National Operational Guidance Programme

Local Government Association | CFOA Chief Fire Officers Association | in partnership with LFB London Fire Brigade

Title:	Fires in the built environment
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Synopsis:	This guidance focuses on how the design and construction materials of buildings, along with their facilities and systems, can impact on, or assist with, fire and rescue service operations.
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National Operational Guidance – Fires in the built environment first edition version one (ARCHIVED on 26-04-2016)

Introduction

This section of the guidance identifies the hazards and control measures that should be considered when writing policies for dealing with fires in the built environment. For the purposes of this guidance the built environment has been defined as “permanent surface or sub-surface structures that are partially or wholly covered”.

It contains information relating to buildings, their design and construction materials. It also describes how building facilities and systems can assist with fire and rescue service intervention. The guidance recognises and reflects findings from significant incidents in the UK in recent years and draws on observations of relevant fires in buildings worldwide.

Depending on the nature and scale of the operational incident, a variety of significant hazards may be encountered. Where appropriate, refer to other sections of National Operational Guidance, including:

- Operations guidance
- Incident Command guidance
- Performing Rescues guidance
- Environmental Protection guidance

The Fires and Firefighting guidance directly supports dealing with fires in the built environment, as it includes:

- Fire loading
- Fire development
- Compartment firefighting
- Firefighting media and techniques
- Damage control and salvage

This guidance should be read together with information on the aims and intended use of the National Operational Guidance Programme.

Legislation

A legislative framework addresses fire safety in buildings:

- Building Act 1984
- The Building Regulations 2010
- The Regulatory Reform (Fire Safety) Order 2005
- Fire and Rescue Services Act 2004

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 regard to all stakeholders including the local resilience forum and the fire and rescue service's risk management plan.

Hazard and control statement

Hazards	**Control measures**
Fires in the built environment	Apply situational awareness Refer to Site-Specific Risk Information (SSRI) Establish scene safety and cordons Carry out appropriate intervention
Undetected firespread	Apply generic control measures Identify and investigate fire in concealed spaces Access the concealed area Consider the effects of ventilation
Firespread within a compartment	Apply generic control measures Identify and consider the impact of wall linings
Firespread breaching a compartment	Apply generic control measures Identify compartmentation Secure access and egress routes Survey adjacent areas or compartments
External firespread	Apply generic control measures Carry out external surveys Co-ordinate external and internal activity Provide external protection
Cable entanglement	Apply generic control measures Isolate the electricity supply Identify whether lightweight conduit, trunking and cable fixings are present Avoid the areas or secure/remove loose cabling
Partial and structural collapse	Apply generic control measures Look for signs of collapse Position cordons appropriately Maintain safe access and egress Take preventative action Make a tactical and controlled withdrawal
Fixed installations fail, or are operated inappropriately	Apply generic control measures Liaise with the Responsible Person Give authority to operate or alter fixed installations

Hazards	Control measures
Complex fire engineering	Apply generic control measures Carry out information gathering Identify firefighting access points Use integral communications
Design features causing delayed intervention	Apply generic control measures Use of forcible entry Maintain safe access and egress Control fixed installations and integral communication systems Identify appropriate location(s) for a bridgehead (forward BA entry control point) Confirm the occupier evacuation policy or strategy Consider how time delays may affect incident development

Fires in the built environment

Hazard	Control measures
Fires in the built environment	Apply situational awareness Refer to Site-Specific Risk Information (SSRI) Establish scene safety and cordons Carry out appropriate intervention

Hazard knowledge

The generic control measures for this hazard should be applied when dealing with any fire in the built environment, whatever its size or complexity.

This guidance is underpinned by comprehensive information from the Building Research Establishment (BRE) making it easier for the user to find their way through the guidance without an overload of technical information. The knowledge sheets developed by BRE include information such as:

- Building design
- Construction materials
- Fire protection
- Facilities for firefighters
- Building occupancy

The knowledge sheets have been supplemented with considerations developed by fire and rescue service contributors.

Throughout the guidance there are references to the technical information contained in the knowledge sheets. These are shown in italics for initial publication but will be replaced with hyperlinks early in 2015.

The guidance presumes that buildings comply with relevant regulations. However some buildings may have been altered or changed since their original construction, such as a change of use, extensions or conversions. These changes may have been unregulated and could have an impact on the incident. For example, the structure or compartments may have been breached due to modifications to the original construction. As a result, fire separation within the building may have been compromised.

When dealing with incidents, illegal activities should be considered as they can present significant hazards. Illegal activities can include the cultivation and production of illegal drugs, tampering with utilities and meters, or illegal storage of hazardous materials including fireworks or fuel.

Control measure – Apply situational awareness

Control measure knowledge

Situational awareness concerns the perception and understanding of a situation and the anticipation of how the situation may develop in the near future. For further information refer to the Incident Command guidance.

Understanding a building's design, construction, nature of occupancy (including the type of *population*) and its performance in a fire, will assist incident commanders and firefighters to make safe, informed decisions.

Depending on the size and complexity of the incident, other agencies may attend, making effective joint working critical for safety on the incident ground. Shared situational awareness is a multi-agency, common understanding of the circumstances and immediate consequences of the emergency, together with an appreciation of the capabilities available and the priorities of the emergency services. Further information can be found in the Joint Emergency Services Interoperability Programme (JESIP) Joint Doctrine, Joint Decision Model.

So that fire and rescue service personnel can operate safely and effectively at incidents involving fires in the built environment, they should develop an appropriate understanding of building design and construction materials, along with building use and occupancy. They should also appreciate the effects of fire and firefighting activity upon a structure. Guidance about fire behaviour and firefighting techniques within compartments can be found in the Fires and Firefighting guidance. To make a judgement on an effective deployment, the incident commander should also be aware of the capabilities of the resources at the scene.

Control measure actions

Consider all available sources of information and assess the developing incident. Objectives should be based on the incident needs and a plan should be constructed to achieve them. Continuous evaluation throughout the incident will determine if the current objectives and tactical plan are appropriate.

The following sources of information should be considered throughout the incident:

- Building use and occupancy
- Site-Specific Risk Information

- Building and site plans
- Premises information box
- The *Responsible Person*
- Building facilities and systems, such as:
    - *Fire detection systems*
    - Fixed installations
    - *Control rooms* or closed-circuit television (CCTV)
- *Signage*
- Observation, including
    - External surveys of the building – consider the use of thermal imaging cameras
    - Identifying the location of the fire and assessing fire development
    - Reconnaissance of the location reported to be involved
- Information from:
    - Occupiers
    - Personnel operating within the building
    - Other agencies

Control measure – Refer to Site-Specific Risk Information (SSRI)

Control measure knowledge

Each 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 the pre-planning of firefighting tactics. Further information can be found in the Operations guidance.

Control measure actions

If available, Site-Specific Risk Information should be referred to during an incident.

Control measure – Establish scene safety and cordons

Control measure knowledge

Refer to the Incident Command guidance for control measure knowledge.

Control measure actions

To provide sufficient scene safety, consider and implement the following, as appropriate:

- The positioning of fire appliances on arrival (rendezvous point and marshalling)
- Identification of hazards
- Establishing, maintaining and reviewing cordons

  - Restrict the number of personnel in hazard or restricted areas
  - Brief all personnel entering the risk area on hazards and restricted areas
  - Confirm the emergency evacuation procedure and signal
- Evacuation strategies and their impact on operations and members of the public
- The isolation of utilities
- Appointing safety officers
- Using thermal imaging cameras
- Using fire and rescue service tactical advisers, for:
  - *Fire protection*
  - High volume pump (HVP)
  - Hazardous materials and environmental protection – HazMat guidance and Environmental Protection guidance
  - Urban Search and Rescue (USAR)
- Take external specialist advice from, for example:
  - The *Responsible Person* or site specialist
  - Structural engineers
  - Environment Agency/Scottish Environment Protection Agency/Northern Ireland Environment Agency/Natural Resources Wales
- Liaise with other attending agencies and agree areas of responsibility

Control measure – Carry out appropriate intervention

Control measure knowledge

Underpinning knowledge of the built environment, compartment fire behaviour and whether any occupants are present and at risk will determine the timing and level of intervention. In particular, gaining knowledge of any fire protection systems and facilities for firefighters within the building is necessary, including how they are operated and whether they are functioning. To make an effective deployment the incident commander should be aware of the capabilities of available resources.

Control measure actions

Following the incident ground risk assessment, and when a safe system of work is implemented, risk-critical information should identify priority actions – where intervention will be required – as part of the overall tactical plan.

Priority objectives include saving life, preventing the incident from escalating and extinguishing the fire. Guidance to determine appropriate intervention and tactics can be found within the Fires and Firefighting guidance and the Performing Rescues guidance.

Undetected firespread

Hazard	Control measures
Undetected firespread	Apply generic control measures [as detailed for the hazard of 'Fires in the built environment'] Identify and investigate fire in concealed spaces Access the concealed area Consider the effects of ventilation

Hazard knowledge

Concealed spaces in a building's construction may provide a route for products of combustion to travel. Where *cavities* in the construction are extensive, a fire can develop undetected and smoke may spread or fire may break through in unpredicted areas, possibly at some distance from the area of fire origin.

Concealed spaces may include external wall *cavities*, suspended ceilings, *roof spaces*, chimneys, utility *ducting* or space under floors and behind *cladding*. *Combustible insulation* used in wall *cavities* and *insulated panels* can contribute to undetected firespread. Fire involving the combustible core of *sandwich panels* and *structural insulated panels (SIPs)* may result in elements of the panel failing, which may be a cause of partial or structural collapse.

Control measure – Identify and investigate fire in concealed spaces

Control measure knowledge

Recognise building design and construction materials, like the presence of *insulated panels* or *timber frame* construction, to identify concealed spaces – utilise site-specific information if available. Early investigation of such features reduces the risk of firespread both within the concealed space and to other areas of the structure.

Electrical fittings like sockets or switches may provide signs, such as blackening around the area of firespread within a wall cavity. Damage to panels, from fire or other causes, may indicate the type of *insulation* used in their construction and allow the risks associated with the particular type of panel to be assessed. Combustible *sandwich panels* may cause dense, corrosive and toxic smoke. However, it is important to consider that a single building may feature more than one type of *sandwich panel*.

It may be difficult to identify the structural elements and materials of the building if they are hidden behind *cladding*.

Control measure actions

- Identify *cavities* and *insulation* materials that may enable firespread
- Consider using thermal imaging cameras to determine the location and spread of fire. They may provide useful information, but proceed with caution as temperatures may be masked by certain types of material, such as *insulated panels*.
- Pay attention to:
    - The ongoing status of the *fire detection* system

  - Further *alarms*
  - *Alarms* activating remotely from the initial zones
- Consult with the *Responsible Person*
- Check adjacent compartments for signs of firespread
- Identify firespread in voids and *cavities* by cutting away and opening up for examination
- Consider the building's construction type and evaluate possible early partial or structural collapse
- Evaluate whether and when to evacuate the building
- Investigate unexplained smoke remote from the seat of the fire
- Examine *ducting* or heating, *ventilation* or *air-conditioning* outlets for heat or smoke

Control measure – Access the concealed area

Control measure knowledge

Inspection covers or *doors* may give access to a concealed area if firespread is suspected. Lifting floorboards or ceiling tiles and opening loft access hatches may allow access to under the floor or above the ceiling areas. Other techniques like cutting away or removing areas of *brickwork* to expose wall cavities may be required. To avoid the risk of electrocution or damaging pipework, isolate utilities before accessing concealed areas. Concealed areas may contain hazardous materials such as asbestos.

Control measure actions

- Identify the location of potential firespread in concealed areas
- Consider the impact on structural stability before cutting away
- Isolate utilities before cutting away, having liaised with the *Responsible Person* to ensure fixed installations will not be affected
- Consider the presence of hazardous materials and implement appropriate personal protective equipment (PPE) and respiratory protective equipment (RPE)
- Use appropriate methods to cut away to gain access to or expose the cavity or concealed area for inspection
- Ensure there is no firespread beyond the concealed area
- Consider using specialist teams and equipment
- Ensure availability of appropriate firefighting media
- Avoid the unintentional creation of flow paths that could worsen the firespread

Control measure – Consider the effects of ventilation

Control measure knowledge

Natural or mechanical *ventilation* could have a considerable effect, and may intensify the speed of firespread through a concealed space. Identify sources of *ventilation* and evaluate and monitor potential effects on fire development.

Control measure actions

- Identify appropriate locations for suitable and sufficient firefighting media
- Consider designating safety officers to evaluate changes in fire behaviour, in particular smoke issuing under pressure
- Control the flow path of *ventilation*

Further reading
Leo's Supermarket (Avon Fire and Rescue Service, 1996)
Sun Valley Limited (Hereford and Worcester Fire and Rescue Service, 1993)

Firespread within a compartment

Hazard	Control measures
Firespread within a compartment	Apply generic control measures [as detailed for the hazard of 'Fires in the built environment'] Identify and consider the impact of wall linings

Hazard knowledge

Wall linings may impact on fire development within a compartment. This hazard should be read in conjunction with the Fires and Firefighting guidance, which contains information about fire loading, fire development and compartment firefighting.

The Building Regulations cannot control the effects a permanent resident may have on a building with regard to fire safety. For example, the resident may have installed decorative wall and ceiling *linings* made from materials such as timber, plastics or polystyrene.

The *spread of flame* across the wall lining of a compartment may not be predicted during a fire, and may contribute significantly to firespread and the creation of toxic fumes.

Control measure – Identify and consider the impact of wall linings

Control measure knowledge

Along with general considerations regarding compartment fire behaviour, the presence of wall *linings* and the type of material used may directly influence the speed and intensity of fire development. A lack of building controls regarding *substrate* material selection can lead to significant effects on the spread of fire and rate of fire growth within an area.

Control measure actions

- Identify the presence and type of wall *linings* and *substrate*
- Consider the impact on fire behaviour (speed and intensity of development) and implement appropriate firefighting tactics.

Firespread breaching a compartment

Hazard	Control measures
Firespread breaching a compartment	Apply generic control measures [as detailed for the hazard of 'Fires in the built environment'] Identify compartmentation Secure access and egress routes Survey adjacent areas or compartments

Hazard knowledge

Fire will breach a compartment when there is a failure of an element or elements of *compartmentation*, either through the period of fire development or because inappropriate building methods or materials have been used. Firefighters are trained to interpret individual rooms within a building as 'compartments' although this does not necessarily constitute true *compartmentation*. Factors that may result in a breach of *compartmentation* include:

- Retrofitted cabling or pipework with ineffective *fire stopping*
- Failure of devices such as *collars* or *dampers* that are designed to stop the spread of smoke and/or heat
- Severity of fire within the compartment
- Duration of fire development
- Interference with integral fire safety provisions, for example, wedged *fire doors*
- Firefighting tactics

Control measure – Identify compartmentation

Control measure knowledge

Fire compartmentation of a building is provided by fire-resisting construction with the aim of preventing or delaying the spread of fire and smoke from one space within a building to another. Occasionally this includes limiting external firespread from the building.

Dividing spaces into cells or compartments, or separating the buildings by walls and floors constructed as compartment walls and compartment floors, can restrict firespread within buildings. Factors like occupancy, fire loading, height to top storey and the presence of *sprinklers* can affect the level of *compartmentation*. Together these factors determine evacuation needs in a fire.

The effectiveness of *fire compartmentation* relies upon good workmanship at installation and a good state of repair. Penetrations that are not fire stopped, defects or a lack of maintenance can lead to the early failure of *compartmentation*. The state of *compartmentation* in the building should be investigated.

Compartmentation is particularly relevant in residential buildings as the occupants of a house need to be reasonably protected from a fire in an adjoining house – walls separating one house from another need to be compartment walls. The same applies to occupants of flats and maisonettes.

Fire doors are installed at strategic locations in a building, where passage through a line of fire resisting construction is required. Not all *doors* within a building are *fire doors*, but *general purpose doors* may carry some inherent fire-resisting properties.

Where there are not enough fire-resisting elements, such as *doors* or separation not designed to provide a level of fire protection, fire may spread beyond the compartment.

Control measure actions

- Consider areas of *compartmentation* like *fire doors*, means of escape and protected shafts using site-specific information, building plans or visual indications
- Maintain the integrity of *compartmentation* as far as possible when carrying out firefighting operations. Avoid opening and wedging *doors*, unless part of a considered firefighting tactic.
- Investigate for indications of early failure of *compartmentation* elements and ensure the availability of sufficient firefighting media

Control measure – Secure access and egress routes

Control measure knowledge

To prevent escape routes becoming compromised, *compartmentation* and suitable access and egress routes for firefighting teams should be identified and maintained. Buildings may have a fire strategy, which will include the procedure and designated evacuation routes.

Control measure actions

- Identify appropriate access and egress points to and from the scene of operations, utilising building plans where available
- Consult with the *Responsible Person* to identify the fire strategy and potential evacuation routes
- Evaluate the impact of firespread on the evacuation procedure and consider alternative actions
- Consider appointing firefighting team(s) to protect routes – Fires and Firefighting guidance
- Ensure access and egress routes are not compromised by firefighting actions
- Consider the use of positive pressure ventilation (PPV) to pressurise evacuation routes such as stairwells
- Consider providing alternative means of access or escape

Control measure – Survey adjacent areas or compartments

Control measure knowledge

If there are breaches in protection, fire may spread. Identify areas or compartments surrounding the fire, including concealed spaces such as wall *cavities*. Also inspect openings made in walls or ceilings to accommodate retrofitted services to check *fire stopping*.

Collars are devices designed to prevent fire and/or smoke passing through pipework, through a line of fire-resisting construction. They may be fire *dampers* or smoke and fire *dampers*, designed to prevent the passage of fire, or smoke and fire respectively.

Control measure actions

- Consider building design and construction, including the presence of domestic chimneys
- Investigate any floor levels directly above, below or adjacent to the suspected fire compartment, paying particular attention to breaches of compartmentation and the effectiveness of *fire stopping*
- Consider using thermal imaging cameras
- Consider compartment boundary cooling techniques to maintain the integrity of *compartmentation*

Further reading
Telstar House (London Fire Brigade, 2003)
Rosepark Care Home (Strathclyde Fire and Rescue Service, 2004)

External firespread

Hazard	Control measures
External firespread	Apply generic control measures [as detailed for the hazard of 'Fires in the built environment'] Carry out external surveys Co-ordinate external and internal activity Provide external protection

Hazard knowledge

If the fire is sufficiently intense it may breach the external envelope of the building. This may be a result of external window *glazing* or wall panels failing, or via open *windows*. External firespread may compromise compartments above the fire floor, or floors at other levels of the building. Firespread may also occur from an external source such as refuse, vehicles or adjacent premises.

Climatic conditions, such as wind strength and direction, may impact on external firespread. Further information about fire phenomena, which may impact on external firespread, can be found in the Fires and Firefighting guidance.

Figure 1: External firespread
Source: Building Research Establishment

Control measure – Carry out external surveys

Control measure knowledge

Evaluating the likelihood and impact of external firespread requires an appropriate understanding of the building design, construction materials and status of the fire. Depending on the building, site-specific information may be available to indicate construction materials and *compartmentation*.

Falling combustible *cladding* may cause firespread to floors below the original or primary seat of the fire.

Control measure actions

- Identify breaches in *windows* and external wall panels or open *windows*
- Check that any external firespread has not compromised the structural elements or *compartmentation* of the building
- Look for indications that the building has external *cladding*
- Investigate and monitor areas surrounding buildings adjacent to the fire, looking for visible signs of fire
- Consider using thermal imaging cameras, including those fitted to police helicopters, whilst taking any limitations in their use into account
- Include floor levels directly above or below the suspected fire compartment in any investigations
- Identify any sources of renewable energy, like *photovoltaic panels*, which may facilitate firespread and/or fall from height

Control measure – Co-ordinate external and internal activity

Control measure knowledge

To limit firespread or prevent internal conditions deteriorating, it may be necessary to direct external hose lines or monitors into compartments. It is essential that any external activity does not compromise the safety of personnel operating inside the building – internal and external activities should be risk assessed and strictly co-ordinated.

Control measure actions

To prevent external activities compromising firefighter safety and internal operations, make sure effective communications are provided for co-ordinating personnel.

Control measure – Provide external protection

Control measure knowledge

To limit firespread or prevent internal conditions deteriorating, external firefighting tactics and various types of firefighting media may be needed – refer to the Fires and Firefighting guidance. The resources required to provide external protection should be understood, and any impact on safety should be appraised, before proceeding.

Control measure actions

- Provide early protection of external boundaries to prevent firespread, flame extension and radiant heat
- Consider the impact of climatic conditions, for example wind strength and direction
- Evaluate different types of firefighting media and firefighting tactics to establish what is appropriate for the task – refer to the Fires and Firefighting guidance
- Consider removing external fire loading

Cable entanglement

Hazard	Control measures
Cable entanglement	Apply generic control measures [as detailed for the hazard of 'Fires in the built environment'] Isolate the electricity supply Identify whether lightweight conduit, trunking and cable fixings are present Avoid the areas or secure/remove any loose cabling

Hazard knowledge

Electrical and data *cables* are used extensively in buildings, with an increased reliance on surface mounted conduit and trunking during installation.

Plastic conduit or trunking that is surface mounted on ceilings and walls will fail at relatively low temperatures (more than 100°C). Thin section aluminium trunking may also fail.

When the conduit or trunking fails, *cables* may be released. Because this can occur at relatively low temperatures, *cables* may drop some distance from the seat of the fire and may hang down, presenting a risk of entanglement and/or electrocution. Hanging *cables* pose a significant hazard for firefighters and have contributed to firefighter deaths in the past. This hazard should be considered in any building with an electrical supply.

Figure 2: Cables dislodged from suspended ceiling fixings following a fire in compartment
Source: B. Massie, Merseyside Fire and Rescue Service

Control measure – Isolate the electricity supply

Control measure knowledge

Large or complex sites or buildings may have more than one electrical intake. If electricity is being extracted illegally, it may be difficult to isolate the supply. It may also be difficult to isolate the electricity supply if there is a *photovoltaic* system present.

Site-specific information may provide the relevant information, as could liaising with the *Responsible Person*. Specialist advice on zone or area isolation may be required for large buildings.

Control measure actions

- Establish the location of the electrical intake and how the supply can be safely isolated
- Consider isolating the electricity supply at the earliest opportunity to mitigate the risk of electrocution, but make sure the wider impact of isolation on the incident is understood before proceeding
- Consider specialist advice from the electricity supplier or National Grid before proceeding

Control measure – Identify whether lightweight conduit, trunking and cable fixings are present

Control measure knowledge

Electrical upgrades and retrofitting additional electrical sockets, light fittings, security or fire alarms and data cables mean that lightweight cable fixings may be more common in older buildings. Cabling may also be concealed above suspended ceilings, with little or no fixing. Suspended ceilings may also become distorted or fail at relatively low temperatures.

Control measure actions

- Identify or confirm the presence of lightweight conduit, trunking and cable fixings and consider the likelihood that they will fail
- Consider inspection above suspended ceilings to identify or confirm the presence of unsecured *cables*

Control measure – Avoid the areas or secure/remove any loose cabling

Control measure knowledge

Before touching or securing damaged *cables*, isolate the electrical supply. Ensure any alternative route is safe before proceeding.

Control measure actions

- Consider the controlled release of *cables* from trunking or fixings if they may be affected by heat and become loose
- Identify alternative access and egress routes to avoid contact with loose *cables*
- Secure loose *cables* by suitable means and consider removing them if the electricity supply has been isolated and secured
- Consider using specialist equipment, such as anti-entanglement covers/straps and cable cutters

Further reading
Harrow Court (Hertfordshire Fire and Rescue Service, 2005)
Shirley Towers (Hampshire Fire and Rescue Service, 2010)
Fire and Rescue Service Immediate Bulletin 4/2011

Partial or structural collapse

Hazard	Control measures
Partial or structural collapse	Apply generic control measures [as detailed for the hazard of 'Fires in the built environment'] Look for signs of collapse Position cordons appropriately Maintain safe access and egress

	Take preventative action Make a tactical and controlled withdrawal

Hazard knowledge

Behaviour of structural materials

Elements of construction may distort or fail at different temperatures and speeds, depending on how the various construction materials have been used or combined. This can result in varying stages and severity of collapse.

Degrees of collapse

Lightweight or fragile building features may collapse including, for example, non-structural elements like conservatories or felt *roofs*.

Floors, *walls*, ceilings, ancillary features, fixtures and fittings can partially collapse. Partial collapse can follow on from the failure of lightweight or decorative features. This may expose elements of the structure and, if not controlled, a structural collapse may follow.

Figure 3: Structural collapse of building
Source: Building Research Establishment

Control measure – Look for signs of collapse

Control measure knowledge

An appropriate understanding of building design and construction materials, and the effects of the fire and firefighting activity both internally and externally will help identify and evaluate signs of collapse.

Control measure actions

- Look for signs of collapse, which may include:
  - Cracks in *walls*
  - Sagging *floors* or *floors* deflecting from wall
  - Displaced *columns*
  - Dropping *arches*

  - Bulging *walls*
  - Buckling *columns* or *beams*
- Consider seeking specialist advice from a structural engineer or tactical adviser
- Monitor the effects of firefighting activity. For example, if there is little or no water run-off this may indicate that the structure is holding an increased load, which may result in collapse.

Control measure – Position cordons appropriately

Control measure knowledge

When positioning cordons, construction materials, the height of the building and weather conditions should be taken into account. The wider impact of collapse, such as damage to surrounding premises, the environment, utilities and infrastructure, should be considered. Implement appropriate cordon distances when mitigating the hazard of an entire building collapse.

In the UK, a *portal or rigid frame* construction is designed for inward collapse – in a fully developed fire a basic single storey structure may be expected to collapse within 30 minutes. *Portal frame* structures are generally designed so that if they collapse they do so within their own footprint.

Glass (*glazing*) or other flat panels falling from height may travel significant distances from the building, particularly in windy conditions. Cordon distances should be set accordingly.

Control measure actions

- Assess the likelihood and impact of any collapse, including objects falling from the building, when establishing cordons
- Continually re-evaluate cordon distances, particularly as the incident develops or if there are adverse weather conditions
- Consider taking specialist advice on cordon positioning from a building surveyor, tactical adviser or other subject matter expert

Control measure – Maintain safe access and egress

Control measure knowledge

The location of the point of access, in relation to the fire and its impact on structural elements, should be considered. Safe access and egress points may be identified by recognising construction materials that have been or are likely to be affected by fire, and predicting the likelihood and impact of collapse. It may not be safe to commit personnel into the building.

Control measure actions

- Do not commit personnel into the building if it is considered unsafe to do so
- Consider the location of the point of access in relation to the fire and any impact of collapse
- Consider alternative means of access, like using ladders
- Consider establishing an additional point or method of egress to avoid the area involved and

ensuring it remains usable

Control measure – Take preventative action

Control measure knowledge

Consider preventative action to minimise the potential impact of a fire on the inherent structural stability of a building. Preventative action may include cutting away *cladding* to expose concealed areas or using sprays to reduce temperatures. Partial collapse may expose structural elements to fire or heat and therefore speed up the potential for further collapse.

Control measure actions

- Consider using cooling sprays/protective media
- Consider using thermal imaging cameras
- Consider cutting away and opening up to expose and inspect structural elements to check whether they have been affected by fire
- Consider seeking specialist advice from a structural engineer or tactical adviser

Control measure – Make a tactical and controlled withdrawal

Control measure knowledge

If the potential for collapse is recognised, an overall appreciation of the areas affected and the deployment and proximity of personnel should inform the decision on the scale of withdrawal.

Control measure actions

- Identify or establish an evacuation strategy and communicate this to the relevant people
- Identify the locations of personnel and the tasks being undertaken
- Consider a timely and appropriate level of withdrawal
- Implement immediate and full withdrawal if necessary

Further reading
Atherstone on Stour (Warwickshire Fire and Rescue Service, 2007)

Fixed installations fail, or are operated inappropriately

Hazard	Controls
Fixed installations fail, or are operated inappropriately	Apply generic control measures [as detailed for the hazard of 'Fires in the built environment'] Liaise with the Responsible Person Give authority to operate or alter fixed installations

Hazard knowledge

Personnel should assume that fixed installations are functioning correctly unless there are indications they are not, and should adjust the dynamic risk assessment accordingly. Fixed installations are designed to perform a specific function and for a range of purposes including:

- Protecting lives
- Firefighting and fire suppression
- Building protection
- Environmental protection

Fixed installation and *facilities for firefighters* may include the following:

- A *firefighting shaft* is a protected enclosure provided for attending firefighters containing a firefighting stair and firefighting lobby
- *Fire mains* are provided in buildings to ensure firefighting water supplies can be provided from outside the building to various strategic locations inside the building
- A *firefighting lift* is designed to operate, so long as it is practicable to do so, when the building fire is beyond the confines of the firefighting shaft. It is used to transport firefighters and their equipment to a floor of their choice.
- *Fixed communication systems* are normally provided in large or complex buildings and underground structures. They are provided to support firefighter communications where standard radios may be compromised.
- *Fire detection* systems offer the means to detect fire, heat and smoke in a building. Various types of detection mechanism may be present in a building.
- *Sprinkler systems* are designed to apply water to a fire once temperatures within the local area have reached a threshold temperature, causing sprinkler heads to activate. Only sprinkler heads that are exposed to the required elevated temperature will activate. Sprinklers are connected to a water supply, commonly a sprinkler tank, sprinkler pump set, sprinkler valve sets and network of pipes.
- Other fixed installations include *ventilation* systems, *foam*, *steam*, *drenchers*, *water mist*, *dry powder*, *oxygen-reduction (Redox)* and CO^2

Systems may already be operating before the fire and rescue service arrives, or they may not be functioning because of poor maintenance or defective design or installation. If systems are not operating correctly the incident may be more hazardous and/or arduous. Firefighting tactics may influence the effectiveness of any fixed installations, such as the efficiency of mechanical smoke controls following gas cooling techniques. Refer to the Fires and Firefighting guidance for detail on firefighting tactics.

The incident commander should seek advice on fixed installations from the *Responsible Person*.

Control measure – Liaise with the Responsible Person

Control measure knowledge

Pre-planning should be carried out to identify the types of fixed installations installed. This should determine good practice and alternative actions in the event of failure or inappropriate operation, and the *Responsible Person* should be involved if required. This may include the use of aerial appliances, hose lines as temporary rising mains and supplementary water supplies. The impact of these actions on resources should be considered.

Control measure actions

- Liaise with the *Responsible Person* and identify whether fixed installations are present, and their purpose, for example life safety or building protection
- If the system is operating, evaluate its effectiveness
- If fixed installations are not operating appropriately, consider using alternative or supplementary methods or tactics

Control measure – Give authority to operate or alter fixed installations

Control measure knowledge

Incident ground operations should include steps to ensure that no adjustments are made to fixed installations during the incident without authority of the fire and rescue service. It is essential to assess the situation before altering the state of the fixed installation – if the situation is under control or is improving, do not change the state of the fixed installation.

Fixed installations, such as *sprinkler systems*, should only be altered or switched off under direct instruction of the incident commander. The incident commander should first satisfy themselves that this will not increase the severity of the fire or worsen conditions for firefighters. Local familiarisation to confirm location of the water supply and sprinkler valve sets is recommended.

Control measure actions

- Consider requesting specialist advice before attempting to alter or disable any fixed installation
- Appoint appropriate personnel to manage the controls for the fixed installation, such as valves and switches
- Controls for fixed installations should not be altered unless the fire is under control, and only on the direct instruction of the incident commander
- Consider isolating the sprinkler alarm to improve fireground communications, when appropriate
- Consider the impact of large volumes of water (for example, damage and/or the environmental effects of water run off)

Further reading: Digital Equipment Limited (Hampshire Fire and Rescue Service, 1990)

Complex fire engineering

Hazard	Controls
Complex fire engineering	Apply generic control measures [as detailed for the hazard of 'Fires in the built environment'] Carry out information gathering Identify firefighting access points Use integral communications

Hazard knowledge

Buildings with complex fire engineering solutions rely on pre-planning by the local fire and rescue service to identify systems and establish a site-specific plan or procedure.

Complex fire engineering has been identified as a specific issue that needs to be considered in this guidance as a wide variety of approaches are permitted. These varied approaches mean that buildings may behave in a range of ways during the course of a fire – most are consistent with the behaviour of a 'traditional' or 'Approved Document B' building, but some may behave significantly differently.

For example, a building incorporating an innovative *smoke control* system may be capable of forcing smoke to move in directions that are not expected by attending firefighters. Equally, firefighting attack that makes heavy use of gas cooling may have an adverse effect by reducing the buoyancy of the smoke and dropping it beneath the system's zone of operation.

Fire engineering is defined by the Institution of Fire Engineers as:

"… The application of scientific and engineering principles, rules [codes], and expert judgment, based on an understanding of the phenomena and effects of fire and of the reaction and behaviour of people to fire, to protect people, property and the environment from the destructive effects of fire."

Approved Document B makes the following statement regarding fire engineering:

"Fire safety engineering can provide an alternative approach to fire safety. It may be the only practical way to achieve a satisfactory standard of fire safety in some large and complex buildings and in buildings containing different uses, e.g. airport terminals. Fire safety engineering may also be suitable for solving a problem with an aspect of the building design which otherwise follows the provisions in this document.

British Standard BS 7974 [Fire safety engineering in buildings] and supporting published documents (PDs) provide a framework and guidance on the design and assessment of fire safety measures in buildings. Following the discipline of BS 7974 should enable designers and Building Control Bodies to be aware of the relevant issues, the need to consider the complete fire-safety system and to follow a disciplined analytical framework.

Factors that should be taken into account include:

a. *the anticipated probability of a fire occurring*
b. *the anticipated fire severity*
c. *the ability of a structure to resist the spread of fire and smoke*
d. *the consequential danger to people in and around the building*

A wide variety of measures could be considered and incorporated to a greater or lesser extent, as appropriate in the circumstances. These include:

a. *the adequacy of means to prevent fire*
b. *early fire warning by an automatic detection and warning system*
c. *the standard of means of escape "Structural means whereby [in the event of fire] a safe route or routes is or are provided for persons to travel from any point in a building to a place of safety."*
d. *provision of smoke control*
e. *control of the rate of growth of a fire*
f. *structural robustness and the adequacy of the structure to resist the effects of a fire*
g. *the degree of fire containment*
h. *fire separation between buildings or parts of buildings*
i. *the standard of active measures for fire extinguishment or control*
j. *facilities to assist the fire and rescue service*
k. *availability of powers to require staff training in fire safety and fire routines*
l. *consideration of the availability of any continuing control under other legislation that could ensure continued maintenance of such systems*
m. *management*

It is possible to use quantitative techniques to evaluate risk and hazard. Some factors in the measures listed above can be given numerical values in some circumstances. The assumptions made when quantitative methods are used need careful assessment."

Fire safety engineering uses calculations and quantitative data on numerous topics including:

- Ignition
- Fire growth
- Compartment fire behaviour
- Production of smoke and toxic gases
- Structural response
- Fire detection
- Fire suppression
- Human behaviour
- Firefighting

The *Responsible Person* must ensure that facilities provided for fire and rescue service personnel are maintained effectively and make information about their operation available.

Systems are interdependent – if one element fails it is likely to affect other elements. Fire and rescue service personnel should consider the following when attending buildings with fire engineering solutions:

- Extended travel distances to the scene of operations
- Larger compartments
- Specific access location for fire and rescue service personnel
- Fixed installations
- Complex smoke/heat control systems

Control measure – Carry out information gathering

Control measure knowledge

Information on the presence and status of fire engineering solutions and associated fixed installations should be available from the *Responsible Person*, the building's *fire control room* or from pre-planned, site-specific information.

A reliable means of *fixed communications* for firefighters may be installed throughout the building. Where provided, it should be connected with the building's *fire control room*.

Control measure actions

- Liaise with the *Responsible Person* or specialist for information and the status of fire engineering solutions
- If available, consider using the building's *fire control room* facilities to inform progress on the tactical plan and the effectiveness of the building's facilities
- Identify the potential benefits of systems and any hazards that may arise due to operation or non-operation during a fire

Control measure – Identify firefighting access points

Control measure knowledge

The fire and rescue service initial fire appliance should attend the specific access point and make use of integral communication facilities and/or the building's *fire control room*. Specific access points may determine the location of any rendezvous point (RVP) or *bridgeheads* (forward BA entry control points) required.

Control measure actions

- Report to designated firefighting access points on arrival

Control measure – Use integral communications

Control measure knowledge

In large, complex or fire-engineered buildings a reliable means of communicating from the fire service access level to all *firefighting lobbies* is needed, such as a fire telephone. Where fire telephone handsets are provided they should be located at strategic points. For example, they may be located at each building entrance, in *firefighting lobbies* or in the building's *fire control room* and should be permanently-fixed equipment.

Firefighters will normally use personal radio sets for communicating with each other and with their own command points. However, personal radio sets have disadvantages, such as occasional poor reception due to local screening or limited battery life. The building may have a fire and rescue service compatible leaky feeder radio signal booster system installed.

Control measure actions

- Identify pre-planned information to determine the location and suitability of *fixed communications system* like leaky feeders, refuge communications or public announcement systems
- Be aware that the system may have a dual use – for example, it may also be used by people in refuge areas
- Exercise caution when using *fixed communications systems*, as people other than fire and rescue service personnel may also use them
- Do not broadcast sensitive information using these systems, for example, about casualties or fatalities

Design features causing delayed intervention

Hazard	Control measures
Design features causing delayed intervention	Apply generic control measures [as detailed for the hazard of 'Fires in the built environment']
	Use of forcible entry
	Maintain safe access and egress
	Control fixed installations and integral communication systems
	Identify appropriate location(s) for a bridgehead (forward BA entry control point)
	Confirm the occupier evacuation policy or strategy
	Consider how time delays may affect incident development

Hazard knowledge

Gaining access to the location of a fire within large, complex or secure buildings due to travel distance or security measures, may significantly delay firefighting operations. This delay may contribute to, or result in, increased fire development. Security measures in premises such as places of lawful detention or banks may also restrict access, resulting in delay.

Buildings with *basements* or windowless areas can have restricted access and may only contain a single point of access. Size, construction and internal layout can mean that incident ground communications may also be challenging.

Control measure – Use of forcible entry

Forcible entry may be used to gain access to a building in an emergency when normal means of entry are locked, secured, obstructed, blocked or unable to be used. Refer to the Fires and Firefighting guidance for control measure knowledge and actions if the use of forcible entry is required.

Control measure – Maintain safe access and egress

Control measure knowledge

Safe routes for accessing the scene of operations should be identified, taking account of *compartmentation* and other engineered solutions. These routes should be monitored and maintained.

Premises with enhanced security may have features that could delay assessment and subsequent firefighting operations. These features may include:

- *Security doors* or glazing
- Reinforced *walls*
- One way access *doors* (that can only be opened by a key from the secure side)
- Control lobbies or holding areas under electronic door control
- Time delay locks
- Limited access and egress routes
- Limited firefighting facilities in older premises
- Entry control systems

Control measure actions

- Liaise with the *Responsible Person* to determine the location and operation of any door locking arrangements
- Consider requesting an override of door locks or positioning on-site staff or personnel to secure access and egress
- Ensure incident ground personnel are aware of the designated access and egress routes

Control measure – Control fixed installations and integral communication systems

Control measure knowledge

In large or complex buildings, fixed installations like *sprinkler systems* may be operating, and may be able to suppress and contain a fire within a compartment while access is gained to the location of the fire and firefighting can commence. Fixed installations, such as sprinklers, should only be altered or switched off under direct instruction of the incident commander. The incident commander should first satisfy themselves that this will not increase the severity of the fire or worsen conditions for firefighters.

Facilities for firefighters like *fire mains* and *firefighting lifts* should be identified. *Lifts*, including *firefighting lifts*, may be used as part of the building evacuation policy. *Fixed communication systems* may be provided in large or complex buildings and underground structures to support firefighter communications where standard radio communications may be compromised. Integral communications such as refuge communication systems may not be exclusively used by the fire and rescue service.

Control measure actions

- Liaise with the *Responsible Person* or specialist for information

- On arrival, identify whether fixed installations are present and operational
- Ensure control of systems like *sprinkler systems* and *ventilation*
- Commandeer and control *firefighting lifts*, while considering their wider use for evacuation purposes
- Ensure the appropriate *fire main* is charged and maintained to the scene of operations
- Identify and use *fixed communication systems* to enhance incident ground communications, but note that sensitive information, for example about casualties or fatalities, should not be passed on dual use systems.

Control measure – Identify appropriate location(s) for a bridgehead (forward BA entry control point)

Control measure knowledge

A *firefighting shaft* is a protected enclosure provided for attending firefighters, containing a firefighting stair and *firefighting lobby*. If a *lift* is provided, this may or may not be a *firefighting lift*. These features are provided to assist firefighters and should be considered when deciding on an appropriate location for a *bridgehead*.

The term bridgehead is defined in the Operational Guidance: Breathing apparatus as:

"This may be considered necessary by the Incident Commander in situations where there is a requirement to provide a BA entry control point at some distance from the initial point of access into a building or risk area, whilst still remaining in a safe air environment.

This arrangement allows an incident to be dealt with through the deployment of BA wearers from a safe air environment within a structure whilst being as close as practical to the scene of operations. This may be necessary for example in high-rise buildings or in large complex structures such as shopping malls.

The location of the BA entry control point in these circumstances will be determined by the Incident Commander based on the operational plan and the level of risk faced by the BA wearers.

Some of the factors that should be taken into account when determining the location of a bridgehead or forward BA entry control point are:

- *The potential for an escalation of the incident*
- *The safe air environment necessary to start up BA*
    - *The best access and egress routes to the scene of operations*
    - *Crew safety and welfare*
    - *Availability of water supplies*
    - *Effective communication with BA wearers*
    - *Effective communication with the incident commander*
    - *The level of supervision and support necessary for the BA Entry Control Operative*
    - *The distance from the initial point of access to the BA entry control point"*

Control measure actions

- Identify *firefighting shafts*, *firefighting lobbies* and other elements of fire protection when determining the suitable location for the *bridgehead*
- Consider the likely development of the incident when positioning the *bridgehead* and protect these areas to prevent the *bridgehead* being compromised by fire or smoke
- Ensure that the *bridgehead* is in close proximity to sufficient water supplies or *fire main*
- Identify evacuation policy and consider the evacuation route of occupants
- Consider establishing a staging area (internal sectorisation) for resources on a floor(s) below the *bridgehead*

Control measure – Confirm the occupier evacuation policy or strategy

Control measure knowledge

To determine the evacuation policy, liaise with the *Responsible Person*. Consider the impact of *phased evacuation*, occupants exiting along firefighting access routes, and exposure to potential hazards. Evacuation strategies may need to be revised to maintain the safety of occupants.

Control measure actions

- Identify the evacuation strategy and potential evacuation routes
- Evaluate the impact of an evacuation on operations
- Locate firespread and smoke boundaries to ensure the safety of evacuating occupants
- Consider the use of positive pressure ventilation (PPV) to pressurise egress routes such as stairwells

Control measure – Consider how time delays may affect incident development

Control measure knowledge

Any delay in accessing the location of the fire and commencing firefighting may have an impact on fire development and therefore the severity of the incident. Tactical plans should anticipate incident escalation and the resources that are required to resolve this safely and effectively.

Control measure actions

- Anticipate fire development and the escalation of the incident
- Consider resource requirements in line with the tactical plan

Glossary

Term	Acronym (if applicable)	Description
Closed-circuit television	CCTV	System used to produce images or recordings for surveillance purposes, and can be either video cameras, or digital stills cameras

Term	Acronym (if applicable)	Description
Dynamic Risk Assessment	DRA	A risk assessment process that is used in a dynamic environment
Envelope		The perimeter of a building is referred to as an envelope
Fire loading		The fire loading of a building or compartment is a way of establishing the potential severity of a hypothetical future fire. It is the heat output per unit floor area, often in kJ/m^2, calculated from the calorific value of the materials present.
Personal protective equipment	PPE	Personal protective equipment includes items such as fire tunics, over-trousers, helmets, fire hoods, gloves and boots. Enhanced 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. The effect of using the fan will be to increase the pressure inside the building relative to atmospheric pressure.
Premises information box		Premises information boxes contain key information that will be needed by fire and rescue crews at the time of an incident. The information should be simple and usable with the following being the essential items: • Operational contingency plans • Simple plans and or schematic representations of the building and information about equipment or fixed installations, such as the design and functions provided for means of escape or firefighting operations • Basic operating instructions for fire protection and fixed firefighting equipment
Rendezvous point	RVP	After initial response, emergency services personnel attending an emergency or major incident should be directed to a designated rendezvous point.
Respiratory protective equipment	RPE	Respiratory protective equipment includes breathing apparatus, particle masks and respirators
Responsible Person		The Fire Safety Order details the duties of a Responsible Person for carrying out a fire risk assessment and ensuring the building is suitably safe for all relevant persons
Safety officer		Safety officers are appointed by the incident commander. They will be located at points which provide them with overall view and control of the inner cordon and scene of operations.
Seat of the fire		Origin of the fire
Site-Specific Risk Information	SSRI	The process of collecting operational risk information for buildings to identify those where the availability of accurate, relevant and timely information may be of value for any reasonably foreseeable incident.
Situational awareness		The perception and understanding of a situation and the anticipation of how the situation may develop in the near future
Structural		Relating to a load-bearing element of a building
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.
Urban Search and	USAR	Urban search and rescue locate, extricate and provide initial

Term	Acronym (if applicable)	Description
Rescue		medical stabilisation of casualties trapped due to structural collapse, natural disasters, mines or collapsed trenches

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Further reading

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