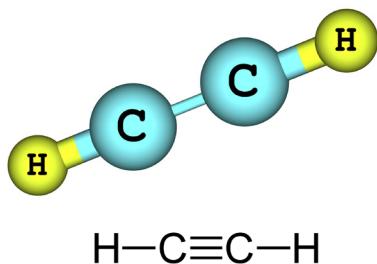


Acetylene

Pure acetylene is a unique gas with hazards that arise from its high energy bonds and flammability. These same properties give acetylene its value as a high temperature cutting and welding gas with a very wide range of applications. However, free acetylene can undergo explosive decomposition when compressed or overheated. Decomposition is a spontaneous reaction forming hydrogen and carbon (in the form of "lampblack" or "soot"). A considerable amount of heat and pressure is generated by this dissociation, which can produce high energy explosions.

Acetylene is normally dissolved in a solvent, typically acetone, at pressures up to 19 barg (275 psig) at 20°C (68°F). The dissolved acetylene is packaged in specially designed cylinders filled with a porous material to prevent voids where gaseous acetylene could collect. The combination of these two features, solvent and porous filler material, allows acetylene to be contained in cylinders at moderate pressure without danger of decomposition. To prevent decomposition during use, acetylene gas system pressures must not exceed 1.5 barg (22 psig).



Uses

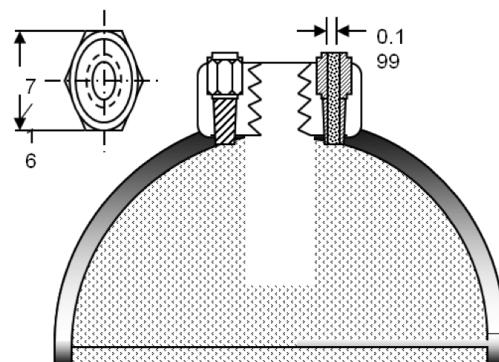
Acetylene is principally used for oxyacetylene cutting, heat treating, and welding. Bulk acetylene can be also used as a raw material in the chemicals processing industry for the production of organic compounds, including acetaldehyde, acetic acid and acetic anhydride.

Acetylene has the highest flame temperature of any common hydrocarbon because of its triple bond structure. Combustion with oxygen achieves a flame temperature of 3090°C (5594°F), releasing 54.8 kJ/litre (1470 BTUs/ft³) of energy. Its high flame temperature allows acetylene to be used in a variety of metal working applications like cutting, welding, brazing and soldering.

Health effects

Studies have shown there to be no harmful effects from exposure to acetylene. While acetylene is classified as non-toxic, it is an asphyxiant gas with slight anaesthetic properties. The amount of acetylene gas necessary to dilute the concentration of oxygen in air below levels necessary to support life, is well above the lower flammable limit, making fire and explosion the primary hazards associated with acetylene and air atmospheres.

Examples of fusible plugs:



Acetylene cylinder design safety features

The design of an acetylene cylinder (porous material and solvent) normally prevents any dangerous decomposition reaction of acetylene. If flashback from the attached equipment reaches into the cylinder the mass would normally quench this reaction. Where flashback arrestors are properly installed, then flash back is precluded. Safe storage, use, handling and transport are the key to preventing acetylene cylinder fires.

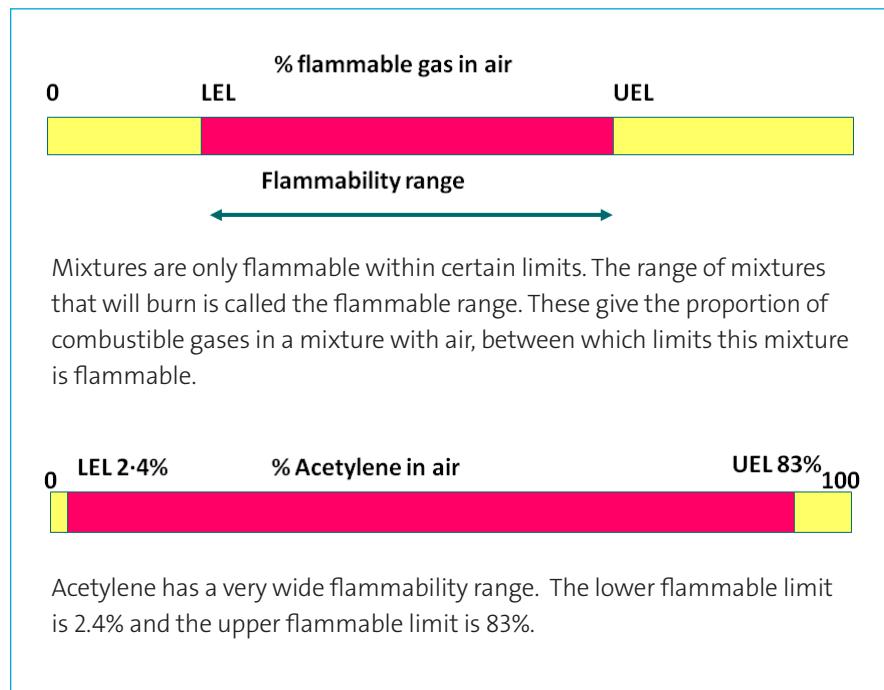
If acetylene cylinders are exposed to fire or extreme heat, where the cylinder contents are heated above 305°C a decomposition reaction can develop. A brief exposure from a torch would not normally reach this temperature. In the event of any brief flame exposure, simply closing the acetylene cylinder valve would extinguish the flame and prevent over-heating.

If the acetylene is heated above 305°C, the decomposition reaction will begin and if the heat is sustained, can result in a significant temperature and pressure increase, causing the cylinder to rupture, even if fitted with a pressure relief device (PRD). [Note that PRD including fusible plugs are not used in Europe]. The porous material inside the cylinder is hard to heat and will tend to act like a flame arrestor unless there is a leak or release from the cylinder. Similarly moving or shaking an overheated acetylene cylinder can aggravate the decomposition by bringing fresh gas into the heated area.

Note: Please note that cylinder colour coding systems may differ between regions.

Table 1: Acetylene Physical Properties

Molecular Weight	26.04
Gas density at 21 °C (70 °F)	1.1 g/l (0.068 lb/ft ³)
Specific Gravity, Gas (Air = 1) @ 20°C (68°F)	0.899
Specific Volume at 21 °C (70 °F)	0.92 m ³ /kg (14.8 ft ³ /lb)
Solubility in Acetone @ 20°C (68°F), 1.01 bar (1 atm)	27.9 g/kg
Solubility in Acetone @ 20°C (68°F), 15.2 bar	472 g/kg
Auto ignition Temperature	305°C (581°F)
Flash Point (Closed Cup)	-18°C (0°F)
Flammable Limits in air	2.4 – 83 % (by volume)



This wide flammable range means that almost any leak of acetylene will result in a flammable gas mixture. Acetylene also has a very low ignition energy, so even low energy sparks such as static electricity can cause ignition and explosion. Acetylene must only be used and stored in well ventilated areas. Fires which have been extinguished without stopping the flow of gas can easily reignite with explosive force.

Pure acetylene is odourless, but commercial grade acetylene from some manufacturing sources can have a distinctively garlic-like smell from impurities typically present. Odour should not be relied on to detect the presence of acetylene.

Materials selection for acetylene piping systems

Steel and wrought iron are recommended for use in acetylene piping. Rolled, forged, or cast steel or malleable iron fittings may be used. Cast iron is not acceptable for fittings.

Certain materials must be avoided as explosive acetylides can be formed in acetylene service. Acetylides are highly sensitive to shock or friction. Materials that should not be used in direct contact with acetylene include unalloyed copper, silver, or mercury. Alloys containing more than 65% copper or more than 43% silver should not be used. Aluminium-bronze alloys and 70–30 (red) brass produce acetylides with wet acetylene and must never be used.

Figure 1: Cutaway photo of an acetylene cylinder



Acetylene is normally packaged as a dissolved gas in cylinders ranging in size from 3 to 60 litres internal volume (water capacity). Common acetylene cylinders are different from all other cylinders in that they contain a porous filler material and a solvent (acetone or dimethylformamide, DMF). By using the porous material and solvent, it is possible for a cylinder to contain much more acetylene than could safely be compressed into the same cylinder without solvent. The filling parameters of a cylinder or a bundle of cylinders depend on the porous material and volume and are specified by the cylinder manufacturer.

Acetylene cylinder shells are made from welded steel, seamless steel or sometimes seamless aluminium. Acetylene cylinders may be subjected to wear and tear. Prior to every refilling, the cylinder and valve are inspected for general integrity (freedom from shell defects such as dents, torch burns or corrosion) and to confirm that the valve is operating properly and that the outlet connection is undamaged and functional. Cylinders are also subject to periodic requalification inspections by authorized facilities in accordance with Transport regulations.

Figure 2



Valves/outlet connections

Acetylene cylinders are normally fitted with brass valves that may be either hand wheel or key operated depending on local norms. (Since ammonia attacks brass material, common soap solutions such as washing liquid should not be used for leak checking of acetylene cylinder valves). Acetylene valves commonly use non-adjustable o-rings or packing to prevent leakage through the top works. Some cylinders may be equipped with residual pressure valves with non-return function (NR/RPV) or with an integrated valve-pressure regulator device. Acetylene cylinder valves have various outlet configurations in accordance with national/regional standards. For specifications, type testing and marking of acetylene cylinder valves see EN ISO 10297. For test and inspection requirements of valves see EN ISO 14246.

Ancillary equipment

Any equipment (torch, hoses, regulator, flashback arrestors, etc.) used should be designed and constructed to recognized standards for use with acetylene. Equipment designed for use with other flammable gases must not be used with acetylene.

- Keep equipment (torch, hoses, regulator, flashback arrestors, etc.) in good working condition and free from oil or grease.
- For cutting and welding applications, it is essential to install flashback arrestors and check (non-return) valves and ensure that they are in good working condition. Figure 2 is an example of the damage to a regulator from flashback, if no flashback arrestor was used.

Figure 3

Transporting acetylene cylinders

Acetylene containers are subject to the Dangerous Goods Transport regulations.

- International shipments by water must comply with International Maritime Organization (IMO) regulations.
- For air shipments, all packages must be in compliance with International Air Transport Association/ International Civil Air Organization (IATA/ICAO) Dangerous Goods Regulations.
- The regulations governing national and international transport by road differ by region; (e.g. ADR in Europe and DOT in North America).

For all transport modes cylinders must be shipped, stored and transported in the upright position, ensuring that the valve is properly closed and not leaking.

Because small leaks can create explosive atmospheres, acetylene cylinders must not be transported in an unventilated compartment within a vehicle. Do not store cylinder(s) inside any vehicle. Figure 3 shows an explosion that resulted from a leak of acetylene stored in a vehicle.



Safety considerations

Users of acetylene should know and understand the construction of the cylinders and the properties of acetylene. The following guidelines apply to the storage, handling and use of acetylene cylinders.

- ✓ When not in use, store gas cylinders closed and in a secure well-ventilated area.
- ✗ Never store acetylene cylinders in an occupied building, unventilated rooms, underground rooms or in areas accessible to the public.
- ✓ Store and use acetylene cylinders in an upright position to avoid loss of solvent which reduces the cylinder capacity. Provide a means of preventing cylinders from falling if accidentally bumped.
- ✓ Keep cylinders away from external sources of heat.
- ✓ Avoid exposing cylinders to temperatures in excess of 50°C (122°F).
- ✓ Protect the acetylene cylinder base from damp ground that may cause cylinder corrosion.
- ✓ Separate flammable gas cylinders from oxygen and other oxidizing gas cylinders during storage.
- ✓ Separate full acetylene cylinders from empty cylinders.
- ✓ When in storage or being moved, keep cylinder valves closed.
- ✓ When valve caps/guards are provided, they must be kept on the cylinders when being moved and in storage.
- ✓ If a cylinder protective cap is difficult to remove (immediately before cylinder use), do not apply excessive force or pry the cap loose with a bar inserted into the ventilation openings. Attach a label or tag to the cylinder identifying the problem and return the cylinder to the supplier.
- ✓ Move cylinders using a suitable hand truck or trolley.
- ✓ Before commencing work, ensure the work area is adequately ventilated, free from clutter and that appropriate risk assessments have been conducted.

(continued on page 6)

Safety considerations

(continued from page 5)

- 6 Do not use acetylene at pressures above 1.5 bar(g) (22 psig).
- 4 Open and close acetylene cylinder valves slowly to minimize pressure surges. Cylinder valves should be opened no more than one and one-half turns. This is sufficient to provide adequate flow but allows the valve to be closed quickly in an emergency situation.
- 4 Use the correct flow rate for the acetylene application. To minimize the withdrawal of liquid solvent, acetylene should be withdrawn from the cylinder at a rate not to exceed 1/10 (one-tenth) of the capacity of the cylinder per hour during intermittent use. For full withdrawal of the contents of the cylinder on a continuous basis, the flow rate should be no more than 1/15 (one-fifteenth) of the capacity of the cylinder per hour. Too high a flow rate causes solvent carry-over, flame disturbance and reduces the effectiveness of flashback prevention devices. Alternately, flashback may occur when the acetylene flow rate is lower than equipment needs.
- 4 Always close the cylinder valve and bleed the pressure off the regulator and torch equipment at the end of the shift or work day. Even though the pressure gauge reads zero the acetone will still contain a quantity of dissolved acetylene; therefore, an "empty" cylinder still represents a potential hazard in a fire.
- 6 Do not handle cylinders roughly or carelessly to prevent damage to the cylinder or the porous material. Dropping cylinders can cause leaks to develop. Sharp dents in the cylinder can damage the porous material in the area of the dent and cause voids where free acetylene can accumulate.
- 4 If an acetylene cylinder receives a sharp or deep dent, the metal is gouged, or if any other mechanical defect is noted, stop using the cylinder and circle the defect with a marking pen to alert the supplier of the defect. Arrange timely return to the supplier. Never attempt to repair acetylene cylinders. Disposal of unserviceable cylinders should only be done by the supplier in accordance with local regulations.
- 4 Wrenches should not be used on valves equipped with a hand wheel. If the valve is faulty, attach a label or tag to the cylinder identifying the problem and arrange timely return to the supplier.
- 4 Remove leaking acetylene cylinders to an open area and tag them indicating the danger. Notify the supplier and local authorities as needed.
- 4 Be aware that refilling and shipping a compressed gas cylinder without consent of the owner is not allowed, is extremely dangerous and may be expressly forbidden by regulation in some countries.

Personal protective equipment

Safety glasses, safety shoes, and ordinary work gloves are recommended for cylinder handling. For cutting and welding operations use: welder's gloves, welder's helmet and goggles, leather sleeves, a leather apron and other standard protective equipment in accordance with the appropriate task risk assessment.

Suspected or actual acetylene leaks

Because acetylene and air mixtures in almost all proportions are flammable, care should always be taken to prevent acetylene leakage.

If a leak is suspected, do not operate lights or other electrical equipment as these could be a source of ignition. Close the cylinder valve. Brush or spray the suspected leakage area with an appropriate leak detection solution. Bubbles of escaping acetylene through the film will indicate a leak. If the leak has stopped, take the cylinder out of service, identify the cylinder, inform the supplier and arrange for the cylinder to be collected.

If the cylinder is still leaking, ventilate the room by opening doors and windows. Avoid ignition sources such as electrically operated fans. If possible and safe to do so, move the cylinder to a safe area outside and away from ignition and heat sources and public access. Evacuate the area within the vicinity of the cylinder. Contact the cylinder supplier and emergency services as needed.

Rescue considerations in the event of acetylene leak

The amount of acetylene gas necessary to dilute the concentration of oxygen in air, below levels necessary to support life, is well above the minimum flammable concentration, making fire and explosion the primary hazards associated with acetylene and air atmospheres. Only trained and competent rescue teams should contemplate entering a potential acetylene atmosphere. These actions would normally be undertaken only by external emergency services. Rescuers must always assure their own safety before entering an unknown atmosphere. Adequate assessment of the fire risk must be made for rescue situations. As a minimum, self-contained breathing apparatus and fire-retardant personal equipment should be worn.

First Aid after exposure

Persons who have become incapacitated or comatose through oxygen deprivation or from the anaesthetic action of acetylene should be moved promptly to fresh air and medical assistance sought. Consult the latest version of Air Products safety datasheet from: www.airproducts.com/MSDS

Operational procedures for acetylene cylinders at and after fire/heat exposure

Any gas cylinder that is exposed to fire or extreme heat may rupture due to an increase of temperature and pressure. If acetylene cylinders are exposed to fire or extreme heat, the following actions are recommended:

- Warn personnel and evacuate the area. For heated cylinders, a suitably sized hazard zone of up to 200 meters should be established, based on a number of criteria, such as the size and number of cylinders involved and shielding available
- Prevent access to the area.
- Call the emergency services and the gas supplier.
- If safe to do so, immediately start the cooling of heated cylinders by deluging them with water from a safe place (behind heavy machinery or a solid wall) without approaching the cylinders.
- Where possible, establish information about the time that the fire started, the number and location of acetylene cylinders and other cylinders or chemicals involved. Give this information to the emergency services on arrival.

In the event of any cylinder fire, the area should be evacuated as quickly as possible. If acetylene is involved in the fire, caution should be taken in extinguishing the fire until the source of gas can be stopped. It is important to prevent acetylene gas from collecting in a confined area, because the leaking gas may reignite and/or explode.

Water cooling is the most effective method of preventing failure of any cylinder and should be used whenever it can be implemented without compromising the safety of emergency personnel. After the fire has been extinguished, do not move the cylinder, continue cooling with water and ensure that experienced and competent personnel are in charge of the emergency in order to apply the recommended protocols.

UK HAZMAT guidance

The UK Fire & Rescue Services (FRS) have published protocols including the following decision trees to assist emergency services in managing such incidents. Excerpts are shown on the following pages:

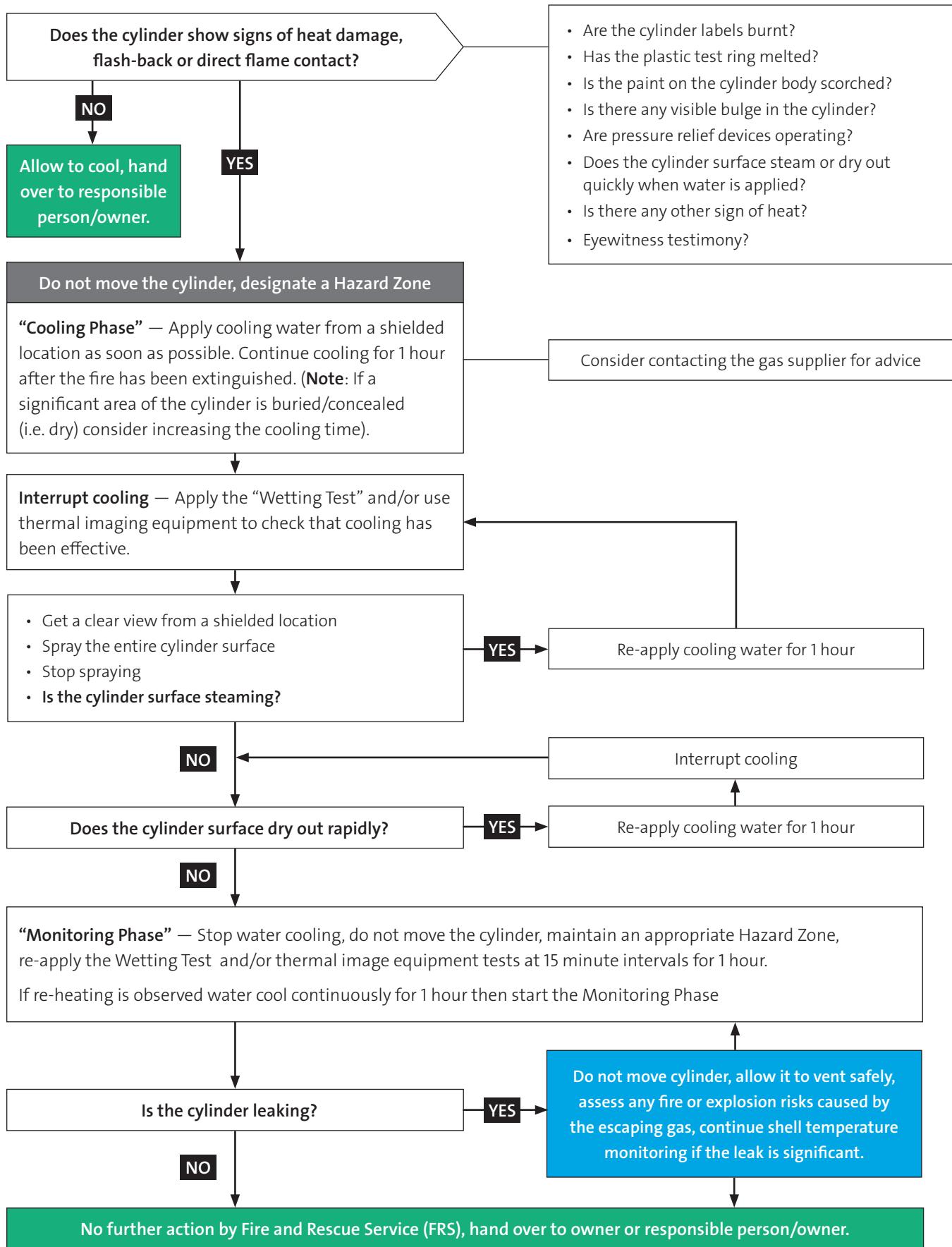
Reproduced from United Kingdom Fire and rescue Operational guidance Incidents involving hazardous materials

<https://www.gov.uk/government/publications/hazardous-materials-operational-guidance-for-the-fire-and-rescue-service>

See Section C5. pages 295-349

Open licence government document per: <http://www.nationalarchives.gov.uk/doc/open-government-licence/version/2/>

Suspected acetylene cylinder exposed to heat



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 to keep the public away.
- **COOLING PHASE** – Water cooling should be continued for at least 1 hour. Ground monitors and lashed jets should be used; any fire-fighters carrying out essential tasks within the Hazard Zone must have appropriate PPE and make full use of all available substantial cover/shielding.
- After a minimum of 1 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 at least 1 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 1 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 (i.e. the shell temperature remains at ambient temperature for 1 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 FRS (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 IC (Incident Commander) considers that significant areas of the cylinder are ‘dry’ then the cooling phase should be extended (e.g. if 50% of a cylinder is not being touched by cooling water (i.e. dry metal) then consider increasing the cooling phase to 3 hours).

A flame from an acetylene cylinder whose valve cannot be closed shall normally be left to burn while cooling the cylinder with water. If the flame is extinguished and the acetylene continues to escape, it can cause a flammable gas accumulation. The flame should only be extinguished if; it is safe to do so and no additional risks are incurred in approaching the cylinder. In such a case, apply the relevant recommendations above and ventilate abundantly and naturally.

Additional resources

- Acetylene safety data sheet (www.airproducts.com/MSDS)
- European Industrial Gas Association (EIGA) publications (www.eiga.eu/index.php?id=156)
 - Safety Leaflet SL 04, the safe transport, use and storage of Acetylene cylinders.
 - EIGA document IGC Doc 123, Code of practice Acetylene.
 - EIGA Safety Information Info 05 Flashback and flame arrestors. (currently under revision)
 - EIGA Safety Information Info 02, Handling of Gas Cylinders at and after Fire/ Heat Exposure.
 - EIGA PP18 Transfilling of Industrial Gas Cylinders
- BAM research report on cooling of Acetylene Cylinders involved in fires
- Compressed Gas Association (CGA) pamphlet G-1, Acetylene. (www.cganet.com)
- CGA SB-4, Handling Acetylene Cylinders in Fires. (www.cganet.com)
- ANSI/AWS Z49.1:2005, Safety in Welding, Cutting and Allied Processes.
- NFPA 51, Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting and Allied Process. (www.nfpa.org)
- NFPA 51B, Standard for Fire Prevention During Welding, Cutting, and other Hot Work.
 - (www.nfpa.org)
- ISO 10297: Transportable gas cylinders — Cylinder valves — Specification and type testing
- ISO 14246: Transportable gas cylinders. Gas cylinder valves. Manufacturing tests and inspections

Emergency Response System

T 800-523-9374 (Continental U.S. and Puerto Rico)

T +1-610-481-7711 (other locations)

For regional ER telephone numbers, please refer to the local SDS 24 hours a day, 7 days a week
for assistance involving Air Products and Chemicals, Inc. products

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Technical Information Center

T 800-752-1597 (U.S.)

T +1-610-481-8565 (other locations)

Monday–Friday, 8:00 a.m.–5:00 p.m. EST

F 610-481-8690

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