Safety Information

Prepared by the WG-2 Gas Cylinders SI 2/21

Handling of Gas Cylinders During and After Exposure to Excessive Heat or Fire

Introduction

All gas cylinders, whatever the gas content, are potentially dangerous when exposed to fire or excessive heat. Excessive heat exposure can weaken the cylinder and, in extreme cases, result in the failure of the cylinder. For definition of "excessive", see TB 21 Recommendation for Cooling and Heating of Gas Cylinders.

It is essential that customers and first responders, such as the emergency services, at incidents involving gas cylinders have the appropriate advice on the correct handling of gas cylinders exposed to excessive heat or a fire.

This Safety Information (SI) provides guidance, on how to handle gas cylinders exposed to fire or excessive heat and is intended for persons familiar with the properties and safe handling of gases and gas cylinders in general.

It should be noted that each situation involving a cylinder exposed to fire or excessive heat requires a detailed assessment of the risks involved.

This Safety Information is based on the knowledge of the gas industry and specifically for acetylene cylinders, the work that has been carried out by the British Compressed Gases Association, BCGA, and the German Federal Institute for Materials Research and Testing, BAM.

Customers and emergency services should be made aware of this SI, as well as the personnel in EIGA member companies who deal with cylinder incidents.

When the term "cylinders" is used within this SI, it is also intended to include "cylinder bundles".

For cylinders exposed to heat, see also EIGA Technical Bulletin 21, *Recommendations for Cooling and Heating of Gas Cylinders*.

BASIC HAZARDS OF CYLINDERS INVOLVED IN A FIRE

The properties of some gases or the construction of their cylinders and/or valves can introduce additional hazardous factors that need to be addressed during and after fire events.

Any gas cylinder that is exposed to fire or excessive heat can rupture due to an increase of pressure caused by the increase of temperature. This is valid even for cylinders that have pressure relief devices (PRD) as in extreme circumstances the device cannot operate quickly enough.

Hazards arise from pressure shock as well as parts of cylinders that can become projectiles. For flammable gases the flame from a PRD release can be greater than 10 metres.

The degree of hazard depends on a number of factors such as extent of exposure to the source of heat or fire, the quantities of gases involved, site-specific storage conditions (indoors or outdoors) and the presence of people and/or traffic routes nearby.

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IMMEDIATE ACTIONS FOR CYLINDERS INVOLVED IN FIRE

Instructions for first response actions to be taken in event of a fire

- FIRST **Raise the alarm. Evacuate the area.**
  A safe place is either by distance (200m) or behind a solid object or wall

  SECOND Ensure someone immediately calls the emergency services

With regard to actions between the discovery of the fire and the arrival of the emergency services:

- Do NOT move any cylinder being exposed to direct fire or flame
- Do NOT return to the area to take action
- Do NOT open closed valves to let cylinders vent

IF nearby the cylinders when the fire or heat event starts AND it is safe to do so

Close any open cylinder valves

Examples of when it is potentially safe to intervene include: a hose or gauge fire where there has been no direct or flame impingement onto the cylinder body

- Make a record of the time that the fire or heating started, and if possible, the product, number and location of gas cylinders.
- Give this information and all the information outlined in this SI to the emergency services on arrival.

Do not attempt to intervene before the Emergency Services unless there is a trained on-site emergency team that has an approved procedure to follow with regard to a fire involving cylinders. Intervention to stop the fire must take account of the need to immediately start cooling the affected cylinders and the potential hazard of the cylinders. Possible emergency team actions could include deluging cylinders with water from a safe location, for example from behind heavy machinery or a solid wall.

Intervention shall NOT include moving the cylinders to improve the water cooling or lifting the cylinder into a water bath. Care shall be taken not to knock cylinders over when using fire water hoses for cooling.

SUBSTANCE SPECIFIC HAZARD INFORMATION - FOR CONSIDERATION DURING/AFTER FIRES

In addition to the basic hazards of cylinders in fires described above, there could be additional substance specific hazards relevant to the contents of the cylinder. Product specific information can be found in the applicable safety data sheet, SDS. A summary of some properties which are of concern include:

Cylinders containing toxic or corrosive gases
Gases which are toxic can be released and dispersed and/or consumed during a fire. Therefore, any action shall be decided and directed by a trained and competent person who is able to fully assess the cylinders' location, exposure to fire or excessive heat and then take the most appropriate measures to reduce the risks.

Cylinders containing a flammable gas
A flame from a gas cylinder and whose valve cannot be closed shall normally be left to burn while cooling the cylinder with water. If the flame is extinguished and the gas continues to escape into an enclosed space it can lead to an explosion.

Acetylene cylinders
Acetylene cylinders, if heated by flame or fire, may explode – even after the fire is extinguished.
For dealing with acetylene cylinders involved in a fire see following section on acetylene.
NOTE Acetylene is a very efficient and necessary gas, which cannot be replaced with other gases in many applications. An example is in underground welding and metal-cutting work (e.g. in mines and maintenance for underground public transport). Acetylene's lighter-than-air nature allows it to escape upwards if leaks occur, as opposed to Propane, which will collect on the floor level.

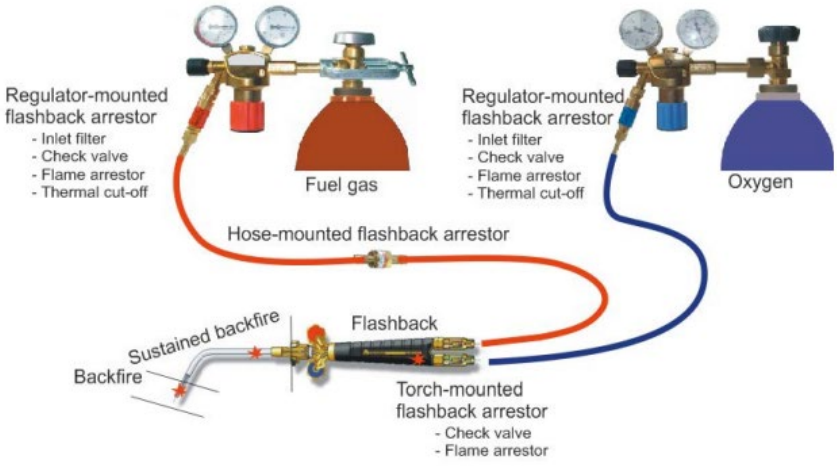
Hydrogen cylinders
Hydrogen flames are not always visible. This fact should be highlighted in training of personnel transporting and using hydrogen.

Cylinders containing liquefied gases
Cylinders containing liquefied gases (e.g. LPG, carbon dioxide, and nitrous oxide) shall normally be stored in an upright position. If cylinders have been overturned, establish that the cylinder is in a safe condition and return to the upright position taking precautions to protect the individual in case the rupture disc activates which could result in liquid being expelled from the valve or pressure relief device.

ACETYLENE CYLINDER DESIGN

If acetylene cylinders are exposed to fire or heat where the cylinder contents are heated above approximately 300ºC a decomposition reaction can develop. Where a welding or cutting torch inadvertently touches an acetylene cylinder, this will not normally allow the acetylene to reach decomposition temperature. In event of any brief flame exposure, the cylinder valve should be closed and the cylinder allowed to cool.

If the acetylene is heated above approximately 300ºC, the decomposition reaction will begin and if the heat is sustained, can result in a significant temperature and pressure increase, causing the cylinder to burst. As the porous material is a cellular structure, it is a thermal insulating material. This means a decomposition heat developing within a fire-exposed cylinder might not be immediately detected at the cylinder shell surface by Thermal Imaging. The design of an acetylene cylinder means that the use of a pressure relief device is ineffective vs internal decomposition. The porous material inside the cylinder will tend to act as 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.

The design of an acetylene cylinder (which includes a porous material and solvent) normally prevents any dangerous decomposition reaction of acetylene. The 'porous material' is a fine, chalk-like structure which is baked into the acetylene cylinder before the solvent and gas are filled. NOTE The acetylene cylinder is the only cylinder shell containing a porous material.	
To further protect the cylinder from a flashback, a flashback/ flame arrestor shall always be used with acetylene cylinders. If flashback does reach the cylinder, the porous material would normally quench this decomposition reaction. See EIGA Safety Info 05, *Flashback and flashback arrestors* [1]	

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Users may believe an acetylene cylinder to be ''empty'' when little gas flows (no noise of gas flow – no hiss) when the valve is opened. However an acetylene cylinder will always contain solvent and gas in sufficient quantity to present hazard, if exposed to fire.

ACETYLENE CYLINDERS IN FIRES

The actions on discovering and fighting a cylinder fire involving acetylene cylinders is exactly the same as for other cylinder fires until after the main fire is extinguished.

Do not move, or attempt to move, acetylene cylinders that have been exposed to heat or fire. Moving an acetylene cylinder that has been exposed to heat or fire is not advised for two reasons.

Firstly, there is the exposure of the person or persons involved to the possible explosion of the cylinder.

Secondly, the act of moving acetylene cylinder which has an internal decomposition occurring may increase the risk of explosion of the cylinder.

Acetylene cylinders which have been exposed to significant heat or fire must be properly and effectively cooled for one hour after the fire has been extinguished. Then a further hour shall be allowed to ensure that the cooling effect of the fire water has safely reduced the temperature inside the cylinder by observing from a safe place that there is no steam from the cylinder. If there is steam or signs of heat from the cylinder the cooling shall be repeated for another hour and the observation step repeated. Experience has shown this procedure to be both successful and sufficient.

The most common time for an acetylene cylinder in a fire to explode is early, in the first 15 minutes after starting being heated (This may not be the time the fire started. The cylinder may have been heated later as the fire grows). This is associated to run-away decomposition inside the cylinder being 'beyond the point of no return' and cooling will not be sufficient to stop the decomposition.

If it is not clear whether acetylene cylinders were involved then all cylinders should be treated, on a precautionary basis, as if they held acetylene.

The United Kingdom Fire & Rescue services have published protocols including the following decision trees to assist emergency services in managing such incidents. Excerpts are shown on the following pages. [2] [1]

This work was based on extensive work carried out by the German Federal Institute for Materials Research and Testing that was sponsored by a number of organisations based in the United Kingdom, including the British Compressed Gases Association. For more information: see the "Cylinders in fires" section of www.bcga.co.uk.

NOTE The research work of the German Federal Institute for Materials Research demonstrated that physical impact is not a credible cause of decomposition inside an unheated, correctly filled cylinder.

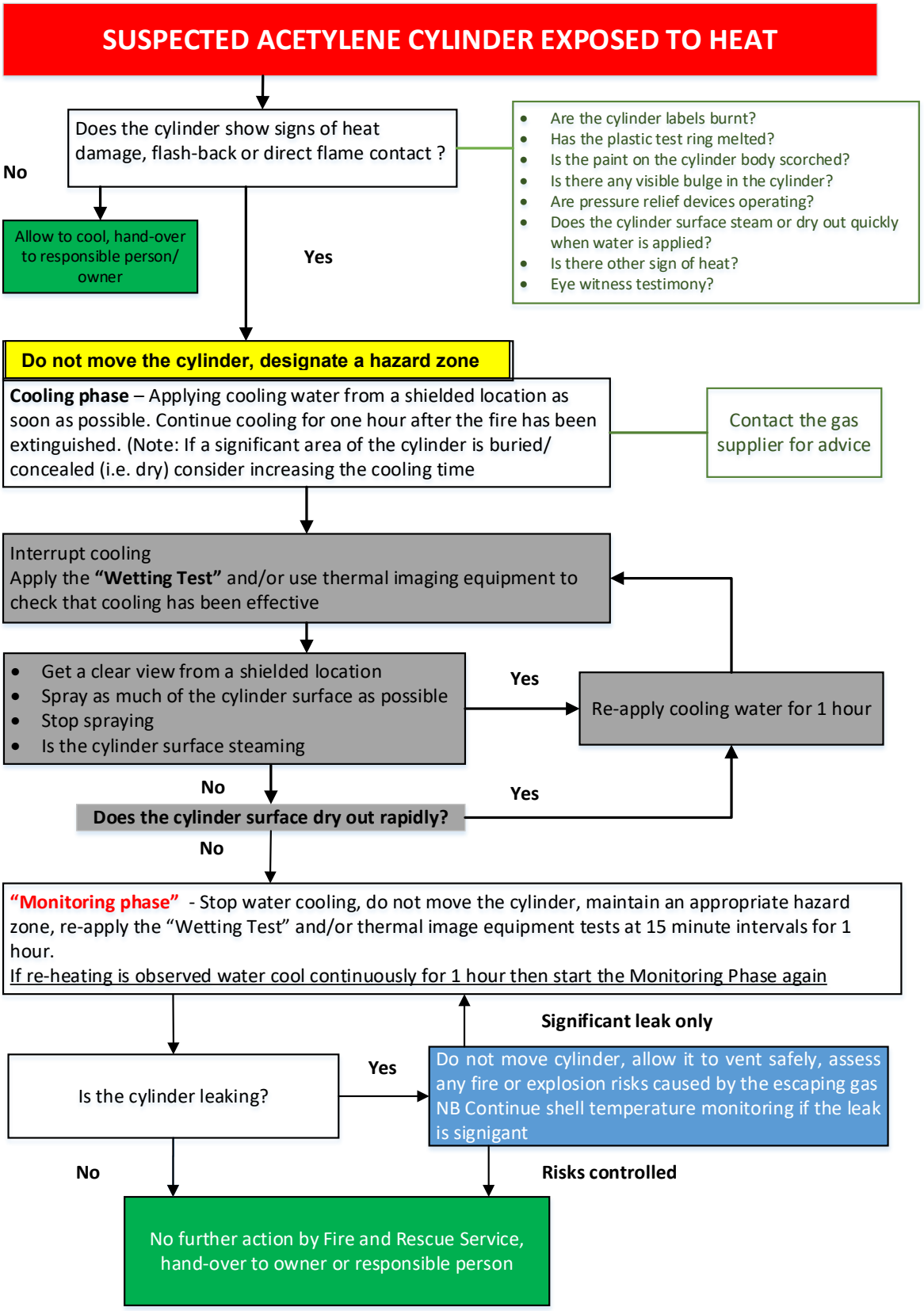
CLOSURE of an INCIDENT INVOLVING ACETYLENE CYLINDERS IN FIRES

To end an incident involving acetylene cylinders in fires requires the cylinders to be safe. To achieve this there are different options. The most common and preferred method is to extinguish the fire, cool the cylinder, wait and then confirm the cylinder is cool internally.

It is noted that some authorities choose to end the event by shooting the cylinder and allowing it to vent (note that the acetylene may burn as a jet flame upon release). Shooting has inherent risks which must be managed to be safe.

[1] Reproduced from United Kingdom Fire and rescue Operational guidance Incidents involving hazardous materials http://www.nationalarchives.gov.uk/doc/open-government-licence/version/2/

EMERGENCY SERVICES ACTIONS: ACETYLENE CYLINDER EXPOSED TO HEAT



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EMERGENCY SERVICES ACTIONS: ACETYLENE CYLINDER IN FIRE

Operational Key Principle:

Single Acetylene Cylinders Involved in Fire

- **Do NOT move (or approach) the cylinder**
  Acetylene cylinders that have been significantly heated or damaged by fire must not be moved. There is an explosion hazard until the internal contents of the cylinder are cooled

- 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 1 hour. Ground monitors and lashed jets should be used, any firefighters 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 Fire 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 or buried by debris, there could 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 (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).

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SUMMARY OF ACTIONS FOR DEALING WITH CYLINDER IN FIRE

To ensure that consistent advice is given and that all excessive heat affected cylinders are managed correctly, EIGA member companies are recommended to develop and document a process for responding to reports of cylinders in fires and to identify competent persons to deal with these events. For definition of "excessive", see TB 21 *Recommendations for Cooling and Heating of Gas Cylinders.*

Personnel giving advice on how to deal with cylinders during and after an exposure to excessive heat or fire shall be trained and their competence assessed and documented. An outline of the process to be considered by the competent person during and after a fire event includes:

- Prompt initial advice by telephone to a customer, or to emergency services at the scene, to assist in identifying the product(s) involved and the extent to which cylinders could have been affected by a nearby fire. Factors to be considered in this evaluation include; the condition of the paint, external coating and plastic neck ring and valve condition.
- When, and if appropriate, a competent person from an EIGA member company can assist, after the event, in person at the scene (or again by telephone), to:
  - Establish, from a safe distance, that the cylinders are in a safe condition,
  - Inspect any cylinders which were directly involved in a fire, or which could have been subjected to excessive heat.
  - Make all cylinders safe for transport, by confirming integrity (no apparent leaks). Clearly label these cylinders with; "Not to be filled, exposed to fire or heat" and provide an indication of the hazards of any known residual gas, using N.O.S. labels (non-other specified labels). Ideally include the name of person intended to receive the cylinders at the destination site should be indicated. The label shall be attached prominently and securely to the cylinder.
  - Cylinders should be returned to the nearest site of the member company owning those cylinders.
  - Arrangements shall be made, in consultation with technical experts, if any cylinders are found to be leaking. ADR does not permit the transport of leaking cylinders unless undertaken by competent authorities for the purpose of emergency response (see ADR: 1.1.1.3(d)) [3].
  - Cylinders returned after exposure to fire or excessive heat shall be assessed by specialist personnel to determine whether suitable to be returned to service or scrapped.

REFERENCES AND FURTHER INFORMATION

[1] EIGA Safety Information 05, *Flashback and flashback arrestors* in Welding Applications, www.eiga.eu
[2] UK Fire and Rescue Service - Operational Guidance - Hazardous Materials Incidents
Part B Technical Operational Guidance Section 5 UN Class 2 Gases (including acetylene)
https://www.gov.uk/government/publications/hazardous-materials-operational-guidance-for-the-fire-and-rescue-service See Section C5. Pages 295-349
[3] ADR, Directive 2008/68/EC of the European Parliament and of the Council of 24 September 2008 on the inland transport of dangerous goods, *https://eur-lex.europa.eu/*

EIGA HF 06 *Organisation - Site Emergency Response*, www.eiga.eu
EIGA SL 03 *Safe Transport of Gases*, www.eiga.eu
EIGA SL 04 *Safe Transport, Use and Storage of Acetylene cylinders,* www.eiga.eu
EIGA TB 21 *Recommendations for Cooling and Heating of Gas Cylinders* www.eiga.eu

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