HANDLING GAS CONTAINER EMERGENCIES

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1. Introduction

This document describes the special requirements and techniques used in handling emergencies involving gas containers containing speciality gases.
Owing to the high integrity of gas cylinders, emergencies involving them are rare. However, when incidents do occur it is important that they are dealt with in a safe and professional manner. This document has been prepared as a practical guide to handling such emergencies.

2. Scope and purpose

2.1. Scope

This practical guide is limited to handling emergencies involving pressurised gas containers including cylinders, small cryogenic vessels (up to 450 litres), drums, bundles, battery vehicles and tube trailers.
This practical guide is intended for the use of technically competent and trained practitioners only. Before attempting to tackle an emergency situation, the methods and techniques to be employed should be discussed and agreed with the customer and/or emergency services representatives.
The management issues associated with setting up and operating an Emergency Service are outside the scope of this practical guide.

2.2. Purpose

The purpose of this practical guide is:

- to identify potential emergency scenarios
- to provide guidance on initial advice that can be given to persons at the scene
- to set out the “tried and tested” techniques that can be employed to bring an emergency situation under control and to a safe conclusion
- to provide guidance on the equipment that may be required by personnel who deal with such emergencies

3. Definitions

- *Cold-welding*: Cold-welding can occur where two similar materials which are in contact with each other apparently fuse together without the application of heat.
  Note: Such a phenomenon occasionally occurs between a cylinder valve outlet threaded connection and the outlet connector nut. Normally this is associated with stainless steel cylinder valves fitted with stainless steel outlet connector nuts that have either been cross-threaded or over-tightened or where the tolerances between the nut and valve outlet are insufficient for the threads to run smoothly. Wherever possible, connector nuts used on stainless steel valve outlets should be made from a different material (e.g. brass or monel). Where this is not possible, it is recommended that the connector nut threads should be plated with a lubricating metal (e.g. silver), with adequate allowance made in the connector nut thread tolerance to allow for the thickness of the plating.
- *Cylinder recovery vessel:* A pressure vessel which is designed to safely contain a cylinder and its content for transportation and storage, until it can be safely emptied. A cylinder recovery vessel could be fitted with a gauge to indicate internal pressure and valves to enable purging. A cylinder recovery vessel is identified as a “salvage packaging” in the Regulations for the international transport of dangerous goods (UN Model regulations, ADR/RID, etc)
- *Emergency:* Unplanned situation that could give rise (or has given rise) to a hazard to people or the environment and or damage to equipment.
- *Gas:* For the purposes of this document any product gaseous or liquefied transported in gas containers.
- *Gas cabinet:* A locally ventilated enclosure designed to contain a gas supply cylinder and, where appropriate, an associated purge supply gas cylinder. The term *gas cabinet* usually also includes the gas supply handling equipment such as purge manifolds and pressure reducing regulators. The gas cabinet can be quite complex in design, often being equipped with automatic microprocessor control. *Gas cabinets* are commonly used by the microelectronics industry.

- *Gas supplier's emergency response team:* A Group of suitably equipped, technically competent and trained personnel with the purpose/function to bring an emergency to a safe conclusion by providing technical advice and or practical assistance.
- *Gas Supplier's Representative:* A person who acts on behalf of the Gas Supplier to provide safety & technical advice to persons at the scene of an emergency.
- *Gas user:* Personnel from the customer / manufacturer working with the cylinder / gases
- *Public emergency services:* Public Services that may be involved or present at the scene of an emergency. These include fire brigade, police, medical personnel (such as doctors, nurses & ambulance).
- *Pressure:* In this publication bar shall indicate gauge pressure unless otherwise noted –i.e., (bar, abs) for absolute pressure and (bar, dif) for differential pressure.

4. Emergency Service

4.1. Advice to emergency scene

To ensure that safety is not compromised, the Gas Suppliers should make appropriate arrangements to enable sound technical advice to be made available (e.g. over the telephone) to persons at the scene of an emergency.
The nature and detail of the initial advice given may depend on a number of factors, including

a) hazards of the gases involved
b) quantities and the type of products
c) location of the emergency
d) knowledge and experience of persons at the scene

4.2. Control of emergencies

In most situations, emergencies are controlled by the Public Emergency services or the site owner. The gas suppliers input should be limited to providing technical advice on the hazards and where necessary practical assistance in abating product release and making the containers safe.

4.3. Emergency response team

Where a Gas Supplier has established an *Emergency Response Team* to assist bringing an emergency to a safe conclusion, the team members should be suitably equipped, technically competent and experienced in required techniques. This Team should be able to make cylinders safe and, under some circumstances, remove them to the *Gas Supplier's* site, where the contents can be safely emptied and the causes investigated.

4.4. Emergency reports

It is recommended that a recording system is in place for all emergencies reported. This should cover:-

- location of incident and products / containers involved.
- the timetable of events
- the names and telephone numbers of all known persons involved
- details of any reported injuries or material damage
- details of initial advice given
- details of any follow-up actions taken (e.g. a report from the *Gas Supplier's Emergency Response Team* on their visit to the scene of the emergency).
- details of any media involvement

5. Emergency scenarios

Emergency scenarios can be divided into four broad categories - fire, gas leaks, transport emergencies and other emergency scenarios. (see 5.4)

This section outlines many of the potential emergency scenarios that may be encountered and gives guidance on the initial advice that may be given to persons at the scene and subsequent follow-up actions that may be taken.

5.1. Fire in the vicinity of cylinders

Cylinders heated to temperatures in excess of 65°C can represent a significant hazard due to the increased pressures developed and for certain gases, on the stability of the gas itself. Generally, the rates of pressure increase are greater for *liquefied* gases than for *compressed* gases. In extreme cases, there may be a risk of the cylinder rupturing or exploding. It should be noted that even if cylinders are not directly within the fire, there may be a risk of them becoming over-heated from the radiant heat emitted from a fire in the vicinity.
In addition to the potential hazards rising from cylinders, similar hazards may arise from pressurised systems that are not designed for high temperature operation.

5.1.1. Advice to persons at scene

It is recommended that the following advice is given to persons at the scene:-
a) There may be a risk of cylinders exploding or 'rocketing'.
b) Cylinders should be sprayed with water from a safe distance to keep them cool. Care should be taken not to extinguish the flame of a leaking gas cylinder unless it is safe to do so.
c) The identity of the contents of the cylinders should be sought, as certain gases may be thermally unstable (e.g. acetylene, ethylene oxide, 1,3 butadiene, organometallics, diborane etc.), where heating may initiate an exothermic reaction which could eventually result in the cylinders exploding. Such reactions may not manifest themselves until long after the fire has been extinguished. For this reason, advice should be given not to approach such cylinders and to maintain the cooling and surveillance for at least 24 hours after the fire has been extinguished and it has been confirmed that the cylinder has remained cool.
d) After the fire has been extinguished and any cylinders involved have cooled down and have been deemed to be safe to approach, they should be appropriately labelled as having been involved in a fire and bonded to await further instructions from the Gas Supplier.

A copy of a Safety Information paper on Information for customers and Fire Brigades is included in appendix 1.

5.1.2. Follow-up actions

It is recommended that the *Gas Supplier's* should make arrangements for suitably trained personnel to visit the site to inspect any cylinders involved in a fire to ensure that they are safe to be transported. Such an inspection could be particularly important if the cylinders are not empty and contain toxic or flammable gases or appear to be swollen.
In some cases, after assessment, it may be deemed most appropriate to either empty fire damaged cylinders before they are transported or to transport them in a *cylinder recovery vessel*.

5.2. Leaking cylinder

Leakage from a cylinder can arise from six possible sources, as follows:-
a) From the connection between the valve outlet and the *Gas User's* equipment. This may be due to damage to one or more of the valve outlet sealing components (e.g. the sealing faces of the connector/valve outlet/gasket) or the incorrect connection tightening torque. Experience has shown that *Gas Users* can mistakenly believe that a leak from the valve outlet connection is arising from the cylinder valve itself.
b) From the valve outlet - this may be due to the valve seat being damaged or valve operating mechanism being damaged or seized. The *Gas User* may experience this problem when initially removing the cylinder valve outlet cap-nut (in readiness to connect the cylinder for use) or when disconnecting the cylinder (after use), finding that the cylinder valve is leaking.
c) From the valve gland - this may be due to a loose gland packing nut or diaphragm sealing nut. In these cases, it may be possible to rectify the leakage by tightening the gland nut. Other possible causes (rare) are, in the case of diaphragm-seal valves a fractured diaphragms and in the case of an 'O' ring seal valve, failure of the 'O' ring seal - leaks of this nature cannot be cured by tightening the gland nut. Normally, all valve gland leaks can be overcome by closing the cylinder valve. Once

the cylinder valve has been closed, the leak should cease once the pressure in the system has been released.

d) From the joint between the valve and the cylinder (commonly known as 'neck-leak') - this may be due to

- the valve being tightened insufficiently into the cylinder
- insufficient sealant on valve threads
- damage to the valve thread
- mechanical damage during handling
- overheating of cylinder e.g. during fire

e) From the cylinder body itself - this is very rare and extremely unlikely. Occasionally, cylinders of a welded construction have been known to develop a pin-hole leak at a welded seam. Certain cylinders (such as drums) may be fitted with a flange into which the valve(s) are screwed. Flanges are fitted to this type of cylinder to facilitate the fitting of dip-tubes (for liquid or gas withdrawal). Occasionally, small leaks can develop from the joint between the flange and the container body.

f) From a pressure relief device which may be fitted to some cylinder valves and very rarely in the bottom of Acetylene cylinders. Such a device is normally incorporated into a small plug which is screwed into the valve body and which is permanently exposed to the cylinder pressure (i.e. cannot be isolated by closing the cylinder valve). This pressure relief device is commonly referred to as a 'safety relief device' in some parts of the world (e.g. North America). Types of pressure relief device in use include:-

- 'fusible plug' type - this consists of a plug of metal which melts at a predetermined temperature and is intended to protect the cylinder from over-pressurisation in the event of a fire. Once the fusible plug has melted, the entire cylinder content will be discharged. Very small leaks from this type of device can arise from the joints between the fusible metal and the plug and between the plug and the valve body.
- 'bursting disc' type - this consists of a metallic disc designed to rupture at a predetermined pressure and is intended to protect the cylinder from over-pressurisation arising from any cause. Once the disc has ruptured, the entire cylinder content will be discharged. Very small leaks from this type of device can arise from the joints between the disc and the plug and between the plug and the cylinder valve body.
- 'spring-loaded' type - this consists of a spring loaded relief valve, the spring being set to allow the valve to open at a predetermined pressure and thus protect the cylinder from over-pressurisation from any cause. Once any excess pressure has been released, the pressure relief device will close, preventing any further gas release. Very small leaks from this type of device can arise from the failure of the valve to re-seat properly after a gas release and from the joint between the plug and the cylinder valve body.

Note: Where the cylinder content is hygroscopic and corrosive to the valve body or cylinder, the leak rate may increase as the materials around the leak path corrode away.

5.2.1. Advice to persons at scene

The *Gas Supplier's Representative* should seek to have a dialogue with a competent person at the scene of the emergency. The following lists some of the more important issues that may be relevant, together with some guidance notes.

The Gas Supplier's Representative will decide whether to mobilise the Emergency Response Team (where such a team is available). In some instances, the *Gas User* and/or the Public Emergency services may have sufficient equipment and expertise to safely deal with the emergency - this possibility should also be discussed before the *Gas Supplier's Emergency Response Team* is mobilised.

a) Initially, the leaking gas should be identified. The properties of the gas and the potential hazards can then be established (from the appropriate SDS). If the name of the gas (or gases) cannot be readily identified by the person at the emergency scene, it is recommended that the cylinder(s) are observed from a safe distance for other possible identifying marks, labels or colour-codes. Further clues might be evident from whether the leaking gas is fuming and whether anyone had smelt any unusual odours. Persons not wearing positive pressure breathing apparatus and other personal protective equipment should not approach leaking unidentified cylinders. If it is not possible to identify the leaking gas, then it is recommended that it should be assumed to be toxic, flammable/pyrophoric and corrosive.

b) The severity of the leak should be established (e.g. whether the leak is audible, if it is fuming and if so, how much).
c) If the leaking gas is toxic and is located in the open, then people should be kept away, preferably up-wind. The toxic gas leak should not be approached by unprotected people.
d) If the leaking gas is toxic and is located inside a ventilated enclosure, discharging to a safe place or to an abatement system, then it can be safely left, appropriately labelled, but with no further immediate action.
e) If the leaking gas is flammable, then it should be located in a well ventilated area and ignition sources eliminated from the vicinity.
f) If the gas is liquefied in the cylinder, it should be established whether the leak is from the gas or liquid phase. If the latter, consideration should be given to moving the cylinder to get the leak into the gas phase and thus reduce the quantity escaping.
g) All gases except air and oxygen and especially liquefied gases represent a potential asphyxiation hazard if leaking into a confined or poorly ventilated area.
h) Leaking valve outlet connections can usually be cured by remaking the connection with a new gasket, after cleaning the connector sealing faces and checking that they are free from damage (see 5.2 a). ***Additional torque must never be applied to valve outlet connections whilst they are under pressure.***
i) Leaks from valve outlets (i.e. valve not properly closed) can often be cured by applying more torque to the valve spindle. If it is necessary to remove the valve hand-wheel to enable a spanner to be used directly on the valve spindle, then the torque applied must be controlled by using a torque wrench, set to an appropriate maximum torque (most valves will withstand a torque of 30 Nm applied to the valve spindle, however this should be checked with the valve manufacturer) Alternatively, if the leak is only small, it should be possible to fit and tighten the valve outlet cap-nut, making certain that the cap-nut gasket is in good condition (see 5.2 b) above).
j) Leaks from a valve gland can sometimes be cured by tightening the gland nut. This is only applicable to adjustable gland packed valves fitted with an adjustment nut, below the valve handwheel. The gland nuts on some valves should only be tightened when the valve is in the open position, to avoid forcing the spindle into the valve seat. Generally these are valves where the spindle actuating threads are located in the gland nut and not in the valve body.
   Note : No attempt should be made to tighten non-adjustable gland nuts (e.g. diaphragm, « 0 » ring types and certain packed type valves). Leakage from this type of valve is rare and can be rectified by closing the valve (see 5.2 c) above).
k) Leaks from between the valve and cylinder ('neck-leak') or leaks from the body of the cylinder itself should only be dealt with by the *Gas Supplier's Emergency Response Team*.
l) Leaks from pressure relief devices should only be dealt with by the *Gas Supplier's Emergency Response Team.*

5.2.2. Follow-up actions

Should it be deemed necessary to send the *Gas Supplier's Emergency Response Team* to the scene of the emergency, guidance on some of the practical techniques that they may apply and the equipment that they may require is given in Section 6 of this *guide*.

5.3. Transport emergencies

Transport emergencies could arise from:-

- a fire threatening cylinders on the vehicle.
- cylinders falling from vehicle as a result of a road traffic accident or being improperly secured. Such cylinders may have suffered mechanical damage.
- a gas leak being noticed by the vehicle driver or some other person.

The *Public Emergency Services* are likely to be involved. Media attention is also possible, particularly if there is any significant disruption to road traffic or if there is any likelihood of direct involvement of the general public.

5.3.1. Advice to persons at scene

The knowledge, expertise and status of the person at the scene should be carefully assessed before any advice is given. The advice given to a member of the general public may be simply to keep away and keep others away, and to call the Public Emergency Services. The advice given to the Public

Emergency Services may be more detailed, depending on the nature of the emergency and any gases identified as involved.
Sections 5.1 (fire) and 5.2 (gas leaks) above and 5.4 (other) below should be referred to by the *Gas Supplier's Representative* when giving advice to an appropriately qualified person (e.g. Fire Brigade).
The role of the *Gas Supplier's Representative* should be limited to providing guidance on the nature of the gases involved and the hazards that may arise. The decision to evacuate members of the general public or to close the road should be made by the Public Emergency Services (not by the *Gas Supplier's Representative*).

5.3.2. Follow-up actions

Should it be deemed necessary to send the *Gas Supplier's Emergency Response Team* to the scene of the emergency, guidance on some of the practical techniques that they may apply and the equipment that they may require is given in Section 6 & 7 of this *practical guide*. It may also be necessary to organise a vehicle and lifting equipment to clear up the emergency site once all the cylinders have been checked/made safe.
The role of the Gas Suppliers Emergency Response Team should be limited to dealing with any problem cylinders, under the supervision of the Public Emergency Services (who remain in charge of the emergency).
Discussion by the Gas Suppliers Emergency Response Team with the media should be carefully controlled. Where possible the media should be referred to the Public Emergency Services, as they are in charge of the emergency, or to the Public Relations department of the Gas Supplier.

5.4. Other emergency scenarios

Other possible emergency scenarios that have been experienced include the following:-

5.4.1. Excessive cylinder pressure

A *Gas User* may report an abnormally high pressure when connecting a cylinder. Possible causes of abnormally high cylinder pressure include:-

a) the cylinder may have been stored at an exceptionally high temperature immediately prior to use. During hot sunny weather, cylinders can reach quite high temperatures (in excess of ambient) due to the radiant heat from the sun. No action is normally required.
b) it is possible that the *Gas User* may have allowed a back-feed of gas or some other contaminant (e.g. a reactive liquor) from another source into the cylinder. Whilst this is unlikely, the possibility should be checked with the *Gas User*. If back-feeding is suspected, the possible reactions of the contaminant, the cylinder content and the cylinder walls must be assessed immediately by a competent person and advice given accordingly. In certain cases, prompt action may be necessary to prevent failure of the cylinder due to potentially hazardous exothermic reactions or corrosion of the cylinder's internal walls. In all cases, the cylinder must be labelled with details of the suspected contaminant and set aside for collection by the *Gas Supplier*. Such cylinders must be handled with great care.
c) if the gas is liquefied, the cylinder could be 'hydraulically full' (i.e. full of liquid). If this is suspected, the cylinders can be weighed and checked against the tare weight stamped on the cylinder shoulder. Prior to beginning operations it is recommended that the cylinder is cooled (no lower than -20^0C, typically the temperature of a domestic freezer) to minimise the possibility of rupture during handling. If the cylinder has been overfilled, the *Gas User* should be encouraged to withdraw some product from the cylinder (either by using it, or if the product is non-toxic, by discharging some product to atmosphere in a well ventilated place). If the *Gas User* is unable to take this action, then the cylinder must be placed in a cool place (away from direct sunlight or heating appliances) until the *Gas Supplier's Emergency Response Team* arrive. Their role will be to either discharge some product, if it is safe to do so, or cool the cylinder and apply appropriate thermal insulation so that it can be safely transported back to the *Gas Supplier's* site.
d) if the gas is corrosive when wet (e.g. hydrogen halides) the cylinder over-pressurisation could be due to a reaction taking place between the gas and the cylinder internal walls and, in the case of hydrogen halides, generating an over-pressure of hydrogen. In such circumstances, prompt action should be taken to reduce the cylinder pressure, owing to the potential corrosion weakening of the cylinder walls. In all cases, the cylinder must be labelled and set aside for the attention of the *Gas supplier*. Such cylinders must be handled with great care.

5.4.2. Cylinder explosion

In the event of receiving a report of a cylinder explosion, there is little that can be done by the *Gas Supplier* to make the situation safe other than to advise of potential atmospheric or other contamination and possible damage to other cylinders in the vicinity of the explosion. It is recommended that the *Gas Supplier* should offer assistance in the follow-up investigation to establish the cause of the explosion and to recover cylinder fragments.

5.4.3. Small cryogenic vessel

Portable vacuum insulated cryogenic vessels (e.g. dewars) are used to transport small quantities of cryogenic gases such as liquid carbon dioxide, liquid nitrogen, liquid oxygen and liquid helium. Occasionally these vessels may suffer from a loss of their thermal insulating vacuum. This results in an increase in the cryogenic boil-off rate and in extreme cases, can cause a vapour cloud from the dewar pressure relief valve or opening. Such a cloud may cause concern to persons who are not familiar with these products. The principle hazards arise from the large quantities of gas that may be released in a relatively short time (several hundred volumes of gas per volume of liquid) and the low temperatures involved. The following potential hazards should be conveyed to the person at the scene:-

a) If the gas is oxygen, there is a risk of oxygen enrichment in the atmosphere, particularly if the release is in a confined or poorly ventilated area. Ignition sources must therefore be excluded.
b) If the gas is asphyxiant there is a risk of oxygen depletion in the atmosphere, particularly if the release is in a confined or poorly ventilated area. Personnel should not enter such areas unless they are wearing positive pressure breathing equipment or unless the oxygen content of the atmosphere has been confirmed to be greater than 20%.
c) There is a risk of cold burns if the vessel is handled or the cold liquid comes into contact with the body. Eye protection/face visor and thermally insulating gloves should be worn.
d) Flammable cryogenic gases are not normally packaged in dewars, however, if the gas is flammable, there is a risk of ignition (and possible explosion if the release is in a confined or poorly ventilated area). All ignition sources must therefore be excluded.

It is normally safe to allow the dewar to discharge its content to a well ventilated place, (keeping people away) and leave it to warm up before it is moved.

5.4.4. Large cylinder (tube trailer, battery vehicle, bundle & drum)

Generally, the same principles apply as for emergencies involving smaller cylinders, however the consequences may be much more severe. Some of the emergency equipment used for smaller cylinders may not be appropriate (e.g. cylinder recovery vessels) and other specialised equipment and a specific emergency team may be required.

6. Emergency Response Team techniques

The advice given in section 5 above should be considered by the Emergency Response Team together with the techniques described below.
These techniques must only be carried out by trained and experienced technicians who are aware of the content of the cylinder and have knowledge of the construction of the cylinder and the valve. Technicians must also be equipped with suitable protective equipment and clothing.

The following sequence is the recommended strategy for tackling leaking cylinders.

Can the leak be stopped?

↓

Can contents be vented safely to atmosphere?

↓

Can the contents be disposed of by local scrubbing or incineration?

↓

Can the container be fitted into a recovery vessel?

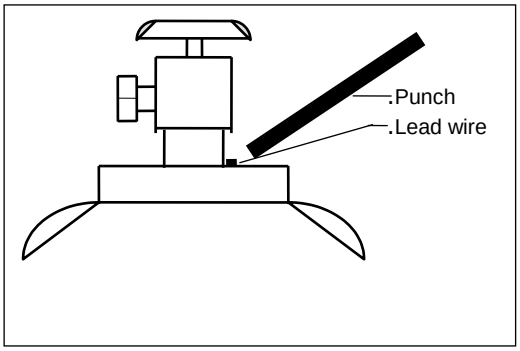
↓

Can contents be transferred to other cylinders?

The recommended methods for the disposal of common products are listed in Appendix 3

6.1. Neck leaks

Attempting to tighten valves into cylinder under pressure (particularly high pressure) is potentially dangerous and should be avoided. If the cylinder contains a low pressure gas (e.g.SO2), the leak can often be temporarily cured by forcing soft lead wire into the leak using a hammer and punch.



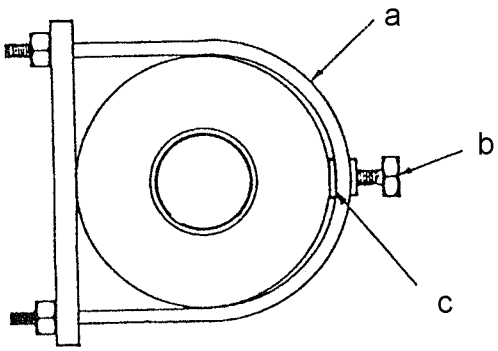
If unable to repair leak refer to section 6.11.

6.2. Cracked necks / bodies

Such leaks are extremely rare. Examples may include:

- localised weld failure on welded cylinders
- stress cracks at the neck of cylinders in some aluminum alloys
- pin hole leaks on wall of cylinders due to corrosion from particularly corrosive environments (e.g. cylinder standing in a pool of acid or suckback of water or other liquor into a cylinder containing corrosive gas). Beware of thin wall areas if leak is due to corrosion.

Such leaks are difficult to stop. A temporary seal can sometimes be achieved by the use of a compatible sealing material clamped to the cylinder body.



a - Container clamp
b - Screw to apply localised pressure to sealing pad
c - Sealing pad

Where the gas is in a low pressure welded cylinder pin hole leaks can sometimes be manually drilled out and the leak plugged using a self tapping screw or rubber plug with screw and nut. Before attempting this technique ensure that the pin hole is in the gas phase of the cylinder.

6.3. Gland leaks

There are two general types of spindle (gland) seals in common use. These are:

- Adjustable gland packing (fitted with an adjustment nut, below the valve handwheel). Leakage from this type of valve may be rectified by tightening the gland nut. The gland nuts on some valves should only be tightened when the valve is in the open position, to avoid forcing the spindle into the valve seat. Generally these are valves where the spindle actuating threads are located in the gland nut and not in the valve body.
- Non-adjustable gland (diaphragm, « 0 » ring types and certain packed type valves). Leakage from this type of valve is rare and can be rectified by closing the valve.

Both types of spindle (gland) seals will only leak when the valve is open (or backpressured by a system), hence if the leak cannot be readily cured, close the valve (and depressurise the system). If unable to close the valve refer to section 6.11.

6.4. Flange leaks (drum)

Flange leaks: Tighten the flange nuts in the correct order, in accordance with the drum manufacturers instructions using a torque wrench. Gradually increase the torque until leak tight seal is achieved (avoid exceeding manufacturers recommended maximum torque). If not possible to achieve leak tight seal refer to section 6.11.

6.5. Seized open valves

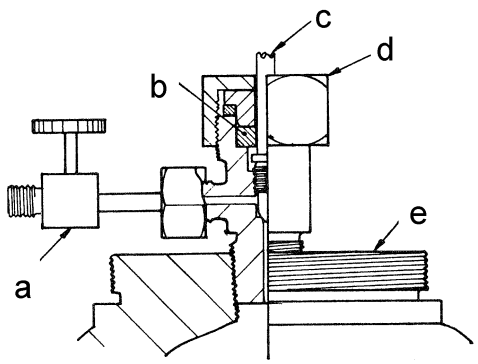
The following techniques may be tried to free a seized valve

- gently heating the valve
- applying compatible easing lubrication
- removing handwheel to allow extra torque to be applied to valve spindle
- slackening the valve gland nut and tapping the valve key with a hammer (adjustable gland packed valves only)
- applying torque clockwise and counterclockwise to the valve spindle to work the valve towards the closed position

If this fails to allow the valve to be closed, then it may be necessary to remove part of the customers installation up to the first closed line valve, to enable the cylinder to be safely removed.

6.6. Leaks past the seat

The valve can usually be closed by the careful application of a greater closing torque to the valve spindle (a valve fitted with a handwheel may require removal of the handwheel before this extra torque can be applied). Whilst applying the extra torque, the valve spindle should be carefully observed. Application of extra torque should cease when the leakage stops or if any sign of distortion of the spindle occurs. This approach is not applicable to pneumatically actuated valves.
If the valve cannot be closed, then usually a valve outlet plug or cap nut can be fitted to provide an effective gas tight seal to the valve outlet. Note that valve outlet cap nuts or plugs must be of a suitable pressure rating and must be fitted with a gasket where appropriate.
If it is not possible to fit a gas tight valve outlet plug or cap nut due to high pressure/flow an open secondary valve may be fitted, which can be subsequently closed after the connection has been made.



a - Auxiliary valve
b - Gland packing
c - Valve spindle
d - Gland nut
e - Cylinder

If this is not possible refer to section 6.11.

6.7. Leaks from pressure relief safety devices

Refer to section 6.11.

6.8. Leaks from downstream equipment

Close the cylinder valve. Purge equipment with inert gas.

6.9. Valve outlet connections

6.9.1. Leaking valve outlets

Leaking valve outlet connections can usually be cured by remaking the connection with a new gasket, after cleaning the connector sealing faces and checking that they are free from damage (see 5.2 a). ***Additional torque must never be applied to valve outlet connections whilst they are under pressure.***

6.9.2. Cold-welded connecting nut

This is not necessarily an emergency; however the Gas User's application is likely to be disrupted until the cylinder is replaced.
Close the cylinder valve. Purge equipment with inert gas. Disconnect from customer system (it may be necessary to cut the pipework close to the cylinder valve).

To enable the cylinder valve protection cap to be fitted, it may be necessary to remove the cold-welded connector nut from the cylinder valve outlet, either by splitting the nut or by cutting the entire valve outlet off.

6.10. Valve body leak

It should be possible to stop such a leak by closing the cylinder valve (unless the leak is upstream of the valve seat) otherwise refer to section 6.11.

6.11. Other techniques

The following techniques can be employed:

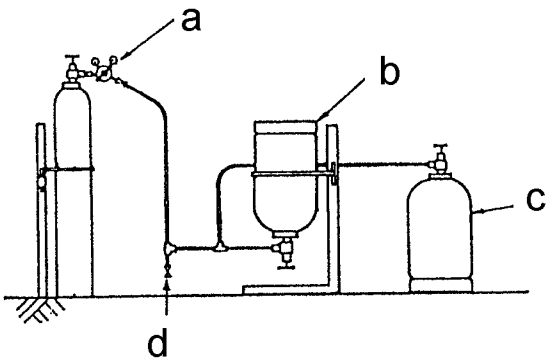
6.11.1. Reducing liquefied gas leak-rates

Liquefied gas leaks can often be reduced by

a) cooling the cylinder - this will reduce the liquefied gas vapour pressure and consequently the rate of leakage. In some cases, it may be possible to reduce the temperature sufficiently to enable a damaged cylinder valve to be exchanged for a new one or to enable a temporary repair to be made to the point of leakage. Cylinders should not be cooled below their safe working temperature (e.g. some steel cylinders may become embrittled at low temperature). Cylinders should not be cooled below -25ºC unless it is known that it is safe to do so.
b) rotating or moving the cylinder - where the leak is from the liquid phase (i.e. liquefied gas is escaping and then vapourising in the atmosphere), it may be possible to change the orientation of the point of leakage to the gas phase. This should significantly reduce the rate of leakage, as most liquefied gases will readily vapourise to several hundred times their liquid volume.

6.11.2. Decanting contents

a) Compressed gas content: Sequentially decanting the contents of the leaking cylinder into several evacuated cylinders can significantly reduce the pressure in the leaking cylinder.
   As an example, if the receiving cylinders are the same capacity as the leaking cylinder, the pressure in the leaking cylinder can be approximately halved (assuming the gas is “ideal”) at each decant operation. This would mean that, given four evacuated cylinders, the pressure in a leaking cylinder at 200 bar can be reduced to approximately 20 bar. Such a reduction in pressure is likely to significantly reduce the leakage rate.
b) Liquefied gas content
   A liquefied gas may be decanted into an evacuated receiving cylinder. The liquefied gas must be withdrawn from the liquid phase of the leaking cylinder (i.e. if no dip-pipe is fitted, the cylinder must be inverted and if a 90º eductor tube is fitted, the cylinder must be laid horizontally so that the eductor tube is dipping into the liquid phase). It will normally be necessary to establish and maintain a pressure drop between the leaking and receiving cylinders to enable the liquid transfer to take place. A small pressure drop may be achieved by gravity, however, in most cases this is unlikely to be sufficient. An adequate pressure drop can be achieved by:
   - either pressurising the leaking cylinder with an appropriate compressed gas which will not react with the liquefied gas to be decanted. Care must be taken to ensure that the leaking and receiving cylinders are not over-pressurised



a - Nitrogen supply (via regulator with relief valve and non-return valve)
b - Leaking cylinder of liquefied gas
c - Receiving cylinder
d - Vent

- or cooling the receiving cylinder to reduce the contained liquefied gas vapour pressure. The receiving cylinder can be placed in a cold bath which is maintained at well below ambient temperature. Unless it is known to be safe to do so, cylinders should not be cooled below -25ºC. If it is not possible to cool the receiving cylinder in this manner, cooling can be achieved by periodically stopping the liquid transfer and allowing a small amount of the transferred liquefied gas in the receiving cylinder to vaporise and discharge to a safe place (or abatement system for toxic gases - see 6.11.4). This will cause the remaining liquefied gas in the receiving cylinder to cool. A better approach is to use a receiving cylinder fitted with a dual-port valve. The second port of the valve (which must be in the gas phase) should be connected to a safe discharge point as above. This second port can then be opened slightly and adjusted to allow a continuous low flow-rate discharge of gas. This will enable the liquefied gas in the receiving cylinder to be maintained at an appropriately lower temperature than that of the leaking cylinder and hence maintain a continuous liquid transfer.

6.11.3. Temporary abatement of gas leaks

Temporary abatement of small gas leaks can often be achieved by:-

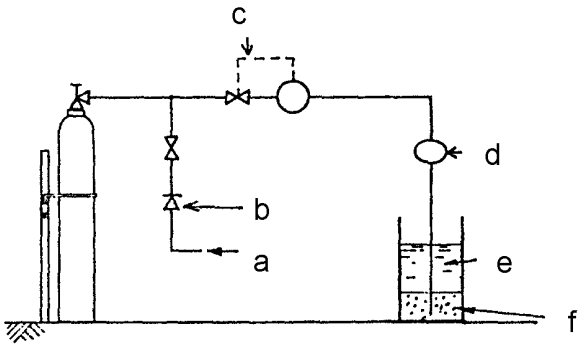
a) fitting a plastic bag containing a suitable solid (granular) scrubbing or adsorbing medium over the source of gas leakage. The plastic bag can be secured and sealed over the point of leakage using adhesive tape. Where there is a risk of the bag filling up and bursting (e.g. when the gas to be scrubbed is diluted in a non absorbable gas), the bag should be pierced in such a manner so as to ensure that the leaking gas passes through the scrubbing medium before leaking to atmosphere through the hole in the bag. Suitable solid scrubbing or adsorbing mediums include:-
   - activated charcoal (for many gases)
   - moist soda lime (for many acidic gases)
b) fitting and sealing a special cylinder cap with a built-in vent-pipe over the cylinder valve. The vent-pipe can be attached to a flexible pipe leading to an abatement system. The abatement system could consist of a small vessel containing a solid scrubbing or adsorbing medium such as described in 6.11.3.a) above, or an appropriate scrubbing liquor. See 6.11.4b) below.

6.11.4. Disposal of cylinder contents

a) To atmosphere: Toxic and flammable gases shall not be vented to atmosphere unless deemed safe to do so. The cylinder should be supported. Gases should be vented to a safe place in the open air.

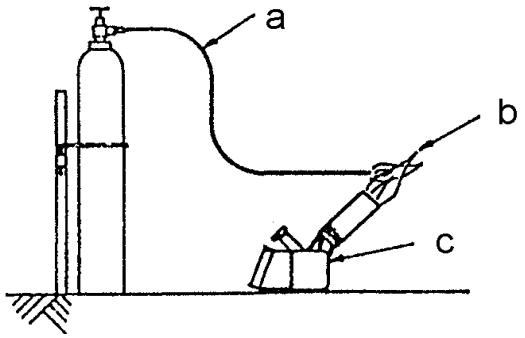
b) To temporary scrubbers: A simple kind of gas scrubber for using on-site can be made up from a plastic hose leading to the bottom of a suitable open topped vessel containing shingle (to improve the gas/liquor contact) and a suitable acid/alkaline or other liquor. This method is recommended where absorbent liquor is available which strongly and readily absorbs the gas. A flow control system should be installed to enable the gas flow to be matched to the capacity of the scrubber.

The plastic hose should be transparent to indicate “suckback“ conditions. This operation should be carried out in a well ventilated or open area.



a - Inert purge gas
b - Non-return valve
c - Flow control
d - Sight glass
e - Absorbent liquor
f - Shingle

c) To an incinerator / burner. A simple kind of incinerator can be made up from a metal pipe and a blowlamp (or gas-fired burner). This method is recommended for flammable gases which can be burnt completely yielding non-toxic products. The air should be purged from the waste gas line. The burner should be located in a safe position away from combustible material. In the case of liquefied gases, suck back of air should be avoided

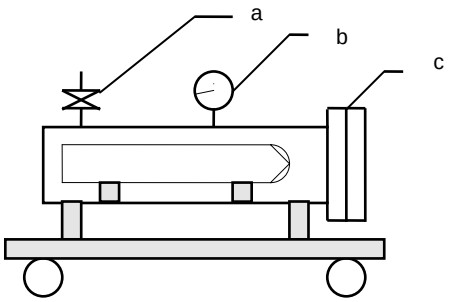


a - Metal pipe
b - Blow lamp flame
c - Blow lamp (Kerosene or gas)

Appendix 3 lists products to which the above disposal methods can be applied. Additional information regarding disposal methods can be found in the AIGA 083/EIGA document 30‘Disposal of Gases’.

6.11.5. Cylinder recovery vessel

Leaking gas cylinders which cannot be repaired at the emergency site may be transported safely inside suitable cylinder recovery vessels.



a - Purge/depressurise valve
b - Pressure gauge
c - Flange

Special care must be taken to purge all air out of the cylinder recovery vessel using an inert gas such as Nitrogen if the leaking cylinder contains a flammable gas. This is to eliminate the risk of an explosive flammable gas/air mixture in the vessel. Unless this purging can be effectively carried out and confirmed (e.g. with an Oxygen meter), a leaking cylinder containing a flammable gas must not be placed in the vessel.
Leaking Acetylene cylinders must not be placed in cylinder recovery vessels.
A complete list of compatible gases and operating procedures should be agreed with the cylinder recovery vessel supplier.

As to the recovery vessel itself, the following key safety points should be taken into consideration:

- the recovery vessel must be capable of withstanding the resultant pressure after release of gas from the cylinder.
- the recovery vessel is a pressure vessel and must be designed and periodically tested to conform to relevant legislation.
- the recovery vessel must be constructed from materials compatible with the gases expected to be contained. Special care must be taken in selecting materials for highly oxidising gases.
- for oxygen (in excess of 23.5 volume percent) and oxidants, the recovery vessel, gaskets and external surface of the cylinder and valve must be oxidant compatible, degreased and dried.
- the recovery vessel may be used to contain more than one cylinder. The contents of each cylinder shall be compatible with the recovery vessel materials and with the contents of the other cylinders.

There must be a documented operating procedure for the use and transportation of the cylinder recovery vessel including:

a) before use :
- the vessel has to be regularly checked.
- the vessel should be closed and filled with nitrogen.

b) during introduction of a cylinder :
- only trained people using adequate safety equipment are authorised to use the vessel.
- the leaking cylinder should be secured in the vessel.
- there should be an indication of the cylinder contents attached to the vessel.
- for corrosive gases, the system must be dry.

Note: additional requirements to be observed for the transport of recovery vessel can be found in Appendix 2.

c) after use :
the cylinder recovery vessel should be purged and cleaned in readiness for the next use.

7. Emergency Response Team equipment

To enable the emergency team to respond in a safe, effective and rapid manner the equipment listed in section 7.1 should be identified and be available for immediate use. An inventory detailing all items in the emergency kit should also be created. The inventory list should be updated regularly and a copy stored close to the emergency kit items. Major changes in the equipment in the emergency kit must be communicated to all Emergency team members and appropriate training in the use of the equipment must be given. Wherever possible, the equipment in the emergency kit should be dedicated only for use in emergencies.

Maintenance schedules for inventory items should be established and written records of tests and repair work performed stored.

Consideration should be given to the portability of the emergency kit items (i.e. use of containers, trailers etc). Decentralisation of the Emergency response resources may assist in providing a more rapid and efficient response.

7.1. General emergency kit items

Safety Data Sheets (SDS)
Tremcards
Gas data books
Road atlas / maps
AIGA/EIGA Document 30/07 Disposal of Gases
Useful telephone numbers (e.g. Hospitals, Public emergency services, National poisons centre etc.)

Torch complete with spare batteries
Rope
First aid kit (including special gas specific items where appropriate e.g. Hydrogen Fluoride kit)
Portable flashing warning light

Oxygen deficiency/enrichment monitor
Flammable gas detector
Toxic gas detectors, e.g. detector tubes
Camera
Portable telephone
Warning tape

7.2. Specific emergency kits items

The type of equipment to be placed in an emergency kit depends on the scenario and the properties of the gases to be handled. In all cases all members of the emergency response teams should be trained and be familiar with the use of the tools and safety equipment.

7.2.1. Tools & materials to tackle leaks from cylinders

The following is a list of possible tools that could be included in the Emergency kit

Screw drivers
Allen keys
Adjustable wrenches
Torque wrench
Easing fluid (for rusted / seized valves)
Chain wrench
Valve keys
Pipe extension (extra torque)
Cylinder support clamp
Cylinder recovery vessel (coffin)
Cylinder body clamp
Valve clamp

Hammer
Mallet
Chisels / punch
Soft lead sealant
Saws with blades
Pliers
Wire cutters
Wire brush

Valve connectors to suit outlet to be encountered (e.g. BS, CGA, AFNOR, DIN etc)
Outlet cap nuts and plugs to suit outlet to be encountered (e.g. BS, CGA, AFNOR,DIN etc)
Replacement washers / gaskets
Pipe connectors (Compression fittings and connectors to NPT, VCR etc)
Stainless steel pipe
Pipe cutter
Needle valve
Pressure gauges
PTFE tape
Sealant pastes / tapes
Hose pipe
Containers to mix caustic solutions
Caustic soda or common soda crystals (NaOH or Na_2CO_3)

Plastic bags
Absorbents (charcoal, Soda lime)
Temporary cylinder cap scrubber
Small gas burner

7.2.2. Personal Protective Equipment (PPE)

Management shall ensure that the Emergency Response Team have been provided with and trained in the use of Personal Protective Equipment that is to be used in dealing with emergency incidents.

Management shall ensure that the PPE items selected are appropriate for the gases that will be handled and that they are maintained in good condition.
Depending on the type of emergency and the possible product hazards, the following items should also be considered for use by the Emergency Response Team.

a) Inert, non toxic oxidant gases and cryogenic liquids
- Safety glasses
- Overalls
- Leather type gloves
- Protective footwear
- Breathing apparatus (2 sets minimum)

b) Flammable gases
- Safety glasses
- Flame retardant overalls
- Heat resistant gloves
- Protective footwear
- Breathing apparatus (2 sets minimum)

c) Toxic non corrosive gases
- Safety glasses
- Overalls
- Leather type gloves
- Breathing apparatus (2 sets minimum)

- Protective footwear

d) Toxic / corrosive gases
- Goggles / face shield
- Anti acid suits
- Anti acid gloves
- Breathing apparatus (2 sets minimum)
- Anti acid protective footwear

In addition, personnel involved in rolling cylinders shall wear protective footwear.

Additional protective equipment may be required for specific gases. (e.g. ClF_3 & HF)

7.2.3. Detection equipment

Consideration needs to be given to the selection of appropriate leak detection equipment for use by the Emergency Response team. This equipment must be portable and be suitable to detect gas leaks that could be hazardous to personnel at the incident site.

The type of gas detection equipment used by the team will depend on the extent of the leakage and the properties of the gases contained in the cylinders.

Typical detection equipment
- leak detection fluid
- ammonia puffer bottle (most acidic gases)
- chemical reaction detection tubes and pump
- portable gas detectors
  - % Oxygen meter (asphyxiation risk)
  - flammable gas detector
  - hydride detector
  - specific gas detectors

8. Emergency response personnel

8.1. Selection of personnel

It is desirable that all personnel involved in emergency response should have had several years practical experience of handling the products involved. It is also important that such personnel have demonstrated the following:-
- an in-depth knowledge and understanding of the properties and potential hazards of the products, cylinders and cylinder valves involved.
- good communication skills.
- clear thinking (logical & analytical).
- mechanical aptitude.
- a good safety record.
- a thorough knowledge of the Company's emergency response system and the techniques & procedures that can be employed to deal with an emergency situation.
- an understanding of the gas supply systems that may be encountered at *Gas User's* premises (e.g. *gas cabinets*).

8.2. Personnel training

Management shall ensure that all personnel involved in
- the maintenance of emergency equipment
- receiving of emergency calls
- giving advice to persons on site
- dealing with the emergency on site

are fully aware of their responsibilities and be given sufficient training to perform their roles.
This training should be documented, recorded, reviewed and updated as appropriate on a periodic basis.

8.2.1. Personnel who provide initial advice to persons at the scene of an emergency

They should have good communication skills and should be technically competent to advise and assess what immediate actions should be performed.
It is recommended that training of such personnel include the topics listed below

- Company emergency response procedures
- Role playing of emergency scenarios
- Emergency team contact list
- Properties of gases and using SDS
- Valve design and repair techniques
- Cylinder sizes and identification
- Operation and use of Breathing Apparatus
- Use of Personal Protective Equipment
- Operation and use of gas detection equipment
- Preparation of factual reports

8.2.2. Emergency Response Team

Emergency response team members should have practical experience in dealing with cylinder problems. It is recommended that training of such personnel include the topics listed below

- Company emergency response procedures
- Gas properties and using SDS
- Valve design and repair techniques
- Cylinder sizes and identification
- Operation and use of Breathing Apparatus
- Use of Personal Protective Equipment
- Operation and use of gas detection equipment
- Preparation of factual reports

8.3. General safety issues

Personal safety must always take precedence when dealing with any emergency situation. Actions taken by the emergency team personnel must never compromise either their own safety or that of others. Care must also be taken to minimise any adverse effects on the environment. The following is also strongly recommended:-

- Prior to taking any actions at the scene of an emergency a risk assessment should be performed.

- Two fully equipped persons are required when tackling cylinder emergencies (normally one to act as back-up)
- Members of the Emergency Response Team must be physically fit. This is particularly important for those using breathing apparatus.

- When the location of the emergency requires the team to travel a long journey, the use of a separate driver should be considered.

APPENDIX 1

Reproduced from document “Safety Info 02/02/E” prepared by the EIGA Safety Advisory Group.

Handling of Gas Cylinders at and after Fire/Heat Exposure

1. Introduction

It is of utmost importance that customers and emergency services could at emergencies receive proper and immediate advice on the handling of gas cylinders in fire. This Safety Info including the attached leaflets is issued by EIGA and represents the presently best knowledge on the safe handling of gas cylinders in general and acetylene cylinders specifically involved in a fire. The Safety Info should be made known to appropriate personnel in the member companies as well as customers and emergency services.
The purpose of the Info is to give guidance on how to handle gas cylinders exposed to fire or excessive heat to persons familiar with the properties and safe handling of gases and gas cylinders. ***As with any recommendation of this nature, each situation requires a careful assessment of the risks involved.***

2. Cylinders after a fire/heat exposure

Cylinders subjected to fire or heat could be affected by the heat exposure entailing a loss of the safe properties of the gas cylinders. This is especially critical when using composite or aluminium cylinders. To ensure that all heat affected cylinders are taken out of service in a reliable way, each EIGA member company should adopt the following:
Personnel of the EIGA member company giving advice on how to deal with cylinders at and after a fire should be properly trained. When appropriate, a competent person should visit the scene of the fire at a suitable time to judge if the cylinders are affected or not affected by the fire.
This person should :

- Inspect any cylinders involved directly in the fire or which may have been subjected to heat.
- Estimate the extent of the fire or heat exposure.
- Label the appropriate cylinders as follows “Not to be filled, exposed to fire/heat” and the name of the site and person receiving the cylinder. The message shall be attached prominently and robustly.
- Make the cylinders safe for transport to the place where they can be properly examined before returning to service or scrapping.

Where it is judged that a visit to the customer’s site is not needed, the customer should be given appropriate advice by telephone, fax or e-mail on the inspection requirements and the importance of clearly label the cylinders as described above.
If the presence of heat or fire affected cylinders from other suppliers is noticed at the visit at the customer, the customer should be strongly advised to contact also the other gas supplier for collection. The member company should also directly inform the other supplier as a further precaution against the circulation and use of unsafe gas cylinders.
Cylinders permanently unfit for recharging should be taken out of circulation and properly destroyed.
Clearly label any cylinder which has been affected or damaged by fire or heat. Coordinate further procedure with gas supplier.
Below please find one leaflet giving information to member company personnel, customers and emergency services on the handling of heat exposed cylinders in general and one leaflet specifically addressing the acetylene cylinders.

Information for Customers and Fire Brigades

TREATMENT OF GAS CYLINDERS EXPOSED TO FIRE OR HEAT (EXCEPT ACETYLENE CYLINDERS)

Any gas cylinder that is exposed to fire or extreme heat may rupture due to increase of temperature and pressure. This is valid even for cylinders that have pressure relief devices as in extreme circumstances the device can not operate quickly enough. Hazards arise from pressure shock, flying cylinder pieces and from flammable, toxic or corrosive content of the cylinder. A ruptured gas cylinder can fly a distance of 100 meters or more.

1. Cylinders containing non toxic or non corrosive gases, arranged in bank or in a storage area

- Warn personnel and evacuate the area.
- Prevent access to the area by roping off and warning notices.
- Call the fire brigade and the gas supplier.
- Immediately start the cooling of cylinders by deluging them with water from a safe place – behind heavy machinery or solid wall.
- Establish the time the fire started and the content, number and location of gas cylinders involved.
- Give this information and all recommendations in this leaflet to the fire brigade on arrival.

Cylinders containing liquefied gases (e.g. LPG, carbon dioxide, and nitrous oxide) must be stored in an upright position.
Restore any overturned cylinder to avoid liquid being expelled from the valve or pressure relief device.
Care must be taken not to knock cylinders over when cooling.

Acetylene cylinders present increased dangers and require special treatment as outlined on the specific leaflet.

2. Single cylinders in use containing non toxic or non corrosive gases

Time of fire not established:
- Apply recommendations in 1 above.

Starting of fire or heat exposure witnessed:
- If safe to do so considering the fire or heat exposure, close cylinder valves if open and remove all cylinders nearby if any.
- Warn personnel and evacuate the area.
- Prevent access to the area by roping off and warning notices.
- Call the fire brigade and the gas supplier.
- Establish the time the fire or heating started, cylinder(s) content, and give this information and all recommendations in this leaflet to the fire brigade on arrival.
- Immediately start the cooling of the cylinders by deluging them with water from a safe place – behind heavy machinery or solid wall.
- Interrupt cooling for short time after the fire has been extinguished.
- If the cylinders dry quickly or steam forms on cylinder surface, immediately continue cooling.
- Stop cooling when the cylinders remain wet for 10 minutes without water spraying.

3. Single cylinder in use containing a flammable gas leaking and burning at the valve

- Close the cylinder valve if safe to do so. This will usually stop the gas flow and any flames from the valve.

A flame from a gas cylinder which is in a room and whose valve can not be closed shall normally be left to burn while cooling the cylinder with water. If the flame is extinguished the gas continues to escape and can cause an explosion. The flame may only be extinguished if :

- It can give rise to a dangerous situation. In such a case, apply the relevant recommendations in 2 above and ventilate abundantly and naturally.
- The gas flow is very small and the cylinder can be safely and quickly carried out in the open air, in a safe place.

4. Cylinders containing toxic or corrosive gases

Time of fire or heating witnessed or not

In addition to the extent of the source of heat or fire, the degree of hazard depends on the properties, quantities of gases involved and storage conditions. Therefore, ***any action must be decided and directed by a person properly trained who is able to quickly take the adequate measures to reduce the risks***.
Prior to such action :

- Warn personnel and evacuate the area.
- Prevent access to the area by roping off and warning notices.
- Call the fire brigade and the gas supplier.
- Establish the time the fire or heating started, cylinder(s) content, and give this information and all recommendations in this leaflet to the fire brigade on arrival.

(Treatment of gas cylinders exposed to fire or heat, except acetylene cylinders, Page 2 of 2)

Information for Customers and Fire Brigades

TREATMENT OF ACETYLENE CYLINDERS EXPOSED TO FIRE OR HEAT

The safety system of an acetylene cylinder (porous mass and solvent) normally prevents any dangerous decomposition reaction of acetylene. But if acetylene cylinders are exposed to fire or extreme heat or if flashback from the burner into the cylinder occurs, a decomposition reaction can develop. This will be promoted if additionally acetylene escapes from the hot cylinder. Owing to the decomposition reaction temperature and pressure increase and the cylinder can burst. Hazards arise from flames, pressure shock and flying cylinder pieces. A ruptured acetylene cylinder can fly a distance of 100 meters or more.

1. Acetylene cylinders in fire, arranged in bank or in a storage area

- Warn personnel and evacuate the area.
- Prevent access to the area by roping off and warning notices.
- Call the fire brigade 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 solid wall.
- Establish information about number and location of acetylene cylinders involved, and the time the fire started.

Give this information and all recommendations in this leaflet to the fire brigade on arrival.

2. Single acetylene cylinders in use

Time of fire or heating not established

- Apply recommendations in 1 above.

Starting of fire or heating witnessed

- If safe to do so considering the fire or heat exposure, close cylinder valve if open.
- Warn personnel and evacuate the area.
- Prevent access to the area by roping off and warning notices.
- Call the fire brigade and gas supplier.
- Establish the time the fire started and give this information and all recommendations in this leaflet to the fire brigade on arrival.
- Immediately start cooling the cylinder(s) by deluging the whole cylinder(s) with water from a safe place – behind heavy machinery or solid wall.
- If acetylene cylinders dry quickly or steam forms on the cylinder surface, continue cooling with water.

When the cylinders remain cool and wet at least 30 minutes, it is usually safe to approach them to check for leakage. If no leakage is observed, remove them from the place and immerse them in water for at least 24 hours. Afterwards place them in a safe location. ***A leaking cylinder should be left, cooled and the area roped off during 24 hours.***

3. Acetylene cylinder affected by flash back or leaking and burning at the valve

Flash back from the burner into an acetylene cylinder or burning acetylene at the cylinder valve create a dangerous situation. Only when it can be done immediately after ignition, close the cylinder valve to stop the gas flow.

(Treatment of acetylene cylinders exposed to fire or heat, page 1 of 2)

Feel the cylinder shell with the bare hands for any rise in temperature. If
- the cylinder becomes hot
- the flame or gas flow does not stop
- any doubt of other reason

apply recommendations in 2 above.

A flame from an acetylene cylinder which is in a room and whose valve can not be closed shall normally be left to burn while cooling the cylinder with water. If the flame is extinguished, the acetylene continues to escape and can cause an explosion. The flame may only be extinguished if :
- It can give rise to a dangerous situation. In such a case, apply the relevant recommendations in 2 above and ventilate abundantly and naturally.
- The acetylene flow is very small and the acetylene cylinder can be safely and quickly carried out in the open air, in a safe place.

4. Acetylene bundles

When a flashback has occurred, close only the central bundle valve - not the valves of single cylinders – if safe to do so and if it can be done immediately after the ignition.
Apply the checking procedure and recommendations as mentioned in 3 and 2 above.

As the cylinders in a bundle are close to each other, effective cooling with water can not be guaranteed. For this reason, ***bundles in which decomposition is suspected should be hosed down with water at least 24 hours*** after the source of fire or heat has been removed and the cylinders have remained cool and wet at least 30 minutes. ***Do not approach such bundles during this period and prevent access to the area by roping off and warning notices.***

5. Shooting of acetylene cylinders

Rupture of a hot acetylene cylinder can also be prevented by perforating the cylinder with at least two holes by rifle shots.
The method is allowed and occasionally used by some countries emergency services. The following conditions must be considered:
- Shooting must be proposed and duly authorized by the relevant Authority.
- ***Shooting will only be carried out by an experienced rifleman from the authorized emergency services***.
- Shooting will only be carried out at single acetylene cylinders located in a free area.
- Shooting will be carried out from a distance of at least 100 meters in order not to endanger the rifleman.

After the cylinder has been punctured it may be regarded as harmless.

APPENDIX 2 - Salvage Packaging for Class 2.

These are typically pressure vessels into which damaged or leaking pressure receptacles can be placed allowing safe transport from a location to a point where the product and receptacle can be safely inspected by a competent person and a decision made about safe treatment.

This is normally to cover recovery in emergency situations.

They are also known as 'cylinder coffins', and their use is strictly controlled by the industrial gas companies.

The transport regulations of ADR allow the use of a salvage packaging:

- *Chapter 1.2 defines a salvage packaging as* a special packaging into which damaged, defective or leaking dangerous goods packages, or dangerous goods that have spilled or leaked are placed for purposes of carriage for recovery or disposal;
- *Clause 4.1.1.18 regulates the use of a salvage packaging and*
- *Clause 6.1.5.1.11gives some general test requirement for a salvage packaging without making reference to packagings of class 2*
- *Clause 5.2.1.3 requires marking of the salvage packaging with the word "SALVAGE".*

This note details the general requirements to transport a salvage packaging for class 2 (and the receptacle it contains) in accordance with ADR. It does not consider how the receptacle is loaded, unloaded or the tests required to ensure the receptacle and its product are safe to transport or the ultimate recovery and or disposal of the product. There are a number of different types of salvage packaging in use by the different gas companies therefore it is the responsibility of a competent person to identify the hazards and assess the risks involved in the use of this type of equipment and to take appropriate precautions.

Prior to transport a competent person from the gas company shall assess the damaged receptacle to ascertain:
The product that it contains and the actual damage or defect of the receptacle. The risk assessment shall be made carefully if any doubt exists on the product and/or in case of unidentified receptacles; see also other EIGA publications listed below of the reference list.
Note: Certain gases should not be transported in a salvage packaging e.g. acetylene (see also EIGA Safety Information 02 "Handling of gas cylinders at and after fire/heat exposure")due to the risk of explosion.

If the receptacle is considered to be safe to be transported (to a point of disposal) under the authority of the competent person then a number of points shall be considered.

Is the salvage packaging in test?
These pressure vessels are usually designed to a pressure vessel code, and should be inspected at regular intervals.
Is it suitable for the product to be transported?
The competent person decides whether the product may damage the salvage packaging (including gaskets, valves etc.) e.g. due to incompatibility of the materials of construction.
The pressure of the receptacle.
This is to ensure the developed pressure of the leaking receptacle inside the salvage packaging may not exceed the design pressure of the salvage packaging.

The marking and labelling of the salvage packaging and documentation shall comply with the relevant section of the current ADR for the product concerned.

The salvage packaging shall be attached to the transport vehicle to achieve the same dynamic loading stability as any other receptacle.

The salvage packaging and the damaged receptacle may then be transported to a point where the product and receptacle can be safely inspected by a competent person and a decision made about safe treatment by the gas company.

Where the product or receptacle is consigned for waste treatment or disposal this must be to a licensed facility and this transport must be in accordance with waste regulations (Regulation (EC) No 1013/ 2006 on shipment of waste)

References:

- *EIGA Doc 30, AIGA 083 "Disposal of gases"*
- *EIGA Doc 129, AIGA 025 "Pressure receptacles with blocked or inoperable valves"*
- *EIGA Doc.106 "Environmental issues guide"*
- *EIGA Safety Info 02 "Handling of gas cylinders at and after fire/heat exposure"*
- *EIGA Safety Newsletter NL 84 "Hazards of excavated, unidentified cylinders"*

APPENDIX 3 - List of gases with disposal methods

CHEMICAL FORMULA	GAS NAME	Paragraph 6.11.4
AIR	Compressed air	a
C2H2	Acetylene (dissolved)	c or a
NH3	Ammonia	b or a
AR	Argon	a
AR-®	Argon (refrigerated)	a
AS-F5	Arsenic pentafluoride	b
AS-H3	Arsine	b
B-CL3	Boron trichloride	b
BF3	Boron trifluoride	b
C-BR-CL-F2	Bromochlorodifluoromethane (R12 B1)	a
CH3-BR	Bromomethane	a
BR-F-C=C-F2	Bromotrifluoroethylene (R113 B1)	a
C-BR-F3	Bromotrifluoromethane (R13 B1)	a
(1,2)-C4H6	Butadiene 1,2-	c
(1,3)-C4H6	Butadiene 1,3	c
(N)-C4H10	Butane n-	c
(CIS)-C4H8	Butene cis	c
(TRANS)-C4H8	Butene trans-	c
(1)-C4H8	Butene 1-	c
CO2	Carbon dioxide	a
CO2-®	Carbon dioxide (refrigerated)	a
CO2-S	Carbon dioxide (solid)	a
CO	Carbon monoxide	c or a
COF2	Carbonyl fluoride	b
COS	Carbonyl sulphide	b
CL2	Chlorine	b
CL-F5	Chlorine pentafluoride	b
CL-F3	Chlorine trifluoride	b*
C2H3-CL-F2	Chlorodifluoroethane (R142 b)	a
C2H-CL-F2	Chlorodifluoroethylene (R1122)	a
CH-CL-F2	Chlorodifluoromethane (R22)	a
C2H5-CL	Chloroethane	a
CH3-CL	Chloromethane	a
C2-CL-F5	Chloropentafluoroethane (R115)	a
C2H-CL-F4	Chlorotetrafluoroethane (R124a)	a
C2H2-CL-F3	Chlorotrifluoroethane (R133a)	a
C2-CL-F3	Chlorotrifluoroethylene (R1113)	a
C-CL-F3	Chlorotrifluoromethane (R13)	a
CN-CN	Cyanogen	c
CN-CL	Cyanogen chloride	b
(CYCLO)-C4H8	Cyclobutane	c
(CYCLO)-C3H6	Cyclopropane	c
D2	Deuterium	c or a
B2H6	Diborane	b
C-CL2-F2	Dichlorodifluoromethane (R12)	a
CH-CL2-F	Dichlorofluoromethane (R21)	a
SI-H2-CL2	Dichlorosilane	b
C2-CL2-F4	Dichlorotetrafluoroethane (R114)	a
C2H4F2	Difluoroethane (R152a)	a
CF2=CH2	Difluoroethylene 1,1- (R1132a)	a
NH(CH3)2	Dimethylamine	b

CHEMICAL FORMULA	GAS NAME	Paragraph 6.11.4
(CH3)2-O	Dimethylether	c
SI-H2(CH3)2	Dimethylsilane	c
SI2-H6	Disilane	c
C2H6	Ethane	c
C2H6-(R)	Ethane (refrigerated)	c or a
(C2H5)-C2H	Ethyl acetylene	c or a
(C2H5)-O-(CH3)	Ethyl methyl ether	c or a
NH2-(C2H5)	Ethylamine	b
C2H4	Ethylene	c or a
C2H4-(R)	Ethylene (refrigerated)	c or a
C2H4O	Ethylene oxide	c
F2	Fluorine	b
C2H5F	Fluoroethane (R161)	a
CH3F	Fluoromethane	a
GE-H4	Germane	c
HE	Helium	a
HE-(R)	Helium (refrigerated)	a
C3HF7	Heptafluoropropane (R227)	a
(CF3)2CO	Hexafluoroacetone	a
C2F6	Hexafluoroethane (R116)	a
(ISO)-C4H2F6	Hexafluoroisobutene	a
C3F6	Hexafluoropropene (R1216)	a
H2	Hydrogen	c or a
H2-(R)	Hydrogen (refrigerated)	c or a
H-BR	Hydrogen bromide	b
H-CL	Hydrogen chloride	b
HF	Hydrogen fluoride	b
HI	Hydrogen iodide	b
H2-SE	Hydrogen selenide	c
H2S	Hydrogen sulphide	c or b
H2-TE	Hydrogen telluride	c
(ISO)-C4H10	Isobutane	c or a
(ISO)-C4H8	Isobutene	c or a
KR	Krypton	a
KR-(R)	Krypton (refrigerated)	a
CH4	Methane	c or a
CH4-(R)	Methane (refrigerated)	c or a
CH2=CH-CH(CH3)2	Methyl 3- butene 1	c or a
(CH3)-O-C2H3	Methyl vinyl ether	c or a
(CH3)C2H	Methyl acetylene	c or a
NH2-(CH3)	Methylamine	b
SH-(CH3)	Methyl mercaptan	c
SI-H3(CH3)	Methyl silane	c
NE	Neon	a
NE-(R)	Neon (refrigerated)	a
(NEO)-C5H12	Neopentane	c or a
NO	Nitric oxide	b or a
N2	Nitrogen	a
N2-(R)	Nitrogen (refrigerated)	a
N02	(1)Nitrogen dioxide/ (2)Dinitrogen tetroxide	b
NF3	Nitrogen trifluoride	a
NO-CL	Nitrosyl chloride	b
N2O	Nitrous oxide	a
N2O-(R)	Nitrous oxide (refrigerated)	a
C4F8	Octafluorobutene (R1318)	a

CHEMICAL FORMULA	GAS NAME	Paragraph 6.11.4
(CYCLO)-C4F8	Octafluorocyclobutane (RC318)	a
C3F8	Octafluoropropane (R218)	a
O2	Oxygen	a
O2-(R)	Oxygen (refrigerated)	a
CO-CL2	Phosgene	b
PH3	Phosphine	c or b
PF5	Phosphorus pentafluoride	b
PF3	Phosphorus trifluoride	b
C3H4	Propadiene 1,3	c
C3H8	Propane	c or a
C3H6	Propylene	c or a
SE-F6	Selenium hexafluoride	c
SI-H4	Silane	c
SI-F4	Silicon tetrafluoride	b
SB-H3	Stibine	c
SF6	Sulphur hexafluoride	a
SF4	Sulphur tetrafluoride	b
SO2F2	Sulphuryl fluoride	a
SO2	Sulphur dioxide	b
C2F4	Tetrafluoroethylene (R1114)	a
CF4	Tetrafluoromethane (R14)	a
C2H3F3	Trifluoroethane (R143a)	a
CHF3	Trifluoromethane (R23)	a
SI-H(CH3)3	Trimethylsilane	c
N-(CH3)3	Trimethylamine	b
WF6	Tungsten hexafluoride	b
C2H3-BR	Vinyl bromide	c
C2H3-CL	Vinyl chloride	c
C2H3F	Vinyl fluoride	c
XE	Xenon	a