National Operational Guidance Programme

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

Title:	Utilities and fuel
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Synopsis:	This 'context guidance' has been developed to assist fire and rescue services in identifying hazards and implementing control measures at operational incidents where utility or fuel supplies might need to be managed or controlled. Because of similarities in the production, storage and distribution of utilities, this guidance also covers generic hazards for the fuel industry.
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National Operational Guidance – Utilities and fuel first edition version one (ARCHIVED on 20-09-2017)

Introduction

This 'context guidance' has been developed to assist fire and rescue services in identifying hazards and implementing control measures at operational incidents where utility or fuel supplies might need to be managed or controlled.

The guidance deals with utility or fuel supplies at operational incidents, from the point of generation or production through to the point of supply to the customer.

Because of similarities in the production, storage and distribution of utilities, this guidance also covers generic hazards for the fuel industry. However, in accordance with the structure of the National Operational Guidance framework, any hazards relating to specific fuel types will be dealt with in the guidance for hazardous materials.

This guidance does not deal with fire and rescue service operations such as incident command, fires and firefighting, performing rescues or environmental protection; other National Operational Guidance deals with those activities.

This guidance is supported by supplementary information that provides further detail on individual subject areas.

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 consider all stakeholders, including local emergency planning groups and the fire and rescue service risk management plan.

Responsibility of fire and rescue services

Fire and rescue services are responsible, under legislation and regulations, for developing policies and procedures and to provide information, instruction, training and supervision to their personnel about foreseeable hazards and the control measures used to mitigate the risks arising from those hazards.

This guidance sets out to provide fire and rescue services with sufficient knowledge about the potential hazards their personnel could encounter when attending any incident that involves managing utilities or fuel. Fire and rescue services should ensure their policies, procedures and training cover all of the hazards and control measures contained within this guidance.

Hazard and control statement

Hazards	Control measures
Dealing with utility or fuel supplies at an incident	Apply situational awareness Seek specialist advice or assistance for dealing

	with utilities or fuel Refer to Site-Specific Risk Information (SSRI) and emergency response plans for utility or fuel incidents Apply cordons and control for utilities or fuel Isolate utility or fuel supply to the premises Isolate utility or fuel supply within the national grid
Radiation (nuclear power generation)	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Implement hazardous materials procedures
Electricity	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Isolate and make safe electricity supplies Implement safe working practices in the proximity of high-voltage electricity Consider wearing electrical gloves
Overhead power lines and transmission towers	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Locate the correct identification number for the transmission tower
High-security features	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident')
Battery storage and uninterruptible power supplies (UPS)	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Isolate battery power supplies
Electrical standby generators	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies

	at an incident') Isolate standby generator
Overheating transformers and cooling systems	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Implement hazardous materials procedures
Presence of chemicals	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Implement hazardous materials procedures
Sulphur hexafluoride (SF6)	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Implement hazardous materials procedures
Polychlorinated biphenyls (PCBs)	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Implement hazardous materials procedures
Irrespirable atmospheres	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Implement hazardous materials procedures
Ground becoming live	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Make a safe withdrawal from ground affected by voltage
Vehicle becoming live	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Remain in the vehicle affected by voltage Make a safe withdrawal from the vehicle affected by voltage

Photovoltaic (PV) systems	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Isolate power at inverter
Renewable energy turbines	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Isolate the turbine
Underground utility incidents	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident')
Presence of wiring	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Implement breathing apparatus (BA) procedures
Dangerous wiring	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Adopt defensive tactics until the electricity supply is isolated
Illegal activity involving electricity	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Adopt defensive tactics until the electricity supply is isolated Share intelligence about illegal activity involving electricity
Luminous discharge tubes (‘neon’) signs	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Isolate power supply to luminous discharge tube signs
On-site alarms and warning systems	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident')

Exposure to extremes of temperature	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident')
Superheated steam and hot pipes	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Consider using thermal imaging or scanning
Flammable or explosive atmospheres	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Use intrinsically safe equipment Carry out atmospheric monitoring Control ignition sources
Pipeline failure	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Isolate pipelines Implement hazardous materials procedures
Pressurised storage vessels	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Implement hazardous materials procedures
Confined space entry	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident')
Water holding facilities	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Implement working near water procedures Identify and control the hazard area around a water holding facility

Dealing with utility or fuel supplies at an incident

Hazard	Control measures
Dealing with utility or fuel supplies at an incident	Apply situational awareness Seek specialist advice or assistance for dealing with utilities or fuel Refer to Site-Specific Risk Information (SSRI) and emergency response plans for utility or fuel incidents Apply cordons and control for utilities or fuel Isolate utility or fuel supply to the premises Isolate utility or fuel supply within the national grid

Hazard knowledge

The generic control measures for this hazard should be considered when dealing with any incident where gas, electricity, water or fuel are present and may require safe management by the fire and rescue service.

Failure to control or manage utilities and fuel supplies at operational incidents could result in a significant increase in risk for responding fire and rescue service personnel, other responding emergency services, the public and the environment.

This guidance is supported by 'all-incident' National Operational Guidance; Incident command, Operations and Environmental protection.

Control measure – Apply situational awareness

Control measure knowledge

Situational awareness concerns the perception and understanding of a situation, along with anticipating how the situation may develop in the near future.

Understanding which utility or fuel needs to be managed and controlled, and the consequences of isolating and controlling those supplies, will assist the fire and rescue service in making safe, informed decisions.

Depending on the size and complexity of the incident, other agencies and utility response teams may attend, making effective joint working critical for safety on the incident ground.

For more information about shared situational awareness, refer to National Operational Guidance: Incident command – Organisation at an incident.

To make a judgment on the effective deployment of resources, fire and rescue services should be aware of the capabilities of the resources at the scene, the specialist knowledge available and the specialist equipment on-site and off-site.

Strategic actions

Fire and rescue services should:

- Carry out pre-planning site visits and inspections to gain risk information on utilities and fuel, which can be made available to responding personnel
- Participate in multi-agency exercises to test planning assumptions and familiarise fire and rescue service personnel with the utility and fuel industry

Tactical actions

Incident commanders should:

- Identify the presence of utilities or fuels and the location of relevant isolation points
- Consider site use and occupancy in relation to the presence of utilities or fuel
- Obtain information about utilities or fuel from the responsible person (or appointed competent person) for the site
- Obtain information from a scene survey
- Be aware of a possible rapid escalation of the incident, especially when dealing with petrochemical industries
- Consider the impact of current and forecast weather conditions, including wind direction and strength, on utilities or fuel supplies
- Share information with relevant third parties to assess the impact of dealing with utilities or fuel supplies

Control measure – Seek specialist advice or assistance for dealing with utilities or fuel

Control measure knowledge

Specialist advice or assistance, in-service or external, may be needed to deal with an incident involving utilities or fuel. This will give the fire and rescue service access to a range of information sources and expertise.

The extent and urgency of specialist advice or assistance required will be dictated by the size, complexity and type of incident.

Gas industry

In the UK, gas leaves the transmission system and enters the distribution networks at high pressure. It is then transported through a number of reducing pressure tiers until it is finally delivered to consumers. There are regional distribution networks – refer to the supplementary information for

the gas industry, liquefied petroleum gas (LPG) and liquefied natural gas (LNG).

Seek specialist advice or assistance from:

- Gas distributor for the area
- Gas supplier to the premises
- Gas industry helpline
- On-site personnel and management team
- Responsible person

Electricity industry

Electricity, in the main, is generated by large power stations. It is also produced by renewable energy facilities such as hydroelectricity sites, wind turbines and solar panels. Electricity generation can be described as micro-generation or mass generation.

Micro-generation refers to small wind turbines, solar panels, etc., whereas mass generation refers to large generating sites, such as power stations using fossil fuels or nuclear power.

Distribution network operators (DNOs) own and operate the towers and cables that deliver electricity from the national transmission network to homes and businesses. Electricity suppliers sell electricity to consumers.

Specialist advice or assistance may be required to isolate equipment; this should only be carried out by a trained and competent person. See control measure – Isolate utility or fuel supply to premises, and control measure – Isolate utility or fuel supply within the national grid.

Seek specialist advice or assistance from:

- Distribution network operator
- Electricity supplier to the premises
- Relevant high-voltage electricity network
- On-site personnel and management team
- Responsible person

Water industry

Water supplies and sanitation in the UK are provided by a number of water and sewerage companies. Refer to the supplementary information for further detail.

Some consumers are supplied with water from private reservoirs or water supplies, such as springs.

Water and wastewater services can be supplied by water-only companies and water and sewerage companies. Where water-only companies are the clean water supplier, sewerage services will be provided by a different service supplier (for example, water may be provided by Affinity and sewerage by Thames Water).

It is important to make contact with both companies if both services are at risk of being affected.

Seek specialist advice or assistance from:

- Water distributor for the area
- Water supplier to the premises
- Sewerage company
- On-site personnel and management team
- Responsible person

Petrochemical industry and fuel

Each year, many millions of tonnes of petroleum products are moved around the UK. The oil, gas, refining and petrochemical industries fall into either the upstream or downstream category.

Upstream

This relates to obtaining crude oil and gas from natural resources and includes:

- Exploration of potential new oil and gas reserves using seismic and geophysical surveys and prospective drilling
- Development of oil or gas fields, including constructing the well head and production facilities

Downstream

This relates to processing, marketing and distributing crude oil into consumer products. It includes:

- Transporting crude oil and gas by:
    - Pumping systems
    - Pipeline networks
    - Rail
    - Ship
    - Road
- Liquefied natural gas systems, including liquefaction and regasification sites, oil refineries, petrochemical sites and gas processing

Seek specialist advice or assistance from:

- Fuel distributor or supplier to the premises
- Owners of the pipelines or infrastructure
- On-site personnel and management team
- On-site firefighting teams (if available)

Strategic action

Fire and rescue services should:

- Develop arrangements and procedures with identified sources of specialist advice or assistance for dealing with utility or fuel incidents
- Maintain the details of any tactical adviser (TacAd) or subject matter expert (SME) for utility or fuel incidents and know how to request their attendance

Tactical actions

Incident commanders should:

- Consider requesting specialist advice or assistance based on the extent and urgency of the utility or fuel incident
- Consider the timely attendance of a tactical adviser (TacAd) or subject matter expert (SME)

Control measure – Refer to Site-Specific Risk Information (SSRI) and emergency response plans for utility or fuel incidents

Control measure knowledge

The management of the incident and the safety of personnel can be positively informed by referring to Site-Specific Risk Information (SSRI) and emergency response plans, including COMAH internal and external plans. Close and ongoing liaison with site staff will greatly contribute to a joint understanding of the utility or fuel hazards to be managed.

For further information on pre-planning, refer to National Operational Guidance: Operations – Risk information gathering.

Strategic actions

Fire and rescue services should:

- Develop Site-Specific Risk Information (SSRI) and emergency response plans for production, distribution and supply of utilities and fuel in their area
- Provide operational personnel with risk information about identified utility and fuel sites
- Regularly exercise plans to ensure they are fit for purpose

Tactical actions

Incident commanders should:

- Refer to Site-Specific Risk Information (SSRI) and/or emergency response plan information relevant to utilities or fuel, at the earliest opportunity
- Confirm the accuracy of the information about utilities or fuel with site specialists

Control measure – Apply cordons and control for utilities or fuel

Control measure knowledge

For generic information on cordons and control, refer to National Operational Guidance: Incident command – Structuring an incident.

Numerous cordon distances are appropriate for electricity, gas and fuel. Guidance about distances relevant to electrical sources are included in the control measure – Implement safe working practices in the proximity of high-voltage electricity.

Cordon distances for gas and fuel are given in National Operational Guidance: Hazardous materials.

Pre-planning is a key part of determining safe distances for different scenarios involving utility or fuel supplies, providing responding fire and rescue service personnel with accurate and relevant information. Depending on the nature of the utility or fuel incident, specialist advice from utility suppliers and ongoing liaison with on-site specialists, where available, will be required to ensure cordons are suitable and adequate.

In the petrochemical industry, cordon distances can be assessed by calculating the heat flux for different petrochemical products and storage facilities. These calculations are normally undertaken by consultants and experts in the field as part of pre-planning risk assessments and to identify suitable rendezvous points (RVPs), holding points, etc.

Strategic actions

Fire and rescue services should:

- Ensure that Site-Specific Risk Information (SSRI) identifies locations at utility and fuel sites that are likely to provide suitable cover from on-site hazards; this may be a combination of distance and/or substantial cover

Tactical actions

Incident commanders should:

- Implement cordon control to maintain the appropriate cordons or safe approach distances for the utilities or fuel present
- Identify suitable cover from hazards at utility and fuel sites

Control measure – Isolate utility or fuel supply to the premises

Control measure knowledge

Domestic and commercial gas, electricity, water and oil supplies to premises can ordinarily be isolated at the intake point in the building or in meter boxes outside the building.

This level of isolation can usually be carried out by responding fire and rescue service personnel, but assistance from the utility company may be required if supplies need to be isolated in the street.

Gas supplies

Gas supplies into small premises will be controlled by a clockwise quarter-turn on a gas supply pipe, which will be located on the supply side of the meter.

In commercial kitchens, there may be an emergency isolator, located near the kitchen exit.

Figure 1: Gas isolation valve – photograph courtesy of Janet Guthrie

Liquefied petroleum gas (LPG)

Where no mains gas is available, small gas tanks can be provided above or below ground level; the supply line to the premises will be fitted with an isolation control facility, as above. LPG in smaller cylinders can also be used; these are isolated by a control valve on top of each cylinder.

Figure 2: LPG storage tank – photograph courtesy of Peter Martin

Electricity supplies

For more information on the safe management of electricity supplies, refer to the hazard – Electricity and the supplementary information for domestic supply.

Water supplies

Stopcocks in the property, or control valves in the street, can isolate a water main for domestic or commercial premises.

Fire and rescue service personnel can usually isolate water supplies but may need to request assistance from the water supplier.

Sewerage systems

Fire and rescue service personnel may need to enter sewerage systems to deal with operational incidents.

'Sewer' is a generic term for pipework, usually sub-surface, that carries foul water, i.e. domestic, industrial and other waste. The size of sewers can range from a small, household 150mm pipe to a tunnel large enough for a person to stand in.

Many sewers also carry surface water from roads; more recently a twin-pipe system has been used to ensure sewerage works are not overloaded during periods of heavy rain.

Normally, sewerage systems cannot be isolated as they are open-vented and gravity-fed systems; supply cannot therefore be easily diverted or shut down. However, there may be sluice gates that can be closed to assist with controlling or altering sewage flows.

Sluice gates are physical barriers that are usually operated automatically by fluid pressure or controlled remotely for flood control to prevent backwash. They are intended to direct or divert flow, usually at tunnel intersections, and will be under the direct control of the sewage or wastewater undertaker.

Figure 3: Sluice gate

Fuel oil

Domestic and commercial premises may use fuel oil for boiler systems and heating. These fuel storage facilities will have an isolating control valve between the tank and the premises.

Figure 4: Fuel oil tank – photograph courtesy of Peter Martin

Strategic actions

Fire and rescue services should:

- Liaise with local utility supply companies and maintain up-to-date emergency contact details in their fire control rooms
- Ensure that Site-Specific Risk Information (SSRI) contains details of utility shut-off facilities in commercial premises

Tactical actions

Incident commanders should:

- Determine which utilities are involved in the incident
- Isolate any utilities that may affect the incident or crew safety, and secure against reconnection
- Consider seeking specialist advice or assistance for managing and controlling utility supplies to larger premises, or where isolating supply is problematic. See control measure – Seek specialist advice or assistance for dealing with utilities or fuel.
- Consider the consequence and impact of shutting off utility supplies for larger premises, such as schools or hospitals

Control measure – Isolate utility or fuel supply within the national grid

Control measure knowledge

The decision to isolate high-voltage electricity supplies, high-pressure gas mains, large trunk mains water supplies and fuel other pipelines will need to be made in close consultation with the supplier. This will take into consideration the consequences of such actions to the community both downstream and upstream of the incident.

Fire and rescue services cannot isolate these types of utility or fuel supplies. This can only be achieved by asking the appropriate utility or fuel supplier to isolate the supply. However, the request may take a considerable amount of time to achieve.

Strategic actions

Fire and rescue services should:

- Liaise with local utility and fuel supply companies and maintain up-to-date emergency contact details in their fire control rooms
- Consider adopting memoranda of understanding (MoU) with their utility and fuel suppliers to improve joint working at emergency incidents

Tactical actions

Incident commanders should:

- Request assistance from the service supplier to isolate the utility or fuel supply from the national grid
- Consider the consequences of isolating utility or fuel supplies

Radiation (nuclear power generation)

Hazards	Control measures
Radiation (nuclear power generation)	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Implement hazardous materials procedures

Hazard knowledge

A nuclear power site is a thermal power station in which the heat source is a nuclear reactor. As is typical in conventional thermal power stations, the heat is used to generate steam, which drives a steam turbine connected to an electric generator, which produces electricity.

These sites are very secure and have detailed emergency procedures that any responding fire and rescue service will be aware of and will have exercised on a regular basis.

All generating nuclear power stations (and those in the first stages of decommissioning) will be patrolled by armed officers from the Civil Nuclear Constabulary and will have a wide range of protective security systems. All fire and rescue service activity on these sites will be carried out under escort and in accordance with predetermined arrangements.

The radioactive source, such as uranium rods, will be an additional hazard at these sites, and will require additional consideration for fire and rescue service personnel when attending incidents on site.

Refer to the Industry supplementary information about Decommissioning of nuclear power stations.

Control measure – Implement hazardous materials procedures

For guidance on dealing with radioactive hazardous materials, refer to National Operational Guidance: Hazardous materials.

Electricity

Hazard	Control measures
Electricity	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Isolate and make safe electricity supplies Implement safe working practices in the proximity of high-voltage electricity Consider wearing electrical gloves

Hazard knowledge

Fire and rescue service personnel are at risk of coming into contact with electrical equipment and components at operational incidents, which can result in electrocution. Contact with electricity can cause serious physical injury or prove fatal.

Electrocution can occur in a number of ways:

Direct contact	Direct contact with live electricity is potentially lethal. This can be from direct or alternating current, as well as static discharge from domestic or industrial supplies.
Arcing	Electricity can ‘jump’ through air, smoke or a column of water. The higher the voltage the more likely, and the further, the electricity may ‘jump’. Arcing can also generate intense heat and ignite flammable substances in the vicinity.
Flash down (flashover)	High-voltage electricity has the potential to cause death or serious injury to a person in the vicinity through flash down. This is also referred to as ‘flashover’ in the electricity industry. The high-voltage electricity can find a path to earth through thick smoke (sometimes referred to as carbon tracking) or through a column of water from a monitor or jet. The flash down hazard particularly applies to higher voltage overhead power lines. However, as it is often not possible to identify the voltage carried by a conductor, all high-voltage overhead lines should be assumed to be capable of creating this flash down situation.
Re-energising circuits and	Substations generally have automatic switches, which are programmed to attempt to re-energise circuits that have been broken. Some re-energising may

equipment	also be caused by human error. It cannot be assumed, therefore, that a circuit is isolated.
Residual charge	Certain high-current equipment, including transmission overhead lines, and high-voltage equipment, including photovoltaic cells, are not made safe by merely switching off the supply, and may still carry a significant residual charge that is sufficient to cause fatal injury. This residual charge may remain until the equipment is made safe, usually by the electricity company.
Electrical feedback	Electrical feedback is a relatively new phenomenon that can occur when electricity supplies in the road or on an industrial estate are thought to have been made safe and have been disconnected by the electricity supplier. However, domestic and commercial premises producing their own can feed it back into the national grid, thereby re-energising the dead cable.

Refer to the supplementary information for:

- Electricity basics
- Domestic power supply
- Electricity generation in the UK
- High-voltage networks (national grid)
- Sealing end compounds
- Substations
- The difference between a single-phase and a three-phase power system
- Three-phase high-voltage systems
- Three-phase low-voltage systems
- Transmission and distribution network
- Transmission towers (pylons) and wooden poles

National grid

Power stations produce electricity at 25kV. Electricity is sent through the national grid network at 400kV, 275kV and 132kV.

Step-up transformers are used at power stations to produce the very high voltage needed to transmit electricity through the national grid power lines. These high voltages are too dangerous for use in homes and businesses and therefore step-down transformers are used locally to reduce the voltages to a safe level, resulting in the following supplies:

Large industrial consumers – 33kV

Rail network – 25kV to 33kV

Small industrial consumers – 415V to 11kV

Residential and small commercial – 240V

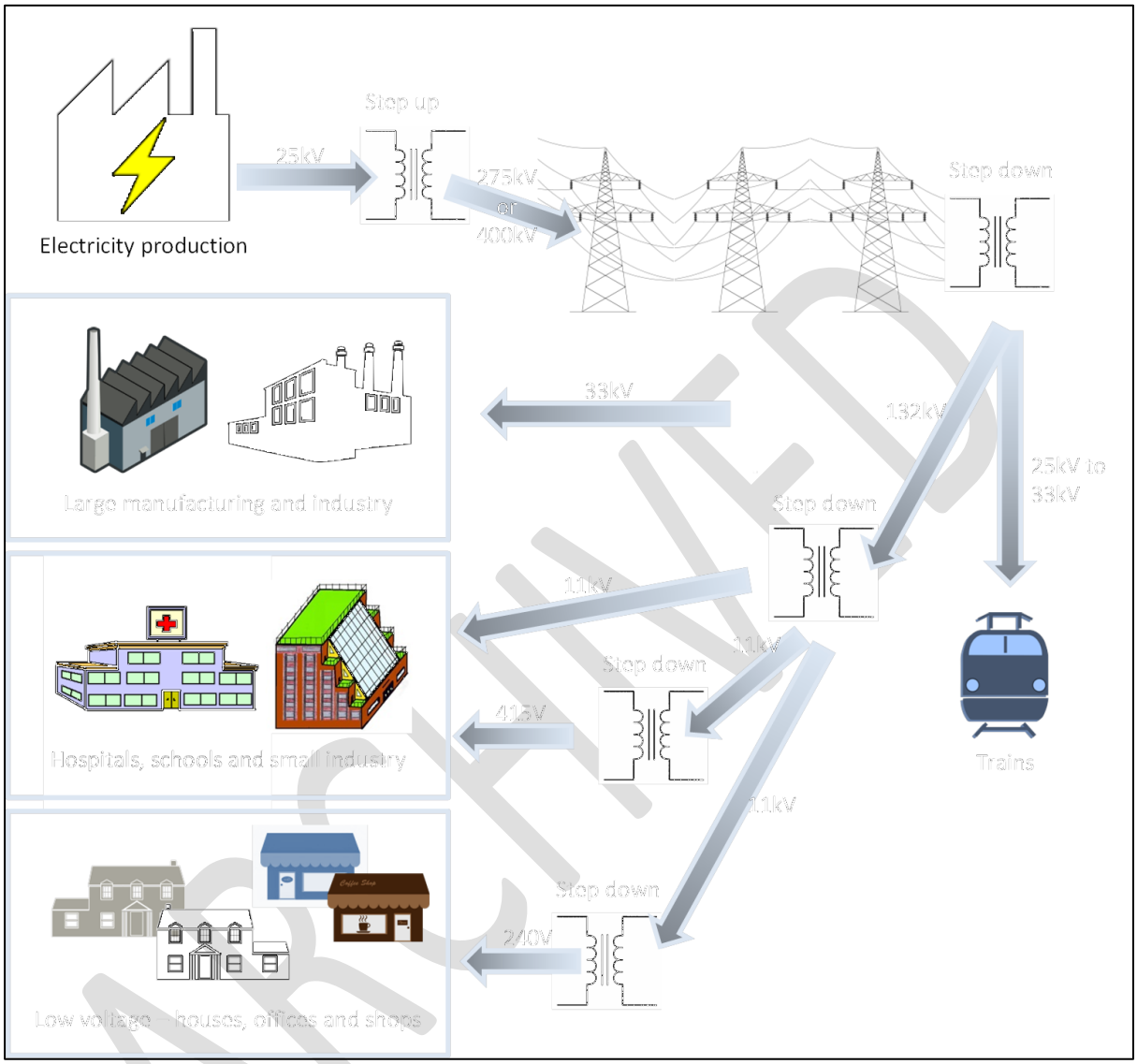

Figure 5: UK electricity distribution – diagram courtesy of London Fire Brigade

Overhead lines are normally uninsulated; if an object gets too close, it is possible that electricity will jump over a distance to reach earth via the object.

It should be assumed that an overhead power line can be lethal. All objects (such as appliances, ladders, masts, poles and tools) and personnel should be kept away from the power lines at all times.

High-pressure jets coming into contact with an overhead line with horizontal conductors may cause them to clash together, resulting in arcing. This could lead to conductor breakage, resulting in live conductors falling to the ground. Water can also cause heated porcelain insulators to shatter, creating a needlestick or projectile hazard.

High-pressure jets playing on overhead conductors may also result in earth leakage through the water stream to ground. This may cause the branch to become live, with potentially fatal consequences.

Control measure – Isolate and make safe electricity supplies

Control measure knowledge

Electrical isolation to small premises can be achieved by isolating electricity at the consumer unit (or fuse board) or by removing the supplier's main fuse, found on the supply side of the meter.

Removal of this fuse could be carried out by fire and rescue service personnel in extreme circumstances. Due to the possibility of small quantities of asbestos being present in older fuses, appropriate personal protective equipment (PPE) and respiratory protective equipment (RPE) should be worn.

All commercial premises will have electricity isolation points at the electrical intake. At larger sites, there may be isolation points that control areas of the site or separate pieces of machinery or equipment.

Fire and rescue service personnel will benefit from having access to risk information about equipment and its location such as:

- Substations
- Transformers
- Switchgear
- Emergency stops
- Consumer units (fuse boards)

If fire and rescue service personnel need to deal with three-phase power supplies, they may need to request assistance from the electricity supplier, unless there are on-site engineers competent in dealing with, and controlling, this hazard.

Health and Safety Executive – electrical definitions

It is critically important that fire and rescue service personnel understand electrical terminology when discussing isolation of electricity supplies with electricity distributors or any attending electrical engineers. Failing to understand this terminology may increase the risks encountered.

The definitions in the table below provide the explanation for words and terms used in this guidance, unless otherwise stated. Note that some of these terms are definitions from the Electricity at Work Regulations (1989):

Charged	Means that the item has acquired a charge either because it is live or because it has become charged by other means such as by static or induction charging, or has retained or regained a charge due to capacitance effects even though it may be disconnected from the rest of the system.
Dead	Not electrically 'live' or 'charged'

Designated competent person (also known in some industries as 'authorised person' or 'senior authorised person')	A competent person appointed by the employer, preferably in writing, to undertake certain specific responsibilities and duties, which may include issuing and receiving safety documents such as permits-to-work. The person must be competent by way of training, qualifications and/or experience and knowledge of the system to be worked on.
Disconnected	Equipment (or a part of an electrical system) that is not connected to any source of electrical energy
Electrical equipment	Includes anything used, intended to be used or installed for use, to generate, provide, transmit, transform, rectify, convert, conduct, distribute, control, store, measure or use electrical energy
High voltage	Voltages greater than 1000V AC or 1500V DC. Voltages below these values are low voltage.
Isolated	Equipment (or part of an electrical system) that is disconnected and separated by a safe distance (the isolating gap) from all sources of electrical energy in such a way that the disconnection is secure, i.e. it cannot be re-energised accidentally or inadvertently
Live	Equipment that is at a voltage by being connected to a source of electricity. Live parts that are insulated and exposed so they can be touched either directly or indirectly by a conducting object are hazardous if the voltage exceeds 50V AC or 120V DC in dry conditions.
Live work	Work on or near conductors that are accessible and live or charged. Live work includes live testing, such as using a test instrument to measure voltage on a live power distribution or control system.
Low voltage	Voltages up to 1000V AC or 1500V DC. Voltages above these values are high voltage.

Note: on a nuclear site, the designated competent person would be referred to as the duly authorised person.

The Energy Networks Association has produced Safety Information for the Fire Service. This contains information on emergency situations involving electricity, along with important contact numbers for electricity companies. It contains a rescue flow chart that may assist with risk assessments.

Strategic actions

Fire and rescue services should:

- Liaise with local utility and fuel supply companies and maintain up-to-date emergency contact details in their fire control rooms

- Consider adopting memoranda of understanding (MoU) with their electricity suppliers to improve joint working at emergency incidents

Tactical actions

Incident commanders should:

- If required, isolate electricity supplies to domestic and commercial premises as soon as reasonably practicable, using appropriate isolation points
- Implement appropriate procedures to prevent electrical systems being switched on inadvertently, for example, using locks, signs or supervision
- Consider seeking specialist advice or assistance where isolating supply is problematic
- Consider the consequences of isolating electricity supplies
- Request and record permission from the designated competent person (authorised person or senior authorised person) before commencing fire and rescue service activities near high-voltage equipment
- Ensure that stored charge or stored energy is discharged
- Always assume the system is live until relevant power company engineers or other competent engineers confirm otherwise, for example, through a permit-to-work certificate

Control measure – Implement safe working practices in the proximity of high-voltage electricity

Control measure knowledge

Rescue of a casualty within 5m of a high-voltage conductor

If it is necessary to rescue a casualty who is within 5m of a high-voltage conductor, the following steps should be taken:

- Request permission from the designated competent person to perform the rescue of a casualty, providing information such as:
    - Condition of casualty
    - Distance and position of the casualty in relation to the conductor
    - Whether the casualty is at, above or below ground level
    - Weather conditions
    - Transmission tower markings and signs
- Record permission when received
- Carry out a risk assessment
- Proceed with caution

However, if it can be determined that a casualty is in direct contact with a low-voltage conductor:

- Carry out a risk assessment
- Pull the casualty clear using electrical gloves or other dry insulating material

Operational activity in the close proximity of transmission towers

Columns or jets of water should not be applied to transmission towers and their components, as solid jets of water coming into contact with any electrical equipment creates a risk of electrocution.

When firefighting in the close proximity of transmission towers, branches with spray, fog or mist can be used at ground level, as electricity is less able to conduct through droplets of water.

As high-voltage electricity can find a path to earth through thick smoke (sometimes referred to as carbon tracking), a hazard area needs to be established. This should be a minimum of 10m either side of the overhead lines at the widest point of the transmission tower.

Thick smoke with a high carbon content may be generated by fires involving rubber tyres or plastics, and wildfires.

Any activity in close proximity of transmission towers should be subject to a risk assessment, taking into account:

- The conditions, such as dense smoke
- Wind direction
- The equipment being used, such as ground monitors or aerial ladder platforms

Strategic actions

Fire and rescue services should:

- Liaise with local distribution network operators (DNOs) and maintain up-to-date emergency contact details in their fire control rooms

Tactical actions

Incident commanders should:

- Seek advice from the designated competent person
- Request the isolation of electricity if operationally required, taking into consideration the consequences of isolating electricity supplies
- Ensure personnel do not enter any enclosure surrounding electrical apparatus, or climb any steel tower, structure or pole supporting overhead lines, unless permission has been received from the designated competent person
- Take precautions when carrying metal ladders or other operational equipment; these should be carried horizontally and as low to the ground as possible
- Adopt appropriate rescue procedures
- Adopt appropriate firefighting procedures

- Consider authorisations received from the designated competent person when developing tactical plans
- Adopt defensive tactics where there is no risk to life

Control measure – Consider wearing electrical gloves

Control measure knowledge

The decision to use electrical gloves should be made with extreme caution; they should only be used when dealing with low-voltage electricity supplies. Low voltage is defined as voltage up to 1000V AC or 1500V DC.

Where it is necessary to come into contact with low-voltage electricity, electrical gloves should be worn, for example, when removing people from contact with electricity.

Where there is high-voltage electricity (greater than 1000V AC or 1500V DC), or it is not possible to verify the actual voltage, the only safe course of action is to ensure that the supply is cut off and declared safe by a competent person.

Strategic actions

Fire and rescue services should:

- Consider providing electrical gloves to personnel

Tactical actions

Incident commanders should:

- Consider the appropriate use of electrical gloves, in line with service procedures

Overhead power lines and transmission towers

Hazard	Control measures
Overhead power lines and transmission towers	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Locate the correct identification number for the transmission tower

Hazard knowledge

Overhead lines are at various voltages and are usually uninsulated.

Low-voltage (up to 1000V) lines are suspended by wooden poles and arranged into either:

- Vertical arrays of up to six lines (with the lowest cable being the neutral)

- Single lines with live and neutral cores (known as concentric cables)

Some high-voltage (greater than 1000V) lines may also be suspended by wooden poles. These can be identified as they are:

- Usually in either a horizontal array of two or three lines, or in a six-cable array with three lines on each side of the pole
- Separated from the wooden pole by circular insulators

Transmission towers (often referred to as pylons) have an array of three cables (or sets of cables) to each side of the tower. Each side of the transmission tower represents three phases of electricity; however, each side of the transmission tower may have a different origin and may be operated by a different distribution network operator (DNO).

Figure 6: 132kV transmission towers – photograph courtesy of Peter Martin

Control measure – Locate the correct identification number for the transmission tower

Control measure knowledge

Identification number plates

Transmission towers or poles have a unique identification number plate. In instances where each side of the transmission tower or pole is supplied by a different distribution network operator (DNO), there will be two identification number plates.

Figure 7: Identification number plate on transmission tower – photograph courtesy of Peter Martin

Colour bands

There is a colour-coding scheme for transmission towers.

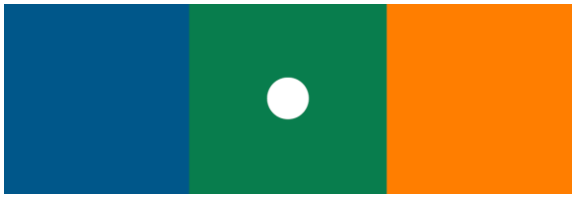

Figure 8: Example of a colour band for a 132kV tower - diagram courtesy of UK Power Networks

Contacting the electricity company

If a transmission tower is operated by two companies, details from both plates should be passed to the fire control room. Contacting the wrong company may result in delays, as some work can only be carried out once the correct designated competent person is on scene and able to issue a permit-to-work.

The following information should be given to fire control rooms and passed to the correct distribution network operator(s) (DNO):

- Exact address
- Identification numbers and colour band information
- Physical description of the site
- Distances from live equipment
- Whether the incident is at ground level, above or below ground level
- Weather conditions on site
- Current plan of action required
- Any time limits or other operational pressures
- Any other relevant information

Yellow ‘danger of death’ signs should be present on all high-voltage transmission towers or poles. They may sometimes be displayed on low-voltage poles.

Strategic actions

Fire and rescue services should:

- Liaise with local distribution network operators (DNOs) and maintain up-to-date emergency contact details in their fire control rooms

Tactical actions

Incident commanders should:

- Identify and communicate the reference number of any transmission tower or pole involved to the relevant distribution network operator (DNO)

- Implement high-voltage procedures if there is a yellow danger of death sign present

High-security features

Hazard	Control measures
High-security features	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident')

Hazard knowledge

Utility and fuel sites across the UK form a part of the critical national infrastructure (CNI) and as such they are protected to a very high level. All CNI sites will have a risk-assessed level of intruder detection and protection.

Security features may make entry to a site problematic or hazardous; close liaison with the site operator will be required.

Active nuclear and first-stage decommissioning sites will have armed Civil Nuclear Constabulary protection and a wide range of personnel and vehicle mitigation measures; entry will be escorted at all times.

Site-Specific Risk Information (SSRI) may contain details of security features such as:

- High fencing with barbed wire or razor wire
- Electrified fencing
- Anti-climbing guards on transmission towers and poles
- High walls
- Armed on-site protection

Entry to an electrical installation, such as a substation, can only be achieved following confirmation from the relevant distribution network operator (DNO) that the area is safe to enter.

Electrical installations will have signage detailing hazards and contact details on access points to the sites, as well as danger of death signs around their perimeters.

Figure 9: Substation access door (also showing SF6 warning sign) – photograph courtesy of Peter Martin

Battery storage and uninterruptible power supplies (UPS)

Hazard	Control measures
Battery storage and uninterruptible power supplies (UPS)	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Isolate battery power supplies

Hazard knowledge

Larger electricity substations will usually have a building with racks of 12V batteries. The hazards presented by these are:

- Stored electrical charge
- Hazardous substances such as sulphuric acid

Uninterruptible power supplies (UPS)

An uninterruptible power supply is electrical equipment that provides emergency power when the input power source, typically the mains, fails.

Uninterruptible power supplies provide immediate protection from input power interruptions; this is done by supplying energy stored in batteries, super capacitors or flywheels.

The operating time of most uninterruptible power sources is relatively short, usually only a few minutes. This is sufficient to start a standby power source or to properly shut down and protect the equipment, such as:

- Computers
- Data centres
- Telecommunication equipment

- Other electrical equipment where an unexpected power disruption could cause injuries, fatalities or serious business disruption

Battery storage for domestic and commercial solar photovoltaic (PV) systems

With advancements in solar-powered domestic and commercial photovoltaic systems, battery storage is becoming an economically viable option for some households and businesses.

The two types of batteries most commonly offered for solar photovoltaic storage in the home are lithium-ion and lead-acid batteries. These units will usually be located near the system's inverter and often found in a utility room, garage or similar location.

For illustrations of, and further information about, battery storage, refer to BRE and RECC (2016) Batteries and Solar Power: Guidance for domestic and small commercial consumers.

Also refer to the BRE knowledge sheets, Photovoltaic (PV) systems.

Control measure – Isolate battery power supplies

Control measure knowledge

Isolation of uninterruptible power supply systems

If an uninterruptible power supply system is providing back-up to a whole building, there should be a cut-off point, usually located near to the isolation point for the mains power.

Isolation of battery storage for solar PV systems

If there is solar PV system battery storage, there should be a cut-off switch for the batteries near to their location. Remember that the DC power may still be going to the batteries.

Strategic actions

Fire and rescue services should:

- Ensure that Site-Specific Risk Information (SSRI) includes details of uninterruptible power supply systems or battery storage for PV systems, such as emergency cut-off points or switches

Tactical actions

Incident commanders should:

- Consider isolating the power supplies, taking into account the impact on any critical systems
- Consider the appropriate use of electrical gloves, in line with service procedures

Electrical standby generators

Hazard	Control measures
Electrical standby generators	Apply generic control measures (as detailed for the

	hazard of 'Dealing with utility or fuel supplies at an incident') Isolate standby generators

Hazard knowledge

Fire and rescue service personnel attending incidents may need to manage electrical standby generators and associated fuel supplies.

In the event of the electricity supply to the facility being interrupted, the standby generator will automatically start to operate, resulting in the re-energising of power supplies.

Control measure – Isolate standby generators

Control measure knowledge

If a standby generator is providing back-up to the facility, it will need to be isolated to prevent the automatic re-energising of power supplies.

Strategic actions

Fire and rescue services should:

- Ensure that Site-Specific Risk Information (SSRI) includes details of standby generators

Tactical actions

Incident commanders should:

- Consider isolating the standby generator, taking into account the impact on any critical systems

Overheating transformers and cooling systems

Hazard	Control measures
Overheating transformers and cooling systems	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Implement hazardous materials procedures

Hazard knowledge

Transformers generate significant heat and are generally cooled by the circulation of mineral oils. If a transformer overheats, it may rupture; this could result in very hot mineral oil and toxic and/or flammable gases being released.

Some switchgear is also oil-cooled and can rupture in a similar manner to transformers.

Control measure – Implement hazardous materials procedures

For guidance on dealing with the release of hot mineral oils, refer to National Operational Guidance: Hazardous materials.

Presence of chemicals

Hazard	Control measures
Presence of chemicals	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Implement hazardous materials procedures

Hazard knowledge

Throughout the utility and fuel industries, chemicals play a key part in the processes of production, transportation and supply to the customer.

Fire and rescue service personnel, at any incidents in these industries, need to be aware of the presence of chemicals and the possibility that they may need to be managed and controlled.

While gathering information for Site-Specific Risk Information (SSRI) and emergency response plans, a list of chemicals and quantities of those chemicals needs to be recorded.

Below are some examples of chemicals that could be found in different utility and fuel industries.

Water industry

- Algaecides (copper sulphate, iron salts, rosin amine salts and benzalkonium chloride)
- Disinfectants (chlorine, chlorine oxide, ozone)
- Boiler water chemicals (scale inhibitors, corrosion inhibitors, etc.)
- Coagulants (aluminium and iron)
- Neutralising agents (sodium hydroxide solution, calcium carbonate and lime suspension)
- Oxidants (hydrogen peroxide, ozone, combination ozone and peroxide and oxygen)
- Resin cleaners (sodium chloride, potassium chloride citric acid and chlorine oxide)

Electricity industry

- Boiler water chemicals (scale inhibitors, corrosion inhibitors, etc.)
- Sulphur hexafluoride (SF6) – refer to the hazard for Sulphur hexafluoride (SF6)
- Polychlorinated biphenyls (found in older electrical equipment) – refer to the hazard for Polychlorinated biphenyls

- Dielectric fluid (mineral oils used to cool or insulate underground transmission feeders)
- Transformer oil (generic term for oil used to cool and insulate transformers)
- Sulphuric acid (contained in lead-acid batteries)
- Lithium (component of lithium-ion battery systems)

Gas industry

- Mercaptan (chemical added to natural gas to give it an odour similar to rotten eggs)

Petrochemical industry

There will be numerous refined petroleum products and chemicals in a facility. Examples include:

- Corrosion inhibitors
- Sulphuric acid (contained in lead-acid batteries)
- Resin cleaners (sodium chloride, potassium chloride, citric acid and chlorine oxide)

Control measure – Implement hazardous materials procedures

For guidance on dealing with any chemical release, refer to National Operational Guidance: Hazardous materials.

Sulphur hexafluoride (SF6)

Hazard	Control measures
Sulphur hexafluoride (SF6)	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Implement hazardous materials procedures

Hazard knowledge

Sulphur hexafluoride gas is used at low pressures to insulate certain areas of power stations and substations, and for arc extinction in switchgear. Sulphur hexafluoride gas in its pure form is inert, colourless, non-flammable, non-toxic and five times heavier than air.

In substations it is sealed in compartments that should have a warning sign denoting SF6 presence. It can only escape in fault conditions, which include fires, when it can generate toxic and corrosive gases or powder that can cause skin burns and severe damage to eyes.

Control measure – Implement hazardous materials procedures

For guidance about dealing with sulphur hexafluoride (SF6) release, refer to National Operational Guidance: Hazardous materials.

Polychlorinated biphenyls (PCBs)

Hazard	Control measures
Polychlorinated biphenyls (PCBs)	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Implement hazardous materials procedures

Hazard knowledge

Polychlorinated biphenyls (PCBs) were used as dielectric filler liquids in some types of electrical equipment such as transformers, switchgear, capacitors and in the starter units of fluorescent lights and fractional horsepower motors. If manufactured before 1986, these may contain PCBs.

Some equipment is labelled as containing PCBs, but signs may be missing because of age or as a result of the incident.

PCBs are highly toxic, and can lead to chronic illnesses including liver damage and skin rashes. They pollute the environment, accumulate in the food chain and are not biodegradable.

Control measure – Implement hazardous materials procedures

For guidance about dealing with any PCB release, refer to National Operational Guidance: Hazardous materials.

Irrespirable atmospheres

Hazard	Control measures
Irrespirable atmospheres	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Implement hazardous materials procedures

Hazard knowledge

Some compartments in electrical sites are protected by fixed installations, including reduced oxygen (redox) and gaseous suppression systems. There should be visual and audible warnings outside and inside any compartment containing this type of fixed installation.

For further information on fixed installations, refer to National Operational Guidance: Fires in buildings – Fixed installations.

Atmospheric conditions in sewers

The waste carried in sewers may result in the atmosphere being:

- Toxic (e.g. presence of hydrogen sulphide H2S)
- Explosive/flammable (e.g. presence of methane CH4)
- Oxygen deficient (caused by certain micro-organisms)

If there has been a pumping failure, there may also be a considerable amount of organic material that will have been there for some time, which may lead to significant amounts of hydrogen sulphide being produced if disturbed.

Oxygen-deficient atmosphere

A reduced through-flow of fresh air due to a lack of natural ventilation or insufficient air currents from sewerage movement (blockage or pump failure) can lead to higher concentrations of other gases (asphyxiants), resulting in an oxygen-deficient atmosphere.

The operation of equipment, such as internal combustion engines, in or near the opening may not only use up oxygen from the air but also produce exhaust gases, such as carbon monoxide, which can accumulate in low areas.

Control measure – Implement hazardous materials procedures

For guidance about working in irrespirable atmospheres, refer to National Operational Guidance: Hazardous materials.

Ground becoming live

Hazard	Control measures
Ground becoming live	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Make a safe withdrawal from ground affected by voltage

Hazard knowledge

When high-voltage equipment is in contact with the ground (or an uninsulated object is touching the ground), there is a risk of the ground itself becoming live and transferring the voltage to anybody present within a few metres. This can happen whether the ground is wet or dry.

The highest voltage is on the ground closest to the point of contact. It gradually reduces, in concentric rings, the further you are from the point of contact. This hazard is also known as potential gradient or voltage gradient.

When walking towards or away from the point of contact, each foot can have a difference in electrical potential, resulting in one foot touching one voltage while the other is touching another voltage.

The two voltages will try to equalise by flowing up one leg, through the body and down the other leg. This will be indicated by a tingling sensation.

If the ground has become live a similar situation can occur when standing with a charged hose. The voltage differential will be between where you are standing and where the hose is in contact with the ground.

The Energy Networks Association has produced Safety Information for the Fire Service. This contains information on emergency situations involving electricity, along with important contact numbers for electricity companies.

Control measure – Make a safe withdrawal from ground affected by voltage

Control measure knowledge

An exclusion zone of at least 5m should be implemented. To minimise the effects of the equalisation of voltages when leaving the exclusion zone, one of the following methods should be used:

- Shuffle, keeping both feet close together, maintaining contact with the ground at all times
- Hop, making sure that both feet hit the ground at the same time
- Make leaping strides, so that one foot is off the ground at all times

Tactical actions

Incident commanders should:

- Implement an exclusion zone of at least 5m, subject to risk assessment
- Instruct people to leave the exclusion zone using an appropriate method

Vehicle becoming live

Hazard	Control measures
Vehicle becoming live	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Remain in the vehicle affected by voltage Make a safe withdrawal from the vehicle affected by voltage

Hazard knowledge

There may be occasions when high-voltage equipment is in contact with a vehicle but not with the ground. The vehicle tyres may insulate the electricity from the ground. Any personal contact with the vehicle and ground at the same time will offer the electricity a path to the ground and may result in electrocution.

The Energy Networks Association has produced Safety Information for the Fire Service. This contains information on emergency situations involving electricity, along with important contact numbers for electricity companies.

Control measure – Remain in the vehicle affected by voltage

Control measure knowledge

If somebody is in a vehicle that has become affected by high-voltage equipment and there is a risk of the vehicle becoming live, they should be instructed to remain in the vehicle, if safe for them to do so, until the power supply has been isolated.

Until the supply to the electrical installation can be isolated by the distribution network operator (DNO) or competent person, responding emergency personnel should keep a safe distance from the vehicle.

Strategic actions

Fire and rescue services should:

- Establish arrangements with local distribution network operators (DNOs) and maintain up-to-date emergency contact details in their fire control rooms

Tactical actions

Incident commanders should:

- Pass the reference number for the transmission tower or pole involved to the relevant distribution network operator (DNO)
- Instruct the vehicle occupants to remain in the vehicle, if it is safe for them to do so

Control measure – Make a safe withdrawal from the vehicle affected by voltage

Control measure knowledge

In extreme circumstances, for example, if the vehicle is on fire, it may not be safe for people to remain in the vehicle. If this is the case, they will need to leave the affected vehicle in a safe manner.

An exclusion zone of at least 5m should be implemented. To minimise the effects of the equalisation of voltages when leaving a vehicle in the exclusion zone, one of the following methods should be used:

- Shuffle, keeping both feet close together, maintaining contact with the ground at all times
- Hop, making sure that both feet hit the ground at the same time
- Make leaping strides, so that one foot is off the ground at all times

If the person is unable to self-extricate, refer to National Operational Guidance: Performing rescues – Extrication from vehicle.

Tactical actions

Incident commanders should:

- Implement an exclusion zone of at least 5m, subject to risk assessment
- Advise the vehicle occupants to jump out of the vehicle, breaking all contact with it before touching the ground
- Consider using equipment, such as rubber airbags, for the vehicle occupants to step onto as they leave the vehicle
- Advise the vehicle occupants to move away from the vehicle and leave the exclusion zone using an appropriate method

Photovoltaic (PV) systems

Hazard	Control measures
Photovoltaic (PV) systems	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Isolate power at inverter

Hazard knowledge

At any incident involving photovoltaic (solar) systems, there is a potential electrical hazard from energy produced by these units. Panels or tiles may be mounted onto building roofs or walls. Panels can also be located at ground level, for example in solar farms. Even when isolated at the consumer unit or inverter, the system may remain live between the panels and the isolation point.

The potential for the system to continually produce electricity presents a hazard for fire and rescue service personnel. The generation of electricity will not only happen in direct sunlight but also in cloudy conditions. Moonlight will generate negligible current. However, artificial scene lighting may be sufficiently bright to generate electricity.

Damaged photovoltaic panels can cause arcing and subsequent fire, with the potential for firespread via molten glass dropping underneath the panels.

The security of the panels may be compromised by fire or building collapse, with the potential for them to fall from the roof.

Other methods have been used to deactivate photovoltaic systems, for example, in the United States they have investigated covering the panels with a 100% light-blocking material, such as certain types of tarpaulin. However, this is a difficult tactic to implement because many tarpaulins are not 100% light-blocking and the panels are often too large for this to be successfully achieved. Additionally, wind, fire or other external influences may make it difficult to maintain coverage.

With the growth of photovoltaic systems, there is emerging technology looking at ways to deactivate production of DC power from photovoltaic systems.

For further information, refer to the BRE knowledge sheet: Photovoltaic (PV) systems and the supplementary information for solar panel (photovoltaic) systems.

Control measure – Isolate power at inverter

Control measure knowledge

One or more DC isolation switches should be provided to isolate the photovoltaic array from the inverter. Isolation should be carried out at the point closest to the panels. Anywhere between the DC isolation point(s) and the panels will remain live.

For further information about the components of photovoltaic systems, refer to BRE's Fire safety and solar electric/photovoltaic systems webpage.

Tactical actions

Incident commanders should:

- Consider the appropriate use of electrical gloves, in line with service procedures
- Isolate any photovoltaic system as close to the panels as possible
- Ensure there is no unprotected direct contact by personnel or equipment with any part of the photovoltaic system
- Consider the presence of lithium-ion battery storage units – see hazard for Battery storage and uninterruptible power supplies (UPS)

Renewable energy turbines

Hazard	Control measures
Renewable energy turbines	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Isolate the turbine

Hazard knowledge

Water turbines

Hydroelectricity is produced when the kinetic energy of flowing water is converted into electricity by a turbine connected to an electricity generator. There are large-scale and small-scale schemes. Refer to the supplementary information for further detail.

Due to the volume of water required for a hydroelectricity system, there may be a risk of flooding or a need to work near water. Refer to National Operational Guidance: Operations - Health, safety and welfare for further information.

Wind turbines

Wind turbines range from micro-size (used for signposts and caravans, for example) through to large wind farms. Refer to the supplementary information for further detail.

Turbines have both a brake and gearbox mechanism behind the blades, which allows for greater control of the system and for the generator to be shut down in case of a fault.

Large-scale wind farms will have on-site transformers that increase the voltage of the generated electricity before being fed into the national grid.

Fire and rescue services will not be expected to attend incidents at offshore wind turbine sites. Those sites are required to be self-sufficient for dealing with fires and performing rescues.

For attending incidents at height at onshore wind turbine sites, refer to National Operational Guidance: Sub-surface, height and structures.

At an incident involving a wind turbine, electrical hazards include those typical of any other equipment producing electricity. Short circuits, overheated alternators or generators and gearbox oils are all known to have caused fires in wind farms.

Because of the height of these units, there is a possibility that any item falling from the upper part of the wind turbine could 'plane' and travel a considerable distance from the base of the turbine.

Control measure – Isolate the turbine

Control measure knowledge

All the time turbines are rotating they are producing electricity which, because of their location and size, may be difficult to isolate and control. However, monitoring stations may be able to remotely provide information and remotely control the turbines.

Strategic actions

Fire and rescue services should:

- Ensure that Site-Specific Risk Information (SSRI) includes details of turbines and information on emergency procedures for isolating the turbine

Tactical actions

Incident commanders should:

- Identify how to isolate the turbine; this could be remotely or on-site
- Isolate the turbine– this may require specialist advice or assistance
- Ensure personnel and equipment avoid contact with any part of the electrical system
- Consider the appropriate use of electrical gloves, in line with service procedures

Underground utility incidents

Hazard	Control measures

Underground utility incidents	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident')

Hazard knowledge

Underground utility incidents may be indicated by damaged or displaced covers (for example manhole or inspection covers) or paving slabs, resulting in:

- Open pits or cavities
- Exposed utilities
- Projectile hazards

Electricity

High-voltage underground cables are insulated with oil or gas under pressure. Overheating can lead to fire and an increase in the oil or gas pressure. This pressure can result in covers or paving slabs at ground level being damaged or displaced (blown-off).

These incidents may present additional hazards, such as toxic fumes spreading along cable ducting, potentially into nearby properties.

Bituminous insulation may also be damaged, resulting in exposed electrical cables and equipment. This could create a risk of electrocution to the public, responding fire and rescue service personnel or other agencies.

Gas

Gas leaks underground may also result in an explosion or fire, if ignited by an electrical fault or an above ground ignition source.

Water

Storm rain covers may be displaced due to storms, flooding or burst water mains.

Presence of wiring

Hazard	Control measures
Presence of wiring	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Implement breathing apparatus (BA) procedures

Hazard knowledge

Wiring may present hazards to emergency service personnel and occupants.

Entanglement hazard

Hanging cables pose a significant hazard for firefighters and have contributed to firefighter deaths in the past. This hazard should be considered wherever there is an electricity supply.

For guidance on the hazard of cable entanglement, refer to National Operational Guidance: Fires in buildings.

Hazardous products of combustion (acrid smoke)

Most electrical cables are sheathed or protected with polyvinyl chloride (PVC), polyethylene (PE) or thermoplastic polyurethane (TPU).

In a fire, these plastic material releases dioxins (a range of complex chemical compounds), hydrogen cyanide and hydrogen chloride.

- Dioxins are extremely harmful to life
- Hydrogen cyanide (HCN) and hydrogen chloride (HCl) are both poisonous gases
- Hydrogen cyanide is highly toxic (35 times more toxic than carbon monoxide)
- Hydrogen chloride is a poison that forms hydrochloric acid when it comes in contact with water

Control measure – Implement breathing apparatus (BA) procedures

For further information about breathing apparatus (BA) procedures refer to National Operational Guidance.

Dangerous wiring

Hazard	Control measures
Dangerous wiring	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Adopt defensive tactics until the electricity supply is isolated

Hazard knowledge

This hazard may exist where the wiring:

- Has been damaged
- Has been carried out incorrectly
- Has deteriorated with age

Figure 10: Damaged wiring due to a fire – photograph courtesy of Peter Martin

Control measure – Adopt defensive tactics until the electricity supply is isolated

Control measure knowledge

It may not be possible for the fire and rescue service to isolate and make safe the electricity supply using normal methods. Assistance is therefore likely to be required from the relevant electricity supplier or competent person to make the electricity supply safe.

Strategic actions

Fire and rescue services should:

- Establish arrangements with local electricity suppliers and maintain up-to-date emergency contact details in their fire control rooms

Tactical actions

Incident commanders should:

- Adopt defensive tactics where appropriate
- Inform emergency service personnel about the presence of dangerous wiring
- Seek specialist assistance to make the electricity supply safe
- Consider the appropriate use of electrical gloves, in line with service procedures

Illegal activity involving electricity

Hazard	Control measures
Illegal activity involving electricity	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Adopt defensive tactics until the electricity supply is isolated

	Share intelligence about illegal activity involving electricity

Hazard knowledge

This hazard may exist where:

- The consumer unit has been tampered with to steal electricity
- There is direct wiring to doors or windows to create a booby trap
- Complex wiring is providing heat and illumination for drug laboratories or cannabis cultivation
- There has been cable theft or attempted cable theft

The impact of illegal activity involving electricity may extend far wider than a single building; it could affect power supplies to other buildings, disrupt train services, cause telecommunications to fail, etc.

Control switches can indicate that the supply has been switched off when actually it remains live. Therefore all electrical systems need to be treated with caution until made safe by a competent engineer.

Control measure – Adopt defensive tactics until the electricity supply is isolated

Refer to the hazard of Dangerous wiring.

Control measure – Share intelligence about illegal activity involving electricity

Control measure knowledge

Fire and rescue services engage in a wide range of intelligence-sharing opportunities through normal activities. They should use these to build a picture of possible properties or locations where illegal activity involving electricity may occur.

Local intelligence can come from a number of sources, such as:

- Police
- Local authorities
- Utility suppliers
- Community leaders
- Local knowledge of operational personnel
- Members of the public

During normal fire and rescue service activities, personnel may come across situations where there has been suspected illegal activity involving electricity. These instances will need to be reported to the United Kingdom Revenue Protection Association and/or the police.

Strategic actions

Fire and rescue services should:

- Have procedures to flag sites where intelligence has been received about illegal activity involving electricity
- Consider establishing appropriate arrangements, such as memoranda of understanding, with electricity suppliers for cable theft or other illegal activity involving electricity

Tactical actions

Incident commanders should:

- Use local intelligence to anticipate the possibility of illegal activity involving electricity
- Request the attendance of the police and the electricity supplier where illegal activity involving electricity is identified or suspected
- Preserve evidence of illegal wiring and pass this information to the police and the electricity supplier

Luminous discharge tube (neon) signs

Hazard	Control measures
Luminous discharge tube (neon) signs	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Isolate power supply to luminous discharge tube sign

Hazard knowledge

These signs work using high-voltage electricity to excite a gas in the tubes. This gas will not always be neon; the tubes will more commonly contain argon gas with a small amount of mercury, which is a toxic substance. When energised, this creates a mercury vapour that can be released if the tube fails.

Figure 11: Luminous discharge tube ('neon') sign – photograph courtesy of Janet Guthrie

Typically, a luminous discharge tube sign will require a high voltage (such as 3kV) to start up, but the voltage is reduced once the light is working. If a luminous discharge tube breaks or goes out, this

does not necessarily mean the electrical circuit is broken. Connections and 'jumper wires' between the tubes may still be live.

Also refer to the BRE knowledge sheets, Luminous discharge tube ('neon') signs.

Control measure – Isolate power supply to luminous discharge tube signs

Control measure knowledge

Figure 12: Fire switch for luminous discharge tube sign – photograph courtesy of Janet Guthrie

Larger displays should have a fire switch in a prominent position; this may be located inside or outside a building depending on the location of the luminous discharge tube sign.

Tactical actions

Incident commanders should:

- Isolate the sign using the fire switch if available and accessible
- Always assume there is a high voltage (3kV)
- Request attendance of the electricity supplier or competent person where isolation is not possible
- Ensure that care is taken if any signs need to be removed, and if so consider the use of respiratory protective equipment (RPE)
- In the event of a tube failing, implement hazardous materials procedures; refer to National Operational Guidance: Hazardous materials

Exposure to extremes of temperature

Hazard	Control measures
Exposure to extremes of temperature	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident')

Hazard knowledge

Extreme heat

Fire and rescue service personnel may encounter extreme heat when attending petrochemical sites and may be at risk of burns or scalds from steam and other hot pipes. The hazard increases near tanks of bitumen and heavy oils, as steam coils are used to keep these substances fluid enough to be pumped.

For information about working in environments where industrial processes produce heat, refer to National Operational Guidance: Industry.

Extreme cold

When attending incidents involving cryogenic liquids, fire and rescue service personnel may encounter extreme cold that could cause burns. Refer to the supplementary information on liquefied natural gas (LNG) and liquefied petroleum gas (LPG).

For further information on dealing with cryogenic hazards, refer to National Operational Guidance: Hazardous materials.

Superheated steam and hot pipes

Hazard	Control measures
Superheated steam and hot pipes	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Consider using thermal imaging or scanning

Hazard knowledge

Some electrical turbines that rely on steam to generate electricity have complex pipelines that may contain superheated steam as part of the power-generation process.

These pipelines will be hot and present a significant burn hazard to fire and rescue service personnel.

Pipes are likely to be lagged; lagging can obscure leaks and can expose firefighters to sudden high pressures when disturbed.

Superheated steam leaks are potentially very dangerous because they are:

- Colourless
- Not visible to the naked eye (no vapour cloud visible)
- At temperatures from 200°C to 1200^{o}C
- Capable of igniting material in close proximity to the leak

- Released at high pressure

Control measure – Consider using thermal imaging or scanning

Control measure knowledge

Due to superheated steam not being visible to the naked eye, the use of thermal imaging cameras or scanners can help to identify the location of leaks.

For further information on their use refer to National Operational Guidance: Fires and firefighting – Consider using thermal imaging or scanning.

Flammable or explosive atmospheres

Hazard	Control measures
Flammable or explosive atmospheres	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Use intrinsically safe equipment Carry out atmospheric monitoring Control ignition sources

Hazard knowledge

When attending incidents within the petrochemical industry and fuel distribution network, fire and rescue service personnel may need to manage flammable or explosive atmospheres.

Some examples of these are:

Unconfined vapour cloud explosions (UVCE)

Large quantities of flammable gases or vapours in open air that are ignited and may cause deflagration with pressure waves or, less commonly, supersonic (detonation) advancement of flame fronts (e.g. ethylene vapour cloud).

Confined vapour cloud explosions (CVCE)

Flammable substances igniting in a container (e.g. process vessel) that generate pressure build-up and detonation velocities (e.g. natural gas explosions).

Boiling liquid expanding vapour explosions (BLEVE)

Caused by the failure of pressure vessels containing volatile flammable liquid and/or gases involved in fire.

Oil storage tank fire phenomena

- Steam explosions
- Boil over
- Froth over
- Slop over

For further information, refer to National Operational Guidance: Fires and firefighting.

Demolition or repair of tanks

Fire and rescue service personnel may encounter an explosion hazard from 'empty' tanks, which may contain an explosive mixture in the tank. This is because flammable vapours may be emitted when the sludge or residual contents are heated, e.g. from repair work, demolition, or radiated heat from a nearby fire.

Control measure – Use intrinsically safe equipment

Refer to National Operational Guidance: Hazardous materials.

Control measure – Carry out atmospheric monitoring

Refer to National Operational Guidance: Hazardous materials.

Control measure – Control ignition sources

Refer to National Operational Guidance: Hazardous materials.

Pipeline failure

Hazard	Control measures
Pipeline failure	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Isolate pipelines Implement hazardous materials procedures

Hazard knowledge

General

The utility industry uses pipelines extensively to transport products around their sites and for distribution around the UK. Pipelines are considered a safe mode of transport for conveying hazardous substances and are often safer than alternative methods, for example by road or rail. Refer to Health and Safety Executive's Further guidance on emergency plans for major accident hazard pipelines.

Fire and rescue service personnel may need to work in close proximity to pipelines while attending incidents at utility and fuel sites.

Other pipelines transport fuels, chemicals, other industrial products and water; these include over 1,000km of Major Accident Hazard Pipelines (MAHPs). Special duties apply to MAHP operators, including a notification regime, production of a major accident prevention document and emergency plan arrangements.

Pipelines buried underground have marker posts and indicators wherever they pass under roads or rail lines. These can be seen in all rural areas and are visible from the air by way of aerial marker posts. See the Linewatch website for typical pipeline markers and examples of marker posts and signs.

While it may be possible to identify the routes of buried pipelines, there is likely to be some delay in the arrival of a pipeline specialist or other specialist at remote rural locations.

Natural gas pipelines

Natural gas distribution in the UK consists of high-pressure gas mains. More than 95% of these are underground, or underwater to supply Northern Ireland.

Pipeline networks make up the UK gas transmission and distribution system for industrial and domestic consumers. These include:

- 278,00km of distribution mains
- 7,500km of high-pressure National Transmission System (NTS) pipelines operating at up to 85 bar
- 14,500km of high-pressure Local Transmission System (LTS) pipelines operating at up to 38 bar

For further information see the Health and Safety Executive's Onshore gas and pipelines sector strategy 2014-17.

High-pressure gas leaks will need to be dealt with by the appropriate gas utility; isolating leaks is not a straightforward task. Gas supplies cannot be isolated quickly and close liaison with the gas supplier will be required.

High-pressure gas is supplied at above 7 bar, and in the UK pressures can be up to 85 bar. This type of pressure can result in significant surface disruption when a leak occurs, and a resulting gas cloud will need to be mapped and monitored.

If there is a serious gas leak in close proximity to an airport, the airport and the Civil Aviation Authority need to be informed of the gas cloud because of the potential effect on aircraft.

Typical causes of pipeline failure

There are occasions when pipeline failure results in loss of containment or accidental release of the pipeline contents, including:

- Impact on the pipelines by construction workers
- Failure of the pipes through stress fractures and corrosion
- Unauthorised drilling into the pipelines for fuel theft
- Impact from external sources such as:
    - Aircraft accidents
    - Pressure waves caused by explosions
    - Structural collapse

Consequences of pipeline failure

Damaged pipelines can result in:

- Fire or explosion hazards
- Release of gases and liquids under high pressure
- Excessive noise
- Impact hazards
- Environmental damage – fuel entering watercourses, etc.
- Flooding

Undamaged pipelines also create problems such as:

- Difficult access and egress
- Extremes of temperature
- Working at height

Control measure – Isolate pipelines

Control measure knowledge

Isolating the pipeline is an action that will need to be carried out by, or under the close supervision of, pipeline specialists with a full understanding of the consequences of those actions. For example:

- It may be better to keep pipelines flowing to prevent their contents overheating
- Shutting down the supply in pipelines could have a major effect on processes and equipment, both downstream and upstream of the incident
- It may be better not to extinguish fires because an unignited gas or vapour cloud may be a greater hazard
- Depressurisation of pipelines can take some considerable time
- The edges of a vapour cloud are more prone to ignition because of the gas and air mix

Refer to the control measure of Isolate utility or fuel supply within the national grid.

Strategic actions

Fire and rescue services should:

- Consider recording locations of pipelines that are located in their area

Tactical actions

Incident commanders should:

- Request specialist advice on an urgent basis

Control measure – Implement hazardous materials procedures

In the event of a leak of a hazardous substance from a pipeline, refer to National Operational Guidance: Hazardous materials.

Pressurised storage vessels

Hazard	Control measures
Pressurised storage vessels	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Implement hazardous materials procedures

Hazard knowledge

Fire and rescue service personnel attending incidents at utility or fuel sites may need to manage pressurised storage vessels.

The utility industries will have, as part of their processes, a number of different types and sizes of pressurised containers holding liquids and gases under pressure.

Examples of vessels will be:

- Liquefied petroleum gas (LPG) bulk storage and small vessels
- Liquefied natural gas (LNG) cryogenic storage
- Oil
- Petroleum spirit, including numerous products within the petrochemical industry

Control measure – Implement hazardous materials procedures

For guidance on dealing with pressurised storage vessels, refer to National Operational Guidance: Hazardous materials.

Confined space entry

Hazard	Control measures
Confined space entry	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident')

Hazard knowledge

Fire and rescue service personnel attending incidents at utility or fuel sites may need to enter confined spaces.

This could include

- Tanks
- Pump rooms
- Sub-surface sewerage systems
- Culverts

For guidance on working in confined spaces, refer to National Operational Guidance: Sub-surface, height and structures.

Water holding facilities

Hazard	Control measures
Water holding facilities	Apply generic control measures (as detailed for the hazard of 'Dealing with utility or fuel supplies at an incident') Implement working near water procedures Identify and control the hazard area around a water holding facility

Hazard knowledge

Fire and rescue service personnel attending incidents may need to work near to water holding facilities. These include:

- Open vats
- Tanks
- Pits
- Bunds
- Rivers

- Reservoirs
- Flooding as a result of ruptured pipes and overtopping of water-holding facilities

Control measure – Implement working near water procedures

Control measure knowledge

The incident, and the safety of fire and rescue service personnel working in these environments, need to be managed carefully by the incident commander, who must create safe systems of work and implement working near water procedures.

Refer to National Operational Guidance: Operations – Health, safety and welfare.

Control measure – Identify and control the hazard area around a water holding facility

Control measure knowledge

An appropriate hazard area around a water holding facility should be identified and controlled. Access into the hazard area should be prevented, or limited to essential tasks with only the minimum number of fire and rescue service personnel.

For further information, including strategic actions and tactical actions, refer to the National Operational Guidance: Incident command – Structuring an incident.

Glossary

Term	Acronym	Description
Boiling liquid expanding vapour explosion	BLEVE	An explosion caused by the rupture of a vessel containing a pressurised liquid above its boiling point.
Confined vapour cloud explosion	CVCE	Type of explosion in a liquefied hydrocarbon or other flammable gas cloud in a confined space, such as vessels, pipelines or buildings.
Critical national infrastructure	CNI	Critical elements of infrastructure (namely assets, facilities, systems, networks or processes, and the essential workers that operate them), the loss or compromise of which could result in: • Major detrimental impact on the availability, integrity or delivery of essential services • Significant impact on national security, national defence, or the functioning of the state
Control of major accident hazards regulations	COMAH	Regulations that apply to any establishment storing or handling large quantities of industrial chemicals of a hazardous nature. Types of establishments include chemical warehousing, chemical production facilities and some distributors.
Distribution network	DNOs	Companies that own and operate the distribution network

operators		of towers and cables that deliver electricity from the national transmission network to homes and businesses. They do not sell electricity to consumers.
Drain earth		A fixed or portable earthing device applied for purpose of protection against voltages from transmission towers or poles.
Fractional horsepower motor	FHP	An electric motor with a rated output power of 746 watts or less.
Heat flux		Heat flux or thermal flux is the rate of heat energy transfer through a given surface per unit time. The SI derived unit of heat rate is joule per second, or watt. Heat flux density is the heat rate per unit area.
Inverter		An inverter (or power inverter) is an electronic device or circuitry that changes direct current (DC) to alternating current (AC) or vice versa
Liquefied natural gas	LNG	Natural gas stored at -161°C, creating a cryogenic liquid which reduces its volume by 600%.
Liquefied petroleum gas	LPG	Hydrocarbon gases, such as propane and butane, which are stored under pressure as a liquid.
Memorandum of understanding	MoU	A formalised mutual agreement between two or more parties.
National grid		The national grid is a term used to describe the high-voltage networks that are operated by: • National Grid – England and Wales • Scottish Power – Southern Scotland • Scottish Hydro – Northern Scotland and Scottish islands • Northern Ireland Electricity – Northern Ireland
National Inter-agency Liaison Officer	NILO	A member of a multi-agency cadre of trained and qualified (vetted) officers, who can advise and support fire and rescue service commanders, police, medical, military and other government agencies in their service's operational capacity to reduce risk and safely resolve incidents.
Photovoltaic	PV	An electrical device that converts the energy of light into electricity.
Polychlorinated biphenyls	PCBs	A group of manmade compounds that were widely used in electrical equipment, but which were banned at the end of the 1970s in many countries because of environmental concerns.
Polyvinyl chloride	PVC	The third most widely produced synthetic plastic polymer after polythene and polypropylene, which can be rigid or flexible.

Site-Specific Risk Information	SSRI	This is fire and rescue service risk information, gathered for the benefit of responding personnel attending a SSRI-qualifying location.
Uninterruptible power supplies	UPS	Electrical apparatus that provides emergency power to a load when the input power source, typically mains power, fails.
Unconfined vapour cloud explosion	UVCE	When a flammable vapour is released, its mixture will form a flammable vapour cloud. If ignited, the flame speed may accelerate to high velocities and produce significant blast overpressure.

Bibliography

South Wales Fire and Rescue Service – Confined space USAR SOP

GRA 2.1-rescues-from-confined space

GRA 5.1 Incidents involving electricity

GRA 3.10 Fighting fire in petrochemical plant and pipelines

www.hse.gov.uk/pipelines/index.htm

www.hse.gov.uk/gas/

www.ukpia.com/industry_information/distribution.aspx

www.nibusinessinfo.co.uk/content/overview-oil-gas-refining-and-petrochemical-sector

www.water.org.uk/consumers/find-your-supplier

www.energynetworks.org/gas/she/national-gas-incident-site.html

www.energynetworks.org

http://ifpmag.mdmpublishing.com/risk-based-fire-protection-strategy-in-crude-oil-storage-facilities/?pdf=4314

www2.nationalgrid.com/UK/Our-company/Gas/The-role-of-our-LNG-terminal/

http://web.anglia.ac.uk/estates/downloads/environment/ISO14001/03-Guidance/PPG2%20Above%20Ground%20Oil%20Storage%20Tanks.pdf

www.world-nuclear.org/nuclear-basics/how-does-a-nuclear-reactor-make-electricity.aspx

www.netl.doe.gov/publications/proceedings/02/ngt/Quillen.pdf

BRE and RECC (2016) Batteries and Solar Power: Guidance for domestic and small commercial consumers

Volume 2: Fire Service Operations – Electricity

Volume 2: Fire Service Operations – Petrochemical incidents

HSE Electricity at work – safe working practices (HSG85)