  - affect of the potential fireball
  - cylinder may be thrown some distance when not contained within the structure or building which would provide substantial shielding
  - cylinder fragments and other projectiles (eg valve assembly) may be thrown a considerable distance and have high looping trajectories
  - flying glass and other structural material
  - structural damage to buildings in the vicinity
  - possible need for an exclusion zone within the hazard zone
  - other hazards inside or close to the initial cordon
  - proximity and importance of adjacent occupancies and key infrastructure, such as major roads and railways.

- If cylinders, including acetylene, have not been heated then they do not represent a hazard and should be handed over to the site operator. In a developing fire situation consider carefully moving them if there is a risk that the fire will spread and involve them
- Acetylene cylinder identification:
  - It should be easy to distinguish between liquefied petroleum gas and other cylinders (including acetylene) on the basis of their shape (see photo of liquefied petroleum gas cylinders below right, acetylene below left).

  - To distinguish positively between acetylene and other non-liquefied petroleum gas cylinders is more difficult when they have been subjected to a fire.

    NOTE: If in doubt, treat the cylinder as though it is an acetylene cylinder, until a positive identification can be made.

    When cylinders are not affected by fire they can be identified by their label, colour (acetylene cylinders are maroon) or by their markings. In addition the cylinder industry now marks Acetylene cylinders with tape or a plastic collar . Absence of these does not indicate that it is not acetylene.

    NOTE: Due to the possibility of foreign acetylene cylinders being imported into the UK, it is essential that operational staff called to deal with an incident involving cylinders carry out a risk assessment and consider the possibility of incorrect colour markings. The Incident Commander should use as many sources of information as possible to verify that the contents of the cylinder match the colour coding. These may include confirmation with the owner, occupier or operative; any documentation available; 7(2)(d) information; visual information for example a cylinder connected to an oxygen cylinder or strapped to a welding trolley etc If there is any doubt as to the identification of the cylinder and the risk assessment indicates that there is a possibility that acetylene may be involved, the cylinders should be treated as acetylene until otherwise confirmed.

  - Contact the cylinder owner by telephone for specialist advice. Consider asking for the attendance of a specialist at the scene, although there has to be good visibility for this to be productive (gas cylinder supplier contact details are contained below in Phase 3: Planning the response.

- If non-acetylene cylinders have been heated but not damaged, they should be cooled, or allowed to cool then handed-over to the site operator who should be fully advised of the circumstances. In a developing fire situation consider cooling and carefully moving them if there is an imminent risk that the fire will spread and involve them

- Does the cylinder show signs of heat damage or direct flame contact?

  - Check to see whether there is any obvious fire damage to any structure or material near to the cylinders.
  - Do the cylinders appear to be scorched?
  - Are the labels burnt?
  - Are the plastic guard or test rings melted?
  - Is the cylinder paintwork burnt or blistered?
  - Does the cylinder surface steam or dry out quickly when water is applied?
  - Have eye witnesses seen flame impingement etc?
  - Is there any visible bulge in the cylinder?
  - Are pressure relief devices operating?

    NOTE: The operation of a pressure relief disc or fusible plug through a fire situation indicates an increased likelihood of catastrophic failure and should not be regarded as a sign of safety.

- As cylinders heat up in a fire the pressure inside them increases. Direct flame contact may also weaken the cylinder wall. If heat continues to be applied then the maximum safe working pressure of the cylinder may be exceeded. This may eventually cause the cylinder to burst or fail in a violent manner resulting in the release of a considerable amount of energy. Subsequent events will depend upon the gas type. For inert gases no further action is required. Cylinders containing oxidant, toxic or flammable gases may produce other hazards and specialist advice should be sought from a hazardous materials adviser and/or the gas supplier. For example, flammable gases such as hydrogen or methane will rapidly expand explosively following the cylinder rupture because of the very high internal pressure. This could actually extinguish the fire by blasting it out but also could result in a delayed ignition of the unconfined gas cloud.

Operational key principle

- **Cylinder cooling** – As soon as a cylinder is discovered at a fire, regardless of the contents, the Incident Commander should make every effort to extinguish any fire affecting the cylinder and apply cooling sprays directly on to any affected cylinders.
- It is important to quickly cool cylinders with water if they have been heated in a fire. This applies to cylinders suffering direct flame contact and also to those affected by radiant heat.
- Firefighters carrying out this task should continually risk assess the situation and take advantage of all available substantial shielding/cover. They should consider using ground monitors and lashed jets where severe or prolonged heating has taken place and should always wear appropriate personal protective equipment.

NOTE: If firefighters encounter cylinders that have been fully involved in a severe fire for an unknown period of time they should treat them with extreme caution and adopt defensive tactics.

- Initial crews discovering cylinders should make every effort, without exposing themselves to unnecessary risk, to identify the type, contents, location and number of any cylinders involved as this will determine the appropriate course of action. In particular, crews should attempt to identify if cylinders are acetylene
- Where a cylinder is alight at the valve group, it should be ascertained whether or not it is alight around the cylinder neck (from the base of the valve group where it enters the cylinder) or from where the hoses attach to the valve group itself. A risk assessment needs to be carried out to identify whether

the cylinder can be safely turned off. Where the cylinder is alight at the neck (ie the base of the valve group) this indicates that the valve group or cylinder neck is damaged and potentially will not be able to be shut off

- In most cases, non-acetylene cylinders which have not failed can be made safe by the application of cooling water. Internal pressure will be reduced as heat is removed from the cylinder and a heat or pressure weakened cylinder shell will recover most or all of its original strength as it is cooled. Once water has been applied and the cylinder wall temperature reduced, the cylinder is very unlikely to fail. Consideration should then be given to reducing the hazard zone.

Phase 3: Planning the response

7C5.40 The Incident Commander should ensure that a risk assessment is carried out in order to develop the response plan including appropriate and relevant control measures.

7C5.41 The response plan may be developed with the:

- On-site responsible person
- Hazardous materials adviser
- British Compressed Gas Association Competent Person.

Support from a gas industry competent person

7C5.42 A support network has been established between the Fire and Rescue Service and the British Compressed Gas Association (the trade association for all the major cylinder companies). During an incident involving cylinders it is important to identify the gas company that owns the cylinder. This will enable the gas company to provide assistance in identifying the contents of the cylinder and to provide any assistance required in order to manage the incident effectively. The owner of the cylinder can be identified in a number of ways:

- via the owner of the premises, by asking for the name of the gas supplier
- from the cylinder label if it is possible to get close enough safely
- by inspecting the label on any other cylinders in safe locations elsewhere on the premises.

7C5.43 The following are the 24-hour telephone numbers of the main gas cylinder companies:

Four main gas cylinder companies

Company	*Contact*
Air Products	0500 02 02 02
BOC	0800 111 333
Energas	01482 329 333
Air Liquide	01675 462 695

The British Compressed Gas Association competent persons are designated staff from the various cylinder companies who have passed a training course specialising in the subject of acetylene cylinders in fires. The competent person would only normally be requested to attend difficult or protracted incidents. The competent person is able to offer telephone advice to the Incident Commander on the numbers and types of cylinders delivered to the premises and support the decision making process.

It is not the role of the competent person to instruct Incident Commander on actions to be carried out. The Incident Commander, in liaison with the hazardous materials adviser should advise the competent person of the situation, the actions that have been taken and proposed further actions.

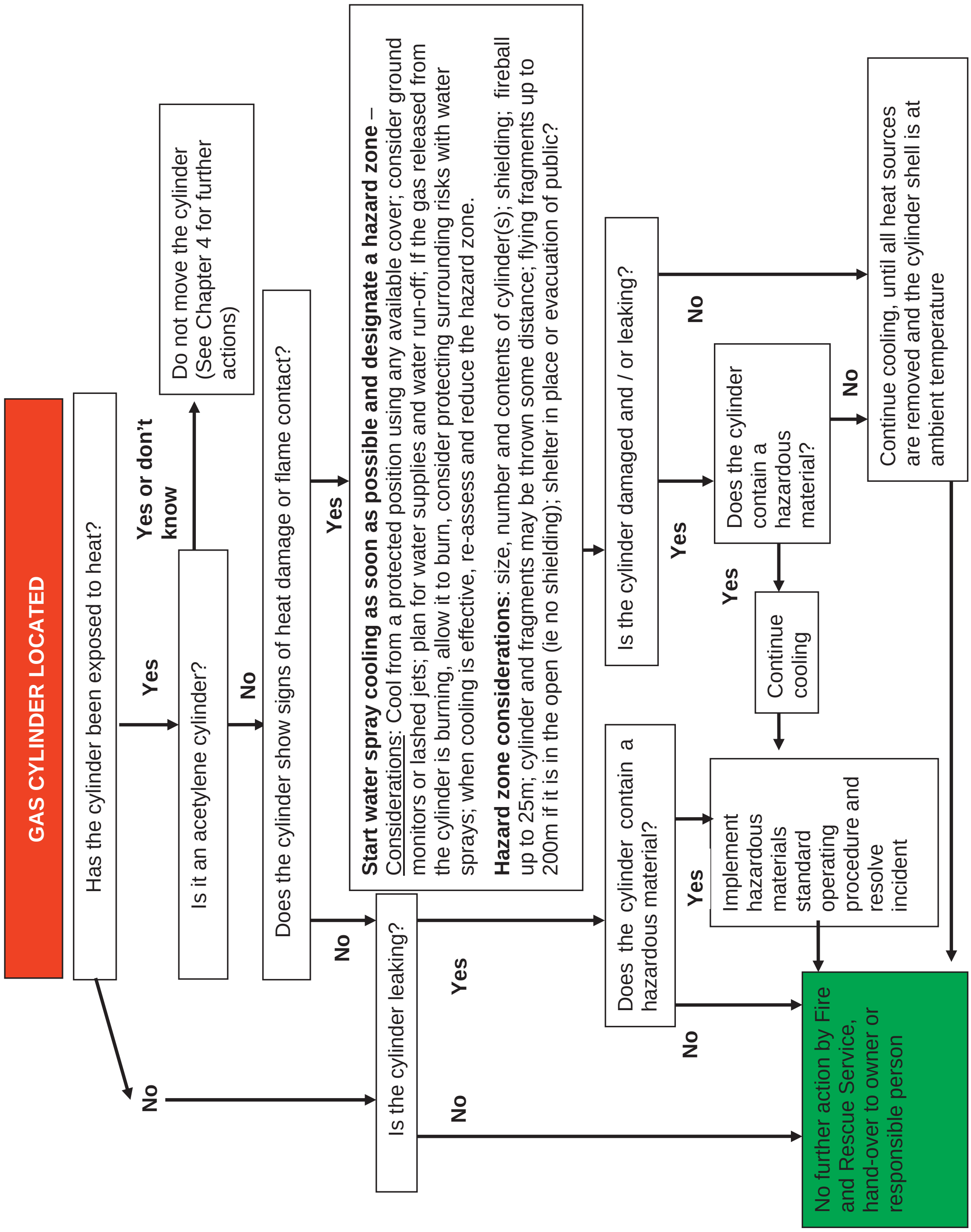
The competent person can also make arrangements to have cylinders collected at the end of an incident. However, there is usually no need for the cylinders to be collected at the end of the Fire and Rescue Service incident. The owner or manager of the premises should be advised that the competent person will arrange collection of the cylinder during office hours.

7C5.44 In a situation where a composite cylinder is involved in a direct flame contact but is not leaking, the fire can be extinguished and the cylinder cooled. However, caution should be exercised when considering moving the cylinder as the resin may have become weakened to an extent where it may begin to leak when handled. In these situations it is best to leave the cylinder in place and consult a hazardous materials adviser or product specialist.

Phase 4: Implementing the response

7C5.45 The Fire and Rescue Service response to incidents involving gas cylinders should be based on the following procedural flow chart.

NOTE: If there is doubt over the contents of a cylinder affected by heat or fire, it should be treated as an acetylene cylinder, until a positive identification can be made.



Start water spray cooling as soon as possible and designate a hazard zone – Considerations: Cool from a protected position using any available cover; consider ground monitors or lashed jets; plan for water supplies and water run-off; If the gas released from the cylinder is burning, allow it to burn, consider protecting surrounding risks with water sprays; when cooling is effective, re-assess and reduce the hazard zone.

Hazard zone considerations: size, number and contents of cylinder(s); shielding; fireball up to 25m; cylinder and fragments may be thrown some distance; flying fragments up to 200m if it is in the open (ie no shielding); shelter in place or evacuation of public?

Phase 5: Evaluating the response

7C5.46 Incident Commanders should constantly evaluate the risk posed by the gas cylinder(s); the effectiveness of specific operational procedures being adopted; and the advice upon which the risk assessment and tactics are based. Evaluation is not a one-off process but should be continual throughout the incident as circumstances change or new information is gathered. After evaluation, if necessary, the Incident Commander should adjust the response plan, amend or implement control measures and communicate the changes to all staff.

Phase 6: Closing the incident

7C5.47 At the end of any incident involving hazardous gases further control measures may include:

- **Liaison between the Incident Commander and the Fire Investigation Officer**
  The Fire Investigation Officer must be briefed regarding the location, condition, type and actual involvement of any cylinders or other gases at the incident.

- **Hand-over of the incident to the appropriate authority**
  This will be the site owner or occupier in most instances. The outcomes of the analytical risk assessment should form part of the incident hand-over.

- **Notification of the Health and Safety Executive**
  The Health and Safety Executive should be informed whenever cylinders or pressure vessels have exploded.

Acetylene

Characteristics

General

7C5.48 Acetylene has the following properties.

Operational key principle

Decomposition – Acetylene is distinguished from other flammable gases by its ability to continue to “self-heat” after the fire has been extinguished.

When involved in a fire, acetylene can begin to decompose, that is, break down into its constituent elements of hydrogen and carbon. The decomposition reaction is exothermic, that is, it produces heat.

Acetylene cylinders are designed to contain and inhibit decomposition, however, if left unchecked decomposition could lead to the failure of the cylinder.

This means that unlike other fuel gases, **acetylene may continue to be a hazard after the fire has been extinguished and requires specific operational procedures.**

However, only a high heat source such as direct flame contact can initiate decomposition.

Cold Shock – Mechanical shock alone to a cold cylinder cannot initiate decomposition.

- Flash point -17°C
- Vapour density 0.91
- Acetylene is slightly lighter than air
- Boiling point-85°C
- Flammable limits 2.5 to 80 per cent

  NOTE: However, for practical purposes, if it has leaked it will mix with air and should be presumed to be present in an explosive mixture.
- Critical temperature 36°C
- Storage pressure 15.5 bar at 15°C
- Naturally odourless, but industrial acetylene smells of garlic due to impurities

- Industrial grade acetylene is colourless
- Unstable gas at ambient temperature and pressure, and is significantly more so at elevated temperatures and pressures
- Soluble in many organic liquids, especially acetone which is the most common solvent used in acetylene storage.

Acetylene cylinder identification

7C5.49 It should be easy to distinguish between liquefied petroleum gas and other cylinders (including acetylene) on the basis of their shape (see photo of liquefied petroleum gas cylinders below right and an acetylene cylinder below left).

Acetylene and liquefied petroleum gas cylinders

7C5.50 To distinguish positively between acetylene and other non-liquefied petroleum gas cylinders is more difficult when they have been subjected to a fire.

NOTE: If in doubt, treat the cylinder as though it is an acetylene cylinder, until a positive identification can be made.

7C5.51 When cylinders are not affected by fire they can be identified by their label, colour (acetylene cylinders are maroon) or by their markings. In addition the cylinder industry now marks acetylene cylinders with tape or a plastic collar (see photos below). Absence of these does not indicate that it is not acetylene.

Markings on acetylene cylinders

7C5.52 **NOTE:** Due to the possibility of foreign acetylene cylinders being imported into the UK, it is essential that operational staff called to deal with an incident involving cylinders carry out a risk assessment and consider the possibility of incorrect colour markings. The Incident Commander should use as many sources of information as possible to verify that the contents of the cylinder match the colour coding. These may include:

- confirmation with the owner, occupier or operative
- any documentation available
- 7(2)(d) information
- visual information for example a cylinder connected to an oxygen cylinder or strapped to a welding trolley etc.

Acetylene cylinders

7C5.53 Acetylene cylinders (sometimes referred to as dissolved acetylene cylinders) differ from other compressed gas cylinders in that they contain a filler material, known as a porous mass, usually monolithic in form. They also contain a solvent, typically acetone, that is absorbed by the mass. The acetylene dissolves into the acetone and is held by it in a stable condition. The function of the porous mass is to evenly distribute the acetone throughout the cylinder and prevent the presence of large internal voids.

7C5.54 The porous mass or filler used for new cylinders is a monolithic mass poured in as slurry and baked in an oven to form a porous solid. Older cylinders may be filled with a granular filler. The materials used for the mass or filler include:

- lime/silica/asbestos
- fibreglass/lime/silica
- charcoal/kieselghur.

7C5.55 Cylinders containing granular type fillers are still in use but are less common. These can suffer from settlement problems that can allow free acetylene gas to collect at the head of the cylinder, with consequential implications should a decomposition reaction occur, however, gas suppliers carry out regular inspections and maintenance to minimise this risk.

7C5.56 Monolithic mass type fillers are not prone to settlement problems and investigative research on cylinders which have been subject to mechanical damage shows that the monolithic mass is extremely resilient and does not readily split or separate from cylinder walls.

7C5.57 Gas companies are aware of ways in which either mass type can be adversely affected and routinely check for such problems at each re-fill.

7C5.58 At the top of an acetylene cylinder, just below the valve assembly, there is a small cylindrical ‘‘gas space’’ hollowed out of the porous mass which is subsequently pugged with gauze or felt. The gas space is around 2cm diameter and 5cm deep typically. Its purpose is to allow free dissolution of acetylene from its carrier solvent to feed free gas out through the valve assembly for use (see diagram below).

Cross section through an acetylene cylinder showing the "gas space"

7C5.59 It should be noted that, due to atmospheric pressure, the acetone will still contain a quantity of dissolved acetylene even though the gauge reads zero and the cylinder is normally considered to be empty (eg a large cylinder could contain up to 500 litres of acetylene). Therefore an "empty" cylinder still represents a potential hazard in a fire.

7C5.60 Historically, some acetylene cylinders were fitted with pressure relief devices such as fusible plugs or bursting discs. These were designed to release the gas if the temperature or pressure rises excessively. In general, steel welded type cylinders were fitted with two fusible plugs in the shoulder of the cylinder, whilst those drawn from solid ingots were fitted with bursting discs, usually in the valve group. Some older cylinders may still be in circulation with fusible plugs in the base. The efficacy of these devices was tested by Health and Safety Laboratory and found to offer no significant contribution to safety. The operation of the pressure relief device allows gas (ignited or un-ignited) to leak from the heated cylinder increasing the risk of an explosion of a cylinder or further feeding the fire The main reason for the ineffectiveness of the pressure relief devices is that they cannot vent gas generated by decomposition fast enough. They can also cause fresh acetylene to be drawn into a hot spot and feed the reaction, and any leaking gas can form a cloud around the cylinder. Such pressure relief devices are, therefore, no longer fitted to new cylinders, and are being removed from older cylinders.

7C5.61 Cylinders are designed to suppress decomposition and to self extinguish it if it does occur. The porous mass contains thousands of small pores, which act as a stabiliser by dividing acetylene into small units. If decomposition were to occur, the acetylene would absorb heat to the stage where decomposition can no longer continue. This enables the cylinders to withstand most flashbacks and non-severe heating.

7C5.62 Acetylene at realistic fill pressures has to reach a temperature of approximately 300°C to initiate decomposition. This can be caused by a flashback from welding or cutting equipment (if the flashback arrester is missing or faulty), or by exposure to intense heat. The latter is only usually achieved by direct contact of flames on a cylinder.

7C5.63 Type approval testing of acetylene cylinders has shown that the porous mass does contain and effectively 'snuff' out decomposition. However, mechanical impact/shock to a heated acetylene cylinder could cause it to burst and must be avoided. Therefore acetylene cylinders exposed to severe heat in a fire should not be approached or moved until after they have been cooled and checked to ensure that decomposition is not occurring.

7C5.64 Re-development of heat at the cylinder surface is a good indicator of the decomposition reaction occurring and this is why it is recommended that the "Wetting Test" or Thermal Imaging equipment is used to check the temperature of the cylinder shell.

7C5.65 **NOTE:** An acetylene cylinder that has been heated and is also leaking presents an extra hazard. This is because fresh acetylene may be drawn through the internal mass of the cylinder and if a decomposition reaction is taking place may provide additional fuel for the reaction and promote the potential for catastrophic failure.

Hazards

7C5.66 The general hazards:

- highly flammable
- high concentrations may cause asphyxiation
- low concentrations may cause narcotic effects
- decomposition producing heat
- acetylene cylinders are normally used in conjunction with oxygen cylinders thereby increasing the potential hazard.

7C5.67 Acetylene can decompose to its constituent elements if exposed to extreme heat or, heat and shock.

NOTE: Decomposition cannot be initiated by cold shock alone.

7C5.68 Decomposition, if left unchecked, could result in a the failure of a fire exposed cylinder. Hazards from this could include:

- A blast pressure wave
- Fireball of up to 25 metres
- Cylinder may be thrown up to 150 metres*
- Flying fragments and other projectiles (eg valve assembly) may be thrown up to 200 metres*

  NOTE: The steel used to make acetylene cylinders is heat treated to ensure that when they do fail, they do so in ductile mode rather than brittle failure. Many merely split open, releasing the gas contents but if they explode the typical result is three or four large pieces which may have high looping trajectories

- Flying glass and other structural material
- Structural damage to buildings in the vicinity.

* Possible maximum travel distances for acetylene cylinders in the open (ie not within a structure or building which would provide shielding and therefore reduce the distances projectiles could travel).

Operational considerations

7C5.69 The following information is specific to incidents involving acetylene cylinders and augments the general guidance on gas cylinders given earlier in this Section.

Pre-planning

7C5.70 Fire and Rescue Services should liaise with local police, the Health and Safety Executive, Environment Agency, acetylene cylinder suppliers, users, Highways Agency, Network Rail, and other local authority agencies that will be affected by this type of incident. Liaison will ensure:

- a possible reduction in the number of acetylene cylinder incidents
- all parties involved understand the implications of such an incident
- the safe and effective management of the incident
- the safe and effective handover of affected cylinders.

7C5.71 Types of premises likely to contain acetylene cylinders should be identified as part of an on-going integrated risk management plan.

7C5.72 Fire and Rescue Services need to have in place systems that support operational staff in dealing with incidents involving acetylene cylinders. It is vital that crews rehearse the safe systems of work described below in order to develop relevant task management skills in conjunction with the knowledge and understanding provided by this guidance document.

7C5.73 Operational staff should be made aware of the specific dangers posed by acetylene cylinders involved in fire. Staff should be able to implement the key operational procedures for dealing with this type of incident at all role levels.

Acetylene cylinder procedure

7C5.74 Due to the risk of decomposition occurring within acetylene cylinders after any fire involving them has been extinguished, specific operational procedures are required for acetylene incidents.

7C5.75 The flow chart below includes guidelines to assist in deciding if a cylinder has been involved in a fire sufficiently to cause decomposition. An often encountered situation where a cylinder operator damages a hose should not always be considered sufficient to initiate decomposition, provided any flames from the damaged hose are extinguished in a timely fashion.

Operational key principle

Single acetylene cylinders involved in fire

- Acetylene cylinders that have been significantly heated or damaged by fire must not be moved
- They should be cooled as soon as possible with water spray and a hazard zone designated around them (Up to 200m for cylinders in the open with no shielding). Where cylinders are heavily involved in fire an exclusion zone should also be considered
- **COOLING PHASE** – Water cooling should be continued for at least one hour. Ground monitors and lashed jets should be used, any firefighters carrying out essential tasks within the hazard zone must have appropriate personal protective equipment and make full use of all available substantial cover/shielding. After a minimum of one hour of water cooling the cylinder's temperature should be checked to see if it has been effectively cooled

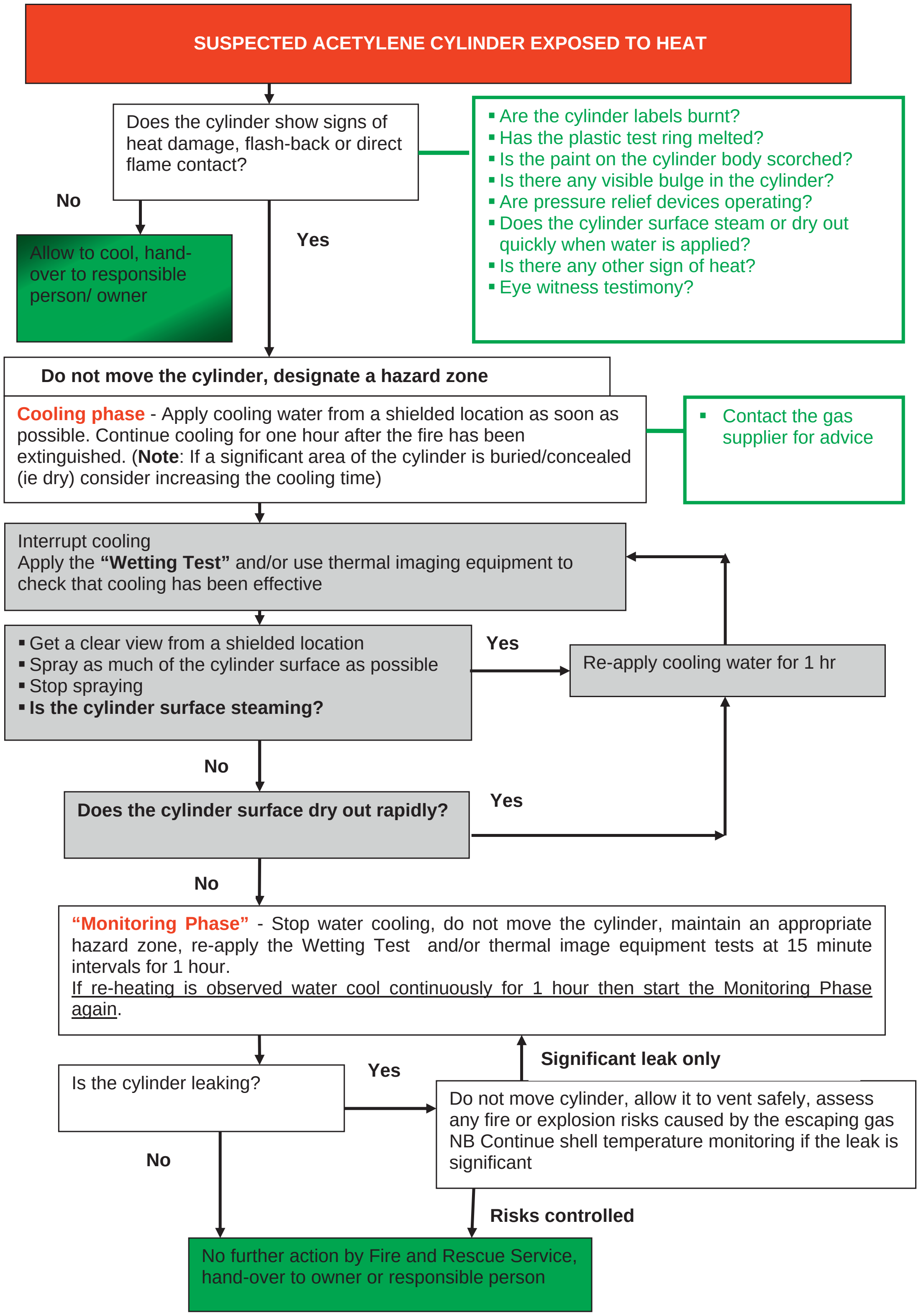
  NOTE: "effective cooling" means bringing the cylinder shell temperature down to ambient temperature. The "Wetting test" and/or thermal imaging equipment should be used to do this
- **MONITORING PHASE** – When effective cooling of the cylinder shell has been achieved, water cooling should be stopped. The cylinder should still not be moved for a further one hour and an appropriate, risk assessed hazard zone should be maintained. This monitoring phase is required due to the possibility of internal decomposition occurring

  NOTE: Leaking acetylene cylinders have a higher risk of decomposition occurring
- During the monitoring phase, temperature checks of the cylinder shell should be made every 15 minutes. If any increase in temperature is observed a further one hour continuous water cooling should be applied to the cylinder before its temperature is re-checked
- When the cylinder remains effectively cooled for the whole of the monitoring phase (ie the shell temperature remains at ambient temperature for one hour without being water cooled, and is not leaking, there is no risk of cylinder failure and it should be handed over to the responsible person or agency on-site

  NOTE: A cylinder which is leaking significantly should not be moved and should be allowed to vent safely. The Fire and Rescue Service should assess any fire or explosion risks caused by the escaping gas and continue cylinder shell temperature monitoring.

Multiple cylinders (or substantially concealed single cylinders)

Where cylinders are very closely packed, and/or concealed/buried by debris, there may be a risk that the cooling water may not come into contact with a substantial proportion of the cylinder shell, therefore limiting the effect of cooling. If the Incident Commander considers that significant areas of the cylinder are 'dry' then the cooling phase should be extended (eg if 50 per cent of a cylinder is not being touched by cooling water, that is dry metal, then consider increasing the cooling phase to three hours).


SUSPECTED ACETYLENE CYLINDER EXPOSED TO HEAT
Does the cylinder show signs of heat damage, flash-back or direct flame contact?
▪ Are the cylinder labels burnt?
▪ Has the plastic test ring melted?
▪ Is the paint on the cylinder body scorched?
▪ Is there any visible bulge in the cylinder?
▪ Are pressure relief devices operating?
▪ Does the cylinder surface steam or dry out quickly when water is applied?
▪ Is there any other sign of heat?
▪ Eye witness testimony?
No
Allow to cool, hand-over to responsible person/ owner
Yes
Do not move the cylinder, designate a hazard zone
Cooling phase - Apply cooling water from a shielded location as soon as possible. Continue cooling for one hour after the fire has been extinguished. (Note: If a significant area of the cylinder is buried/concealed (ie dry) consider increasing the cooling time)
▪ Contact the gas supplier for advice
Interrupt cooling
Apply the "Wetting Test" and/or use thermal imaging equipment to check that cooling has been effective
▪ Get a clear view from a shielded location
▪ Spray as much of the cylinder surface as possible
▪ Stop spraying
▪ Is the cylinder surface steaming?
Yes
Re-apply cooling water for 1 hr
No
Does the cylinder surface dry out rapidly?
Yes
No
"Monitoring Phase" - Stop water cooling, do not move the cylinder, maintain an appropriate hazard zone, re-apply the Wetting Test and/or thermal image equipment tests at 15 minute intervals for 1 hour.
If re-heating is observed water cool continuously for 1 hour then start the Monitoring Phase again.
Is the cylinder leaking?
Yes
Significant leak only
Do not move cylinder, allow it to vent safely, assess any fire or explosion risks caused by the escaping gas NB Continue shell temperature monitoring if the leak is significant
No
Risks controlled
No further action by Fire and Rescue Service, hand-over to owner or responsible person

Explanatory notes for the procedural flow chart

Does the cylinder show signs of heat damage, "flash-back" or direct flame contact?

7C5.76 It is important to assess whether the cylinder has been sufficiently heat affected for decomposition to be initiated. It requires a significant temperature increase (ie above 300°C), this is normally only achieved by direct contact of flames on a cylinder.

7C5.77 There are signs which can be used to detect possible heating:

- If there is any visible bulge in the shell treat the cylinder with extreme caution as this indicates a greatly increased likelihood of catastrophic failure!
- Do any of the cylinder labels appear to be burnt?
- Are any of the plastic rings around the cylinder valve melted in any way?
- Is the cylinder paintwork burnt or blistered?
- Does the cylinder surface steam or dry out quickly when water is applied?
- Are pressure relief devices operating, if fitted?

NOTE: The operation of a pressure relief disc or fusible plug with gas burning off or leaking, indicates an increased likelihood of catastrophic failure and should not be regarded as a sign of safety.

7C5.78 Eye witnesses may be able to provide information to enable the Incident Commander to confirm:

- whether a cylinder has suffered direct flame contact and if so for how long
- the severity and duration of any heating of a cylinder
- whether a flash-back, and not a backfire (ie a single cracking or 'popping' sound), has occurred.

7C5.79 Flashback might be accompanied by a shrill hissing sound. A flashback occurs when the flame travels back through the hoses into the body of the cylinder. This may be caused by user error or poorly maintained or faulty equipment. Flashback arrestors fitted to the hoses will detect and stop reverse gas flow preventing a flammable oxygen and acetylene mixture from forming in the hose.

7C5.80 Flashback arrestors are mandated under DSEAR in the UK and are designed to prevent a flashback. It is an automatic flame trap device designed not only to quench the flame but also to prevent the flame from reaching the regulator.

NOTE: Extra care should be taken with unofficially imported cylinders which may not have flashback arrestors.

7C5.81 Flash backs into acetylene cylinders which may initiate decomposition are generally due to the failure to fit a flame arrestor.

7C5.82 An acetylene cylinder is designed to suppress decomposition and to self-extinguish if decomposition does occur. The porous mass contains thousands of small pores, which act as a stabiliser by dividing the acetylene into small units. If decomposition were to occur, the acetylene in some of the units would decompose slowly but the walls of the cells would absorb heat to the stage where decomposition can no longer continue. If a flame were to develop, the small pores would act as arrestors. This enables the cylinders to withstand most flashbacks and non-severe heating.

7C5.83 Where cylinders are in the proximity of a fire but show no signs of direct heating (see list above), they are likely to be safe to move. However, before doing so the temperature of the cylinder walls should be checked by spraying with water and seeing whether they remain wet or through the use of thermal imaging equipment. Staff must be made aware of the manual handling problems associated with moving an unheated cylinder to a safe location. Acetylene cylinders are comparatively heavy in relation to other cylinders and are awkward to carry, especially when wet.

“Cooling phase” – Do not move the cylinder. Designate a hazard zone. Apply cooling water from a shielded location as soon as possible. Continue cooling for one hour after the fire has been extinguished.

7C5.84 If a decomposing cylinder is leaking or is moved, the rate of decomposition and heat generated may be increased to such an extent that the cylinder walls are weakened abnormally and rupture. Greater safety can be achieved if the decomposition process is slowed or arrested by water spray cooling.

7C5.85 Water cooling is currently the most effective method of preventing failure of an acetylene cylinder and should be used whenever it can be implemented without compromising the safety of firefighters (eg where protection is offered by suitable shielding).

7C5.86 The period of greatest risk is when the cylinder shell is hot, so every effort should be made to cool it comprehensively taking full advantage of any available substantial shielding/cover and the use of ground monitors and/or lashed jets.

7C5.87 The application of water will result in the cylinder shell cooling quickly. This in turn will slow down any internal decomposition process occurring inside the cylinder. As a consequence of this and after carrying out a risk assessment the Incident Commander, in liaison with the hazardous materials adviser, could reduce the initial cordon distance in favour of a risk assessed hazard zone.

7C5.88 Considerations when determining the hazard zone include:

- size of cylinder(s)

- number of cylinders
- shielding provided by any buildings or structures
- type and extent of adjacent structures
- local topography (eg protection provided by slopes and gradients of ground levels etc)
- affect of the potential blast pressure wave
- affect of the potential Fireball of up to 25 metres*
- cylinder may be thrown up to 150 metres*
- flying fragments and other projectiles (eg valve assembly) may be thrown up to 200 metres*

  NOTE: The steel used to make acetylene cylinders is heat treated to ensure that when they do fail, they do so in ductile mode rather than brittle failure. Many merely split open, releasing the gas contents but if they explode the typical result is three or four large pieces which may have high looping trajectories.

- flying glass and other structural material
- structural damage to buildings in the vicinity
- possible need for an exclusion zone within the hazard zone
- proximity and importance of adjacent occupancies and key infrastructure, such as major roads and railways.

NOTE: * Possible maximum travel distances for a cylinder in the open (ie not within a structure or building which would provide shielding and therefore reduce the distances projectiles could travel).

7C5.89 Consideration should always be given to the use of any substantial, portable materials, that might offer shielding between the cylinder(s) and risks (eg a public highway, railway or other thoroughfare), to reduce the hazard zone. This might be particularly possible where such materials are paletted and can easily be moved into place without subjecting the operative to any undue risk. This may be necessary when cylinders cannot be water cooled due to their location within, for example, a dangerous structure.

7C5.90 There may be circumstances where attempts to apply cooling water would expose firefighters to unacceptable levels of risk that outweigh the benefit likely to be gained. At such incidents the alternative would be to leave the cylinder in place without applying water until it bursts or all sources of heating are removed. Remotely operated vehicles (have been used at cylinder incidents to assist the Incident Commander in monitoring the condition, degree of heat damage and temperature of cylinders.

Consider contacting the gas supplier for advice

7C5.91 Remotely operated vehicles may be available from a number of sources, for example the military, police, multi-agency initiatives (eg Highways Agency, Network Rail and Transport for London, used by London Fire Brigade) and private commercial companies. Fire and Rescue Services should consider the need to pre-plan for the availability of remotely operated vehicles based on their integrated risk management plan.

7C5.92 During an incident involving acetylene cylinders it is important to identify the gas company that owns the cylinder. This will enable the gas company to provide assistance in identifying the contents of the cylinder and to provide any assistance required in order to manage the incident effectively. Contact details are contained in 7C5.43.

7C5.93 When contacting the relevant cylinder supplier the following information is required:

- State which Fire and Rescue Service is attending and the name of the caller
- State the address of the incident and the premise name if applicable
- State what advice is required. ie telephone support or on-site support
- If on-site attendance is required be prepared to provide a map reference and directions
- Confirm that the police at the outer cordon are aware that the cylinder supplier's representative is attending
- Number of cylinders involved and if collection will be required?

7C5.94 The supplier company will then pass the call onto the 'competent person'. As all the companies are different in size and therefore have different levels of resource the way in which the first call is dealt with may vary but the technical advice offered will be standard across all companies.

7C5.95 If the Incident Commander would like on-site assistance this will be arranged by the 'competent person'. However, before requesting a site visit certain questions need to be considered such as:

- **Is it definitely acetylene involved?** If unsure try to gather as much information as possible from the site occupier and over the telephone from the 'competent person'. If still unable to determine a site visit may be required
- **Is the cylinder visible?** If it is covered in debris or behind other shielding and it can't be seen it must be questioned if the attendance of the 'competent person' will add value to the decision making process?
- **Is there adequate lighting for the 'competent person' to be able to clearly see the cylinder/s involved?** If not it would be best to advise the 'competent person' not to arrive on site until after first light.

7C5.96 Attendance on site by competent persons should be managed in daylight hours where at all possible unless the incident involves severe disruption such as closing major arterial routes.

7C5.97 The 'competent person' will be able to help in identification and if necessary assist with providing guidance for the "Wetting Test". They can also arrange for the removal of the cylinder(s) at the conclusion of the incident. The Incident Commander can discuss all relevant issues with the 'competent person', Police, Local Authority and any other relevant organisations in attendance in order to make an informed decision with regard to maintenance of the initial hazard zone or its reduction.

Apply the "Wetting Test" and/or use thermal imaging equipment to check that cooling has been effective?

7C5.98 Decomposition of the acetylene contained within a cylinder may take place after the external heat source has been removed if there has been sufficient transfer of energy to start the reaction. Once started it will continue until all of the acetylene is consumed or until the cylinder is effectively cooled and made safe. Acetylene cylinders are designed and tested to withstand such decomposition and can cool naturally without any problem. The porous mass is designed to assist in this. Cooling will slow the reaction and allow it to self extinguish.

7C5.99 It is therefore important to be able to identify if an acetylene cylinder is hot or becoming hotter by itself. This can be achieved by carrying out a "Wetting Test" and/or the use of thermal imaging equipment.

7C5.100 Testing may be performed immediately upon discovering cylinders that may have been exposed to heat, or during the cooling process for cylinders known to have undergone heating.

7C5.101 The purpose of testing is twofold, firstly to establish if the cylinder shell is cool and secondly to confirm that acetylene is not undergoing internal decomposition. To achieve the second purpose a number of successful tests spread over at least one hour must be observed. This procedure will ensure that any heat build up will be noticed externally before it can reach temperatures likely to weaken the cylinder shell or cause dangerous internal pressures. Due to high conductivity of steel, any decomposition occurring in a part of the cylinder that cannot be seen will still be observable using the 'wetting test' on any visible part of the cylinder shell.

7C5.102 When externally cool, the cylinder should be safe to approach as long as no gas is leaking but it must not be moved in case there is a large internal cavity due to damage to the porous mass. Movement of the cylinder may accelerate decomposition and result in catastrophic failure hence the importance of continuing to apply 'wetting tests' for at least one hour after a perceived 'test pass' has been observed.

7C5.103 The ‘wetting test’ involves:

- Getting a clear view of the cylinders from a shielded location
- Briefly spraying water on to the cylinder surface
- Stopping spraying and looking for signs of steam rising from the surface of the cylinder
- If steam is not seen rising, checking to see whether the wetted cylinder surface dries out quickly (ie one – two minutes).

  NOTE: During the process of combustion tars and oils may be released and deposited on the cylinder surfaces. The oil and tar deposits may make the ‘drying out’ part of the test difficult to interpret due to the reaction between oil and water

- If either check is failed then water cooling must be re-applied for one hour before testing again. If both tests are passed then the “monitoring phase” should start.

NOTE: Use of thermal imaging equipment and remote temperature measuring equipment gives additional confidence and should be used whenever possible.

‘Monitoring phase’ – Stop water cooling, do not move the cylinder, maintain hazard zone, re-apply the wetting test and/or thermal image equipment tests at 15 minute intervals for one hour.

If any re-heating is observed water cool continuously for one hour then start the monitoring phase again.

7C5.104 Water cooling must be completely stopped during the monitoring phase to allow any internal heating to show itself by raising the temperature of the exterior of the cylinder shell. Testing should be carried out at 15 minute intervals so that any heat build up through decomposition will be noticed before it can reach a dangerous temperature. A written record of the results of the tests should be maintained throughout the monitoring phase.

7C5.105 It should be noted that effective water cooling may reduce the cylinder temperature down to the temperature of the cooling water which may be lower than the ambient temperature. This means that during the monitoring phase when no water is being used to cool the cylinder its temperature may rise slowly and naturally to its ambient temperature. The Incident Commander should take care not to misinterpret this rise in temperature as the result of internal decomposition.

7C5.106 The natural heating effect of direct sunlight on dark coloured or blackened cylinders will also result in a rise in the cylinder shell temperature which is not attributable to decomposition. If in doubt the Incident Commander should extend the monitoring phase or, if the temperature rises above ambient/expected levels, recommence water cooling for at least one hour.

7C5.107 An appropriate, risk assessed hazard zone should be maintained throughout the monitoring phase because should re-heating of the cylinder take place, it may be difficult to quickly reintroduce cooling phase cordons due to staffing levels and adverse public reaction.

7C5.108 If any re-heating above ambient cylinder temperature (either steaming or rapid drying out) is observed at any of the wetting tests then the cylinder must be continuously water cooled for a further one hour. After this period the wetting test and/or testing with thermal image equipment should be carried out again. If no re-heating has occurred the full monitoring phase procedure should be also started again (ie stop water cooling and carry out “wetting Tests” at 15 minute intervals for one hour).

7C5.109 It should be remembered that failure of the cylinder occurs because the cylinder has reached temperatures of over 300oC and the cylinder walls are loosing their tensile strength. Cylinders at temperatures close to 300oC will cause the water to violently boil off, as seen when red hot metal is plunged into cold water. The “failure” of the Wetting Test due to a “hotspot” does not imply that the cylinder is at immediate risk of failure unless there is an extremely violent reaction.

Is the cylinder leaking?

7C5.110 The monitoring phase will have established that the cylinder shell has been effectively cooled from its original temperature, but more importantly that any decomposition reaction has stopped. However, If there is still any low-level decomposition within the cylinder then this will be fuelled, and potentially accelerated, if fresh acetylene passes through this area (ie if a leak pulls gas across the decomposition zone). The leak would need to be serious to stimulate rapid decomposition. A leak such as this would be seen from a melted fusible plug, should that be present or a massive release from the valve. The porous mass should be adequate to self extinguish in the event of small leaks. If decomposition is fuelled, then the cylinder will heat up. This heating will then be detectable as the shell of the cylinder shows signs, once again, of heat. If there is a significant leak the Incident Commander should consider re-establishing the monitoring phase (ie cylinder shell temperature checks at 15 minute intervals for a further hour)

7C5.111 Leaking acetylene gas may also cause an additional fire and/or explosion hazard if it is confined around the leaking cylinder. This risk needs to be assessed and managed by the Fire and Rescue Service.

No further action by Fire and Rescue Service, hand-over to owner or responsible person

7C5.112 Heat damaged cylinders are not the responsibility of the Fire and Rescue Service. Once the fire and explosion risk has been dealt with the site and cylinder(s) should be handed over to the responsible person, owner or operator. A full brief should be given by the Incident Commander to the responsible person detailing what action has been taken and why. If the cylinders are not at a premises but on public land, contact the local authority or the Highways Agency as appropriate.

Multiple cylinders (or substantially concealed single cylinders)

7C5.113 Where multiple cylinders are encountered and they are very closely packed, and/or concealed/buried by debris, there may be a risk that the cooling water may not come into contact with a substantial proportion of the cylinder shell, therefore limiting the effect of cooling.

7C5.114 If the Incident Commander considers that a significant area of any cylinder is 'dry' then the cooling phase should extended (eg if 50 per cent of a cylinder is not being touched by cooling water (ie dry metal) then consider increasing the cooling phase to three hours).

7C5.115 In extreme circumstances where the vast majority of the cylinder(s) is concealed or buried and is believed to be 'dry', the Incident Commander should consider increasing both the cooling phase and the monitoring phase.

Liquefied petroleum gas

Characteristics

7C5.116 This section provides a brief over-view of liquefied petroleum gas. Further detailed information can be found in *Fire Service Manual (Volume 2 Fire Service Operations) Petrochemical incidents – Chapter 8 Liquefied petroleum gas*.

7C5.117 Many hydrocarbons exist as gases at normal atmospheric temperatures but they can be liquefied under moderate pressure. As the liquids occupy only about 1/250th of the space they would occupy if they were stored as gases, from a commercial point of view, it is more practicable to store and convey the hydrocarbons as liquids.

7C5.118 Liquefied petroleum gas may be stored as a liquid either at ambient temperature under its own vapour pressure or in a refrigerated condition at a lower pressure. If the temperature of the storage is sufficiently low, the liquefied petroleum gas may be stored at atmospheric pressure.

Propane and butane main properties of the gases

	Propane	Butane
Specific gravity of liquid (water = 1)	0.5	0.5
Density of gas (air = 1)	1.5	2.0
Vapour pressure at 15ºC	7 bars	2 bars
Boiling point of liquid	-42ºC	-0.5ºC
Flammability range in air	2% to 10%	1.5% to 9%
Critical temperature	97ºC	152ºC
Expansion ratio liquid to vapour	274	233

7C5.119 Given that liquefied petroleum gas vapour is heavier than air, it will flow along the ground and into drains, etc, sinking to low levels. In still air conditions any accumulation of vapour will take some time to disperse. This means that a flammable mixture might become ignited some distance from the point of leakage with the flame travelling back to that point.

7C5.120 Liquefied petroleum gas is colourless, odourless, and has anaesthetic properties. For this reason liquefied petroleum gas is usually odorised enabling detection by smell down to one fifth of the lower limit of flammability (ie, approximately 0.4 per cent gas in air). In some circumstances, however, the odorant would not be used.

7C5.121 Escaping liquefied petroleum gas can also be recognized by its cooling effect on the surrounding air, causing condensation and freezing of water vapour in the air, showing as frost at the point of leakage. Owing to its consequent lowering of temperatures, liquefied petroleum gas can cause severe frost burns to the skin.

Hazards

7C5.122 Liquefied petroleum gas is highly flammable

7C5.123 **Boiling Liquid Expanding Vapour Explosion (BLEVE)** – When liquefied petroleum gas pressurised containers (road/rail tanker storage vessels) are heated, without adequate cooling, a boiling liquid expanding vapour explosion could occur. This is usually a result of the heating of a vessel containing a flammable liquid by an external fire. The contents of the vessel are heated above their boiling point and the pressure in the vessel increases. The failure occurs when the flames impinge on an area which does not have liquid on the other side. As the liquid is heated and boils it absorbs heat, it is generally when the liquid has boiled away from the area of impingement that weakening of the vessel wall will occur. The vessel ruptures and pieces can be propelled considerable distances. The spillage of the overheated liquids and then ignition create a large fireball with explosion pressure effects. This can mean that it is extremely difficult to predict when, and if, a boiling liquid expanding vapour explosion will occur. A vessel that is venting in a fire does not mean that everything is safe, more than likely the opposite is the case. A boiling liquid expanding vapour explosion can occur at any time and some have occurred many hours into an incident.

7C5.124 For further details on a boiling liquid expanding vapour explosion, its causes and effects refer to *The Fire Service Manual (Volume 2, Fire Service Operations) Petrochemical Incidents*.

7C5.125 An unconfined vapour cloud explosion is an event where a flammable cloud of fuel/air burns in free space, generating shock waves, the flame front accelerating from a low initial velocity to sonic velocity. One of the main differences with this type of explosion is that the explosion centre may be a substantial distance from the incident (up to 5Km) due to cloud drift, possibly creating significant additional problems for firefighters.

Calculations of fireball diameters for containers of differing size

Vessel volume (m^3)	Diameter fireball (m)	Duration fireball (sec)
1600	520	29
270	300	18
180	260	16
55	170	12
45	160	11
35	150	11

Operational considerations

Liquefied petroleum gas cylinders firefighting considerations

- There is no ‘safe period’ when a pressurized liquefied petroleum gas container is subjected to heat, especially when heating is due to direct flame contact. Expect a boiling liquid expanding vapour explosion at any time if adequate cooling is not available
- Ideally do not try to put out a fire involving liquefied petroleum gas, isolate the supply of gas to extinguish the flames or allow it to burn out
- If extinguishment is the only course of action use dry powder type media but beware the build up of flammable/explosive atmosphere

- Assess any immediate crew and public life risks, then gather information to establish an initial cordon around the potential hazard zone. Consideration should be given to evacuation of the public and non-essential responders
- Protect surrounding risks and cool the cylinder with water spray. Generally as soon as effective water cooling takes place hot cylinders are unlikely to fail. However, firefighters should take advantage of any available substantial shielding/cover and keep as low as possible to the ground. Lashed jets and monitors should always be considered
- Any flame contact on liquefied petroleum gas cylinders is dangerous and can lead to cylinder failure and explosion, but contact on the cylinder surface area above the level of the liquid (ie 'dry walled' areas at the top of the cylinder) is most dangerous as the internal gas will not conduct heat away as quickly as internal liquid.

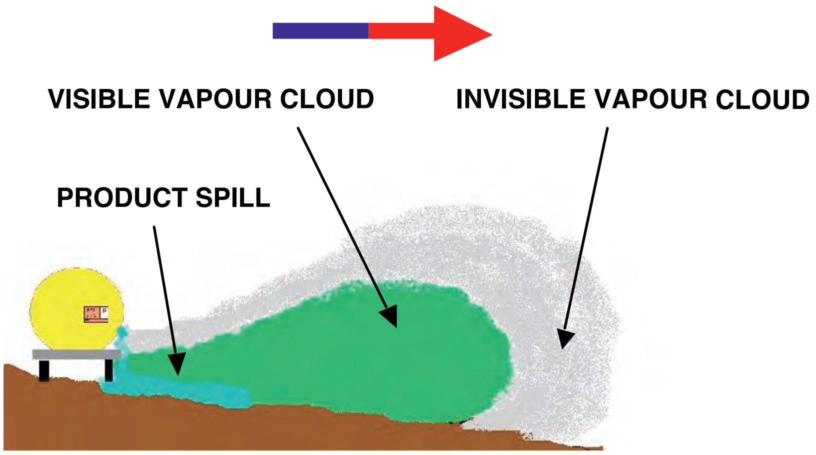
Bulk liquefied petroleum gas firefighting considerations

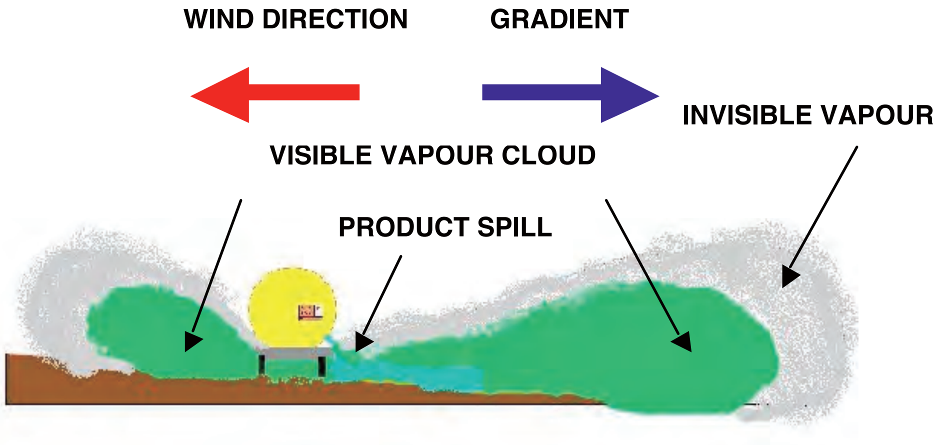
- In the case of small leaks only that have ignited and posed an contact hazard, the flames may be extinguished with dry agent and freeze-sealing techniques applied if staff have received appropriate training
- Where there is no risk to life, serious consideration should be given to employing a 'defensive' or 'non-attack strategy'
- Evacuation of the surrounding area should be considered a priority – debris may be projected over 1 km from the fire site
- If it is decided to attack the fire, immediate, massive cooling should be applied, paying particular attention to 'dry wall' areas. This cooling is also important in securing adequate time to evacuate the danger zone
- Responders should be fully briefed as to the potential danger of the situation
- The Incident Commander should exercise strict control and supervision over crews involved
- Ground monitors or lashed jets/branches should be employed as early into the incident as possible
- Consider employment of water bottoming techniques if specialist advice is available
- Consider flame bending to prevent flame contact on pressurized containers
- Reduction of tank inventory may hasten the onset of a boiling liquid expanding vapour explosion due to the increase in dry wall area as the tank is emptied
- Remember that in the event of a boiling liquid expanding vapour explosion the fireball can engulf exposed crews. The use of heavy coarse sprays to provide a measure of protection for crews and equipment against fire effects should be considered

- If a boiling liquid expanding vapour explosion occurs, the ground flash can exceed the size of the arising fireball with the attendant risk to crews.

Unignited leaks

- The primary considerations are the size of the leak, wind strength and direction, and the potential for vapour cloud ignition
- Consider the need for evacuation of members of the public.
- Wind direction and gradient are same





Wind and gradient in opposite directions

- Elimination of ignition sources
- Consider the need for evacuation of members of the public
- Elimination of ignition sources
- Consider vapour containment and dispersal by the use of fog branches or monitors, flat fan or other ground sprays to form a barrier to movement of vapour clouds and to reduce the gas concentration to below the lower explosive limit by the entrainment of air

- Vapour clouds can be controlled by water sprays/walls but the application of water to liquid spills will increase the rate of vaporisation
- Use explosimeters to determine the effectiveness of procedures
- Responders should only enter vapour cloud in exceptional circumstances in order to effect rescues or to attempt to stem the leak. Even then, they should wear structural firefighting kit (including flash/fire-hoods), breathing apparatus and be provided with the protection of heavy water spray or fog coverage. If necessary, the crew providing this cover should be similarly protected
- Pools of liquefied petroleum gas should be covered by medium/high foam in order to reduce gassing off
- Strict control of hazard area should be implemented to prevent inadvertent entry to area of danger
- Consider possible accumulations of gas at low levels, eg, in basements, drain and water courses.

Water injection into liquefied petroleum gas vessels (water bottoming)

- If the escape of burning liquefied petroleum gas is from an outlet near the base of the vessel and the installation includes a fire brigade inlet, water may be gently introduced into the vessel to lift the liquefied petroleum gas above the outlet, which will extinguish the fire at this point and allow staff to approach the vessel to carry out the necessary actions to stem the flow of liquid
- However, extreme caution should be exercised when using this method, particularly to ensure that only sufficient water pressure is used to lift the vessel's contents above the outlet. If such precautions are not observed, liquefied petroleum gas could be forced out of the safety relief valves in the top of the vessel, which could lead to a far worse situation than the original incident
- This technique must not be used under any circumstances for refrigerated containers because the water will freeze and the refrigerated liquid will boil with potentially catastrophic consequences

  NOTE: Specialist advice is imperative prior to pumping water into an liquefied petroleum gas vessel, to ensure that other dangers are not introduced – such as over-pressure in the vessel due to admission of water in excessive quantities or at excessive rates, and freezing of leaking valves, etc, where evaporation of liquefied petroleum gas will cause cooling below the freezing point of water. Such ice formation could melt later, resulting in possible undetected leakage of liquefied petroleum gas.

Liquefied natural gas

Characteristics

7C5.126 Comprehensive information on all forms of natural gas can be found in *Fire Service Manual (Volume 2 Fire Service Operations) Natural Gas Incidents and Fire Service Manual (Volume 2 Fire Service Operations) Petrochemical Incidents, Chapter 7 Liquefied Natural Gas*.

7C5.127 When natural gas is cooled to a temperature of approximately –160 0C and it is at atmospheric pressure it condenses to a liquid called liquefied natural gas.

7C5.128 Liquefied natural gas is odourless, colourless, non-corrosive and non-toxic, it vaporises rapidly to form a highly flammable gas when mixed with air. It is not explosive in its liquid state; its vapour can explode when mixed with air in the right proportions.

Liquefied natural gas main physical properties	
Boiling point	–161ºC
Specific gravity of liquid (water=1)	0.42
Vapour density (air=1)	0.55 at 15ºC
Flammability range in air	5% to 15%
Expansion ratio liquid to vapour	1/600

Hazards

- Accidental leakage of liquefied natural gas will boil (vaporise) instantly gaining heat from its surrounding area: gas is initially heavier than air with the vapour cloud above the spillage
- Liquefied natural gas will ignite easily at very low concentrations in air 5 to 15 per cent, edges of gas cloud most likely to find ignition source causing rapid burn back towards the evaporating liquid
- Liquefied natural gas is 83-99 per cent methane, when ignited generates vast quantities of heat radiation quickly (twice the heat from the equivalent quantity of petrol)
- Bulk storage of liquefied natural gas poses a severe cryogenic hazard
- High concentrations of liquefied natural gas may cause oxygen deficiency and asphyxiation. Whilst not toxic liquefied natural gas vapours are capable of causing asphyxiation by displacing the air necessary to support life
- Liquefied natural gas will react explosively at room temperature with chlorine and bromine

- May explode on contact with chlorine trifluoride.

Operational considerations

Firefighting

- If possible extinguish flame by isolating source of supply, only if considered essential should flame be extinguished using fine water spray (fog) without isolating source, due to danger of unignited vapour explosion.

Spillages

- Small spills – establish cordon in all directions, stay upwind, vapour will initially collect in low lying areas, eliminate all ignition sources, use water sprays to control vapours
- Do not direct water at the spill or source of the leak as this will lead to an increase in vaporisation
- Large spills – Consider evacuation and/or shelter-in-place (ie keep people indoors closing all windows and doors)
- Environmental – prevent spillage from entering drains or water course.

Cryogenics

Characteristics

7C5.129 Cryogenic liquids are liquefied gases that are kept in their liquid state at very low temperatures. All cryogenic liquids are gases at normal temperatures and pressures. These gases must be cooled to below room temperature before an increase in pressure can liquefy them.

7C5.130 The vapours and gases released from cryogenic liquids also remain very cold. They often condense the moisture in air, creating a highly visible fog.

7C5.131 Each cryogenic liquid has its own specific properties but most cryogenic liquids can be placed into one of three groups:

INERT GASES

Inert gases do not react chemically to any great extent. They do not burn or support combustion. Examples of this group are nitrogen, helium, neon, argon and krypton.

FLAMMABLE GASES

Some cryogenic liquids produce a gas that can burn in air. The most common examples are hydrogen, methane and liquefied natural gas.

OXYGEN

Many materials considered as non-combustible can burn in the presence of liquid oxygen. Organic materials can react explosively with liquid oxygen. The hazards and handling precautions of liquid oxygen must therefore be considered separately from other cryogenic liquids.

7C5.132 Cryogenic liquids are shipped and used in thermally insulated containers. These cryogenic liquid containers are specifically designed to withstand rapid temperature changes and extreme differences in temperature.

Liquid dewar flasks

7C5.133 Liquid dewar flasks are non-pressurized, vacuum-jacketed vessels, somewhat like a "Thermos bottle". They should have a loose fitting cap or plug that prevents air and moisture from entering, yet allows excess pressure to vent. Flasks containing helium, hydrogen and other low boiling point liquids have an outer vessel of liquid nitrogen for insulation.

Laboratory liquid dewar flasks

7C5.134 Laboratory liquid dewars have wide-mouthed openings and may not have lids or covers. These small containers are primarily used in laboratories for temporary storage.

Liquid cylinders

7C5.135 Liquid cylinders are pressurized containers specifically designed for cryogenic liquids. This type of container has valves for filling and dispensing the cryogenic liquid, and a pressure-control valve and a pressure relief valve with a frangible (bursting) disk as backup protection. There are three major types of liquid cylinders designed for dispensing:

- liquid or gas
- only gas
- only liquid.

Hazards

Extreme cold

- Cryogenic liquids and their associated cold vapours and gases can produce a thermal burn. There is no initial pain, but there is intense pain when frozen tissue thaws
- Unprotected skin can stick to metal that is cooled by cryogenic liquids. The skin can then tear when pulled away. Prolonged breathing of extremely cold air may damage the lungs.

Asphyxiation

- When cryogenic liquids form a gas, the gas is very cold and usually heavier than air. This cold, heavy gas does not disperse very well and can accumulate near the floor. Even if the gas is non-toxic, it displaces air. Oxygen deficiency is a serious hazard in enclosed or confined spaces
- Small amounts of liquid can evaporate into very large volumes of gas. For example, one litre of liquid nitrogen vaporises to 695 litres of nitrogen gas when warmed to room temperature (21°C).

Toxicity

- The chances of the Fire and Rescue Service encountering toxic cryogenic substances is extremely remote as they are only likely to be found in tiny quantities in one or two research establishments in the world. If they are encountered reference should be made to the material safety data sheet for information about the toxic hazards of a particular cryogen.

Fire hazard

- Flammable gases such as hydrogen, methane, liquefied natural gas and carbon monoxide can burn or explode. Hydrogen is particularly hazardous. It forms flammable mixtures with air over a wide range of concentration; it is also very easily ignited.

Oxygen-enriched air

- Liquid hydrogen and liquid helium are both so cold that they can liquefy the air they contact. For example, liquid air can condense on a surface cooled by liquid hydrogen or helium. Nitrogen evaporates more rapidly than oxygen from the liquid air. This action leaves behind a liquid air mixture which, when evaporated, gives a high concentration of oxygen.

Liquid oxygen hazard

- Liquid oxygen contains 4,000 times more oxygen by volume than normal air. Materials that are usually considered non-combustible, (such as carbon and stainless steels, cast iron, aluminium, zinc and teflon (PTFE),) may burn in the presence of liquid oxygen. Many organic materials can react explosively, especially if a flammable mixture is produced. Clothing splashed or soaked with liquid oxygen can remain highly flammable for hours.

Explosion due to rapid expansion

- Without adequate venting or pressure-relief devices on the containers, enormous pressures can build up. The pressure can cause an explosion called a ‘boiling liquid expanding vapour explosion’(BLEVE)
- Unusual or accidental conditions such as an external fire, or a break in the vacuum which provides thermal insulation, may cause a very rapid pressure rise. The pressure relief valve may not be able to handle this increased pressure. Therefore, the containers must also have another backup device such as a frangible (bursting) disc.

Operational considerations

- Once cryogenic products have escaped from their containment vessel there is no mechanism for recovering the product
- Large volumes will eventually absorb enough heat from the atmosphere to boil and form a gas, which can then be dispersed
- This process can take along time and the resultant freezing of land or structures can cause other problems
- Cryogenic products will form dense vapour clouds.

Spillages

- Stop the flow of liquid. Consider the use of water to freeze seal a small slow leak, water can not always be used safely, some materials will react violently with water or could make a corrosive solution that would enlarge the hole
- Where possible contain the leak, disperse the vapours using water sprays or reduce vaporisation by covering the liquid with a tarpaulin or appropriate foam layer
- Dry agents only near the liquid
- Do not allow anyone to enter the vapour cloud unless they are wearing appropriate personal protective equipment
- Consider evacuation of the public.

Ammonia gas

Characteristics

7C5.136 Ammonia is a colourless, corrosive and toxic gas that is about one half as dense as air at ordinary temperatures and pressures. It is regarded as flammable however because of the high ignition temperatures and the narrow flammable range of 15-28 per cent. The possibility of ignition is remote. Ammonia has a characteristic pungent, penetrating odour and forms a minute proportion of the atmosphere.

Ammonia gas main physical properties	
Boiling point	-33°C
Relative vapour density gas (air=1)	0.6
Relative density liquid (water=1)	0.7
Flammability range	15–28%
Auto-ignition temperature	651°C

Hazards

- Although generally lighter than air, ammonia gas can mix with water vapour and become heavier than air, collecting in pockets at floor level. It is not normally flammable, but at extremely high concentrations it can create an explosive mixture with air
- Ammonia is a severe irritant of the eyes, nose and throat
- Exposure in excess of the allowable workplace limits can cause headaches, coughing and difficulty breathing. Prolonged exposure to high concentrations of ammonia can lead to pulmonary oedema, which can be fatal
- Skin contact with liquid ammonia can cause burns. Eye contact can cause severe damage to the eye
- Ammonia, even at dilute concentrations, is highly toxic to aquatic animals, and for this reason it is classified as dangerous to the environment
- Ammonia has a high reactivity and may react enthusiastically or violently with some materials, including acids and aldehydes.

Operational considerations

Unignited leaks

- In a spillage situation water sprays or fog may be used to dissolve, reduce or divert any vapours but the run off should be contained to avoid severe and long-term impact to the environment
- If possible the leak should be stopped, but any spilled liquid will rapidly vaporise and disperse over a large area. Initial isolation of 100m should be maintained until the gas has dispersed.

Ignited leaks

- The main concerns will be to prevent the gas interacting with other materials and to cool containers. Only if essential (ie to save life) should the flame be extinguished without isolating source, due to the danger of unignited gas leak explosion
- Any heating of the contained gas will cause pressure rise and the potential of the risk of containers rupturing or exploding
- Firefighting should be undertaken from the maximum distance possible utilising ground monitors or unmanned hose holders
- Toxic and corrosive fumes may be produced in a fire
- Warn the public to stay indoors, close all windows and doors, alternatively, consider evacuation.

NOTE: Ammonia is transported and used as either aqueous or anhydrous ammonia. The former is ammonia dissolved in water which is substantially less hazardous than the latter, which contains no water and to which the above precautions apply.

Chlorine gas

Characteristics

7C5.137 Chlorine is very reactive and widely used for water purification, sanitation, as a bleaching agent, as a versatile raw material in synthetic chemistry etc

7C5.138 It exists as a pale green gas about 2.5 times as dense as air. It is poisonous with a detectable odour in concentrations ranging between 0.2 and 0.4ppm.

Chlorine main physical properties	
Boiling point	–34°C
Relative density (water = 1)	1.4 at 20°C
Vapour pressure, kPa at 20°C	673
Relative vapour density (air=1)	2.5

7C5.139 Chlorine is normally found as a gas, but can be pressurized and cooled to change to a liquid for shipping and storage. If released chlorine liquid will quickly revert to a gas that stays close to the ground and spreads rapidly.

Hazards

- very toxic by inhalation and can be recognized by its pungent, irritating odour similar to that of bleach
- may cause severe damage to eyes
- corrosive to skin and most materials
- oxidising substance
- can ignite combustible substances
- it is not itself flammable, but can react explosively or form explosive compounds with other chemicals such as turpentine and ammonia
- spilled liquid has a very low temperature and evaporates quickly
- persons exposed to chlorine become restless, sneeze, develop sore throat and salivate copiously
- liquefied pressure gas
- heating may cause pressure rise leading to a risk of bursting
- marine pollutant and acutely toxic to the aquatic environment

  NOTE: Effects are likely to be severe and long term.

Operational considerations

Spillage

- Do not spray water on to a spillage or leaking cylinder
- In emergencies limited water sprays may be used with extreme caution to ‘knock down’, control or divert vapours but the run off should be contained to avoid severe and long-term impact on the environment
- If possible the leak should be stopped, but any spilled liquid will rapidly vaporise and the resultant gas is heavier than air and so will settle in any low-lying areas
- Isolation of the area should be maintained until the gas has dispersed
- Consider evacuation but it is generally safer to keep people indoors with all doors and windows closed, in an upstairs room if possible
- If chlorine gas comes into contact with moist tissue, such as is found in the eyes, throat and lungs, an acid is produced that can cause damage to these tissues
- Prevent from entering watercourse and sewers
- The UK chlorine industry has established a free mutual-aid scheme known as ‘Chloraid’ available 24/7 to provide expert help and guidance on all matters involving chlorine. Further information may be found by reference to the following web link:

  www.chloraid.srst.co.uk/

Fire

- Emergency Action Code – 2XE therefore use fine water spray or fog

  NOTE: Prevent run-off from entering drains and watercourses
- The gas itself will support combustion therefore avoid the gas interacting with other materials

  NOTE: Steel will burn in a chlorine atmosphere
- Cool intact and undamaged containers as they may explode when exposed to heat
- Any heating of the contained gas will cause a pressure rise and therefore the potential for risk of bursting and explosion
- Firefighting should be undertaken from the maximum distance possible or by using unmanned hose holders or ground monitors

  NOTE: Consideration of boiling liquid expanding vapour explosion(BLEVE) situations should be anticipated and actions taken accordingly. Further information is contained in 7C5.123 and 7C2.39.

PART C–6

UN Class 3 Flammable liquids

General information

Introduction

7C6.1 There is no simple 'response for all occasions' when it comes to incidents involving flammable liquids. In addition to posing the threat of fire, most of these materials also present a health hazard for the worker or emergency responder. When dealing with flammable liquids it is safe to assume that they possess more than one hazard, this section deals only with those that directly influence its fire hazards.

Characteristics and classification

7C6.2 UN Class 3 Flammable Liquids covers substances and articles, which:

- are liquids at 20°C and at a pressure of 101.3 kPa, with a melting point or initial melting point of 20°C or less at a pressure of 101.3 kPa
- at 50°C have a vapour pressure of not more than 300kPa
- have a flash point of not more than 60°C.

7C6.3 This group also contains:

- liquid substances and molten solid substances with a flash-point of more than 60°C that are carried or handed over for carriage whilst heated at temperatures equal to or higher than their flash-point
- liquid desensitised explosives, which are explosive substances that are dissolved or suspended in water or other liquid substances to form a homogeneous liquid mixture to suppress their explosive properties.

7C6.4 Flammable and potentially flammable liquids can be identified in a number of ways:

- hazard warning diamonds
- hazard warning symbols
- United Nations Class 3 or hazard sub risk 3
- ADR hazard identification number containing 3
- description as a Class I, II or III flammable liquid

- description of a liquid as ‘flammable’, highly flammable’ or extremely flammable’
- chemical name showing the material is carbon based, for example, ethanol or butanone.

UN Class 3 hazard symbol for flammable liquids

Hazards and risk assessment

7C6.5 Once it has been established that a flammable liquid is present and will impact upon the risk assessment for the incident, the physical properties of the material should be determined as a matter of urgency to assess the significance the fire risk is.

7C6.6 Having investigated the documented inherent physical properties of the substance the relevant environmental properties also need to be considered (eg the ambient temperature, wind strength and direction etc).

Factors that increase fire risks from flammable liquids

QUANTITY AND SURFACE AREA

7C6.7 As the quantity of a flammable liquid increases so does the risk because a large quantity can generate a spill with a greater surface area than a small quantity. Increased surface area facilitates the evolution of vapour and the potential size of the ignitable plume or fire. Additionally, any fire that results from a large quantity of liquid can be deeper and thus last longer than one from a small quantity.

HEATING

7C6.8 Hot materials are more reactive and ‘volatile’ (produce more vapours) so a heated flammable liquid will generally be more ignitable than a cold one and more likely to exhibit rapid fire growth.

CONTAINMENT

7C6.9 If materials are released in a poorly ventilated or confined situation then the hazards they bring will be increased above those anticipated at an open area where dispersion is possible. Toxic, flammable/explosion hazards are increased by confinement.

PRESSURE

7C6.10 Apart from the very obvious danger of bursting its container the fact that a material is under pressure means that it will be likely to give off far more vapour if it is allowed to escape. Increased vapour can exaggerate toxicity and flammability hazards. Additionally reactions of gaseous materials are often increased by the application of pressure.

INCOMPATIBLE MATERIALS

7C6.11 Some materials, especially oxidizing agents, are likely to react chemically with flammable liquids. The heat of the reaction and/or presence of oxidizing agent will make the mixture liable to ignition and rapid fire growth.

ABSORBERS, ADSORBERS AND WICKS

7C6.12 The common belief that ‘absorbing’ hazardous materials makes them safer is not entirely true. Many adsorbers can act as a wick and enable materials to be ignitable below their documented flashpoints.

LOCATION

7C6.13 Proximity to human or animals, property, sensitive or protected habitat will increase the risk that any loss will be significant.

TOPOGRAPHY AND METROLOGY

7C6.14 Slopes will spread a spill, depressions in the surface and trenches, etc can collect/concentrate vapours that are heavier than air. Strong sunshine can heat materials and surfaces they may contact. Rain can cause the boiling of liquefied gases and react with water-reactive materials.

INERTING AGENTS

7C6.15 By replacing the air with a gas that does not support combustion the risk of fire can be greatly reduced or eliminated.

ABSORBERS AND ADSORBERS

7C6.16 These can be used to immobilise or contain a spill to restrict its surface area and prevent movement towards sensitive areas or other hazardous features such as ignition sources or incompatible materials.

LOCATION

7C6.17 Locations remote from risk to life, property or vulnerable habitat decrease the likelihood of significant damage occurring should ignition occur.

TOPOGRAPHY AND METROLOGY

7C6.18 Strong winds can disperse vapours and gases, rain can dissolve soluble gases, ‘wash them out’ of the atmosphere and promote mixing/dilution of any vapour plume. Spills can collect in depressions in the ground to limit spread and surface area.

Operational considerations

7C6.19 Incidents involving flammable liquids will fall into one of two categories:

- unignited leak of substance
- substance involved in fire.

Unignited leak of substance

7C6.20 Incidents involving an unignited leak of substance, unless dealt with effectively and efficiently, will evolve quickly into an incident involving fire. It is imperative, therefore, that the Incident Commander and hazardous materials adviser fully understand the hazards and risks involved.

7C6.21 Having identified and interpreted the physical properties of the material and relevant environmental influences on risk, the following actions should be considered:

- eliminate all ignition sources
- stop leak, if practicable
- prevent the substance entering water courses, drainage systems, basements, etc
- absorb the substance with sand, earth or other non-combustible material
- consider foam suppression of vapours
- consider water sprays to control vapours
- use spark-proof equipment.

Additional operational considerations when involved in fire

7C6.22 Dealing with a flammable liquid directly involved in fire is relatively simple albeit hazardous. Consider:

- For small fires, CO_2 or dry powder may be effective media
- Do not apply water to burning flammable liquid fires unless a full assessment of its physical properties has been made as a dangerous, violent reaction, boil-over or slop-over may occur
- For larger fires normal foam, alcohol resistant foam or fine spray is usually appropriate. These should be applied from a safe distance, preferably using fixed monitors. Foam should be applied gently where possible using spray techniques. Care must be exercised to avoid surface disturbance and spreading the burning liquid

- Generally large scale foam attacks should not be started until all resources, including foam concentrate, are available on-site
- Whilst efforts will be made to extinguish the fire, the surrounding risks may well be a priority
- Spill fires can be most difficult to deal with especially when being fed by a storage tank or pressurised pipeline. The source of the leak should be identified and isolated as soon as possible
- With a flowing spill fire it is generally best to commence at the furthest point of the fire and work towards the source of spillage. It is good practice to form a deep blanket of foam beyond the farthest point at the lowest level so that flowing burning liquid will flow beneath it and be extinguished
- Beware fires involving tanks and containers of flammable liquids as over-pressurisation and explosion may occur. Cool any affected containers with water spray
- Beware flammable liquids entering drains, sewerage systems and other confined spaces where it may vaporise and create explosive atmospheres
- Further detailed information on fighting petroleum fires is contained in chapter 6 of the *Fire Service Manual (Volume 2 Fire Service Operations), Petrochemical incidents*
- Further detailed guidance on using foam for firefighting is contained in *Fire Service Manual (Volume 2 Fire Service Operations) Firefighting Foam*
- Further technical guidance on firefighting foam is contained in *Fire Service Manual (Volume 1 Fire Service Technology, Equipment and Media) Firefighting Foam – Technical.*

Factors that decrease fire risks from flammable liquids

QUANTITY

7C6.23 Decreased quantities mean smaller potential surface area of any spill, and fires of shorter duration.

COOLING

7C6.24 As flammable liquids are cooled they become less reactive and less volatile to produce less vapour.

SURFACE AREA

7C6.25 The smaller the surface area the less vapour will be evolved; so a small, deep spill will last longer than a large, shallow one of the same volume (quantity of material) but will have a smaller vapour hazard surrounding it and thus is less likely to come into contact with an ignition source.

FOAM BLANKETS

7C6.26 An appropriate foam can put a barrier between the flammable liquid and supporter of combustion to inhibit the formation of an ignitable fuel/air mixture. Foam blankets can limit the size of any ignitable plume and slow the fire growth if an ignition does take place.

VENTILATION

7C6.27 Good ventilation can assist in dispersing flammable vapours to minimize the size of any ignitable plumes. By providing an easy path for the escape of any gases heated by an ignition, the risk of explosion is reduced.

PRESSURE

7C6.28 Adjusting pressure to match the ambient pressure decreases hazard by reducing the strain on mechanical features thus reducing the potential to explode, implode or eject the contents.

PART C–7

UN Class 4 Flammable solids; substances liable to spontaneously combust; substances which on contact with water emit flammable gases

General information

Introduction

7C7.1 Flammable solids are amongst the most common of all flammable materials, but relatively few are included in the UN hazardous substances classifications.

7C7.2 Those included can exhibit special risks and this section highlights some of the more important problems associated with these hazardous materials.

Characteristics, classification and hazards

Division 4.1 Flammable solids, self-reactive substances and desensitized explosives

Division 4.1: Flammable solids, self-reactive substances and desensitized explosives

7C7.3 This division includes:

- Desensitized explosives such as those wetted with sufficient water, alcohol, or plasticizer to suppress explosive properties (eg UN 1356 Trinitrotoluene, wetted with not less than 30 per cent water by mass; UN 3319 Nitroglycerine mixture desensitised, solid)

- Readily combustible solids. Examples include:
    - solids that may cause a fire through friction, such as matches, eg, UN 1331 Matches ‘Strike Anywhere’
    - UN 1327 Hay, Straw or Bhusa
    - UN 2000 Celluloid.
- Self-reactive materials that are thermally unstable and can undergo a strongly exothermic (heat-evolving) decomposition even without the presence of oxygen (air). Certain exclusions apply, eg, the material meets the definition of an explosive, oxidizer or organic peroxide as prescribed in the UN transport regulations.

Division 4.2: Substance liable to spontaneous combustion

Division 4.2: Substances liable to spontaneous combustion

7C7.4 Substances (solids and liquids) which are liable to spontaneous heating under normal conditions encountered in transport, or to heating up in contact with air, and being then liable to catch fire.

7C7.5 Spontaneously combustible materials include:

- Pyrophoric (literally, ‘fire-loving’) materials. These are materials (solids and liquids) that can ignite with no external ignition source within five minutes after coming in contact with air (eg UN 1854 Barium alloys, pyrophoric)
- Self-heating materials, those that exhibit spontaneous ignition or heat themselves to a temperature of 200°C during a 24-hour test period in the presence of air but in the absence of an energy supply (This behaviour is called spontaneous combustion, eg UN 2002 Celluloid)
- Generic advice on dealing with these materials is contained in Emergency Response Guidebook GUIDE NUMBER: 136.

Other considerations

7C7.6 There is a range of factors which influence whether solids are included in Division 4.1 or 4.2. Some of these are discussed below.

7C7.7 Normally it is the vapours produced from liquids or solids which burn, not the actual materials themselves. In practical terms, solids rarely produce enough vapours at ordinary temperatures to be ignitable; naphthalene and camphor being notable exceptions. However as solids are heated then vapour production will increase as they melt and possibly boil (eg sulphur). Some solids, normally organic in nature, will decompose as they are heated to produce small combustible molecules which, eventually, when mixed with air, may ignite (eg wood, plastics, paper).

7C7.8 For naturally occurring flammable solids the water content of the material can determine its ignition temperature. For example, it is relatively easy to ignite dry grass but rather more difficult to ignite damp grass.

7C7.9 Similarly the shape and surface area of solids also affects the ignition temperature. It is considerably more difficult to ignite a bar of metal where the access of oxygen in the air to the metal surface is limited and heat is rapidly spread throughout the bulk of the solid, than to ignite a similar weight of finely divided metal dust where the access of oxygen is much increased and the ability of the metal particles to lose heat quickly is reduced (ie the particles heat up more quickly than the bar of metal). Should the dust be confined in any way then the ignition process may give way to a deflagration reaction.

7C7.10 To further complicate matters, some elements can exist in different structural forms called allotropes, for example, graphite and diamond are allotropes of the element carbon. All the allotropes contain exactly the same atoms of the element, but as the atoms are bonded together in different ways they have different properties. Graphite and diamond are chemically inert except at very high temperatures; pure graphite and oxygen will not react until about 700°C. Amorphous forms of carbon (ie forms of carbon that can have varying structures) are much more reactive than their allotropic forms. Coal, coke, charcoal and animal charcoal are examples of amorphous forms of carbon that will burn readily provided they are suitably activated.

7C7.11 Phosphorus is another example of an allotropic element and exists as:

- white phosphorus (or yellow phosphorus)
- red phosphorus
- black phosphorus (extremely rare).

7C7.12 White phosphorus is toxic and in air fumes readily, ignites at relatively low temperatures (~ 30°C) and is normally stored under water. Due to its reactivity with air (oxygen), it is normally classified as a UN 4.2 material. Red phosphorus, on the other hand, is of low toxicity, only ignites at about 260°C and does not need to be stored under water because of its low reactivity with air (oxygen). In industry, red phosphorus is used in the manufacture of matches, phosphate fertilisers and insecticides. It is also used in the illegal production of Methamphetamine.

Division 4.3: Substances which in contact with water emit flammable gases

Division 4.3: Substances which in contact with water emit flammable gases

7C7.13 Substances (solids and liquids) which, by interaction with water, are liable to become spontaneously flammable or to give off flammable gases in dangerous quantities.

7C7.14 Examples include:

- aluminium phosphide (liberates phosphine gas)
- calcium carbide (liberates acetylene on contact with water)
- sodium.

Health hazards

7C7.15 It is relatively easy to reduce exposure to flammable solids as a group unless they are reacting. The primary hazard is inhalation of dusts and finely divided powders as they are easily inhaled. Some dusts such as sodium metal react with the moisture in lungs to form a caustic solution that causes burning of sensitive tissues.

7C7.16 The mixture of some metallic dusts with moisture on the body may result in chemical burns. It is imperative to avoid all clouds of smoke as they may include toxic by-products of the burning metal.

Operational considerations

7C7.17 Considerations:

- Most flammable solids can be handled easily unless they are on fire or otherwise reacting in some fashion
- Do not allow flammable solids to mix with other materials unless you are certain of the resulting reaction

- Some flammable solids are very active chemically, so great care must be taken to ensure compatibility with other stored materials and their containers
- Some solid spills can be covered with a heavy plastic sheet to minimise dust blowing around or water contact from rain
- Regardless of the material involved, avoid adding any water until you are sure the situation will not worsen
- One exception to the use of water on flammable solids is in the case of contamination through skin contact. In such cases it is usually best to brush off as much powder as possible followed by the application of large amounts of water to reduce the tissue damage and prohibit the creation of a toxic paste being formed on the victim's body
- Most emergency actions are based on letting the incident stabilise through fire or just sweeping up the material on the ground.

NOTE: Consider use of respiratory protection and other personal protective equipment.

7C7.18 Beware dust explosions. Increasing the surface area of a combustible solid enhances the ease of ignition. This means that dust burns more rapidly than the corresponding bulk solid. Particles behave in some ways similar to gas and a flammable dust-air mixture can form within certain limits. A dust explosion occurs when the suspended dust particles are ignited. Dust explosions are relatively rare but can involve an enormous energy release. Precautions to avoid or mitigate dust explosions:

  - eliminate ignition sources
  - control dust concentrations
  - avoid or limit disturbing dust.

PART C-8

UN Class 5 Oxidising substance and organic peroxide

General information

Introduction

7C8.1 Oxidizing agents are the natural enemy of fuels as when they mix and react there is always the possibility that the fuel will ignite. Normally oxygen (from the air) is the main ‘oxidizing agent’ in combustion reactions but other materials can cause similar behaviour. This section describes how and why these materials act in the way they do and outlines general hazards that a firefighter may face when encountering them.

Characteristics, classification and hazards

Oxidation

7C8.2 In chemistry, the term oxidation has several levels of meaning:

COMBINATION WITH OXYGEN
At the simplest level, oxidation may be defined as combination with oxygen. Most oxidation processes of practical importance are exothermic; many take place slowly, eg, the rusting of iron, but if the heat is produced so quickly that at least red-heat is achieved, the process is a typical combustion process.

COMBINATION WITH ANY SUPPORTER OF COMBUSTION
In a wider sense, oxidation may be defined as combination with any supporter of combustion. When heated magnesium is placed into a jar of oxygen gas, it burns with a brilliant white light and produces dense clouds of white smoke; exactly the same things are observed when heated magnesium is placed into a jar of chlorine gas. Therefore, it seems to make no sense to include one of these reactions in a set of reactions called oxidation processes and to exclude the other; in fact, both reactions are considered oxidation processes, as is combination with any supporter of combustion.

Oxidizing agents

7C8.3 Oxidizing agents may be defined in two ways, in parallel with the two definitions of oxidation given above:

- oxidizing agents are substances that supply oxygen to another substance

- oxidizing agents are substances that supply any supporter of combustion to another substance.

7C8.4 It can be argued that the first definition above is the one most relevant to a fireground situation, since most combustion processes involve rapid combination with oxygen, and most of the rest of this note is concerned with oxidation in this sense. However, large quantities of other supporters of combustion (particularly chlorine, but also fluorine and bromine) may be encountered in the chemical industry, so that an awareness of oxidation in the sense of the second definition is also very important for a firefighter.

Classification of oxidizing agents

7C8.5 If the discussion of oxidation is now limited to combination with oxygen, it is obvious that two criteria must apply to any oxidizing agent:

- it must itself contain some oxygen
- it must be able to supply this oxygen to another substance.

7C8.6 Many substances fulfil the first criterion, eg, oxygen itself, oxides, and any compound with a name ending in -ite or -ate; of these, only a limited number fulfil the second.

7C8.7 Thus, although sodium chlorate, $NaClO_3$, is a powerful oxidizing agent, calcium carbonate, $CaCO_3$, and calcium sulphate, $CaSO_4$, are not, because although they apparently contain at least as much oxygen as sodium chlorate, they do not easily give up this oxygen to another substance.

Identification

7C8.8 These materials can be identified from:

- UN hazard warning diamond
- Chemicals Hazard Information and Packaging for Supply (CHIP) Regulations 2009 label
- A hazard class containing 5, 5.1 or 5.2
- The chemical name.

Fire hazards of oxidizing agents

7C8.9 The fire hazards presented by oxidizing agents depend on whether they come into the category of inorganic, or organic, oxidizing agent. Each of these types of material is dealt with separately.

Inorganic oxidizing agents

Division 5.1: Oxidising substances other than organic peroxides

- These are the most commonly encountered oxidizing agents
- In terms of the fire triangle, these materials belong not to the fuel side of the triangle but to the supporter of combustion side
- These substances are non-flammable, even though some of them (such as sodium chlorate and, particularly, ammonium nitrate) may decompose explosively when heated, especially if present in large quantities in a confined space
- The main problems arise when inorganic oxidizing agents come into contact with combustible materials, thus putting two sides of the fire triangle together:
  - The oxidizing agent oxidizes the 'fuel', perhaps only slowly at first, but the process is exothermic, generating a little heat so that the temperature rises gradually. This accelerates the process, producing more heat, raising the temperature a little more, and the process accelerates further. Eventually sufficient heat is generated to raise the 'fuel' to its ignition temperature, and it begins to burn. Spontaneous combustion often happens when fuels are allowed to come into contact with oxidizing agents. Sometimes the combustion occurs almost immediately, as with highly concentrated hydrogen peroxide in contact with wood, sometimes after a short delay, as with glycerol in contact with potassium permanganate, and sometimes after a prolonged period, as with rags soaked in linseed oil in contact with atmospheric oxygen
  - Many fuel and oxidizing-agent combinations appear to be free from the spontaneous combustion hazard outlined above. However, problems still arise when the fuel becomes ignited, perhaps by contact with an ignition source; the combustion is no longer dependent on the limited availability of oxygen from the surrounding air because the oxidizing agent ensures the presence of available oxygen in a concentrated form. The fuel will burn much more fiercely than would otherwise be the case. This situation could arise if cellulosic material, such as a wooden floor or shelves, becomes impregnated with an oxidizing agent such as sodium nitrate or even concentrated nitric acid.

- **NOTE:** Fuels and oxidizing agents must be stored in such a way that accidental contact between them is impossible.

Organic oxidizing agents

Division 5.2 Organic peroxides

7C8.10 The main class of materials under this heading consists of organic peroxides, widely used as catalysts in the manufacture of plastics. Typical examples are dibenzoyl peroxide and methyl ethyl ketone peroxide.

7C8.11 These substances are particularly hazardous because as well as being oxidizing agents, their organic nature ensures that they can also burn, unlike the inorganic oxidizing agents. Two sides of the fire triangle, therefore, are already present in a sample of organic peroxide; the input of only a little energy may complete the triangle, and the peroxide will burn very fiercely, and possibly, particularly in a confined space, explosively.

7C8.12 The extra energy may be supplied as heat; organic peroxides possess a self-accelerating decomposition temperature, above which the decomposition proceeds spontaneously. The self-accelerating decomposition temperature for both dibenzoyl peroxide and methyl ethyl ketone peroxide is over 50°C, but for some organic peroxides it is so low that they must be stored under refrigeration.

7C8.13 If warmed, organic peroxides are also likely to become sensitive to heat, shock and friction.

7C8.14 These substances are so hazardous in the pure state that the safest way to store and handle them is to dilute them with a chemically inert material, and they are normally met in this form. For example, dibenzoyl peroxide can be obtained as a 50 per cent paste with phthalate plasticizer or with water, or as a 50 per cent powder, mixed with an inert powder. Even in this form, the material may burn very fiercely when ignited.

Other hazards of oxidizing agents

TOXICITY

7C8.15 Many concentrated oxidizing agents are corrosive towards living tissue, such as the skin and, especially, the eyes. They may also be toxic for additional reasons.

WATER REACTIVITY

7C8.16 Many oxidizing agents do not react with water and may safely be diluted (eg hydrogen peroxide); others are violently water-reactive. For example, sodium peroxide reacts rapidly with water, producing hydrogen peroxide and considerable heat. If sodium peroxide in contact with cotton wool is wetted, the cotton wool immediately ignites and burns fiercely. Other peroxides formed from reactive metals behave similarly.

Operational considerations

7C8.17 It is essential to understand fully the potential hazards that oxidizing agents present at an incident, in particular consider the following:

- They can be extremely unpredictable
- Be alert to the possibility of sudden container failure. For example, peracetic acid will detonate if its concentration rises above 56 per cent and this can happen when a container has been incorrectly stored, allowing acetic acid to evaporate
- Beware of potential impact or frictional ignition hazards
- Separate oxidizing agents from ‘fuels’ if this is practicable
- Use ventilation and sprays to cool containers or oxidizing agent / fuel mixtures
- If a fire has developed, consider the choice of extinguishing agent. Water may be the best option but consider the problems of water “reactives” and environmental damage
- Also consider the danger of impregnating combustible material in the area with water containing dissolved oxidizing agents which might become spontaneously flammable much later on when the water evaporates
- If water is used to extinguish a fire ensure appropriate application of water to achieve a maximum cooling effect (fog or fire spray)
- If organic peroxides are involved in, or exposed to, fire, evacuate the area and attack the fire from a safe location. Consider structural cover for firefighters, lashed branches and ground monitors.

PART C–9

UN Class 6 Toxic and infectious substances

General information

Introduction

7C9.1 Toxic (poisonous) and infectious substances, are those liable to cause death or injury if swallowed, inhaled or absorbed through skin contact. Within UN Class 6 there are two divisions:

- **Division 6.1 toxic substances** – a poisonous material, other than a gas, known to be so toxic to humans that it presents a health hazard during transportation.

Division 6.1: Toxic substances

- **Division 6.2 infectious substances** – means a material known to contain or suspected of containing a pathogen. A pathogen is a virus, micro-organism or proteinaceous infectious particle (prion) that has the potential to cause disease in humans or animals.

Division 6.2: Infectious substances

Toxic substances – characteristics, classification and hazards

7C9.2 Toxicity is the capability of a poison, or toxin, to produce injury in an animal, a human being or the environment. Many poisons cause harm to living tissues at very small doses because they interfere with one or more of the large number of complex chemical processes that take place continuously in all living creatures. These processes are catalysed by enzymes and often a poison works by blocking the action of an enzyme, or by changing the direction of a particular process.

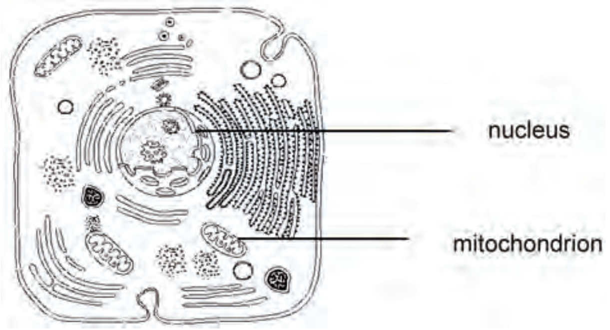
7C9.3 To appreciate the hazards presented by poisonous substances it is helpful to know some general principles that apply to all living creatures.

7C9.4 All living things are composed of cells. One of the simplest creatures is the amoeba, which is in fact a single cell about the size of a full stop. It may be found in pond water and can carry out in itself all the processes necessary to live, that is, breathing, eating, elimination of waste products and reproduction (where it divides into two identical cells). A human body is composed of about 250 different types of cell and human cells are much smaller than an amoeba. All living cells have certain common features and a typical living animal cell is shown below. It is important to note that red blood cells do not have a nucleus as they are designed to transport oxygen, and lose their nuclei after they are fully grown, before being released from the bone marrow into the blood stream.

7C9.5 The two parts of a cell that are especially sensitive to poisons are:

- the mitochondrion (the power-house of the cell)
- the nucleus (the control centre of the cell).

A typical animal cell (often called a Eucaryotic cell)



The mitochondrion

7C9.6 In the mitochondrion a chemical called adenosine triphosphate (ATP) is generated by a complex series of reactions in what is referred to as the 'respiratory chain'.

7C9.7 The overall reaction may be represented as: $4H^+ + O_2 + 4e^- = 2H_2O$

7C9.8 As a result of the energy liberated by this reaction, 34 molecules of adenosine triphosphate are generated. The oxygen comes from the air inhaled and every living cell must be adequately supplied with oxygen if it is to function properly. All cells require a continuous supply of adenosine triphosphate, which supplies the energy necessary to sustain life. All muscle cells are powered by adenosine triphosphate, so breathing and the beating of the heart are dependent on a continuous supply of adenosine triphosphate to the relevant cells. All nervous impulses depend on adenosine triphosphate, so to think or to use any of our senses requires a continuous supply of adenosine triphosphate. Each adult uses and synthesises many millions of adenosine triphosphate molecules every minute of the day. Almost all acute poisons act by reducing supplies of adenosine triphosphate to the cells or vital organs of the body, so that muscles or nerve cells cease to function normally.

The nucleus

7C9.9 This contains the chromosomes, which in turn are made up of genes. The basic material of all chromosomes and genes is deoxyribonucleic acid (DNA) and through the DNA all the functions of the cell are controlled. If a cell is to divide into two healthy cells to replace cells that become worn out, the DNA must be copied perfectly. Anything that affects the DNA may injure the cell.

7C9.10 Three possible effects of a poison are:

- to slow down the cell
- to kill the cell
- to cause the cell to go out of control and develop into a tumour, or a cancer (here the time-scale is 10–30 years, because even a small tumour will contain about 1,000,000,000 cells).

Some important characteristics of different types of cell

7C9.11 Some cells are replaced on a regular basis, such as those that line the intestine, or red blood cells (made in the bone marrow). Skin cells are also continuously renewed. The outer layers of skins are dead cells that are shed continuously. On the other hand, nerve cells and brain cells do not change very much and are not replaced if they get damaged.

Sperm cells and egg cells (gametes)

7C9.12 These are produced by special organs (gonads) in the male, and in the female by a process called meiosis. Normal cell division (referred to as mitosis) involves the production of two new cells that are perfect copies of the original cell. Each normal cell in a human body contains 46 chromosomes. During the formation of sperm cells two types of cell division occur, a special type of mitosis followed by a second division where each of the new cells contains only 23 chromosomes, one of which is an X or Y chromosome. The egg cells also contain only 23 chromosomes, one of which is an X chromosome. Thus when the sperm fuses with the egg cell, a new cell (zygote) is formed that contains 46 chromosomes. This cell has in its DNA all the instructions necessary to make a human body and will develop normally into a body, if it is given normal nurture and is not exposed to any toxic substance.

7C9.13 Sperm cells are generated continuously; a woman carries all her egg cells in her ovaries from birth. This has important implications about the effects of exposure to toxic substances in the longer term, as both the cells that generate sperm and the immature egg cells could be affected.

Absorption of poisons

7C9.14 Chemicals can cause poisoning if they reach sensitive parts of a person or living organism in sufficiently high concentrations and for a sufficient length of time. For a chemical to cause harm it must enter the body and poisons may be absorbed into the body in four main ways:

INHALATION – THROUGH THE LUNGS

Not only may gases and vapours be absorbed in this way, but also mists, smokes and dusts and fibres (depending on their size and shape). The peak retention depends on aerodynamic shape with particles of 1-2 µm in size being retained most effectively. Larger diameter dust particles do not penetrate the lungs but tend to be trapped further up the respiratory tract where cilia eventually return them to the oesophagus. From the oesophagus dusts tend to be excreted through the gut and it is possible that the dusts may cause toxic effects as though they were ingested like food. Most inhaled dust will enter the gut directly and may chemically react with the gut or interfere with micro-organisms living in the gut. Systemic action is also possible.

Irritation by dust particles is also possible but tends to be dependent on the solids being dissolved. Asbestos fibres cause fibrosis and cancer even though they are insoluble; a similar effect can occur with manmade mineral fibres. Insoluble particles such as coal and silica dusts readily cause fibrosis of the lung.

The volume of air inspired and expired with each normal breath increases with physical exertion. Thus the rate of physical work will directly affect the amount of toxic material inhaled by a person from a contaminated atmosphere.

INGESTION – THROUGH THE GASTRO-INTESTINAL TRACT

Such a process could occur through bad housekeeping, such as the practice of eating food in laboratories, but generally results from accidental exposure.

The physical state of a toxic substance can have an important bearing on the ease with which it may be absorbed by the body. Fine sub-division, and in some cases, the fact of solubility or insolubility in water, may aid absorption. Barium chloride, which is soluble in water and is a component of ternary eutectic chloride (a well known fire-extinguishing medium), is very poisonous, whereas the insoluble barium sulphate is not poisonous, and is used in the barium meal administered to patients for X-ray photographs of their gastro-intestinal tract.

DERMAL ABSORPTION – THROUGH THE SKIN

There is far less awareness of this mode of absorption than there is of the other two modes. Certain liquids, including methanol (methyl alcohol), organic mercury compounds, organophosphate pesticides and benzene, can be absorbed in this way.

Toxic materials may also enter the body through cuts and grazes, although this is not a common entry route.

INJECTION – THROUGH AN OPENING IN THE SKIN

Normal skin provides an excellent barrier to most chemicals. When the skin is punctured in some way (eg from a syringe needle, from handling animals or broken glassware, from cuts and grazes etc) this protection is bypassed. Any poison or toxic contamination on the skin or on the device causing the puncture wound is capable of directly passing into the bloodstream and eventually finding its way to internal organs where it may exert its toxic effect.

When decontaminating skin, care should be exercised to not rub so hard that it becomes damaged. Reddening of the skin is a sign that it is being damaged and further decontamination effort may be counter-productive as it may facilitate injection.

Operational key principle

In general, for exposure to a given concentration of a substance, for a given time, inhalation is likely to cause more harm than ingestion, which in turn will be more harmful than dermal exposure.

Descriptive terms used in poisoning

7C9.15 Terms used to describe cases of poisoning:

- **Acute** – This means that adverse health effects occur within a short time (up to a few days) after exposure to a single dose (or given concentration) of poison. The time component of the dose is not important, as the concentration of poison is responsible for the effect.
- **Chronic** – This term refers to delayed health effects that occur many years after exposure to a poison and which persist over a long period of time. In industry the effects generally occur by repeated exposures over a period of days, months or years. However, certain materials, notably asbestos and respiratory sensitisers, can exert chronic effects after a single exposure to the substance. Chronic effects are dependent on the dose (or concentration) and time of exposure to toxins and do not refer to the severity of symptoms, or the amount of pain experienced.
- **Local** – Refers to the site of action of an agent and means that action takes place only at the particular area of contact between the organism and a toxic material. Absorption does not necessarily occur. Local effects occur usually to the skin, eyes and respiratory tract.
- **Systemic** – The site (target organ) or region of toxic action is other than at the point of contact between the organism and the poison and presupposes that absorption and distribution of the toxin has already taken place in the body. With systemic effects the whole body or many organs can be affected. Methylene chloride is an example of a substance causing systemic toxicity. Once inhaled into the body this material can be metabolised to carbon monoxide that initially may cause feelings of euphoria (similar to alcohol). At higher concentrations unconsciousness can result and repeated exposures to the material can lead to permanent brain damage.
- **Teratogen** – These substances cause mental or physical harm to an unborn foetus. The ‘harm’ cannot be passed on to future generations. The drugs lysergic acid diethylamide, methyl mercury, rubella virus (German measles) and herpes virus are teratogens (X-rays and gamma rays also can act as teratogens).
- **Mutagen** – Mutagenic substances can cause physical or mental harm to an unborn foetus which is heritable by future generations.

- **Carcinogen** – These are materials that can cause cancer.

Mutagens and carcinogens:

In practice it is not possible to draw a clear line of division between these classes because a given chemical may cause either a mutation, or a cancer, or both, depending on the circumstances.

Some common examples are: benzene, vinyl chloride, acrylonitrile, chloroform, benzapyrene (present in many fire-gases), asbestos, and the elements: beryllium, cadmium, cobalt, nickel, silver, lead and arsenic. Moulds that grow on foods produce some of the most deadly chemicals such as aflatoxin. X-rays, gamma rays and ultra-violet light are also capable of producing similar effects.

- **Irritant** – An irritant is a chemical that is not corrosive but which causes a reversible inflammatory effect on living tissue by chemical action on the local site of contact. This effect is often referred to as irritation and typical sites of contact on the body are skin, eyes and the respiratory system.

  Allergies are different from irritants as they require interaction with the body's immune system to generate their effect (see below). The allergic effect is dependent on the individual's sensitivity to the allergen whereas an irritant acts on an individual in a non-specific manner, ie the effect of an irritant on an individual is largely not dependent on that individual's sensitivity to the irritant.

- **Allergens and hypersensitivity** – An allergy is the tendency of the body to react adversely to certain substances. Hay fever, hives and some types of asthma are typical examples of allergies.

  An allergic reaction is really composed of two contacts with a foreign substance. In the first contact the defence mechanisms of the body detect the foreign substance, an 'antigen', and manufacture antibodies to it. This change in the body is sometimes referred to as 'sensitisation' and any subsequent exposure to the same antigen provokes a massive response from the body and is the condition known as an allergy. In some allergic reactions, cells affected by the antigen–antibody reaction may liberate toxic chemicals such as histamine, which is responsible for some of the symptoms that accompany certain allergies such as a runny nose, itching eyes and hives. Thus anti-histamine drugs are sometimes prescribed.

  The chemical most widely known as an individual cause of allergy is toluene di-isocyanate. One exposure can sensitise a person, so that subsequent exposures can cause severe asthmatic attacks.

  Some people maintain that certain food additives, such as the yellow dye tartrazine (E102), can cause allergies in certain cases.

- **Convulsant** – A convulsant is a material that results in violent, abnormal, uncontrollable contraction or series of contractions of muscles in the body. The convulsions produced are often referred to as 'seizures'. Convulsions may have an 'organic' origin or may be induced using drugs. Some typical causes of seizures are:
    - high fever, eg heatstroke, infections
    - brain infections, eg meningitis, malaria, tetanus
    - metabolic disorders, eg high/low levels of sugars or sodium
    - inadequate oxygen supply to the brain
    - structural damage to the brain, eg through accident, stroke
    - exposure to toxic drugs/substances, eg amphetamines, lead, strychnine
    - withdrawal after heavy use of alcohol, sedatives including sleeping pills
    - prescription drugs.

  It is believed that seizures are caused by disorganised and sudden electrical activity in the brain.

Dosage

7C9.16 A major factor in cases of poisoning is the dosage received. Indeed, substances not normally regarded as poisonous may become so if dosage is sufficiently massive (usually resulting in acute effects). It is therefore not always easy to make a clear-cut distinction between poisonous and non-poisonous substances. The concentration of poisonous material is not the only factor to be considered when assessing the degree of poisoning experienced, and other factors can also have an important influence:

- duration of exposure
- sizes of particles or physical state
- affinity for human tissue materials
- solubility in human tissue fluid
- sensitivity of human tissues and organs
- age of a person
- health of an individual.

Occupational exposure limits

7C9.17 In an attempt to limit long term damage to industrial workers by chronic exposures to poisons, the Health and Safety Executive has, via the *Control of Substances Hazardous to Health (COSHH) Regulations*, established limits to the **airborne concentrations** of poisons to which workers can be exposed.

7C9.18 The ideal underlying the original occupational exposure limits was that it was possible to define average levels of substances in air that could be inhaled continuously by an industrial worker during a working shift (normally taken as eight hours/day), every week (normally taken as five working days) for their working life (normally taken as 40 years), without any ill effects occurring. That is still the ideal, but it is not always possible to achieve it and that was recognised in the *Control of Substances Hazardous to Health Regulations*.

7C9.19 Occupational exposure limits are intended to be used to control the exposure of workers to airborne hazardous substances in the workplace and are not designed to deal with serious accidents or emergencies such as a major gas release arising from plant failure.

7C9.20 Airborne control levels for hazardous substances that are recommended in the *Control of Substances Hazardous to Health Regulations* are reproduced in the current Health and Safety Executive document, which is reviewed periodically. The document contains information on a single type of occupational exposure limit known as the workplace exposure limit.

7C9.21 The control levels for gases and vapours in air, workplace exposure limits, are usually expressed in parts per million (ppm) by volume or parts of gas per million parts of air. Concentrations of dusts, smokes and fumes are often quoted as milligrams per cubic metre (mg/m3) of air at a standard temperature and pressure.

Workplace exposure limits

7C9.22 'Workplace exposure limits' are occupational exposure limits set under the *Control of Substances Hazardous to Health Regulations* in order to protect the health of workers. Workplace exposure limits are defined as the maximum concentrations of hazardous substances in air averaged over a reference period (ie a time weighted average) to which employees maybe exposed by inhalation.

- An 8-hour reference period is used to control exposures to a hazardous substance during a typical workshift. Workplace exposure limits quoted for this period of time are known as 'long term exposure limits'
- A 15-minute reference period is used to prevent acute effects such as eye irritation, coughing etc which may arise following exposure for a few minutes. Workplace exposure limits for this period of time are known as 'short term exposure limits'. For substances where a long term limit is quoted but no short term limit is specified, it is recommended that a figure of three times the long term limit is used as a guideline for controlling short-term peaks.

7C9.23 When making an assessment on the chronic risk of a substance, it would be prudent to identify any risk phrases associated with the material to ascertain the long-term health effects on affected humans. Under the *Chemicals Hazard*

Information and Packaging for Supply Regulations 2009 (CHIP) these phrases must appear on packaging labels when these materials are transported unless they are exempted.

7C9.24 Every employer, including the Fire and Rescue Service, has a responsibility to identify the materials in the workplace that may put employees' health at risk, to assess the risk and introduce the necessary controls to ensure exposures are below workplace exposure limits and as low as reasonably practical. Employers have a legal responsibility to inform their staff about those materials in the workplace that may damage their health and to identify the effects of those materials. When managing an incident at which hazardous materials will be encountered this responsibility falls to the incident commander.

Threshold odour concentration

7C9.25 Many poisonous substances have a characteristic smell (carbon monoxide is a well-known exception). In some cases the threshold of smell, or odour, is above the occupational exposure limit value. That means a person can suffer from toxic effects without realising that a poisonous gas or vapour is present.

7C9.26 Two common examples of that effect are benzene (Workplace Exposure Limit = 1 ppm, threshold odour concentration about 100 ppm) and methyl alcohol (Workplace exposure limit = 200 ppm, threshold odour concentration about 2000 ppm).

Other systems

7C9.27 If information on the occupational exposure limit is not available then it may be possible to use the threshold limit value (TLV) which is a roughly equivalent limit imposed on employers in the USA. Other limits associated with these basic threshold limit values are:

- short-term exposure limits (STELs) for a 15-minute reference period
- ceiling exposure limits (TLV-Cs) are for concentrations of materials that must never be exceeded even instantaneously.

Lethal dose 50 per cent (LD50)

7C9.28 This is the concept used to assess the **acute** toxicity of a material.

7C9.29 It has long been recognised that if similar quantities of poison are given to different people (or animals) in a population, it will produce differing health effects in the population. In order to have a quantifiable response to a poison, death is chosen as the discriminator as it is easily measurable. For this reason, lethality studies are normally carried out on animals. To obtain a representative value for lethality for an animal species, it is necessary to carry out tests on a group (or population) of animals so a statistical determination can be made on the amount of poison necessary to kill a certain percentage of the group in a certain time.

7C9.30 The lethal dose 50 per cent is thus defined as:

- the quantity of poison that will kill one half of a batch of ten or more animals within 14 days.

7C9.31 The LD50 is expressed as milligrams per unit body weight (mg/kg).

7C9.32 When quoting values for the LD_{50} it is necessary to quote the animal species being tested and the route the poison was given to the animal. For example the LD_{50} may be quoted as:

- LD_{50}(oral, rat) = 414 mg/kg indicating that poison introduced to a group of 10 or more animals by ingestion (oral) at the level of 414mg/kg caused the death of half (50%) of the group within 14 days.

7C9.33 Owing to the above-mentioned dosage values being obtained mainly from studies of rats, mice and guinea-pigs, they should be regarded with caution, and if evidence concerning human beings is available it is used in preference to that obtained from animal experiments. Individuals vary greatly in their susceptibility to poisons for reasons that are not well understood, and conditions that may be safe for some are not safe for all.

Other terms

- Lethal Concentration 50 Per Cent (LC_{50}) is used to denote the concentration of a gas present in the atmosphere for a given period of time that eventually kills half of a batch of ten or more animals within 14 days.
- LDLO and LCLO denote the lowest published lethal dose and concentration respectively. These figures, unlike LD_{50} and LC_{50}, are not statistically derived and are often obtained from post-mortem examinations on accidental death victims. If these figures are available they should be used as the guide to toxicity of the material.

Biohazards/infectious substances – characteristics, classification and hazards

7C9.34 A biological hazard, or biohazard, is any microorganism, cell culture or human endoparasite, including any that have been genetically modified, that can cause infection, allergy, toxicity or otherwise create a hazard to human health.

7C9.35 Biohazards arise from exposure to a range of pathogenic or disease causing organisms. Acute or chronic infectious diseases may be caused by bacteria, viruses, protozoa or fungi. The pathogen can enter the body via skin contact, puncture wounds, cuts, and inhalation of aerosols or dusts and also by ingestion of contaminated food or drink.

7C9.36 These pathogens are found almost everywhere in varying forms and exist as a biohazard when the numbers exceed what is regarded as an 'infective dose'.

Pathogenic organisms

7C9.37 Most biohazards arise from single-celled organisms of various types, which are collectively referred to as 'pathogenic organisms', ie disease-causing organisms. These can be grouped into four different classes:

- Bacteria (eg escherichia coli or E.coli; tuberculosis or TB, salmonella, legionella etc)
- Viruses (eg hepatitis B, C, HIV etc)
- Protozoa (eg toxoplasmosis, ringworm, malaria etc)
- Fungi and spores (eg aspergillosis etc).

NOTE: Included within the above list, there is a serious health risk to firefighters by the transmission of infectious diseases through direct or indirect contact with animals (zoonoses), which are alive or dead and animal waste. Examples of zoonoses are rabies and ringworm. Contact between pregnant firefighters and sheep and goats carrying chlamydia psittaci can also result in miscarriage

BACTERIA

- About 0.01mm in length
- Primarily found in moist medium with small hairs used for locomotion
- Rapidly increase in numbers in ideal conditions
- Not able to withstand high temperatures (above 60°C for half an hour will destroy), and large doses of gamma radiation will kill
- Many bacteria are harmless
- Necessary in soil, human and animal bodies
- Some can produce toxins and cause symptoms of disease such as TB, anthrax, tetanus or bubonic plague.

VIRUSES

- Much smaller than bacteria, consisting of nuclear material (DNA or RNA) surrounded by complex outer coat of protein
- Attach to host cell to reproduce and then infect other cells
- Typical viruses include Lassa fever, herpes, influenza, HIV, rabies and smallpox.

PROTOZOA

- Larger, single celled-organisms similar to bacteria
- Often water-borne, including malaria and amoebic dysentery.

FUNGI AND SPORES

- Live as parasites on a host
- Examples include thrush, 'athletes foot' and ringworm.

Categorisation of micro-organisms

7C9.38 The Advisory Committee on Dangerous Pathogens advises the Health and Safety Commission, the Health and Safety Executive and appropriate government ministers, as required, on all aspects of hazards and risks to workers and others from exposure to pathogens. In 1995 the Advisory Committee on Dangerous Pathogens issued guidance on the categorisation of biological agents, which classified biological agents into four categories:

Hazard Group 1 – unlikely to cause disease.

Hazard Group 2 – can cause disease and may be a hazard to employees, is unlikely to spread to the community and there is usually an effective prophylaxis or treatment available. Examples include measles and mumps.

Hazard Group 3 – can cause severe human disease and may be a hazard to employees, it may spread to the community but there is usually an effective prophylaxis or treatment available. Examples include hepatitis B and rabies.

Hazard Group 4 – causes severe human disease and is a serious hazard to employees, is likely to spread to the community and there is usually no effective prophylaxis or treatment available. Examples include smallpox and Lassa fever.

7C9.39 The Advisory Committee on Dangerous Pathogens issue an *Approved List of Biological Agents* which is updated regularly and available at:

http://www.hse.gov.uk

Notification

7C9.40 The Advisory Committee on Dangerous Pathogens have placed a duty on employers where a level 4 containment exists (based on control of substances hazardous to health principles) to identify hazards in the workplace and to understand and control the infection risk.

7C9.41 The *Management of Health and Safety Regulations 1999* (MHSR99) recommends the appointment of a competent person such as a Safety Officer/Adviser, whose duties include:

- as part of the emergency plan, to notify local authority fire services, in advance, of substances to be handled that may be a hazard to fire officers in the course of their duties
- responsibility for decontamination procedures
- disposal of infectious waste.

7C9.42 *The Control of Substances Hazardous to Health Regulations* require the Health and Safety Executive to be notified of the intention to use, store or transport certain hazard groups.

Hazards

7C9.43 There are additional hazards associated with biological agent research and development premises, these may include:

- high security levels, including electronic locking mechanisms, preventing unauthorised access
- premises containing Hazard Group 3 and 4 are required to maintain negative pressure (up to –50Pa) in order to prevent the release of biological agents outside the building. Due to security reasons, these types of premises are required to be located above ground floor
- an uninterruptible power supplying lab equipment and building facilities
- regular disinfection of labs generally takes the form of gaseous formaldehyde fumigation over a 12 hour period
- various types of animals used for research purposes
- gases, including nitrogen, hydrogen, helium and oxygen
- chemicals, including acids, bases, alcohols, volatile agents and toxic or carcinogenic organic compounds, eg benzene
- various radiation sources for sterilisation.

Usage, transportation, packaging and storage

Biohazard usage

7C9.44 Biological hazards may be encountered in a wide range of situations:

- hospitals eg isolation wards, post mortem areas, medical schools, laboratories etc
- biotechnology laboratories using genetically modified organisms
- universities, colleges
- veterinary laboratories, quarantine kennels, abattoirs
- government research establishments
- biological, medical, animal research establishments
- farms, zoos, wildlife parks

- sewers, sewage treatment plants and flood water
- casualty handling/cadavers at fires, transport incidents or other special service calls
- residential premises where persons maybe infected
- post offices and mail delivery couriers
- funeral parlours/embalmers
- biological warfare or terrorist
- pharmaceutical laboratories
- government establishments.

Biohazard transportation, packaging and storage

Transportation

7C9.45 The transport categories are defined as:

- **Category A** – An infectious substance which is transported in a form that, when exposure to it occurs, is capable of causing permanent disability, life-threatening or fatal disease to humans or animals.
- **Category B** – An infectious substance which does not meet the criteria for inclusion in Category A.

7C9.46 For all substances a triple packaging system is used. This includes:

- a primary, watertight and leakproof receptacle surrounded by sufficient absorbent material to absorb any spills caused by breakage
- a secondary, watertight and leak proof packaging, again containing sufficient absorbent material to absorb any spills
- an outer packaging that protects the secondary packaging from physical damage.

7C9.47 The outer wrapping of any package should bear the international warning signs and a warning that the package should be neither opened nor touched. On the outer packaging there should be an indication of the nature of the contents, together with the name and address of both the consignor and consignee. The latter details should also be provided with the package.

7C9.48 For transportation, infectious substances will be assigned to UN 2814, UN 2900 or UN 3373. Vehicles used for the transportation of biological agents will come under UN hazard classification 6.2 and may display the warning triangle for “substances containing disease-producing micro-organisms”.

Postal

7C9.49 Group 4 materials must not be sent through the postal system. Special arrangements apply to their transportation, nationally and internationally.

7C9.50 Group 2 and 3 materials may be transported either by post or an authorized courier provided they comply with the packaging requirements and bear the international warning signs together with the names and addresses of the sender and recipient.

7C9.51 Organisations that regularly send such materials through the post should have procedures in place for contacting competent personnel in the event of an accident.

Location and meaning of signs

7C9.52 Many establishments will display the international biohazard sign. However, the use of this sign varies considerably. Other black and white signs may relate to animals (eg 'Do Not Remove', 'May be Removed in Cages' etc).

7C9.53 Where biological agents are present within a building there should always be a warning symbol present at the entrances to laboratories and refrigeration units for agents of Hazard Groups 2, 3 and 4, but they may not be found externally.

Operational considerations

Biohazard pre-planning

Contact

7C9.54 *The Control of Substances Hazardous to Health Regulations* require that any premises that contain biohazards of Hazard Group 3 or 4 have written contingency plans for dealing with an emergency. In premises where Hazard Group 4 agents are in use, expert advice will be available at all times,

7C9.55 Establishments Handling Group 4 organisms are required to appoint a Safety Officer/Adviser with whom contact should be made. This should include out-of-hours contact facilities.

7C9.56 Most laboratories and research establishments generally have a rota of knowledgeable persons, some work on an 'alert' basis during times that the substances are present. Staff must stay on the premises in case of an emergency.

Nature of hazards

7C9.57 The type, quantity and level of hazards will determine the extent of Fire and Rescue Service pre-planning. There could be hazards involving toxins that present an immediate threat to human life (eg typhoid, tetanus etc). Other hazards cause a threat to fish and marine life or plants, but pose no direct hazard to humans.

7C9.58 The physical state of the organism presents different levels of risk. Some may be frozen and stored in plastic bags. Some are kept in water, which may boil in the event of a fire, sterilising them. Some are kept in the dry state in glass phials or bottles and here the risk is through aerosolization and subsequent inhalation of the powder. Some may be found in bulk, usually in glass or stainless steel vessels.

Extent of hazards

7C9.59 The extent of the possible hazard to firefighters from such materials in the event of a fire or other incident may vary. Most micro-organisms are killed in temperatures in excess of 60°C but some are thermophilic and live and multiply in higher temperatures than this.

7C9.60 Guidance should be sought on how the micro-organisms react in fire and perhaps how long the fire would have to burn before destruction.

7C9.61 In addition to the biohazard, consider other laboratory risks such as:

- chemicals (acids, alkalis, toxics and flammables)
- gases (hydrogen cylinders, cryogens for storing bacteria and viruses)
- radiation (used for sterilisation and biological tracers).

The exact location

7C9.62 In some laboratories the main concentration of pathogens would be found in the main laboratory, but other smaller concentrations may be found elsewhere (ie freezers, cold stores or incubation rooms where temperatures may be controlled). Culture collections of freeze-dried materials may also be present.

7C9.63 All establishments handling infectious substances are required to have a safety manager and emergency plans.

7C9.64 These plans can vary between returning all substances to cabinets, to the sealing of rooms and evacuation in hospitals.

Expert assistance

7C9.65 In premises where Group 4 agents are in use, expert advice will be available at all times. Other premises may be hazard free most of the time and then go on ‘Alert’ during which time staff must live on the premises.

7C9.66 Fire and Rescue Services will need to consider the levels of multi-agency liaison and advice that are required to resolve all foreseeable incidents involving biological agents within their areas. Stakeholders that are likely to provide positive benefits in this regard will include:

- Health Protection Agency
- Local Resilience Forum
- Emergency planning departments
- Environment Agency
- Environmental Health Department
- Police Service
- Ambulance Service
- Health and Safety Executive
- Highways Agency (for incidents on major roads)
- Specialist advice through industry experts
- Hospitals.

Incidents involving biohazards

7C9.67 The following considerations must be read in conjunction with the generic standard operating procedure described in Part B of this operational guidance.

- Approach upwind and uphill as appropriate (**NOTE:** Firemet information)
- Any decision to use 'controlled burn' tactics at a fire should be made on the basis of prior discussion with the site Safety Officer/Advisor or other subject matter advisers and a thorough written risk assessment
- The use of water should be minimised and any run off should be prevented from entering water courses
- All staff and other responders should be strictly controlled to restrict the potential for exposure
- Restrict the number of staff entering the hazard zone
- A thorough safety brief prior to deployment of staff within the hazard zone must be carried out
- The Incident Commander or hazardous materials adviser should maintain constant liaison with the on-site specialist or safety officer/adviser
- Appoint and brief Safety Officers to strictly supervise the inner cordon which should be based on pre-planning or specialist advice
- Staff should be made aware of the potential risks of disease and infection at off-site incidents such as animal incidents and road traffic collisions

- All responders should be prohibited from eating, drinking and smoking whilst at the incident
- Animal testing establishments – the likelihood of biologically infected animals escaping during an incident is remote, however, the capture of such animals could be dangerous and no attempt should be made without specialist advice
- Where an intense fire is involved and there is the possibility that micro-organisms could be carried into the atmosphere by convection currents, downwind evacuation should be considered
- In cases of suspected exposure to HIV or hepatitis virus consider the need for post exposure prophylaxis within one hour
- Incident Commanders should be aware of the risks of infection to female firefighters who could be in the early stages of pregnancy when dealing with incidents involving sheep. Female firefighters can become seriously ill and possibly miscarry if infected with chlamydia psittaci (enzootic abortion)
- Specialist advice about on-site decontamination may be required especially if the incident involves group 3 or 4 pathogens
- Generally, personal protective equipment should be washed down with disinfectant (hypochlorite solution of 10,000 ppm recommended) but advice from subject matter advisers must be sought
- Contaminated chemical protective clothing and other equipment should not be removed from the incident until thoroughly disinfected and then only with authorisation from subject matter advisers
- The level of personal protective equipment required will depend on:
  - the nature of any biohazard present
  - the potential for exposure to known biohazards and due to the nature of the incident, those biohazards that it could reasonably expected may be present (eg animal rescues, road traffic collisions etc)
  - the advice of biohazard subject matter advisers
  - operational circumstances (eg immediate life saving rescues, fires etc).
- Consider other hazards:
  - high security levels, including electronic locking mechanisms, preventing unauthorised access
  - premises containing Hazard Group 3 and 4 are required to maintain negative pressure (up to -50Pa) in order to prevent the release of biological agents outside the building
  - an uninterruptable power supplying lab equipment and building facilities
  - regular disinfection of labs generally takes the form of gaseous formaldehyde fumigation over a 12 hour period

  - the presence of various types of animals used for research purposes
  - the presence of other pressurised gases, including nitrogen, hydrogen, helium and oxygen
  - the presence of chemicals, including acids, bases, alcohols, volatile agents and toxic or carcinogenic organic compounds
  - the presence of radiation sources for sterilisation.
- Records should be kept of anyone exposed to biohazards during operations together with details of the organism. Medical advice should be sought
- Arrangements should be in place for effective health surveillance of all staff that are suspected of being exposed to any bio-hazards during an incident. This may be by means of an on-site specialist, occupational health provider or Health Protection Agency whilst the incident is still in progress, although certain circumstances may require antibiotic prophylaxis to be given for potential exposures
- Plans should be in place to provide monitoring and recording of bio-hazard exposure. *Control of Substances Hazardous to Health Regulations* require that employers keep a list of all personnel exposed to Hazard Group 3 and 4 agents be kept for at least 10 years (for those agents with delayed effects this list should be kept for 40 years)
- Staff should also be provided with follow-up monitoring by the occupational health provider as necessary. This will enable more sensitive whole body monitoring or analysis of biological samples, such as urine etc to be carried out.

PART C–10

UN Class 7 Radioactive materials

General information

Introduction

7C10.1 Radiation is the general term given to the process by which energy is transmitted away from an energy source. The term can equally be applied to heat, light, sound, microwave, radio or atomic sources of energy. This guidance is only concerned with the radiation arising from atomic sources as these uniquely have the property of causing ionisation when they interact with other substances and are often referred to as 'ionising radiations'.

7C10.2 Ionising radiation generally arises by one of two processes:

- radioactivity
- X-ray emission.

Radioactivity

7C10.3 This is the phenomenon by which unstable isotopes[1] of some atoms break down to form a more stable isotope of a different atom by expelling a small amount of matter from the nucleus (centre) of the unstable atom. Although there are several ways in which this can occur, by far the most dominant are by alpha emissions or by beta emissions. Shortly after an alpha or beta emission has occurred it is usually, but not always, followed by a gamma emission. Radioactive materials continue to undergo this process, often many millions of times per second until all the original unstable atoms have changed into the new stable atoms whereupon the radioactive material ceases to exist. Radioactivity cannot be destroyed other than by allowing it to decay away. The time taken for a radioactive source to reduce to half its original quantity is known as the half-life. If a radioactive material is burned in a fire, the equivalent amount of radioactivity will still exist in the smoke and the ash.

X-ray emission

7C10.4 This occurs when electrons are accelerated by high voltages inside an evacuated tube and are allowed to collide with a target made from a heavy metal, usually tungsten. The energy associated with the colliding electron is transmitted to the

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[1] Isotopes are different forms of the same atom which are distinguished by having different numbers of neutrons in the nucleus but the same number of protons.

tungsten target and stimulates the emission of an x-ray from the target metal. Since x-rays can only be created through the application of a very high voltage, as soon as the electrical power is switched off, all x-ray emission ceases.

7C10.5 Radiological emergency incidents differ to other hazardous materials incidents in the following ways:

- firefighters generally have no experience with radiation emergencies as they are very rare
- even very low levels of radiation, that pose no significant risk, can be detected rapidly with simple, commonly available instruments
- radioactive materials can cause radiation exposure even when firefighters are not in contact with them
- the health effects resulting from radiation exposure may not appear for days, weeks or even years
- the public, media and firefighters often have an exaggerated fear of radiation.

Characteristics and classification

7C10.6 When describing radioactive processes extremely large numbers and very small numbers are frequently discussed therefore it is necessary to be able to use multiples and sub multiples of the units used.

Commonly used multiple and sub multiples

Fraction or multiple	Number	Prefix	Symbol
10^{-9}	0.000,000,001	nano-	n
10^{-6}	0.000,001	micro-	μ
10_{-3}	0.001	milli-	m
10^{0}	1		
10^{3}	1000	kilo-	k
10^{6}	1000,000	mega-	M
10^{9}	1,000,000,000	giga-	G
10^{12}	1,000,000,000,000	tera	T
10^{15}	1,000,000,000,000,000	peta	P

7C10.7 As described above, there are in effect three types of radiation arising from radioactivity.

Types of radiation arising from radioactivity

Alpha radiation

Has the greatest ionising potential of the three types. However, partly because of this, it has very poor penetrating power. Typically, alpha radiation can only travel about 3 cm in air and is completely absorbed by very thin layers of other materials eg paper, layers of dead skin, or water droplets.

Beta radiation

Has moderate ionising power. The penetrating range of beta radiation in air is approximately 1 m. It is fully absorbed by relatively small thicknesses of metals and plastics (eg 1 cm thick Perspex).

Gamma radiation

Has the lowest ionising potential of the three types but by far the greatest penetrating power. Gamma radiation will travel many hundreds or even thousands of metres in air. It is capable of passing through solid materials such as brick, concrete and metals although it will be attenuated as it does so. The more matter it passes through, the more its intensity is reduced. For this reason, dense metals such as lead or steel are the most efficient at absorbing gamma radiation.

(There are other nuclear processes which give rise to radioactive emissions but these are much less common and are therefore beyond the scope of this guidance)

7C10.8 When measuring radiation (alpha beta, gamma or x-ray) there are two properties which need to be classified, the activity (or strength) of the source and the dose (or amount) of ionising energy which is being absorbed by the body.

7C10.9 The modern unit of activity which has been adopted throughout Europe is the becquerel (abbreviated as Bq). All radioactive sources found in the UK legally have to be measured in becquerels. The becquerel is however, an extremely small quantity (it is defined as one nuclear disintegration per second) and most sources will have activities of thousands, millions, billions or even trillions of becquerels. This means that the usual SI multiples kilo, mega, giga, tera etc are often encountered when recording the activity of a source. It should however be noted that an older unit, the curie, is sometimes encountered particularly if the source originally came from the USA. Becquerels and curies measure the same dimension in much the same way as centimetres and miles measure the same dimension but on a different scale and magnitude of measurement.

7C10.10 The modern unit for measuring the radiation dose received by a person that has been adopted throughout Europe is the sievert (Sv). All personal dose (and dose rate) measurements legally have to be expressed as sieverts. In contrast to the becquerel, the sievert is a very large unit, and the common SI sub multiples of milli and micro are commonly encountered.

7C10.11 It should also be noted that another unit of dose, the gray is also widely used throughout Europe. Under most circumstances the sievert and the gray are numerically identical. The differences between the two units are beyond the scope of this guidance and for its purposes can be ignored.

7C10.12 Different units for dose measurement are used in the USA. These are the Rad (dimensionally equivalent to the gray) and the Rem (dimensionally equivalent to the sievert). One Rem is equal to 10 millisieverts (mSv).

7C10.13 Most hand held monitoring equipment measures the dose rate, which is the speed at which dose is being accumulated, although it is only the total dose received which is relevant as the cause of health problems.

7C10.14 A simple analogy which may assist firefighters in understanding the difference between 'dose' and 'dose rate' is a journey in a car:

- **The dose**, usually measured in millisieverts (mSv), a firefighter has received can be compared to how far you have travelled as shown the car's odometer (miles)
- **The dose rate**, usually measured in millisieverts per hour (mSv/hr), can be compared to how fast you are travelling at any given moment as shown on the car's speedometer (miles per hour).

Hazards

7C10.15 There are two principal hazards which arise from radioactivity, regardless of the type of radiation. These are:

- irradiation – which presents an external risk (ie from outside the body)
- contamination – which presents both an internal (ie inside the body) and possibly an external risk.

Irradiation

7C10.16 Irradiation is mainly a problem with materials which emit gamma radiation or from x-ray machines. Ionising energy is radiated out from the source and passes through a person's body. As it does so, some of the energy is absorbed by the body tissues and the ionising properties can cause chemical changes in human cells. This can lead to damage and possibly disease. The source material however, never enters the body but a 'hazardous materials exposure' has occurred and a radiation dose will be received.

Radioactive contamination

7C10.17 Contamination is a potential problem with any radioactive material except electrically generated x-radiation. If a material which contains radioactive isotopes are in a form which is easily dispersed (ie dusts, powders, liquids, gases) the radioactive substance can become attached to the exterior of the body by direct contact or airborne dispersion (eg dust, spray, mist etc). It may also enter the body through inhalation, ingestion or through an open cut or wound. In this sense, internal radioactive contamination poses much the same threat as any other chemical toxin or 'hazardous materials exposure'. Once inside the body, alpha and beta emissions, which were not considered high risk in terms of external contamination, may produce damaging ionising radiation directly into the cells of the lymph system, blood and internal organs.

Sealed and unsealed sources

7C10.18 It is important for emergency responders to make a distinction between sealed (closed) sources of radioactivity and unsealed (open) sources of radioactivity.

- **Sealed sources** – A sealed source is a radioactive source that is encapsulated into a solid material, usually metal. The encapsulation is intended to prevent the escape of radioactive material while allowing the radioactive energy to pass through. Sealed sources are designed to withstand rough handling and elevated temperatures without releasing the radioactive material. Because the radioactive source substance is encapsulated or plated onto a surface, sealed sources do not present a contamination hazard under normal conditions, however, they can present an irradiation hazard.
- **Unsealed sources** – Unsealed sources consist of powders, liquids or sometimes gases which contain radioactive elements and which could easily be released from their containers through leaks and spillages and dispersed into the environment. The main hazard with unsealed sources is contamination although there may also be a significant irradiation hazard from the bulk material
- **Shielding** – Both sealed and unsealed sources are generally stored or transported in such a way that they are 'shielded' by solid materials, usually their containers. These prevent or limit irradiation hazards. If a source's shielding is removed or damaged the radioactive hazards are increased.

Damage caused by radiation

7C10.19 The damage caused by radiation may be divided into two different categories

- deterministic
- stochastic (or probabilistic).

7C10.20 Deterministic effects are those which occur at a relatively high dose and the severity of the effect is proportional to the dose. In all cases it is necessary to exceed a threshold dose before the effect is experienced at all. The most common effects in this category are skin reddening, hair loss, impaired fertility, lowered blood count, nausea, vomiting and diarrhoea. The threshold for detectable deterministic effects is about 100mSv. At this level no symptoms would be exhibited but tests on blood may start to show signs of damage.

As dose levels increase the severity of effects and the rapidity of their onset increases. Doses above 5000 millisieverts in a short period of time are life threatening.

7C10.21 Stochastic effects are those where the probability of experiencing the effect is proportional to the dose but the severity of the effect is independent of the dose. The most common effect in this category is cancer. The likelihood of contracting cancer increases with the dose but the severity of the disease is the same irrespective of the dose that caused it. Genetic effects are also believed to be stochastic although these have never been demonstrated in humans. As such it is assumed that any level of dose of radiation caries some risk and therefore all doses need to be kept as low as possible.

7C10.22 In summary, if the total dose is kept below 100 millisieverts, there will be no risk of any immediate effects such as skin reddening, hair loss, reduced fertility, nausea etc. However, the maximum annual dose to all radiation workers (male and female) is 20 mSv. There is an additional limit on females of reproductive capacity of 13 mSv in any three month period. The reason for this additional restriction is to protect a recently conceived foetus within a female who may be unaware of her pregnancy. In this sense it is not so much a restriction designed for the protection of females but is a restriction to protect a foetus.

7C10.23 Under the *Ionising Radiation Regulations 1999* (IRR99), further restrictions apply to females who have announced they are pregnant or breast feeding but it is assumed that female firefighters would not be used in an emergency operational capacity once the pregnancy was declared (See Chapter 3 for further information).

7C10.24 **NOTE:** All doses referred to in this document are whole body doses unless otherwise stated. The IRR99 allow for higher annual doses if the radiation is delivered only to localised parts of the body. However, this is a very specialised area of workplace safety and is beyond the scope of this guidance document.

Summary of whole body dose and effect

Dose	Effect	Comments
5 sieverts (5,000 mSv, or 5,000,000 µSv)	Probable lethal dose	Very dependent on rate of delivery and health of individual.
3 sieverts (3,000 mSv or 3,000,000 µSv)	Erythema (skin reddening)	May not appear for several days.
3 sieverts (3,000 mSv or 3,000,000 µSv)	Depilation (hair loss)	Temporary between 3 and 7 Sv; permanent above 7 Sv
1 sievert (1,000 mSv, or 1,000,000 µSv)	Threshold for radiation sickness	Dependent upon other factors eg health, rate of delivery, skin type etc.
700 mSv (700,000 µSv)	Threshold for temporary sterility	Can be permanent at higher doses in excess of 3 Sv
100 mSv (100,000 µSv)	Chromosomal changes in blood cells detectable Small increase in existing cancer risk	Minimum dose at which any physical changes can be detected. No noticeable effects by the person receiving the dose.
5 mSv (5000 µSv)	Very small increase in overall cancer risk	No immediate observable effects.

NOTE: This table is designed to give a general awareness of the order of magnitude required for various effects to be observed and should only be regarded as a very approximate guide. In practice there are likely to be many other factors which would influence the response to various levels of dose.

Usage, transportation, packaging and storage

Usage

7C10.25 Radioactivity has a number of uses in society, these may be summarised as follows in an approximate order of severity of hazard:

Weapons

Vanguard class submarine carrying trident nuclear missiles

7C10.26 Nuclear weapons, their use, manufacture and transportation are subject to the highest levels of security and it is unlikely that the Fire and Rescue Service would ever be called upon to attend an incident involving a nuclear weapon without there also being an emergency response with expert advice from the military. The Ministry of Defence maintains a Nuclear Accident Response Organisation (NARO) to respond to an incident including one arising through terrorist acts, involving defence nuclear assets. For fixed Ministry of Defence sites local arrangements should be in place to integrate the Fire and Rescue Service response with that of the base site.

7C10.27 For road convoys, hazardous materials and other safety information is available from the Convoy Command Team.

7C10.28 For air accidents involving nuclear materials a response team will deploy by helicopter to assist the response to the incident.

7C10.29 Further information is available in the *Local Authority and Emergency Services Information; Defence Nuclear Materials Transport Contingency Arrangements* on the Ministry of Defence website.

Power production

7C10.30 The UK currently has ten sites where electricity is generated by nuclear means although this number may change in time. These are all based in coastal locations. In addition to these, as part of the nuclear fuel cycle, there is a nuclear fuel production facility near Preston in Lancashire and the nuclear reprocessing works at Sellafield in Cumbria. The power stations themselves are secure locations with their own emergency teams. The hazards associated with the reactor and with stored nuclear fuel on site are high although the risk of an accident is generally accepted to be low.

7C10.31 Spent nuclear fuel (ie fuel which has been removed from the core of the reactor, is highly radioactive and probably represents the greatest potential radiation hazard anywhere within the UK. When fuel is removed from the reactor it is stored on site for several months in ponds before being transported to Sellafield by rail in specially constructed steel containers known as fuel flasks. These are extremely robust but they are filled with water for cooling and shielding purposes and loss of cooling water could be a potentially serious problem. The total inventory of a fuel flask is likely to be hundreds of TBq or more.

7C10.32 New fuel is not highly radioactive and is transported to power stations by road. Uranium ore, ore concentrate and uranium hexafluoride are the raw materials used by the fuel production facility. The chemical properties of these materials are usually more problematic for the emergency services than their radiological properties.

Sterilisation plants

7C10.33 Very large sources of gamma radioactivity, usually cobalt 60 with activity of up to 10 PBq are used to sterilise instruments and utensils. These are always sealed sources and therefore the main hazard arises from irradiation.

Medical diagnostics

7C10.34 The main type of radiation used in diagnostics is x-rays. These do not pose a risk to firefighters if the power has been switched off.

7C10.35 Specialist departments within hospitals may however use radioactive materials which are either ingested or injected into the patient prior to the radiation emissions being detected in a scanner. These tend to be materials with a short half-life because the doctors do not want the radioactivity to remain in the body longer than necessary. The most commonly used material is technetium 99m (Tc-99m). It is usually supplied by a pharmaceutical company and is delivered by road. Other radioactive pharmaceuticals (eg Iodine 131) may also be produced by a company and sent to hospitals or clinics. Sometimes these are shipped to or from the UK by air. It is not unusual for the Fire Service to be requested to attend radiation incidents in the cargo handling areas of airports where packages have been compromised. These are usually encountered in MBq quantities.

7C10.36 Some hospitals may have their own facilities for producing short lived radioactive isotopes. These are produced in a particle accelerator known as a synchrotron.

Iodine 131 packages damaged in cargo warehouse

Medical treatment

7C10.37 The main types of medical treatment are chemotherapy which involves the injection of radioactive drugs into the body and radiotherapy which involves the external exposure of body to highly collimated (directional) beams of gamma radiation. Radiotherapy sources are usually highly active but are well shielded in steel and lead housings. Radiotherapy frequently uses cobalt 60 as the source with activity up to about 10 GBq.

7C10.38 Brachytherapy sources are also used which are inserted into the body to deliver a localised radiation dose (eg Cs-137).

Brachytherapy sources

Industrial radiography

7C10.39 Powerful gamma emitting radionuclides are housed inside a shielded metal box with a shutter at one end. The box is placed in front of an engineering structure (usually during the construction phase, in order to take an x-ray (in fact it is a gamma ray) image of an engineering component in order to determine if it is free from defects and therefore able to withstand the load being applied to it. The shutter is normally opened and closed remotely by using a bicycle cable operating system. Note that although confusingly often referred to as x-rays, these instruments do contain radioactive sources and cannot be made safe by simply cutting the power supply.

7C10.40 These are often found on construction sites and are used during the construction of load bearing structures to check for defects. They typically contain iridium 192 with activity in the range of 10 to 3000 GBq.

Industrial process measurement (level gauges, density/moisture gauges)

7C10.41 Level or thickness gauges may often be encountered on production lines. They generally use a beta source such as strontium 90 in order to determine whether or not the objects passing between the source and a detector are of the correct thickness or filled to the correct level. Size of source is typically 1 MBq.

7C10.42 Combined density and moisture gauges are often used on site in civil engineering projects for testing road surfaces. These use a caesium 137 source of approximately 300 MBq and an americium 241 source (combined with beryllium to produce neutrons) of approximately 1.5 GBq.

Agricultural sources

7C10.43 Combine harvesters sometimes have a yield gauge which may contain an americium-241 source of approximately 35 MBq.

Massey Ferguson combine harvester with grain level gauge

Teaching and research

7C10.44 The size and type of radiation are subject to wide variation dependent upon the particular research interests of the establishment concerned. The largest sources are likely to be found in the physics department of a university or the medical research department of a hospital.

Anti static devices

7C10.45 These are used to prevent the build up of static electricity in some industrial processes by ionising the air around them. The most widespread application is in a car body repair workshop where paint spraying is conducted. Spray shops typically use sources of polonium 210 with activities up to 5 GBq.

Scientific instruments

7C10.46 Small radioactive sources are sometimes used in particular measuring instruments in order to ionise the material under test in order to facilitate its analysis. Typical the sources are fairly small in the region of 1 kBq to 1 MBq.

Luminising

7C10.47 Radioactive materials are sometimes mixed with light emitting material known as phosphors in order to convert radiation energy into light energy (eg the luminous hands on a watch). Any modern luminous article will be fully encapsulated such that little or no radiation can be measured on the outside of the article. However older articles (typically manufactured during the period from the 1940s to the 1960s might contain significant quantities of radium 226 eg the original instruments on a World War II Spitfire. It should also be noted that there are a number of sites around the country where luminising operations have taken place in the past which may have resulted in significant contamination of the ground and/or buildings.

Luminised watch dial

Gaseous tritium light devices

7C10.48 Tritium is a radioactive isotope of hydrogen. It is sometimes used as an energy supply inside a glass tube in order to energise phosphor coatings which then emit light. These are known as gaseous tritium light devices. They are self-contained light emitting devices, that is, they have no external power source. They may be encountered in various locations where self-luminous signs or objects are in use. It is worth noting that the amount of tritium in individual devices will not give rise to a significant risk even if broken and the tritium is released. However, if the Fire and Rescue Service is mobilised to a premises where these devices are manufactured or stored in bulk, there may be terabecquerel amounts on site and special precautions may be appropriate.

7C10.49 In any incident involving tritium the principal concern will always be contamination rather than irradiation. It emits weak beta radiation only and has one of the weakest energy emissions of any radioactive material. Because of this it presents a unique problem in that no hand held instrumentation available to the Fire and Rescue Service is sufficiently sensitive to detect it.

7C10.50 It is therefore recommended that if a Fire and Rescue Service is mobilised to an incident involving a potential release of tritium appropriate chemical protective clothing and breathing apparatus is donned if entering a building. It is recommended that all responders contaminated by a significant release of tritium should undergo biological monitoring as it can breach chemical protective clothing in certain circumstances. This will require the staff affected to provide urine samples which will be analysed subsequently to determine the quantity of any tritium absorbed and to calculate any resultant internal dose.

7C10.51 It is worth noting that tritium may be found in gaseous form stored in a glass flask or it may be found as either tritiated water or organically bound tritium where the radioactive form of hydrogen is substituted for normal hydrogen. If gaseous tritium is involved it should be borne in mind that it readily exchanges with normal hydrogen atoms in molecules and therefore firefighting water run off may quickly become a source of tritium which could spread contamination widely.

Luminous key rings incorporating trintium

Smoke detectors

7C10.52 A small source of americium 241 typically 50 kBq is used in some domestic smoke alarms.

Lightning conductors

7C10.53 In the past radium 226 up to 500 kBq has been used as part of the construction on lightning conductors to improve their efficiency. Although they are no longer used in modern lightening protection systems, there is still a legacy of these sources in older building particularly in church steeples.

Lightning conductors

Transportation

7C10.54 The transport of radioactive materials within the UK is governed by strict regulations (see Section 7 Part C-3 Transportation, packaging and supply of hazardous materials for further information).

7C10.55 The general requirements for all packaging and packages used for the transportation of radioactive substances and articles are that:

- The package shall be so easily and safely transported and shall be designed that it can be properly secured in or on the conveyance during transport
- Any lifting attachments on the package will not fail when used in the intended manner and shall take account of appropriate safety factors to cover snatch lifting
- As far as practicable, the packaging shall be designed and finished so that the external surfaces are free from protruding features and can be easily decontaminated
- As far as practicable, the outer layer of the package shall prevent the collection and the retention of water. Any features added to the package at the time of transport which are not part of the package shall not reduce its safety
- The package shall be capable of withstanding the effects of any acceleration, vibration or vibration resonance. In particular, nuts, bolts and other securing devices shall be designed as to prevent them from becoming loose or being released unintentionally, even after repeated use
- The materials of the packaging and any components or structures shall be physically and chemically compatible with each other and with the radioactive contents. Account shall be taken of their behaviour under irradiation

- All valves through which the radioactive contents could otherwise escape shall be protected against unauthorised operation
- The design of the package shall take into account ambient temperatures and pressures that are likely to be encountered in routine conditions of transport
- For radioactive material having other dangerous properties the package design shall take into account those properties.

7C10.56 There are five basic container types for the transportation of radioactive materials.

Five basic container types for transportation of radioactive materials with their performance statements

- Excepted Packages – "may survive a minor accident"
- Industrial Packages – "may survive a minor accident"
- Type A Packages – "survives a minor accident"
- Type B Packages – "survives a major accident"
- Type C Packages – "survives an air accident"

EXCEPTED PACKAGES

For certain very small quantities of radioactive materials. The marking with the UN number is a requirement under the latest transport regulations. Common examples of contents are radiopharmaceuticals, calibration sources and some experimental apparatus. Surface dose rates must be below 0.005 mSv per hour. Excepted packages can be conveyed by all modes of transport in the UK (including the postal service).

INDUSTRIAL PACKAGES

For materials of which the concentration of radioactive material is very low and possibly also where it is in a form which is not easily dispersed. These are basic containers used for materials of low specific activity or surface contaminated objects, such as natural uranium ores or depleted uranium and worn protective clothing such as gloves and overalls. These containers are not necessarily expected to survive accident conditions. These packages are usually transported by road, rail or sea, although some air transport does occur.

TYPE A PACKAGES

For relatively large quantities of radioactive materials (compared with Industrial packages) such as radiopharmaceuticals, or radiochemicals. These packages are designed to withstand minor accidents, and only release a small fraction of their contents in a more serious accident. Surface dose rates are normally limited to no more than 2 mSv per hour. These packages are normally conveyed by all modes of transport, especially air as this reduces travel time for short-lived isotopes.

TYPE B PACKAGES

For larger amounts of radioactive materials, such as irradiated nuclear fuel, nuclear wastes or large radiation sources for radiotherapy. These are very strong packages and typically contain large quantities of radioactive material. They are specially designed containers able to withstand accident conditions. Surface dose rates are generally much less than 1 mSv per hour, and are limited to 2 mSv per hour under standard conditions. Type B packages are the predominant package type conveyed by rail, they are also transported by road, air and sea.

TYPE C PACKAGES

For large amounts of radioactive materials carried by air. A robustly designed package for high activity dispersible sources, including fissile material exclusively for air transport. Testing of these packages ensure that the package remains intact should it be involved in an air accident. Type C packages are relatively rare internationally.

OTHER PACKAGES

7C10.57 In nuclear engineering, a **fissile material** is one that is capable of sustaining a chain reaction of nuclear fission. Fissile materials can be used to fuel:

- a nuclear reactor (eg at a nuclear power station)
- a nuclear explosive.

7C10.58 Fissile material can be carried in industrial packages, Type A packages, Type B packages or Type C packages, but in this case the package will be designed to withstand accidents similar to the Type B or Type C package.

7C10.59 An additional type of package is that used for **uranium hexafluoride**. These packages may be any of the above types (except not normally Type C). However, they require special treatment in emergencies, particularly in fires. These packages are normally cylindrical and range in size. They may be contained in a protective outer box, which gives the package protection against severe accidents. The material they carry is corrosive in nature, reacting with water to form hydrofluoric acid and this may be the major concern in an emergency. The radioactive material they carry is often of such a low concentration that it carries little risk from radiation.

Marking and labelling

7C10.60 Radioactive materials are classified under UN category 7.

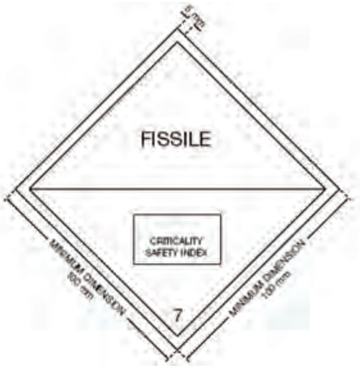
7C10.61 Unless the package is an excepted package (in which case it is unlabelled), all packages are labelled according to the external radiation hazard associated with the individual package as represented by the maximum radiation dose rate at the surface of the package. This rate of surface radiation is defined by the term '**Transport Index**' (TI). TI is used to express the external radiation hazard arising from a package in practical terms. The TI is determined by measuring the radiation dose rate at 1 metre from the package in μSv/hour and dividing the measured value by 10. If the material is fissile the TI is accompanied with the Criticality Safety Index and this is defined and measured differently. For further information regarding the transport index see the *Regulations for the Safe Transport of Radioactive Materials*, published by the International Atomic Energy Agency.

7C10.62 For the purpose of labelling, type A and type B packages are divided into three categories, which are:

- Category I – White
- Category II – Yellow
- Category III – Yellow

7C10.63 The label must include the radiation trefoil symbol, the name or symbol of the radionuclide, the activity (in Bq multiples) and the TI in the case of category II and III packages. Labels must be fixed to two opposite sides of the outside of the package. Examples of these labels are shown below.

Fissile material



Radioactive substance

Placard for separate display of United Nations numbers

7C10.64 Where the consignment in the freight container or tank is unpackaged LSA-I (low specific activity) or SCO-1 (surface contaminated objects) or where an exclusive use consignment in a freight container is packaged radioactive material with a single United Nations number, the appropriate United Nations number for the consignment shall also be displayed, in black digits not less than 65 mm high, either in the lower half of the placard and against the white background, or on the placard.

Category I – WHITE label

Category II – YELLOW label

Category III – YELLOW label

Documentation

7C10.65 ADR[2] does not require that a transport document (consignment note) must be prepared by the consignor and accompany the package when it is transported but in practice it usually is. If the package is to be transported by more than one mode of transport, it is accepted practice for a single transport document to be provided – for example, in the case of a package travelling by road to the airport, thence by air, the document provided would be the airline's 'shippers' declaration for dangerous goods'.

7C10.66 The transport document must include a signed declaration by the consignor and specified information relating to the package, including the UN number and proper shipping name assigned to the material. In addition, the consignor must provide the carrier with a written statement of any additional actions required of the carrier, for example any supplementary operational requirements relating to the loading, stowage, transport or handling, and any emergency actions appropriate to the consignment. Where no such supplementary operational requirements are necessary, a written statement to this effect must be provided to the carrier.

7C10.67 ADR requires that all transport documents are provided for excepted packages, and specifies that the information be provided in respect of each package.

7C10.68 The information contained in the documentation will give details such as the following:

- Name and address of the consignor
- Contact telephone number
- Name of material(s) being carried
- Description of materials

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[2] The **European Agreement concerning the International Carriage of Dangerous Goods by Road**, commonly known as **ADR** (from the French abbreviation **A***ccord européen relatif au transport international des marchandises* **D***angereuses par* **R***oute*), governs transnational transport of hazardous materials.

- Activity of material
- Package category
- Transport index.

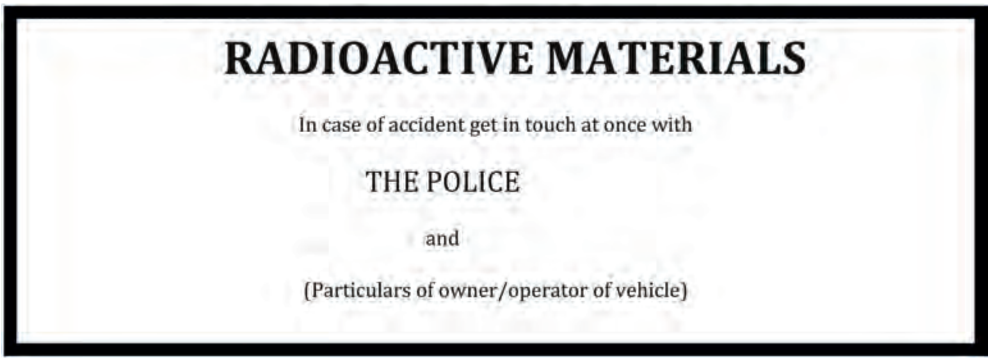
Other warning signs to be displayed

7C10.69 In the UK, unless the vehicle is carrying only excepted packages, it must also display either:

- a fireproof notice (a stamped metal plate) in the vehicle cab such that it is plainly visible to the driver; or
- rectangular, reflective, orange-coloured plates at the front and rear of the vehicle.

7C10.70 The fireproof notice or orange-coloured plates must be removed or covered when the vehicle is not carrying radioactive consignments.

Fire proof signs



RADIOACTIVE MATERIALS

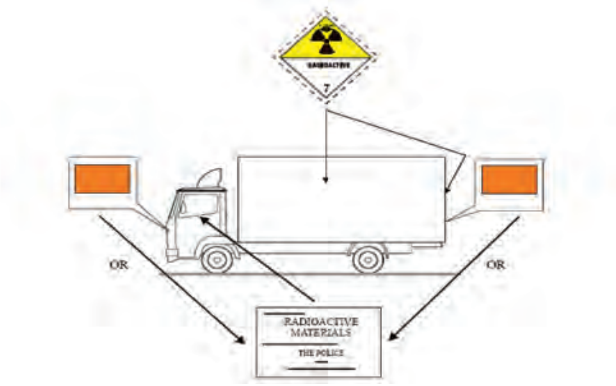
In case of accident get in touch at once with

THE POLICE

and

(Particulars of owner/operator of vehicle)

Vehicle placarding for radioactive materials



Storage

- The storage of radioactive materials is regulated via the *Environmental Permitting Regulations 2010* (EPR2010), and the *Radioactive Substances Act 1993* (RSA93). Since 6 April 2010 EPR2010 has come into force in England and Wales whereas RSA93 is still in force in Scotland and Northern Ireland. Section 23 of EPR2010 contains most of what was previously contained in RSA93
- Any operator handling or storing radioactive materials must be registered under RSA93 or EPR2010
- Section 7 of the Act deals with the storage conditions of sealed and unsealed sources
- Section 10 deals with the storage of mobile sources
- Sections 13 and 14 deal with the conditions under which sources may be accumulated and disposed of
- If an operator stores sealed sources with activity in excess of a certain limit (limit varies according to the type of source) the *High Activity Sealed Sources and Orphan Sources 2005 Regulations* must also be complied with. These regulations are now incorporated into the *Environmental Permitting Regulations in England and Wales* (Section 23)
- *High Activity Sealed Sources and Orphan Sources 2005 Regulations* are designed to ensure the security of high activity sealed sources in order to prevent them falling into the hands of terrorist groups. Among other things, the organisation seeking to store the sources must contact the counter terrorism security adviser of the local police service who will give recommendations on the physical security of the storage. An authorisation under *Radioactive Substances Act 1993/Environmental Permitting Regulations 2010* will now only be issued if these recommendations have been followed
- In addition *High Activity Sealed Sources and Orphan Sources 2005 Regulations* require the organisation to have in place suitable management processes in order to control and account for the use of the radioactive materials. Provision must also be made in the financial accounts to cover the cost of final disposal.

Operational considerations

Pre-planning

7C10.71 Fire and Rescue Services should adopt a pro-active approach to identifying potential radiation sources wherever possible within their response area. The use of radioactive materials is tightly controlled in the UK through the *Radioactive*

Substances Act 1993 and the *Environmental Permitting Regulations 2010*. All users of radioactive materials must be in receipt of an authorisation under Section 8 of the Act in order to hold radioactive materials. The authorisation states the maximum activity of each radionuclide the user may hold and whether the source is sealed or unsealed.

7C10.72 Copies of all such authorisations are sent to the relevant Fire and Rescue Service. It is recommended that an easily accessible central register of all these notifications is maintained. Once the Fire and Rescue Service has compiled a register of the location of the registered source users, it is good practice for the local fire station to arrange for familiarisation visits. The Fire and Rescue Service may need to prioritise the visits according to the nature of the sources or possible complexity of on-site processes.

Ionising Radiation Regulations 1999

7C10.73 The *Ionising Radiation Regulations 1999* are made under the *Health and Safety at Work Act*. They place a duty upon the employer (ie the Fire and Rescue Authority) to put in place systems to ensure that its employees are protected from excessive exposure to radiation. As part of the pre-planning procedure Fire and Rescue Services must have a written procedure stating how they will manage a radiation incident and stating how they intend to discharge their duties under the ionising radiations regulations. In particular the document must address the following points:

DOSE LIMITS

7C10.74 The maximum annual dose to all radiation workers (male and female) is 20 mSv. Firefighters attending a radiation incident fall under the definition of a radiation worker. There is an additional limit on females of reproductive capacity of 13 mSv in any three month period. The reason for this additional restriction is to protect a recently conceived foetus within a woman who may be unaware of her pregnancy. In this sense it is not so much a restriction designed for the protection of females but is a restriction designed to protect a foetus.

7C10.75 Further restrictions apply to females who have announced they are pregnant or breast feeding but it is assumed that female firefighters would not be used in an emergency operational capacity once the pregnancy was declared.

DOSE CONSTRAINTS

7C10.76 The regulations stipulate that, where appropriate to do so at the planning stage, dose constraints are used to restrict exposure to radiation as far as is reasonably practicable. This dose constraint will usually be significantly lower than the legal dose limits. Fire and Rescue Services should consider any possible operations <u>not involving situations immediately threatening to life</u> where they may wish to impose a dose constraint below the legal annual limit. This could possibly be the case at a protracted incident or if it was considered possible that crews may have to attend more than one radiation incident within a 12 month period.

7C10.77 It is recommended that a dose constraint of 5 mSv per incident is introduced at operational incidents. The reasons for this level of constraint are:

- It corresponds to the alarm setting on the electronic personal dosimeters, supplied through the Fire and Rescue Service National Resilience Project, which would naturally prompt staff to leave the hazard zone
- It is in line with dose reference levels used by the Ambulance Service
- It does not legally preclude female firefighters from entering the hazard zone as it is less than 13 mSv
- If a firefighter were to receive a dose in excess of one third of any formal dose limit (ie 1/3 of 20 mSv), the employer must conduct an investigation into the circumstances. This would equate to approximately 6 mSv for a whole body dose as measured by an electronic personal dosimeter and by using 5 mSv as the dose constraint level this should avoid crossing this reporting threshold.

AS LOW AS REASONABLY PRACTICABLE

7C10.78 At all times, it is not simply sufficient to avoid exceeding dose constraints or dose limits, the Fire and Rescue Service must take active measures to ensure that all doses received are 'as low as reasonably practicable'. Dose limits are not aspirational, they are the last line of defence. In practical terms this means that if a task can be carried out in more than one way and one method is likely to result in lower radiation doses, this method must be used if reasonably practicable.

EMERGENCY EXPOSURE

7C10.79 Although the preceding paragraphs are based upon the legal requirements under *Ionising Radiation Regulations 1999*, there is an exception to these dose limits. Under the *Radiation (Emergency Preparedness and Public Information) Regulations 2001* (REPPIR) it is permissible to disapply the *Ionising Radiation Regulations 1999* dose limits at a licensed nuclear site or at an incident involving transport by rail if in doing so it might be possible to save life or maintain critical infrastructure.

7C10.80 In these instances it may be permissible for an informed volunteer to be exposed to a dose of up to 100 mSv[3]. The authorisation for the disapplication of dose limits (ie allowing emergency exposure to take place) must be given by an officer or manager within the Fire and Rescue Service who has received appropriate training.

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[3] The figure of 100 mSv is not stipulated in the REPPIR, it has been arrived at through multi-agency collaboration. Where Fire and Rescue Services have licensed sites within their turn-out areas they should develop risk assessed emergency exposure procedures with site operators.

7C10.81 The REPPIR state that employees of the emergency services who may receive emergency exposures should be pre-identified as part of the planning process. Fire and Rescue Services should liaise with radiation risk operators or carriers, as appropriate, to obtain the expert advice needed to plan for emergency exposures.

7C10.82 Fire and Rescue Services that develop emergency exposure operational procedures which disapply the dose limits in the *Ionising Radiation Regulations 1999* should record specific risk assessments on this aspect of their plans. Even when operating under emergency exposure conditions the principles of 'as low as reasonably possible' should still be taken into consideration

7C10.83 **Chemical, biological, radiological and nuclear incidents** – Fire and Rescue Services should note that REPPIR applies to premises and transportation where a known source of certain strength exists. This is clearly not the case in a terrorist attack involving a radiation source at other premises. In this case therefore, the *Ionising Radiation Regulations 1999* cannot legally be disapplied and the limitations in the regulations indicated above will apply.

7C10.84 However, this anomaly in law has been recognised and after consultation with the Nuclear Installations Inspectorate of the Health and Safety Executive the following has been determined.

- "Terrorist incidents are not considered by the Health and Safety Executive to be applicable to either the *Ionising Radiation Regulations 1999* or *The Radiation (Emergency Preparedness and Public Information) Regulations 2001 (REPPIR)*. However REPPIR does provide a good framework which can be used for planning and management of risk with regard to intervention at this type of incident".

INFORMED VOLUNTEER

7C10.85 An informed volunteer in terms of the application of REPPIR is a radiation worker who has agreed to receive an emergency exposure above the limits imposed by *Ionising Radiation Regulations 1999*.

7C10.86 To be considered as an informed volunteer a firefighter should have received:

- appropriate training in the field of radiation protection
- suitable and sufficient information and instruction for them to know the risks to health created by exposure to ionising radiation and the precautions which should be taken
- a briefing on the risks and control measures associated with the specific emergency tasks in question.

NOTE: Informed volunteers should be asked to confirm their agreement to potentially receive an emergency exposure at this briefing.

7C10.87 The REPPIR also require that employers of informed volunteers:

- Provide equipment that is necessary to restrict the exposure of informed volunteers to radiation
- Identify, and appropriately train, managers/officers who are authorised, in the event of a radiation emergency, to permit informed volunteers to be subject to an emergency exposure
- Make arrangements for medical surveillance by an appointed doctor or employment medical adviser to be carried out without delay in the event of a radiation emergency
- Make arrangements with an approved dosimetry service for the assessment of doses during emergency exposures, and for the separate recording of such doses in dose records. Further information and the names of approved dosimetry services approved under REPPIR can be found on the Health and Safety Executive website:

  www.hse.gov.uk/radiation/ionising/dosimetry/ads.htm

- Ensure that no employee under 18 years of age, no trainee under 18 years of age and no female employee who is pregnant or breast-feeding is subject to an emergency exposure.

CLASSIFIED PERSONS

7C10.88 Classified persons are those who work regularly with radiation in regulated areas. It is unlikely that any firefighters would ever need to become 'classified workers'. However, a situation could arise with part-time or retained duty system firefighters where their primary employment might be in an organisation where they are exposed to ionising radiations and by virtue of this would be classified workers.

7C10.89 This situation could arise where retained firefighters are recruited from an area where a licensed nuclear site is a major employer. Under these circumstances, the Fire and Rescue Service would have a duty under the *Ionising Radiation Regulations* to have a system in place whereby the annual doses received by individual retained staff from their other employment is captured so that they do not exceed any applicable dose limit.

7C10.90 The most convenient way of addressing this might be to issue each of the relevant member of staff with a radiation passbook. This is a recognised scheme within the nuclear industry whereby staff that may have to visit many sites during a year have their dose monitored by the health physics department of each site in question. This dose is then entered into the book which is issued on a personal basis. The classified person then takes it with them from site to site and the 'running total' is noted in order to ensure that dose limits and constraints are not exceeded.

7C10.91 It is recommended that if this is identified as an issue for any Fire and Rescue Service contact is made with the radiation protection adviser at the main licensed nuclear site in order to arrange for such a scheme to be implemented.

DESIGNATED AREAS

7C10.92 Restricted and controlled areas are specially marked areas where radiation dose rates in excess of prescribed limits (6 mSv per year or 3 tenths of any other relevant dose limit) are likely to be encountered. If entering a 'radiation controlled area' at a licensed site, Fire and Rescue Service staff shall do so under the supervision of the site radiation protection supervisor and shall wear any additional dosimetry equipment required by the site. If the incident occurs at an unregulated location the establishment of the inner cordon and entry controls would satisfy this requirement.

LOCAL RULES

7C10.93 The radiation employer (ie the Fire and Rescue Service) must produce a set of written local rules which set out the procedure to be followed when working with radioactive materials. In most cases this Fire and Rescue Service Operational Guidance would form the basis for fulfilling this requirement as amended by local risk assessments and standard operating procedures.

RADIATION PROTECTION ADVISER AND RADIATION PROTECTION SUPERVISOR

7C10.94 The Fire and Rescue Service should consult a radiation protection adviser if it considers it needs advice on compliance with the *Ionising Radiation Regulations*.

7C10.95 The appointment of a radiation protection supervisor within the Fire and Rescue Service is a useful role in helping to ensure adherence to the operational procedures for radiation incidents. The radiation protection supervisor needs to:

- understand the requirements of the local procedures within the Fire and Rescue Service
- command sufficient authority to be able to supervise the radiation protection aspects of incident
- understand the necessary precautions to be taken to restrict exposures
- understand the procedures to follow in the event of an emergency.

7C10.96 The hazardous materials adviser position within Fire and Rescue Services should be considered suitable for the radiation protection supervisor role.

PRIOR RISK ASSESSMENT

7C10.97 There must be a prior risk assessment carried out for all work involving radioactivity. The national Fire and Rescue Service generic risk assessment on radiation incidents (*GRA 5.5 Incidents involving radiation*) should be considered when Fire and Rescue Services carry out or review their own risk assessments.

DOSIMETRY AND RECORD KEEPING

7C10.98 All staff who enter an area designated by the Fire and Rescue Service as potentially containing a radiation hazard should be issued with a dosimeter to record the external dose received. The Fire and Rescue Service should have a system in place to be able to capture this information and to store the dose record for up to 50 years.

7C10.99 The requirement to keep records only applies once a firefighter has received a radiation dose other than from normal background radiation. If after being worn the dosimeter is only displaying the normal background level of accumulated dose then there is no requirement to keep this record.

MEDICAL SURVEILLANCE

7C10.100 In the event of firefighters receiving a significant exposure to radiation they must be referred to a suitably qualified employment medical adviser to conduct medical surveillance. Fire and Rescue Services should consider making provision in their occupational health arrangements for this service to be commenced should the need arise. This may also include the provision of bioassay services in the event of suspected internal exposure.

7C10.101 It is possible that the health physics departments of a local Licensed Nuclear Site may be willing to provide this service locally, and liaison with the site radiation protection adviser is therefore recommended.

EQUIPMENT MAINTENANCE AND CALIBRATION

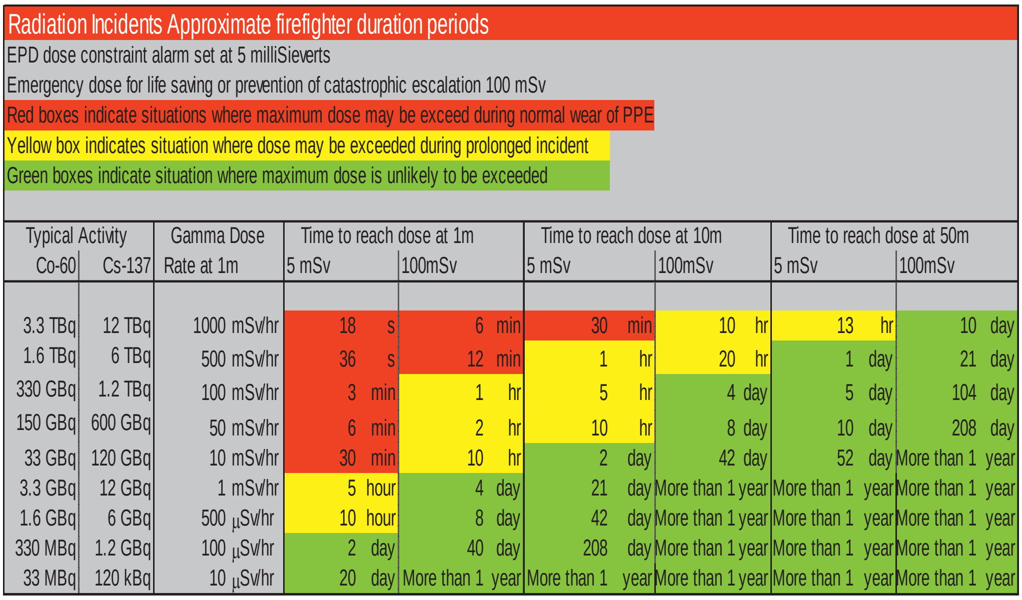
7C10.102 Reliance is placed in this guidance on the ability to accurately measure the dose and dose rates to which firefighters are exposed. It is therefore essential that the equipment is properly maintained and subject to annual calibration tests.

TRAINING

7C10.103 All staff expected to encounter radiation should be properly trained to undertake the tasks expected of them. The Fire and Rescue Service should arrange for role appropriate training (including acquisition, application and maintenance of competence) of staff. This should be reinforced by exercising both at specific locations of radiation risks and of general radiation procedures.

EMERGENCY INCIDENT PLANS

7C10.104 For planning purposes only, the following table may be useful in estimating the likely realistic working times for various dose rates and separation distances before the recommended dose constraint level of 5 mSv (Fire and Rescue Service National Resilience electronic personal dosimeter standard alarm) and the emergency exposure limit of 100 mSv (electronic personal dosimeter emergency alarm) are reached.



Radiation Incidents Approximate firefighter duration periods

EPD dose constraint alarm set at 5 milliSieverts

Emergency dose for life saving or prevention of catastrophic escalation 100 mSv

Red boxes indicate situations where maximum dose may be exceed during normal wear of PPE

Yellow box indicates situation where dose may be exceeded during prolonged incident

Green boxes indicate situation where maximum dose is unlikely to be exceeded

Typical Activity		Gamma Dose	Time to reach dose at 1m		Time to reach dose at 10m		Time to reach dose at 50m	
Co-60	Cs-137	Rate at 1m	5 mSv	100mSv	5 mSv	100mSv	5 mSv	100mSv
3.3 TBq	12 TBq	1000 mSv/hr	18 s	6 min	30 min	10 hr	13 hr	10 day
1.6 TBq	6 TBq	500 mSv/hr	36 s	12 min	1 hr	20 hr	1 day	21 day
330 GBq	1.2 TBq	100 mSv/hr	3 min	1 hr	5 hr	4 day	5 day	104 day
150 GBq	600 GBq	50 mSv/hr	6 min	2 hr	10 hr	8 day	10 day	208 day
33 GBq	120 GBq	10 mSv/hr	30 min	10 hr	2 day	42 day	52 day	More than 1 year
3.3 GBq	12 GBq	1 mSv/hr	5 hour	4 day	21 day	More than 1 year	More than 1 year	More than 1 year
1.6 GBq	6 GBq	500 µSv/hr	10 hour	8 day	42 day	More than 1 year	More than 1 year	More than 1 year
330 MBq	1.2 GBq	100 µSv/hr	2 day	40 day	208 day	More than 1 year	More than 1 year	More than 1 year
33 MBq	120 kBq	10 µSv/hr	20 day	More than 1 year	More than 1 year	More than 1 year	More than 1 year	More than 1 year

7C10.105 **NOTE:** This table assumes that there is no shielding between the source and the firefighter and that the source is a point source (ie very small in relation to the size of the firefighter). It has been calculated for two very common sources and it is important to be aware that the same activity from different sources can give rise to very different dose rates. Whilst this is useful for initial planning, real dose rate information needs to be gathered at an actual incident using radiation detection and monitoring equipment. The figures shown should be treated with caution and be regarded as approximations only.

7C10.106 If Fire and Rescue Services have significant radiation risks in their area they should arrange joint exercises with the facility concerned. This is especially important if there is a licensed nuclear site within their turn-out area. Early contact with the Radiation Protection Adviser or the Head of Radiation Protection Advisory Services would enable both the facility and the Fire and Rescue Service to understand each other's role in an emergency and what would be expected of the Fire and Rescue Service. Licensed sites often operate their own fire brigade and are usually very helpful to the local authority Fire and Rescue Service.

7C10.107 The safety of nuclear installations in the UK is the responsibility of holders of Nuclear Site Licences granted by the Health and Safety Executive under the *Nuclear Installations Act 1965*. The Nuclear Site Licence, which permits the use of the site for certain specified activities, contains a number of standard licence conditions. Licence Condition 11 (Emergency Arrangements) requires the licensee to ensure that adequate arrangements are in place to respond effectively to any incident ranging from a minor on-site event to a significant release of radioactive material. In the event of a real fire at a nuclear installation, the Fire and Rescue Service would be required to support. For this reason, it is recommended that Fire and Rescue Services that have a nuclear installation within their area should establish formal links with these installations and exercise the emergency response arrangements.

7C10.108 Licensed nuclear sites are typically nuclear power stations, facilities for the manufacture or reprocessing of nuclear fuel, production and maintenance of nuclear weapons and sites operating a nuclear reactor.

7C10.109 The Nuclear Emergency Planning Liaison Group is a forum which brings together a wide range of organisations, including CFOA, with interests in off-site civil nuclear emergency planning. The Group issues consolidated guidance on planning which can be found at:

http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/nuclear/issues/emergency_plan/neplg/neplg.aspx

Phase 1: Mobilising and en-route

7C10.110 Informative messages to mobilising control should state 'RADIATION SUSPECTED' when involvement is suspected but not yet confirmed, and "RADIATION CONFIRMED" when radiation is known to be involved. On receipt of either of these messages, mobilising control should inform all responders of the situation, it may also trigger other Fire and Rescue Service specific pre-determined attendances.

7C10.111 Radiation monitoring instruments should be switched on before reaching the incident.

7C10.112 Radioactive materials may be involved in incidents at premises or during transport. Their involvement may be suspected in the following cases:

- knowledge or intelligence that radioactive materials are in a building from operational information sources (eg 7(2)d visits, agency notifications, fire safety inspections/assessments etc)
- a radioactivity warning placard on a vehicle or package
- the caller may state that radioactive materials are present
- an electronic personal dosimeter alarm actuates
- a survey meter shows a dose rate above background
- terrorist or other malicious acts.

Phase 2: Arriving and gathering information

Operational key principle

Radiation dose control measures – Where it is known that the only radiation at an incident is from a sealed source (ie there is no contamination risk) protection will depend upon a combination of **TIME, DISTANCE and SHIELDING**

TIME – the shorter the duration of exposure the smaller the accumulated dose

DISTANCE – the greater the distance from the source of radiation the lower the dose rate

NOTE: Inverse square relationship (eg doubling the distance from a radiation source quarters the dose received)

SHIELDING – in general the higher the density and greater the thickness of the shielding, the better the protection.

- Response vehicles should approach the incident from the upwind direction wherever possible as a precaution. This is essential if it is believed that there has been a significant release of contamination from an unsealed source of radiation
- Initially response vehicles should be parked a safe distance from the incident
- The table below gives generic initial cordon distances based on the guidance given by the International Atomic Energy Agency in the *Manual for First Responders to a Radiological Emergency*. This manual provides practical guidance for those responding within the first few hours of a radiological emergency. It does not address the response to emergencies involving facilities or operations for which specific emergency arrangements should have been developed. Further information can be found at:

  www.iaea.org

Radiation incidents – generic initial cordons	
Outside buildings	
Unshielded or damaged potentially dangerous source	45 metres around
Major spill from a potentially dangerous source	100 metres around
Fire, explosion or fumes involving a potentially dangerous source	300 metres radius
Suspected bomb (exploded or unexploded)	400 metres radius or more to protect against an explosion.
Inside buildings	
Damage, loss of shielding or spill of a potentially dangerous source	Affected and adjacent areas (including the floor above and below).
Fire or other event that can spread a potentially dangerous source materials throughout the building (eg through the ventilation system)	Entire building and outside distances detailed above.

- If immediately available, a survey meter (eg RADOS 200) should be deployed to check that the vehicles are not parked in an area affected by any gamma radiation. As a general guide the reading should be in the range 0.04 to 0.2 microsieverts per hour which is the normal background range. At a large site, there may be a formal rendezvous point and at some sites there may be several to take account of differing wind directions. If survey meters are not available to the first responders the electronic personal dosimeters issued to Fire and Rescue Services through the National Resilience Assurance Team provide a basic dose rate measuring capability

- If the survey meter indicates normal background readings the appliances may be moved closer if this is desirable. If the survey meter indicates elevated gamma dose rates the appliances should be withdrawn to a point where normal background readings are obtained

- The Incident Commander should liaise with a responsible person on site, if available. This may be a radiation protection supervisor or radiation protection adviser at a fixed installation or possibly the driver of the vehicle if in transit. At a licensed site there may be a written emergency plan. At a transport incident there should be documentation which will describe the type and size of sources being carried. The class of sign on packaging should also give information about the likely dose rates

- The Incident Commander should attempt to determine the following information then carry out a risk assessment:
  - Is radioactivity the reason for the incident or is it a secondary issue which happens to be present?
  - What type of source is involved? What nuclide is involved?
  - Is it sealed or unsealed (ie irradiation or contamination risk)?
  - What is the size of the source (activity) in Bq? Which types of radiation are emitted? Remember most sources will emit more than one type of radiation
  - What is the exact location of the source within a building? Is this the same as the location of the incident or is it likely to become involved in the incident?

Operational key principle

Radiation dose management

DOSE LIMIT – Under the *Ionising Radiation Regulations 1999* the maximum annual dose to firefighters is **20 mSv**. There is an additional limit on **females of reproductive capacity of 13 mSv** in any three month period.

DOSE CONSTRAINT – It is recommended that a dose constraint of **5 mSv per incident** is introduced at operational incidents involving radiation.

EMERGENCY EXPOSURE – At a licensed nuclear site or at an incident involving transport by rail the legal dose limit can be exceeded if in doing so it might be possible to save life or maintain critical infrastructure. In these instances an informed volunteer may be exposed to a dose of up to **100 mSv**. The authorisation of “emergency exposure” to must only be given by an officer or manager within the Fire and Rescue Service who has received appropriate training

NOTE: As low as reasonably possibly

At all times, it is not sufficient to avoid exceeding dose constraints or dose limits, the Fire and Rescue Service must take active measures to ensure that all doses received are ‘as low as reasonably possible’.

- Consider contacting RADSAFE in the event of a transport incident to gain expert advice and support.

Assistance and liaison:

RADSAFE

RADSAFE is a consortium of organisations that have come together to provide mutual assistance in the event of a transport accident involving radioactive materials belonging to a RADSAFE member. RADSAFE is designed to ensure the early provision of advise and support to the emergency services. It is activated by calling **0800 834153**. Further information is available at:

www.radsafe.org.uk

RADSAFE has three levels of response:

- **Level 1** – Notification/communication service, provision of generic radiological protection advice provided by Command and Control Centre
- **Level 2** – Provision of radiological advice/support at the incident scene
- **Level 3** – Consignment owner response and 'clean-up'

NAIR

The NAIR (National Arrangements for Incidents involving Radioactivity) scheme exists to provide protection to the public in the event of incidents involving radioactivity in cases where no specific plans are available or existing plans fail to operate effectively.

NAIR provides the emergency services with expert advice where the public might be at risk and acts as a 'long stop' to other emergency plans.

The Fire and Rescue Service may call upon NAIR assistance through the police who should call **0800 834153** (same number as RADSAFE).

NAIR response is provided in two stages:

- **Stage 1** – provided by a radiation expert equipped with simple monitoring and protective equipment. They can quickly advise whether a radiological hazard exists. They are not equipped to deal with larger incidents. In such events the they will advise the police to initiate the Stage 2 response.
- **Stage 2** – provided by a well equipped team from a nuclear establishment with facilities to deal with larger incidents

NOTE: NAIR will not organise substantial recovery operations or carry out large scale decontamination.

- If there is no responsible person available and the premises/vehicle/source is not secure, the assistance of the police should be sought in order secure it
- The Environment Agency should be informed whenever a registered radioactive source is involved in an incident. This is particularly important if any contamination is released into the environment from for example water run off
- The local water undertakers should be informed if it is believed that radioactive contamination has entered a sewer or watercourse.

Phase 3: Planning the response

7C10.113 The Incident Commander must ensure that a full risk assessment is carried out prior to the deployment of staff in order to develop an appropriate and proportionate response plan.

7C10.114 The Incident Commander, in conjunction with the hazardous materials adviser, should determine the tasks to be undertaken. Consideration should be given to the following:

- The need to deploy crews
- If it is deemed necessary, determine if the risk involves a sealed source in which case the only hazard is likely to be irradiation or an unsealed source since in which case the main hazard is likely to be contamination
- If the hazard is irradiation only (ie a sealed source), structural firefighting kit with breathing apparatus is an appropriate level of personal protective equipment (personal protective equipment)
- If the hazard is contamination chemical protection clothing plus breathing apparatus is often an appropriate level of personal protective equipment

  NOTE: If it is not known whether sealed or unsealed sources are involved, chemical protective clothing should be worn.

- The type of source and the type of radiation emitted

  NOTE: Determining the type of radiation is secondary to the need to determine whether the risk is from irradiation or contamination or both. Be aware that the majority of radioactive sources will emit more than one type of radiation

- Be clear about the objective in committing crews eg fire fighting, search and rescue, maintaining critical infrastructure
- Brief the crews thoroughly about their task and emphasise the need to enter, carry out specific task then leave

- Remind crews that personal protective equipment will protect them fully from the effects of contamination and the principles of Time, Distance and Shielding will protect them from the effects of irradiation. Spend as little time as possible in the proximity of the source; keep as far away from the source as possible (survey meter readings will assist in this); make use of any available shielding eg concrete, metallic structures, water tanks etc
- The use of a survey meter will help them to manage any possible dose to an acceptable level
- Dosimeters will record the personal dose received by each firefighter and the reading for each firefighter will need to be robustly recorded for future reference
- Electronic personal dosimeters issued to Fire and Rescue Services through the National Resilience Assurance Team provide an audible alarm which should prompt the wearer's withdrawal from the hazard zone before any significant doses are received.

  NOTE: Three stage alarm.

  - The **first alarm** is a dose rate alarm which gives a warning that the wearer is entering an area affected by radiation. This can, and should be cancelled by the wearer. Temporary shielding could cause this alarm to sound more than once during a deployment.
  - The **second alarm** will operate when the total accumulated dose reaches 5 mSv. Crews would normally withdraw at this point. This alarm can be cancelled by the wearer.
  - The **third alarm** which would only ever operate if an emergency intervention was being made will operate at 100mSv. This must not be ignored, wearers must aim to leave the inner cordon before it sounds. This alarm cannot be cancelled by the wearer.

Phase 4: Implementing the response

- Establish and mark an inner cordon. Set up a breathing apparatus entry control point as its "gateway". The cordon boundary should be at a point where the background dose rate is about normal for the area (Note: normal background in most parts of the UK will vary from approximately 0.04 to 0.2 microsieverts per hour (μSv/hr))

  NOTE: In certain circumstances, where a qualified radiological assessor has assessed the entire radiological hazard, the inner cordon may be set at a level slightly higher than background
- The Incident Commander should assign staff with survey meters to monitor the boundary in order to ensure that the situation does not change during the incident

NOTE: Gamma radiation will radiate outwards 360° so consider monitoring all around the perimeter of the cordon but be aware that differences in shielding of the source may mean that the hazard zone is not circular in shape.

- If an outer cordon is required, establish this at an appropriate position. The space between the inner and outer cordons should be unaffected by radiation from the incident
- Set up a decontamination area across the boundary of the inner cordon but slightly away from the breathing apparatus entry control point. Maintain a clean path in and out of this area throughout the incident
- Every person passing through the breathing apparatus entry control point and entering the hazard zone must be wearing a dosimeter. A system should be set up to record the displayed dose on entry and to record it again on exit. At the entry point, note the serial number of the dosimeter issued to each firefighter.
- If chemical protective clothing is being worn and it becomes necessary to read the electronic personal dosimeter display or to operate the unit, the wearer should withdraw his arm from the suit unclip the electronic personal dosimeter and pass it through the collar, if fitted within the suit, into the head compartment. The wearer may experience difficulty in reading his own electronic personal dosimeter due to the proximity to his eyes but it is easily read by a companion outside the suit. It is therefore suggested that a buddy system is used to read each other's electronic personal dosimeters when deployed in chemical protective clothing
- Each crew entering the hazard zone should have a dedicated operator of a survey meter accompanying them. The purpose of the survey meter operator, who should be assigned no other task, is to monitor the dose rate of the whole crew and direct their pathway to ensure that all doses are kept as low as reasonably practicable. The use of the survey meter is the primary means of ensuring external radiation safety
- The survey meter operator needs to be aware that the gamma radiation source may be located at any height even on the floor above or the floor below and should periodically move the meter vertically and horizontally in order to ascertain the direction from which the gamma radiation is coming. He should use this information in order to direct the crew away from the source as far as is practical and to take advantage of any available shielding
- When using a survey meter it is important to understand that in some circumstances, gamma radiation beams may be highly collimated, that is to say, may be emitted in a narrow beam which may not impinge upon the survey meter at hand height
- It is essential that crews are aware of the three stages of the electronic personal dosimeter alarm and the associated warning tones. The first alarm (which measures the dose rate) is intended to alert the wearer to the fact that a radiation affected area has been entered. This can be cancelled by

the wearer. The next alarm will operate when the wearer has received an accumulated dose of 5 mSv. The crew should withdraw on hearing this alarm (**NOTE:** if only one person's alarm sounds, the whole crew should withdraw). A new crew should then be committed if there are further objectives to be completed

- On exiting the incident the crews should be directed to the decontamination area. If there was originally no known risk of contamination (ie a sealed source) and the crews can confirm that they encountered no other contamination risks decontamination is not required and they should present their electronic personal dosimeters to the breathing apparatus entry control officer for formal recording of their personal dose record
- If there is a contamination hazard present crews should initially be checked with a contamination meter prior to disrobing. If the Fire and Rescue Service does not have dedicated contamination meters it may be acceptable under some circumstances to use a Rados 200 connected to the contamination probe (Beta probe) but advice should be sought prior to undertaking this task. Monitoring effort should be concentrated in the first instance on the parts of the suit with the highest risk of becoming contaminated, usually the boots and the gloves followed by knees and elbows

  NOTE: Contamination meter readings of more that 5 counts per second (cps) above background level is usually taken as evidence of contamination. Licensed installations may have on-site emergency teams who could assist with contamination monitoring

- If no contamination is found (usually taken as 5 or less cps) the suits should be subject to appropriate cleaning procedures. If found to be contaminated, it is recommended that the suit is removed from the wearer using a safe undressing procedure and is double bagged prior to disposal or decontamination by a specialist contractor. It will assist the latter process if a record is kept of where on the suit the contamination was detected
- It is not generally regarded as good practice to use water/showers for decontamination of radioactive materials. The reason for avoiding the use of water is to prevent spread of contamination and prevent self absorption by water of alpha radiation. Having said this, where large numbers of contaminated people require urgent mass decontamination wet-containment may be the most appropriate method.

Phase 5: Evaluating the response

- Incident Commanders should constantly evaluate the risk posed by radioactive materials and the effectiveness of radiation procedures and of specialist advice obtained. Evaluation is not a one off process but should be continual throughout the incident as circumstances change or new information is gathered. After evaluation the Incident Commander should review and adjust the response plan, amend or implement additional control measures and communicate the changes to all staff

- Aside from the general considerations which would form part of the evaluation process for any incident, the Incident Commander should particularly check the dose readings as measured by the electronic personal dosimeters of crews who have been committed and ensure that no limits or constraints have been exceeded and that all doses have been as low as reasonably practicable. The Incident Commander should also ensure that any issues relating to contaminated staff or equipment leaving the hazard zone are being adequately managed
- Consider the dose rates reported inside the hazard zone and the consequent need to deploy more crews. Gather clear information regarding potential radioactive contamination within the building.

Phase 6: Closing the incident

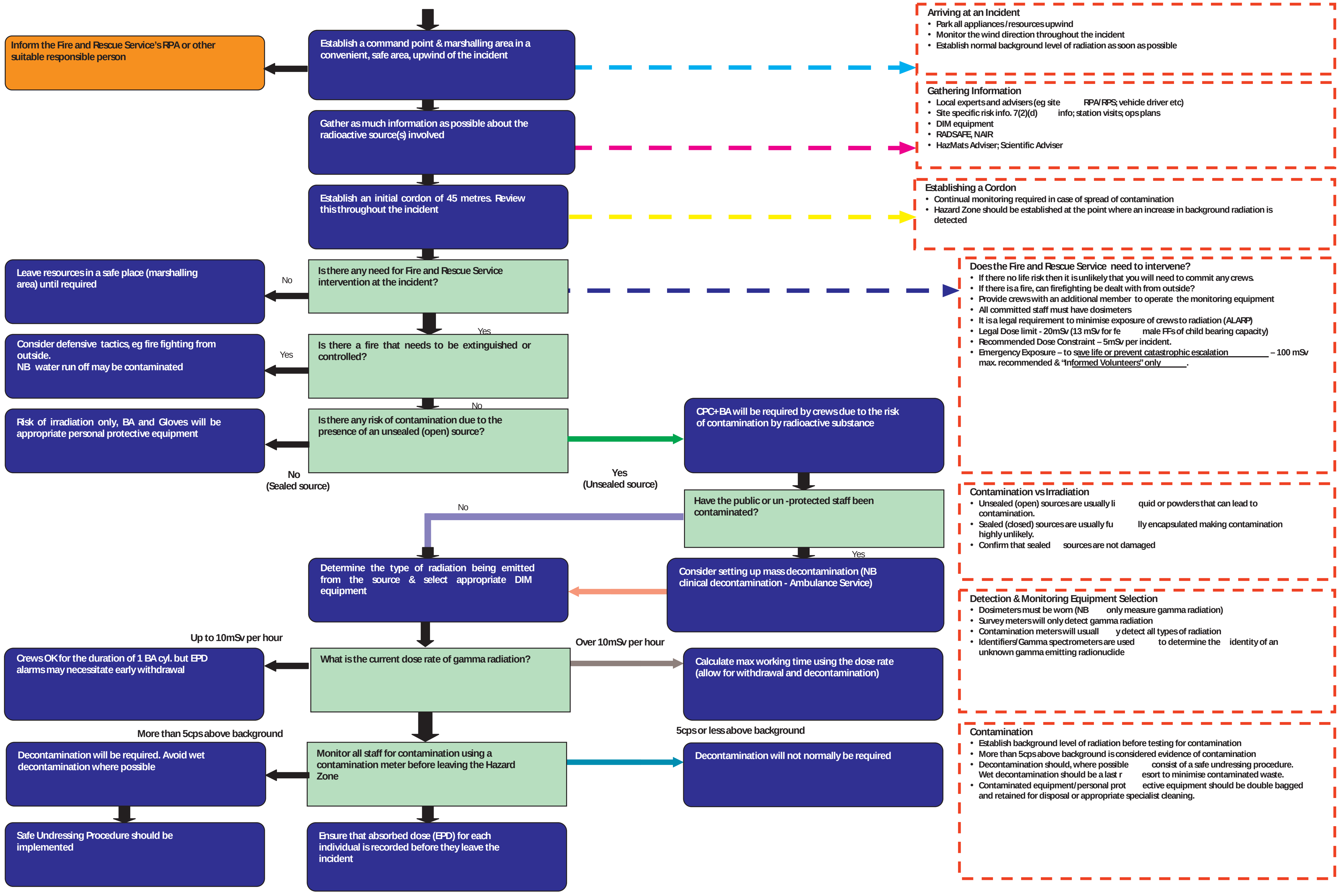
7C10.115 At the end of the incident the following measures will need to be considered:

- If the source has been made safe or the affected area contained, it should be handed over to the appropriate authority. In many cases this will be the owner of the source. If the incident has occurred at site registered under the *Radioactive Substances Act* there should be a representatives of the organisation on hand to deal with
- There is a growing awareness of ‘orphan sources’. These are radioactive sources which have no traceable owner (eg lost, stolen etc). If the incident has involved an orphan source the NAIR scheme should be implemented
- Collation and recording of radiation exposure dose records for all committed staff. These need to be transferred to a robust recording system and need to be kept for 50 years
- Introduce medical surveillance for significantly exposed firefighters
- Debrief crews. Provide advice and reassurance to firefighters on nature of risks from radiation. If available enlist the help of a specialist adviser to assist with this
- Consider engaging with the media and public relations issues. Radiation incidents will attract a great deal of interest and it is usually advisable to keep the media well informed
- Conduct a formal investigation if the level of 6mSv whole body dose has been exceeded by any staff.

Additional operational considerations when involved in fire

- Consider defensive firefighting tactics. Try to minimise the use of water and take active measures to prevent contaminated run off from entering watercourses. If the sources are in a complex building eg a hospital or university and the fire does not initially affect the radiation sources consider deploying resources specifically to protect radiation stores or sources.
- Consider the effect on dose rate if lead shielding were to melt (the melting point of lead is 327 degrees Celsius) and be lost as a result of heat from a fire. It may be necessary to adjust firefighting tactics to protect stores of radioactive substance.

Radiation suspected or confirmed



Establish a command point & marshalling area in a convenient, safe area, upwind of the incident

Inform the Fire and Rescue Service's RPA or other suitable responsible person

Gather as much information as possible about the radioactive source(s) involved

Establish an initial cordon of 45 metres. Review this throughout the incident

Is there any need for Fire and Rescue Service intervention at the incident?

Leave resources in a safe place (marshalling area) until required

Is there a fire that needs to be extinguished or controlled?

Consider defensive tactics, eg fire fighting from outside.
NB water run off may be contaminated

Is there any risk of contamination due to the presence of an unsealed (open) source?

Risk of irradiation only, BA and Gloves will be appropriate personal protective equipment

CPC+BA will be required by crews due to the risk of contamination by radioactive substance

Have the public or un-protected staff been contaminated?

Consider setting up mass decontamination (NB clinical decontamination - Ambulance Service)

Determine the type of radiation being emitted from the source & select appropriate DIM equipment

What is the current dose rate of gamma radiation?

Crews OK for the duration of 1 BA cyl. but EPD alarms may necessitate early withdrawal

Calculate max working time using the dose rate (allow for withdrawal and decontamination)

Monitor all staff for contamination using a contamination meter before leaving the Hazard Zone

Decontamination will be required. Avoid wet decontamination where possible

Decontamination will not normally be required

Safe Undressing Procedure should be implemented

Ensure that absorbed dose (EPD) for each individual is recorded before they leave the incident

Arriving at an Incident
- Park all appliances/resources upwind
- Monitor the wind direction throughout the incident
- Establish normal background level of radiation as soon as possible

Gathering Information
- Local experts and advisers (eg site RPA/RPS; vehicle driver etc)
- Site specific risk info. 7(2)(d) info; station visits; ops plans
- DIM equipment
- RADSAFE, NAIR
- HazMats Adviser; Scientific Adviser

Establishing a Cordon
- Continual monitoring required in case of spread of contamination
- Hazard Zone should be established at the point where an increase in background radiation is detected

Does the Fire and Rescue Service need to intervene?
- If there no life risk then it is unlikely that you will need to commit any crews.
- If there is a fire, can firefighting be dealt with from outside?
- Provide crews with an additional member to operate the monitoring equipment
- All committed staff must have dosimeters
- It is a legal requirement to minimise exposure of crews to radiation (ALARP)
- Legal Dose limit - 20mSv (13 mSv for female FFs of child bearing capacity)
- Recommended Dose Constraint – 5mSv per incident.
- Emergency Exposure – to save life or prevent catastrophic escalation – 100 mSv max. recommended & "Informed Volunteers" only.

Contamination vs Irradiation
- Unsealed (open) sources are usually liquid or powders that can lead to contamination.
- Sealed (closed) sources are usually fully encapsulated making contamination highly unlikely.
- Confirm that sealed sources are not damaged

Detection & Monitoring Equipment Selection
- Dosimeters must be worn (NB only measure gamma radiation)
- Survey meters will only detect gamma radiation
- Contamination meters will usually detect all types of radiation
- Identifiers/Gamma spectrometers are used to determine the identity of an unknown gamma emitting radionuclide

Contamination
- Establish background level of radiation before testing for contamination
- More than 5cps above background is considered evidence of contamination
- Decontamination should, where possible consist of a safe undressing procedure. Wet decontamination should be a last resort to minimise contaminated waste.
- Contaminated equipment/personal protective equipment should be double bagged and retained for disposal or appropriate specialist cleaning.

PART C–11

UN Class 8 Corrosive substances

General information

Introduction

7C11.1 Materials whose primary hazard is 'corrosive' will be assigned to UN Hazard Class 8. It covers substances and articles which by chemical action attack epithelial tissue of skin or mucous membranes with which they are in contact, or which in the event of leakage are capable of damaging or destroying other goods, or means of transport, and may also cause other hazards. The heading of this class also covers other substances which form a corrosive liquid only in the presence of water, or which produce corrosive vapour or mist in the presence of natural moisture in the air.

7C11.2 Corrosive materials can be identified in a number of ways:

- UN hazard warning diamond
- Chemical Hazard Information and Packaging for Supply (CHIP) Regulations label
- Material safety data sheet as a UN Class 8 material
- Name eg sulphuric acid, caustic potash.

CHIP label for UN Class 8 material

7C11.3 The corrosive nature of a material may be established practically by testing the solution with either litmus paper or pH paper. This is most easily done if the unknown material is in a liquid state but damp paper can be used on gases and solids although the results should be used with caution.

7C11.4 Most corrosives encountered are either acids, bases, alkalis or salts but a number of other materials in UN classes other than 8 may have a corrosive hazard eg chlorine, an oxidising, toxic, corrosive gas. Chlorine is a UN Class 2 material because its primary hazard is that it is a gas but anyone unwise enough to spray a leaking chlorine vessel will find that their spray will dissolve some of the chlorine so as to form a corrosive liquid that may attack the container or other unprotected metal surfaces. The ADR Hazard Identification Number[1] will indicate if a material is corrosive, chlorine's hazard identification number is 268.

Acids – characteristics, classification and hazards

Acidic materials

7C11.5 An acid is a material that will liberate H+ ions into solution in excess of any OH- ions.

Characteristics:

- Many acids react and corrode many metals to produce hydrogen gas but whether a particular reaction will occur or not depends on the particular acid and metal concerned and also on the conditions; whether the acid is concentrated or dilute and whether it is hot or cold. The hydrogen produced is both lighter than air and likely, in confined spaces, to produce flammable/explosive atmospheres
- Acids will produce carbon dioxide from a carbonate, eg sodium carbonate (soda ash). This reaction may be used as a test for an acid and in certain circumstances can be used to deal with acid spillages
- Acids are neutralized (potentially violently) by bases (or alkalis) to give only salts and water. For this reason it is not recommended that alkalis be used as neutralizing agents for acid spills unless specialist advice is sought
- All acids have a sour taste in dilute solution. This can be observed in the organic acids contained in: lemon juice (citric acid), vinegar (acetic acid) and sour milk (lactic acid)

NOTE: Under <u>no</u> circumstances should responders taste unknown substances to help identify them.

- Acids change the colour of some dyestuffs and are consequently referred to as indicators. The best known of these substances is litmus. Aqueous acids turn blue litmus paper to red
- Acids are often corrosive to metal or flesh and hence toxic to some extent
- Acids, in solution, have a pH below 7.

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[1] The **European Agreement concerning the International Carriage of Dangerous Goods by Road**, commonly known as **ADR** (from the French abbreviation ***A****ccord européen relatif au transport international des marchandises* ***D****angereuses par* ***R****oute*), governs transnational transport of hazardous materials.

7C11.6 Somewhere in the chemical formula of an acid (at the front for mineral acids) there will be at least one H, eg HCl, HF, HNO_3, H_2SO_4. In the case of an organic acid the important H may not be so visible as in the case of CH_3COOH. This is important because unlike the other H's that can be found in chemical formulae these H's can be released as H^+ ions into solution to carry out the typical reactions of an acid. Other H's found in the chemical formula are not freely available as H^+ and hence do not behave in the manner of an acid, eg CH_4, methane or C_2H_5OH, ethanol. Some experience of chemistry is required to recognise an acid from its chemical formula.

7C11.7 In order to determine how much acidic behaviour a material can exhibit the chemical industry will determine how many H^+ are potentially released into each litre of acid and how many actually have been released.

7C11.8 The first parameter – how many H^+ can potentially be released is expressed in terms of the concentration of the acid. A concentrated acid contains a lot of acid and a little water; a dilute acid contains a lot of water and a little acid. Unfortunately the assessment of how corrosive a material is cannot be limited to its concentration as not all acids are equally good at releasing all their H^+ all at once. The ability to release H^+ is described in terms of the strength of the acid. A strong acid will be good at releasing its H^+ and a weak acid not so good.

7C11.9 It follows that two litres of equally concentrated acids, one weak and one strong – both capable of releasing the same quantity of H^+ will be able to dissolve equal amounts of metal but the strong one will do it faster.

7C11.10 Operationally, the Incident Commander should be interested in how much acid is involved and how corrosive it is likely to be. The quantity can be used to consider the options to deal with it and its corrosiveness can be used to assess the corrosion hazard.

7C11.11 Corrosiveness will probably be described in terms of a pH value, where 1 indicates very corrosive and 6.99 indicates it is very nearly water as pure water has a pH of 7. The lower the pH values the stronger and generally more concentrated the acid is, but even a very concentrated weak acid is incapable of establishing a pH of less than 3. A pH of less than 3 will mean the acid in question will certainly be a strong acid. Almost all organic acids are weak acids.

7C11.12 The lower the pH the greater the likelihood that the acid has corroded metals to form an atmosphere containing a flammable proportion of hydrogen, especially in a confined space where appropriate precautions will be demanded.

7C11.13 In the same way concentrated and dilute apply to acids; they may be applied to solutions of alkalis. These materials are essentially the opposite of acids as they take H^+ out of solution or release OH^- ions. A solution containing a lot of material potentially capable of doing this would be concentrated and a material particularly effective at doing this rapidly would be strong. Any solution with a pH of more than 7 is an alkali and the more concentrated and stronger alkali solutions would have a pH close to the maximum value of 14. Weak alkalis would not be capable of establishing a pH of more than 12.

The pH scale

Acidic Alkaline							Neutral							
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Hydrochloric acid		Coffee	Orange juice	Beer		Urine	Pure water	Blood	Baking soda	Milk of magnesia			Caustic soda	

7C11.14 The pH scale is a ‘logarithmic’ scale and when we dilute an acid to increase its pH we must increase the volume by a factor of 10 to increase the pH by one unit, eg to dilute 10 litres of acid pH 2 to increase the pH to 4 will require making the 10 litres into 10 x 10 x 10 = 1000 litres. Doubling the volume will not halve the pH.

Some important inorganic (or mineral) acids

- **Nitric acid HNO_3** (aquafortis) – Nitric acid is sold as a 70 per cent solution and is referred to as concentrated nitric acid. It is possible to obtain 100 per cent nitric acid, which is referred to as fuming nitric acid. The chemical behaviour of nitric acid is dependent on concentration.

  - very dilute solutions show typical acid properties
  - concentrated solutions show oxidizing properties.

  With some metals (eg copper), concentrated nitric acid reacts to produce the brown toxic gas nitrogen dioxide (nitrous fumes). However, not all metals react in this way and, for example, iron, aluminium and chromium react rapidly with nitric acid to form a layer of oxide. This oxide is insoluble even in concentrated acid and consequently prevents further corrosion (attack). Nitric acid is said to render these metals ‘passive’.

  On heating, as in a fire, nitric acid readily decomposes yielding nitrogen dioxide and oxygen. It thus falls into the ‘assists fire’ category (oxidizing).

- **Hydrochloric acid HCl** (spirits of salt, muriatic acid) – Hydrochloric acid is marketed in the UK as ‘concentrated hydrochloric acid’, a solution that contains about 35 per cent dissolved hydrogen chloride.

  Hydrochloric acid is obtained by dissolving hydrogen chloride gas in water. On heating hydrochloric acid it releases fumes of hydrogen chloride, which are very pungent and irritating. As hydrogen chloride dissolves very readily in water, inhaling these toxic corrosive fumes results in the formation of hydrochloric acid in the lungs causing irritation and possible oedema.

  Hydrochloric acid is not oxidizing but does exhibit all the characteristics of a typical acid.

- **Sulphuric acid H_2SO_4** (oil of vitriol) – Concentrated sulphuric acid can be marketed in two forms:
  - approximately 98 per cent sulphuric acid
  - fuming sulphuric acid, oleum or pyrosulphuric acid, all names given to sulphuric acid containing dissolved sulphur trioxide (SO3).

7C11.15 The properties of sulphuric acid may be considered under three headings:

Behaviour towards water – Sulphuric acid in concentrated solution is a very powerful dehydrating agent, that is, it has the ability to remove and/or absorb large quantities of water. It does this with the evolution of a large quantity of heat, sufficient to boil the added water. Hence diluting such acid with water is a dangerous process and should be done with extreme care. For spillages requiring dilution, large volumes of water should be added from a safe distance (assuming neutralization is not practical). Some organic compounds containing carbon, hydrogen and oxygen may be dehydrated (have water removed from them) by concentrated sulphuric acid. For example sugar is dehydrated by concentrated sulphuric acid to produce sugar charcoal (ie carbon). Similarly any cellulosic material, cloth, paper, etc, undergoes a 'burning' reaction with the acid.

- **Behaviour as an acid** – Concentrated sulphuric acid (98%) contains little water and consequently shows little reaction towards metals at room temperature (at higher temperature the oxidizing properties of the acid are significant – see below). When, however, the concentration is reduced to a lower level, say 60 per cent, the reactivity of the acid increases considerably. These facts suggest that if a spillage of concentrated sulphuric acid occurs, dilution with water will produce a more corrosive acid unless sufficient water can be added to make the acid very dilute; at this point the reactivity would again decrease.

- **Behaviour as an oxidizing agent** – Concentrated sulphuric acid is a vigorous oxidizing agent, especially when hot, and is accompanied by production of the gas sulphur dioxide (SO_2). For example, copper can be oxidized to copper sulphate. The sulphur dioxide produced can dissolve in water to give the weak acid sulphurous acid ($H2_SO_3$). Sulphuric acid can ignite some organic compounds, especially if also in contact with another oxidant such as nitric acid, potassium dichromate, potassium chlorate, etc

Other halogen acids

- The other hydrogen halides, hydrogen fluoride, hydrogen bromide and hydrogen iodide, are all gases that dissolve in water to give acid solutions

- **Hydrofluoric acid** has the unusual property of dissolving glass and for this reason it is employed in industries where the etching or frosting of glass is performed. It is generally transported and handled in polyethylene containers.

When the toxicity of the common acids is compared, hydrofluoric acid is by far the most hazardous acid. Inhalation of hydrogen fluoride vapour causes oedema of the lungs, an abnormal accumulation of fluid in the lung cavities.

Due to its solubility in water, the acidic vapour dissolves easily in the eye and can permanently damages someone's sight.

Externally, hydrofluoric acid causes more painful and usually more severe burns than the other mineral acids. Burns occur almost instantaneously from solution stronger than 60 per cent. Extremely severe burns can result from even a very mild exposure to the acid; tissues beneath the skin are destroyed, the destruction spreading even to the bones.

Chemdata and material safety data sheets refer to the use of Calcium Gluconate 'antidote' to treat hydrofluoric acid burns and some urban myths suggest that cutting away flesh contaminated with hydrofluoric acid may be appropriate. Where a hydrofluoric acid threat is known to exist, preplanning should include the provision of the antidote cream.

Organic acids

Organic (carbon-based) acids are weak acids. Unlike their inorganic counterparts, organic acids will burn.

Unusual acids

- **Picric acid** is explosive when dry
- **Peroxyacetic acid** is a fairly typical organic peroxide
- **Oxalic acid** is toxic.

Bases/alkalis – characteristics, classification and hazards

Basic (or alkaline) materials

7C11.16 Bases can be defined as any metal oxide, or as something that will react with acids to produce only a salt and water (sometimes violently).

Characteristics:

- water soluble bases are referred to as alkalis
- alkalis can corrode some metals to release hydrogen
- bases can be very effective at removing flesh from bones; the strong concentrated alkalis are perhaps more corrosive to flesh than many strong concentrated acids
- spills of bases can make surfaces very slippery, notably ladders and walkways

- alkalis turn red litmus paper to blue, and have a pH above 7.

Some important bases/alkalis

- **Sodium hydroxide** and **potassium hydroxide** are important members of the alkalis:
  - sodium hydroxide NaOH (caustic soda)
  - potassium hydroxide KOH (caustic potash).

7C11.17 Both are white solids at room temperature, and are marketed as pellets, as well as in flake and stick form, and all are very soluble in water. They are corrosive towards aluminium, zinc and lead but do not attack most other common metals. Concentrated solutions dissolve silk, wool and animal tissues.

- **Calcium hydroxide**: $Ca(OH)_2$ (slaked lime) – Calcium hydroxide is a white solid which dissolves only slowly in water to give a weakly alkaline solution, often called limewater
- **Calcium oxide** CaO (lime, quicklime) – which reacts exothermically with water to give calcium hydroxide. As with other alkalis, lime is corrosive towards eyes, skin, etc
- **Ammonia: NH_3** – Ammonia gas dissolves readily in water to give ammonium hydroxide, an alkaline solution of about pH 10. It is thus frequently referred to as a weak base. Ammonia is encountered as a pressurized liquid (anhydrous ammonia) and in aqueous solution. The concentrated aqueous solution is known as '880' ammonia, where 880 indicates the specific gravity, or relative density is 0.88. Although it is capable of burning, in practice, it is not considered a fire hazard because of its high auto-ignition temperature and narrow flammable range. The possibility of ignition is very remote, but should not be overlooked. In 1999 two American firefighters tried to start a forklift truck in a refrigeration plant where ammonia had leaked. One escaped with only severe injuries whilst the other died, engulfed in the fire.
- **Organic bases** – Ammonia NH_3 is a base and if one or more of the H's are replaced by organic groups then an organic base results, ie, using CH_3, a methyl group, to replace H we get CH_3NH_2 methylamine. If we replace two H with two CH_3 we get $(CH_3)_2NH$ dimethylamine. As bases are corrosive and to some extent toxic, and organic materials are flammable, we would be wise to expect these materials to be flammable, toxic and corrosive.

Other corrosives

7C11.18 Many materials are corrosive to flesh and metal although they are neither acids nor bases. Although the primary hazard of chlorine is 'gas', it is a notable corrosive as are other halogens and many of their compounds encountered as solids, liquids or gases. Virtually all non-metal chlorides, fluorides and bromides are corrosive along with some metal chlorides, notably aluminium and ferric [iron III].

Salts (not common salt, sodium chloride)

7C11.19 Firefighters should not assume that as a salt is the product of neutralization then it is safe. Sodium cyanide is a salt but is highly toxic. Sodium peracetate is also a salt and is explosively unstable. Nitrates are generally good oxidizing substances. Many chlorides made by the neutralization of hydrochloric acid are corrosive in their own right. Sometimes the hazards of the parent acid are not exhibited by the salt, for example, sulphates made by neutralizing sulphuric acid or otherwise are not water reactive.

7C11.20 **NOTE:** Firefighters should understand that whilst neutralisation may remove the corrosive hazard of the acid or alkali, it might accentuate other hazards and generate a salt that is itself corrosive or hazardous in some other way. A list of common salts and the acid from which they were formed is shown below.

List of common salts and the acid from which they were formed

Acid	Derived salt
Sulphuric	Sulphate
Sulphurous	Sulphite
Nitric	Nitrate
Nitrous	Nitrite
Hydrochloric	Chloride
Hydrofluoric	Fluoride
Acetic a.k.a. Ethanoic	Acetate, ethanoate
Oxalic	Oxalate
Carbonic	Carbonate

7C11.21 The other half of the name of the salt comes from the base with which it has reacted, eg, sodium hydroxide will produce sodium salts and ammonium hydroxide will produce ammonium salts.

Operational considerations

Practical treatment of acid and base spillages

7C11.22 There are four principal ways of dealing with spills of corrosives:

- **Contain and recover** by a specialist waste disposal company or the owner of the material
- **Contain and absorb** in some inert material, earth or vermiculite, etc, prior to appropriate disposal
- **Contain and 'neutralise'** with soda ash (anhydrous sodium carbonate). Strictly speaking this is not a neutralization reaction between an acid and a base but is often called one. This method does not work with alkali spills, only acids
- **Dilute and disperse** to drain using copious quantities of water. This method should be regarded as a last resort if no other method can be employed. Specialist advice should be taken to ensure the acid is able to be safely and effectively diluted. Before washing any corrosive 'away' please consider that the upper tier 'control of major accident hazard' threshold for some acids is 1kg, so to dilute and disperse a few kilograms of these materials would be a serious mistake. Consultation with the Environment Agency and the site operators must take place.

7C11.23 In practice, any treatment of a spill of corrosive will contain elements of all these tactics, the spill will be contained and recovered, residues will be absorbed and if possible neutralised before the last traces are diluted and dispersed.

7C11.24 Other considerations:

- Acids and alkalis are normally transported at very high concentrations, eg 90-95 per cent sulphuric acid, 65 per cent nitric acid, 30 per cent hydrochloric acid, 50 per cent sodium hydroxide and 50 per cent phosphoric acid. At these concentrations the pH value is not important, the substances are simply very corrosive
- Corrosive substances can attack and corrode many materials, for example, cloth, paper and several metals. Decomposition often produces heat and gases, and in some cases extremely flammable hydrogen gas
- It can take some time before the consequences of corrosive effects are visible
- Accidental mixing of different corrosive materials can in some cases lead to violent reactions, which may give off large amounts of gases
- In the case of strong alkalis there is a latent period before a feeling of burning on the skin is experienced. By then the damage is already done. Skin contact with strong acids produces an immediate feeling. Both types of corrosive substances can cause serious skin and eye damages.

PART C–12

UN Class 9 Miscellaneous dangerous substances and articles

General information

Introduction

7C12.1 These are substances and articles which during transport present a danger not covered by other classes.

7C12.2 Magnetic materials are classified in this category (magnetism may affect the navigation systems of airplanes). Polychlorinated biphenyls are placed in Class 9 because they may damage the environment. Dry ice (solid carbon dioxide) can evaporate, producing asphyxiant fumes, and displace oxygen in the air in confined places such as cargo holds in ships and storage cellars. Asbestos can damage the lungs and the effect on health is not immediate, the damage appears after many years, therefore, asbestos is not placed in Class 6.1 but in Class 9.

Characteristic, classification and hazards

7C12.3 Unlike many other UN classes, UN Class 9 Miscellaneous Dangerous Substances can be substantially different in its meaning to ADR Hazard Identification Number 9, which relates to risk of spontaneous, violent reaction, usually relating to the risk of explosion, disintegration and polymerization reaction with the release of considerable heat or flammable and/or toxic gases.

7C12.4 Acetylene 239 is a flammable gas, which can lead to spontaneous violent reaction, is an example.

7C12.5 When used as ADR Hazard Identification Number 90 it has specific meanings: environmentally hazardous substance; miscellaneous dangerous substances.

7C12.6 Not all environmentally hazardous materials will be marked as UN Class 9 or ADR Hazard Identification Number 90; many foodstuffs are amongst the most hazardous to the aquatic environment but they are not carried as hazardous materials. Milk is even more damaging to a watercourse than raw sewage, but despite this it is not a ‘hazardous material’.

7C12.7 Dibromodifluoromethane is an example of a hazardous material whose principal hazard is damage to the environment.

7C12.8 In addition to environmentally dangerous materials, other packages assigned to UN Class 9 include:

- lithium batteries
- ammonium nitrate based fertilizer
- polychlorinated biphenyls liquid
- polyhalogenated terphenyls liquid
- battery-powered vehicles
- blue asbestos (crocidolite)
- brown asbestos (amosite, mysorite)
- white asbestos (chrysotile, actinolite, anthophyllite, tremolite)
- polymeric beads, expandable, evolving flammable vapour
- benzaldehyde
- engines, internal combustion
- genetically modified micro-organisms
- elevated temperature liquid, N.O.S., at or above 100°C and below its flash point (including molten metals, molten salts, etc)
- elevated temperature solid, N.O.S., at or above 240°C
- fish meal (fish scrap), stabilized
- air bag inflators or air bag modules or seat-belt pretensioners
- plastics moulding compound in dough, sheet or extruded rope form evolving flammable vapour
- chemical kit or first aid kit
- aviation regulated liquid, N.O.S.
- aviation regulated solid, N.O.S.
- fumigated unit
- dangerous goods in machinery, dangerous goods in apparatus.

NOTE: N.O.S is the term used for a substance 'Not specified in Part I of the approved list of UN Substance Identification'

7C12.9 Each of the above hazardous materials has its own UN number but each will be displaying the same hazard warning diamond.

CHIP label for UN Class 9 miscellaneous hazardous materials

Operational considerations

Introduction

7C12.10 It must be appreciated that no single plan or set of procedures can cope with the range of hazards presented by materials encountered in UN Class 9, but some materials are regularly encountered and therefore worth considering in detail.

Ammonium nitrate based fertilizer

Background

7C12.11 The chemical compound ammonium nitrate (AN), the nitrate of ammonia with the chemical formula NH_4NO_3, is a white crystalline solid at room temperature and standard pressure. It is commonly used in agriculture as a high-nitrogen fertilizer, and it has also been used as an oxidising agent in explosives, including improvised explosive devices. It is the main component of ANFO, a very popular explosive.

7C12.12 All fertilizers fall into one of three categories:

- oxidisers belonging to Class 5.1, UN Number 2067
- NPK / NP / NK fertilizers capable of self-sustaining decomposition belonging to Class 9, UN Number 2071
- non-hazardous.

7C12.13 Ammonium nitrate-based fertilizers are of two main types:

- **Straight nitrogen fertilizers** – these products contain only nitrogen (N) as the principal plant nutrient. Typical products are ammonium nitrate (AN) and calcium ammonium nitrate (CAN), which are mixtures of AN and dolomite / limestone / calcium carbonate, and ammonium sulphate / ammonium nitrate (ASN) mixtures
- **Compound fertilizers:** NPK / NP / NK – These products contain, in addition to nitrogen, at least one other nutrient such as phosphate (a source of P_2O_5) and/or potash (a source of K_2O).

N:P:K fertilizers

Nitrates and ammonium compounds are often present in mixed fertilizers, or balanced mixtures as they are sometimes called. On the bag a code will be found, eg, 6-12-12.

The numbers, in order, refer to:

- N % of nitrogen
- P % of phosphorus as if it were phosphorus pentoxide (P2O5)
- K % potassium as if it were potassium oxide (K2O).

NOTE:
The first number is the only one of interest to the Fire and Rescue Services. The higher it is, the greater the amount of nitrates or ammonium compounds, and thus the greater the danger from the mixed fertilizer if it is near or becomes involved in fire.

Historically, any %N figure of 20 or more (maximum 35%) should be regarded as a potential explosive risk when the fertilizer is close to, or directly involved in, any fire. The production of brown fumes from the fertilizer is also a sign of potential danger.

7C12.14 The main methods of handling are:

- packaged in intermediate bulk containers of 500-1500 kg capacity
- 25 or 50 kg bags
- on pallets with up to 1.5 tonne load
- loose bulk.

Hazards

7C12.15 The three main potential hazards of relevance to ammonium nitrate-based fertilizers are:

FIRE

Ammonium nitrate itself does not burn, but is an oxidising substance and as such can support combustion. Therefore, combustible material must be present to have a fire involving ammonium nitrate. When an ammonium nitrate-based fertilizer is involved in a fire, or if it is heated to a certain extent, the ammonium nitrate will decompose and provide oxygen, thus increasing the fire hazard. The decomposition hazard can increase if the product, particularly spillage, is contaminated with combustible materials such as coal, grain, sawdust or oil spills.

In a fire the fertilizer will decompose with the release of toxic gases such as NOx, ammonia, hydrogen chloride and nitric acid vapours.

DECOMPOSITION

Ammonium nitrate-based fertilizers can chemically break down under the influence of heat and this is known as decomposition. The presence of a combustible substance is not necessary for decomposition to take place. The decomposition hazard is dependent on the type of product, the temperature of the heat source, the duration of exposure to the heat source, and the containment of the fertilizer.

Ammonium nitrate decomposes into gases including oxygen when heated (non-explosive reaction), however, ammonium nitrate can be induced to decompose explosively by detonation.

Large stockpiles of the material can be a major fire risk due to their supporting oxidation, and may also detonate.

Ammonium nitrate decomposes in temperatures normally well above 200°C. However the presence of impurities (organic and/or inorganic) will often reduce the temperature point when heat is being generated.

Once the ammonium nitrate has started to decompose then a runaway reaction will normally occur as the heat of decomposition is very large. Ammonium nitrate evolves so much heat that this runaway reaction is not normally possible to stop. This is a well-known hazard with some types of N-P-K fertilizers.

There are certain compositions of compound fertilizers (NPK/NP/NK) which are capable of undergoing self-sustaining decomposition, ie once a hot source (eg a hot electric light bulb or hot welding material) has initiated the decomposition, the reaction in the fertilizer is sufficiently thermally energetic to continue on its own without further heat input from any outside source. Such fertilizers are described as ‘self-sustaining decomposition’ type.

The decomposition hazard in straight “N” fertilizers such as AN, CAN, ASN and in non- self-sustaining decomposition type compound fertilizers (NPK, NP, NK) is dependent on contamination with sensitising materials such as chromates, chlorinated chemicals and various metals such as zinc and copper and their salts.

Decomposition is generally accompanied by the evolution of toxic gases such as NO_x, ammonia, hydrogen chloride and nitric acid vapours.

EXPLOSION

There are two major types of incidents resulting in explosions:

- Explosion happens by the mechanism of shock to detonation transition. The initiation happens by an explosive charge going off in the mass, by the detonation of a shell thrown into the mass, or by detonation of an explosive mixture in contact with the mass
- Explosion results from a fire that spreads into the ammonium nitrate itself, or from a mixture of ammonium nitrate with a combustible material during the fire. The fire must be confined at least to a degree for successful transition from a fire to an explosion (a phenomenon known as 'deflagration to detonation transition'). Pure, compact ammonium nitrate is stable and very difficult to ignite.

Ammonium nitrate and ammonium nitrate-based fertilizers are capable of detonating under certain conditions, requiring a strong source of initiation. Standard good quality fertilizer products have high resistance to denotation.

This resistance, however, can be adversely affected by a number of factors, such as:

- substantially smaller particle size
- higher porosity (hence a lower bulk density)
- high levels (above safe limits) of combustible, organic and other sensitising materials.

Operational considerations:

7C12.16 Action in case of decomposition and fire:

- If possible, remove the heat source and extinguish the fire or decomposition
- Decomposition is indicated by the release of white/brownish fumes from the fertilizer mass
- If an area of slow decomposition or smouldering of the ammonium nitrate-based fertilizer should occur, the following steps should be taken immediately:
    - look for the source of heat and, if found, turn it off or remove it
    - if the area of decomposing material is still small and easily accessible, make an attempt to remove it from the main heap of the fertilizer by the use of picks, shovels or ship's grab, and to cool it down by localised quenching with water.
- If it is impossible to remove the decomposing mass, soak the fertilizer involved as rapidly as possible with a large quantity of water preferably directed through high pressure jets against the centre of the decomposition. This may cause the additional problem of large quantities of contaminated water run-off

- Fighting the decomposition by other means such as foam, carbon dioxide, steam, covering with sand is useless and may even promote the decomposition
- If fumes are present, use self-contained breathing apparatus
- If suppression of the slow decomposition should prove impractical or unsuccessful use defensive tactics and consider evacuation
- In ships or containerised stores open doors, hatches etc immediately to maximise ventilation, if safe to do so
- Use defensive firefighting and evacuation if explosive decomposition is suspected.

Asbestos

7C12.17 As asbestos containing materials are one of the most common hazardous materials encountered by Fire and Rescue Services at operational incidents. Section 7 Part C-13 is devoted to the substance.

Polychlorinated biphenyls

Background

7C12.18 Polychlorinated biphenyls were once used as dielectric fluids in electrical equipment such as transformers and capacitors. The use of this chemical was banned internationally in the mid-1980s, however, so called ‘closed systems’ that contain the substance are allowed to be kept until the end of their useful life. As such, polychlorinated biphenyls may be present at electrical installations in transformers and capacitors that were manufactured before 1987.

7C12.19 Polychlorinated biphenyls are UN class 9, they present a danger to the environment and should not be allowed to enter drains or surface waters. Exposure to polychlorinated biphenyls from transformers and capacitors may also have serious acute and chronic effects on human health.

Hazards

7C12.20 The three basic health hazards from polychlorinated biphenyl-containing transformers and capacitors are:

- electrocution from live equipment
- explosion hazards of oil-filled equipment
- exposure to toxic liquids or vapours.

7C12.21 There are two major routes of exposure from incidents involving polychlorinated biphenyl oil-filled equipment:

Dermal. Skin exposure to polychlorinated biphenyl liquids or vapours may lead to a condition called chloracne, or a number of other symptoms as detailed below. Symptoms may not be immediately apparent.

Inhalation. Toxic vapour inhalation from volatised oils may lead to the same symptoms as for dermal exposure. Symptoms may not be immediately apparent.

7C12.22 The symptoms of exposure to polychlorinated biphenyls are the same regardless of the route of exposure. Severe acute exposure to polychlorinated biphenyls may result in chloracne, the onset of which may be delayed by several months. Chloracne is an acne-like condition, which may also take the appearance of cysts or pustules typically involving hair follicles on the face and neck. Chloracne may also affect upper arms, back, chest, abdomen, outer-thighs and genitalia. Mild cases may clear several months after exposure; in severe cases the lesions may still be present several decades after onset.

7C12.23 Acute exposure may also cause irritation of the skin, eyes and lungs, nausea, vomiting, diarrhoea, liver damage and neurological effects – including headaches, weakness, muscular pains, damage to the peripheral nervous system, loss of appetite, sexual dysfunction and short-term weight loss.

7C12.24 Acute exposure to polychlorinated biphenyl is not anticipated to result in increased risk of serious long-term health issues. However, polychlorinated biphenyls have a half life of 7–12 years and so there is a high potential for repeated or chronic exposure to lead to accumulation in human body tissues, particularly in the liver and fat tissues.

7C12.25 The International Agency for Research on Cancer has classified polychlorinated biphenyls as probable human carcinogens. Prolonged or repeated exposure to polychlorinated biphenyls has been linked to an increased incidence of cancer, particularly cancer of the liver.

Operational considerations

PRE-PLANNING

7C12.26 The Environment Agency holds a register of polychlorinated biphenyl contaminated equipment in England and Wales, however, they continue to receive new registrations for old equipment and so there can be no assumption that polychlorinated biphenyls are not present in any unregistered equipment that was manufactured prior to 1987.

ARRIVING AND GATHERING INFORMATION

7C12.27 The Incident Commander will need to risk assess the likelihood of transformers and/or capacitors being present on-site. Sites that were built after 1987 are significantly less likely to contain polychlorinated biphenyl-contaminated equipment.

7C12.28 When attending any incident that involves transformers or capacitors, a precautionary approach should be taken. The oil-filled equipment should be treated as though polychlorinated biphenyls are present unless there is labelling clearly visible on the equipment that states it does not contain polychlorinated biphenyls.

7C12.29 When polychlorinated biphenyls are suspected to be involved the incident should be designated as a hazardous materials incident and generic standard operational procedures followed.

PLANNING THE RESPONSE

7C12.30 Specific polychlorinated biphenyl considerations include the following:

- For incidents, including fires, where inhalation exposure to polychlorinated biphenyls is possible, self-contained, positive pressure breathing apparatus must be worn
- If there is risk of explosion of the oil filled equipment or fluid leaks are suspected, chemical protective clothing should be worn in order to prevent dermal exposure to polychlorinated biphenyl-containing oils
- Decontamination of persons exposed to polychlorinated biphenyls and subsequent medical attention should be undertaken without delay
- Fire water that is suspected to be contaminated with polychlorinated biphenyls must be contained and disposed of as an environmentally hazardous substance. Advice must be sought from the Environment Agency
- Polychlorinated biphenyl contaminated personal protective equipment for disposal should be stored in appropriate sealed and labelled containers. Polychlorinated biphenyl contaminated waste must be disposed of as hazardous material, preferably by high temperature incineration.

Specific risks from substances not classified under UN Class 9

Introduction

7C12.31 There are a number of specific risks or substances which although are not classified as “dangerous” under UN Class 9 may pose hazards to firefighters at operational incidents. This chapter outlines some of the more important hazardous materials risks that firefighters may encounter.

Fibre reinforced polymer composites

Background

7C12.32 Fibre reinforced polymer composites, are increasingly being used for primary and secondary structural components in aircraft. Incineration of composites in post crash aircraft fires generates a complex mixture of combustion products comprised of gases, organic vapours, and particulate matter including fibres. There are concerns regarding the health hazards posed to firefighting, investigation, and cleanup personnel exposed to these combustion products.

7C12.33 Polymer structural composites are engineered materials comprised of continuous, high-strength fibres impregnated with a polymer matrix to form a reinforced layer (ply), which is subsequently bonded together with other layers under heat and pressure to form an orthotropic laminate. The strength and stiffness of the laminate are determined by the orientation of the fibres with respect to the loading direction and their volume fraction in the composite.

7C12.34 Fibres used for composite reinforcements, in order of increasing cost (decreasing quantity), are high-strength glass, aramid, carbon/graphite, and boron. E-glass is the predominant reinforcement for polymer matrix composites used in aircraft interior applications due to its low moisture affinity and superior electrical insulating and mechanical properties.

7C12.35 However, it is now true to say that polymer composites are found increasingly in everyday objects and structures in the modern world so the guidance and precautions found in this section will be of use to a wide range of fires and other incidents that Fire and Rescue Services are called to.

7C12.36 Data from fire tests and crash-site investigations suggest that only a small fraction of the fibres released in fires are of respirable size. However, detailed chemical analysis of organic vapours revealed a high number of toxic organic compounds that are associated with the fibres.

Hazards

7C12.37 The three basic health hazards from polymer composites in an aircraft crash-fire situation are:

- the sharp splinters of exposed material
- the fibrous dust dispersed by the fire or blast
- the toxic gases generated during burning of the polymer matrix resin in the fire.

7C12.38 As the organic resin burns off, the continuous, reinforcing fibres are exposed to a turbulent, oxidizing environment that causes them to break up and erode into small microfibre fragments. The concentration of respirable airborne microfibres increases when the accident involves fire and impact or explosion. In addition, the toxic chemicals produced from the combustion of the organic resin may be adsorbed on respirable fibres and enter the respiratory system with acute or chronic effects.

7C12.39 Extensive studies have been accomplished regarding health hazards associated with natural and man-made mineral fibres such as asbestos and glass. The existing framework of information on asbestos and glass fibres delineates the contributing factors in fibre toxicity, which may be applied for consideration of carbon fibre toxicology. Inhalation toxicity of asbestos is primarily attributed to the fibre's dimensions.

7C12.40 There are two major routes to exposure from fibres

- **Dermal** – Irritation of the skin and eyes is a typical response to dermal exposure resulting from a reaction to sharp, fragmented fibres of diameter greater than 4-5 µm. The severity of the exposure depends on the fibre size and stiffness and the irritation is not permanent
- **Inhalation.**

7C12.41 The inhalation hazard from fibres poses the greatest potential for adverse health effects on humans and depends on the total dosage and the physical dimensions of the fibres. Smaller particles are deposited in the lower regions of the lungs and chronic toxicity is associated with this type of exposure. For purposes of hazard assessment, fibres are defined as high aspect ratio particles having a length-to-diameter ratio (L/D) greater than three.

7C12.42 The fibre dimensions and total deposition deep into the lung determine the inhalation hazard from fibres. Fibres with diameters smaller than 3 µm and lengths shorter than 80 µm are respirable and can penetrate deep into the lungs. The fibre retention time inside the lung is primarily dependent on the fibre dimensions. Fibres smaller than 15 µm long are cleared from the lungs by cellular activity. However, longer fibres saturate the self-clearance mechanism of the lungs and can lead to pathological effects.

7C12.43 Animal studies on exposure to respirable size raw polyacrylonitrile/medical and pitch-based carbon fibres do not indicate that there are significant adverse health effects. Studies involving animals exposed to aerosols of composite dust and carbon fibres from machining and grinding of fibre composites are inconclusive with respect to pathological effects.

Operational considerations

7C12.44 The Incident Command will need to risk assess the likelihood of fibre liberation by the incident, Fire and Rescue Service operations or by other causes such as wind and weather, other aircraft movements or other agency activities. If airborne particulates are suspected then enhanced levels of respiratory protective equipment should be used within the hazard zone.

7C12.45 For fire situations self-contained breathing apparatus should be the minimum level of respiratory protective equipment.

7C12.46 Airborne dusts and particulates can be controlled by damping down residues using water sprays.

7C12.47 It is generally considered that normal washing protocols for personal protective equipment will suffice following normal Fire and Rescue Service operations at aircraft fire/crash scenario. Incident commanders may wish to liaise with the Air Accident Investigation Branch or Ministry of Defence on the scene advisers with regards to cleaning protocols.

7C12.48 Fire and Rescue Service personal protective equipment cleaning contractors should be informed of the potential irritant hazard with regards fibres and this should be risk assessed accordingly.

7C12.49 Where there is likelihood of body fluids / biohazards/chemicals contamination being adsorbed by fibres, then personal protective equipment should be managed in accordance with Fire and Rescue Service contaminated personal protective equipment protocols.

7C12.50 Further more detailed information is contained in *Operational guidance-Aircraft Incidents:*

http://www.communities.gov.uk/publications/fire/aircraftincidents

Chemical suicide

Background information

7C12.51 Chemical suicide (sometimes also referred to as detergent suicide) is a relatively new method of suicide that has its origins in Japan. The process involves combining common household chemicals to create a lethal gas.

7C12.52 Suicides typically take place in a confined space (eg a vehicle, a cupboard, a small room, a toilet, or bathroom). The method used is often the same, that is, duct tape or a similar material is placed around vents/windows in order to contain the gas; household chemicals are then mixed in a suitable container liberating a toxic gas (eg hydrogen sulphide) that is lethal in low concentrations. In some cases the subject places homemade signs around the vehicle, to warn responders of the hazard.

7C12.53 One of the most common forms of chemical suicide involves the use of portable, disposable barbeques. In a confined space the smouldering charcoal produces carbon monoxide as well removing the oxygen thereby causing death.

Hazards and risks

7C12.54 Properties of hydrogen sulphide:

- very low boiling point –60°C which means it will be gassing off at room temperature
- toxic
- corrosive
- highly flammable
- wide explosive range 4% – 46% Volume in air
- heavier than air
- at 700 parts-per-million just 2-3 breaths can cause immediate death, these concentrations can easily be attained in an enclosed environment.

Incident indicators

7C12.55 Some indications that the person has carried out a chemical suicide might include:

- a person appears unconscious and unresponsive
- tape over vents, doors and windows
- suicide note or posted notes warning emergency services of present dangers
- buckets, containers or cool boxes containing chemicals
- burnt disposable barbeques or charcoal etc
- empty containers of chemicals in or around the vehicle/room
- smell of rotten eggs.

NOTE: Warning signs may not always be present.

Acid sources	Sulphur sources
Hydrochloric acid (sometimes referred to as muriatic acid) (Spirits of salt/ hydrochloric acid)	Artists oil paints
Sulphuric acid	Dandruff shampoos
Toilet disinfectant	Pesticides
Toilet bowl cleaner	Some timber filler pastes
Some shower and tile cleaners	Latex paints
Some stone and brick cleaners	Garden fungicides
	Lime sulphur

Operational considerations

7C12.56 Where it is identified that an individual may have attempted/committed chemical suicide the following actions should be considered:

- The primary responsibility of first responders is to preserve and protect life without compromising their own safety, or the safety of their colleagues or the public
- Consider STEP 1-2-3 procedure
- Resources should approach from and be located upwind from the incident
- Establish an initial cordon and restrict access to the area
- Request additional advice (eg hazardous materials adviser etc)
- Evaluate the downwind hazard zone and consider evacuation from immediate area and/or shelter-in-place advice
- Air monitoring equipment may be used (available on detection identification monitoring units)

- Liaise with other agencies to formulate a response plan
- Where the risk assessment indicates that there is the potential for contamination from the substance or the casualty, chemical protection clothing and breathing apparatus should be worn
- Suicides involving portable barbeques/charcoal can be dealt with using breathing apparatus only. Once the affected area has been well ventilated breathing apparatus can be discontinued
- Chemical resistant body bags are available and can generally be accessed through the police or Ambulance Service's hazardous area response team
- Clean up of the site is not the responsibility of the Fire and Rescue Service; it is generally carried out by specialist contractors secured by the local authority.

Methamphetamine and other illicit drug laboratories

Introduction

7C12.57 The risk posed by illicit drug laboratories, particularly 'methamphetamine', is increasing within the UK. There are many examples from Canada, the United States, Australia and New Zealand of emergency service first responders being killed by hazards associated with illicit drug laboratories.

7C12.58 Operational responders need to be aware of these particular illicit drugs, the serious risks from their manufacture and some of the signs that may indicate their presence.

Methamphetamine and amphetamines

7C12.59 Amphetamine, dextroamphetamine, methamphetamine, and their various salts are collectively referred to as amphetamines. Street terms for methamphetamines are 'meth', 'poor man's cocaine', 'crystal meth', 'ice', 'glass', 'speed', 'yaba'.

7C12.60 Typically methamphetamine can be found in the following forms:

- white odourless powder that easily dissolves in water
- clear chunky crystals (crystal meth, ice)
- small brightly coloured tablets (yaba)

Manufacture

7C12.61 A clandestine or illicit drug laboratory will by the very nature of its purpose present many hazards to Fire and Rescue Service personnel. The risks from the materials used in the manufacturing process should not be underestimated.

7C12.62 There are three main types of laboratories:

- **Extraction:** Finished drug or precursor is removed from raw material by use of chemical solvents.
- **Conversion:** One form of drug is changed into a more desirable form, eg methamphetamine hydrochloride (powder) to crystal meth (chunky crystals).
- **Synthesis:** Raw materials are combined through chemical processes to produce the desired drug. The originals may already be controlled substances. Examples include methamphetamine from pseudoephedrine and heroin from morphine.

7C12.63 It is possible that each of these types of laboratory could be present at a single site. Alternatively, illicit operators may split the various processes across a number of different sites.

7C12.64 Each laboratory may vary in terms of the: chemicals used in manufacture, location, method of process, scale of production, equipment used, expertise/knowledge of the operator, hazardous nature of the process and the security measurers taken by the operator eg booby traps. The drugs are easily manufactured using every-day materials and simple apparatus, with illicit drug laboratories likely to be encountered in almost any type of premises, including domestic dwellings.

Common indicators of illicit drug laboratories

7C12.65 There is no hard and fast description of a manufacturing facility but emergency responders should be alert to situations and circumstances that seem out of place. For example, one kilo of methamphetamine produces five kilos of toxic waste. Often that waste is disposed of in areas like farmland or dumped on the side of roads or on wasteland.

Methamphetamine crystals

7C12.66 The list below gives brief details of the most common indicators or the location of an illicit drug laboratory.

Outside the premises

- chemical odours coming from the premises such as ammonia/bleach, cat urine, strong solvent and burnt rubber
- windows blacked out or curtains drawn
- occupants unfriendly, appear secretive about their activities
- access denied
- rubbish containing a large amount of common cold cure medication packaging or containers.

Indicator of illicit drugs laboratory in household waste

Inside the premises:

- laboratory glassware and equipment
- containers with clear liquids, chalky coloured solid on bottom or similar
- containers with two layered liquids in them, one dark and one pale yellow
- used coffee filters containing either a white paste or reddish brown substance
- baking dishes or similar containing a white crystalline substance
- presence of hot plates or similar heating elements near chemicals.

Indicator of illicit drugs laboratory inside house

Hazards

7C12.67 The hazards found at these sites may either be chemical or physical in nature. They may be present at both active and inactive sites. When combined with a lack of quality control and unsafe working practices by illicit operators they will present a serious potential for injury to first responders and members of the public.

7C12.68 Chemical hazards posed by the chemicals used within the manufacturing process range from mild skin irritation to the ability to severely burn and poison. Part of the process involves heating a mixture of chemicals (known as cooking) and this can give off poisonous and flammable gases that may be inhaled, adsorbed or ingested. Contamination of the premises is usually present, however this may be difficult to ascertain at a site that is no longer active. Chemicals used in illicit drug laboratories include acids, bases, solvents, poison gas, organic peroxides, radioactive substances and corrosives.

7C12.69 Fire and explosion hazards exist, particularly during the cooking process. The gases produced can be ignited by the occupants or by emergency responders turning on lights or using non-intrinsically safe electrical equipment.

7C12.70 Physical hazards can include: drug affected occupants and adapted premises that include unsafe use of electricity, gas and heating equipment. In order to protect sites occupants may set booby traps; these can be in any form from electrical wiring to doors and windows to hazardous liquids placed above doors. Extreme examples in mainland Europe include grenades being placed amongst barrels of chemicals.

7C12.71 Dumpsites and contamination also pose a significant hazard. If methamphetamine production has been conducted within a building, chemicals from the process will have spread not only in the specific area but also throughout the whole building. The contaminated waste produced by the process will need to be disposed of which usually is undertaken without care.

For example waste is often poured down domestic drains and toilets, left in parks, refuse sites and left in vehicles and set on fire. This behaviour may also have serious consequences for the environment.

Management of incidents

OPERATIONAL ACTIVITY WHERE THE LOCATION OF THE INCIDENT IS NOT DIRECTLY LINKED TO THE AREA OF MANUFACTURE

7C12.72 Emergency responders should withdraw from an incident site if they discover the potential manufacture of drugs in areas not directly affected by operational activities.

7C12.73 The whole site should be considered to be contaminated and the remainder of the incident should be treated as a hazardous materials incident with appropriate actions taken to protect Fire and Rescue Service staff and the public. The situation should be made as safe as possible and any actions undertaken should be done so as not to raise unnecessary alarm.

7C12.74 A situation report should be passed to the Police Service via mobilising control and any further action should be carried out under supervision and in consultation with the senior police officer.

OPERATIONAL ACTIVITY THAT DIRECTLY INVOLVES AN ILLICIT DRUG LABORATORY

7C12.75 If the presence of an illicit drug laboratory is identified during operations, the incident should be treated as a hazardous materials incident with appropriate attendance and procedures being adopted.

7C12.76 A situation report should be passed to the police via Fire and Rescue Service control and firefighting and any rescues should be dealt with taking account of the potential risks associated with illicit drug laboratories. Once this phase is complete close liaison with the senior police officer should determine the next steps.

General operational considerations

7C12.77 The first priority at incidents where no fire/explosion has occurred is to preserve the scene and let the Police Service establish and contain the situation. Fire and Rescue Service presence may simply be for safety reasons in case of a subsequent fire/explosion.

7C12.78 If the police establish that an illicit drug laboratory is involved then they will probably call the national Illicit Lab Unit team in to assist. This may take several hours to fully deploy.

7C12.79 The aim will usually be to establish a suitable cordon and stand off rather than intervene and put responders at risk. There may however be occasions when lives may be at risk and immediate intervention is appropriate. This may be due to the occupants of the premises being overcome or where the lack of intervention may lead to a critical escalation of the incident (fire and/or explosion). Joint risk assessments with the police should be undertaken and proposed actions agreed.

7C12.80 In the event of accidental discovery, action should be taken to ensure that all Fire and Rescue Service staff and occupants leave the site immediately and remain at a safe distance. Fire and Rescue Service staff should:

- react in the event of a fire, explosion or life at risk utilising standard operating procedures
- treat as a hazardous materials incident
- enter the site fully equipped with suitable respiratory protective equipment and personal protective equipment
- not use phones/radios until clear of the site
- not turn on/off any lights or electrical appliances
- not shut down any on-going chemical process or remove power source to the premises
- not touch, open or remove any bottles or containers as some chemicals involved can be fatal if inhaled
- not allow persons to re-enter the site
- provide information regarding the illicit laboratory to mobilising control
- where possible, make notes of what they have seen and done
- keep the premises under observation from a safe location
- evacuate the immediate area and establish a hazard zone in consultation with the police
- note reaction if water is applied to a fire
- contain water run-off.

7C12.81 Methamphetamine users:

- users may show signs of increased agitation, hyperactivity, Irritability, confusion, anxiety, paranoia and aggression.

Training and awareness

7C12.82 A key aspect of dealing successfully with these incidents is the training and awareness of relevant staff. It is important for Fire and Rescue Services to establish arrangements/protocols with their local police force to ensure information is shared and procedures are compatible.

7C12.83 All staff likely to come across illicit drug laboratories in their work should be made aware of the hazards and gain an understanding of what actions they should be undertaking.

7C12.84 Specific training is recommended for Fire and Rescue Service decision makers. This will include hazardous materials advisers who need a greater degree of knowledge regarding specific risk assessments and the various options available, ie decontamination issues, size of hazard zones and advice to the Incident Commander.

7C12.85 Joint training with the police is recommended. This will assist with the effectiveness of joint arrangements and agreed procedures.

PART C–13

Asbestos containing materials

General information

Introduction

7C13.1 Asbestos is the generic name given to the fibrous forms of naturally occurring silicate minerals. Asbestos containing materials were used in commercial products because of their high tensile strength, flexibility, low electrical conductivity, and resistance to fire, heat and chemicals. Asbestos became most prevalent in building construction from the 1950s onwards and was used extensively until it was prohibited in construction. Blue and brown asbestos were banned in 1985, white asbestos in 1999.

7C13.2 When work with asbestos, or work which may disturb asbestos, is being carried out, the *Control of Asbestos Regulations* require Fire and Rescue Authorities to prevent exposure to asbestos fibres. Where this is not reasonably practicable, they must make sure that exposure is kept as low as reasonably practicable by measures other than the use of respiratory protective equipment, then controlled by respiratory protective equipment.

7C13.3 The spread of asbestos must also be prevented. The Regulations (Approved code of Practise and Guidance L143) specify the work methods and controls that should be used to prevent exposure and spread.

7C13.4 Staff exposure must be kept as low as reasonably practicable below the airborne exposure limit. The Regulations specify control limits for all types of asbestos these can be found on the Health and Safety Executive's web site:

www.hse.gov.uk

7C13.5 All work with asbestos requires a licence issued by the Health and Safety Executive unless it is exempted from current Regulations.

7C13.6 The Health and Safety Executive can issue certificates of exemptions from certain requirements of the Regulations, for example, the requirements to hold licenses to work with asbestos or to notify work with asbestos in advance. The exemptions are normally subject to specific conditions, such as compliance with a specific method statement.

7C13.7 The presence of asbestos containing materials does not necessarily mean that they are, or will be, adversely affecting the safety of those at the incident. Therefore to safeguard human health, the emphasis during all incidents must be on continuous risk management and the implementation of appropriate and proportionate control measures.

Characteristics and classification

7C13.8 There are three main types of asbestos which have been used in asbestos products. These are crocidolite (blue) asbestos, amosite (brown) asbestos and chrysotile (white) asbestos. Blue and brown asbestos are amphibole minerals while white asbestos is a serpentine mineral. The two mineral types have different physical properties and characteristics which leads to differences in their hazardous nature and disease potential.

Amphiboles (blue and brown asbestos)

7C13.9 Amphibole fibres are needle shaped which can split to form many new fibres from an initial single unit. The fibres are also more durable than white asbestos fibres and consequently have a greater potential to cause disease.

Amphibole fibres caught on a membrane filter

Serpentine (white asbestos)

7C13.10 Serpentine fibres are curly in nature and will usually split longitudinally when disturbed or subject to impact. Therefore their potential to generate fibres is less than the amphiboles and their disease potential is also lower.

7C13.11 While the three main types of asbestos are often described in terms of their common names which are based on colour, in practice this is not a reliable guide to identifying the type of asbestos. Colour is often distorted by deterioration, age, painting and heating. It is also common to have different types of asbestos mixed together.

Types of asbestos as classified by the United Nations		
Blue (crocidolite)	**Brown (amosite)**	**White (chrysotile)**
UN 2212 EAC 2X (Amphibole)	UN 2212 EAC 2X (Amphibole)	UN 2590 EAC 2X (Serpentine)

Hazards

7C13.12 Inhalation of asbestos fibres is the major hazard to human health. If inhaled, the smallest of the fibres may remain deposited in the lungs. Symptoms resulting from this may not occur for 15-60 years following exposure. The principle diseases known to be caused by exposure to asbestos fibres are asbestosis, lung cancer, malignant mesothelioma and asbestos pleural disease.

Asbestosis

7C13.13 Asbestosis involves fibrous scarring of the lung in which the tissue becomes less elastic making breathing progressively more difficult. It is irreversible and may progress even after cessation of exposure to asbestos. Asbestosis is an industrial disease arising from repeated high levels of exposure to airborne dust. There is no risk of contracting this disease from normal levels of environmental exposure to asbestos.

Lung cancer

7C13.14 An increased incidence of lung cancer has been found amongst people who have worked with asbestos. The increased risk depends on the degree of exposure and is very much greater for smokers than non-smokers.

Mesothelioma

7C13.15 Mesothelioma is a cancer of the inner lining of the chest or of the abdominal wall. The incidence in the general population is very low; the majority of cases are attributable to occupational or, more rarely, para-occupational exposure to asbestos (ie those living in the same house as an asbestos worker).

Asbestos pleural disease

7C13.16 This is a non-malignant disease that causes scarring of the thin membranes lining the lung and chest.

Other diseases and conditions

7C13.17 Asbestos may cause cancer of the digestive tract, colon, larynx, oesophagus, kidney and some types of lymphoma. These asbestos related diseases may be due to swallowing some of the longer asbestos fibres that are caught in the upper airways and that are carried to the throat in mucus. However, the risk here is much smaller than those diseases caused by inhalation.

7C13.18 Skin and eye irritation may arise from acute exposure to fibres.

Hazards from chrysotile (white asbestos)

7C13.19 Crocidolite (blue), amosite (brown) and chrysotile (white asbestos) all cause cancer and have been classified by the International Agency for Research on Cancer as category 1 human carcinogens. It is recognised that chrysotile (white asbestos) is less potent (ie has a lower cancer risk) than the other types but it is still a carcinogen. In addition many asbestos products contain a mixture of asbestos types such that exposure to chrysotile will not be in isolation. Consequently all three forms should be treated the same.

Hazards posed to the general public at serious fires

7C13.20 In all cases of incidents involving asbestos containing materials it is important to put the health risks to the general public into perspective. Asbestos is a naturally occurring substance and also a widely distributed industrial pollutant and consequently is found in low to moderate levels everywhere in the UK. These levels can be as high as 1000 fibres per cubic metre of air in urban or industrial areas. Exposure to these background levels is therefore unavoidable[1].

7C13.21 Asbestos containing materials in good condition and left undisturbed, in place cannot cause ill health as fibres will not be released. Handling or touching asbestos containing materials in good condition will also generally not present a risk. However, handling would require precautionary controls (such as wetting and personal protective equipment) in case the material had been damaged or crumbles/breaks up during movement. In such situations fibres are likely to be released.

7C13.22 The key factor however in the risk of developing an asbestos-related disease is the total number of fibres inhaled. Inhaled fibres can become lodged in the chest tissue and the body's natural defences may not be able to easily break them down.

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[1] Source data from the World Health Organisation provided by the Health Protection Agency

Usage, transportation, packaging and storage

Construction materials

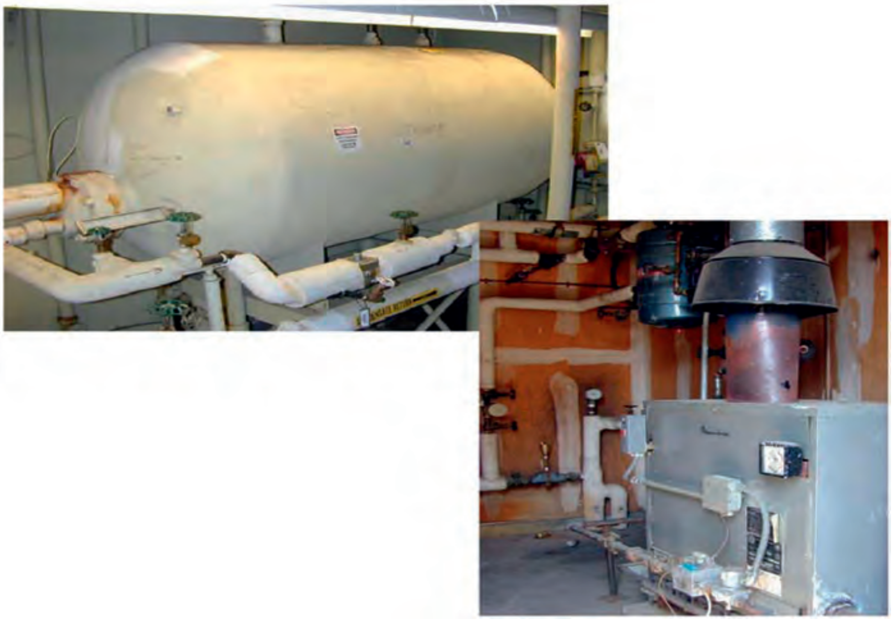
7C13.23 Prior to asbestos being banned, it was predominantly used in the building industry as heat resistant insulation and lagging, and roof sheeting. Asbestos is likely to be present in the vicinity of heating and ventilation systems, pipe work, boilers, structural insulating panels or as a roofing material.

7C13.24 It is estimated that approximately six million tonnes of asbestos has been used in the UK in the last one hundred years. It may be found in the form of cement sheeting, impregnated cloth and rope or sprayed onto structures as slurry. Composites containing asbestos have also been used in decorative coatings and cladding for both internal and external use.

Potentially high hazard (NOTE: If disturbed or involved in fire)	
Asbestos coatings	Widely used mixtures containing asbestos that were used to provide fire protection, acoustic properties, heat and condensation control by: • spraying onto structural beams, girders etc • loosely packing between floors and in partition walls • lagging eg on pipework, boilers, calorifiers, heat exchangers, insulating jackets for cold water tanks, around ducts. Typical buildings include: office blocks, cinemas, theatres, swimming pools, multi-storey car parks, cold stores, hospitals, shops, derelict industrial buildings where old lagging has not been maintained etc.
Asbestos Insulating Boards (AIB)	Used for fire protection, thermal insulation, eg ceiling tiles, partition walls, soffits, service duct covers, fire breaks, heater cupboards, door panels, lift shaft linings, fire surrounds, backing panels for radiators, heater and boilers.
Asbestos insulation	Asbestos containing materials which were not in practice applied as coatings. They include preformed sections for pipe insulation, laggings, void infills and packing around cables which pass through floors, millboards used for electrical as well as thermal insulation.

Lower hazard (if disturbed or involved in fire)	
In some asbestos containing materials the asbestos is firmly embedded and the fibres are more difficult to release examples include:	
Asbestos cement products	**The potential for fibre release is usually low.** However contamination can arise when asbestos cement is damaged or removed without suitable controls. Cement products include flat or corrugated roof sheets, wall cladding, guttering and downpipes, water tanks, bath panels, boiler and incinerator flues, fire surrounds etc. They generally contain between 10 and 15 per cent asbestos.
Certain textured coatings	eg artex (prior to the mid-1980s).

Moulded and sprayed asbestos pipe lagging. This is an example of a potential 'high hazard' asbestos containing material.



Asbestos in buildings

7C13.25 Any building that was constructed or underwent major refurbishment between the 1950's and mid 1980's is likely to contain asbestos containing materials as they were used in hundreds of different products and buildings during this period. Asbestos products continued to be used until 1985 when blue and brown asbestos were banned and 1999 when the use of all asbestos containing materials was banned.

7C13.26 The use of asbestos containing materials peaked in the 1960's and early 1970's therefore premises built or refurbished during this time are the most likely to contain asbestos containing materials.

Asbestos ceiling tiles

Railway rolling stock

7C13.27 Asbestos containing materials that remain in refurbished rail vehicles used on network rail's infrastructure have been securely encapsulated. Therefore fibre release and possible exposure to the fibres will only occur in the event of a catastrophic failure of the vehicle eg as a result of a serious collision.

Ships

7C13.28 All types of asbestos have been widely used in shipping, in a processed form, because of the properties of heat resistance, insulation and the strengthening of other materials when used as reinforcement. Asbestos is likely to be found on board a ship in:

- cladding of fire-retardant bulkheads
- glands of high temperature valves
- friction materials in machinery
- lagging on boilers and steam pipes.

The environment

7C13.29 Asbestos is non-degradable, and if released into the environment could constitute a public health hazard. The Health Protection Agency, local authority and Environment Agency should assess and manage this risk.

7C13.30 Fibres once released into the air will be dispersed in natural air currents and by wind movement.

7C13.31 Land contaminated by asbestos containing materials and/or fibres may present a clean-up issue for the landowner or 'responsible person' where significant amounts of fibres have been released during an incident. The Health Protection Agency and local authority may consider asbestos sampling to assess if the risk is above that normally encountered in the environment or for 'public reassurance' purposes (ie to show nothing has been detected above normal background levels).

7C13.32 Consideration should always be given to the potential hazards posed by water run off. Water may run into drains but may also collect on hard surfaces which, after drying off, may contain an asbestos residue.

Operational considerations

Pre-planning

7C13.33 The *Control of Asbestos Regulations* require 'duty holders' to actively manage asbestos in non-domestic premises. To achieve this, they must prepare a written plan (commonly known as an Asbestos Register or Asbestos Survey Report) identifying where asbestos is or is likely to be present, and the measures taken to manage the risk. The plan should be readily available on site for anyone to examine. The 'duty holder' is also required to ensure that information about the location and condition of any asbestos is made available to the emergency services.

7C13.34 Guidance in The Management of Asbestos in Non-domestic Premises Approved Code of Practice states:

"……. the Fire and Rescue Service are the emergency service most likely to disturb or come into contact with disturbed asbestos and they should be contacted to see what information they want, in what form they would like it and if they would like the information sent to them".

7C13.35 **NOTE:** Although the Approved Code of Practice puts the emphasis on the duty holder to contact the Fire and Rescue Service, in practice this is unlikely to happen to an extent whereby the Fire and Rescue Service is made aware of all the asbestos in its area. Also where information does come from surveys or registers this information may not be completely accurate or maintained up to date.

7C13.36 Fire and Rescue Services should therefore consider augmenting information provided by duty holders by gathering data themselves. Examples of how data could be gathered would include:

- risk information visits (eg 7(2)(d))

- fire safety inspections
- operational intelligence
- site exercises.

7C13.37 Fire and Rescue Services may want to consider a hierarchy of risk approach when responding to asbestos containing materials incidents with eg the highest risk being where owner/occupiers of buildings built prior to 1999 do not provide the Fire and Rescue Service with sufficient information when requested.

Known licensed asbestos removal

7C13.38 The Health and Safety Executive or the local authority environmental health department receive notifications of work involving the removal of asbestos by licensed contractors. Fire and Rescue Services should ensure that local protocols are in place for relevant information to be shared with them where significant risks to firefighters are foreseeable.

Phase 1: Mobilising and en-route

7C13.39 Where it is known that asbestos is involved at the address of the incident mobilising control should provide wind direction information to responders.

7C13.40 Crews should select a route to known, or suspected, asbestos incidents from the up-wind direction where they believe there is a risk of inhaling asbestos dust, fibres or composite particles (ie asbestos fibres attached to a bonding material).

Phase 2: Arriving and gathering information

7C13.41 Crews should approach known, or suspected, asbestos incidents from the up-wind direction where they believe there is a risk of inhaling asbestos dust, fibres or composite particles (ie asbestos fibres attached to a bonding material). Where appropriate, crews should notify mobilising control of the best approach route for other response vehicles to follow.

7C13.42 The Incident Commander should ensure all response vehicles and staff, if not yet deployed at the incident, are kept in an up-wind marshalling area or rendezvous point and establish an initial cordon around the suspected hazard zone and strictly control access into it.

7C13.43 Any immediate action to save life should be carried out using breathing apparatus[2] and structural firefighting kit[3] as a minimum level of personal protective equipment (personal protective equipment).

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[2] Breathing apparatus means self-contained, positive pressure breathing apparatus conforming to the current Fire and Rescue Service European standards.

[3] Structural firefighting kit should comprise boots, over trousers, tunic, gloves, fire hood and helmet conforming to the current Fire and Rescue Service European standards.

7C13.44 The Incident Commander should ascertain whether asbestos containing materials are involved at the incident and present a hazard to those attending as part of their risk assessment. If a hazard exists it should be managed through appropriate control measures contained in standard operating procedures. Further guidance on hazard identification is contained below.

7C13.45 Where there is doubt as to whether or not materials contain asbestos, Fire and Rescue Services should mobilise a hazardous materials adviser or subject matter adviser to the incident to assist the Incident Commander. Their training, knowledge and experience will improve the risk assessment process and they may be able to arrange analysis of suspected asbestos containing materials.

7C13.46 There are strict occupational exposure control limits which must not be exceeded. It is difficult to measure the amount of asbestos fibres that may have been released during operational incidents. Any release is likely to be unpredictable, variable, intermittent and short term ('peaks'). It is therefore prudent for Fire and Rescue Services to assume, when carrying out their risk assessment that all activities will require control measures eg respiratory protective equipment (respiratory protective equipment), even when any possible exposure to released fibres maybe below the exposure limits (eg asbestos containing materials in which the fibres are firmly embedded).

Asbestos hazard identification guidance

7C13.47 Due to the nature of Fire and Rescue Service operational activities, it will not always be practical to identify asbestos at incidents or events. Therefore, the Fire and Rescue Service has adopted a precautionary policy for asbestos. Fire and Rescue Services should implement asbestos standard operating procedures whenever it is foreseeable that asbestos containing materials are present at the incident and involved in such a way that fibres may be released and inhaled by those present.

7C13.48 The following three step hazard identification process will assist the Incident Commander's initial risk assessment:

- Step 1 – Are asbestos containing materials present?
- Step 2 – Can asbestos fibres be released or disturbed?
- Step 3 – Do responders have to enter the hazard zone?

STEP 1 – ARE ASBESTOS CONTAINING MATERIALS PRESENT?

7C13.49 Sources of information, which may be available to establish the presence of asbestos containing materials are:

- asbestos hazard signage
- visual appearance of construction/materials (eg asbestos cement roofs, insulation on plant/pipes etc)
- age of building/materials

NOTE: Those constructed between 1950-1980 but note that white asbestos (particularly asbestos cement products) may be present up until 1999

- hazardous materials adviser or subject matter adviser
- operational intelligence (eg 7(2)(d) inspections, asbestos register etc)
- multi-agency information sharing agreements (eg asbestos removal licences shared by the local authority etc)
- premises asbestos management plan and/or asbestos register, available from the 'duty-holder' of building
- knowledge of building stock

NOTE: Local authority building control department may be able to assist.

7C13.50 Clues such as the age of the building/alterations and visual appearance of materials may support the risk assessment process but they should not be relied upon as the only evidence for discounting the presence of asbestos containing materials.

7C13.51 Once the presence, or suspected presence, of asbestos containing materials is established, the next part of the assessment process is to determine the risk of responders inhaling asbestos fibres.

STEP 2 – CAN ASBESTOS FIBRES BE RELEASED OR DISTURBED?

7C13.52 Asbestos is not hazardous to health if it remains intact and undamaged. The asbestos containing material should be assessed and ideally visually examined to determine its condition (eg smashed/broken boards or sheets; damage with debris; degradation of bonding such as weathering etc) and therefore, the likelihood that fibres or composite particles can be released into the air.

7C13.53 The risk is lower in asbestos containing materials with a strong bonding material (eg asbestos cement sheeting etc). This contrasts with other asbestos containing materials, such as sprayed coatings and lagging which generally have a greater, more hazardous fibre content and are loosely bound, therefore, they release fibres relatively easily when damaged or disturbed.

7C13.54 It should also be ascertained whether the asbestos containing material has been mechanically altered (eg cut, sanded, smashed, machined etc) as this will release asbestos dust, fibres or composite particles. The risk of releasing fibres is lower for work with hand tools than powered tools.

7C13.55 There may also be occasions where asbestos dust, fibres and composite particles have been released prior to the arrival of crews. Where this is suspected the quantity and likelihood of disturbing the fibres should be assessed.

7C13.56 Asbestos fibres are extremely small and light, they are not visible to the naked eye. Therefore it can be difficult to detect them without air sampling equipment. However, in any disturbance there will always be asbestos dust and fibres released. The extent of fibre release may not be visible but it will generally reflect the amount of dust/composite particles created. The greater the extent of destruction and the greater quantity of asbestos material, then the greater the extent of dust and fibre release. Dust and fibres will generally disperse fairly quickly where there is good unrestricted air movement. It is highly unlikely that this will increase the normal background level of fibres appreciably.

7C13.57 **NOTE:** Positive pressure ventilation may be used to improve firefighting conditions, however, crews should be aware that its use could disturb asbestos containing materials.

7C13.58 The risk of fibres being present, above background levels, will be lower where asbestos containing materials are in the open air as opposed to those releasing fibres inside buildings.

STEP 3 – DO RESPONDERS HAVE TO ENTER THE HAZARD ZONE?

7C13.59 The hazard zone is the area where asbestos fibres or composite particles could be airborne, or made airborne by the activities being carried out. If responders do not need to go into the hazard zone then the risk of inhaling fibres is eliminated.

7C13.60 If responders do need to enter the hazard zone then asbestos standard operating procedures must be followed and the asbestos containing materials should be categorised by the level of hazard posed. For simplicity and safety at fire related incidents it is recommended that they be designated as either:

- ‘lower hazard’ or
- ‘high hazard’

NOTE: **‘lower hazard’** – means asbestos cement products and textured coatings only. Other asbestos containing materials are also classified as ‘minor’ or ‘less significant’ hazard under the Regulations (eg asbestos paper, rope seals etc). But they have not been included in the ‘lower hazard’ category within this hazard identification process for fires because of their increased potential to release asbestos fibres in a fire.

‘high hazard’ refers to all other asbestos containing materials.

Phase 3: Planning the response

7C13.61 The Incident Commander must ensure that a risk assessment is carried out prior to the deployment of staff to the hazard zone in order to develop a response plan with appropriate asbestos control measures. The risk assessment should consider the:

- asbestos hazard assessment
- level of asbestos hazard involved (ie ‘lower hazard’ or ‘high hazard’)
- extent of asbestos containing material involvement

- necessity to expose staff
- tasks that are required in the hazard zone
- effect of non-asbestos hazards on asbestos procedures
- control measures.

7C13.62 The Incident Commander should assess the risks and select the most suitable personal protective equipment and respiratory protective equipment based on pre-planning and on-site monitoring of the hazards and the tasks that need to be achieved.

7C13.63 The options available to the Incident Commander are:

- **Breathing apparatus and chemical protective clothing**
  Worn at 'high hazard' asbestos incidents to increase the effectiveness of decontamination procedures (eg removing asbestos lagging from a boiler or ancillary pipe work etc).

  NOTE: Chemical protective clothing should not to be worn in a fire situation if the heat or flames could have a detrimental affect on the protective clothing's material.

- **Breathing apparatus and structural firefighting kit**
  Worn where chemical protective clothing is not appropriate, for example during firefighting tasks or other operations where the disadvantages (ie heat stress, impaired visibility and mobility etc) outweigh the advantages (ie ease of decontamination).

- **Other respiratory protective equipment[4] and structural firefighting kit**
  May be worn for 'lower hazard' asbestos incidents (ie asbestos cement and textured coatings) and where staff will not be involved in 'hot' zone working which would disturb composite particles (eg assisting with decontamination where there is a very low risk of airborne fibres, dusts and composite particles; fire investigation activities which do not involve the disturbance of asbestos containing materials; re-inspections of incidents which do not involve the disturbance of asbestos containing materials; operating in areas where there are asbestos cement sheeting fragments etc).

  NOTE: All respiratory protective equipment used at asbestos incidents must be CE[5] marked and subject to face-fit testing procedures. Where responders are working hard and there is a risk that the face seal may be compromised, breathing appparatus should always be worn.

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[4] Such respiratory protective equipment can only be used by an Fire and Rescue Service following a pre-planned systematic respiratory protective equipment assessment. Further information is contained in Section 7 Part C-14 and specific guidance on the process to be followed is available from the Health Safety Executive's website. Respiratory protective equipment, other than breathing apparatus, should not be used in fire situations where the harmful products of combustion could be inhaled.

[5] The CE marking is a declaration by the manufacturer that his product meets the requirements of the applicable European Directive(s).

7C13.64 The Incident Commander should liaise with a hazardous materials adviser to identify appropriate and proportionate decontamination procedures.

7C13.65 The responsibility for the environmental impact and site cleaning rests with the owner/occupier of the premises. However, every effort should be made, within the response plan, to mitigate the impact of the incident on the environment.

Phase 4: Implementing the response

7C13.66 Work area considerations:

- establish a hazard zone and ensure it is controlled and monitored
- if different asbestos containing materials are present within a large incident site it may be necessary to have a number of hazard zones each with their own control measures
- keep the number of responders at the incident to the minimum required to safely deal with it
- allow only essential staff to enter the hazard zone and ensure they use appropriate respiratory protective equipment and personal protective equipment
- use and monitor personal protective equipment and respiratory protective equipment in line with the asbestos hazard assessment and the response plan
- ensure appropriate and proportionate decontamination is carried out when leaving the hazard zone
- ensure equipment is washed down of prior to leaving the incident
- brief all staff on the asbestos hazards
- smoking, drinking or eating should not be allowed on-site unless designated rest areas with appropriate hygiene facilities are set up
- early notification and liaison with other responders (eg Police Service, Ambulance Service, utility workers etc) is essential
- liaise with the police and Health Protection Agency over the risk of exposure to members of the public
- inform the Environment Agency, Health Protection Agency and the local authority environmental health officer of the asbestos hazard
- ensure good personal hygiene both during and post incident.

7C13.67 Work method considerations:

- avoid disturbing asbestos containing materials (eg cutting away an area to gain access) unless it is absolutely essential. If essential, the area should be wetted and disturbance kept to a minimum

- leave intact individual pieces of asbestos cement sheeting if the fire has disturbed and distributed it over a wide area
- if disturbed asbestos containing materials have to be moved, ensure they are wetted, using a fine spray and moved as short a distance as possible to a safe place within the hazard zone
- water use should be kept to a minimum and the run-off controlled where possible
- avoid use of positive pressure ventilation fans unless to do so is imperative as they are more likely to release airborne asbestos fibres and composite particles from any disturbed/damaged structure
- do not intentionally break any asbestos containing materials into smaller pieces unless absolutely necessary
- use hand tools in preference to abrasive or power tools when cutting away as their use reduces the amount of potential fibre release
- avoid the use of cleaning methods, such as dry sweeping, which will increase airborne dust/particles
- keep to a minimum the movement of ash and debris (eg turning over) and ensure it is carefully carried out to prevent/reduce the amount of fibres and composite particles that maybe released.

7C13.68 The presence of asbestos containing materials may not be confirmed or apparent until the closing stages or even until the end of an incident and personnel may already have been exposed, if fibres have been released. In such circumstances the unintentional spread of fibres may have already occurred via:

- clothing – fibres trapped in fabrics
- breathing apparatus sets – fibres trapped on webbing etc.
- equipment – fibres trapped in crevices etc.

7C13.69 Considerations where asbestos is discovered during the course of an incident:

- stop non-critical operations in the hazard zone and immediately assess the asbestos hazards
- identify staff who have been exposed, carry out retrospective decontamination measures
- inform mobilising control, who may mobilise additional resources
- reassess the response plan, tactics and working practices – implement asbestos procedures.

Asbestos decontamination guidance

7C13.70 Decontamination should be in place, and communicated to staff, prior to work being carried out in the hazard zone, except where there is an immediate life risk.

Operational key principle

Firefighter decontamination

The success of decontamination depends on the strict observance of a disciplined procedure within the defined area.

7C13.71 All decontamination should take place on-site to avoid spreading asbestos, but if, in exceptional circumstances, staff need to continue decontamination off-site then, following cleaning, a thorough visual inspection of any rooms used or accessed should be conducted to ensure the absence of any dust. Air sampling may also be considered for reassurance purposes.

NOTE: The visual inspection is the most important control.

7C13.72 When considering the site of the decontamination area the Incident Commander should consider the following:

- Access to and egress from the building
- Establish sufficient distance from the 'hot' zone to the decontamination area to ensure that no airborne contamination can reach the decontamination area. However, attempt to keep them as close as possible to contain any decontamination run off to the initial site and limit the spread of asbestos
- Numbers requiring decontamination
- Location of the breathing apparatus entry control point
- Wind direction
- Location of the pump and availability of hose reel for washing off and damping down
- Slope of ground and drainage
- Hard standing with good vehicular access
- Weather conditions and welfare of staff.

DECONTAMINATING WEARERS IN CHEMICAL PROTECTIVE CLOTHING

7C13.73 Chemical protective clothing wearers should be decontaminated using standard wet or dry methods as appropriate.

DECONTAMINATING BREATHING APPARATUS WEARERS IN STRUCTURAL FIREFIGHTING KIT

7C13.74 Use a standard procedure as follows:

- Breathing apparatus wearers should carry out visual inspection of each other for any exposed skin or hair, note any areas/locations if they are found

- Vacuum[6] each other if appropriate or
- Damp down all areas of personal protective clothing to ensure that any particles cannot become airborne. Start at the highest point (ie helmet) and work down, pay particular attention to folds and creases in the personal protective equipment
- Debris and dust can be gently removed using water spray, sponges, cloths etc
- Remove helmet
- Gently wash off and wipe facemask and dampen fire hood
- Wash off boots and gloves
- Step into the undressing area or bag (within the ‘dirty area’)
- Remove contaminated gloves and don disposable medical gloves
- Remove fire hood and breathing apparatus set

  NOTE: The method used to achieve this must ensure that no residual contamination can be inhaled by the wearer.

- Remove tunic
- Roll down over-trousers over boots ensuring that they are inside out
- Carry out secondary check for contamination of skin or hair

  NOTE: Thoroughly wash any areas found on either the initial inspection above or this secondary inspection

- Carry out inspection of the clothes layer under the structural firefighting kit. If any clothes are believed to have been contaminated, they must be damped down and removed
- Step out of ‘dirty area’ and into the decontamination ‘clean area’
- Remove disposable medical gloves and deposit in ‘dirty area’
- All contaminated clothing and equipment should be assessed and cleaned appropriately. Generally hard items can be wiped and rinsed clean. Soft or textured items may require a more thorough cleaning process. Fire and Rescue Services should risk assess their specific personal protective equipment, respiratory protective equipment and other equipment in liaison with local contractors and add this to their asbestos standard operating procedures.

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[6] Only Class H vacuum cleaners with true or absolute ‘high efficiency particulate arrestor’ filters should be used. However, it is now generally regarded that dry decontamination by use of a vacuum cleaner is not in its own right a complete decontamination process and should be followed by wet decontamination. Also they are best suited to dry, still-air conditions. As these are rarely encountered at operational incidents, Fire and Rescue Services should ensure that other methods of decontamination are always available.

7C13.75 Where contamination is heavy or the number of wearers is large, this process can be enhanced by the addition of decontamination operatives wearing appropriate respiratory protective equipment and personal protective equipment based on a risk assessment of the hazards and the likelihood of cross contamination between wearers and operatives.

7C13.76 Further information is contained in Section 7 Part C-15 – Firefighter decontamination.

7C13.77 It is good practice for wearers to shower on return to station after any fire or hazardous materials incident for personal hygiene reasons and as an additional safety precaution, this does not form part of decontamination.

DECONTAMINATING FIREFIGHTERS WEARING RESPIRATORY PROTECTIVE EQUIPMENT, OTHER THAN BREATHING APPARATUS, AND STRUCTURAL FIREFIGHTING KIT

7C13.78 <u>This level decontamination should only be considered for 'lower hazard' asbestos incidents (ie asbestos cement and textured coatings) and staff who have not been involved in 'hot' zone working which would disturb composite particles</u>.

7C13.79 When decontaminating, the principle should be to /vacuum/wet/wash/wipe areas that are <u>visibly contaminated</u> (eg dirt, dust, debris etc), or areas that are known to have contacted asbestos containing materials (eg boots and gloves):

- visual inspection for any exposed skin or hair, that has been visibly contaminated note any areas/locations if they are found
- remove and rinse helmet
- gently vacuum (if appropriate), wash off and sponge wipe the areas of personal protective equipment that are visibly contaminated or have been touched by asbestos containing materials
- wash off gloves
- wash off boots
- thoroughly wash any areas of skin or hair with visible contamination
- remove the respiratory protective equipment
- consider further laundering of personal protective equipment dependant on local risk assessments.

7C13.80 **NOTE:** If the Incident Commander, hazardous materials adviser or decontamination director has any doubt over the effectiveness of the decontamination procedure, or the asbestos hazard level, the decontamination procedures above for breathing apparatus wearers in structural firefighting kit should be used.

Assessment of the effectiveness of decontamination of 'lower hazard' asbestos (ie asbestos cement and textured coatings only)

If decontamination has effectively cleaned all visible deposits (eg dirt, dust, debris etc.) from personal protective equipment and other equipment, then no further decontamination action should be necessary.

This is because, although individual asbestos fibres can potentially be detached from the bonding materials, it is more likely that composite particles will be released, especially where the asbestos containing material has been mechanically altered.

This will commonly be visible as dust or fine debris. Composite particles pose a lower risk than fibres, as the body's normal defences and filtering systems may deal with them, but asbestos containing material dusts should always be treated as an asbestos risk, hence this abridged decontamination option.

NOTE: This decontamination assessment method is only appropriate for 'lower hazard' asbestos incidents (ie asbestos cement and textured coatings) and staff who have not been involved in 'hot' zone working which would disturb composite particles.

DECONTAMINATING APPLIANCES AND EQUIPMENT

7C13.81 If contamination is found on the outside of an appliance, this may be removed using water spray. The likelihood of contamination of appliance interiors is considered to be extremely low, provided all the foregoing procedures are followed. However, should it occur, cabs should be ventilated and cleaned using disposable damp cloths, these should be disposed of as asbestos waste.

7C13.82 Lockers and equipment should be washed and wiped down with disposable cloths. Hose and other hard-surfaced equipment should be cleaned using water spray. The level of personal protective equipment/respiratory protective equipment for the staff carrying this out should be decided through risk assessment. This procedure should be carried out at the scene of operations to avoid the potential spreading of asbestos containing materials.

Phase 5: Evaluating the response

7C13.83 Incident Commanders should constantly evaluate the risk posed by asbestos containing materials and the effectiveness of asbestos procedures and advice. Evaluation is not a one-off process but should be continual throughout the incident as circumstances change or new information is gathered. After evaluation, if necessary, the Incident Commander should adjust the response plan, amend/implement control measures and communicate the changes to all staff.

Phase 6: Closing the incident

7C13.84 The *Hazardous Waste Regulations* apply to asbestos waste. This must be consigned to a site that is authorised to accept asbestos waste. Contaminated cloths and any other asbestos waste must be appropriately bagged and marked as asbestos waste and sent for specialist disposal.

7C13.85 At the end of any incident involving asbestos, further control measures will include:

- **Liaison between the Incident Commander and the Fire Investigation Officer**
  The Fire Investigation Officer must be briefed regarding the location, condition, type and actual involvement of asbestos at the incident. This will allow the Fire Investigation Officer to carry out a risk assessment and decide upon the appropriate level of personal protective equipment/respiratory protective equipment for their task. Consideration should also be given to the method or need for decontamination.

- **Hand-over of the incident to the appropriate authority**
  This will be the owner or occupier in most instances, however, if the site/building is derelict, unoccupied or it is not possible to contact the owner/occupier then the site should be handed-over to the police or local authority who have responsibility in these circumstances. The findings of the asbestos risk assessment must form part of the incident hand-over. Where there is a significant risk to the general public and it is not possible to hand-over the site to a responsible person consideration should be given to the positioning of appropriate warning signs.

- **Extent of public health protection requirement**
  The local Environmental Health Department and the Health Protection Agency should be informed whenever asbestos is involved. Further information can be found in the Health Protection Agency's *Responding to large-scale fires involving asbestos Part 1 – HPU Toolkit and Resource Pack*. At large or complex incidents a joint agency debrief should be carried out.

- **Environmental impact and control measures**
  Asbestos is an environmentally hazardous substance. The Environment Agency should be informed of substantial asbestos releases or as agreed in the Fire and Rescue Service's local memorandum of understanding.

Responsibility for the clean-up

The *Control of Asbestos Regulations* requires an employer to ensure that premises are thoroughly cleaned, this does not apply to a Fire and Rescue Service in respect of attendance at premises in response to emergency calls. The responsibility for the environmental impact and cleaning up rests with the owner/occupier of the premises.

Records and health surveillance

7C13.86 Fire and Rescue Authorities must maintain a written record of their work activities that involve exposure of staff to asbestos (ie inhaled or ingested asbestos fibres). These must be held for 40 years. Authorities should have procedures in place to record the individual circumstances of the exposure along with the asbestos risk assessment and also procedures for recording details of staff who suspect they have been exposed.

7C13.87 Fire and Rescue Services should maintain, and have available for inspection by the Health Safety Executive or local authority inspector as required, the following documentation:

- training records
- details of decontamination procedures
- maintenance records of all decontaminated equipment and test certificates where appropriate
- method statement, ie standard operating procedure for dealing with asbestos incidents
- risk assessment
- records of respiratory protective equipment inspections and tests
- records of work activities involving possible exposure of staff to asbestos
- exposure records for personnel.

Additional operational considerations when involved in fire

7C13.88 All operational guidance given in the previous paragraphs of this part is applicable to fire and non-fire situations, however, the following additional information and advice is specific to fire situations.

- **Effect of fire and heat on asbestos**
  Asbestos fibres can have their mineral structure changed following prolonged exposure to heat. Research has shown that at temperatures above 450°C[7] asbestos fibres are denatured rendering them of lower hazard than non-heated fibres. In fires the outer layers of asbestos containing materials are altered with the interior often remaining unaffected. This means those asbestos fibres present in the debris and ash may still present a risk to firefighters when turning over and damping down, albeit reduced.

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[7] *The public health significance of asbestos exposures from large scale fires* by KR Smith and P Saunders.

- **Effect of fire and heat on cement asbestos containing materials**
  It can be anticipated that temperatures in excess of 450°C would be required to release asbestos fibres from cement bonded asbestos containing materials. Therefore, the risks from asbestos fibres and composite particles released from asbestos cement products during intense fire conditions is of lower risk than other operational scenarios. Also asbestos that exists within a cement material is heavily bonded within the cement matrix and consequently is far more difficult to get into a respirable form. Even where fibres are released, for example following intense heating of asbestos cement roofing sheets where a characteristic 'popping' of the sheeting can occur, they will not be released in isolation. It is highly likely that the vast majority of fibres, or composite particles, will be attached to larger fragments of cement. This means that the risk to health of asbestos inhalation is lower than for other asbestos containing materials as the body deals better with larger composite particles should they enter it.

- **Effect of fire and heat on chemical protective clothing**
  Most chemical protective clothing offers very little protection against heat and fire. Chemical protective clothing is likely to melt, burn or malfunction in fire conditions, therefore it is extremely hazardous to commit staff wearing it in to such environments and should be avoided.

- **Hazards posed to the general public at serious fires**
  The Health Protection Agency offers the following advice on serious fires in buildings involving asbestos containing materials:

  - main health effect may be anxiety about potential health effects and contamination
  - no evidence of direct health effects of asbestos particles released in fires, although the data are limited
  - available epidemiological evidence shows that long term health effects are negligible
  - majority of asbestos involved in fires is likely to be chrysotile (white asbestos), which is considered to pose a lower hazard that other forms of asbestos, but there is the possibility of all forms of asbestos being involved in a fire
  - risks from short term inhalation contributes only very slightly to total lifetime risk – one estimate of an extreme exposure scenario following a fire indicated that this would add a less than one in a million extra lifetime risk
  - asbestoes containg material debris, if in a good condition (eg unweathered) and if dampened down to suppress any potential release of fibres, does not present a hazard to human health if handled carefully.

- **Public health mitigating factors[8]:**

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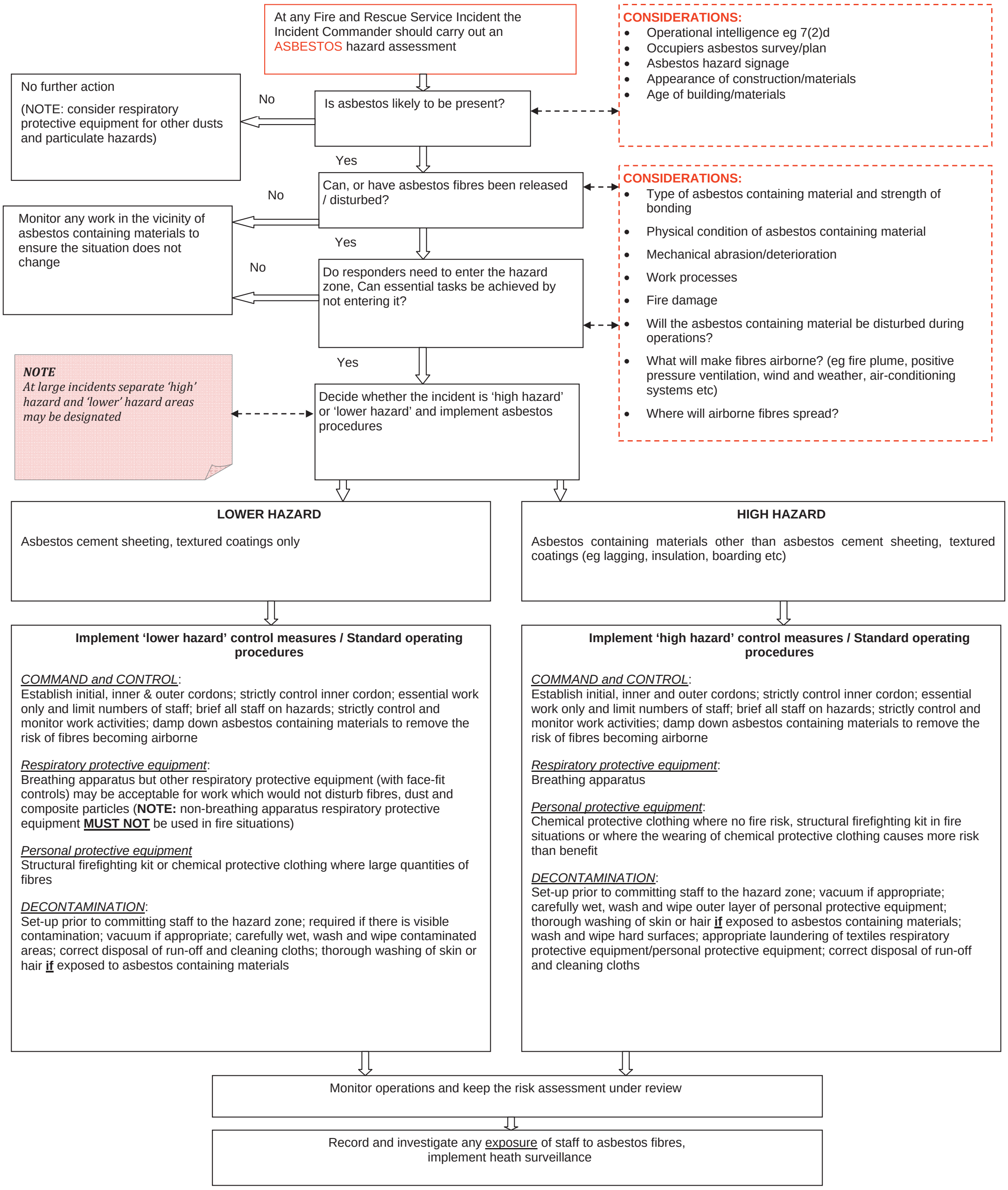
[8] *The public health significance of asbestos exposures from large scale fires* by KR Smith and P Saunders.

- not all asbestos containing material may be involved in the fire
- fibres may be entrapped, in larger pieces of material etc
- respirable fibres will be a fraction of the total released
- some fibres may be denatured at the temperatures involved
- atmospheric dispersion and deposition (particularly as a result of rain) will reduce concentrations
- the duration of exposure will be short.



At any Fire and Rescue Service Incident the Incident Commander should carry out an ASBESTOS hazard assessment

CONSIDERATIONS:

- Operational intelligence eg 7(2)d
- Occupiers asbestos survey/plan
- Asbestos hazard signage
- Appearance of construction/materials
- Age of building/materials

Is asbestos likely to be present?

No

No further action

(NOTE: consider respiratory protective equipment for other dusts and particulate hazards)

Yes

Can, or have asbestos fibres been released / disturbed?

No

Monitor any work in the vicinity of asbestos containing materials to ensure the situation does not change

Yes

Do responders need to enter the hazard zone, Can essential tasks be achieved by not entering it?

No

CONSIDERATIONS:

- Type of asbestos containing material and strength of bonding
- Physical condition of asbestos containing material
- Mechanical abrasion/deterioration
- Work processes
- Fire damage
- Will the asbestos containing material be disturbed during operations?
- What will make fibres airborne? (eg fire plume, positive pressure ventilation, wind and weather, air-conditioning systems etc)
- Where will airborne fibres spread?

Yes

NOTE
At large incidents separate 'high' hazard and 'lower' hazard areas may be designated

Decide whether the incident is 'high hazard' or 'lower hazard' and implement asbestos procedures

LOWER HAZARD

Asbestos cement sheeting, textured coatings only

Implement 'lower hazard' control measures / Standard operating procedures

COMMAND and CONTROL:
Establish initial, inner & outer cordons; strictly control inner cordon; essential work only and limit numbers of staff; brief all staff on hazards; strictly control and monitor work activities; damp down asbestos containing materials to remove the risk of fibres becoming airborne

Respiratory protective equipment:
Breathing apparatus but other respiratory protective equipment (with face-fit controls) may be acceptable for work which would not disturb fibres, dust and composite particles (**NOTE:** non-breathing apparatus respiratory protective equipment **MUST NOT** be used in fire situations)

Personal protective equipment
Structural firefighting kit or chemical protective clothing where large quantities of fibres

DECONTAMINATION:
Set-up prior to committing staff to the hazard zone; required if there is visible contamination; vacuum if appropriate; carefully wet, wash and wipe contaminated areas; correct disposal of run-off and cleaning cloths; thorough washing of skin or hair **if** exposed to asbestos containing materials

HIGH HAZARD

Asbestos containing materials other than asbestos cement sheeting, textured coatings (eg lagging, insulation, boarding etc)

Implement 'high hazard' control measures / Standard operating procedures

COMMAND and CONTROL:
Establish initial, inner and outer cordons; strictly control inner cordon; essential work only and limit numbers of staff; brief all staff on hazards; strictly control and monitor work activities; damp down asbestos containing materials to remove the risk of fibres becoming airborne

Respiratory protective equipment:
Breathing apparatus

Personal protective equipment:
Chemical protective clothing where no fire risk, structural firefighting kit in fire situations or where the wearing of chemical protective clothing causes more risk than benefit

DECONTAMINATION:
Set-up prior to committing staff to the hazard zone; vacuum if appropriate; carefully wet, wash and wipe outer layer of personal protective equipment; thorough washing of skin or hair **if** exposed to asbestos containing materials; wash and wipe hard surfaces; appropriate laundering of textiles respiratory protective equipment/personal protective equipment; correct disposal of run-off and cleaning cloths

Monitor operations and keep the risk assessment under review

Record and investigate any exposure of staff to asbestos fibres, implement heath surveillance

PART C–14

Personal protective equipment for hazardous materials incidents

General information

Introduction

7C14.1 This section of operational guidance provides information for Fire and Rescue Services on the selection and use of personal protective equipment at hazardous materials incidents. It is supported by the current relevant personal protective equipment European standards which are prepared under a mandate given to CEN (European Committee for Standardisation) by the Commission of the European Communities and the *European Free Trade association. These standards support the requirements of the European Personal Protective Equipment Directive.*

7C14.2 The field of chemical protective clothing is one of constant development and change, with new materials and processes becoming available all the time. It is therefore important to understand that the information provided should not be regarded as definitive but as the best available at this time.

7C14.3 It should be recognised that in line with the concept of the 'hierarchy of controls' in risk management, personal protective equipment forms the last line of defence for an individual working within a hazardous environment.

7C14.4 The importance of the effective selection and usage of appropriate respiratory protective equipment and chemical protective clothing at an incident involving hazardous materials can not be over stated. This can only be achieved by understanding the performance standards and level of protection afforded by personal protective equipment ensembles, and identifying any additional measures that may be required in order to deal safely with the hazards presented. These could include the following:

- physical properties of the substance
- form (ie solid, liquid, gas)
- toxicity / infectivity
- concentration
- quantity (ie amount of spill)
- likelihood of direct contact (contamination and possibly exposure)

- fire or potential involvement in fire
- nature and extent of proposed action or task to be performed
- environment (eg open air or enclosed compartment or structure)
- prevailing weather conditions (eg, wind direction/strength)
- potential decontamination strategy
- balancing the benefits of chemical protective clothing against negative aspects for the intended application at a particular incident (eg donning time scale, heat stress etc).

7C14.5 This list is not exhaustive, and will have to be considered with the operational circumstances, legal obligations, standard operating procedures, manufacturer's guidance, suggested levels of protection information data bases, *Emergency Action Codes, Additional Personal Protection Codes* and scientific advice.

Legislation

7C14.6 It is a requirement of the *Personal Protective Equipment at Work Regulations* that personal protective equipment be supplied and used whenever there are risks to health and safety that cannot be controlled in other ways.

7C14.7 The regulations also require that personal protective equipment:

- **BE PROPERLY ASSESSED BEFORE USE TO ENSURE ITS SUITABILITY**
  This can only be achieved after a full analysis of the hazards presented at an incident, working proximity, weather conditions, etc, and the task to be performed. The selection of the most appropriate level of personal protective equipment, including respiratory protective equipment, at a hazmat incident will require understanding of specifications and performance standards against the chemical or identified hazard of the various options available, to interpret the protection that might be afforded to the wearer and for how long. Additional information such as the *Additional Personal Protective Codes* will also determine any additional personal protective equipment requirements such as thermal protection and briefing of wearers on potential limitations of protection and aspects of the task in hand to maximise their safety.
- **BE MAINTAINED AND STORED PROPERLY**
  Correct testing, maintenance and storage regimes are not only essential to ensure that chemical protective clothing remains in a state of operational readiness and is fit for purpose, it can also significantly extend the life of a suit.
- **BE PROVIDED WITH INSTRUCTIONS ON HOW TO USE IT SAFELY**
  Wearers should be provided with instructions on how a chemical protection suit is to be checked prior to wearing, the donning/disrobing procedure, the requirement for additional protection (such as headgear), and the arrangements for distress procedures.

- **BE USED CORRECTLY**
  The use of chemical protective clothing must always be evaluated against the nature of the task being undertaken to ensure any benefits of wearing the suit are not outweighed by other hazards. An example of this might be the operation of hydraulic cutting equipment at a road traffic collision balanced against the wearer's impeded vision, mobility, hand dexterity and the potential for manual handling injuries.

Respiratory protective equipment

Introduction

7C14.8 The law requires Fire and Rescue Services to prevent or control the exposure of employees and others to hazardous substances at work. Before using respiratory protective equipment, exposure should be controlled by reasonably practicable measures other than the use of personal protective equipment. Personal protective equipment should only be used as a last line of protection to control the exposure.

7C14.9 Respiratory protective equipment is a particular type of equipment. It is designed to protect the wearer against inhalation of hazardous substances in the air.

7C14.10 Due to the nature of the emergency and wide range of Fire and Rescue Service activity, great care must be taken when selecting and purchasing respiratory protective equipment for operational use. Full risk assessments must be carried out to ensure it is fit for purpose and complies fully with the Health and Safety Executive's legal requirements. Fire and Rescue Services must also consult either:

- safety representatives appointed by recognised trade unions; or
- employees, either directly or indirectly, through elected representatives.

7C14.11 To select the right respiratory protective equipment Fire and Rescue Services will have to take account of:

- the properties of any hazardous substances which could foreseeably be encountered
- the needs of the wearer
- the potential work tasks (eg rescue, leak sealing, decanting, decontamination systems etc)
- foreseeable workplace conditions.

7C14.12 When purchasing respiratory protective equipment, Fire and Rescue Services should consider the issue within their integrated risk management planning process. Within this they should consider their:

- hazardous materials response policy and procedure

- hazardous materials risk profile within their turn-out area (eg known hazardous materials sites/risks, transportation risks, transport routes etc)
- Fire and Rescue Service National Resilience commitments
- training and maintenance skills system.

7C14.13 Further information can be found in:

- HSG53 Respiratory protective equipment at work – A practical guide **www.hse.gov.uk**
- **www.firebuy.gov.uk**

Selecting respiratory protective equipment at emergency hazardous materials incidents

7C14.14 Personal protective equipment should only be used as a last line of protection to control the exposure of staff to hazardous materials. However, due to the dynamic, pressurised environment at emergency incidents, particularly in the initial stages when life may be endangered, it is highly likely that respiratory protective equipment will be required.

Operatonal key principle

Respiratory protective equipment at HazMats incidents

At incidents ('hot' zone) where standard structural firefighting kit affords inadequate protection against hazardous materials and chemical protective clothing is required, breathing apparatus must always be worn. It should be noted that:

- There is the potential for increased air consumption and heat stress especially where physical activity and high ambient temperatures are involved
- Exposure time in the risk area may need to be limited to 20 minutes (breathing apparatus entry control to monitor)
- There may be implications for the level of breathing apparatus control, the application of the procedures and communications. In particular the Incident Commander will need to be aware of the potential early deployment of relief crews.

NOTE: The use of National Resilience powered respiratory protective suits may also be considered, subject to the correct application of the powered respirator protective suits 'hot' zone decision tool and scientific advice. The use of powered respirator protective suits will alleviate many of the limitations indicated above due to its longer working duration, however it should be noted that powered respirator protective suits are not suitable for all types of hazardous materials and gas tight suits with breathing apparatus remains the default level of protection.

7C14.15 The Incident Commander must ask the following questions:

Is it essential for staff to be in a location where it is possible that hazardous materials may have been released?

7C14.16 That is, do they need to enter the hazard zone or can the objectives be achieved without putting staff at risk? If the answer is "YES they must enter the hazard zone" then ask:

Is the substance potentially hazardous?

7C14.17 This is often difficult to assess this at emergencies particularly in the early stages of an incident. Incident Commanders must consider the full range of hazards, for example:

- very toxic
- toxic
- harmful
- corrosive
- flammable
- asbestos
- irritant
- carcinogen
- radioactive substance
- biological agent
- oxygen deficiency (eg confined spaces etc).

7C14.18 If the answer is "YES" or it is suspected that hazardous materials are involved then ask:

Can the substance be inhaled?

7C14.19 This depends on its physical form. Substances can exist as solids, liquids or gases. Under certain conditions, they can exist in more than one form at the same time (eg during paint spraying) and may be inhaled.

- Particulate solids include aerosols, dusts, fibres, smokes and fume:
  - Dusts and fibres are fine particles that are released into the air
  - Fumes are generated by vaporisation of solids and condensation into fine particles
  - Smokes are formed by the incomplete combustion of materials

  - if the solid particulates are very fine, they can behave like gases and vapours and move with air currents. In this way, they can be transported quite a long way from the source of emission.
- Liquids can exist as droplets or as finer sprays, aerosols and mists in air or other gases/vapours
- Gases are like air and behave in the same way. Vapours are the gaseous forms of substances, which normally exist as a solid or liquid at room temperature. These are sometimes wrongly referred to as fumes. Also remember not all vapours will be visible (eg at liquid petroleum gas liquid spills the vapours may extend beyond the visible cloud).

7C14.20 If the answer is "YES" then respiratory protective equipment is required.

NOTE: Additional personal protective equipment in the form of chemical protective clothing may also be required, further guidance on this is contained in 7C14.51.

7C14.21 Full guidance on the process of selecting appropriate personal protective equipment, including respiratory protective equipment, at hazardous materials incidents is contained within the Generic Standard Operating Procedure in Part B of this guidance.

Operatonal key principle

Default level of respiratory protective equipment at hazardous materials incidents

The default level of respiratory protective equipment at hazardous materials incidents should be self-contained, positive pressure breathing apparatus. This should only be varied following a full risk assessment involving a hazardous materials adviser.

7C14.22 For certain specific foreseeable operational scenarios which have respiratory inhalation hazards (eg glass management at road traffic collisions) Fire and Rescue Services may carry out risk assessments to develop standard operating procedures which vary the default level of respiratory protective equipment. Where this is done it must be incorporated into their operational training programme and their audit and review system.

7C14.23 Further guidance on the selection of respiratory protective equipment is contained in HSG53 *Respiratory Protective Equipment at Work – A practical guide* (Health and Safety Executive).

Types of respiratory protective equipment

7C14.24 Respiratory protective equipment in the workplace is divided into two main types:

- Respirator (filtering device) – This uses filters to remove contaminants in the air. They should only be used at hazardous materials incidents following a full risk assessment and should never be used for protection in fire situations or where there is any possibility of reduced oxygen levels. They should always be subject to appropriate face-fit assessment
- Breathing apparatus – This needs a supply of breathing quality air from an independent source (eg air cylinder or air compressor).

Respirators

7C14.25 Types of respirators:

- half mask, particle filters (includes disposable filtering face-piece or ‘dust mask’)
- half mask, gas filters
- full face mask, particle filters
- full face mask, gas filters
- powered (fan-assisted) masks
- powered (fan-assisted) hoods
- powered (fan-assisted) suits.

7C14.26 Types of filters:

- **Particle filters** – These trap and hold particles (dust, mist, fume, smoke, micro-organisms) from the air flowing through them. Large particles are easier to trap than small ones. These filters can be used against both solid particles and liquid mists and droplets. However, particle filters do not trap gases or vapours including organic liquid mists and sprays, or give any protection against oxygen-deficient atmospheres. Some manufacturers may recommend the use of pre-filters (coarse filters) to protect the main filters. Particle filters will be marked with a ‘P’ sign and filtration efficiency number, 1, 2 or 3. If the filter is also usable with fan-assisted respirators then they will also carry the sign ‘TH’ or ‘TM’ and the filtration efficiency number (1, 2 or 3). If colour coding is used, the label will be WHITE.
- **Gas/vapour filters** – These filters are designed to remove gases or vapours as specified by the manufacturer. They do not protect against particles, or oxygen-deficient atmospheres. They don’t last forever – these filters have a limited capacity for removing gases/vapours, so after a time, the gas or vapour will pass straight through (an event known as breakthrough) to the respiratory protective equipment wearer’s respiratory system. Gas/vapour

filters are usually divided according to the type of substance they can be used against, and the capacity of the filter. The filter or the mask it is built into will be marked with a letter (the type) and usually a number to indicate capacity, and a standard colour coding (eg A2 – brown). If the filter is also usable with powered respirators then they will also be marked 'TH' or 'TM'.

NOTE: The capacity identification is not a good indicator of break through time of substances. Some substances can break through before the capacity of the filter is reached. This is due to the complications involved in trapping them. The classification of gas and vapour filters is based on how much of the specified contaminant they can hold in a laboratory test at set conditions.

- **Multi-gas filters** – A filter may be manufactured to contain filters for more than one type of gas or vapour. In this case, they will be marked with types of gas/vapour filters included (eg A1B2 – organic vapour with capacity class 1 and inorganic gases with capacity class 2). Warning: They are manufactured in this way to offer an easy choice for employers who are using different gases and vapours at their sites. They are more expensive to buy than single type filters, heavier, and harder to breathe through in use. If you use multi-type filters, you should take extreme care and be certain that the use of this filter against mixtures of gases/vapours (either at the same time or one after the other) will not result in exposure. Always seek clear instructions from the manufacturer on how this filter may be used safely in your workplace and on replacement intervals. If performance against mixtures of gases is needed, it may be safer to consider using breathing apparatus.
- **Combined filters** – Filters are available for situations where protection is needed against both particles and specific gas or vapour. This type of filter will carry markings for particles and vapours, eg A2P3 – organic vapour filter with capacity class 2 and high efficiency particle filter

7C14.27 Further information is contained in *HSG53 Respiratory Protective Equipment at Work – A practical guide and Standards for Personal Protective Equipment*, OM 2009/03 (**www.hse.gov.uk**)

Breathing apparatus

7C14.28 Further information on breathing apparatus is contained in:

- Home Office Technical Bulletin – 1/1997 Breathing Apparatus Command and Control procedures (**NOTE:** this document will shortly be superseded by a Fire and Rescue Service Operational Guidance document).
- BS EN 137:2006 Respiratory protective devices. Self contained open circuit compressed air breathing apparatus with full-face mask. Requirements, testing and marking. (Type 2 firefighting).
- *BS 8468:2006 Respiratory protective devices for use against CBRN agents.
- BS EN 529:2005 Respiratory protective devices. Recommendations for selection, use, care and maintenance. Guidance document.

- BS EN 136:1998 class 3 Face masks.
- BS 10999:1010 Specification for distress signal units for the Fire and Rescue Service.
- Standards for personal protective equipment, OM 2009/03 (Health and Safety Executive).
- Manual of Firemanship Book 6, Breathing apparatus and resuscitation.

* BS 8468 specifies performance requirements for respiratory protective devices intended to be used during firefighting, rescue, evacuation, escape, hazard containment, decontamination and similar activities by first responders, fire, ambulance, police and associated civilian agencies and workers, in areas containing and contaminated by CBRN(E) agents.

BS 8468 will be published in seven parts as follows:

Part 1: Positive pressure, self-contained breathing apparatus – Specification

Part 2: Negative pressure air purifying devices with full-face mask – Specification

Part 3: Escape hoods – Specification

Part 4: Powered air-purifying respirators – Specification

Part 5: Dual-mode apparatus – Specification

Part 6: Positive pressure compressed airline equipment – Specification

Part 7: Closed circuit breathing apparatus – Specification.

Self-contained breathing apparatus conforming to this standard might be suitable for use in situations other than those involving the specific CBRN(E) agents identified in the standard.

Self-contained breathing apparatus according to this standard shall be positive pressure equipment conforming to BS EN 137, and conforming to the inward leakage specified in this standard, and conforming to the chemical agent penetration and permeation resistance specified in standard. The face-piece shall conform to BS EN 136:1998 class 3.

Chemical protective clothing

Introduction

7C14.29 As the field of chemical protective clothing is one of constant development and change, with new materials and processes becoming available all the time, it is important to understand that the information provided should not be regarded as definitive but as the best available at this time.

7C14.30 Hazardous material incidents involve a wide range of conditions and uncertainty with a potentially wide range of known and unknown substances involved. Consequently the performance requirements for chemical protective clothing contained in the European standards for the Fire Service use are high, reflecting their special needs.

7C14.31 The chemical protective clothing necessary to provide satisfactory protection for hazardous materials incidents necessitates the consideration of a number of complex issues in both selection and use. It is essential therefore that this operational guidance be considered in conjunction with the latest relevant British and European standards together with information available from the manufacturers and/or suppliers of chemical protective clothing.

Standards and markings for protective clothing

7C14.32 Harmonised European Standards for personal protective equipment have been developed as the preferred means of demonstrating equipment conformity with the basic health and safety requirements (BHSRs) of the *EC Personal Protective Equipment Directive* (89/686/EEC). Only equipment which meets these BHSRs is entitled to carry the CE mark and to be sold for use in the EC.

7C14.33 The alternative route to obtaining the CE mark involves the manufacturer producing a 'technical file' for the equipment which also demonstrates that it satisfies the BHSRs. In such cases, the equipment will carry the CE mark but may not display any Standard number. The manufacturer's information will contain the performance specification.

7C14.34 Increasingly, European Standards (prefixed EN – European Norm) are being superseded or subsumed by International Standards (prefixed ISO). Where these are adopted in the UK, they will also be issued as British Standards and be prefixed BS.

7C14.35 The British versions of standards (BS EN, BS ISO or BS EN ISO) may have minor differences from the original versions of the standard, usually in the form of a National Foreword or National Annex, to account for legislative or technical variations specific to the UK.

7C14.36 The following tables list the current standards applicable to the various areas of chemical protective clothing.

Standards applicable to chemical protective clothing – hand protection

Number and title	
EN 659:2003 – Protective gloves for firefighters	(Suitable for EACs ‘S’, ‘T’, ‘Y’, and ‘Z’)
EN 374-3:2003 – Protective gloves against chemicals and micro-organisms: Resistance to permeation by chemicals	Required by DCOL 2/1996
EN 374-1:2003 – Protective gloves against chemicals and micro-organisms	
EN 455-1:2000 – Medical gloves for single use – Part 1: Requirements and testing for freedom from holes	
EN 455-2:2000 – Medical gloves for single use – Part 2: Requirements and testing for physical properties	
EN 455-3:2006 – Medical gloves for single use – Part 3: Requirements and testing for biological evaluation	
EN 374-2:2003 – Protective gloves against chemicals and micro-organisms: Determination of resistance to penetration	

Standards applicable to chemical protective clothing – foot protection

Number and title	Comments
EN 13832-1:2006 – Footwear protecting against chemicals – Part 1:Terminology and test methods	
EN 13832-2:2006 – Footwear protecting against chemicals – Part 2: Requirements for footwear resistant to chemicals under laboratory conditions	
EN 13832-3:2006 – Footwear protecting against chemicals – Part 3: Requirements for footwear highly resistant to chemicals under laboratory conditions	
EN 15090:2006 – Footwear for firefighters	F3 – Hazardous materials and structural firefighting – **(Suitable for EACs ‘S’, ‘T’, ‘Y’, and ‘Z’)** (CH – marking for chemical resistance)
Home Office Specification A 29 and A30	**Suitable for EACs ‘S’, ‘T’, ‘Y’, and ‘Z’, however, A30 Leather boots may not provide adequate chemical resistance and therefore caution should be exercised.**

Standards applicable to chemical protective clothing – eye protection	
Number and title	
EN 166:2002 – Personal eye protection – specifications	Markings: 3 – resistant to liquid droplets (goggles), or liquid splashes (face shields, but not mesh) 4 – resistant to coarse dust particles 5 – resistant to gas and fine dust particles 9 – resistant to molten metals and hot solids G – resistant to radiant heat (EN 1731 face shields only) S – increased robustness (oculars only) F – high speed particles, low energy impact (any type) B – high speed particles, medium energy impact (goggles and face shields only) A – high speed particles, high energy impact (face shields only)
EN 14458:2004 – Face shields and visors for firefighters, ambulance and emergency services	**NOTE:** no chemical, dust or particulate protection criteria

Standards applicable to chemical protective clothing – body protection (in addition to EN340: 2003 – general requirements for protective clothing)

Number and title	Comments
***BS 8467:2006** – Protective clothing – Personal protective ensembles for use against chemical, biological, radiological and nuclear (CBRN) agents – Categorization, performance requirements and test methods *(* see note 1 below this table)*	Category of clothing: A – gas tight with breathable air supply B1 – high levels of vapour challenge B2 – high levels of mainly liquid challenge C – low levels without vapour hazard D – very low levels or risk of contact contamination
****EN 943-2:2002** – Protective clothing against liquid chemicals. Gas-tight (Type 1) chemical protective suits for emergency teams (ET) (NB this was developed with the emergency services in mind and has an increased range of chemical resistance) *** see note 2 below this table*	**Suitable for Additional Personal Protection codes ‘A’ and ‘B’** Type 1a-ET: Gas tight chemical protective clothing for use by emergency teams with a breathable air supply independent of the ambient atmosphere, eg a self-contained open-circuit compressed air breathing apparatus worn inside the clothing Type 1b-ET: Gas tight chemical protective clothing for use by emergency teams with a breathable air supply, eg a self-contained open-circuit compressed air breathing apparatus worn outside the clothing Limited use or reusable
EN 463:1995 Protective clothing – Protection against liquid chemicals: Test method.	Determination of resistance to penetration by a jet of liquid (jet test)
EN 464:1994 Protective clothing against liquid and gaseous chemicals, including aerosols and solid particles: Test method.	Determination of leak tightness of gas tight suits (internal pressure test)
EN 468:1995 Protective clothing against liquid chemicals. Test method.	Determination of resistance to penetration by spray (spray test)

Standards applicable to chemical protective clothing – body protection (in addition to EN340: 2003 – general requirements for protective clothing)

Number and title	Comments
****BS 8428:2004** – Protective clothing against liquid chemicals. Chemical protective suits with liquid-tight connections between different parts of the clothing for emergency teams (type 3-ET equipment) ***see note 2 below this table*	**Suitable when the 2nd character of EAC = 'P', 'R', 'W' or 'X'** plus either limited use or reusable
EN 14605:2005 – Protective clothing against liquid chemicals. Performance requirements for chemical protective clothing with liquid tight (Type 3) or spray-tight (Type 4) connections, including items providing protection to parts of the body only (Types PB[3] and PB[4])	**Suitable when the 2nd character of EAC = 'P', 'R', 'W' or 'X' (Type 3 only)** – Type 3 liquid tight connections for whole body – Type 4 spray tight connections for whole body – PB[3] liquid tight partial body protection – PB[4] spray tight partial body protection
EN 943-1:2002 – Protective clothing against liquid chemicals. Ventilated and non-ventilated gas tight (Type 1) and non gas tight (Type 2) chemical protective suits which retain positive pressure to prevent ingress of dusts liquids and vapours	1a gas tight with breathing apparatus inside 1b gas tight with breathing apparatus outside 1c gas tight air fed suit 2 non gas tight air fed suit
EN 13034:2005 – Protective clothing against liquid chemicals. Chemical protective clothing offering limited protection against liquid chemicals (type 6 and type PB [6] equipment)	Type 6 – full body Type PB[6] – partial body
EN 13982-1:2004 – Protective clothing for use against solid particulates – Part 1: Performance requirements for chemical protective clothing providing protection to the full body against airborne solid particulates (type 5 clothing)	
EN 14126:2003 – Protective clothing. Performance requirements and tests methods for protective clothing against infective agents	
EN 469:2005 – Protective clothing for firefighters. Performance requirements for protective clothing for firefighting (Superseded EN 469:1995)	Additional requirements may be met for penetration by liquid chemicals **Suitable for EACs 'S', 'T', 'Y', and 'Z' with SCBA**

Standards applicable to chemical protective clothing – body protection (in addition to EN340: 2003 – general requirements for protective clothing)

Number and title	Comments
EN 1073-1:1998 – Protective clothing against particulate radioactive contamination – Ventilated suits	
EN 1073-2:2002 – Protective clothing against particulate radioactive contamination – non-ventilated suits	
EN ISO 6529:2001 Protective clothing – Protection against liquid chemicals: Test method.	Resistance of materials to permeation by liquids
EN ISO 6530:2005 Protective clothing – Protection against liquid chemicals: Test method.	Resistance of materials to penetration by liquids
BS 7184:2001 Selection, use and maintenance of chemical protective clothing. Guidance	
EN ISO 13982-2:2004 Protective clothing for use against solid particulates.	Test method of determination of inward leakage of aerosols of fine particles into suits
ISO 13994:1998 Clothing for protection against liquid chemicals. Determination of the resistance of protective clothing materials to penetration by liquids under pressure	
EN 14325:2004 Protective clothing against chemicals. Test methods and performance classification of chemical protective clothing materials, seams, joins and assemblages	
EN 14786:2006 Protective clothing – Determination of resistance to penetration by sprayed liquid chemicals, emulsions and dispersions – Atomizer test	
TR 15419:2006 Protective clothing – Guidelines for selection, use, care and maintenance of chemical protective clothing	

***Note 1:**

BS 8467 specifies performance requirements for personal protective ensembles intended to be used during rescue, evacuation, escape, hazard containment, decontamination and similar associated activities by first responders, fire, ambulance, police and associated civilian agencies and workers, for protection during CBRN(E) events.

This standard has been prepared using, wherever possible, existing British and European standards as a base in order to more easily facilitate both the availability of testing facilities and the CE marking process.

The standard covers a variety of ensembles intended to provide varying levels of protection from chemical warfare agents, toxic industrial chemicals, selected biological warfare agents and contamination by radioactive particles. It is assumed that an equivalent amount of protection from radioactive particles will be provided as a result of the protection that is provided from chemical agents.

The standard does not cover ensembles intended to provide protection from ionizing radiation, ie beta and gamma radiation, and for which no currently available chemical protective clothing will offer protection. Ensembles conforming to this standard might be suitable for use in situations other than those involving the specific CBRN(E) agents identified in the standard. Information supplied by the ensemble suppliers or individual component manufacturers will indicate such additional possible performance applications.

Some typical anticipated environments and activities for which the various categories of ensemble could be used are also provided.

The standard identifies categories of ensembles, their associated performance requirements and test methods in order that ensembles can be categorised including both material specific requirements and whole ensemble testing.

The categories of ensemble have been selected based upon the anticipated activities expected to be undertaken by personnel, and the associated physiological demands, together with the knowledge of ensembles currently available.

****Note 2:**

British Standard BS 8428:2004, *Protective clothing – Protection against liquid chemicals. – Performance requirements for chemical protective suits with liquid tight connections between different parts of the clothing for emergency teams (type 3-ET equipment,)* may be considered complementary to BS EN 943-2:2002 which is for gas tight, Type 1 chemical protective suits for emergency teams.

However it should be recognised that unlike BS EN 943-2, BS 8428 is purely a British Standard, the European work on such a standard having been discontinued through lack of support. Hence BS 8428 does not carry the ‘presumption of conformity’ that comes with *European Harmonised Standards* whereby meeting the standard brings with it conformity with the *Personal Protective Equipment Directive* and the ability by the manufacturer to affix the CE mark.

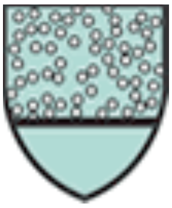
Therefore Fire and Rescue Services should be aware that any manufacturer wishing to utilise BS 8428 to gain CE certification will have to incorporate the standard into their technical file for submission to their notified body for award of the CE mark.

Fire and Rescue Services wishing to procure either gas tight or liquid tight suits are urged to strongly consider the adoption of BS EN 943-2 or BS 8428 respectively into their own performance specifications.

Types of chemical protective clothing

Types of chemical protective clothing designated under the standards		
Description and pictogram		**Types, standards and comments**
Gas tight		BS EN 943: 2002 Protective clothing against liquid and gaseous chemicals, aerosols and solid particles EN 464:1994, internal pressure test Type 1 – Suits which are intrinsically sealed against the environment Type 1a & 1aET – a suit with breathable air supply independent of the ambient atmosphere eg a self-contained open-circuit compressed air breathing apparatus worn inside suit (ET stands for emergency team and relates to firefighters) Type 1b & 1bET – a suit with breathable air supply eg self-contained open-circuit compressed air breathing apparatus, worn outside the suit Type 1c – a suit with breathable air providing positive pressure eg airlines **BS EN 943:part 2 CPC (1aET and 1bET) satisfy APP codes 'A' and 'B'**
Non gas tight		BS EN 943: 2002 Protective clothing against liquid and gaseous chemicals, aerosols and solid particles Suits which retain positive pressure to prevent ingress of dusts liquids and vapours Type 2 – chemical protective suit with breathable air providing positive pressure

Types of chemical protective clothing designated under the standards

Description and pictogram	Types, standards and comments
Liquid tight protective clothing against liquid chemicals 	BS 8428: 2004 BS EN 14605: 2005 – Type 3 EN463: 1994 – "Jet Test" – Determination of resistance to penetration by a jet of liquid Type 3 – liquid-tight connections, including items providing protection to parts of the body only Type PB (3) **BS 8428 and BS EN 14605 Type 3 CPC satisfies the EACs 'P', 'R', 'W' or 'X'**
Spray tight protective clothing against liquid chemicals 	BS EN 14605: 2005 – Type 4 EN468: 1995 – Spray test – Determination of resistance to penetration by spray Type 4 – spray tight connections, including items providing protection to parts of the body only Type PB (4)
Protective clothing for use against solid particulates 	BS EN ISO 13982-1 & 2: 2004 Type 5 – chemical protective clothing providing protection to the full body against airborne solid particulates
Protective clothing offering limited protective performance against liquid chemicals 	BS EN 13034: 2005 / +A1 2009 Type 6 Type PB 6 (part body)

Materials of construction

7C14.37 The selection of materials and construction methods for chemical protective clothing is a complex process. The two most important performance criteria for materials are:

- Protective performance (eg chemical resistance, ie the ability to resist penetration and permeation by hazardous substances)
- 'Wearability' (ie all aspects of fit, mobility, comfort etc)

- Mechanical integrity (ie resistance to abrasion, puncture, etc to ensure safe working conditions and flexibility allowing the material to be assembled into a usable garment)

Performance standards

- **Abrasion resistance** – This requirement is to ensure that chemical protective clothing material achieving a particular class has a degree of abrasion resistance, depending on the intended use. Due to the arduous nature of chemical protective clothing in Fire Service use, the highest performance level is required.
- **Stability to heat** – This requirement indicates whether the chemical protective clothing material tends to 'stick to itself' when subjected to heat. Chemical protective clothing for Fire Service use shall have no blocking (ie shall not stick to itself) when heated. It is important that this test should not be confused with resistance to ignition.
- **Flex cracking** – This requirement is designed to reproduce the effect of the folding and creasing action of the suit due to bending down, movement of arms, etc. In addition, there is a requirement to pass a leak-tightness test.
- **Flex cracking at low temperatures** – A similar requirement to that for flex cracking, but in this case at temperatures of –30C and –60C. A leak-tightness test is carried out after the flex cracking test.
- **Trapezoidal tear resistance** – This requirement indicates the ability of the material to resist tearing, and is dependant on its structure and bonding.
- **Burst resistance** – This requirement is the ability of a material to resist a stretching force.
- **Puncture resistance** – The ability of a material to resist the penetration of a sharp object. If the suit is in use and has cuts in the material, any chemical travelling through such cuts or essential openings is said to have penetrated the suit.
- **Resistance to ignition** – This indicates the material's resistance to ignition, for example if caught in a flash fire situation. For Fire Service use, the material is exposed to a flame for either 5 seconds or 1 second dependant on the performance level to be achieved. The flame should not burn for longer than 5 seconds, or it shall be self-extinguishing. This should be followed by a leak-tightness test.

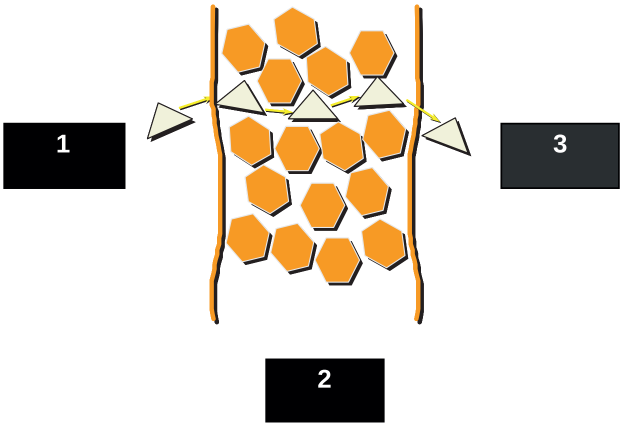
Penetration – a physical process

Penetration

7C14.38 Penetration is a process whereby liquid, gaseous or solid substances penetrate a fabric by passing through pores or holes.

7C14.39 The test for penetration by liquids (EN 6530/EN 368) comprises the material under test having a test sample of 10ml of chemical applied to it for an exposure time of ten minutes. This test rates the resistance of a fabric to permeation by a specified chemical in liquid form.

Permeation



7C14.40 A molecular process, where molecules of the hazard pass through a fabric.

1. Absorption of molecules of liquid on to contact surface.
2. Diffusion of the absorbed molecules through material.
3. Disorption from the opposite surface.

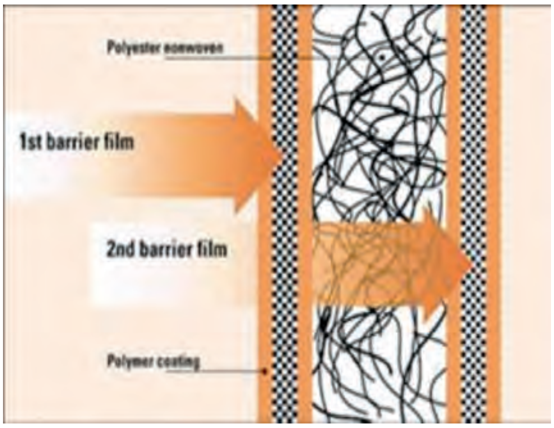
7C14.41 Further details on the permeation test can be found by reference to EN ISO 6529/EN 369/EN 374-3.

Categories of material

7C14.42 The two most common categories of materials available are:

- Laminates/film composites – made up of a plastic film that is laminated on to a substrate (backing material).

Laminated construction of Tychem TK



- Elastomeric – made up of rubber-based materials, such as Butyl, Neoprene, Viton, Hyperlon, and a combination of these coated on to a woven fabric.

Types of usage of chemical protective clothing

- **Reusable chemical protective clothing**
  Generally of elastomeric construction, reuse depends on the type of chemical or chemicals to which the chemical protective clothing has previously been exposed, the effectiveness of any decontamination process, and any possible subsequent degradation of the suit.

- **Limited life chemical protective clothing**
  Generally of laminated construction, provides protection for limited wear life, which is usually determined either by the requirement for repeated hygienic cleaning, or because chemical contamination has occurred.

7C14.43 As the name suggests 'limited life suits' have a shelf life advised by the manufacturer, beyond which they should normally be replaced. In certain circumstances the life of suits may be extended in consultation with the manufacturer providing appropriate conditions for storage, transportation, and periodic testing are met. An example of this is the procedures outlined for extending the shelf life of Tychem TK Limited Life Suits in *Fire Service Circular 25-2004.*

Selection of chemical protective clothing

7C14.44 Chemical protective clothing should only be selected which has the 'CE Mark'. When selecting clothing the user should have an awareness of the *Personal Protective Equipment Regulations*, the relevant European or draft European standards.

7C14.45 There are two main categories of chemical protective clothing currently in use in the Fire and Rescue Service:

- gas tight
- liquid tight.

7C14.46 For both categories it is recommended that a coverall design be used as this provides maximum protection to both the user and their breathing apparatus. In addition, the process of decontamination is usually carried out more effectively on coverall design.

7C14.47 It is further recommended that the performance requirements for the materials of liquid-tight chemical protective clothing are the same as for gas tight.

7C14.48 Also available is the choice of either reusable or limited use chemical protective clothing in both gas tight and liquid tight design.

- **Gloves** – Gloves should meet the requirements of BS EN 374-3 and selection should be made according to the hazard encountered. A dual glove system may afford the best protection. This normally consists of a laminated inner glove having good chemical resistance with an outer elastomeric glove affording protection against mechanical abuse as well as having some degree of chemical resistance

  Ideally the gloves or combination of gloves should afford the same chemical and physical protection as the chemical protective clothing material

  Where gloves are permanently joined to the suit, ie not interchangeable, assurance of their performance data, ie physical and chemical barrier properties, should be sought from the chemical protective clothing manufacturer or supplier

  For exchangeable gloves, similar performance data, ie physical and chemical barrier properties, should be obtained from the glove manufacturer.

- **Visors** – The visor should be permanently fitted to the chemical protective clothing and should be large enough to afford a satisfactory field of vision. Consideration should be given to the fact that, potentially, the visor represents the weakest part of the clothing from the point of view of chemical resistance, and, therefore, unnecessarily large visors should be avoided. The visor should be tested in accordance with BS EN 146.6-7

- **Pass-through** – A pass-through should be fitted to gas tight or liquid tight coverall chemical protective clothing. Breathing apparatus connections require Certification of Conformity from the manufacturer. Reference should be made to BS EN 14594:2005. If chemical protective clothing is selected without a pass-through, risk assessments and standard operating procedures must be in place to address situations where wearers would need a pass-through (eg low air whilst awaiting decontamination etc).
- **Attachment point** – Where an attachment point for a personal line is required, the attachment point should withstand a pulling force of 1000N (Newtons). Any additional exterior attachment points should withstand a pulling force of 250 N

7C14.49 There are many additional considerations that need to be taken into account when selecting chemical protective clothing. The following lists are not intended to be comprehensive and Fire and Rescue Services should consider other matters as necessary during their risk assessment as to the suitability of the clothing, depending upon the intended application.

Practical aspects of chemical protective clothing evaluation

- Is the chemical protective clothing a moderate or severe inducer of heat stress?
- Is the chemical protective clothing material flexible?
- Does the flexibility change with temperature?
- Can the chemical protective clothing accommodate different size wearers?
- Is the chemical protective clothing easy to handle?
- How well is visibility afforded?
- Can the chemical protective clothing accommodate a helmet or hard hat?
- How easy is donning and doffing?
- Does the wearer feel secure and mobile within the chemical protective clothing?

Questions to ask the supplier

- From which materials is the chemical protective clothing constructed?
- Are boots attached to the chemical protective clothing or can different size boots be worn?
- To what European standard is the chemical protective clothing manufactured?
- Are manufacturers' claims supported by data from independent test houses?
- How much does the chemical protective clothing weigh?
- Does the manufacturer provide technical support?

- Is the manufacturer willing to repair/decontaminate damaged chemical protective clothing?
- Will the manufacturer guarantee the integrity of the chemical protective clothing after repair and decontamination?
- Is the manufacturer able to provide comprehensive data on chemical permeation?
- What is the recommended storage time for the chemical protective clothing – how should they be stored?
- How often are pressure tests/visual tests required?
- How does the material perform in specific risks or an incident involving complex mixtures of chemicals, for example pesticides?
- What are the methods of seaming? (Elastomeric materials usually require seaming by adhesives, stitching or curing). What tape material is used?
- How are exchangeable gloves, boots fitted? How easy is the operation of exchange?
- Does the garment provide uniform protection?
- Are the areas of potential mechanical failure minimised (ie seams, joints and interfaces)?
- Does the garment afford maximum comfort, fit and function to the user?
- What special equipment/tooling is required to make the chemical protective clothing functional? Type and amount of labour needed.
- What are the quality control practices of the manufacturer?
- Does the chemical protective clothing require any type of over covers (and why)?
- Can the manufacturer supply contactable references within emergency services?
- Does the manufacturer supply an after-sales service?
- Will the material/chemical protective clothing be of long term availability?
- How is the type of closure fitted?
- How easily are replacement parts available?
- What are the limitations in the manufacturers’ instructions for use?
- Where was the CE Mark obtained?
- Does the manufacturer provide a 24-hour emergency response service?
- What are the visual signs of degradation or fatigue of materials or component parts?

When you have asked all these questions and received satisfactory answers, you should be able to make direct comparison between different products.

Risk assessment

7C14.50 In establishing a policy of operational risk assessment, the following may be considered:

- How long is a chemical protective clothing to be worn? Maximum – minimum duration.
- Is gas tight or liquid tight protection required? Gas tight equipment can be a substitute for liquid-tight equipment, but not the other way round!
- What type of training is necessary?
- What cleaning facilities are available (as opposed to proper decontamination)?
- Are decontamination and after decontamination test facilities available?
- What storage/maintenance facilities are available?
- Is the chemical protective clothing intended for first-response or lengthy clean-up procedure?
- What chemical emergency risk assessments have been made?
- What limitations of use can be expected? Limited mechanical properties and limited chemical resistance properties.
- What fitments/equipment have to be obtained by the user? (Pass-through connections, pressure test kit, gloves, boots, additional over garments, anti-mist/cleaning products, etc)
- Are there site-specific risks?

Selecting chemical protective clothing at emergency hazardous materials incidents

7C14.51 Personal protective equipment should only be used as a last line of protection to control the exposure of staff to hazardous materials. Full guidance on the process of selecting appropriate personal protective equipment at hazardous materials incidents is contained within the generic standard operating procedure (G-SOP) in Part B of this guidance.

7C14.52 There are generally six basic factors that will determine the level and type of protection required by responding crews, which are as follows:

- Toxicity – via inhalation, ingestion or the dermal route
- Corrosiveness – from weak or strong concentrations of acids or alkalis
- Oxidation – where there is a reaction with organics producing heat and/or oxygen

- Temperature – where the substance is at an extreme of temperature hot or cold
- Biohazards – from pathogens and open cultures
- Radiation – (ionising) whether involving an unsealed source or not.

7C14.53 The choice of level of protection may be influenced by reference to the Emergency Action Code; by use of the *Powered respirator protective suits 'hot' zone decision tool;* or by direct access to Chemdata or other similar database.

7C14.54 Before making the final selection, an assessment of the incident should be made, adopting a risk-assessed approach, considering the following aspects:

- The nature of the task to be undertaken
- Whether in the open, or a confined space (eg inside a building)
- Does the substance meet the criteria of being a single substance at normal temperature and pressure? (The basis on which levels of protection are quoted.)
- Is the benefit of wearing chemical protective clothing outweighed by additional hazards presented, ie, fire, working at height, operating hydraulic tools, etc?
- The likelihood of contamination by direct contact with the substance and areas of the wearer most likely to be affected
- Is an immediate life saving action an option, and would the time taken to rig in chemical protective clothing impact on the potential success of that action?

NOTE: It should always be borne in mind that wearing more layers of protection does not always equate to a higher level of safety, and could be detrimental in some circumstances.

7C14.55 It should also be borne in mind that whilst wearing chemical protective clothing incorporating a respirator such as the powered respirator protective suit, constant monitoring for oxygen deficiency in an enclosed working environment should be undertaken.

Dangerous Goods Emergency Action Code List

7C14.56 To determine the level of personal protective equipment required at the initial response phase of an incident involving hazardous materials in a transport scenario, reference may be made to Emergency Action Codes, also known as Hazchem codes. Emergency Action Codes indicate to the emergency services actions that may be necessary, during the first few minutes of an incident involving dangerous goods, should the Incident Commander deem it necessary to take immediate actions.

- Where the 2nd character of the Emergency Action Code is S, T, Y or Z, structural firefighting kit – conforming to BS ENs 469, 659 and 15090) is appropriate with SCBA conforming to BS EN 137

- Emergency Action Code letters P, R, W and X indicate that chemical protective clothing with liquid tight connections for “whole body – Type3” (conforming to the relevant standards such as BS 8428 or BS EN 14605) should be used.

7C14.57 Additional Personal Protection Codes give emergency responders more information on appropriate levels of chemical protective clothing. These codes do not appear on vehicle placards or on Emergency Action Code Cards but are available in the *Dangerous Goods Emergency Action Code List* generally through mobilising controls or mobile data terminals.

7C14.58 The Additional Personal Protection Codes appear as either “**A**” or “**B**” on the list. For both “**A**” and “**B**” codes gas-tight chemical protective clothing should be worn conforming to BS EN 943; part 2.

Operatonal key principle

Additional Personal Protection Codes

Code letter "A" – structural firefighting kit* should be worn, as an additional protective layer, in addition to gas tight chemical protective clothing to protect against one or more of the hazards, indicated in the list by the appropriate character(s) below:

(c)	Liquefied gas with a boiling point below –20C
(fg)	Flammable gas
(fl)	Flammable liquid
(cf)	Liquefied flammable gas with a boiling point below –20C
(h)	The substance may be carried above 100C
(co)	Oxidising gas with a boiling point below –20C
(!)	The substance may have a particularly deleterious effect on chemical protective clothing

NOTE: It should be borne in mind that when directed to apply the Additional Personal Protection Code A, the most vulnerable areas of potential exposure will probably be the hands and feet. Appropriate hand protection relative to the particular hazard must be taken into consideration when conducting the risk assessment of any task to be undertaken. All hazards and control measures must be included in the briefing to the wearers.

Most firefighting gloves cannot be worn with gas tight suits. Even if crews are wearing gloves that meet the additional requirements of Additional Personal Protective Clothing Code "A", they will still not be fully protected against the extremely low temperatures encountered with cryogenic substances.

Code letter "**B**" – Gas tight chemical protective clothing to be worn, in conjunction with self-contained breathing apparatus with no additional requirements.

NOTE: *The structural firefighting kit referred to in code A is specified as tunic and over trousers conforming to BS EN 469, fire fighters gloves conforming to BS EN 659, and fire fighters boots conforming to BS EN 15090 or Home Office Specification. A29 (rubber boots) or A30 (**NOTE:** Leather boots may not provide adequate chemical resistance and therefore caution should be exercised.

Using chemical protective clothing at hazardous materials incidents

7C14.59 The use of chemical protective clothing at an incident must be carefully monitored as wearing the suit can create hazards. Chemical protective clothing crew members have been known to suffer from heat, physical, and psychological stress. The potential for heat stress is increased in staff who:

- have suffered a recent illness (especially vomiting or diarrhoea)
- are suffering from sunburn
- have taken medication that could affect their fluid balance
- are suffering from the after-effects of alcohol consumption.

7C14.60 To avoid excessive heat stress in chemical protective clothing a maximum working period of 20 minutes should be considered. This may be extended by the agreement of the Incident Commander and the wearer. If a wearer displays any symptoms of heat stress such as dizziness, nausea, abdominal discomfort, burning sensation to the skin, dilation of the pupils or possible disorientation, they should be withdrawn immediately.

DRESSING/DISROBING PROCEDURE

7C14.61 It is important that correct dressing and disrobing procedures be adopted at all times to ensure the appropriate level of protection and combined safety and welfare of the wearer.

7C14.62 Examples of dressing/disrobing procedures are outlined in the National Resilience Assurance Team guidance issued for chemical protective clothing provided for Fire and Rescue Service National Resilience. An example safe undressing procedure for gas tight chemical protective clothing conforming to BS EN 943; part2 is contained in section 15 Decontamination, of Part B of this operational guidance.

CLOTHING UNDER CHEMICAL PROTECTIVE CLOTHING

7C14.63 Head protection in the form of a fire helmet or bump hat should always be considered. The level of clothing worn beneath a chemical protection suit should be determined following a risk assessment, which should consider the hazards presented by the substance and environment, task to be undertaken, extremes of temperature (hot or cold) and the potential for heat stress.

WEARING CHEMICAL PROTECTIVE CLOTHING IN FLAMMABLE OR EXPLOSIVE ATMOSPHERES

7C14.64 The rubbing action of synthetic materials used in chemical protective clothing against skin or under garments will cause the build up of electrostatic charge on the fabric. The dissipation of this charge via a spark has the potential to ignite a flammable atmosphere or cause an explosion. In circumstances where the relative humidity is below 25 per cent the likelihood is increased.

7C14.65 For this reason, manufacturers of some chemical protective clothing state that their fabric does not have an anti-static treatment, and should not be used in potentially flammable or explosive environments. Fire and Rescue Services should be aware of any such limitations imposed by manufacturers of their chemical protective clothing. In exceptional circumstances (ie imminent loss of life) where chemical protective clothing has to be worn in flammable or explosive environments, wetting the suit before entry will promote conduction of any electrical charge to ground and reduce electrostatic build up.

Other types of chemical protective clothing

7C14.66 In a potential or identified chemical, biological, radiological, nuclear and explosive (CBRN(E)) or mass decontamination incident, additional forms of chemical protective clothing might be encountered, which could include the following:

POWERED RESPIRATOR PROTECTIVE SUIT

7C14.67 These suits are for use within the 'warm zone' at mass decontamination incidents, and are designed to address some of the limitations of gas-tight suits, such as the working duration of a breathing apparatus set, and physiological effects. From June 2012 they may be used within the 'hot zone at CBRN(E) and hazardous materials incidents subject to a rigorous risk assessment and implementation of strict operating procedures and control measures.

Powered respirator protective suit

7C14.68 A full description of powered respirator protective suits, operational procedures and storage arrangements can be found in the National Resilience *Powered Respirator Protective Suits Manual V2.0* and the *Powered Respirator Protective Suits Hot Zone Standard Operating Procedure.*

CR1 CHEMICAL PROTECTIVE SUIT

7C14.69 This suit evolved as a result of extensive joint trials on behalf of the Police and Fire Service to provide a second generation of chemical protective clothing to meet the needs of both services at a CBRN(E) incident. The evaluation concept was a suit that could give a working duration of up to two hours within the warm zone, with the ability for the wearer to take on refreshment without compromising the level of protection provided.

7C14.70 The CR1 ensemble has been adopted by the Police Service for CBRN(E) incidents but has yet to find an established role within the Fire Service.

CR1 Chemical protective suit

SR3 ‘QUICK DON’ CHEMICAL PROTECTIVE SUIT

7C14.71 The ‘Swift Responder’ 3 suit has evolved as a result of a requirement to have a personal protective equipment that can be donned in under five minutes.

7C14.72 The SR3 ‘Quick Don’ is a single layer suit manufactured from a high performance lightweight material developed by Du Pont and WL Gore that provides the same level of CBRN protection as the CR1, and like the CR1 is coupled with the Avon respirator to form the complete ensemble. The SR3 ‘ Quick Don’ has been supplied to all Police Services within the UK to complement the existing CR1 suits.

SR3 Quick Don suit

PART C–15

Decontamination

General information

Introduction

7C15.1 This section sets out the various types of decontamination systems and procedures that might be employed at hazardous materials incidents. Since the terrorist attacks of 9/11 much research and development has taken place into chemical, biological, radiological, nuclear and explosives CBRN(E) decontamination and it is important to ensure that this work is used to enhance the safety and efficiency of decontamination at conventional hazardous materials incidents where it is appropriate to do so. This operational guidance takes into account the variations between Fire and Rescue Services in the circumstances affecting the rapid provision of full decontamination facilities. Such as the size of the turn-out area, the integrated risk management plan and other geographical features.

7C15.2 Where ever possible reference will be made to some of the tactics, procedures and equipment developed by the Fire and Rescue Service National Resilience programme for CBRN(E) response. This will ensure that all Fire and Rescue Service inter-operability is maintained and all Fire and Rescue Services work to the same principles and definitions. This guidance supersedes all previously issued information including *Fire Service Circulars 8/1976* and *10/1981,* and the *Manual of Firemanship, practical firemanship II, Book 12 part 2.* Separate guidance should be read in conjunction with this note for CBRN(E) specific incidents (eg *Operational and Tactical and Strategic Guidance Documents, Fire and Rescue Service Response to CBRN(E) Events*).

Definitions

7C15.3 It is important that all Fire and Rescue Services adopt common terminology and definitions to improve inter-operability and safety at all hazardous materials incidents whether they are conventional or CBRN(E).

Exposure

7C15.4 Exposure occurs when a harmful substance

- enters the body through a route, for example, inhalation, ingestion, absorption or injection, or
- when the body is irradiated

NOTE: Exposure does not automatically mean you are contaminated.

Contamination

7C15.5 Contamination occurs when a substance adheres or is deposited on people, equipment or the environment, thereby, creating a risk of exposure and possible injury or harm.

NOTE: Contamination does not automatically lead to exposure but may do.

7C15.6 Alpha, beta and gamma emissions in themselves cannot cause contamination, although the actual source materials may be able to depending on their physical properties and their containment.

Cross contamination

7C15.7 Cross contamination occurs when a person who is already contaminated makes contact with a person or object that is not contaminated.

Operatonal key principle

Decontamination

Decontamination is the physical and/or chemical process of reducing contamination to minimise the risk of further harm occurring and to minimise the risk of cross contamination.

Firefighter decontamination (primary decontamination)

7C15.8 Firefighter decontamination is the use of equipment in a planned and structured manner on the incident ground to minimise the risk of further harm occurring and cross contamination to a level as low as reasonably practicable. This is primary decontamination to minimise risk, carried out on-site.

7C15.9 Firefighter decontamination is divided into two levels:

- **Initial decontamination** – the decontamination of firefighters using equipment that is immediately available on a pumping appliance. It should be used in all cases where unforeseen contamination of firefighters has occurred or; where there is an immediate life risk or; where, at a minor incident, the hazards posed by the substance can be adequately controlled by the procedures.

  NOTE: In all cases the Incident Commander must carry out a risk assessment and remember that initial decontamination is intended as a first-aid measure and not a substitute for the provision of full decontamination.

- **Full decontamination** – the decontamination of firefighters using decontamination equipment, structured procedures and staff who have been trained fully in its use.

7C15.10 Fire and Rescue Service’s should also have an ‘**emergency decontamination**’ procedure as an additional control measure for exceptional circumstances such as a break down of personal protective equipment (eg ripped chemical protective clothing, breathing apparatus malfunction, injured wearer etc). The decontamination procedures to be adopted in such circumstances should be adapted from the principles and procedures detailed in this section.

Secondary decontamination

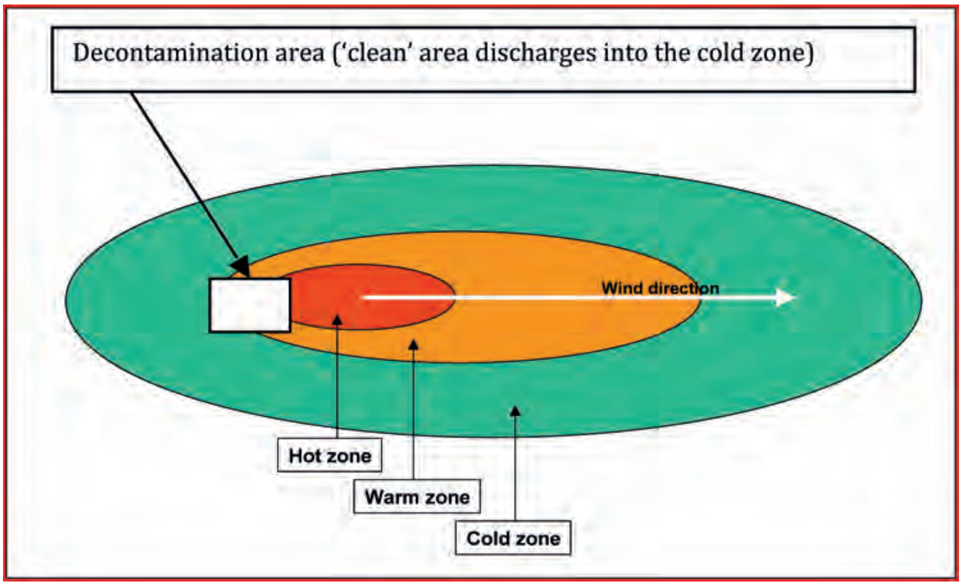
7C15.11 Further off-site decontamination which may involve washing, scrubbing, thermal treatment and airing. This may render the chemical protective clothing clean to visual inspection but does not necessarily assure the complete removal of the contaminant (depending upon the nature of the contaminant). Accurate assessment of the degree of any remaining contamination of clothing or equipment should be made by competent persons.

Decontamination area

7C15.12 This is the area containing the Fire and Rescue Service (and possibly other emergency services’) decontamination staff, equipment and structures. It is a suitable area initially established outside the inner cordon, at first uncontaminated by the initial release, which becomes contaminated by the managed and controlled movement of people who require decontamination. Prior to decontamination commencing, the inner cordon will be adjusted to encompass the decontamination area.

7C15.13 The decontamination area should always be divided into ‘clean’ and ‘dirty’ areas to minimise cross-contamination. Additionally disrobing and re-robing areas may be designated.

Decontamination area



Mass decontamination

7C15.14 Mass decontamination is the planned and structured procedure delivered by the Fire and Rescue Service using purpose designed decontamination equipment where there are large numbers of contaminated casualties.

Improvised decontamination

7C15.15 Improvised decontamination is the use of an immediately available method of decontaminating members of the public prior to the use of specialist resources (eg removal of clothing, rinsing or washing using on-site facilities etc).

Interim decontamination

7C15.16 Interim decontamination is the use of standard equipment to provide a planned and structured decontamination process for large numbers of the public prior to the availability of purpose designed decontamination equipment (eg Fire and Rescue Service hose reels etc).

Clinical decontamination

7C15.17 Clinical decontamination is the process where contaminated casualties are treated individually by trained healthcare professionals using purpose designed decontamination equipment.

Concepts of contamination

7C15.18 The process of decontamination involves the physical and/or chemical reduction or neutralisation of contaminants from staff and equipment. The process is vital to reduce the potential of transferring contaminants beyond the hazard zone and exposing people to harm from the hazardous materials.

7C15.19 The four basic concepts of contamination are:

- avoid contamination, prevent exposure
- surface contamination versus permeation contamination
- direct contamination versus cross contamination
- types of contaminants.

Avoid contamination, prevent exposure

Avoid contamination, prevent exposure

Operatonal key principle

Avoid contamination

The best method of decontamination is to avoid contamination. If you don't get the hazardous materials on you, you can't be exposed to its harmful properties! **(EXCEPTION: Gamma radiation)**

Safe systems of work to prevent or minimise contamination should be part of every Fire and Rescue Service's standard operating procedure for hazardous materials incidents.

7C15.20 A firefighter who has been contaminated when wearing personal protective equipment has not necessarily been exposed. For example, breathing apparatus wearers can be contaminated with asbestos particulates on the outside of their personal protective equipment without having their respiratory system exposed to the contaminant. In order for exposure they must breathe in the particulates through a breach or failure of their breathing apparatus.

7C15.21 Even if a contaminant makes direct contact with a firefighter inside their personal protective equipment, it still does not necessarily mean they will be harmed by the contaminant. Remember harm depends on the dose, route of exposure and the hazards and properties of the contaminant.

7C15.22 Although exposure can occur through a breach or failure of personal protective equipment the most common cause is poor decontamination. Decontamination is a critical control measure at hazardous materials incidents. Fire and Rescue Services should place great emphasis on developing and implementing a well-planned, structured and disciplined approach to decontamination operations. This must be supported by an appropriate training and auditing programme.

7C15.23 If contact with the contaminant is controlled, the risk of exposure is reduced and the need for decontamination can be minimised. To avoid contamination consider the following basic principles:

- Stay up wind and up-hill/slope where possible
- No eating or smoking on-site, and strictly control hygiene where drinking/hydration is provided
- Cover any open wounds
- Staff should refrain from bringing their hands into contact with their face/mouth whilst on-site
- Emphasise work practices that minimise contact with hazardous materials
- Avoid direct contact with hazardous materials wherever possible
- Do not walk through areas of obvious contamination and stay out of areas that potentially contain hazardous materials. Special care should be taken to avoid slips, trips and falls into contaminants
- Do not kneel in contaminants
- If contact is made with a contaminant, move contaminated staff to the decontamination holding area and remove/reduce the contaminant as soon as possible. Generally the longer hazardous materials are in contact with personal protective equipment/staff/equipment the more harm can be done
- Keep the wearers' respiratory protective equipment on as long as possible during the decontamination process
- Use of limited use or disposable chemical protective clothing can significantly reduce the decontamination requirements and mitigate permeation or matrix contamination
- Use a systematic approach to decontamination, don't make it up as you go!

Surface contamination versus permeation contamination

7C15.24 Contaminants can present risks in any physical state (ie gas, liquid or solid). There are two general types of contamination:

- **Surface contaminants** – are found on the outer layer of a material but have not been absorbed into the material. Surface contaminants are usually easy to detect and remove to a reasonably achievable and safe level using Firefighter decontamination procedures (eg dusts, powders, fibres etc).
- **Permeation contaminants** – are absorbed into a material at the molecular level. Permeated contaminants are often difficult or impossible to detect and remove. If the contaminants are not removed they may continue to permeate through the material. Permeation through chemical protective clothing could cause exposure inside the suit. N.B. permeation can occur with any porous material not just personal protective equipment. Factors that influence permeation include:
  - **Contact time**, the longer a contaminant is in contact with an object, the greater the probability and extent of permeation
  - **Concentration**, molecules of the contaminant with flow from areas of high concentration to areas of low concentration. Generally, the greater the concentration, the greater the potential for permeation to occur
  - **Temperature**, increased temperatures generally increase the rate of permeation. Conversely lower temperatures will generally slow down the rate of permeation
  - **Physical state**, generally gases, vapours and low-viscosity liquids tend to permeate more readily than high viscosity liquids or solids.

NOTE: A single contaminant can present both a surface and a permeation threat, this is especially the case with liquids.

Direct contamination versus cross contamination

7C15.25 Direct contamination occurs when a person comes into direct physical contact with a contaminant or when a person comes into contact with any object that has the contaminant on it. Direct contamination usually occurs when working in the ‘hot’ zone but can occur during the decontamination process. Gloves and boots are the most common areas that get contaminated.

7C15.26 Cross, or secondary, contamination occurs when a person who is already contaminated makes contact with a person or object that is not contaminated. It is typically the result of poor site management and cordon control; inadequate decontamination and site safety procedures; or failure to follow safety procedures. Cross contamination is a greater risk when dealing with liquids and solids. It can go on and on, spreading from one person to the next as they touch. This is why it is so important to confine contaminated people and separate the “dirty from the clean”.

Types of contaminants

7C15.27 The more that is known about the contaminant the faster and more focused the decontamination operation can be. The types of contaminants can be divided into categories based on their primary hazards. These include the following:

- **Highly acute toxicity** contaminants can cause damage to the human body as a result of a single or short duration exposure. These can be found in solid, liquid or gas forms and will present risks to firefighters from any route of exposure (eg chlorine, potassium cyanide etc).
- **Moderate to highly chronic toxicity** contaminants, repeated exposure over time to these substances can, cause damage to target internal organs, or the onset of debilitating injuries. These can be found in solid, liquid or gas forms and will present risks to firefighters from any route of exposure (eg certain heavy metals, mercury, benzene etc).
- **Teratogens or embryotoxic** contaminants, these are substances that can act during pregnancy to cause adverse effects on the foetus. The period of greatest susceptibility is the first 8 to 12 weeks of pregnancy. This includes the period when female firefighters may not know they are pregnant, therefore, special precautions must be taken at all times (eg lead compounds, ethylene oxide, formamide etc).
- **Allergenic** contaminants are substances that produce skin and respiratory hypersensitivity. Firefighters are at risk from allergens from both inhalation and direct skin contact. Two people exposed to the same allergen at the same level may react differently (eg chromium, formaldehyde, isocyanates etc).
- **Flammable** contaminants are substances that readily ignite or burn in air and are persistent (ie they hang around and can “stick” to personal protective equipment). Although most are liquids some flammable solids and gases will also present hazards especially when confined (ie indoors etc).Always expect flammables to present more than one contamination problem. Examples – petrol, acetone, benzene, ethanol etc.
- **Highly reactive or explosive** contaminants can react with the oxygen present, others are heat, shock and friction sensitive. The concentration of these contaminates plays an important role in determining the risk involved in decontamination. For example, hydrogen peroxide below 30 per cent concentration presents no serious fire or explosion hazard. However above 52 per cent hazards increase. It is also important to recognise that evaporation and distillation of these materials can cause high risk scenarios. Metal tools such as spatulas and shovels should not be used to clean up peroxides contaminants because metal contamination can lead to explosive decomposition. Obviously firefighters should avoid friction, grinding and other forms of impact.

- **Water reactive** contaminants that react on contact with water or moisture. In many cases, where the amount of the substance deposited on firefighters' personal protective equipment in minimal, decontamination with copious amounts of water will still be an effective method.
- **Etiologic or biological** contaminants are micro-organisms such as viruses, fungi and bacteria. They can cause illness, disease and death. They can enter the body through inhalation, ingestion and direct contact. They are not always labelled clearly and on-site detection techniques and equipment may be limited. Fortunately, most biological contaminants are relatively easy to kill using a wide variety of commercially available decontamination solutions. These are divided into disinfectants and antiseptics.
- **Radioactive** contaminants include some isotopes and radioactive nuclides in the form of a very fine dust or powder. Radioactive contamination can only occur if the radioactive material is unsealed. Unsealed, non-shielded materials pose significant hazards to responders if they enter the body and expose its tissues and organs to irradiation. The physical form of the unsealed material will dictate the type of chemical protective clothing required. Generally, water should not be used to decontaminate wearers as it will spread the contamination and also may also make it more difficult for radiation detection and monitoring equipment to detect areas of contamination. The exception to this is mass decontamination because the large numbers of people involved. For mass decontamination the risk assessment may dictate that full disrobing and wet shower decontamination is most appropriate for the circumstances. Sealed sources may present an exposure risk to responders (ie irradiation) but they cannot cause contamination. Cordon control and monitoring using radiation survey and contamination meters is essential (**NOTE:** Time-distance-shielding) but decontamination will not be necessary unless there is a risk of damage to the source's form of containment. Further information is contained in Section 7 Part C-10 *Radioactive materials.*

NOTE: Beware of contaminants that have multiple hazards.

Decontamination methods

7C15.28 There is no universal decontamination method that will work for every hazardous materials incident. Different decontamination methods will be required for chemical, radioactive and biological contamination. Chemical decontamination for instance may involve mass dilution, whereas minimal quantities of water should generally be utilised for biological and radioactive contamination. Having said that decontamination methods may vary, the general framework of procedures and the structure of Firefighter Decontamination should not. It is vital that operational staff are completely familiar with their set-ups and standard operating procedures. These should be flexible enough to allow for variations in the methods and scale of decontamination. Examples of good practice are detailed in the Chapter 16 of this section.

Physical decontamination

7C15.29 Decontamination methods can be divided into two basic categories:

- **Physical methods** – generally involve physically removing the contaminant from the contaminated person or object. Whilst these methods are often easier to perform and may dilute the contaminant's concentration (ie reducing its harmful effects) it generally remains chemically unchanged.
- **Chemical methods** – generally involve removing the contaminant by some type of chemical process.

NOTE: Some methods may introduce other hazards into the process.

Operatonal key principle

Environmental considerations

The Environment Agency should be notified at the earliest opportunity that decontamination is taking place, with details of the contaminant involved and method of decontamination. The default option should be to contain the contaminated decontamination run-off until Environment Agency liaison has taken place.

Physical decontamination

- **Absorption** – is the process of soaking up a liquid hazardous material to prevent enlargement of a contaminated area. It is primarily used in decontamination for wiping off personal protective equipment, respiratory protective equipment, chemical protective clothing and other equipment using sponges, absorbent pads, towels or disposable cloths. Contaminants in absorbents remain chemically unchanged. Absorbent materials should be inert or have no active properties.

- **Adsorption** – is the process of a contaminant adhering to the surface of another material. The adhesion takes place in an extremely thin layer of molecules between the contaminant and the adsorbent. It is primarily used for the clean up of equipment or an area (eg silica, fuller's earth etc). In some cases adsorption can produce heat and can cause spontaneous combustion.
- **Brushing or scraping** – basically involves using physical movement to remove a contaminant. It can be used for the decontamination of personal protective equipment, respiratory protective equipment, chemical protective clothing and other equipment in both dry decontamination and wet decontamination operations using liquid decontamination solutions. The object should be remove as much of the gross contamination as possible before moving on to further decontamination processes or safe undressing (eg contaminated dirt and mud should be scraped off of boots before entering decontamination showers etc.).
- **Dilution/washing** – is the use of cold or warm water or soap and water solutions to flush the hazardous materials from protective clothing and equipment. The use of detergent or soap takes advantage of the surfactant properties and works well on oils, greases, polar solvents, dirt, grime, powders etc. Dilution/washing using detergents is the most commonly used method for decontaminating firefighters.
- **Freezing** – has limited use at emergency incidents but is used by clean-up contractors to solidify runny or sticky liquids into a solid so that it can be scraped or flaked up.
- **Heating** – usually involves the use of high temperature steam in conjunction with high pressure water jets to heat up and blast away the contaminant. It is primarily used for the decontamination of vehicles, structures and equipment.

  NOTE: Heating techniques should not be used to decontaminate chemical protective clothing or people.
- **Isolation and dispersal** – is a form of dry decontamination and is a two step process that does involve the use of any water or decontamination solution. Firstly contaminated articles are removed and isolated in a designated area where they are then bagged and tagged. Secondly the bags are packaged in a suitable transportation container and taken to an approved hazardous waste facility.

  NOTE: Any form of dry decontamination carries the increased risk of cross contamination when the decontamination operatives assist with the removal of chemical protective clothing from wearers.
- **Pressurised air** – may be used to blow dusts and liquids from hard-to-reach places in equipment and structures. It should never be used for firefighter decontamination because pressurised air on skin may result in fatal embolisms. A secondary hazard of this method is the aerosolisation of the hazardous materials.

- **Vacuuming** – involves the use of vacuums to collect a contaminant. This method is primarily used to decontaminate structures and equipment and it can be used on a range of contaminants including asbestos, hazardous dusts, fine powders etc. The vacuum must be designed and approved for the specific application. High efficiency particulate air vacuums should be used for personal decontamination of hazardous dusts and fibres (eg asbestos). High efficiency particulate air filters physically capture the contaminant but must be replaced frequently.

  NOTE: The use of high efficiency particulate air vacuums in fire related incidents may not be effective due to the amount of wet personal protective equipment, respiratory protective equipment and chemical protective clothing.

- **Evaporation** – is simply allowing a contaminant to evaporate or gas-off particularly useful if the vapours do not present a hazard. Its effectiveness can be limited when dealing with porous surfaces and large quantities of materials.

Chemical methods

- **Chemical degradation** – is the process of altering the chemical structure of the contaminant through the use of a second chemical or material. Commonly used degradation agents include calcium hypochlorite bleach, sodium hypochlorite bleach, sodium hydroxide (household drain cleaner), sodium carbonate slurry (washing soda), calcium oxide slurry (lime) etc. Chemical degradation is primarily used to decontaminate structures, vehicles and equipment and should not be used on chemical protective clothing. They should never be applied directly to the skin. Technical advice must be obtained from product specialists to ensure that the solution used is not reactive with the contaminant.

- **Neutralisation** – is the process used on corrosives to bring the pH of the final solution to somewhere within the range of pH 5 to pH 9. The neutralisation process uses an acid to neutralise alkalis or vice versa. Preferably, the less harmful by-product produced is a neutral or biodegradable salt. It is primarily used to decontaminate structures, vehicles and equipment that are contaminated with a corrosive material.

- **Solidification** – is a process by which a contaminant physically or chemically bonds to another object or is encapsulated by it. This method is primarily used to decontaminate equipment and vehicles. Commercially available solidification products can be used for the clean-up of spills.

- **Disinfection** – is the process used to inactivate virtually all recognised pathogenic micro-organisms. Proper disinfection results in a reduction in the number of viable organisms to some acceptable level. It does not cause complete destruction of the micro-organism you are trying to remove.

Consequently, it is important that firefighters obtain technical advice about disinfection techniques prior to their use. There are two major categories of disinfectants:

  - chemical disinfectants, the most practical for on-site operations
  - antiseptic disinfectants are designed primarily for direct application to the skin.

- **Sterilisation** – is the process of destroying all micro-organisms in or on an object. Because of the size of the equipment needed to carry out this form of decontamination it has limited emergency use and cannot be used on operational staff. Emergency response equipment may be sterilised through autoclaving but the ability for the item to withstand this process must be confirmed by the manufacturer.

  NOTE: In 1995 the Home Office Fire and Research and Development Group carried out research into the effectiveness of various methods of decontamination used by Fire and Rescue Services. It was decided to carry out trials using the three following types of chemical protective clothing:

- a non-coverall (breathing apparatus outside) chemical protection suit, made of poly vinyl chloride (PVC)
- a coverall suit, made of neoprene
- a gas-tight suit made of hyperlon/neoprene.

7C15.30 A shortened summary of the effectiveness of various decontamination methods can be seen in the table below. The shower system tested in these trials was of the mass dilution type.

Method summary	Overall average reduction (1–8)
Strong detergent scrub and shower	5.6
Hot detergent scrub and shower	5.0
Scrub with detergent then hose reel	4.7
Scrub with detergent then shower – not rubbing	4.4
Hosereel only – rubbing	4.2
Car wash brush with detergent	3.8
Car wash brush – no detergent	3.3
Shower – rubbing – no detergent	3.1
Shower – no rubbing, no detergent	2.7

NOTE: A score of 8 represents the complete removal of containment. All methods cleaned the suits well enough to remove the wearers from them.

7C15.31 It was found that:

- none of the decontamination methods used were completely successful in removing all the contaminant but some methods were found to be more successful than others
- generally methods that used some form of scrubbing with detergent gave a greater degree of decontamination
- methods which used hose reels or main jet/spray branches out-performed the portable shower units, when used alone
- vacuum cleaners appeared to be relatively ineffective against dry powder contaminants.

7C15.32 The Group recommended that after primary decontamination (ie firefighter decontamination on-site) has been effected, Fire and Rescue Services should consider whether any further action is necessary before a used suit is returned to operational service. This will depend on the chemical encountered and the degree of contamination. Appropriate records, including the nature of contaminants, should be kept. For further information see *DCOL 8/1995 Item D* and *CFBAC Research Report No. 63.*

Firefighter decontamination

Introduction

7C15.33 Firefighter decontamination is the use of equipment in a planned and structured manner on the incident ground to minimise the risk of further harm occurring and cross contamination to a level as low as reasonably practicable. This the 'primary decontamination' and is carried out on-site.

7C15.34 However, it should be recognised that at some incidents the nature or the extent of the contamination may be such that adequate decontamination is beyond the resources of the Fire and Rescue Service and requires specialist treatment. This is the 'secondary decontamination'.

7C15.35 Fire and Rescue Service firefighter decontamination procedures should aim to:

- minimise the risk of people being exposed to contaminants
- enable responders to remove contaminated clothing, personal protective equipment and respiratory protective equipment without being exposed to hazardous materials
- stop hazardous materials being spread beyond the decontamination area.

Operatonal key principle

Firefighter decontamination (primary decontamination)

The success of decontamination depends on the strict observance of a disciplined procedure within the defined area.

Firefighter decontamination should be set-up prior to crews being committed to the hazard zone.

Selection of the level of decontamination

7C15.36 Firefighter decontamination (primary decontamination) is divided into two levels:

- **Initial decontamination** – is the decontamination of firefighters using equipment that is immediately available on a pumping appliance. It should be used in all cases where unforeseen contamination of firefighters has occurred or; where there is an immediate life risk or; where, at a minor incident, the hazards posed by the substance can be adequately controlled by the procedures

  NOTE: In all cases the Incident Commander must carry out a risk assessment and remember that initial decontamination is intended as a first-aid measure and not a substitute for the provision of full decontamination).

- **Full decontamination** – is the decontamination of firefighters on-site using decontamination equipment, structured procedures and staff who have been trained fully in its use.

7C15.37 Both levels of firefighter decontamination usually involve two processes. Firstly:

- contamination reduction, and then
- safe undressing.

7C15.38 The level of decontamination chosen will be based on the:

- nature of the contamination
- degree of contamination
- type of protective clothing worn
- method of decontamination
- life risk and urgency to intervene.

Positioning of the decontamination area

7C15.39 The factors that will influence the positioning of the decontamination area are the:

- operational circumstances and risk assessment
- level and method of decontamination
- weather conditions
- wind direction (see photos of improvised 'wind socks' below)
- slope of the ground
- location of drains, watercourses etc (or their absence)
- position of the inner cordon and 'hot' zone
- location of breathing apparatus entry control
- location of a pumping appliance
- welfare of staff.

Improvised wind socks

Decontamination system

7C15.40 The following is a generic Fire and Rescue Service decontamination system. It is a good practice model which should be considered at every hazardous materials incident irrespective of the level of decontamination selected. Elements of it may not be necessary depending on the operational circumstances.

Generic decontamination system			
No.	**Stages**	**Considerations for initial decontamination**	**Considerations for full decontamination**
1	**Position the decontamination area**	See paragraph 7C15.39 above	See paragraph 7C15.39 above
2	**Brief wearers** (and operatives if applicable)	Hazards Avoid contamination Minimise contact and note areas of contact Safe path to decontamination area Decontamination method – make sure they know what to do! Remove personal items form pockets	As for initial decontamination
3	**Set-out the decontamination area**	See photos below under Initial decontamination procedure 7C15.43	See diagrams below 7C15.51
4	**Drop tools**	Designate an area Brief wearers	Position a suitable sealable container or bags Brief and instruct wearers
5	**Remove or reduce contamination** (from external surfaces or layers of personal protective equipment)	Before starting check for breaches of personal protective equipment and personal exposure Likely to be a single stage Eg hose reel spray Likely to be self or "buddy" operated procedure	Before starting check for breaches of personal protective equipment and personal exposure Wearers assisted by decontamination operators Consider MD4 unit Multiple methods / steps? eg procedure: – remove gross contamination eg boots and gloves – rinse – wash – scrub – rinse Wipe chemical protective clothing zips, personal protective equipment joins and respiratory protective equipment seals

Generic decontamination system			
No.	**Stages**	**Considerations for initial decontamination**	**Considerations for full decontamination**
6	**Undress safely** (external layers of personal protective equipment or chemical protective clothing depending on degree of contamination)	Standard procedure Peel chemical protective clothing back on its self Wearers don medical gloves when working gloves are removed Breathing apparatus removed last **NOTE:** Weather protection (consider 7C15.44 if applicable)	As for initial decontamination but note: Safe undressing procedures for gas tight chemical protective clothing has been developed for mass decontamination these may be used at conventional incidents and are detailed in 7C15.93
7	**Check for exposure**	Gaps in personal protective equipment Visual contamination Radiation – contamination meter	As for initial decontamination
8	**Wash hands, face and any areas of exposure**	General hygiene requirement Soap and water	As for initial decontamination
9	**Re-robe and welfare**	Personal hydration National Resilience re-robe packs	As for initial decontamination Designate a welfare area
10	**Record any exposure**	Medical surveillance	As for initial decontamination
11	**Manage contaminated personal protective equipment and equipment**	Assessment by competent person (eg hazardous materials adviser)	Assessment by competent person (eg hazardous materials adviser, specialist advice, manufacturers etc) Contractor support
12	**Secondary decontamination**	See para 7C15.58	See para 7C15.58

Initial decontamination procedure

7C15.41 The first level of firefighter decontamination is initial and utilises equipment carried on pumping appliances. The equipment may range from hose reels to primary shower units. This level of procedure may suffice at many minor incidents, but there will be some at which full decontamination procedures will be required.

For initial decontamination the Incident Commander should consider the following:

- select a decontamination method
- set up a decontamination area
- nominate a decontamination officer (this may be the Incident Commander at minor incidents)
- arrange for assisting staff.

7C15.42 The decontamination method adopted depends on the type of contaminant, amount of contaminant and information from sources such as Chemdata. But generally under this level, decontamination will be a simple wet method using hose reels, brushes and/or sponges followed by a safe undressing procedure.

7C15.43 Broadly there are two ways of carrying out wet decontamination currently in use within the Fire and Rescue Service. These are:

- decontamination of the wearers by operatives using a hose reel, brush and containment dam
- self-decontamination or “buddy” decontamination by the wearers using a shower system or using a hose reel, brush and containment dam.

7C15.44 Again, normally under initial firefighter decontamination the latter type will be used.

Salvage sheets overlapped and with suction hose positioned beneath

Initial decontamination example layout

7C15.45 The photos above show an example layout of initial firefighter decontamination using salvage sheets and hard suction hose to demark the decontamination area and separate clean from dirty respectively. Note also that the dirty area has been clearly divided into a contamination reduction area (with improvised dam) and a safe undressing area (with undressing bags and tripod to assist with breathing apparatus set removal). The clean area contains a bucket for hand-washing and re-robe clothing.

7C15.46 The following photographs illustrate an example of a safe undressing procedure for wearers in breathing apparatus and chemical gauntlets.

Safe undressing procedure for wearers in breathing apparatus and chemical gauntlets	
1. Stand in decontamination bag and remove helmet	

Safe undressing procedure for wearers in breathing apparatus and chemical gauntlets	
2. Wipe or sponge down face mask seal area and any areas known to have been contaminated	
3. Remove breathing apparatus set from body but keep mask on	
4. Wipe or sponge personal protective equipment fastenings and any area where contamination could have gathered unnoticed	

Safe undressing procedure for wearers in breathing apparatus and chemical gauntlets	
5. Remove chemical gauntlets or firefighting gloves, place in bag. Don surgical/disposable gloves	
6. Remove tunic/fire coat and place in bag. Carefully "peel-back" fire trousers keeping hands inside personal protective equipment as far as possible to avoid touching potentially contaminated areas of personal protective equipment	
7. Slide fire/flask hood over breathing apparatus demand valve hose and remove breathing apparatus facemask	
8. Step into 'clean area'. Remove surgical/disposable gloves and drop into decontamination or waste bag in 'dirty area'	

Safe undressing procedure for wearers in breathing apparatus and chemical gauntlets	
9. As a final precaution wash hands and face (**NOTE:** Check for any areas of exposure, then re-robe and proceed to breathing apparatus entry control and then complete any necessary records	

Full decontamination procedure

7C15.47 Full firefighter decontamination is the decontamination of firefighters on-site using decontamination equipment, structured procedures and staff who have been trained fully in its use. Full decontamination should be supported by a decontamination team.

Decontamination team

7C15.48 Most Fire and Rescue Services will mobilise a decontamination unit and team if it is likely that the resources required are greater than those available from the initial decontamination structure. Alternatively the Incident Commander should immediately make-up for decontamination resources if it is anticipated that they may be needed. The team should be supported by a hazardous materials adviser or scientific adviser with regard to technical advice and information.

7C15.49 The decontamination team will, depending on the decontamination method(s), consist of:

- A decontamination officer (or sector commander), who is responsible for:
  - taking charge of decontamination procedures
  - supervising the decontamination area
  - instructing operatives
  - safeguarding contaminated staff
  - taking direction from the Incident Commander (who will be advised by the hazardous materials adviser) with regard to the decontamination method(s)
  - wearing structural firefighting kit and remaining outside the decontamination area.
- A decontamination assistant, who should:

  - wear breathing apparatus and chemical resistant gloves and remain in the clean area (this may be varied through the hazardous materials adviser's risk assessment)
  - act on the directions of the decontamination officer
  - assist the wearers with safe transition to the clean area.
- Decontamination operatives, who should:
  - wear chemical protective clothing and breathing apparatus - cylinder or airline (this may be varied through the hazardous materials adviser's risk assessment)
  - remain within the dirty area
  - act on the direction of the decontamination officer
  - decontaminate the wearers' chemical protective clothing sufficiently to allow safe undressing and transition to the clean area.

Decontamination equipment

7C15.50 A typical list of equipment for use by a decontamination team may include:

- Chemical protective clothing
- Self-contained breathing apparatus
- Powered respirator protective suits
- Airline breathing apparatus equipment
- Vacuum cleaner (approved type only, see note below)

  NOTE: Only CE marked vacuum cleaners (eg Class H for asbestos) with true or absolute "high efficiency particulate arrestor" (HEPA) filters should be used. It is now generally regarded that dry decontamination by use of a vacuum cleaner is not in its own right a complete decontamination process and should be followed by wet decontamination. Also they are best suited to dry, still-air conditions, as these are rarely encountered at operational incidents Fire and Rescue Services should ensure that other methods of decontamination are always available.

- Plastic bags (possibly water soluble) with ties and labels
- Barrier tape, cones, poles, signs
- Soda ash, detergent, bleach, disinfectant
- Flexi brush with water control
- Shower system
- Water containment system and pump
- Portable dam

- Fire and Rescue Service National Resilience MD4 firefighters' decontamination unit
- Salvage sheets
- Appropriate tabards and loud hailer
- Clean overalls and footwear
- National Resilience disrobe and re-robe packs
- Radiation survey and contamination meters
- Dry encapsulation material (Fuller's earth).

Decontamination good-practice

- Note any areas that come into contact with the hazardous materials and ensure these are focused on during decontamination (eg feet and hands)
- When reducing contaminants from wearers start at the top (ie head or helmet) and work down
- When wiping, scrubbing, brushing or spraying wearers focus on the areas of likely contamination and areas where substances could build up (eg creases, folds and joins in chemical protective clothing, under webbing or straps etc) beware forcing contaminants beneath the layer of personal protective equipment
- Safe undressing procedures for mass decontamination crews carrying out firefighter full decontamination have been developed through the Fire and Rescue Service national resilience project. These are contained in Chapter 3 and should be considered for any firefighter decontamination set-up
- Respiratory protective equipment should generally be the last item removed when carrying out the safe undressing procedure
- When using wet decontamination methods ensure that:
  - zips and other joins in personal protective equipment and chemical protective clothing are sponged before they are opened to avoid water entering the wearers' under-clothing
  - dissolvable bags are of the 'hot wash' type not cold to prevent premature degradation.
- Should wearers, following unforeseen circumstances or immediate life saving rescues, need to carry out emergency dis-robing (ie the stripping away of contaminated, or potentially contaminated, personal protective equipment and clothing in the dirty area prior to 'contamination reduction' actions) consider using the National Resilience dis-robe packs (see emergency decontamination below)

- All procedures should be set-out clearly on water resistant boards to assist the decontamination team and wearers who may experience difficulty in communications.

7C15.51 Recording should be carried out away from the decontamination area including the clean area. Any exposure of staff to hazardous materials must be recorded. The following details may be needed:

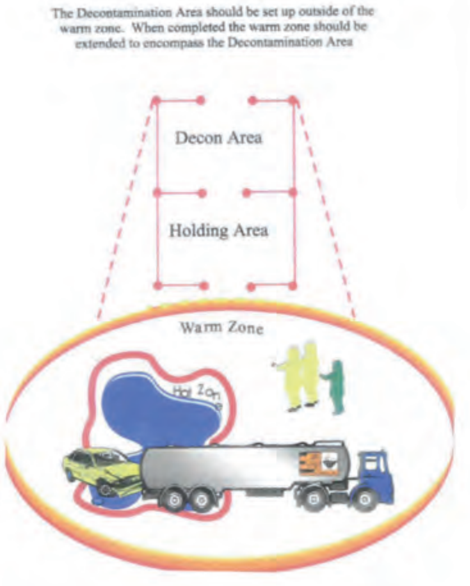
- Names, addresses and contact numbers
- Hazardous materials involved
- Role at the incident
- How exposure occurred
- Period of exposure
- Areas of the body exposed
- Decontamination and medical treatment.

NOTE: This information must be immediately available after the incident in case of delayed physical or medical reactions to the exposure.

7C15.52 The following diagrams and photographs show an example set-up of full firefighter decontamination which could be used with the generic decontamination system detailed in 7C15.40.

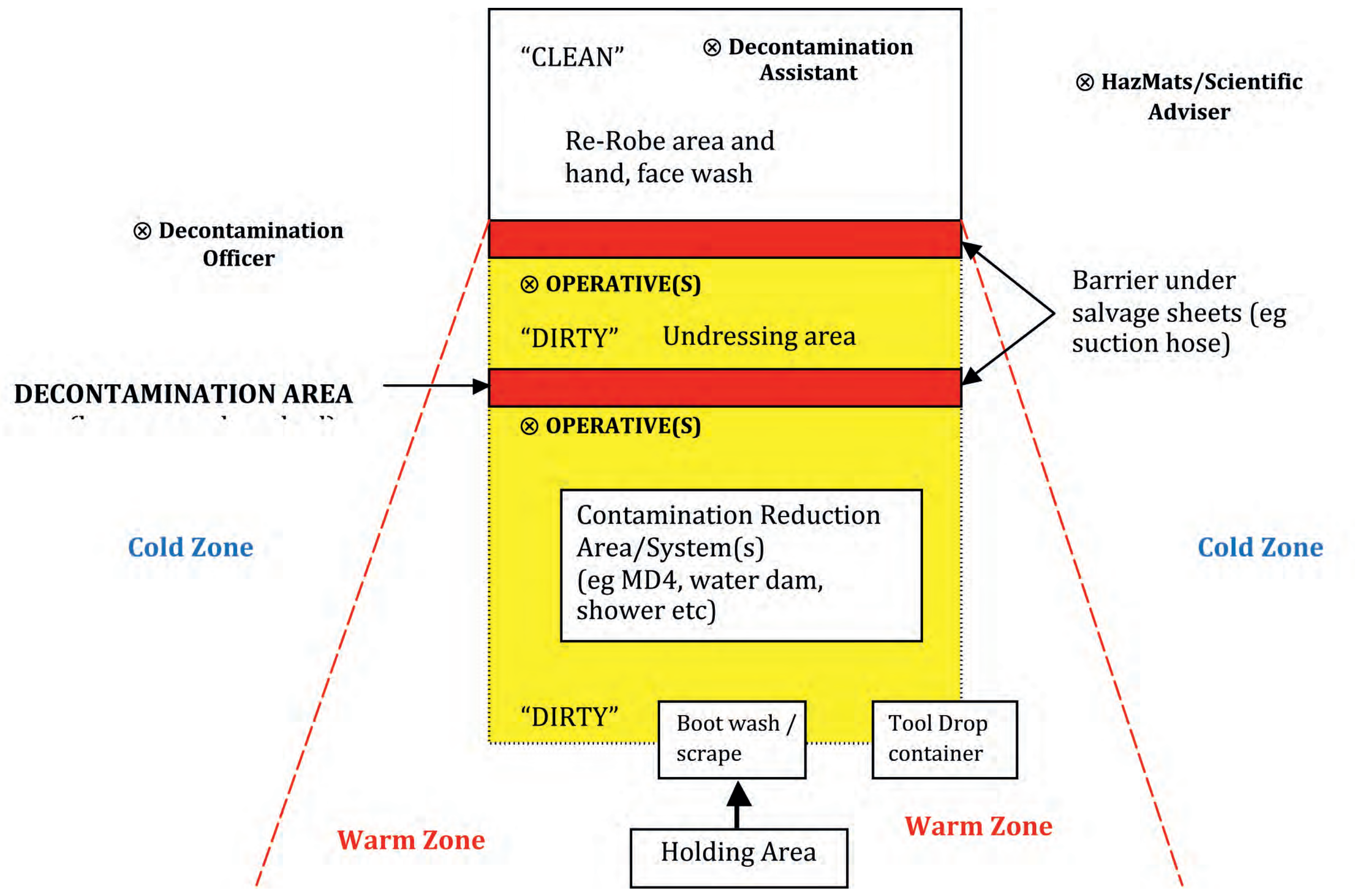
7C15.53 Fire and Rescue Services should tailor their specific procedures and equipment to their local circumstances and risk assessments which should be informed by their integrated risk management plans. Many Fire and Rescue Services are incorporating the MD4 firefighter decontamination unit, provided through the Fire and Rescue Service National Resilience Programme, into their hazardous materials standard operating procedures.

Diagram 1



The Decontamination Area should be set up outside of the warm zone. When completed the warm zone should be extended to encompass the Decontamination Area

Diagram 1


“CLEAN”
⊗ Decontamination Assistant
Re-Robe area and hand, face wash
⊗ HazMats/Scientific Adviser
⊗ Decontamination Officer
⊗ OPERATIVE(S)
“DIRTY” Undressing area
Barrier under salvage sheets (eg suction hose)
DECONTAMINATION AREA
⊗ OPERATIVE(S)
Cold Zone
Contamination Reduction Area/System(s) (eg MD4, water dam, shower etc)
Cold Zone
“DIRTY”
Boot wash / scrape
Tool Drop container
Warm Zone
Holding Area
Warm Zone

Use of a "tool drop" bin within a full decontamination set-up

Firefighters in gas tight CPC in the "contamination reduction area" of a Full Decontamination set-up using the "buddy" system to wash down contaminants

MD4 Firefighter decontamination shower incorporated into an example of a full decontamination set-up

Emergency decontamination

7C15.54 Fire and Rescue Services should also have an ‘emergency decontamination’ procedure as an additional control measure for exceptional circumstances such as a break down of personal protective equipment (eg ripped chemical protective clothing, breathing apparatus malfunction, injured wearer etc). The decontamination procedures to be adopted in such circumstances should be adapted from the principles and procedures detailed above.

7C15.55 The occasions where emergency decontamination will be necessary include:

- where Fire and Rescue Service staff have:
  - inadequate protection
  - sustained damage to their chemical protective clothing (including boots)
  - sustained injury
  - breathing apparatus set failure, low on air
  - wearer distress; or where there are
- members of the public or site staff who are not protected or who have inadequate protection.

7C15.56 Where responders are wearing chemical protective clothing and require emergency decontamination, every effort should be made to remove the suit whilst ensuring that contamination does not contact the skin of the wearer. A peel-back or dry-peel procedure should be used.

7C15.57 If they have suffered skin contamination, either via a damaged suit or because of inadequate or no protection, contaminated clothing should be removed and affected skin washed with warm soapy water. Casualties should then be removed to hospital, accompanied by details of the extent and type of contamination.

7C15.58 It should be noted that the removal of outer layers of clothing in a controlled way will in most cases remove up to 80 per cent of the contaminant.

7C15.59 The use of a Fire and Rescue Service shower system at normal pressure is not normally recommended for the emergency decontamination of people unless breathing apparatus is worn. This is due to the irrespirable atmosphere created within a shower.

Secondary decontamination

7C15.60 Chemicals which adhere to the surface of the chemical protective clothing (surface contamination) are fairly easy to remove, this means that until the clothing has been decontaminated the surface contamination presents the most significant risk to unprotected staff handling it or to the wearer during disrobing. This is the reason chemical protective clothing is decontaminated at the site to remove the surface contamination before undressing (ie primary decontamination). Primary decontamination may or may not remove any chemicals that have been absorbed or permeated into the chemical protective clothing material (permeation or matrix contamination).

7C15.61 Accurate assessment of the degree of any remaining contamination of chemical protective clothing can only be made by proper laboratory procedures which may involve a destructive test, thereby making re-use of a "test suit" impossible.

7C15.62 Chemicals that have been absorbed into the matrix of the chemical protective clothing material may in some cases continue to diffuse through the material during storage thereby presenting a possible risk of contamination to those who next wear or handle the clothing.

7C15.63 The practice of firefighter or primary decontamination of chemical protective clothing on-site after contamination by hazardous materials is intended to clean the suit and reduce any contamination, to assist safer undressing procedures. This should generally be considered as only part of a decontamination process.

7C15.64 Further off-site decontamination (ie secondary decontamination), which may involve washing, scrubbing, thermal treatment and airing, will generally be needed. Fire and Rescue Services should put systems in place to assess chemical protective clothing, respiratory personal equipment, equipment and other kit. This should take place as soon as possible after the incident and should be carried out by a competent person who has access to specialist advice. The assessment and its findings should be recorded.

NOTE: Just because chemical protective clothing appears to be clean to visual inspection, but does not necessarily assure the complete removal of the contaminant, depending upon the nature of the contaminant.

7C15.65 Consideration as to whether re-use is possible should be based upon this assessment of the hazardous materials involved and the circumstances of the particular incident. Care should be taken in the re-use of chemical protective clothing and advice, relating to its ability to continue to be used safely, may need to be sought from the clothing manufacturer/supplier or other competent person/agency.

NOTE: General degradation of chemical protective clothing may lessen the standard of chemical protection afforded. Degradation may be due to:

- exposure to chemicals
- mechanical damage
- ageing
- any combination of the above.

7C15.66 Further information on decontamination is contained in the *Home Office Fire Research and Development Group report 9/94* and *2/95* and *DCOL 8/1995 Item D.*

Mass decontamination

Introduction

7C15.67 Mass decontamination is the planned and structured procedure delivered by the Fire and Rescue Service using purpose designed decontamination equipment where there are large numbers of contaminated casualties.

7C15.68 The responsibility for decontaminating members of public lies with the Department of Health. The decision on whether or not to decontaminate people will be taken by the Ambulance Service in consultation with the Fire and Rescue Service and the police.

7C15.69 Full specific guidance on mass decontamination is outside the scope of this document, further information can be found in the following documents:

- Fire and rescue services Circular 58-2006 – Memorandum of Understanding on Mass Decontamination, DCLG
- Tactical Guidance Document – Fire and Rescue Service Response to CBRN Events, DCLG 2008
- Fire and Rescue Service Response to CBRN(E) Events – Operational Guidance Document, DCLG 2012
- Fire and Rescue Service response to CBRN(E) Events – Strategic Guidance Document, DCLG 2012
- National Resilience IRU and Mass Decontamination Manual V3.

Fire and Rescue Service mass decontamination structures under construction

Improvised decontamination

7C15.70 Improvised decontamination is the use of an immediately available method of decontaminating members of the public prior to the use of specialist resources.

7C15.71 Generally in the very early stages of the incident and dependant on the symptoms and needs of contaminated people, improvised decontamination may be initiated by emergency service personnel, witnesses to the incident, passers by or even the contaminated people themselves.

7C15.72 The need to commence improvised decontamination depends on the type of contamination, the availability of a means of decontaminating and the symptoms displayed by the contaminated people.

7C15.73 Improvised decontamination may take many forms, including removal of contaminated clothing, wiping down, washing, wiping, rinsing etc and can have a positive effect on the contaminated people eg removing contaminated clothing will achieve reduction of personal levels of contamination.

7C15.74 The Ambulance Service and police may initiate the use of improvised decontamination in the early stages of a CBRN(E) event, dependant on the symptoms and needs of contaminated people.

7C15.75 The Fire and Rescue Service Incident Commander may also consider improvised decontamination but would normally consider establishing the more structured approach of interim decontamination.

7C15.76 Any contaminated people who are subject to improvised decontamination should also subsequently be processed through clinical decontamination or through mass decontamination.

Interim decontamination

7C15.77 Interim decontamination is the use of standard equipment to provide a planned and structured decontamination process for large numbers of the public prior to the availability of purpose designed decontamination equipment.

7C15.78 In the early stages of the incident and dependant on the symptoms and needs of contaminated people the Fire and Rescue Service Incident Commander may decide to establish interim decontamination systems. This decision should be taken in consultation with Ambulance Service and Police Service Incident Commanders where they are present. In the absence of the Ambulance Service or police personnel then the Fire and Rescue Service Incident Commander may make the decision unilaterally.

7C15.79 Consideration should be given to the benefits of establishing interim decontamination and also to the risks (eg dependant on the method used there may be issues around maintaining systems for long periods, little disrobe provision, no re-robe provision, no ability to warm water, no enclosures, no ability to capture water run off, limited Fire and Rescue Service personnel protective equipment, contamination of appliances and equipment etc).

7C15.80 Where interim decontamination is established and used, Fire and Rescue Service disrobe packs should be deployed if necessary prior to and (if available) after interim decontamination as people await passage through full clinical decontamination or mass decontamination systems.

7C15.81 There is no national standard for interim decontamination, each Fire and Rescue Service having established its own individual methods, however interim decontamination has the advantage of being a more structured and controlled method than improvised decontamination.

7C15.82 The following is an example of how standard pumping appliances can be used to provide interim decontamination. Methods such as this may prove invaluable where incident response units carrying mass decontamination assets have long travel and set-up times.

Position the appliances

7C15.83 Position two appliances approximately 1.5 to 2 meters apart, with the near side of both vehicles parallel to each other.

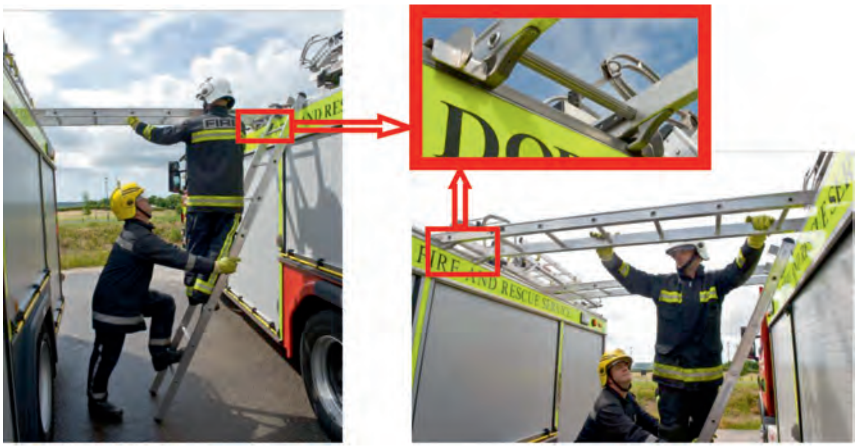
NOTE: (Ensure the exhausts face outermost), and the bodies of the vehicle inline with each other so the rear locker on one vehicle is opposite the front locker of the other vehicle.

Positioning of Fire Service vehicles

Set-up the shower frame

7C15.84 Separate a short-extension ladder and place the widest extension up against one appliance inline with the middle locker to use to gain access to the appliance roofs. At no time should operational staff mount the roof of an appliance. Position other extensions of ladders to bridge the gap between the vehicles (ensure the ladder pawls are against the roof of the vehicle).

Shower frame



Set-up the shower units

7C15.85 Using both hosereels from each vehicle. Lock each branch open and set to wide spray on maximum flow. Hang the branches over rounds nearest to the vehicle and position branch to spray inwards. Ensure all windows and doors are shut, and lockers closed as far as possible.

7C15.86 Set in to the nearest hydrant or other water supply and charge hosereels to 10-20 bar. Adjust nozzles to ensure a good 'mist' affect is achieved.

Shower nozzles mist effect

7C15.87 This set-up is an example only. Fire and Rescue Services should risk assess it, or any other method, fully before adopting it into their standard operating procedures.

Clinical decontamination

7C15.88 Clinical decontamination is the process where contaminated casualties are treated individually by trained healthcare professionals using purpose designed decontamination equipment.

7C15.89 The Ambulance Service defines casualties and prioritise in the following manner:

- **Priority 1 (P1) Casualties:** Patients with a high priority for either immediate emergency medical care or immediate emergency life-saving decontamination or both
- **Priority 2 (P2) Casualties:** Less severely affected patients who need either emergency medical care or early decontamination to prevent further intoxication
- **Priority 3 (P3) Casualties:** Patients with slight to moderate intoxication and without contamination at a level that requires immediate action. Of these P3 casualties a percentage will leave the scene and self-present to local hospitals and clinics.
- **Fatalities**

7C15.90 Clinical decontamination is the responsibility of the Ambulance Service and is a structured and thorough decontamination process carried out by Ambulance Service personnel for contaminated P1 or P2 casualties, who by definition are unable to proceed unaided through the MD process.

7C15.91 The Ambulance Service consider all contaminated people to be casualties, however all P3 casualties will proceed without physical assistance to the decontamination structures and will then proceed through the Fire and Rescue Service ambulant decontamination structures again without the need for physical assistance. P1 and P2 casualties will normally be rescued by Fire and Rescue Service staff and will be taken to the Ambulance Service decontamination structures for clinical decontamination, which will be undertaken by Ambulance Service personnel. A more in depth casualty sort will be conducted by Ambulance Service personnel as soon as time and resources permit.

7C15.92 It is assumed that there will be a large number of people within the inner cordon who will require precautionary decontamination. These people will proceed to the decontamination structures and will then proceed through the Fire and Rescue Service ambulant decontamination structures without the need for physical assistance.

7C15.93 Clinical intervention within the inner cordon may also be possible. The Ambulance Service has developed a capability to provide hazardous area response capability with the introduction of Hazardous Area Response Teams (HART).

Safe undressing procedures

Gas tight chemical protective clothing safe undressing procedures

7C15.94 The following is an aide memoir for crews carrying out firefighter Full Decontamination using the National Resilience gas tight chemical protective clothing.

7C15.95 Procedure:

1. **Operative:** Provide prepared Tyvek/decontamination bag and place adjacent to veranda ready to receive Wearer
2. **Wearer:** Step into Tyvek/decontamination bag
3. **Operative:** Disarm automatic distress signal unit with spare key provided
4. **Wearer:** Withdraw arms into suit and disconnect gas tight chemical protective suit umbilical from breathing apparatus set and unfasten gas tight chemical protective suit waist belt
5. **Wearer:** Don the pair of *nitrile/medical gloves and cross your arms on your chest
6. **Operative:** Open zip flap and mop zip area from top to bottom with paper towel, place used paper towel in bag
7. **Operative:** Unzip suit, fold back zip carefully and peel down to boot level ensuring the outside of the suit including the zip does not touch the wearer
8. **Wearer:** If necessary use your gloved hands to lean on operatives for support
9. **Wearer:** Step out of suit remove nitrile/medical gloves and place in bag, walk to the edge of salvage sheet and don personal issue **footwear
10. **Operative:** Secure bag by placing hands under roll over and pull up to the closed position, secure with a cable tie
11. **Wearer:** Go to disrobing area, remove breathing apparatus facemask and report to the entry control officer and collect tally and complete suit log sheet.

Note: (a) * These are to be given to the wearer prior to entry and carried within the suit until required in the safe undressing procedures.

(b) ** The Home Office Project 'Mass Decontamination and Undressing Procedures' report ECM/2008/01 recommends a safer path for the Wearers to don their shoes and exit the area. The report recommends either a clean path, alternative temporary footwear or a narrow salvage sheet folded back on itself lengthways.

7C15.96 Decontamination operative:

- Avoid kneeling down, and carry out the safe undressing procedure at arms length to prevent unnecessary contact with the wearer
- Ensure the outside of suit does not touch the wearer during disrobe. If any obvious cross contamination is observed immediately seek scientific advice.

Showering times when using the MD4 unit

7C15.97 The showering times used should be decided by hazard assessment. The following times were used in the trials whilst developing the safe undressing procedure and may be an appropriate system to use.

- **3 mins:**
  Self washing with brushes including washing the brush handles themselves
- **2 mins:**
  Rinse each other
- **2 mins:**
  Wearer 1 washes Wearer 2 with brush culminating in zip under Velcro flap
- **2 mins:**
  Wearer 2 washes Wearer 1 with brush culminating in zip under velcro flap
- **2 mins:**
  Rinse each other.

Gas tight suit safe undressing procedure	
The safe undressing procedure takes place off the MD4 unit's "veranda" because of difficulties experienced by operatives in removing the gas tight chemical protective clothing when carried out on the higher level of the veranda.	
Wearers are passed clean nitrile/medical gloves from the 'clean area' as an additional control. These are discarded at the end of the undressing procedure.	
The wearer in nitrile/medical gloves crosses his arms to minimise any possible contact with the outside of the chemical protective clothing or decontamination operatives.	
The wearer is assisted into the 'clean area' by the decontamination assistant who is wearing breathing apparatus as an additional precaution, and for emergency situations.	

Powered respirator protective suit safe undressing procedure

7C15.98 The following is an aide memoir for crews carrying out firefighter full decontamination using the national resilience powered respirator protective suit. This procedure should be used after undergoing MD4 showering procedures.

7C15.99 Procedure:

1. **Operative:** Provide prepared Tyvek bag and place in front of veranda ready to receive wearer
2. **Wearer:** Step into Tyvek bag with operatives' assistance if required
3. **Wearer:** Stretch arms out to your side
4. **Operative:** Open zip flap and mop entire zip area, place used paper towel in bag
5. **Operative:** Unzip suit, fold back zip edge, hold wearer's gloves to allow wearer to pull their arms from the sleeves
6. **Wearer:** If wearing helmet undo securing strap then cross arms across chest.
7. **Operative:** Hold hood to allow wearer to duck down out of hood
8. **Wearer:** Duck out of suit hood
9. **Operative:** Fold hood to the rear of wearer and roll the suit down away from the wearer to waist level
10. **Wearer:** Release support belt and disconnect hydration tube
11. **Operative:** Fold suit down to top of boots
12. **Wearer:** Step out of boots by steadying yourself on operative if necessary, walk to edge of disrobe area and don personal issue footwear, report to the entry control officer to collect tally and complete log book
13. **Operative:** Switch off the respirator power pack
14. **Operative:** Secure bag by placing hands under roll over and pull up to the closed goose neck position, and secure with cable tie and complete on label and bag
15. **Operative:** Bagged suits are to be stored adjacent to inner cordon to await further advice.

7C15.100 Decontamination operative:

- Avoid kneeling down, and carry out the safe undressing procedure at arms length to prevent unnecessary contact with the wearer
- Ensure the outside of suit does not touch the wearer during disrobe. If any obvious cross contamination is observed immediately seek scientific advice.

PART C–16

Environmental protection

General information

Introduction

7C16.1 This section is deliberately kept focused on the essential risk-critical information required by Fire and Rescue Service staff at emergency hazardous materials incidents as there is a dedicated *Fire and Rescue Manual on the subject.*

7C16.2 *Fire and Rescue Manual (Volume 2 – Fire Service Operations) Environmental Protection*, 2008, is published by The Stationery Office and is available at:

http://www.communities.gov.uk/publications/fire/environmentprotectvol2

7C16.3 This fire and rescue manual provides information and guidance designed to support firefighters, Fire and Rescue Service managers, and trainers in their work at operational incidents, training events, and during day-to-day activities. It contains guidance for Fire and Rescue Services on preventing and if necessary, dealing with incidents with the potential to pollute. Through its guidance this manual also ensures that services can help minimise their own impact on the environment by providing advice on how to prevent pollution from their own premises.

7C16.4 Fire and Rescue Service intervention can significantly reduce the impact that spillages or firewater runoff containing environmentally damaging materials may have on the environment. Such actions can provide public health benefits. Public drinking water is drawn from rivers, lakes, lochs and groundwater; Fire and Rescue Service activities to protect these waters will help safeguard public and private drinking water supplies and consequently public health. Fire and Rescue Service pollution prevention and control activities can therefore be associated with the Fire and Rescue Service's stated aim of protecting public safety. This philosophy should be borne in mind by Fire and Rescue Service planners and Incident Commanders when prioritising environmental protection as an objective within their strategic, systematic and placed on Fire and Rescue Services to consider the environment within Fire and Rescue Service legislation and the integrated risk management process or equivalent.

Characteristics and classification

Pollution of the water environment

7C16.5 The environment is often considered as three components:

- air
- land
- water.

7C16.6 The water component is often divided into sections: oceans, rivers, ground waters, lakes, etc. Elements within the water component are all interlinked. River pollution can lead to oceanic pollution; surface water pollution can lead to ground water pollution.

7C16.7 Pollutants are defined as anything that causes harm to the environment. So water pollutants include not only chemicals, oils and pathogens but also organic materials, heat and suspended solids. Pollutants released during fires or other emergency incidents, including hazardous materials and other spills, have the potential to pollute air, land and the water environment. However, the water environment is arguably the most vulnerable to pollution from emergency incidents. It is also the part of the environment that the Fire and Rescue Service can protect most readily.

ORGANIC POLLUTANTS

7C16.8 Not all pollutants are toxic (ie poisonous); for example, organic matter (carbon- and hydrogen-based material that can decompose; associated with living organisms). Sources of organic matter include agricultural wastes (eg slurry, silage), blood, food (eg milk, beer and orange juice, etc), sewage and many other materials. Although many of these pollutants are not toxic to aquatic organisms they can still have serious indirect consequences. This is because rivers, lakes, etc are organic matter processing systems. If large quantities of organic matter (eg sewage or a tanker of milk or beer) are added this has effects that are similar to adding large quantities of dead leaves, etc except that it is finely divided and so easy for the bacteria and fungi to consume rapidly.

BIOCHEMICAL OXYGEN DEMAND

7C16.9 The biochemical oxygen demand is a measure of the quantity of oxygen used by micro-organisms to breakdown organic matter in a liquid. A substance with a high biochemical oxygen demand such as milk or sewage if discharged into a waterbody can cause dissolved oxygen levels to fall in the waterbody resulting in the death of fish and other aquatic life.

Typical biochemical oxygen demand values for different waste/effluents	
Typical biochemical oxygen demand values	**(mg oxygen/litre)**
Natural rivers	0.5 – 5
Treated sewage	3 – 50
Paper mill effluent	100 – 400
Crude sewage	200 – 800
Dairy waste	300 – 2,000
Brewery waste	500 – 1,300
Poultry waste	24,000 – 67,000
Typical firefighting foam concentrate	50,000
Silage liquor	60,000
Orange juice	80,000
Milk	140,000

OTHER FORMS OF POLLUTION

7C16.10 Other forms of pollutants include inorganic substances, like metals and acids, and man-made organics such as pesticides, polychlorinated biphenyls, polycyclic aromatic hydrocarbons, phenols, etc. When considering toxic substances entering a watercourse, some key terms in the science of eco-toxicology need to be considered. When Fire and Rescue Services attend incidents which involve substances with these properties they should be prioritised accordingly.

- **Persistence** – Persistence of chemicals indicates that they are stable and long-lived in the environment, resisting degradation, eg lead, cadmium, mercury, polychlorinated biphenyls, and many man-made organics.
- **Xenbiotic** – Not friendly to biological organisms in general (includes many man-made substances, especially pesticides, lead, cadmium and mercury).
- **Bioaccumulation** – Concentration of pollutant; gradient that occurs in moving from one trophic level to another, ie when an animal eats a plant or another animal, also known as biomagnifications.
- **Bioconcentration** – Extraction of chemicals from the environment, and concentration within the organism. For example, seaweed concentrates iodine from the seawater within its tissues, so it is very useful for humans as a source of concentrated iodine. Similarly, plutonium is present at very low levels in seawater. It is concentrated within tiny algae (phytoplankton) that make up the producers in the open sea ecosystem (up to 3,000 times stronger in one of these algae than in the sea water). Algae also concentrate polychlorinated biphenyls to 2,000 times the ambient sea water levels.

- **Biodegradation** – Breakdown of a complex chemical into (simpler) components by actions of biological organisms.

  NOTE: Not always broken down into more benign components. eg the pesticide dieldrin biodegrades into photodieldrin which is considerably more toxic.

Incidents that threaten the water environment

7C16.11 UK Fire and Rescue Services deal with a variety of emergency incidents where there is often a risk of polluting the water environment. The situation might be a spillage or leak entering a drain, watercourse or seeping into the ground. The highest priority in these situations will always be public and crew safety. However, protection of public and private drinking water supplies and the environment should still be a high priority to Incident Commanders and crews.

7C16.12 Where fire extinguishments or precautionary actions, such as applying a foam blanket to reduce vapour emission, are taken, it may be the Fire and Rescue Service actions that are either causing the pollution or contributing to its severity. In these circumstances, UK environmental law requires mitigating actions to be taken by the Fire and Rescue Service (see Section 4 Legal framework). Where the risk to the environment is high, Incident Commanders may decide on a course of action to reduce or eliminate environmental impact completely.

7C16.13 The range of potentially polluting incident types is summarised in the table below.

Fire and Rescue Service incident types with the potential to pollute the aquatic environment

Type of pollution	Effects
Fires	Fires involving buildings, vessels, plant or materials, where firewater, contaminated with products of combustion and materials stored on site and if used, firefighting agents (such as firefighting foam) that can flow from the fire scene into drainage systems, surface or groundwater.
Road traffic collisions	Road traffic collisions where the contents of vehicle fuel tanks, engine block, cooling system, braking system, steering system, suspension system, etc are likely to be released following a moderate to serious collision.
Hazardous materials	Incidents involving hazardous materials classified by the UN in the current United Nations (UN) Recommendations on the Transport of Dangerous Goods, known as the 'Orange Book', where toxic or harmful matter can flow into water.

Fire and Rescue Service incident types with the potential to pollute the aquatic environment

Type of pollution	Effects
Eco-toxic	Incidents involving the spillage of eco-toxic materials such as inks, dyes, detergents etc that are not classified by the UN as hazardous.
Organic	Incidents involving the spillage of organic matter such as milk, beer, blood, sewage, etc that enters the water environment.
Inorganic	Incidents involving inorganic matter such as silt, cement, sand etc that enters the water environment.

Sensitivity of watercourse and groundwater

7C16.14 An understanding of the sensitivity of local watercourse and groundwater is useful for Fire and Rescue Service planning officers and crews. For areas that drain to environmentally sensitive locations, a high priority should be given, during the planning process and at incidents, to the containment of spillages and polluting fire water run-off. In less sensitive areas whilst containment is still desirable it is recognised that there may be other priorities which take precedence over environment protection work. Fire and Rescue Services should consult with their local Environment Agency office to obtain this information.

Sensitivity of receiving waters in relation to location

Sensitivity	Location
HIGH	Over a major aquifer
HIGH	Within a major groundwater source protection zone
HIGH	Within 250m of any well, spring or borehole used for drinking water abstraction other than a groundwater source protection zone
HIGH	Above a shallow water table (<2m and with free-draining ground)
HIGH	Above a fissured rock, eg chalk, posing risk of rapid flow to groundwater or surface water
HIGH	Less than 5 km upstream of a surface water drinking water abstraction point
HIGH	Less than 5 km upstream of an important surface water industrial or national agricultural abstraction point
HIGH	Firewater/spillage would impact on a commercial fishery and/or a national or internationally important conservation site

Sensitivity of receiving waters in relation to location	
Sensitivity	**Location**
HIGH	Firewater/spillage would impact on a site of high amenity value
MEDIUM	Situated over a minor aquifer
MEDIUM	Between 5 km and 20 km upstream of a surface water drinking water abstraction point
MEDIUM	Between 5 km and 20 km upstream of an important surface water industrial or agricultural abstraction point
MEDIUM	Firewater/spillage would impact on a coarse fishery or locally important conservation site
MEDIUM	Firewater/spillage would impact on a site of moderate amenity value
LOW	Situated on low permeability ground such as clay
LOW	Situated over a non-aquifer
LOW	Outside any designated groundwater source protection zone
LOW	Situated above deep water tables
LOW	More than 20 km upstream of a surface water drinking water abstraction point
LOW	More than 20 km upstream of an important surface water industrial or agricultural abstraction point
LOW	Firewater/spillage would have limited impact on fish populations or wildlife
LOW	Firewater/spillage would impact on a site of limited amenity value

Smoke from fires

7C16.15 The Environment Agency is not responsible for the impact of smoke within the environment from a fire or fire training. This duty rests with environmental health departments in local authorities. The Environment Agency will seek to minimise the likelihood of a fire at sites they regulate by setting conditions relating to accidents as part of the operator’s permit. This could include for instance, fire sprinklers. If a fire should occur they may also be able to provide the Fire and Rescue Service and other responders details of products and processes at the site and their likely environmental impact.

7C16.16 However, the Environment Agency co-ordinates air quality data during a major incident in England or Wales, to assist the Health Protection Agency in providing fast and effective public health advice.

7C16.17 The Health Protection Agency will provide public health advice directly to Silver or tactical Commanders or, via the Science and Technical Advice Cell, to the Strategic Coordination Centre (or Gold). The Air Quality Cell therefore requires a Silver or Gold multi-agency group to be operating in order to provide an appropriate communications route for their advice.

7C16.18 The Air Quality Cell operates 24/7 and can be contacted through the normal Environment Agency incident route. The request will be passed to a Competent Officer who will assess the information against the triggering criteria:

- Is it a major incident?
- Does it involve a fire, explosion or chemical release?
- Is there likely to be a significant risk to public health?

7C16.19 Further information on the Air Quality Cell is contained in Section 7 Part C-1 7C1.35.

Drainage and sewerage systems

7C16.20 During emergency incidents involving fire or spillages, contaminated firewater runoff or polluting materials including hazardous materials may flow towards and then enter drains and drainage systems. These systems will then transport the polluting materials into streams, rivers, lakes, lochs or groundwaters, or to sewage treatment works or waste water treatment systems. Some industrial sites will have their own waste water treatment system. To facilitate emergency pollution prevention and control strategies effectively, Fire and Rescue Service staff need to have obtained information about the direction and destination of drainage systems both at pre-planning stage and during incidents. The consequence of allowing pollution unchecked into drainage systems is the direct or indirect pollution of the water environment. Further information, which provides a basic understanding of how these systems operate and their vulnerability to polluting material, is found in *Fire and Rescue Manual – Environmental protection.*

SEWERAGE SYSTEMS

Sewage is the waste water carried in sewers to the sewage treatment works. Sewerage is the network of pipes and sewers (ie sewerage system), which carry the sewage to the sewage treatment works. Fire and Rescue Services can utilise sewerage systems at incidents either to contain polluting material, including fire run-off water, or to divert the material to a holding facility such as a storm tank or balancing pond until it can be safely removed. Caution must be exercised when considering using foul sewers to contain polluting material as they may have storm water overflows built in and blocking the foul system could cause a direct discharge via these overflows to a watercourse. Where practicable permission to discharge polluting materials into sewers must be obtained from sewerage undertakers, not the Environment Agency, before the discharge takes place.

Where polluting material has, either before the arrival of the Fire and Rescue Service or during Fire and Rescue Service intervention, unintentionally entered the sewerage system, notification to sewerage undertakers must take place.

Types and functions of sewers	
Sewer type	**Function**
Surface water sewers	Transport rainwater direct to the nearest river, lake or groundwater **NOTE:** Should have BLUE coloured access chamber covers
Foul sewers	Transport sewage to a sewage treatment works **NOTE:** Should have RED coloured access chamber covers
Combined sewers (found in urban areas)	Transport both sewage and rainwater to the sewerage treatment works. During storms they may overflow into watercourses

Sewerage systems	
System	**Description**
Cesspool or pit	Sealed tank, no discharge; must be pumped out regularly by tanker
Septic tank	Solids settle out in tank, liquids discharge to ground; should be emptied regularly
Private sewerage treatment plant	Small treatment plant with discharge to ground or surface water. Treats effluent on site
Industrial treatment works	Treatment on site; usually effluent discharges to the foul sewer but may discharge to surface or groundwater

OIL SEPARATORS

Oil separators, sometimes referred to as ‘interceptors’, are installed within drainage systems to protect receiving waters (surface or ground) from pollution by oil or fuel. Such pollutants may be present due to minor leaks from vehicles and plant, from accidental spillages or due to deliberate and illegal tipping into drains. Oil separators are found on fuel station forecourts, at oil storage facilities, vehicle workshops, etc. These units are often identified at ground level by the presence of three inspection covers in line and in close proximity, although single chamber models are now the preferred design. They are designed to hold back floating materials such as oils and fuels but to let clean water pass through.

Oil separators will only be effective if they are regularly maintained and emptied. Some installations will have an oil level alarm fitted to indicate when emptying is required. A common misconception associated with oil separators is that they will collect all types of pollutants. This is not the case, as only floating materials such as oil or fuel are contained. Other material that is miscible with water will pass through the system entering the foul or surface water system. Also, a separator will not work effectively for dissolved (soluble or emulsified) oils or detergents (eg firefighting foam) or if degreasers are present, as in vehicle wash water. Such discharges should be drained to foul sewer.

Although standard size oil separators are effective at containing fuels and oils in 'daily' spillage conditions, they are unable to separate products from large quantities of water that might be found during fire run-off conditions. In these circumstances the system may be overcome by the 'shock load' allowing the pollution to pass through into surface water.

ROAD DRAINAGE

Unlike urban roads, which are almost all kerbed and drained using gullies, rural roads (which include most motorways) can be drained using a variety of methods. The drainage method chosen for any particular location will vary according to the volume and quality of the run-off, distance from a watercourse, local geological, topographical features and availability of drainage infrastructure in the locality.

Road drainage can be broadly classified into two elements: surface and subsurface. These are not completely separate, as surface water will infiltrate into road foundations, earthworks or structures through any surface that is not completely impermeable, and will then be removed by the sub-surface drainage.

Because it is important that water drains quickly from the road surface, it can be difficult to intercept polluted run-off from an emergency incident before it enters a local watercourse. It is only since the early 1990s that effective pollution prevention measures have been installed in new roads. Their effectiveness will depend on a number of factors, including the type of pollutant involved and the suitability of the pollution prevention measure installed.

Operational considerations

Pre-planning

7C16.21 Considerations:

- To facilitate emergency pollution prevention and control strategies effectively, Fire and Rescue Services need to have obtained information about the direction and destination of drainage systems at pre-planning stage
- Some industrial sites will have their own waste water treatment systems

- Sensitive environmental and groundwater collecting sites within a fire authority's turn-out area must be established and a system put in place to make this information available to mobilising controls and crews attending hazardous materials incidents. Specific information should include:
  - local watercourse plans
  - water abstraction points
  - local drainage plans
  - vulnerable habitats
  - groundwater
  - vulnerability of the water environment.
- The local highway authority or Highways Agency's agents for motorways and trunk roads should maintain drainage plans of their local network including the location of any pollution prevention systems. These should be available to Fire and Rescue Services for use during the pre-planning process
- Fire and Rescue Services should be aware of the types of drainage system most commonly found on roads in their area, whether they discharge into environmentally sensitive receptors, and whether they can be used to contain spillages or firewater run-off. Such information should be included in operational response plans. It is recommended that plans are produced in consultation with environment agencies and highway authorities
- Fire and Rescue Services should establish local agreements with the Environment Agency, based on the protocol established between the Environment Agency and the Local Government Association, to ensure good liaison and information sharing at operational incidents
- Fire and Rescue Services should identify 'at-risk' sites (ie premises and sites with activities or materials that pose a particular environmental risk eg agrochemical stores, timber treatment plants, plastics manufacturing, recycling sites etc) through 7(2)(d) arrangements and liaison with the Environment Agency and site operators.
- Further information on conducting environmental risk management evaluation and site-specific incident response plans is contained in *Fire and Rescue Manual (Volume 2 – Fire Service Operations) Environmental protection, Chapter 2.*

Phase 1: Mobilising and en-route

7C16.22 Considerations:

- Pre-planning information should be readily available en-route in an easy to read and understandable format (eg environmentally protected or sensitive areas, contingency plans, risk cards, site-specific incident response plans etc)

- Notify the responsible agencies. Mobilising notification criteria, including threshold quantities of environmentally damaging substances, are contained in *Fire and Rescue Manual – Environmental protection, Appendix 4.*
- **NOTE:** Fire mobilising controls should also inform the Environment Agency if the actions of the Fire and Rescue Service at an emergency incident cause potentially harmful materials to enter the water system (eg firefighting run-off water). In such case the Fire and Rescue Service should take all steps that are reasonably practicable in the circumstances to minimise the extent of the entry and its polluting effects.

Phase 2: Arriving and gathering information

7C16.23 The following table gives a basic guide to the responsibilities of other groups or agencies.

Basic guide to responsibilities

Group/Agency	Responsibility
Local authority	Responsible for materials on playing fields, public open spaces, beaches, etc
Landowner or occupier	Responsible for materials on own private land or inside premises
Highways Agency or their representative	Responsible for materials on motorways and major trunk roads
County, metropolitan or unitary authority	Responsible for materials on roads not covered by the Highways Agency
Environment Agency	Protection of water resources (eg discharge of pollution, conservation, redistribution/augmentation of surface and groundwater supplies, etc)
Local Authority Environmental Health Dept.	Enforcement of air pollution legislation
Water/sewerage undertaker	Action following pollution of sewers

Phase 3: Planning the response

7C16.24 Consider the hierarchy of pollution control – to identify the most effective method of controlling or mitigating the effects of a pollutant, the following hierarchy can be used:

1. Stemming or reduction of leak at source. (Intervention examples – close valves, clay sealing putty, pneumatic leak sealing devices, overpack drums etc)

2. Containment of leak close to source. (Intervention examples – absorbents, pop-up pool etc)
3. Prevention of pollutant entering drains (containment on the surface). (Intervention examples – polyboom, clay drain mats, peristaltic pumps and flexi-dams etc)
4. Control pollutant in drainage system. (Intervention examples – pollution control devices, pipe blockers, sewerage control systems etc)
5. Booming or containment in water courses. (Intervention examples – river booms, damming etc).

7C16.25 Also consider the type of water pollution, its effects and possible treatments:

Suspended solids – Soils + minerals (mining, farming, etc), industrial by-products (paper mills, etc)

EFFECTS

- Substrates change due to the river bed being covered with silt
- Fish gills and filter feeders become blocked
- The penetration of light is reduced
- Changes in the community of organisms present
- A loss of diversity.

TREATMENT

- Point source – settlement or filtration, eg, tanks, filter-beds and reed beds
- Non-point source – barriers, traps and engineered wetlands.

Thermal pollution – Power stations and other cooling units, sewage works, fire water run-off

EFFECTS

- Water is heated
- Oxygen content of the water is reduced
- The capacity for self-purification is decreased
- Changes in the community of organisms present
- A loss of diversity.

TREATMENT

- Cool effluent before discharge, eg, in holding lagoons, or using cooling towers.

Inorganic chemicals – Mining and industry (eg, heavy metals)

EFFECTS

- Some are toxic

- Some cause change to acidity or alkalinity of the water
- Change in the community of organisms present
- A loss of diversity.

TREATMENT

- Chemical – neutralization and precipitation
- For spillages, contain and remove if possible.

Organic matter – Agriculture and sewage (phosphates and nitrates)

EFFECTS

- Reduction of oxygen levels
- Changes in the community of organisms present
- A loss of diversity.

TREATMENT

- Standard sewage works treatment, and land treatment
- For spillages, contain and remove if possible, or dilute and aerate until biochemical oxygen demand recovers.

Nitrogen and phosphates – Sewage, agriculture and industry

EFFECTS

- Eutrophication
- Toxic algal blooms
- Blockage of drains and filters with algal mass
- Changes in the community of organisms present
- A loss of diversity.

TREATMENT

- Phosphate stripping or biological treatments such as reed beds
- For spillage, isolate and remove if possible – or once again be prepared to oxygenate downstream.

Toxic organic chemicals – Agriculture and industry (pesticides, phenols, etc)

EFFECTS

- Poisonous
- Changes in the community of organisms present
- A loss of diversity.

TREATMENT

- For spillage, contain and remove if possible.

Pathogens – Viruses, bacteria, protozoa, etc (sewage and farm wastes)

EFFECTS

- The spread of disease
- Therefore the need to remove them from drinking water supplies.

TREATMENT

- Removal of 99 per cent by standard sewage treatment
- Disinfection of drinking water by chlorination or ozone and ultra-violet light treatment
- Accidental spillage – isolate and allow to die naturally (over a few days in natural UV light from sun, most will die). Avoid use as a drinking water source.

Phase 4: Implementing the response

Pollution control techniques

7C16.26 Once the emergency operations have ceased at an incident, and pollution control is the only issue, the Environment Agency's representatives would assume the lead role. In doing so, a Fire and Rescue Service may enter into a contractual arrangement with the Environment Agency whereby equipment and personnel are utilised to assist the 'clean up'

CONTAIN OR DILUTE?

- If given the option to contain or dilute when attending an incident, a fire officer should always opt for containment. Whether this containment is at the source of the leakage or at a distance, a spillage that is contained is preferable. Once the spillage is in a contained state an expert's advice can be sought for a method of dealing with it. If however vaporization of a product occurs, causing possible flammable or toxic atmospheres, the officer should consider covering the spillage with a foam blanket or alternatively with a salvage sheet, depending on the product's properties
- Dilution of any spillage should be considered as a last resort, and in liaison with the pollution control officer
- In forming this strategic decision, the officer should consider the identity, properties, qualities and location of the substance involved
- To enable the officer to determine a course of action, the following list identifies certain useful information:
  - chemical name and formula
  - trade name/formulation
  - strength of solution
  - miscibility in water

  - heavier/lighter than water
  - flammable or explosive risk
  - toxicological data
  - acid, alkali, oxidizing agent.
- Techniques available when faced with a serious spill:
  - **Diversion –** Creating physical barriers or laying booms to direct the flow. The greater the speed of flow, the greater the length and angle of the barrier required to slow and direct the flow.
  - **Covering –** A physical method of confinement: usually a temporary measure achieved with a salvage sheet over a solid spill or powder.
  - **Damming –** Barriers are constructed to prevent or reduce the quantity of liquid entering the environment mainly by the construction of a dam across a waterway to prevent or reduce product flow and attempt to separate out liquids or solid containments.
  - There are two types of dams, overflow and underflow. Overflow dams are built to trap sinking heavier-than-water materials behind the dam (specific gravity greater than 1) whilst allowing uncontaminated water to flow over the dam. This works best on narrow and slow moving waterways. Underflow dams are built to catch floating lighter-than-water materials behind a dam (specific gravity of less than 1). Uncontaminated water flows unobstructed under the dam while containing the contaminant at or near the service.
  - **Dilution –** Where water-soluble solutions, usually corrosives, are diluted by adding large volumes of water to the spill. There are four important criteria that must be met before dilution is attempted. These are to determine in advance that the substance:
    - is not water reactive
    - will not produce a toxic gas on water contact
    - will not form any kind of solid or precipitate
    - is totally water soluble.
  - **Absorption –** The process of picking up or absorbing a liquid contaminant using an absorbent – clay, straw, sawdust, 'pigs', pillows, pads and/or absorbing tubes, etc. Useful only for dealing with spills of less than 250 litres.
  - **Dispersion –** Using biological or chemical agents on materials such as hydrocarbon spills.
  - **Aeration –** Organic pollutants such as milk and sewage will remove oxygen from water bodies. The Environment Agency and a number of specialist contractors are equipped to oxygenate affected watercourses

to raise dissolved oxygen levels; either physically, using aeration units which bubble air through the water, or chemically, through the controlled introduction of hydrogen peroxide. Pumping of affected water into the air through hose jets during the initial stages of an incident is less efficient but is a technique which can be used to some effect.

  - **Treatment –** Treatment of pollution in a watercourse, for example, using activated carbon or hydrogen peroxide, can be problematical and is a specialised technique used by an environment agency or specialist contractors.

- Controlled burn – A controlled burn is a defensive operational strategy to prohibit or restrict the use of extinguishing media on fires so that damage to the environment is minimised. In some cases this strategy can act to protect public health, as an Incident Commander may choose to use a controlled burn strategy when there are significant risks to public drinking water supplies (**NOTE:** This does not relate to controlled burn of moorland, heathland, etc) agricultural or other waste. This operational strategy will normally be used to prevent water pollution but when applied may also benefit air quality due to the improved combustion and dispersion of airborne pollutants. Conversely, it may have adverse impacts, such as allowing or increasing the formation of hazardous gaseous by-products. The balance of potential water and airborne impacts is one of the factors that must be taken into account before the strategy is used. Ideally this decision should be made at the planning stage. The protection of people will always take precedence over environmental considerations. Incident Commanders may also decide to adopt a controlled burn strategy where there are significant risks to Fire and Rescue Service staff from offensive firefighting tactics. Further information is contained in *Fire and Rescue Manual – Environmental protection, Chapter 3.6*.

Phase 5: Evaluating the response

7C16.27 Incident Commanders should constantly evaluate the risk posed by pollutants at the incident and the effectiveness of specific operational procedures and advice. Evaluation is not a one-off process but should be continual throughout the incident as circumstances change or new information is gathered. After evaluation, if necessary, the Incident Commander should adjust the response plan, amend/implement control measures and communicate the changes to all staff.

Phase 6: Closing the incident

Decontamination residual hazards

7C16.28 *The Fire and Rescue Services (Emergencies) (England) Order 2007* places a requirement on the Fire and Rescue Service to contain, for a reasonable time, any water used for removing chemical, biological or radioactive contaminants from people in the event of an emergency. Also the Fire and Rescue authority must make arrangements for ensuring reasonable steps are taken to prevent or limit serious harm to the environment.

Hand-over of the incident to the appropriate authority

7C16.29 This will be the duty local authority, owner or occupier in most instances. The outcomes of the analytical risk assessment should form part of the incident hand-over.

Environment Agency

7C16.30 In general, the Environment Agency will look to the landowner, site occupier/operator or polluter to clean up a site, watercourse or groundwater following an environmental incident. They will advise, wherever possible, on suitable contractors and appropriate disposal routes for any wastes generated during the incident. Where the built or natural environment is contaminated following a pollution incident, the Government Decontamination Service can be contacted for advice on clean-up protocols.

UK Government Decontamination Service

7C16.31 The Government Decontamination Service provides advice, guidance, management support and contractual arrangements to support those responsible for decontamination of the built and natural environment.

Charging protocols

7C16.32 Pollution prevention activities of the Fire and Rescue Service during the emergency stages of an incident may allow the incident to be closed down quickly or provide the Environment Agency with time to call in commercial clean-up contractors to manage the cleanup and subsequent restoration of the environment. However, on the rare occasions where contractors' attendance times are not suited to the needs of the incident or a suitable contractor is not available, the Fire and Rescue Service may be able to assist environment agencies over a protracted period. In such cases and when the emergency phase of the incident is over, the Fire and Rescue Service, subject to operational priorities and resources, might agree to a request from the Environment Agency for assistance and commit resources to environmental protection work. When doing so the Fire and Rescue Service will in effect be working as a contractor to the Environment Agency and they will therefore meet Fire and Rescue Service costs. In England and Wales this will be subject to the following:

- Fire and Rescue Service costs will only be met by the Environment Agency when an agreement between the Environment Agency Site Controller and the Fire and Rescue Service Incident Commander about the work required has been made. This agreement can be made verbally at the incident or over the telephone and will normally involve the provision of an order number. Details of the agreement and the officers involved, including time and date, etc must be recorded and signed at the earliest opportunity

- When the Environment Agency requests the Fire and Rescue Service to attend an incident that they would not attend under normal circumstances, Fire and Rescue Service costs associated with the incident will be met by the Agency
- Chargeable activities will conclude when the Environment Agency advises the Incident Commander that no further action is required or the Fire and Rescue Service withdraws due to other operational priorities.

PART C–17

Additional chemical, biological, radiological, nuclear and explosives (CBRN(E)) considerations

What is CBRN(E)

Introduction

7C17.1 This section does not contain comprehensive details on CBRN(E) but provides a general awareness, including characteristics, possible visual indicators and the overarching strategic objectives for managing a CBRN(E) event.

7C17.2 Specific guidance on the Fire and Rescue Service response to a CBRN(E) event in provided in the following:

- Operational Guidance Document – Fire and Rescue Service Response to CBRN(E) Events 2012
- Tactical Guidance Document – Fire and Rescue Service Response to CBRN(E) Events 2012
- Strategic Guidance Document – Fire and Rescue Service Response to CBRN(E) Events 2011.

7C17.3 If Fire and Rescue Service Commanders follow the generic operational guidance outlined for hazardous materials incidents at CBRN(E) events they would broadly achieve a satisfactory outcome. However, to provide a truly effective response, it is important for Fire and Rescue Service personnel to understand the differences between CBRN(E) events and hazardous materials incidents, particularly the multi-agency dimension.

7C17.4 Initial responders should note that what initially may appear to be a hazardous materials incident, may in fact be a CBRN(E) event.

CBRN(E)

7C17.5 CBRN is a term used to describe chemical, biological, radiological or nuclear materials. It is often associated with terrorism. CBRN(E) is a term used to describe chemical, biological, radiological, nuclear and explosive materials. CBRN(E) terrorism is the actual or threatened dispersal of chemical, biological, radiological, nuclear material (either on their own or in combination with each other or with explosives), with deliberate criminal, malicious or murderous intent, targeted at a given population or economic or symbolic points.

7C17.6 CBRN(E) events may not only involve the release of hazardous materials but also include related threats, hoaxes and false alarms. CBRN(E) events are classified into three generic types:

- intelligence led
- device found, not activated
- device activated.

7C17.7 Whereas hazardous materials incidents are predominantly accidental (ie caused by human error or natural or technological reasons), CBRN(E) incidents are deliberate malicious acts with the intention to kill, cause sickness or disrupt society, for example:

- the deliberate dumping or release of hazardous materials with malicious intent
- the malicious poisoning of one or more individuals
- terrorist acts (as defined by law) that involve serious violence to persons or property for a political, religious or ideological purpose and/or that are a matter of national interest
- threats, hoaxes and false alarms involving hazardous substances.

7C17.8 In the hands of terrorists, CBRN(E) materials can pose a significant threat and cause great harm in the form of weaponised or non-weaponised release. Weaponised materials can be delivered using conventional bombs (eg pipe bombs), improvised explosive materials (eg fuel oil–fertilizer mixture) and enhanced blast weapons (eg ‘dirty bombs’). Non-weaponised materials can include contaminated food, livestock and crops.

7C17.9 Chemical, biological, and radiological material can be dispersed in the air we breathe, the water we drink, or on surfaces we come into contact with. Dispersion methods may be as simple as placing an open container in a heavily used area or using conventional garden/commercial spray devices, or as elaborate as detonating an improvised explosive device.

7C17.10 While there are obvious similarities between ‘conventional’ hazardous materials incidents and those termed CBRN(E), the response to an intentional CBRN(E) event will differ because there are unique implications relating to:

- public safety
- public confidence
- national security
- wider international relations

- security measures
- risks to Fire and Rescue Service staff
- complexity of multi-agency working.

7C17.11 It must be stressed that terrorist or CBRN(E) events do require a more specific response due to:

- potential for secondary devices
- potential for perpetrators to use virulent agents that are both persistent and difficult to identify
- potential to conceal the identity and/or remove and/or replace signage and material information
- potential to utilise locations that exploit the characteristics of the agent
- need to exchange information with off site intelligence and scientific advisers.

Characteristics of CBRN(E) incidents

7C17.12 CBRN(E) incidents may include some or all of the following:

- potential for mass casualties and need for immediate medical treatment
- potential for large loss of life
- potential for long term health and environmental effects
- creation of an extremely hazardous environment that may persist
- relative ease and cheapness of production (eg triacetone triperoxide [TATP])
- ambiguity and/or delay in determining the type of material involved
- potential use of a combination of CBRN(E) materials
- narrow time frame in which to administer life saving interventions/treatments
- need for immediately available specialised pharmaceuticals
- need for specialised detection equipment
- need for timely, efficient and effective mass decontamination systems
- need for pre-planning within health services to establish medical treatment protocols, to stock pharmaceuticals and to determine treatment requirements
- need to establish coordinated incident management/multi-agency response procedures for such incidents.

7C17.13 Countermeasures may include:

- technical equipment that can detect chemical/biological/radiological agents
- protective equipment to prevent exposure

- medical therapy and, for some agents, prophylaxis
- organisational strategies, such as standard operating procedures, training and specially developed 'intelligence' systems.

Visual indicators of a CBRN(E) event

7C17.14 Visual indicators of a CBRN(E) event may include all or some of the following:

- dead or distressed people, birds and animals
- multiple individuals showing unexplained signs of skin, eye or airway irritation; nausea; vomiting; twitching; sweating; pin-point pupils (miosis); runny nose (rhinorrhea); disorientation; breathing difficulties; convulsions; and death
- the presence of hazardous materials or equipment not relevant to the occupancy
- reports of unexplained smells or tastes out of character with the surroundings
- unexplained vapour or mist clouds
- unexplained oily droplets or films on surfaces or water
- withered plant life or vegetation on the exterior of dwellings.

7C17.15 The initial information that an incident has occurred may come from the public, media, emergency service responders at or near the scene, or other information routes.

Strategic objectives for a combined response to a CBRN(E) incident

7C17.16 Irrespective of the particular responsibilities of individual organisations and agencies responding to the incident, the strategic intention is to coordinate effective multi-agency activity in order to:

- preserve and protect lives
- mitigate and minimise the impact of an incident
- Inform the public and maintain public confidence
- prevent, deter and detect crime
- assist in the early return to normality (or as near to it as can reasonably be achieved).

7C17.17 Additional objectives from these principles:

- ensure the health and safety of all those responding to a CBRN(E) incident
- safeguard the environment

- facilitate judicial, public, technical or other enquiries
- evaluate the response and identify lessons to be learned.

The nine key tasks

7C17.18 In order to ensure that emergency responders use the same terminology and plan their response around the same principles, nine key tasks have been identified and defined.

7C17.19 The key task definitions provided have been agreed jointly by the Police Service, Fire and Rescue Service and the Ambulance Service and will form the basis for each service's CBRN(E) event response procedures.

7C17.20 The Nine Key Tasks relate to the management of a known and identified CBRN(E) event on the scale described in *A Model Response to CBRN(E)* Events, from the time of the incident being confirmed until the time the last decontaminated member of the public leaves the scene (encompassing the response and part of the recovery phase of a CBRN(E) event) and also extending into the restoration phase of the incident.

7C17.21 For CBRN(E) events on a smaller scale the principles of the Nine Key Tasks should always be considered and may be applied in part or in full, but the scale of the response should always be proportionate to the risk involved and to the incident scale.

7C17.22 The tactical guidance document, *Fire and Rescue Service Response to CBRN(E) Events*, details several response models, based on a number of incident scales, which should be considered by the Fire and Rescue Service Incident Commander when assessing resource requirements for dealing with a CBRN(E) event.

KEY TASK 1 – COMMAND AND CONTROL

Command and control is an overarching process which directs the CBRN(E) event in the response phase, the recovery phase and part or all of the restoration phases.

KEY TASK 2 – MOBILISATION

The activation and continuous process of deployment and management of resources to a safe area near the scene, following a trigger event and declaration of a CBRN(E) event. The decision to mobilise should follow a process of information/intelligence gathering and assessment.

KEY TASK 3 – ARRIVAL AT SCENE

The structured arrival via safe routes of suitably equipped and resourced responders to a safe area near the scene of a declared CBRN(E) event.

KEY TASK 4 – SCENE ASSESSMENT

The structured and dynamic process of information/intelligence gathering, originating with the trigger event. Refined as further information/intelligence becomes available, allowing hazard/risk assessment to inform the decision-making process. It will inform the decision on the scale and footprint of the scene.

KEY TASK 5 – SCENE MANAGEMENT

The establishment of mechanisms to manage the scene in order to allow a proactive approach to achieve strategic intentions and tactical objectives.

KEY TASK 6 – DELIBERATE RECONNAISSANCE

The planned controlled deployment of suitably protected resources working within defined parameters within the inner cordon. These resources will be deployed to specific locations in order to achieve specific operational objectives.

KEY TASK 7 – RESCUE AND TRIAGE

Rescue: The assisted removal of people unable to remove themselves from the area of greatest danger to a place of relative safety.

Triage: A dynamic method by which people are 'sieved and sorted' in order of medical priority. Triage aims to deliver the right patient to the right place at the right time so they receive optimum treatment while doing the most for the most. Triage would be implemented where the number of casualties exceeds the skilled help immediately available.

KEY TASK 8 – DECONTAMINATION

Is the reduction of contamination to lower the risk of further harm to contaminated casualties and to lower the risk of cross contamination.

KEY TASK 9 – SURVIVOR MANAGEMENT

A survivor is defined as any person who has been involved in a CBRN(E) event and no longer presents a cross-contamination risk. Survivors should be managed within each individual emergency service's existing contingency plans and operational procedures.

Recovery, identification and decontamination of fatalities

7C17.23 Processes and procedures for the recovery, identification and decontamination of fatalities at a CBRN(E) event are subject to ongoing work led by the Home Office.

7C17.24 Further guidance can be found in Home Office publication (RESTRICTED) – *The Safe Handling of Contaminated Fatalities, Guidance Document, JUNE 2009.*

7C17.25 The Police Service are responsible for:

- the recovery of fatalities
- placing fatalities within suitable body bags

- transporting the fatalities to and from the Fire and Rescue Service decontamination structures
- providing suitable storage facilities within the inner cordon
- holding the fatalities within the storage facilities within the inner cordon.

7C17.26 The Police Service responsibilities are delivered by the Police Disaster Victim Identification capability.

7C17.27 The Fire and Rescue Service is responsible for:

- assembling the decontamination and identification tents and maintaining the equipment whilst in use
- undertaking the actual decontamination of the exterior of the closed body bags
- managing any contaminated water run off.

7C17.28 Fire and Rescue Service responsibilities are delivered by the decontamination of body bags capability, managed by CFOA National Resilience.

7C17.29 Provision of decontamination of body bags is located within three English regions that will respond on a national basis to assist the affected Fire and Rescue Service. Further decontamination of body bags provision is located within the devolved administrations.

Fire and Rescue Service National Resilience

Introduction

7C17.30 The concept of ‘resilience’ has long been used to describe individuals with the ability to withstand or recover easily and quickly from illness or hardship. It is a term that can be applied as easily to organisations or societies. The Government uses the term when talking about national security and emergency preparedness, response and recovery. Resilience in this sense means ensuring that the country as a whole can handle and recover quickly from any major emergency, such as a large-scale flood, terrorist attack or major industrial accident.

7C17.31 The Civil Contingencies Secretariat sits within the Cabinet Office at the heart of central government. It works in partnership with government departments, the devolved administrations and key stakeholders to enhance the country’s resilience and ability to prepare for, respond to and recover from the full range of emergencies.

7C17.32 The *Civil Contingencies Capabilities Programme* was the core framework through which the Government built resilience across all parts of the United Kingdom. 'Capability' is a term that includes all of those elements required to respond to an emergency (eg plans, equipment, people, training and supplies).

7C17.33 The 'programme' identified the generic capabilities that underpin the UK's resilience to disruptive emergencies, and ensured that each of these capabilities, split into 18 work streams, was developed. These capabilities include being able to respond to chemical, biological, radiological or nuclear incidents. Each of the work streams has been the responsibility of a designated lead department and in the case of CBRN(E) this is the Department for Communities and Local Government (DCLG). DCLG has delivered three projects as part of a wider programme to increase resilience, interoperability and control within the Fire and Rescue Service; these projects make up the Fire Resilience Programme.

New Dimension Programme

7C17.34 The New Dimension project was a collaboration between DCLG, the Fire and Rescue Service and the Chief Fire Officers Association (CFOA), and has enhanced the ability of the Fire and Rescue Service to respond to major disruptive events involving CBRN(E) agents, collapsed or unstable structures, and the displacement of large volumes of water.

7C17.35 Its origins were a result of the tragic events of the 2001 terror attacks on the World Trade Centre Twin Towers building in New York. Following this, both the UK Government and the Fire and Rescue Service had to adapt to new levels of threat to the population and, at the same time, to the unpredictability of disasters arising from extremes of weather. The aim of the New Dimension programme has been to ensure that Fire and Rescue Services throughout the country are resourced and equipped to provide a fully co-ordinated, coherent and unified national response to the widest possible range of potential national emergency incidents.

7C17.36 The *Fire and Rescue Services (Emergencies)(England)* Order 2007 is a statutory instrument which requires that Fire and Rescue Services make provision for dealing with CBRN(E) (mass decontamination) incidents and incidents involving structural collapse.

7C17.37 As the project concluded, DCLG and CFOA focused on the long-term management plans for New Dimension, or the Fire and Rescue National Resilience Programme as it is now known. DCLG and CFOA aim to ensure the new capabilities are fully integrated into Fire and Rescue Service core business and that standards are maintained to guarantee national interoperability. Long-term arrangements have centred on the following areas:

- physical maintenance of the vehicles and kit
- assurance that the capabilities continue fit for purpose
- funding for the above.

National Resilience Assurance Team (NRAT)

7C17.38 The Fire and Rescue National Resilience Programme is one part of DCLG's contribution to the Civil Contingencies Capabilities Programme. The strategic aim is to continue to enhance preparedness and resilience of the Fire and Rescue Service in England and Wales by maintaining and improving the national resilience assets that have been provided. The programme consists of four distinct capabilities. These are:

- CBRN(E) incorporating mass decontamination and detection, identification and monitoring
- urban search and rescue
- high volume pumping
- command and control.

7C17.39 Operational assurance on a national basis is provided by the Fire and Rescue National Resilience Board, the CFOA led assurance body, which reports to the Local Government Association Fire Services Management Committee. The Fire and Rescue National Resilience Board carries out this function through the National Resilience Assurance Team.

7C17.40 The National Resilience Team provides operational assurance that the national resilience capabilities remain fit for purpose and can be deployed consistently across national and regional boundaries, including managing and monitoring operational practices, procedures and technical advice on the capabilities, and the associated operational IT, communications and training, asset refresh and any siting or re-siting of assets.

Fire and Rescue Service National Co-ordination and Advisory Framework (NCAF)

7C17.41 The *Fire and Rescue Service National Framework 2008-11* outlines the role of the Chief Fire and Rescue Adviser (CFRA) and identifies some of the responsibilities of the position for national co-ordination and advice during incidents of national significance. The *National Co-ordination and Advisory Framework* is the result of work undertaken by the Chief Fire Officers Association (CFOA) and the CFRA to ensure that these responsibilities are discharged through an effective national framework.

7C17.42 The development of the National Co-ordination and Advisory Framework has been designed to ensure that a robust, yet flexible and adaptable, framework is in place that enhances national support arrangements at significant incidents.

7C17.43 The National Co-ordination and Advisory Framework document provides a structure that offers national support to affected Fire and Rescue Service(s) during incidents of national significance or those requiring a level of national coordination. It sets out the arrangements for an enhanced support provision including:

- guidance and support to the affected Fire and Rescue Service and the government department responsible for the Fire and Rescue Service
- the provision of support and information to the CFRA
- guidance and support to enable national interoperability
- the provision of professional fire and rescue advice and support to ministers and the Cabinet Office Briefing Room (COBR).

7C17.44 The National Co-ordination and Advisory Framework gives guidance for the respective roles and responsibilities for the various components of the framework, demonstrating the direct lines of communications that will ensure accurate and timely information is shared in the support of the requirements of the incident(s). The framework has been designed for co-ordination, advice and to ensure the provision of national support to the affected Service(s). The roles include:

- The Chief Fire and Rescue Adviser (CFRA)
- The National Strategic Adviser Team (NSAT)
- The National Resilience Assurance Team (NRAT)
- Subject Matter Adviser (SMA)
- The DCLG Emergency Room (CLG ER)
- The Fire and Rescue Service National Co-ordination Centre (FRSNCC).

7C17.45 The National Co-ordination and Advisory Framework, or any components within it, does not remove any of the statutory duties of the local Fire and Rescue Authority or responsibilities of the Chief Fire Officer or Commissioner. The Incident Commander deployed by the Fire and Rescue Service in question retains the responsibility to resolve the incidents that occur within their area. The framework supplements and augments the existing response arrangements and does not replace them. The National Co-ordination and Advisory Framework should be read in conjunction with the *Fire and Rescue Service Manual for Incident Command: 3rd Edition*.

7C17.46 The National Co-ordination and Advisory Framework would be an essential part of resolving a major CBRN(E) incident. An electronic version of the document is available at:

http://www.communities.gov.uk/publications/fire/opguidancencaf

Section 8

Appendices

APPENDIX A

Generic Standard Operating Procedure Summary

The following pages contain an operational key information summary of the generic standard operating procedure (G-SOP) that may be used as an aide-memoir.

Operational key information summary

Generic standard operating procedure (G-SOP)

HAZARDOUS MATERIALS INCIDENTS – KEY ACTIONS/ CONSIDERATIONS

Mobilising and en-route

- **Assess the level and scale of the incident:**
  - match incident details to site specific predetermined attendances, operational plans, multi-agency plans etc
  - implement 'major incident' plan?
- **Mobilise appropriate resources to the incident, marshalling areas or predetermined rendezvous points**
  - utilise Firemet information
  - consider use of up-wind, pre-planned marshalling sites or rendezvous points for significant known hazardous materials risks.
- **Access incident specific information en-route:**
  - request information on, and begin to think about, the likely hazards and control measures when mobilised to known substances and hazardous materials sites
  - access site specific risk inspection information
  - request and use weather information (eg FireMet)
  - assess and review marshalling/rendezvous points arrangements
- Notify and/or request assistance/attendance from relevant agencies.

Arrival and gathering information

- **Approach the incident safely and estimate the potential hazard zone:**
  - use weather information (eg FireMet) and visual indicators of wind strength and direction (eg wind blown tree foliage etc) to plan your approach to the incident from the upwind direction so that crews are not exposed to hazardous vapours or gases
  - if possible and safe to do so without additional personal protective equipment, approach the incident from higher ground (ie up-slope) especially if hazardous liquids are known to be present
  - ensure response vehicles approach the vicinity of the incident at slow speed

  - when approaching the vicinity of the incident use senses (sight, hearing) to assess 'incident-indicators' to assist in estimating the extent of the hazard zone
  - ensure response vehicles approach the vicinity of the incident at slow speed
  - estimate the potential hazard zone, and position staff and vehicles outside it
  - establish command/contact point in a safe location
  - downwind, dilution, obstacle, oscillation and retention (DDOOR) key factors to remember when dealing with a hazardous release in an urban environment.
- **Recognise hazards and risks from a safe location and implement an initial cordon:**
  - can the hazardous materials cause harm to people by inhalation, ingestion, direct skin contact, absorption through the skin or eyes or entry through cuts and grazes?
  - can the hazardous materials to cause harm to property and the environment?
  - what additional hazards and risks are there? (eg unsafe structures, road traffic, working at height etc)
  - establish an initial cordon (See table)
  - if explosives are known to be involved in fire then initial cordon distances must be treated as exclusion distances.
- **Liaise with persons on-site**
- **Consider the 'Immediate Life Risk' (NOTE: Immediate life risk = immediate human life saving rescues; immediate evacuation to prevent serious injury; prevention of catastrophic escalation likely to endanger life). If rescues or other direct intervention is required (NOTE: Risk verses benefit) consider appropriate control measures (consider – personal protective equipment; crew briefing; safe-route; time/distance/shielding).**
- **Identify the problem and the likely impact:**
  - carry out full survey of the site
  - retrieve and interpret hazard and incident information
  - assess the condition of damaged hazardous materials containment systems
  - predict the likely behaviour of the hazardous materials involved
  - estimate the size of the endangered area
  - estimate the potential harm/impact
  - review the position of the Initial cordon with regard to the information gathered and the predicted hazard zone.
- **Estimate the resource requirements and request assistance**

- **Implement the incident command system:**
  - the benefits of proceeding with a task must be weighed carefully against the risks
  - all commanders must know who they are responsible for
  - all staff must know who they report to
  - all staff must know what their operational brief is
- If a clean area with washing facilities cannot be established prohibit eating, drinking etc. on-site.

Planning the response

- Identify the objectives:
  - Identify any on-going risks to people from the hazardous materials following the initial assessment. Set any human rescues as a critical-priority
  - Identify any fires or fire risks. Set firefighting as a high-priority
  - Identify property that can be saved and that which is already lost
  - Identify the extent of environmental harm
  - Agree and prioritise the objectives in consultation with the relevant agencies/ people.
- Develop a response plan with specialist advisers and other agencies:
  - identify the options to achieve the objectives
  - risk asses the options and select the best course of action
  - develop the response plan
  - identify the tactical mode
  - ensure there is sign-up to the response plan from other agencies. where this practicable.
- Identify the level and type of personal protective equipment required:
  - assess the tasks and associated hazards
  - select the most effective personal protective equipment
  - select the most appropriate/capable staff.
- Identify appropriate decontamination procedures:
  - establish the responsibilities of the Fire and Rescue Service for decontamination
  - assess the hazards posed by the hazardous materials, the site and the tasks being carried out, then select the most effective type of decontamination
  - identify the resources and procedures required by decontamination

  - identify procedures and precautions to deal with decontamination run-off to prevent or minimise environmental pollution.

- Fire and Rescue Service staff must never be committed to ‘hot’ or ‘warm’ zones without decontamination being available
- The scale, level and complexity of the decontamination set-up will depend on the Incident Commander’s risk assessment but must be based on standard operating procedures
- The outcome of decontamination is, as a minimum, to lower risk of harm/cross-contamination to an acceptable level, that is, as low as reasonably practicable

  NOTE: It is not always possible to totally remove the contaminant or clean the personal protective equipment on-site.

Implementing the response

- Review and monitor inner and outer cordons to control access at the scene
- Establish a clear path to the decontamination zone from the ‘hot’ zone ensuring that the ‘warm’ zone is extended as necessary to encompass it
- Communicate and control the response plan:
  - nominate Safety Officers
  - ensure all responders are briefed by their commanders on the response plan
  - designate clean areas with washing facilities for staff hydration and welfare
  - communicate with the local community to ensure public safety and reduce anxiety/concern.
- Establish and operate decontamination
- Implement deliberate reconnaissance to gather further information
- Implement effective firefighting, containment and pollution control techniques:
  - control or extinguish fires
  - carry out ‘defensive’ hazardous materials containment actions (ie the risk outweighs the benefit of committing staff within the Inner Cordon to control the release)
  - carry out ‘offensive’ hazardous materials containment actions
  - work with the responsible agencies to control pollution from the site
  - ensure that all emergency actions are within the realm of reasonable response.
- Work with people and agencies that may provide additional advice and assistance.

Evaluating the response

- Evaluate the effectiveness of the response:
  - select competent staff to carry out evaluation
  - evaluate the effectiveness of 'reactive' stage actions
  - continually evaluate progress of the response plan
  - evaluate the effectiveness of decontamination
  - evaluate the effectiveness of the specialist hazardous materials advice
  - record significant findings.
- Adjust the response plan, implement additional control measures and communicate the changes, if necessary.

Closing the incident

- Close down Fire and Rescue Service operations:
  - minimise the impact to the community by the Fire and Rescue Service leaving the incident
  - return equipment and other resources to the correct place and ensure they are secure and ready for re-deployment
  - report any faults or low levels of supplies
  - extract and clean equipment
  - ensure that correct action has been taken if staff have been "exposed" to hazardous materials.
- Hand-over control of the incident site:
  - identify the responsible person, organisation or agency
  - document the hand-over.
- Carry out on-site incident debrief
- Anticipate post incident considerations:
  - staff health monitoring where exposure has occurred
  - delayed health effects
  - assessment and disposal of contaminated equipment and personal protective equipment
  - repatriation of impounded and/or contaminated equipment
  - trauma incident management – including reassurance briefings for potentially contaminated crews
  - liaison with enforcing authorities where legislation/regulation may have been contravened
  - assess and report any post incident financial liability.

Operational key principle

CBRN(E) incidents, nine key tasks

1) Command and control
2) Mobilisation
3) Arrival at scene
4) Scene assessment
5) Scene management
6) Deliberate reconnaissance
7) Rescue and triage
8) Support to decontamination
9) Survivor management

GENERIC INITIAL CORDON DISTANCES

(NOTE: continuous risk assessment should be carried out to ensure that the cordon remains appropriate and proportionate to the risks identified by the Incident Commander)

Incident type (if known)	**Initial cordon distance (metres radius)**
Explosives – manufacture, storage, transport **NOTE:** Pre-planning for known sites should include rendezvous points at safe distances	100m for transport incident HD1.4 200m for transport incident HD 1.3 600m Transport HD 1.1, HD 1.2 and HD 1.5 (or when HD is not known) 100m for registered premises (fireworks only) 200m for incidents at other registered premises 600m for incidents involving licensed storage (under 2000kg) 1000m for incidents involving licensed storage(more than 2000kg)
Explosives – CBRN, terrorist (* Consider no Fire and Rescue Service attendance or treat as EXCLUSION distances for Fire and Rescue Service staff, take guidance from the Police Service and explosive ordnance disposal experts)	100m for an activated device Unexploded devices:* 100m for a suitcase size device 200m for a car size device 400m for a lorry (or when size of device is not known)
Cylinders involved in fire **NOTE:** Shielding may reduce distances	Fireball up to 25m Cylinder may be thrown up to 150m Flying fragments up to 200m
Radiation	**Outside buildings** 45m – unshielded or damaged potentially dangerous source 100m – major spill from a potentially dangerous source 300m – fire, explosion or fumes involving a potentially dangerous source 400m or more to protect against an explosion – Suspected bomb (exploded or unexploded) **Inside buildings** Affected and adjacent areas (including the floor above and below) – Damage, loss of shielding or spill of a potentially dangerous source Entire building and outside distances detailed above – fire or other event that can spread a potentially dangerous source materials throughout the building (eg through the ventilation system)

APPENDIX B

Hazardous materials incident information record and Fire and Rescue Service Risk assessment template

Example template

The following is an example of a recording template which Fire and Rescue Services could use at hazardous materials incidents. It enables the hazardous materials adviser to:

- systematically record all relevant information
- assess the risks
- recommend suitable and sufficient control measures to the Incident Commander.

1. Incident description Brief description of what's happened Précis of Incident Supporting information including location, time of day, weather etc	
2. Information sources Chemdata / CIRUS ERG Dangerous Goods List MSDS Placards and labelling Product manufacturer	
3. Quantify the scale of the incident Large scale / Small scale Quantities involved Estimate worse case scenario Estimate extent of hazard zones Potential for harm	

4. Identify the hazards Chemical hazards Physical hazards Reactions with other substances Condition of containment system How far will material spread?				
5. Interpret the physical properties Interpret relevant physical properties Predict the likely behaviour of the substance Effect of weather conditions				
6. Identify who/what is at risk	**From what?** (eg contamination, fire fumes, particulates, spillage, run-off etc)	**Risk Rating**		
Fireighters		L	M	H
		L	M	H
		L	M	H
		L	M	H
		L	M	H
		L	M	H
		L	M	H
Other emergency responders		L	M	H
		L	M	H
Public		L	M	H
		L	M	H
Other		L	M	H
		L	M	H
7. Level of personal protective equipment, contamination risk and decontamination strategy Select appropriate personal protective equipment for each task Exposure conditions Identify contamination risk Identify decontamination method				

8. Risk control measures Tactics Safe approach Cordons, inner and outer Crew size Firefighting media Public safety considerations and evacuation Vapour cloud dispersal / suppression	
9. Environmental protection measures Identify environmental vulnerability Identify pollution pathways Source, pathway, receptor Pollution control strategy **NOTE:** Hierarchy of control	
10. Liaison (What agencies and why) Police, ambulance Environment agency Water company Health protection agency Local authority Specialist companies Hand-over and incident closure **NOTE:** Responsible person/agency	
11. Post incident considerations Safe disposal/repatriation of personal protective equipment and equipment Product recovery Debriefs (on-site, off-site, multi-agency) Medical aftercare, occupational health Personal exposure records Investigation (eg learning lessons, enforcement action and cost recovery)	
NAME OF OFFICER	**DATE AND TIME**

Section 9

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Attached to the Office of the Chief Fire and Rescue Adviser from Dorset Fire and Rescue Service.
Editor and co-author

Section 10

Glossary of terms and abbreviations

Glossary of terms and abbreviations

Sector specific acronyms

This guidance deliberately avoids the use of abbreviations and acronyms. However, as they are routinely used in the Fire and Rescue Service and chemical industry the most common ones are contained below.

7(2)(d)

Section 7(2)(d) of the *Fire and Rescue Services Act*. Specifically a fire and rescue authority must put in place effective arrangements for obtaining information which it needs to carry out its statutory functions.

A

Acid – An acid is a material that will liberate H+ ions into solution in excess of any OH- ions.

ACM – Asbestos containing material. A material which contains the fibrous forms of naturally occurring silicate minerals.

Activity – The amount of radiation being emitted by a source. Usually measured in becquerels.

Acute – Severe often dangerous condition in which relatively rapid changes occur.

Acute toxicity – Adverse health effects occurring within a short time period of exposure to a single dose of a chemical or as a result of multiple exposures over a short time period eg 24 hours.

ADN – European Agreements concerning the International Carriage of Dangerous by Inland Waterways.

ADR – European Agreements concerning the International Carriage of Dangerous Goods by Road.

Aerosol – A colloidal suspension of liquid or solid particles dispersed in gas having a negligible falling velocity (generally considered to be less than 0.25 m/s).

AFFF – Aqueous film forming foam which flows on burning liquid as a film.

ALARP – An acronym used in legislation meaning as low as reasonably practicable.

Alcohol resistant foam – Foam for use on fires involving liquids miscible with water eg alcohol, acetone.

Alkanes – Straight and branched chain saturated hydrocarbons.

ALOHA – Aerial Locations of Hazardous Atmospheres is an atmospheric dispersion model used for evaluating releases of hazardous chemical vapours.

Alpha (α) radiation – Type of radiation involving the emission of an alpha particle from the nucleus of a radioactive atom. Can only travel a few centimetres in air. See Section 7, Part C10.

Anoxia – Deficient supply of oxygen to tissues.

Antibody – A modified protein circulating in the serum of an animal, synthesized in response to a foreign molecule, antigen, that has entered the body.

APP – Additional personal protection code used in the UK Emergency Action Code (also known as HAZCHEM).

AQC – Air Quality Cell. An Environment Agency led capability to provide an air monitoring service at major incidents.

ARA – Analytical Risk Assessment, Fire and Rescue Service term from the Incident Command System. It is a detailed risk assessment which is performed after the initial assessment.

Aromatics – Unsaturated hydrocarbons which contain one or more benzene rings.

Asbestos- The generic name given to the fibrous forms of naturally occurring silicate minerals.

Atopy – Hypersensitivity where tendency to allergy is inherited.

Auto-ignition temperature – The minimum temperature required to initiate or cause self-sustained combustion of material in the absence of any external source of energy.

B

Background rate – The radiation dose rate due to environmental radioactivity.

Backfire – A backfire (a single cracking or ‘popping’ sound) is when a welding/cutting flame has ignited the gases inside the nozzle and extinguished itself. This may happen when the torch is held too near the work piece.

Barrel – The standard barrel contains 159.1 litres (35 imperial gallons or 42 US gallons).

Base – A base is a material that will react with an acid to yield salt and water only.

BASIS – BASIS is an independent standards setting and auditing organisation for the pesticide, fertiliser and allied industries.

Becquerel – The unit of activity which measures the number of radioactive disintegrations per second in a source.

Beta (β) radiation – Type of radiation resulting from the emission of a beta particle from the nucleus of a radioactive atom. Can only travel about 1 metre in air.

Bioaccumulation – Concentration of pollutant; gradient that occurs in moving from one trophic level to another, ie when an animal eats a plant or another animal, also known as biomagnification.

Biochemical oxygen demand (BOD) – The biochemical oxygen demand is a measure of the quantity of oxygen used by microorganisms to breakdown organic matter in a liquid. A substance with a high BoD such as Milk or Sewage if discharged into a waterbody can cause dissolved oxygen levels to fall in the waterbody resulting in the he death of fish and other aquatic life.

Bioconcentration – Extraction of chemicals from the environment, and concentration within the organism. For example, seaweed concentrates iodine from the seawater within its tissues, so it is very useful for humans as a source of concentrated iodine. Similarly, plutonium is present at very low levels in seawater. It is concentrated within tiny algae (phytoplankton) that make up the producers in the open sea ecosystem (up to 3,000 times stronger in one of these algae than in the sea water). Algae also concentrate PCBs to 2,000 times the ambient sea water levels.

Biodegradation – Breakdown of a complex chemical into simpler components by actions of biological organisms.

BLEVE – Boiling liquid expanding vapour explosion is a container failure with a release of energy, often rapidly and violently, which is accompanied by a release of gas/vapour to atmosphere and propulsion of the container or container pieces due to an over pressure rupture. If the substance involved is flammable, it is likely that the resulting cloud of the substance will ignite after the BLEVE has occurred forming a fireball and possibly a fuel-air explosion termed a unconfined vapour cloud explosion (UVCE).

Breathing Apparatus (BA) – Self contained, positive pressure, respiratory protective equipment.

C

CAMEO – Computer-aided management of emergency operations.

Carcinogen – An agent, chemical physical or biological, capable of increasing the incidence of malignant neoplasms.

Catalyst – A substance which alters the rate of a reaction. Most catalysts are used to increase reaction rates.

CBRN – CBRN is a term used to describe chemical, biological, radiological or nuclear materials. CBRN is often associated with terrorism (see CBRN(E)).

CBRN(E) or CBRNe – CBRN(E) or CBRNe is a term used to describe chemical, biological, radiological, nuclear and explosive materials. CBRN/CBRN(E) terrorism entails the assumption or knowledge, based on intelligence or actual evidence, of actual or threatened dispersal of chemical, biological, radiological or nuclear material (either on their own or in combination with each other or with explosives), with deliberate criminal, malicious or murderous intent, targeted at a given population or economic or symbolic points.

CE mark – The application of the CE Mark on a product shows conformity with the essential requirements of the ‘new approach’ directive covering that product.

CEN – CEN: The European Committee for Standardisation.

CFOA – Chief Fire Officers Association.

CFRA – Chief Fire and Rescue Adviser.

CHALETS – An acronym used by initial responders at significant incidents (eg CBRN incidents etc) formulate an standard assessment message to their mobilising control. CHALETS stands for casualties, hazards, access, location, emergency, type and safety.

Chemical protective clothing (CPC) – The combined assembly of garments worn to provide protection against exposure to, or contact with, chemicals.

Chemical protective suit (CPS) – Clothing worn to protect against chemicals that covers the whole or greater part of the body. A chemical protective suit may comprise garments combined together to provide protection to the body. A suit may also have various types of additional protection such as hood or helmet, boots and gloves joined with it.

CHIP – *Chemicals (Hazard Information and Packaging for Supply) Regulations*.

Chronic – Occurring for a prolonged period.

Chronic toxicity – Adverse health effects in a living organism resulting from repeated exposures to a chemical for a significant part of the organism's lifespan.

CIRUS – Chemical Information Retrieval Update System.

Class A fire – Fire involving solids, usually organic, in which combustion generally occurs with the formation of glowing embers.

Class B fire – Fire involving liquids or liquefiable solids.

Class C fire – Fire involving gases or liquefied gases.

Class D fire – Fire involving metals.

CLG – The Department for Communities and Local Government, HM Government.

Clinical Decontamination – The process where contaminated casualties are treated individually by trained healthcare professionals using purpose designed decontamination equipment.

CLP – *Classification, Labelling and Packaging of Substances and Mixtures Regulations*.

COBR – Cabinet Office Briefing Room.

COMAH – *Control of Major Accident Hazard Regulations* (replaced CIMAH).

Cold zone – This is the uncontaminated area between the inner cordon and the outer cordon. It is the area within which key operational command positions and other essential activities will be set up. The Police Service, in liaison with the Fire and Rescue Service and the Ambulance Service, should decide whether members of the public need to be evacuated from the cold zone.

Contact dermatitis – Inflammation of the skin due to exposure to a substance that attacks its surface.

Contact point – A designated point, usually an appliance not involved in operations, from which a nominated member of staff will carry out the Command Support function at a small to medium size incident.

Contamination – Contamination occurs when a substance adheres or is deposited on people, equipment or the environment, thereby, creating a risk of exposure and possible injury or harm.

> **NOTE:** Contamination does not automatically lead to exposure but may do. Alpha, beta and gamma emissions in themselves cannot cause contamination, although the actual source materials may be able to depending on their physical properties and their containment.

Command – The authority for an agency to direct the actions of its own resources (both personnel and equipment).

Command line – The line or chain of command at an incident. The incident command system relies upon a single unified command line. With the exception of urgent safety related issues officers should not take control of operations outside their assigned responsibility and should ensure all information and instruction is passed via the relevant command line officers.

Command Point – Point from which the Incident Commander operates; this may be a car, appliance, specialist unit or a part of a building.

Command Support – Command support is a role undertaken by one or more staff at an incident. The role typically provides recording, liaison, detailed resource management and information gathering for the Incident Commander. At large incidents command support may comprise a dedicated team working from a mobile command unit and may include individuals tasked with supporting sector commanders. Command support is not directly in the command line.

Compressed gas – Gas, which, when packaged under pressure for transport, is entirely gaseous at all temperatures above –50°C.

> **NOTE:** All gases with a critical temperature below –50°C belong to this category.

Cordon control – Cordons are employed as an effective method of controlling resources and maintaining safety on the incident ground. They must be continuously monitored and adapted to reflect changes in hazards, weather etc.

Corrosive – A substance that chemically attacks a material with which it has contact.

COSHH – *Control of Substances Hazardous to Health Regulations*.

CPC – Abbreviation for chemical protective clothing: The combined assembly of garments worn to provide protection against exposure to, or contact with, chemicals.

CPS (Chemical Protection Suit) – Abbreviation for chemical protection suits.

CPS (Counts per second) – Number of electrical pulses counted by an instrument arising from ionising radiation and proportional to the level of radioactivity.

Critical temperature – The temperature above which a gas cannot be liquefied by the application of pressure alone.

Cryogen – A substance used to obtain temperatures far below the freezing point of water (less than –78°C).

D

Dangerous substance – Defined substances that may be hazardous to the Fire and Rescue Service in an emergency (from the *Notification and Marking of Sites Regulations* 1990).

DCLG – The Department for Communities and Local Government, HM Government.

DDOOR – Downwind, Dilution, Obstacle, Oscillation and Retention. These are the key factors to remember when dealing with a hazardous release in an urban environment.

Decompose – Separate into its constituent elements, with the release of heat/energy.

Decomposition – Chemical reaction whereby a substance breaks down into its constituent elements. In the case of acetylene this means carbon and hydrogen. This reaction gives out a great deal of heat.

Decontamination – Decontamination is the physical and/or chemical process of reducing contamination to minimise the risk of further harm occurring and to minimise the risk of cross contamination to a level as low as reasonably practicable.

Decontamination Area – The area containing the Fire and Rescue Service (and possibly other emergency services') decontamination staff, equipment and structures. It is a suitable area initially established outside the inner cordon, at first uncontaminated by the initial release, which becomes contaminated by the managed and controlled movement of people who require decontamination. Prior to decontamination commencing, the inner cordon will be adjusted to encompass the decontamination area.

Deflagration – Exothermic chemical decomposition of a material in which the reaction front advances into the unreacted material at less than the speed of sound.

DEFRA – Department for Environment, Food and Rural Affairs.

Deliberate reconnaissance – Deliberate reconnaissance is distinct from scene assessment, which is a specific activity carried out prior to any formal structures being in place and as a necessary part of the initial response. Deliberate reconnaissance differs for each of the different agencies involved, for example the police may deploy for deliberate reconnaissance of a building or for the recovery of evidence, whereas the Fire and Rescue Service will primarily deploy for substance analysis and identification.

Degradation – The continuing action of chemical attack to which chemical protective clothing may be subject to in use or during storage.

Detonation – Explosion in which the flamefront advances at more than supersonic speed.

DIM – DCLG, has provided a suite of Detection Identification and Monitoring (DIM) equipment to the Fire and Rescue Service. **Detection** – The recognition of the presence of a CBRN material. **Identification** – The determination of which CBRN material is present. **Monitoring** – A continuous or periodic process of qualitatively or quantitatively determining the presence or absence of CBRN material.

Dissolved acetylene (DA) – Acetylene dissolved in acetone.

Dose rate – The radiation dose absorbed per unit time.

DSEAR – DSEAR stands for the Dangerous Substances and Explosive Atmospheres Regulations 2002. DSEAR puts duties on employers and the self-employed to protect people from risks to their safety from fires, explosions and similar events in the workplace, this includes members of the public who may be put at risk by work activity.

Dust – Solid particles generated by mechanical action, present as airborne contaminant (less than 0.076 mm in size).

E

EA – Environment Agency.

EAC – Emergency action code (EAC) (also known as HAZCHEM) is designed to cover the first vital step and gives an immediate indication of any actions that could be taken should it be necessary without the use of reference materials or expert advice.

ELS – Enhanced Logistics Support (formerly known as ECS – Enhanced Command Support within the New Dimensions Programme).

Electron – An elementary particle with low mass and a negative charge.

EMARC – Met Office Environment Monitoring and Response Centre.

EMAS – European Eco-Management and Audit Scheme.

Emergency exposure (radiation) – The exposure of an employee to a dose in excess of the IRR dose limits in accordance with REPPIR. Set at 100 milliSieverts.

EMS – Environmental Management Systems.

Encapsulating – Protective clothing which protects the whole body including the respiratory protective device against exposure to and/or contact with chemicals.

Endothermic reaction – Chemical reaction resulting in absorption of heat.

EOD – Explosive Ordnance Disposal – Military specialist units responsible for counter terrorist bomb disposal, Explosive Ordnance Disposal, the recovery and safe disposal of conventional munitions.

EPD – Electronic Personal Dosimeter.

ERG – Emergency Response Guidebook – which is produced by the USDOT for first responders during the initial phase of a dangerous goods/hazardous materials incident.

Erythema – Reddening of skin, inflammation.

Exclusion Zone – This is an area containing hazards that have been risk assessed as so dangerous to health that nobody, including Fire and Rescue Service staff, should be allowed to enter (eg, blast area around explosives involved in fire).

External hazard/external exposure – Hazard to the person that comes from outside of that person, in this context γ or x-rays from an outside source penetrating a person's body.

Exothermic reaction – Chemical reaction in which heat is released and, unless temperature is controlled, which may lead to runaway conditions.

Exposure – Exposure occurs when a harmful substance enters the body through a route, for example, inhalation, ingestion, absorption or injection, or when the body is irradiated.

> **NOTE:** Radioactive exposure, in terms of irradiation, does not automatically mean you are contaminated).

F

FEMA – Federal Emergency Management Agency (USA).

Firefighter Decontamination – Is the use of decontamination equipment in a planned and structured manner to minimise the risk of further harm occurring and cross contamination to a level as low as reasonably practicable. Firefighter decontamination may be divided into two levels, Initial and Full. These procedures usually involve two processes. Firstly, 'contamination reduction' and then 'safe undressing'.

Fire point – Minimum temperature at which a mixture of gas/vapour and air continues to burn in an open container when ignited.

Flammable range – Concentrations of flammable gas/vapour between the LEL and UEL at a given temperature.

Flashback – Occurs when flame from a torch burns back into the tip, the torch or the hose. It is often accompanied by a hissing or squealing sound with a smoky or sharp-pointed flame.

Flash point – Lowest temperature required to raise the vapour pressure of a liquid such that vapour concentration in air near the surface of the liquid is within the flammable range, and as such the air/vapour mixture will ignite in the presence of a suitable ignition source, usually a flame.

Fog (mists) – Liquid aerosols formed either by condensation of a liquid on particulate nodes in air or by uptake of liquid by hygroscopic particles.

Forward Command Post (FCP) – Point, near the scene of operations, where the officer delegated responsibility for command in that area is sited. This may be at a bridgehead.

Fume – Airborne solid particles (usually less than 0.0001mm) that have condensed from the vapour state.

FRA – Fire and Rescue Authority.

FRS – Fire and Rescue Service – provided by a fire authority under the *Fire and Rescue Services Act 2004*.

FRS Act – *Fire and Rescue Services Act 2004*.

FRSNCC – Fire and Rescue Service National Co-ordination Centre – based in West Yorkshire Fire and Rescue Service, established to co-ordinate the mobilisation of national resilience assets in collaboration with Fire and Rescue Service mobilising controls.

G

Gamma (γ) radiation – Type of radiation involving the emission of electromagnetic energy from the nucleus of a radioactive atom. May travel many hundreds of metres in air.

Generic Risk Assessment (GRA) – A fundamental element of the Fire and Rescue Service 5-Step Risk Assessment process. To support FRAs in satisfying their regulatory requirements, under the *Management of Health and Safety at Work Regulations 1999* (MHSWR), a series of Generic Risk Assessments have been produced by HM Government.

Gas – Gas is one of three classical states of matter. Near absolute zero, a substance exists as a solid. As heat is added to this substance it melts into a liquid at its melting point, boils into a gas at its boiling point, and if heated high enough would enter a plasma state in which the electrons are so energized that they leave their parent atoms from within the gas.

A pure gas may be made up of individual atoms (eg a noble gas or atomic gas like neon), elemental molecules made from one type of atom (eg oxygen), or compound molecules made from a variety of atoms (eg carbon dioxide). A gas mixture would contain a variety of pure gases much like the air. What distinguishes a gas from liquids and solids is the vast separation of the individual gas particles.

Gas tight CPC – Gas tight chemical protective clothing: Clothing which satisfies the requirements for ‘leak tightness’ when tested according to the internal pressure test given in the current BS EN.

GHS – Globally Harmonized System of classification and labelling of chemicals. This is a UN scheme aiming to have, worldwide, the same criteria for; classifying chemicals according to their health, environmental and physical hazards; and hazard communication requirements for labelling and safety data sheets. The GHS is not a formal treaty, but instead is a non-legally binding international agreement. Therefore countries (or trading blocks) must create local or national legislation to implement the GHS.

H

Half life – Length of time taken for a radioactive material to disintegrate to half its original strength.

Hazard – A hazard is anything that may cause harm.

Hazard zone – This is an area that contains hazards to which a risk assessment should be applied in order to determine a suitable inner cordon. A hazard zone is not necessarily an ‘exclusion zone’ and would encompass both the hot and warm zones if they exist. The hazard zone is sometimes referred to as the ‘evacuation zone’ by other agencies and generally means the area where they would seek to encourage all members of the public to leave or possibly shelter-in-place.

HazMats – Acronym for hazardous materials. HazMats, also referred to as dangerous/hazardous substances or goods, are solids, liquids, or gases that can harm people, other living organisms, property, or the environment. They not only include materials that are toxic, radioactive, flammable, explosive, corrosive, oxidizers, asphyxiates, biohazards, pathogen or allergen substances and organisms, but also materials with physical conditions or other characteristics that render them hazardous in specific circumstances, such as compressed gases and liquids, or hot/cold materials.

HazMats adviser – HazMats adviser is a generic term for any person, with enhanced knowledge of HazMats operations, used by a Fire and Rescue Service to provide independent specialist advice to the Incident Commander at emergency incidents involving hazardous materials.

HERS – Hazard Emergency Response Service.

HIN – Hazard Identification Number.

HMEPO – A Hazardous Materials and Environmental Protection Officer is a Fire and Rescue Service emergency management role that provides advice to the Incident Commander on tactics and other issues in relation to environmental protection. Such officers will have gained additional knowledge and understanding on environmental protection through specific development programmes and/or training courses.

Hot zone – This is the contaminated area(s) where the initial release occurs or disperses to. It will be the area likely to pose an immediate threat to the health and safety of all those located within it and is the area of greatest risk. It is located within the inner cordon and is part of the hazard zone.

HPA – Health Protection Agency. The Health Protection Agency’s role is to provide an integrated approach to protecting UK public health through the provision of support and advice.

Hydrocarbons – Compounds which are composed of atoms of hydrogen and carbon only.

Hydrogenation (de-) – The addition (removal) of hydrogen.

Hygienic cleaning – The process by which CPC is disinfected internally to allow it to be re-used.

I

IAEA – International Atomic Energy Agency.

IBC – Intermediate bulk container is a container used for transport and storage of fluids and bulk materials.

ICS – Incident Command System.

Improvised decontamination – The use of an immediately available method of decontamination prior to the use of specialist resources (eg on-site washing facilities etc).

IMDG code – International Maritime Dangerous Goods code.

Incident Commander (IC) – The nominated competent officer having overall responsibility for dictating tactics and resource management.

Initial cordon – The initial cordon is temporarily established by the first wave of unprotected emergency responders, before any detailed scene assessment or any other scientific analysis has been conducted. It provides an initial means of controlling, safeguarding and coordinating the immediate response and adds an element of control to the incident.

Inner cordon – The inner cordon surrounds the area where potentially hazardous activity may be conducted and encompasses both the hot and warm zones. It is used to control access to the immediate scene of operations. Access to the area controlled by an inner cordon, which by definition is the hazard zone, should be restricted to the minimum numbers required for work to be undertaken safely and effectively.

Interim decontamination – The use of standard Fire and Rescue Service equipment to provide a planned and structured decontamination process prior to the availability of purpose designed decontamination equipment.

Internal hazard/Internal exposure – Hazard to the person after radioactive material has been inhaled, ingested, absorbed or injected inside the body and continues to emit ionising radiation inside the body's vital organs.

Intrinsic safety – Intrinsic safety (IS) is a protection technique for safe operation of electrical equipment in explosive atmospheres. Intrinsically safe equipment is designed to limit the energy available to create a spark or heat surfaces, under both normal and 'fault' conditions.

There are varying standards of electrical safety, regulate under BSI and EN.

Ionisation – The process by which a neutral atom or molecule acquires or loses an electric charge. The production of ions.

Ionising radiation – Radiation that produces ionisation in matter.

IRR – The *Ionising Radiations Regulations 1999*.

Irradiation – An event where matter has been externally subjected to ionising radiation.

IRU – Incident Response Unit

ISO containers – Intermodal freight transport containers using standard sizes prescribed by the International Organisation for Standardisation (ISO). There are five common standard lengths, 20-ft (6.1 m), 40-ft (12.2 m), 45-ft (13.7 m), 48-ft (14.6 m), and 53-ft (16.2 m.

Isotope – A description of different forms of the same element which have differing nuclear mass. Some isotopes are radioactive.

L

Limited use CPC – Chemical protective clothing for limited wear life usage, ie to be worn until hygienic cleaning becomes necessary, or chemical contamination has occurred, and disposal is required. This includes protective clothing for single use and for limited re-use according to the manufacturer's instructions.

Liquid – Liquid is one of the three classical states of matter. Like a gas, a liquid is able to flow and take the shape of a container, but, like a solid, it resists compression. Unlike a gas, a liquid does not disperse to fill every space of a container, and maintains a fairly constant density. A distinctive property of the liquid state is surface tension, leading to wetting phenomena.

Liquid-tight (CPC) – Resistant to puncture by liquids in the form of a continuous jet when considering CPC.

LC_{50} – Lethal concentration for 50 per cent of the population – Calculated concentration of a substance that causes death in 50 per cent of a population under prescribed conditions in a prescribed period of time.

LD_{50} – Lethal dose for 50 per cent of the population – calculated dose of chemical, mg per kg of body weight, causing death in 50 per cent of test population.

LEL – Lower explosive limit – lowest concentration of vapour/gas in air at a given pressure and temperature that will propagate a flame when exposed to an ignition source.

LPG – Liquefied petroleum gas – essentially either propane or butane.

LNG – Liquefied natural gas

M

Mass decontamination (MD) – The planned and structured procedure delivered by the Fire and Rescue Service using purpose designed decontamination equipment where there are large numbers of contaminated casualties.

Major hazard – An industrial activity involving one or more dangerous substances which have the potential to give rise to serious danger to human health or the environment, immediate or delayed, inside or outside an establishment.

Major incident – Event or situation requiring a response under one or more of the emergency services' major incident plans.

MDT – Mobile data terminal.

MEL – Maximum exposure limit – maximum concentration of an airborne substance to which employees may be exposed by inhalation under any circumstances. **Replaced in COSHH 2005 by the Workplace Exposure Limit WEL**.

MSDS – Material safety data sheets.

MSER – Manufacture and Storage of Explosives Regulations 2005 (MSER).

Mutagen – Chemical or physical agent that can cause a change in the genetic material of a living cell.

N

NAIR – National Arrangements for Incidents involving Radioactivity.

NAME – Numerical Atmospheric-dispersion Modelling Environment is the title of a Met Office atmospheric pollution dispersal model which is a much more sophisticated tool than CHEMET for pollution forecasting.

NAMOS – Dangerous Substances (Notification and Marking of Sites) Regulations.

NCAF – National Co-ordination and Advisory Framework.

NIHHS – Notification of Installations Handling Hazardous Substances Regulations *1982* (NIHHS) (as amended).

NRAT – National Resilience Assurance Team.

NSAT – National Strategic Advisory Team.

Nucleus – The core of an atom, occupying little of the volume, containing most of the mass and bearing a positive charge.

O

Octane number – A value which indicates how smoothly a petrol burns in an engine. It is based on a scale of 2,2,4-trimethylpentane (100 octane) and heptane (0 octane).

OEL – occupational exposure limits – two types MEL and OES, replaced in COSHH 2005 by the workplace exposure limit (WEL).

OES – Occupational exposure standard – a target level of exposure which was deemed to be safe for the majority of the population

> **NOTE:** replaced in COSHH 2005 by the workplace exposure limit (WEL).

Outer cordon – The outer cordon designates the controlled area into which unauthorised access is not permitted. It encompasses the inner cordon and the hot, warm and cold zones. It should be established and maintained by the Police Service.

Oxygen deficiency – Depletion of oxygen content of air to below the normal 21 per cent. Exposure to less than 18 per cent must not be permitted.

Oxygen enrichment – Increase in oxygen content of air to above the normal 21 per cent. Enrichment above 25 per cent in a room can accelerate combustion.

P

PACRAM – Procedures and communications in the event of a release of radioactive material.

Pass-through (or pass-thru) – A means by which air can be passed through the wall of a CP suit and connected to self-contained breathing apparatus to provide supplementary air.

PCB – Polychlorinated biphenyls known as PCBs.

Penetration – The process by which a chemical flows through holes or essential openings in the material of CPC. The holes may be the result of mechanical damage.

Percutaneous absorption – Absorption via the skin, for example due to local contamination or a splash of a chemical.

Permeation – The process by which a chemical moves through a protective clothing material on a molecular level.

Persistence – Persistence of chemicals indicates that they are stable and long-lived in the environment, resisting degradation, eg lead, cadmium, mercury, PCBs, and many man-made organics.

Plasticiser – A chemical added to plastics during manufacture to make them more flexible.

PPE – Personal protective equipment.

Practicable – Capable of being done in the light of current knowledge and invention.

Pressure – Pressure is the force per unit area applied in a direction perpendicular to the surface of an object. Units – 1 atmosphere or bar is approximately 100,000 pascals (100 kPa); 1 bar = 14.5 pounds per square inch (psi).

PRPS – Powered respirator protective suit.

Pulmonary oedema – Production of watery fluid in the lungs.

Pyrophoric substance – A material that undergoes such vigorous oxidation or hydrolysis when exposed to atmospheric oxygen or to water, that it rapidly ignites without an external source of ignition.

R

Radiation – The process by which energy is transmitted away from an energy source.

Radiation emergency – As defined in REPPIR; an event likely to lead to member of public receiving a dose of 5 mSv in the year following the event.

Radiation Protection Adviser (RPA) – A person engaged by a radiation employer to advise on the observance of legislation appertaining to radiation.

Radiation Protection Supervisor (RPS) – A person of sufficient authority and training to supervise employees with respect to observance of local rules.

Radioactive material – A solid, liquid or gas which spontaneously emits ionising radiation.

Radioactivity – The phenomenon by which a radioactive atom transforms into a different atom with the spontaneous emission of ionising radiation.

RCC – Regional Control Centre – regional Fire and Rescue Service emergency mobilising centre.

REACH – Registration, evaluation, authorisation and restriction of chemicals.

'reasonably practicable' – To carry out a duty 'as far as reasonably practicable' means that the degree of risk in a particular activity or environment can be balanced against the time, trouble, cost and physical difficulty of taking measures to avoid the risk. If these are so disproportionate to the risk that it would be quite unreasonable for the people concerned to have to incur them to prevent it, they are not obliged to do so. The greater the risk, the more likely it is that it is reasonable to go to very substantial expense, trouble and invention to reduce it. But if the consequences and the extent of a risk were small, insistence on great expense would not be considered reasonable. It is important to remember that the size or financial position of the employer are not taken into account.

Reportable disease – A disease which must be reported to the UK authorities when linked to specified types of work (*Reporting of Injuries Diseases and Dangerous Occurrences Regulations 1995* – RIDDOR).

REPPIR – *Radiation* (*Emergency Preparedness and Public Information) Regulations 2001* (REPPIR) *Statutory Instrument 2002 No. 1093*.

Respirable dust – That fraction of total inhalable dust which penetrates to the gas exchange region of the lung.

Respiratory sensitiser – A substance that may cause sensitisation on inhalation, causing, for example, asthma, rhinitis.

Responsible person – An individual who has responsibility for a particular area, site, premises, vehicle or other property through ownership (eg owner, occupier, driver etc) or as a representative of a responsible authority or agency (eg local authority, police, environment agency, highways agency etc).

Reusable CPC – Chemical protective clothing constructed from materials which allow the clothing to be cleaned after repeated chemical exposures such that it remains suitable for continued use.

RID – European agreements concerning the International Carriage of Dangerous Goods by Rail.

RIDDOR – *Reporting of Injuries Diseases and Dangerous Occurrences Regulations 1995*.

Risk – Risk is the probability that somebody could be harmed by a hazard or hazards, together with an indication of how serious the harm could be.

Risk Assessment – A risk assessment is simply a careful examination of what, in the workplace, could cause harm to people, in order to weigh up whether enough precautions have been taken or more should be done to prevent harm. The law does not expect the elimination of all risk, but the protection of people as far as is 'reasonably practicable'.

RPE – Respiratory protective equipment.

S

Safe air – An environment where the air is breathable and will not be harmful without the use of respiratory protection.

Safe system of work – A formal procedure resulting from systematic examination of a task to identify all the hazards. Defines safe methods to ensure that hazards are eliminated or risks controlled.

Safety – A state where exposure to hazards has been controlled to an acceptable level.

SAGE – Scientific Advisory Group in Emergencies. Group of scientific and technical experts that is established to provide a common source of advice to inform decisions made during the central government.

Salts – Salts are the product other than water generated when an acid reacts with a base.

Sealed (or closed) – A radioactive source sealed within impermeable material which cannot easily be dispersed.

Sector Commander – An officer commanding a sector, who is tasked with responsibility for tactical and safety management of a clearly identified part of an incident. Subject to objectives set by the Incident Commander the Sector Commander has control of all operations within the sector and must remain within it.

Sensitisation dermatitis – Inflammation of the skin due to an allergic reaction to a sensitiser.

Sensitiser – A substance that causes little or no reaction in a person upon initial exposure but which will provoke an allergic response on subsequent exposures.

SFK – Structural firefighting kit.

SHA – Strategic holding area – an area with suitable space and facilities to accommodate large numbers of crews, appliances and equipment, where these resources can standby or rest whilst awaiting deployment to marshalling areas for a large or serious incident.

Shielding – A physical barrier or protection against the harmful effects of HazMats. Dense materials, walls, vehicles, rolling stock or earthworks may provide a level of shielding. The effectiveness of any shielding will be dependant on (a) the hazards posed by the HazMats (eg irradiation, explosive fragments, fireball/blast, chemical vapour cloud etc) and (b) the physical characteristics of the shield (eg material, density, thickness, stability, integrity, bonding, perforations etc). Shielding may allow a reduction in the initial or inner cordon.

Sievert (Sv) – The unit of dose used when measuring the degree of harm caused to persons exposed to ionising radiation.

Slurry – A free-flowing mixture of liquid and solid.

Span of control – The number of lines of communication that a single individual has to maintain. This is usually defined by the number of people who potentially require an officer's attention for briefing, reporting, passing instructions or other incident management concerns, in order to carry out their role at the incident. As a guide, five such reporting lines are considered the usual optimum for an Incident Commander to maintain during an incident. This may be increased at an incident, which is well in hand or have to be reduced to two or three during the early stages of a rapidly escalating or highly complex incident. Management of the span of control must be effective throughout the command line.

SMA – Subject Matter Adviser – members of a national team who have been identified from within the Fire and Rescue Service who work with New Dimension capabilities on a day-to-day basis. At a large or serious incident they are available to provide advice to the incident commander.

Smoke – Particulate matter, usually less than 0.0005 mm in diameter, in air resulting usually from combustion, including liquids, gases, vapours and solids.

Solid – Solid is one of the classical states of matter. It is characterised by structural rigidity and resistance to changes of shape or volume. Unlike a liquid, a solid object does not flow to take on the shape of its container, nor does it expand to fill the entire volume available to it like a gas does. The atoms in a solid are tightly bound to each other, either in a regular geometric lattice (crystalline solids, which include metals and ordinary water ice) or irregularly (an amorphous solid such as common window glass).

Spontaneous combustion – Combustion that results when materials undergo atmospheric oxidation at such a rate that the heat generation exceeds heat dissipation and the heat gradually builds up to a sufficient degree to cause the mass of material to inflame.

STAC – Scientific and Technical Advisory Cell. Group of technical experts from those agencies involved in an emergency response that may provide scientific and technical advice to the Strategic Co-ordinating Group chair or single service gold commander.

Steam explosion – Overpressure associated with the rapid expansion in volume on instantaneous conversion of water to steam.

Surface contamination – Hazardous materials adhering to a vertical surface or resting on a horizontal surface.

T

Tactics – The deployment of personnel and equipment on the incident ground to achieve the aims of the strategic plan.

Teratogen – Chemical or physical agent that can cause defects in a developing embryo or foetus when the pregnant female is exposed to the harmful agent.

Time-distance-shielding – Summary of the three conditions to limit a γ radiation dose (ie minimise exposure time, maximise distance from source and take maximum advantage from available shielding).

TLV-C – Threshold limit value – ceiling – USA limit for the atmospheric concentration of a chemical which may not be exceeded at any time, even instantaneously in workroom air.

TVL-STEL – Threshold limit value – short term exposure limit – USA limit on the concentration of a chemical in workroom air which may be reached, but not exceeded, on up to four occasions during a day for a maximum of 15 minutes each time with each maximum exposure separated by at least one hour.

TLV-TWA – Threshold limit value – time weighted average – USA limit for the atmospheric concentration of a chemical, averaged over an eight hour day, to which it is believed that most people can be exposed without harm.

TOPS – Total Operations Processing System, information system for the railway.

Total inhalable dust – The fraction of airborne dust which enters the nose and mouth during breathing and is available for deposition in the respiratory tract.

U

UEL – Upper explosive limit – The maximum concentration of vapour/gas in air at a given pressure and temperature in which a flame can be propagated.

UKHIS – United Kingdom Hazard Identification System.

Unsealed (or open) – A radioactive source not confined within impermeable material which could potentially be dispersed into the environment.

USAR – Urban search and rescue team/capability.

UVCE – Unconfined vapour cloud explosion – Explosion involving a large mixed vapour/air cloud in the open (See BEVE).

V

Vapour – Vapour refers to a gas phase at a temperature where the same substance can also exist in the liquid or solid state, below the critical temperature of the substance. If the vapour is in contact with a liquid or solid phase, the two phases will be in a state of equilibrium.

Vapour flashing – If a liquid near its boiling point at one pressure is 'let down' to a reduced pressure, vapour flashing will occur. This will stop when the liquid temperature is reduced to a temperature below the saturation temperature at the new pressure.

VCE – Vapour cloud explosion (See UVCE and BLEVE).

Viscosity – A measure of the resistance to flow of a liquid.

W

Warm zone – The area uncontaminated by the initial release of a substance, which may become contaminated by the movement of people or vehicles. It is surrounded by the inner cordon and is part of the hazard zone but usually contains lower risks than the hot zone.

WEL – Workplace exposure limit – maximum concentration of an airborne substance to which employees may be exposed, averaged over a specific period of time, the two periods used are long term (eight hours) and short term (15 minutes). It is an offence to exceed them (COSHH 2005).

Wetting test – Method used initially to establish if an acetylene cylinder is hot from an internal decomposition caused by a flashback or by exposure to fire. The wetting test may also be subsequently used to indicate if an ongoing decomposition is slowing down inside the cylinder and that the external shell has cooled indicating that a spontaneous explosion is unlikely, given ongoing cooling. This test is only applicable to dissolved acetylene cylinders.

WISER – Wireless Information System for Emergency Responders.

WMD – Weapons of mass destruction.

X

Xenbiotic – Not friendly to biological organisms in general (includes many man-made substances, especially pesticides, lead, cadmium and mercury).

X-ray – A type of radiation caused by the emission of electromagnetic energy from the electrons in an atom.

Section 11

References and bibliography

References and bibliography

Part A – Pre-planning considerations

Nil

Part B – Operational considerations

Managing the Incident (third edition)
Noll, Hildebrand, Yvorra – Red Hat Publishing Maryland USA, 2005

Making the UK safer: detecting and decontaminating chemical and biological agents
The Royal Society Policy document 06/04, April 2004

Hazardous Materials Guide for First Responders
Federal Emergency Management Agency and United States Fire Administration 2003, University of Louisville, 2003

Hazardous Materials Response Hand Book (third edition)
L. Charles Smeby Jr National Fire Protection Association, Massachusetts 1997

Hazardous Materials Regulations, Response and Site Operations
Schnepp and Gantt – Delmar, New York, US, 1999

Hazard Identification and Risk Assessment
G. Wells, Institution of Chemical Engineers, Rugby UK 1996

Fundamentals of Hazardous Materials Incidents
Campbell and Langford – Lewis Publishers, Michigan US, 1991

Hazardous chemicals handbook (second edition)
P. A. Carson and C. J. Mumford, Butterworth-Heinemann, Oxford, 2002

National Co-ordination and Advisory Framework
Chief Fire and Rescue Adviser, Communities and Local Government, HM Government, 2009

A Dictionary of Epidemiology, fourth edition
J M Last, Oxford University Press, 2001.

NATIONAL GUIDANCE DOCUMENT, FIRE SERVICE MASS DECONTAMINATION
Version 1.1
Office of the Deputy Prime Minister, April 2003.

Strategic National Guidance on the Decontamination of People Exposed to Chemical, Biological, Radiological or Nuclear (CBRN) Substances or Material
Home Office, March 2003

Fire and Rescue Service Circular 1/2009 – Tactical Guidance Document Fire and Rescue Service Response to CBRN Events
Chief Fire and Rescue Adviser Communities and Local Government, HM Government, 2009

Tactical Guidance Document Fire and Rescue Service Response to CBRN Events – New Dimension Programme
Communities and Local Government, HM Government, 2008 (PROTECT)

Operational Guidance Document Fire and Rescue Service Response to CBRN(E) Events
Communities and Local Government, HM Government, 2012 (PROTECT)

Multi-Agency National Concept of Operations for CBRN Terrorism
CBRN Tacticians Forum, edition1 2005 (RESTRICTED)

The Safe Handling of Contaminated Fatalities (GUIDANCE DOCUMENT)
Home Office, HM Government, JUNE 2009 (RESTRICTED)

A Model Response to CBRN Events
Home Office, HM Government, July 2006 (RESTRICTED)

Memorandum of understanding between the DoH and DTLR for Fire Service involvement in Mass Decontamination January 2002

Fire and Rescue Service Circular 58/2006 – Memorandum of Understanding on Mass Decontamination
Department for Communities and Local Government, 22 September 2006

Fire and Rescue Manual, Volume 2 – Fire Service Operations, Incident Command
Communities and Local Government, HM Government, 3rd edition 2008

Fire and Rescue Manual, Volume 2 – Fire Service Operations, Environmental Protection
Communities and Local Government, HM Government

Fire Service Manual, Volume 1 – Fire Service Technology, Equipment and Media – Physics and chemistry for firefighters
Communities and Local Government, HM Government

Fire Service Manual, Volume 2 – Fire Service Operations, Acetylene Cylinder Incidents and Natural Gas Incidents
Communities and Local Government, HM Government

Fire Service Manual, Volume 2 – Fire Service Operations, Incidents Involving Rescue from Road Vehicles
Communities and Local Government, HM Government

Fire Service Manual, Volume 2 – Fire Service Operations, Aircraft Incidents
Communities and Local Government, HM Government

Fire Service Manual, Volume 2 – Fire Service Operations, Marine Incidents
Communities and Local Government, HM Government

Fire Service Manual, Volume 2 – Fire Service Operations, Electricity
Communities and Local Government, HM Government

Fire Service Manual, Volume 2 – Fire Service Operations, Petrochemical Incidents
Communities and Local Government, HM Government

Fire Service Manual Volume 1 – Fire Service Technology, Equipment and Media – Inspection and Testing of Equipment
Communities and Local Government, HM Government

Fire and Rescue Service Manual, Volume 4 – Fire Service Training
Communities and Local Government

Manual of Firemanship Book 11 Part 1
HM Government

Manual of Firemanship Book 6, Breathing apparatus and resuscitation
HM Government

Manual of Firemanship Book 4 Part 3 Chapter 22 Dangerous substances carried on trains
HM Government

Manual of Firemanship Part 6c, Practical Firemanship III
HM Government

Manual of Firemanship Book 12 Part 2
HM Government

Manual of Firemanship Part 6b
HM Government

Part C – Technical considerations

Fire and Rescue Services Act 2004 (as amended)

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

Civil Contingencies Act 2004

Health and Safety at Work Act 1974

Management of Health and Safety at Work Regulations 1999 (as amended)

Personnel Protective Equipment Regulations 1992 (as amended)

Fire Service Manual, Volume 1 – Fire Service Technology, Equipment and Media Physics and Chemistry for Firefighters
HM Government

Fire Service Manual, Volume 1 – Fire Service Technology, Equipment and Media) Firefighting Foam – Technical
HM Government

Fire Service Manual, Volume 2 – Fire Service Operations, Firefighting Foam
HM Government

Fire Service Manual, Volume 2 – Fire Service Operations, Petrochemical Incidents
HM Government

Fire Service Manual, Volume 2 – Fire Service Operations, Acetylene Cylinder Incidents and Natural Gas Incidents
Communities and Local Government, HM Government

Fire Service Manual, Volume 2 – Fire Service Operations, Incidents Involving Rescue from Road Vehicles
HM Government

Fire and Rescue Manual, Volume 2 – Fire Service Operations – Environmental Protection 2008
HM Government

Manual of Firemanship Book 6, Breathing apparatus and resuscitation
HM Government

Manual of Firemanship Book 4 Part 3 Chapter 22 Dangerous substances carried on trains
HM Government

Manual of Firemanship Part 6c, Practical Firemanship III
HM Government

Manual of Firemanship Book 12 Part 2
HM Government

Manual of Firemanship Part 6b
HM Government

Fire and Rescue Service Operational Guidance, Generic Risk Assessment 5.7 – Explosives
Communities and Local Government, HM Government

Fire and Rescue Service Operational Guidance, Generic Risk Assessment 3.10 – Petrochemicals and pipelines
Communities and Local Government, HM Government

Fire and Rescue Service Operational Guidance, Generic Risk Assessment 5.3 – Chemicals
Communities and Local Government, HM Government

Fire and Rescue Service Operational Guidance, Generic Risk Assessment 5.4 – Biological Hazards
Communities and Local Government, HM Government

Fire and Rescue Service Operational Guidance, Generic Risk Assessmen 5.9 – Asbestos
Communities and Local Government, HM Government

Fire and Rescue Service Operational Guidance, Generic Risk Assessment – Radiation
Communities and Local Government, HM Government

Emergency Response Guidebook (ERG)
US Department of Transportation, Transport Canada, and the Secretariat of Communications and Transportation of Mexico

Hazardous materials – regulations, response and site operations
Schnepp and Gantt. Thompson Learning, London 1999

IAEA Safety Standards Regulations for the Safe Transport of Radioactive Material
Dangerous Goods and Explosive Atmospheres Regulations

The Storage of Dangerous Substances
HSE Reference L135

Design of Plant and the Workplace
HSE Reference L134

Blast Damage and Injuries
Health and Safety Executive

Control of Major Accident Hazards (COMAH) Regulations 1999

Enschede Final Report

Explosives Industry Forum

Firework Regulations 2004

Pyrotechnic Articles (Safety) Regulations 2010

Fireworks Accident, Kolding, 2004 Operational Incident Response Report
Danish Emergency Management Agency December 2006

Fire and Rescue Service Operational Guidance, Generic Risk Assessment 5.7 – Explosives
Communities and Local Government

HSE Explosives Group – explosives@webcomrnunities.hse.gov.uk

HSE Website – Explosives

International Maritime Organisation – IMDG Code

Literature review of fireworks compositions, propagation mechanisms, storage legislation and environmental effects
CHAF work package 4 Report June 2003

Manufacture and Storage of Explosives Regulations 2005 (MSER) and ACoP L139

MOD Explosives, Storage and Transport Committee Guidance Notes
(D/ESTC series)

Quantification and Control of the Hazards Associated with the Transport and Bulk Storage of Fireworks (CHAF)
EC Contract EVG1 -CT 2002-00074

R. Merrifield, Report on the Peterborough Explosion, Peterborough, UK 1989

Technical Bulletin 1/1992 Explosives
Home Office

Fire and Rescue ServiceC 28/2007 Fire Service Risk Management for Methamphetamine and other illicit drug laboratories
Communities and Local Government

Cryogenic engineering
Thomas M Flynn

Health & Safety Executive – *LNG terminals – consent and operational uses*

Health & Safety Executive – *Review of Ammonia Incidents*

European Agreement on Carriage of Dangerous Goods by Rail 2010 (RID)

European Agreement on Carriage of Dangerous Goods by Road 2010 (ADR)

UN 'Orange Book' – 'Recommendations the Transport of Dangerous Goods' 2009

UN Recommendations on the Transport of Dangerous Goods – Model Regulations

Fire Service College – *Flammable liquids note*

Fire Service College – *Flammable Solids note WHMEP08*

Fire Service College – *Oxidisation note WHMEP08*

Fire Service College – *Gases note WHMEP08*

Fire Service College – *Toxicity note WHMEP08*

Fire Service College – *Agrochemicals and basis note WHMEP08*

Fire Service College – *Personal protection – CPC WHMEP08*

Fire Service College – *Personal protection – decontamination note WHMEP08*

Fire Service College – *Biohazards note WHMEP08*

Fire Service College – *Environmental Protection WHMEP08*

Fire Service College – *UN Class 9 note WHMEP08*

Fire Service College – *Acids, bases and corrosives WHMEP08*

Hazardous Chemicals Handbook (second edition)
Carson and Mumford, Butterworth-Heinmann, Oxford 2002

Usborne Illustrated Dictionary of Science
Usborne Publishing Ltd, London 2001

Chemdata
National Chemical Emergency Centre

Hazardous materials – regulations, response and site operations
Schnepp and Gantt. Thompson Learning, London 1999 by Road

ACDP – *Approved List of Biological Agents Categorisation 2004*

ACDP – *The management, design and operation of microbiological containment laboratories 2001*

ACDP – *Infection at work: controlling the risk 2003*

ACDP – *Biological agents: Managing the risks in laboratories and healthcare premises 2005*

Genetically Modified Organisms Regulations 2002

Anti-terrorism, Crime and Security Act 2001 (Extension to Animal Pathogens) Order 2007, SI 2007 No.926

High Activity Sealed Sources directive

http://www.hpa.org.uk/radiation/default.htm

http://www.hse.gov.uk/cdg/manual/carriage.htm#adr

http://www-pub.iaea.org/MTCD/publications/PDF/Pub1225_web.pdf

International Maritime Dangerous Goods (IMDG) Code

Ionising Radiations Regulations 1999 (IRR99) and Approved Code of Practice

MoD website. www.mod.uk/nr/rdonlyres/226e622e-356-e-4cb0-a2cd-979ae352b848/0/20080424laeslv6u.pdf

Radioactive Substances Act 1993

Manual for First Responders to a Radiological Emergency, International Atomic Energy Agency

NEPLG Consolidated Guidance, Nuclear Emergency Planning Liaison Group, Department for Business, Enterprise and Regulatory Reform, May 2008

Regulations for the Safe Transport of Radioactive Materials 2005 edition

Radiation (Emergency Preparedness and Public Information) Regulations 2001 (REPPIR) Statutory Instrument 2002 No. 1093

The Radioactive Material (Road Transport) Regulations 2002

A Comprehensive Guide to Managing Asbestos in Premises HSG227
HSE

Control of Asbestos Regulations 2006

DCOL 2/2004 Item A – Asbestos method statement
Office of the Deputy Prime Minister, HM Government

Fire and Rescue Service Operational Guidance, Generic Risk Assessment – Incidents involving Asbestos
Communities and Local Government

Fire and Rescue ServiceC 35/2005 Certificate of exemption for work with certain asbestos materials and certificate of exemption 1:2005
Office of the Deputy Prime Minister, HM Government

Health Protection Agency – Responding to large scale fires involving asbestos Part 1- HPU Toolkit and Resource Pack

Health Protection Agency *Compendium of Chemical Hazards – Asbestos*

Introduction to Asbestos Essential HSG213 (HSE)

Dioxins – *Toxicological Overview,* Prepared by JC Wakefield, CHAPD HQ, HPA 2008, Version 1.

Health Hazards of Combustion Products From Aircraft Composite Materials
Office of Aviation Research Washington, D.C. 1998

Selecting Respiratory Protection Equipment for work with Asbestos INDG288 (HSE)

The management of asbestos in non-domestic premises (HSE ACoP L127)

The management of asbestos in non-domestic premises (HSE leaflet INDG 223)

The public health significance of asbestos exposures from large scale fires
KR Smith and P Saunders

Work with Asbestos Insulation, Asbestos Coating and Asbestos Insulating Board (fourth edition) Approved Code of Practice and Guidance (HSE)

Work with materials containing asbestos (HSE ACoP L143)

Standard Operating Procedures Powered Respirator Protective Suit (PRPS) Communities and Local Government, (March 2007)

Mass decontamination of the public, document number ND-MD-PRPS-01, Version 1.1

Respirex Tychem TK Gas-tight suit, Civil Resilience Directorate, New Dimension Programme, December 2004, Version 1.1
Office of the Deputy Prime Minister, (2004)

Permeation Guide for Dupont Tychem Protective Fabrics
DuPont, (2004),

Tychem TK Limited Life Gas-tight suit
Office of the Deputy Prime Minister, (2004)

Fire and Rescue Service Circular 25-2004
HM Government

The End of Life Vehicle Regulations 2003

Food and Environmental Protection Act 1985

Hierarchy of Pollution Controlled Model (FSC 1997)

The Control of Pesticides Regulations 1986 (as amended 1987)

The Control of Substances Hazardous to Health Regulations 2002

The Environment Act 1995

The Environmental Information Regulations 2004

The Environmental Permitting Regulations 2010

The Environmental Damage (Prevention and Remediation) Regulations 2009

The Groundwater Regulations 1998

The Hazardous Waste Regulations 2005

The Special Waste Regulations 1996 (as amended)

The Water Resources Act 1991

Water Industry Act 1999

Guidance for Sea Transport of Ammonium Nitrate Based Fertilizers
European Fertilizer Manufacturers' Association, 2004.

Breathing Apparatus Command and Control procedures
Home Office Technical Bulletin – 1/1997, HM Government

BS EN 137:2006 Respiratory protective devices. Self contained open circuit compressed air breathing apparatus with full face mask. Requirements, testing and marking. (Type 2 firefighting)

BS EN 529:2005 Respiratory protective devices. Recommendations for selection, use, care and maintenance. Guidance document.

BS 10999:1010 Specification for distress signal units for the Fire and Rescue Service.

Standards for personal protective equipment (PPE), OM 2009/03
Health and Safety Executive

DCOL 2/1996
HM Government

DCOL 3/2004 Item C
HM Government

Fire Service Circular 54/2006
HM Government

Home Office Fire Research and Development Group report 9/94 and 2/95
HM Government

DCOL 8/1995 Item D
HM Government

Central Fire Brigades Advisory Committee Research Report No. 63
The fire Experimental Unit (FEU) of the Home Office, 1994, HM Government

Section 12

Record of obsolete or superseded guidance

Record of obsolete or superseded guidance

The table below lists the hazardous material guidance, issued by Her Majesty's Government, which is now deemed to be obsolete or, is superseded by this operational guidance document.

The following abbreviations are used in the table:

FRSM	Fire and Rescue Service Manual
FSM	Fire Service Manual
MoF	Manual of Firemanship
FRSC	Fire and Rescue Service Circular
DCOL	Dear Chief Officer Letter
TB	Technical Bulletin
FSC	Fire Service Circular

Type of guidance	Document title
FSM	Fire Service Manual, Volume 2 – Fire Service Operations, Acetylene Cylinder Incidents and Natural Gas: Acetylene Cylinder Incidents section only
MoF	Manual of Firemanship Book 11: Part 1, Chapter 4 section 4 explosion risks Chapter 4 section 5 dangerous fumes Chapter 5 section 9 Fires involving radioactive substances
MoF	Manual of Firemanship Book 4: Part 2 Chapter 15 Dangerous substances on ships and in port areas Part 3 Chapter 22 Dangerous substances carried on trains Appendix National Arrangements for dealing with incidents involving radioactivity the NAIR scheme
MoF	Manual of Firemanship Book 12: Part 2 Decontamination

Type of guidance	Document title
MoF	Manual of firemanship Part 6b: Chapter 1 Section 6(k) Fire involving fertilisers Chapter 2 The gas industry and fires in gasworks Chapter 3 Electricity and the Fire Service Chapter 4 Fires in aircraft Chapter 5 Fires in Oil Refineries
MoF	Manual of Firemanship Part 6c, Practical Firemanship III Chapter 45: Section 2 Fire involving explosives Section 5 Fires involving fuels Section 11 Radioactive materials Section 16 Dangerous chemicals
Generic Risk Assessment	Section 5.7 (Explosives) of Volume 3: A Guide to Operational Risk Assessment - Generic Risk Assessment Series 2008
Fire and Rescue Service C 58/2008	Fire Service Guidance for Managing Acetylene
Fire and Rescue Service C 19/2008	Hazchem Emergency Response Service (HERS) Scheme
Fire and Rescue Service C 20/2008	Switch Loading of Petrol and Distillate Fuels
Fire and Rescue Service C 3/ 2007	Dangerous Goods Emergency Action Code List 2007
Fire and Rescue Service C 54/2006	Guidance chemical protective clothing
Fire and Rescue Service C 17/2005	Guidance relating to the prohibition of CYMAG Pesticides
Fire and Rescue Service C 43/2008	Generic Risk Assessment 5.7 - Explosives Part 1. Version 2

Type of guidance	Document title
Fire and Rescue Service C 20/2007	Fire and Rescue Service Manual, Volume 2, Operations, Incidents Involving Rescue from Road Vehicles
Fire and Rescue Service C 54/2006	British Standard BS 8467:2006 and British Standard BS 8468:2006
Fire and Rescue Service C 5/2006	Guidance regarding security of tankers at fuel distribution sites
Fire and Rescue Service C 32/2004	Fire Service Manual Volume 2: Fire Service Operations
Fire and Rescue Service C 21/2003	New Dimension incident response units: awareness
Fire and Rescue Service C 13/2003	New Dimension Programme
FSC 4/1989	Environment and Safety Information Act 1988
FSC 1/1984	B. Hazards posed by asbestos
FSC 6/1983	Care, maintenance and testing of gas-tight chemical protection suits
FSC 2/1982	Hazards posed by asbestos
FSC 10/1981	Chemical decontamination procedures for personnel and equipment
FSC 24/1977	Sealing a leak on a tanker or drum containing a dangerous substance
FSC 30/1976	Hazards posed by asbestos
FSC 25/1976	Training courses radiation hazards and dangerous substances
FSC 9/1974	Petroleum (Consolidation) Act 1928: conveyance by road of organic peroxides
FSC 20/1974	Petroleum (Consolidation) Act 1928: conveyance by road of corrosive substances
FSC 4/1974	The protection of firemen from toxic hazards – isocyanates
FSC 2/1974	The keeping of LPG in cylinders and similar containers
FSC 16/1965	Factories Act 1961 Explosives factories
TB 1/1997	BA command and control procedures: Page 7 SP4 chemical protective clothing
TB 2/1993	Incidents involving radioactive materials

Type of guidance	Document title
TB 1/1992	Explosives guide
TB 1/1977	Fires and other occurrences involving bulk quantities of LPG
TB 1/1975	Stored pesticides involved in fires
TB 1/1974	Toxic hazards – fire and other occurrences involving isocyanates
TB 1/1973	Identification on fertilisers involved in fires. Amonium nitrate fertilisers
TB 1/1971	Fires involving fertilisers
TB 5/1952	Plastics
TB 5/1950	Dangerous metals. Cadmium. Metal powders
TB 3/1950	Explosives and dangerous substances
TB 1/1949	Cylinders of dissolved acetylene
DCOL 3/2004	Publication of new British standards
DCOL 2/2003	Dangerous Substances and Explosives Atmosphere Regulations
DCOL 2/2003	Radiation dose rates for firefighters
DCOL 2/2002	Industrial gas cylinder identification
DCOL 3/2002	The Chemical Regulations 2002 (Chip 3) – (Hazard Information and Packaging for Supply)
DCOL 12/1999	Emergency Arrangements for the Transport of Radioactive Material (RADSAFE)
DCOL 12/1999	Control of Major Accident Hazards Regulations COMAH
DCOL 12/1996	New regulations on the transport of dangerous goods by road and rail
DCOL 2/1996	A guidance on selection and use of chemical protective clothing
DCOL 8/1995	Methods of decontamination after chemical incidents: CFBAC research report no 63
DCOL 9/1994	Eating and drinking at chemical incidents
DCOL 10/1991	Radiation protection off site for emergency services in the event of a nuclear accident
DCOL 1991/10	Safety hazards associated with carbon fibre materials
DCOL 4/1991	Hazrad: report by the working group on incidents involving radioactivity
DCOL 10/1990	The Dangerous Substances (Notification and Marking of Sites) Regulations 1990
DCOL 9/1984	The role of the Fire Service at incidents involving radioactivity
DCOL 2/1984	Treatment of leaking chlorine cylinders

Type of guidance	Document title
DCOL 12/1982	Fires and other occurrences involving biological hazards
DCOL 20/1982	Notification of installations handling hazardous substances regulations 1982
DCOL 7/1982	Fires involving liquid petroleum gas (LPG)
DCOL 16/1981	Information on dangerous substances
DCOL 3/1981	British Rail manual on dangerous goods
DCOL 5/1980	Problems associated with gas detection
DCOL 33/1979	Importation of compressed gases
DCOL 42/1979	Sodium chlorate stored in drums
DCOL 5/1979	Importation of compressed acetylene
DCOL 26/1979	Spillages of hazardous chemicals on the highway
DCOL 34/1977	Notification to Health and Safety Executive Inspectors of incidents involving cylinders of dissolved acetylene and other compressed gases
DCOL 58/1977	Hazards to firemen from chemicals on farms
DCOL 72/1976	Manual of firemanship Part 6c Nitrate fires
DCOL 3/1976	Crashed aircraft carrying nuclear weapons
DCOL 172/42	Liquid ethylene traffic
DCOL 19/1972	Dangerous substances guidance on dealing with fires and spillages
DCOL 23/1970	Spillages of dangerous substances on highways
DCOL 36/1967	Hazards from chemical fumes
DCOL 14/1966	Fires and other occurrences involving bulk quantities of liquefied petroleum gas
DCOL 6/1959	Fire fighting hazards of radioactive materials
DCOL 1957/344	High Test Peroxide (“H.T.P.”)
DCOL 1957/363	Fire hazards of titanium
DCOL 1954/214	Hydrogen peroxide
DCOL 1954/227	Use of radioisotopes in industry
DCOL 1952/135	The hydrogen cyanide (fumigation of buildings) regulations, 1951 and the hydrogen cyanide (fumigation of ships) regulations 1951
DCOL 1951/82	Liquid ethylene traffic
DCOL 1951/94	Sulphur fires
DCOL 3/2004	B. Guidelines for smallpox response and management in the post-eradication era (smallpox plan)

Type of guidance	Document title
DCOL 3/2004	C. Publication of new British Standards
DCOL 12/1999	G. Fire Service Manual Volume 2 – Fire Service Operations – Electricity
DCOL 15/1999	A. Fire – Emergency Information Centre
DCOL 2/1999	B. Fire brigade procedures: attendance at terrorist incidents
DCOL 15/1999	C. Military aircraft hazards database
DCOL 15/1999	G. Hazchem list 10 – further advice
DCOL 5/1994	E. Use of LPG cylinders
DCOL 8/1994	F. Airbags: the use of radio
DCOL 5/1994	F. Fire hazards associated with the use and storage of cellular foam in sports and recreational facilities
DCOL 5/1994	H. Storage of rubber tyres project – research report no. 59
DCOL 2/1993	12. Comparison of British Standards BS 5445: part 7 and BS 5446: part 1 – fire research report
DCOL 9/1993	2. The Montreal Protocol on substances which deplete the ozone layer: implications for the Fire Service
DCOL 2/1993	7. British Rail – emergency planning and contact arrangements with emergency services
DCOL 2/1993	8. British Rail – emergency cutting – aluminium rolling stock
DCOL 2/1993	9. Hazards posed to firefighters by asbestos
DCOL 3/1992	1. The Montreal Protocol
DCOL 11/1992	10. A study of tank farm fires in Kuwait: CFBAC research report no. 48
DCOL 3/1992	2. Flammability of paint films
DCOL 6/1992	3. Fire brigade procedures following terrorist incidents
DCOL 11/1992	4. Hazards posed to firefighters by asbestos
DCOL 11/1992	5. MoD guidance document: philosophy of MoD reactor accident contingency planning
DCOL 11/1992	7. An assessment of Fire Service road traffic accident rescue equipment – CFBAC research report no. 44
DCOL 6/1992	7. Technical Bulletin 1/1992: Explosives Guide
DCOL 9/1992	Environmental pollutants
DCOL 10/1991	10. Assessment of fire hazards from solid materials and the precautions required for their safe storage and use

Type of guidance	Document title
DCOL 4/1991	11. The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1985 (RIDDOR)
DCOL 4/1991	3. The Road Traffic (Carriage of Explosives) Regulations 1989
DCOL 7/1990	7. Meteorological Advice in the Event of a Release of Toxic Chemicals: CHEMET
DCOL 5/1990	Vehicle bombs
DCOL 5/1989	A. Fire precautions at LPG cylinder stores: HSE guidance against the use of portable pumps as monitors by fire brigades
DCOL 4/1989	The Road Traffic (carriage of explosives) Regulations 1989
DCOL 3/1984	G: Miniature detonating cord
DCOL 12/1983	A. Classification and labelling of explosives regulations 1983
DCOL 9/1983	A. Polychlorinated biphenyls
DCOL 12/1983	B. Incidents involving military aircraft: the miniature detonating cord
DCOL 13/1983	Hazards from vehicle fires
DCOL 24/1981	Hazards from explosions in vehicles
DCOL 35/1979	Hazards from explosions in vehicles Citroen cars
DCOL 36/1979	Home Office Unit for Educational Methods Hazchem tape/slide presentation
DCOL 12/1979	Possible isocyanate hazards from polyurethane enamelled wires
DCOL 66/1978	Emergency telephone number at Harwell Fire research Notes and Current papers
DCOL 50/1978	Hazards posed by asbestos operational requirements for fire brigade blankets
DCOL 73/1978	Incidents involving electric multiple train units fitted with equipment containing beryllium oxide
DCOL 61/1978	Safety conditions for fire fighting in government explosives establishments (ESTC/220/Leaflet no. 9) amendment no. 5
DCOL 19/1977	Current paper 73/76 Fire behaviour of foamed plastics ceilings used in dwellings
DCOL 66/1977	Explosions in fire extinguishers
DCOL 60/1977	Hazards attending the use of radio equipment in flammable atmospheres or in the vicinity of explosives
DCOL 31/1977	Hazards posed by asbestos

Type of guidance	Document title
DCOL 43/1977	Safety conditions for firefighting in government explosives establishments (ESTC/220/leaflet 9) and Notes for guidance on fire prevention and fire fighting in harbour areas when military explosives are conveyed (ESTC/220/leaflet 10)
DCOL 59/1977	Safety conditions for firefighting in government explosives establishments (ESTC/220/leaflet 9) and Notes for guidance on fire prevention and fire fighting in harbour areas when military explosives are conveyed (ESTC/220/leaflet 10)
DCOL 60/1976	Explosives (Age of Purchase etc) Act 1976
DCOL 9/1970	Petroleum (Consolidation) Act 1928: Conveyance by road of inflammable liquids
DCOL 29/1976	Problems of asbestos
DCOL 30/1976	Smouldering in foam rubber explosion hazards in smouldering fires
DCOL 71/1976	Zinc embrittlement of stainless steel
DCOL 74/1975	The Thermal decomposition products of rigid polyurethane foams
DCOL 33/1975	UN identification numbers rail vehicles
DCOL 17/1974	Fires involving electric multiple train units fitted with equipment containing beryllium oxide
DCOL 45/1974	High alumina cement concrete
DCOL 33/1974	Joint Committee on Fire Brigade Operations Hazchem Working Party
DCOL 28/1974	Marking of rail tanker vehicles pilot scheme
DCOL 8/1973	Explosimeters
DCOL 39/1973	Fire danger from electric panel radiators
DCOL 12/1973	Guide to the Highly Flammable Liquids and Liquefied Petroleum Gases Regulations 1972
DCOL 21/1973	Technical bulletin no 1/1973 Identification of fertilizers involved in fires
DCOL 36/1967	Hazards from chemical fumes
DCOL 42/1972	Liquid ethylene traffic
DCOL 17/1971	Explosive atmospheres in Post Office cable chambers
DCOL 1/1971	Recommended procedures for handling major emergencies
DCOL 16/1971	Safety conditions for fire-fighting in government explosives establishments (Booklet 7/Explos/70)
DCOL 21/1970	Expanded polystyrene ceiling tiles
DCOL 4/1970	Searches for bombs

Type of guidance	Document title
DCOL 15/1969	Supplement to IP pipelines code emergency procedures
DCOL 29/1969	Conveyance of explosives by rail
DCOL 35/1969	Safety conditions for firefighting in government explosives establishments
DCOL 101968	Foot and mouth disease
DCOL 7/1967	Movement of explosives by rail
DCOL 14/1967	Spillages of dangerous substances on highways
DCOL 9/1966	Marking of road tank vehicles
DCOL 21/1966	Safety conditions of fire fighting in government explosives establishments
DCOL 34/1965	Fires involving fertilisers
DCOL 18/1965	Safety conditions for fire fighting in government explosives establishments
DCOL 678/1963	Fire-fighting in government explosives establishments
DCOL 662/1963	Pipelines Act
DCOL 342/1960	Use of inflammable liquids in factories
DCOL 385/1958	Safety conditions for fire fighting in government explosive establishments
DCOL 360/1957	Pilot ejection seats in aircraft
DCOL 319/1956	Fire and the atomic bomb
DCOL 312/1956	Notification to H.M. Inspectors of Explosives of fires involving cylinders of dissolved acetylene
DCOL 10/1954	United Kingdom pipelines
DCOL 197/1953	[Petroleum (Consolidation) Act
DCOL 200/1953	British Railways fire manual
DCOL 198/1953	Fire fighting in government explosives establishments
DCOL 152/1952	Technical bulletin no. 1/1950 Pilot ejection seats in aircraft
DCOL 166/1952	Technical bulletin no. 1/1950 Pilot ejection seats in aircraft
DCOL 156/1952	Civil defence and the atom bomb
DCOL 162/1952	Hazards attending the use of radio transmitters in the vicinity of explosives
DCOL 9/1976	Guidance on the type of protective clothing to be worn in respect of the chemicals listed in the first three volumes of transport emergency cards (tremcards)
DCOL 77/1978	Blast incendiary devices

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