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Incidents involving acetylene

Generic Risk Assessment 5.2

Incidents involving acetylene

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SECTION 1

Generic Risk Assessment 5.2 Incidents involving acetylene

Scope

This generic risk assessment applies to the work of Fire and Rescue Authorities at incidents involving acetylene.

It is not intended to cover every conceivable hazard present but identifies the significant risks inherent with incidents involving acetylene cylinders or other forms of acetylene storage. This document suggests control measures that may be used to effectively deal with such occurrences.

The assessment is particular to firefighting, rescue or other operations, at locations where acetylene may be stored or used and/or stored in a variety of commercial and domestic settings eg:

- motor vehicle garages, scrapyards and other metal fabrication businesses
- industrial areas where there may be bulk storage of acetylene in tanks and cylinders of various sizes including internal pipelines and manifold arrangements of incorporating banks of cylinders
- farms and other agricultural premises, where unused, used and derelict cylinders may be present
- transport vehicles both delivering acetylene and also carrying acetylene cylinders
- members of the public who carry out DIY repairs using oxy acetylene welding equipment.

This, as for all generic risk assessments, provides a starting point for Fire and Rescue Authorities to conduct their own assessments within the context of local conditions and existing organisational arrangements.

Persons at risk

All fire and rescue personnel in attendance at incidents involving acetylene.

The health, safety and welfare of non-service personnel in the vicinity of the incident may also need consideration. In particular:

- members of other emergency response services
- personnel of the affected site/contractors

- members of the public in the vicinity of an incident
- civilian specialists, eg British Compressed Gases Association Competent Person
- members of the media.

Properties of acetylene

- Acetylene is a colourless and flammable gas
- May emit a garlic like odour (pure laboratory grade acetylene has no such odour but commercially used acetylene does)
- Highly flammable (hence its use in welding)
- Lighter than air (this could have a bearing on the tactics if used when venting a cylinder)
- Forms an explosive mixture (when exposed to air) when it reaches above the lower explosive limit 2.5 per cent and below the upper explosive limit 81 per cent. In general terms, any leak of acetylene would in practice, be considered explosive
- When subjected to an activation energy, can undergo a decomposition process. This process is exothermic, and unlike other common flammables, does not require oxygen to proceed. Consequently, acetylene pressure vessels can fail catastrophically with enough heat and time but may also do so after the heat sources have been removed. Such thermal decomposition may release carbon monoxide into the atmosphere
- Shipped and stored dissolved in acetone or very occasionally in dimethylformamide, contained in a metal cylinder with a monolithic porous filler mass (agamassan), which renders it safe to transport and use, given proper handling.

Significant hazards and risks

Acetylene in storage and use represents a risk to fire and rescue personnel working both in urban and rural environments and in areas not normally associated with industrial activity. The impact of an incident involving acetylene requires careful consideration of the location and population nearby.

All pressurised cylinders present significant hazards when involved in a fire. Fuel gases present particular risks because of highly flammable materials stored in pressurised containers with the obvious risk of detonation if involved in a fire.

However, acetylene can also decompose to constituent elements if exposed to extreme heat. Although decomposition alone cannot cause a catastrophic failure, the combination of decomposition and the pressure vessel wall being weakened by exposure to extreme heat, may result in a catastrophic failure similar to the combustion energy released from other fuel gas cylinders if they rupture in a fire.

It is not possible to initiate decomposition by mechanical shock alone. Uniquely, an un-cooled acetylene pressure vessel may continue to present a hazard after the fire has been extinguished and as such requires careful consideration before any movement is initiated as mechanical shock can result in rupture and explosion. It will be necessary to initiate a period of cooling and wet testing before attempting to move such cylinders.

Fire and rescue personnel attending an incident involving acetylene may be exposed to the following significant hazards either singly or in combination.

Explosion hazard

Acetylene has the potential to decompose and with the addition of heat, may result in explosion if the decomposition process is allowed to continue. The following circumstances are relevant to the avoidance of explosions:

- cylinders involved in a fire incident, affected by significant and substantial fire or heat have the potential to burst or explode with a large release of energy
- leaks from cylinders, pressure release devices (where fitted), valves or associated equipment, where the gas has not ignited can lead to the build up of an explosive atmosphere.

Leaking gas or burning gas from cylinders

Venting acetylene from cylinders or storage presents the possibility of ignition should a source of ignition be present. Cylinders, which are already burning, can produce significant flames resulting in the ignition of nearby materials and heating of the cylinder wall potentially leading to decomposition.

Key control measures

Planning

Planning is key to enhancing the safety of firefighters and others likely to be affected by Fire and Rescue Authority's operations at incidents involving acetylene. Each Fire and Rescue Authority's risk plan will set standards and identify the resources required to ensure safe systems of work are maintained.

Each Fire and Rescue Authority must assess the hazards and risks in their area relating to this generic risk assessment. The assessment should include other Fire and Rescue Authority's areas where 'cross border' arrangements make this appropriate. Consideration should also be given to adopting the common principles set out in the Provision of Operational Risk Information System (PORIS) guidance which will support a consistent approach in the development of safe systems of work on the incident ground.

The guidance can be found at: www.gov.uk/government/publications/operational-guidance-for-the-fire-and-rescue-authorities-operational-risk

Site-specific plans must be considered for locations where the hazards and risks are significant and plans should take into account and specify any variation from the normal operational capability of personnel, appliances and equipment. In particular, recognition should be given to the physical and psychological pressures that an operational incident, in particular a highly populated urban area, may apply to fire and rescue personnel.

Site-specific plans should include:

- levels of response
- relevant standard operational procedures
- tactical considerations, including rendezvous points, appliance marshalling areas and access points
- identification and, where necessary, the formal notification to person(s) responsible for the site of any Fire and Rescue Authority operational limitations
- specific site hazards
- hazardous substances
- high risk zones within the premises/area.

Planning is underpinned by information gathering, much of which will be gained through inspections or visits by fire and rescue personnel – for example, those covered by section 7(2)d and 9(3)d of the *Fire and Rescue Services Act 2004*.

Information should also be gathered and used to review safe systems of work from sources both within and outside the Fire and Rescue Authority, including:

- fire safety audits
- incident de-briefs
- health and safety events
- local authorities
- local resilience forums.

Involving others in planning is an effective way to build good working relations with partner agencies and other interested parties, such as site owners.

Fire and Rescue Authorities must ensure that systems are in place to record and regularly review risk information and that new risks are identified and recorded as soon as practicable.

Fire and Rescue Authorities must ensure that information gathered is treated as confidential, unless disclosure is made in the course of duty or is required for legal reasons.

Fire and Rescue Authorities must consider the benefits of using consistent systems and suitable formats to record information from all sources. Consideration must also be given to how timely access will be provided to information to support operational decision-making.

Information needs will vary in proportion to the size and nature of the incident. The capacity of fire and rescue personnel to assimilate information will vary in relation to the complexity of the incident. Arrangements may therefore need to be flexible and be based

on more than one system available. The Incident Commander must make themselves aware of all information sources provided and consider whether further information may be required.

Specific planning for this generic risk assessment should include:

- awareness and collation of significant distribution outlets of acetylene cylinders
- identification and recording of premises which have storage of acetylene cylinders.

Competence and training

When formulating a training strategy Fire and Rescue Authorities should consider the following points:

- Fire and Rescue Authorities must ensure their personnel are adequately trained to deal with the hazards and risks associated with incidents which involve acetylene
- The level and nature of training undertaken should be shaped by informed assessment of operational and individual needs in accordance with the Fire and Rescue Authority's National Occupational Standards, Integrated Personal Development System and any internal training plans
- Training and development should follow the principles set out in national guidance documents
- Training and development programmes should generally be structured so that they move from simple to more complex tasks and from lower to higher levels of risk
- Training and development will typically cover standard operational procedures as well as ensuring knowledge and understanding of equipment and the associated skills that will be required to use it
- Training and development programmes should consider the need for appropriate levels of assessment and provide for continuous professional development to ensure maintenance of skills and to update personnel whenever there are changes to procedure, equipment etc.

Training outcomes should be evaluated to ensure that the training provided is effective, current and meets the defined operational needs as determined by the Fire and Rescue Authority's integrated risk management plan.

Training for personnel to identify acetylene cylinders and their specific properties must be provided.

Command and control

The Incident Commander should follow the principles of the current national incident command system.

Prior to committing personnel into any area, the Incident Commander must take account of the information available regarding the incident at the time. This will assist them in making effective operational decisions in what are recognised as sometimes dangerous, fast moving and emotionally charged environments.

A thorough safety brief prior to deployment of personnel within the hazard zone must be carried out including indicating safe routes.

Steps must be taken to determine whether any acetylene is in use or stored at the incident site. Where the incident site is following a road traffic collision, information must be obtained whether there are likely to be acetylene cylinders in any vehicles.

Safety Officer(s)

The early appointment of one or more Safety Officer(s) will help ensure that risks are either eliminated or reduced to an acceptable level. The term Safety Officer should be noted as relating to the fire and rescue context and not to a specifically qualified person.

Those undertaking the Safety Officer role must:

- be competent to perform the role
- be fully briefed on their role and responsibilities
- ensure personnel are wearing appropriate personal protective equipment
- monitor the physical condition of personnel and/or general or specific safety conditions at the incident, in accordance with their brief
- take any urgent corrective action required to ensure safety of personnel
- update the Incident Commander or Safety Sector Commander regarding any change in circumstances
- not be engaged in any other aspect of operations, unless this is required to deal with a risk critical situation.

Following the briefing of the Safety Officer, the Incident Commander should confirm that the Safety Officer understands:

- their role and area of responsibility
- allocated tasks
- lines of communication.

The role of a Safety Officer can be carried out by any of the fire service roles, but the complexity of the task, size of the incident and scope of responsibility should be considered by the Incident Commander when determining the supervisory level required.

Safety Officers should wear nationally recognised identification to indicate they are undertaking the Safety Officer role.

Fire and Rescue Authorities should ensure that training and other measures (such as aide-memoires) are in place and available to support those staff liable to undertake this role.

Significant hazards and control measures

Typical control measures for identified significant hazards may include:

Hazard: Cylinders involved in a fire incident, affected by fire, heat or in direct contact with flames
Control measures:
Instigate an initial hazard zone considering any appropriate available shielding, which can be obtained from adjacent structures or local topography eg a building or a substantial wall. The extent of the hazard zone may initially extend to a maximum of 200 metres.
Fire and rescue personnel should not be allowed to approach until confirmation of control measures necessary to safeguard their safety on approach are in place.
Seek advice from a competent person ie via British Compressed Gases Association Competent Person Scheme who can advise by telephone or by attendance at the scene if necessary. (Telephone numbers will be held available for Incident Commander to use on site from Fire Control).
Tasks inside the hazard zone carried out using the minimum number of personnel.
Set up monitors or lashed branches to provide cooling jets to cool cylinders involved.
Apply cooling water, as soon as practicably possible, to the cylinder(s) affected by heat or flames for a period of one hour. It is important to reduce the temperature of the cylinder(s) in order to stop decomposition and reduce the temperature of the cylinder body. Thermal Imaging cameras may provide valuable assistance in determining heat loss.
After one hour a wetting test should be carried out covering the cylinder with water and noting whether the water has evaporated (dried) from the cylinder or not. The drying should be more than that expected due to the conditions of the day eg a cylinder in direct sunlight will dry more rapidly than that at night in cool conditions. Evaporation/violent steaming (drying) of the water fails the test and further cooling for another hour will continue until the wetting test is passed.
Following the wet test being carried out the cylinder will enter a monitoring phase in which a wet test is applied at 15 minute intervals for a further hour. Successful conclusion of this monitoring phase will result in the cylinder being declared safe.
The initial hazard zone may be reduced following identification and cooling and successful outcome of the wetting test to a suitable safe distance. The cylinders should be left in place but can be left, utilising a suitable handover procedure, with a responsible person ie police or cylinder user while awaiting the attendance of a competent person (British Compressed Gases Association or the cylinder owner (gas supplier)) who should check the cylinder for safety before arranging for removal.
Personnel must NOT move any cylinder until it has been ascertained that it is safe to do so by a competent person or the Incident Commander following successful testing. Where possible and available, Fire and Rescue Authorities may also seek advice from internal specialist officers.
If an acetylene cylinder has failed catastrophically for no apparent reason the Health and Safety Executive must be informed.

Hazard: Leaks from cylinder pressure release device (where fitted) or valve or associated equipment, whether the gas has ignited or not

Control measures:

Make no attempt to close valves or extinguish ignited gas from a heated acetylene cylinder. In such situations it is more likely that the cylinder is leaking due to heat damage to the valve group.

Continuously carry out cooling where gas is leaking whether the gas has been ignited or not until the gas has vented. If the gas is alight, cooling should be directed away from the valve in order to not extinguish the flame; if the flame is extinguished then a fine spray needs to be maintained to encourage dispersal of the gas.

Allow leaking gas to vent safely while considering the possibility of explosion especially if within building structures. Ensure adequate ventilation.

Where a pressure release device has activated, it must be assumed that the cylinder has been heated and treated accordingly.

Where a cylinder has not been heated but is leaking, except from a pressure release device, and the gas is not ignited, an attempt may be made to close the valve. If this is not possible to do so successfully, the cylinder should be allowed to vent safely with adequate ventilation ensured. (All new acetylene cylinders have no pressure relief devices fitted and there is a programme of removal of pressure relief devices from older cylinders ongoing).

Hazard: Acetylene cylinders that suffer mechanical shock

Control measures:

The British Compressed Gases Association has stated that cold acetylene cylinders suffering shock in a road traffic incident, remaining intact (ie no damage to cylinder valve group) and has not been exposed to fire will not decompose. Such cylinders should be checked to ensure they are not leaking and then may be safely lifted and removed.

The British Compressed Gases Association confirm that from previous research carried out (German Federal Institute for Materials Research and Testing) there is no evidence to suggest that it is possible to initiate decomposition from mechanical shock alone to an undamaged, unheated acetylene cylinder.

Hazard: Cylinders that suffer shock after exposure to fire or heat may potentially fail catastrophically

Control measures:

The tensile strength of steel used in acetylene cylinders begins to be lost at 300°C, which is below the approximate temperature at which decomposition may be initiated in an acetylene cylinder. However, cylinders subjected to these temperatures will be more susceptible to damage from mechanical shock. Therefore such cylinders must not be moved until successful cooling has taken place.

Personal protective equipment

Incidents involving acetylene require no specific extra personal protective equipment above the equipment provided to firefighters. However, the general requirements as noted below are still relevant.

Fire and Rescue Authorities must ensure that any personal protective equipment provided is fit for purpose and meets all required safety standards. When choosing suitable protective garments, the standard of clothing worn beneath the specialist personal protective equipment should also be taken into account. Consideration should also be given to the selection of suitable sizes and gender specific requirements of personal protective equipment.

Personal protective equipment should also take account of the need for rescuers to be visible against the operational background including night working and for the Incident Commander and other managerial and functional roles (defined in the national incident command system) to be distinguishable.

All personnel must use appropriate levels of service provided personal protective equipment as determined by the safe system of work.

Due consideration should be given to the compatibility of different items of personal protective equipment in use at the same time, to ensure their effectiveness is not compromised.

Post incident

The following measures must be considered to help eliminate or remove risks after an incident, as appropriate to the nature and scale of the incident:

- Any safety events; personal injuries, exposure to hazardous substances or near-misses must be recorded, investigated and reported in line with legislative requirements such as the *Reporting of Injuries Diseases and Dangerous Occurrence Regulations 2013* and in compliance with individual Fire and Rescue Authority' requirements for reporting and recording
- Conduct a de-brief to identify and record any 'lessons learned' from the incident. De-briefs will range in complexity and formality, proportionate to the scale of the incident and in line with individual Fire and Rescue Authority's procedures
- Consider any changes required to safe systems of work, appliances or equipment in the light of any lessons learned from debriefs or from safety events
- Consider the need to review existing information held on a premises or location, or the need to add a new premises or location into future planning eg by adding premises to a visit or inspection programme
- Consideration should be given to arranging for staff to make a contemporaneous written record of their actions. This information may be used to assist in any internal or external investigations or enquiries that follow any incident eg the Coroner's Court, public enquiry, etc.

Technical references

1	Fire and Rescue Service – Operational Guidance Incidents Involving Hazardous Materials – Part C-5 UN Class 2 gases (including acetylene)
2	Fire and Rescue Service Circular 32-2004
3	BCGA Guidance Note 15
4	Health and Safety at Work Act 1974
5	Management of Health and Safety at Work Regulations 1999
6	London Fire Brigade – A study of Acetylene cylinder incidents in London 2004 – 2008
7	HSL report FS/06/04 – Safety of Dissolved Acetylene containing cylinders during and after involvement in a fire, Buxton July 2006
8	Safety of Acetylene containing cylinders during and after involvement in fire, Department for Communities and Local Government, London, February 2007
9	The Federal Institute of Material Research and Testing (BAM) reports, Munich 1995
10	The Federal Institute of Material Research and Testing (BAM) presentation to the National Working Group for Acetylene in Fire, Nantwich, May 2007
11	Air Products Report – Investigation of damaged acetylene cylinders “Mechanically Damaged Cylinder Forensics” – NSG Manchester December 2007
12	Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013
13	Health, safety and welfare framework for the operational environment June 2013,

SECTION 2

Summary of generic risk assessment 5.2

Incidents involving acetylene

Ref No.	Activity	Hazard	Risk	Persons at risk	Control measures
1	Assessing the scene and evaluation of the situation on arrival	<p>Uncontrolled decomposition of cylinders</p> <p>Difficulty of access to incident cylinders leading to injury</p> <p>Information not available regarding extent of acetylene present at an incident leading to possibility of persons being put at risk</p>	<p>Fatalities</p> <p>Major injury</p> <p>Minor injury</p>	<p>Fire and rescue personnel</p> <p>Public</p>	<p>Consideration of extent and implementation of the hazard zone to be applied</p> <p>Evacuation of all non-emergency personnel to a safe distance outside the hazard zone.</p> <p>Consideration should be given in situations where evacuation could introduce higher risk, of sheltering in place provided sufficient shielding is in place</p> <p>Securing water supplies</p> <p>Ensure that information is obtained from responsible person about the amount and location of acetylene on the incident ground</p> <p>Utilise any suitable structural cover available to shield from any possible explosion, blast effects, and shrapnel from cylinders or projectile from intact cylinders.</p>

Ref No.	Activity	Hazard	Risk	Persons at risk	Control measures
2	Firefighting	Explosion projectile risk and blast debris	Fatalities Major injury Minor injury	Fire and rescue personnel Public Civilian specialists	Commence cooling operations as soon as practicable utilising standard operating procedure Minimum personnel deployed into the hazard zone Ensure that an effective hazard zone is identified and controls to secure the hazard zone are applied Utilise any suitable structural cover available to shield from any possible explosion and blast Seek guidance from competent person civilian specialist – British Compressed Gases Association.
3	Firefighting	Injuries from structural collapse following explosion or intense heating	Fatalities Major injury Minor injury	Fire and rescue personnel Public Civilian specialists	Minimum number of personnel deployed Safety Officers appointed to oversee condition of structures Ensure evacuation procedures and signals are known and understood Consideration of standby of urban search and rescue personnel and equipment depending on the location of acetylene cylinders and likelihood of explosion.

Ref No.	Activity	Hazard	Risk	Persons at risk	Control measures
4	Firefighting	Injuries from secondary explosions at incident ground	Fatalities Major injury Minor injury	Fire and rescue personnel Public Civilian specialists	Obtain sufficient information regarding other sources of explosion or reaction from acetylene incident Maintain an appropriate safe distance and appropriate cover from the hazard where practicable Identify and deal with any heat sources or flames that may impinge on other materials.