnesses. Where the fire investigation is being undertaken as part of a possible prosecution, this should only be at the direction of the investigation manager so that the necessary legal protocols (primarily the Police and Criminal Evidence Act) are complied with. Alternatively, the fire investigation report may simply need to reference further information or questions that should be raised as part of witness interviews by others.
- Insurance companies: as with any fire investigation, it is useful to confirm the interest and response of insurance companies as early as possible. Liaison with them will help ensure that any investigations are appropriately managed, recognising each party's legitimate role and interest. They may also be able to supply information of relevance to the fire investigation regarding policy conditions in relation to fire safety measures.
- Powers of entry: for fire investigations in relation to fire safety measures powers set out in UK legislation should be used

Strategic actions

Fire and rescue services should:

- Develop tactical guidance and support arrangements for the actions to take and associated hazards in identifying failures in fire safety measures

Tactical actions

Incident commanders should:

- Consult and liaise with responsible persons to access and discuss building plans and associated fire safety measures
- Ensure that contingency plans are formulated to limit failure of fire safety measures
- Where possible, check areas of fire separation, compartmentation and protection to ascertain if the fire safety measures have under-performed or over-performed (for example, pressurised stairwells should maintain a smoke free area in the stairwell
- Formally document any failure of fire safety measures and ensure information is communicated to the relevant fire and rescue service department

Glossary

Term	Acronym (if applicable)	Description
Actuation		The activation of a mechanism or system
Actuator		An actuator is a type of motor that is responsible for moving or controlling a mechanism or system. It is operated by a source of energy, typically electric current, hydraulic fluid pressure or pneumatic pressure, and converts that energy into motion. Actuators are commonly used for aircraft controls.
Alcohol-resistant aqueous film-forming foams	AR-AFFF	Alcohol-resistant foams contain a polymer that forms a protective layer between the burning surface and the foam, preventing foam breakdown by alcohols in the burning fuel.
Analytical risk assessment	ARA	A detailed and recorded risk assessment process. (See also Dynamic Risk Assessment).
Appliance		See emergency fire vehicle.
Aqueous film-forming foam	AFFF	Low-expansion foams such as AFFF are low-viscosity, mobile, and able to quickly cover large areas.
Back burning		Back burning is a way of reducing the amount of flammable material during a controlled burn or wildfire by starting small fires along a manmade or natural firebreak in front of a main fire front.
BASIS Registration Limited		BASIS is an independent standards setting and auditing organisation for the pesticide, fertiliser and allied industries. (Previously: British Agrochemical Standards Inspection Scheme)
Branch		A piece of equipment used at the delivery end of a hose line to increase velocity and to provide an effective firefighting stream of foam or water.
Breathing apparatus (sometimes referred to as self-contained breathing apparatus)	BA (or SCBA)	Self-contained respiratory protective equipment.
Building		A structure with a roof and walls, such as a house or factory.
Bullseye		A hot spot in a fire.
CCTV control		A room containing the controls and monitor screens for closed-

Term	Acronym (if applicable)	Description
room		circuit television.
Closed-circuit television	CCTV	System used to produce images or recordings for surveillance purposes, and can be either video cameras, or digital stills cameras
Coandă effect		The Coandă effect is when a fluid jet tends to be attracted to a nearby surface. This principle was found by a Romanian aerodynamics pioneer, Henri Coandă.
Compressed air foam system	CAFS	A system used in firefighting to deliver fire retardant foam for the purpose of extinguishing a fire or protecting unburned areas from becoming involved in flame.
Confined space		A confined space is a place that is substantially enclosed (though not always entirely), and where serious injury can occur from hazardous substances or conditions in the space or nearby (e.g. lack of oxygen).
Conoid		A conoid roof is a warped plane with a double curvature like the side of a cone. It is a popular design in modern architecture because of its visual drama and litheness, as well its typically non-traditional construction materials.
Control of major accident hazards	COMAH	Regulations to ensure that businesses: • Take all necessary measures to prevent major accidents involving dangerous substances • Limit the consequences to people and the environment of any major accidents which do occur.
Covering jet		Firefighting equipment used to prevent external fire spread and protect surrounding risks.
Critical flow rates	CFR	The flow rate below which a fire is unlikely to be controlled effectively.
Cutting extinguisher		A fire extinguishing technique that combines abrasive water jet cutting with water spray extinguishing through a single hand piece or nozzle.
Deflagration		Combustion which propagates through a gas or across the surface of an explosive at subsonic speeds, driven by the transfer of heat
Detonation		Combustion of a substance which is initiated suddenly and propagates extremely rapidly, giving rise to a shock wave
Department for Communities and Local Government	DCLG	DCLG is a ministerial department, supported by 10 agencies and public bodies.

Term	**Acronym (if applicable)**	**Description**
Department for Environment Food & Rural Affairs	DEFRA	DEFRA is a ministerial department, supported by 35 agencies and public bodies.
Dynamic risk assessment	DRA	A risk assessment process that is used in a dynamic environment. (See also Analytical Risk Assessment).
Emergency fire vehicle		Generic term for fire and rescue service emergency response vehicle other than a light goods vehicle.
Entry control point	ECP	The position for the command and control, deployment and monitoring of breathing apparatus wearers in a risk area.
Exothermic oxidation		A chemical process that results in the release of heat.
Fall arrest system		A personal fall arrest system is a fall-protection system that uses a harness connected to a reliable anchor to arrest and restrict a fall and prevent the user hitting the ground.
Film-forming fluoroprotein	FFFP	The type of foam that is better for cases where the burning fuel can form deeper pools.
Firebreak		A measure to prevent the spread of fire.
Fire control room	FCR	Department or centre that takes emergency calls for the fire and rescue service.
Firefighting jet		Firefighting equipment used to extinguish the fire or by teams committed offensively to locate the fire or casualties.
Fireground		An area in which firefighting operations are carried out.
Free surface effect		The change in stability of a vessel caused by liquids moving about freely in a tank or hold. As a vessel rolls, liquids in tanks or breached compartments accentuate the roll by moving freely from side to side of the tank accumulating first on one side and then the other, and may adversely affect the stability of the ship.
Fuel break		An existing, planned change or discontinuity in fuel that will reduce the likelihood of combustion, fire intensity and/or the rate of firespread.
Health and Safety Executive	HSE	The HSE's work covers a varied range of activities; from shaping and reviewing regulations, producing research and statistics and enforcing the law.
Heating,	HVAC	A control system that applies regulation to a heating and/or air

Term	Acronym (if applicable)	Description
ventilation and air conditioning		conditioning system.
High volume pump	HVP	To counter the threat from a number of water-related scenarios, the National Resilience programme has provided High Volume Pumps, which are strategically positioned around the country and can be used in the following situations: •Natural flooding •Deliberate flooding •Firefighting duties
High-expansion foam	HX	High-expansion foams have an expansion ratio over 200 -1000. They are suitable for enclosed spaces such as hangars, where quick filling is needed.
Incident		Any event or occurrence that requires an emergency response.
Incident Recording System	IRS	A system by which each fire and rescue service submits data about incidents electronically to the Department for Communities and Local Government.
Industrial processes		A systematic series of mechanical or chemical operations that produce or manufacture something.
Inner cordon		An inner cordon is established to control access to the immediate scene of operations.
International shore connection		The international shore connection is a universal hose connection that is to be provided on all ships as per the SOLAS Convention requirements.
Interoperability		The joint working of emergency services, especially during a major or complex incident.
Intraoperability		The joint working of fire and rescue services, through combined use of resources and assets, sometimes in a cross-border situation. This can also mean the combined involvement of a fire and rescue service with National Resilience assets.
Intrinsically safe		Intrinsically safe equipment has been designed and tested to not become an ignition source in a flammable atmosphere.
Joint Emergency Services Interoperability Principles	JESIP	The objectives of JESIP are: • To establish joint interoperability principles and ways of working (joint doctrine) • To develop greater understanding of roles, responsibilities and capabilities amongst tri-service responders

Term	**Acronym (if applicable)**	**Description**
		• To improve communication, information sharing and mobilisation procedures between services including their control rooms • To implement a training strategy for all levels of command • To implement a joint testing and exercising strategy for all levels of command to ensure lessons identified progress into learning and procedural change
Local Government Association	LGA	The LGA is the national voice of local government. They work with councils to support, promote and improve local government.
Low-expansion foam	LX	Low-expansion foams have an expansion rate less than 20 times its original volume
Medium-expansion foam	MX	Foams with expansion ratio between 20 and 200 are medium-expansion.
Memorandum (memoranda) of understanding	MoU (MoUs)	An agreement that may exist between organisations such as the emergency services. It provides clear guidelines for local implementation of policies, strategies, and tactical and operational practice in accordance with local circumstances.
Minimum flow rates	MFR	The flow rate at which suppression is achievable but firefighters may face severe and punishing conditions.
Mobile data terminal	MDT	Provide mobile computer access to information, usually in the form of a rugged laptop.
Mobilise		Inform a fire and rescue service asset that it is required to go to an incident and the process of that asset getting to the incident.
Negative pressure ventilation	NPV	Refers to extracting the hot air and gases from the outlet vent.
Neutral plane		See smoke layer
New Dimension programme		A programme started by the Department for Communities and Local Government in the UK, for fire and rescue services in England and Wales, following the 2001 terror attacks. The programme provides equipment, training and standardised procedures to deal with terrorist attacks and major environmental disasters.
Optimum flow rates	OFR	The flow rate where control of the fire is achievable without unnecessary punishment to firefighters.

Term	Acronym (if applicable)	Description
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.
Positive pressure ventilation	PPV	This is achieved by forcing air into a building using a fan.
Pyrolysis		Decomposition brought about by exposure to heat or high temperatures.
Remotely piloted air systems	RPAS	Often referred to as unmanned air vehicles (UAVs) or ‘drones’, these are pilotless ‘aircraft’ that can be used for surveillance purposes.
Rendezvous point	RVP	After initial response, emergency services personnel attending an emergency or major incident should be directed to a designated rendezvous point.
Rescue		Removal, from a place of danger to a place of relative safety, of people threatened or directly affected by an incident, emergency or disaster
Respiratory protective equipment	RPE	Respiratory protective equipment includes breathing apparatus, particle masks and respirators.
Responsible person		The person responsible for a site, building, or similar (in some cases this may be an appointed competent person). Used in a legislative context they are known as: • Responsible Person (England, Northern Ireland and Wales) • Duty Holder (Scotland)
Road traffic collision	RTC	The law defines a reportable road traffic collision as an accident involving a mechanically-propelled vehicle on a road or other public area.
Run off		Residual firefighting media which can transport pollutants into drainage systems, rivers, groundwater’s and soil.
Rural		The rural environment often refers to areas in the country that are less densely populated. There are different types of rural areas, depending on how accessible they are from urban areas, ranging from the rural urban fringe to extreme or remote rural areas.

Term	Acronym (if applicable)	Description
Safety jet		Firefighting equipment used to protect offensive firefighting teams and maintain safe access to and egress from the scene of operations.
Safety officer		Safety officers are appointed by the incident commander before the start of operations. They will be located at points that provide them with overall view and control of the inner cordon and scene of operations.
Sandwich panel		A type of building material which consists of an insulating material between two metal (usually steel) faces that provides rigidity and robustness to the panel.
Scene survey		An ongoing process to observe an incident from all available observation points.
Seat of fire		Origin of a fire.
Security device		A wide range of fittings that may be fitted to private dwellings and business premises, including bars, shutters, locks and bolts.
Self-ventilation		When fire damages a structure so that increased ventilation occurs.
Site-Specific Risk Information	SSRI	Risk information captured by each fire and rescue service to identify, through a continuous process, new risk information, and the updating of existing information to support the operational effectiveness of the fire and rescue service, ensure the safety of the public and the protection of its firefighters.
Site visit		Pre-planned activity to familiarise emergency responders with specific sites in accordance with current legislation.
Situational awareness		The perception and understanding of a situation and the anticipation of how the situation may develop in the near future.
Slave control panel		Control panels of a secondary nature in building systems; they may not have the full functionality found in the master control panel.
Smoke layer (previously referred to as the neutral plane)		The boundary between the heated smoke and the cooler air.
Stoichiometric mixture		An 'ideal' fuel/air mixture in which both the fuel and the oxygen in the air are completely consumed.
Strategic holding area		A pre-identified area large enough to accommodate the command and logistical support structure for a major or catastrophic incident

Term	Acronym (if applicable)	Description
		including but not limited to chemical, biological, radiological and nuclear (CBRN) events incidents. This includes a marshalling area where resources can standby or rest whilst awaiting deployment to the incident.
Structural		Relating to or forming part of the structure of a building or other object.
Structural firefighting PPE		Helmet, fire hood, fire gloves, tunic, over trousers, and boots suitable for entry into buildings that may be on fire. Must comply with the correct European standards for firefighting operations.
Structural void		An area within a structure that has been intentionally left completely empty.
Structure		A building or other object constructed from several parts.
Tactical ventilation		The intervention of a fire and rescue service to open up the building (in a controlled manner), releasing the products of combustion and allowing air to enter. Tactical ventilation can be achieved either by natural or forced means.
Thermal imaging camera	TIC	A thermal imaging camera is a type of camera used in firefighting. By rendering infrared radiation as visible light, such cameras allow firefighters to see areas of heat through smoke, darkness, or heat-permeable barriers.
Time critical		Term used to describe a casualty who needs immediate treatment or intervention of a life-saving manner.
Topography		The arrangement of the natural and artificial physical features of an area.
Ventilation		The removal of heated air, smoke and other airborne contaminants from a structure, and their replacement with a supply of fresher air.
Vessel		A ship or large boat.
Weight of intervention		The amount of firefighting resources employed at any given time.
Working at height		Working at height means working in any place where, if there were no precautions in place, a person could fall a distance liable to cause personal injury.

Bibliography

3D Firefighting: Training, Techniques, and Tactics, Grimwood, Hartin, McDonough & Raffel, 2005
5/1994: A Survey of Backdraught – main report, Chitty R, Home Office Fire Research and Development Group UK, 1994
A Guide to Fire Investigation, IFE02, The Institution of Fire Engineers
A Pocket Guide to Arson and Fire Investigation, Edition 3, Factory Mutual System, 1990
A Real Scenario for a Ghosting Flame, Proceedings of the Fifth International Symposium, International Association for Fire Safety Science
Air Moving Systems and Fire Protection, NISTIR 5227, National Institute for Standards and Technology (USA), 1993
An Experimental Investigation of Backdraught, Fire Research Report Number 82, Foster JA and Roberts GV, 2003
An Introduction To Fire Dynamics, 3rd Edition, Drysdale D, 2011
Building Fire Other, Standard Operating Procedure F.07, Kent Fire and Rescue Service
Chemistry A* Study Guide: Study and Revision Guide for GCSE and International GCSE, Frank Benfield, 2012
Chemistry FAQs and practice for A level, Max Parsonage, 2001
Crime Scene Management, Scene Specific Methods, Sutton ,P. & K, Trueman Wiley & Blackwell, 2009
Design fires for use in fire safety engineering, BRE, 2010
Edexcel AS and A Level Modular Mathematics - Mechanics 1, 2008
Effect of Positive Pressure Ventilation on a Room Fire, NISTIR 7213; National Institute for Standards and Technology (USA), 2005
Euro Firefighter, Grimwood P, 2008
External fire spread: building separation and boundary distances, BR187, BRE, 1991
Fire and Rescue Manual, Volume 2, Fire Service Operations, Incident Command, 3rd Edition, 2008
Fire and Rescue Manual, Volume 2: Fire Service Operations, Environmental Protection, 2008
Fire and Rescue Service Operational Guidance, Generic Risk Assessments, GRA 5.8, Flashover, Backdraught, and Fire Gas Ignitions
Fire and Rescue Service Operational Guidance, Generic Risk Assessments, GRA 3.1, Fighting Fires in Buildings
Fire and Rescue Service Operational Guidance, Generic Risk Assessments, GRA 3.4, Fighting Fires in Open Rural Locations
Fire safety engineering: a reference guide, BRE 459, BRE, 2003
Fire Service Guide, Volume 3, A Guide to Operational Risk Assessment, 1998

Fire Service Manual, Volume 1, Equipment and Media, Physics and Chemistry for Firefighters, 1998
Fire Service Manual, Volume 1, Fire Service Technical, Equipment and Media, Firefighting Foam – Technical, 2000
Fire Service Manual, Volume 1, Fire Service Technology, Equipment and Media, Hydraulics, Pumps and Water Supplies, 2001
Fire Service Manual, Volume 2, Fire Service Operations, Compartment Fires and Tactical Ventilation, 1997
Fire Service Manual, Volume 2, Fire Service Operations, Compartment Fires and Tactical Ventilation, 1997
Fire Service Manual, Volume 2, Fire Service Operations, Firefighting Foam, 1998
Fog Attack, Firefighting Strategy & Tactics – An International View, Grimwood.P, 1992
Forest and Moorland Fire Suppression, Murgatroyd, Forestry Commission, 2002
Fundamentals of Fire Fighter Skills, 3rd Edition, IAFC, 2013
Fundamentals Of Fire Phenomena, Quintiere JG, 2006
Gas and Vapor Explosion Hazards – Basis of Safety (Control of Ignition Sources), Chilworth Technology Inc., 2012
GCSE Physics, AQA, Jim Breithaupt, 2011
Generic Risk Assessment 1.1: emergency response and arrival at the scene, 2009
Generic Risk Assessment 3.1: fighting fires in buildings, 2011
Generic Risk Assessment 3.4: fighting fires in open rural areas, 2011
Generic Risk Assessment 5.8, Flashover, Backdraught and Fire Gas Ignitions, 2009
Harrow Court Fire, Reference 00342-2005, Coroner's Office, District of Hertfordshire, 2007
Ignition Handbook: Principles and Applications to Fire Safety Engineering, Fire Investigation, Risk Management and Forensic Science, Babrauskas, V, 2003
International Journal of Heat and Mass Transfer, Elsevier Ltd
Kirk's Fire Investigation (7th Edition), Brady Fire, 2011
Manual of Firemanship, Book 12, Practical Firemanship II, 1989
Manual of Firemanship: Elements of Combustion And Extinction, Book 1, Survey of the Science of Fire-fighting, 1974
Manual of Firemanship: Part 6A: Practical Firemanship: 1, A survey of the science of firefighting, 1971
National guidance document on the provision of water for firefighting, 3rd edition, Local Government Association and Water UK, 2007
NFPA 921: Guide for Fire and Explosion Investigations, National Fire Protection Association, 2014

Pollution prevention guidelines – Controlled Burn: PPG28, Environment Alliance, 2007
Safe handling of combustible dusts: Precautions against explosions, Health and Safety Executive, 2003
Sfpe Handbook of Fire Protection Engineering, 4th edition, National Fire Protection Association, 2008
Shirley Towers, HM Coroner for the Southampton City and New Forest District, 2013
Smoke Explosions, Fire Engineering Research Report 99/15, University of Canterbury, 1999
Surviving a Disaster, Counter Disaster Planning, Emery, English Heritage
The Usborne Illustrated Dictionary of Science A complete reference guide to physics, chemistry and biology, Usborne Books, 2007
Theoretical Considerations of the Growth to Flashover of Compartment Fires, Fire Research Notes 663, Thomas PH, 1967
Thermodynamics: An Engineering Approach, 7th Edition, Cengal and Boles, 2010

Websites (accessed March 2015): Evaluation of the Onset of Flashover in Room Fire Experiments Wind Driven Fires Boston Fire, Beacon Street East Sussex Fire and Rescue Service – Black Museum The Institute of Conservation - The Conservation Register Devon and Somerset Fire and Rescue Service - High Volume Pump Warwickshire County Council - Atherstone-on-Stour report