HANDLING GAS CONTAINER EMERGENCIES

AIGA 004/23

Revision of AIGA 004/13

Asia Industrial Gases Association
N0 2 Venture Drive, #22-28 Vision Exchange, Singapore 608526
Tel: +65 67055642 Fax: +65 68633379
Internet: http://www.asiaiga.org | LinkedIn Profile: https://www.linkedin.com/company/asiaigaorg

AIGA 004/23

HANDLING GAS CONTAINER EMERGENCIES

Acknowledgement

This document is reproduced from the European Industrial Gases Association' EIGA Doc 080, Handling Gas Container Emergencies. Acknowledgement and thanks are hereby given to EIGA for permission granted for the use of their document.

ASIA INDUSTRIAL GASES ASSOCIATION
No-2 Venture Drive,# 22-28 Vision Exchange, Singapore 608526
Tel: +65 67055642 Fax: +65 68633307
Internet: http://www.asiaiga.org LinkedIn Profile: https://www.linkedin.com/company/asiaigaorg

Table of Contents

Amendments to AIGA 004/13

4.1	Information about the Intervention in Chemical transport Emergencies (ICE)
4.3	Identification of members of Emergency Response Team
5.1	Paragraph is reworded and hazards from pressurised systems added
6.1	Practice of curing a leak with soft lead wire has been taken out of the text
6.2	Practice of curing a leak with self tapping screw has been taken out of the text
6.11.5	Picture has been added
7.1	Paragraph is restructured
7.2.2	Specific PPE for specific gases has been taken out of the text
7.2.3	Update of detection equipment
Fig 1	Letters added back to Fig 1 on 10th June 2022

1 Introduction

This document describes the special requirements and techniques used in handling emergencies involving gas containers.

Owing to the high integrity of gas pressure containers, 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, MEGCs, and battery vehicles, (including 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

3.1 Publications terminology

3.1.1 Shall

Indicates that the procedure is mandatory. It is used wherever the criterion for conformance to specific recommendations allows no deviation.

3.1.2 Should

Indicates that a procedure is recommended.

3.1.3 May and Need not

Indicate that the procedure is optional.

3.1.4 Will

Is used only to indicate the future, not a degree of requirement.

3.1.5 Can

Indicates a possibility or ability.

3.2 Technical definitions

3.2.1 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. Typically 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.

3.2.2 Cylinder recovery vessel

Pressure vessel which is designed to safely contain a cylinder and its content for transportation and storage, until it can be safely emptied.

NOTE 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 pressure receptacle” in the Regulations for the international transport of dangerous goods (UN Model regulations, ADR/RID, etc) [1,2]

3.2.3 Emergency

Unplanned situation that could give rise (or has given rise) to a hazard to people or the environment and or damage to equipment.

3.2.4 Gas

For the purposes of this document any product gaseous, dissolved or liquefied transported in gas containers.

3.2.5 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.

3.2.6 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. The emergency response team can be a third party contractor.

3.2.7 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.

3.2.8 Gas user

Personnel from the customer / manufacturer working with the cylinder / gases

3.2.9 MEGC (Multiple elements gas containers)

a unit containing elements which are linked to each other by a manifold and mounted on a frame. The following elements are considered to be elements of a MEGC: cylinders, tubes, pressure drums and bundles of cylinders as well as tanks for the carriage of gases of Class 2 having a capacity of more than 450 litres.

3.2.10 Public emergency services

Public Services that may be involved or present at the scene of an emergency. These include fire brigade, police, and medical personnel (such as doctors, nurses & ambulance).

3.2.11 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) chemical formula and hazards of the gases involved

b) types and numbers of gas containers

c) location of the emergency

d) knowledge and experience of persons at the scene

Within the framework of Responsible Care®, the European chemical industry makes efforts to transport goods safely. In the event of an incident, it will provide information, practical help and, if necessary and possible, appropriate equipment to the competent emergency authorities in order to minimise any adverse effects. ICE (Intervention in Chemical transport Emergencies) is the co-operative programme, set up by the European chemical industry to achieve this goal. In each European country, it seeks to create a framework for providing assistance in an effective way. Each national ICE scheme applies only to distribution incidents (i.e. those that occur outside manufacturing sites) and is formalised in a protocol between the national chemical industry federation and the national competent authorities. Refer to https://www.ice-chem.org/

4.2 Control of emergencies

Emergencies are controlled either by the Public Emergency services or by the site owner. Where Public Emergency Services are responsible for controlling the emergency, the Gas supplier’s 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 shall be suitably equipped, technically competent and experienced in required techniques. This team shall be able to make containers safe and, under some

circumstances, remove them to the Gas supplier's site, where the contents can be safely emptied and the causes investigated.

The ER team present at the incident/accident site should be easily identifiable to the public emergency services and site owners etc.

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:

- external 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 containers

The European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR) contains requirements referencing maximum pressures and temperature.[1] In no case the internal pressure at 65 °C shall exceed the test pressure. Above 65 °C, pressures increase and may ultimately reach the container deformation or burst pressure (generally, the rates of pressure increase are greater for liquefied gases than for compressed gases). At the same time, the mechanical properties of the container material may degrade (melting point for aluminium alloys, change of the crystalline structure of steel). 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 might 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 arising from cylinders, similar hazards may arise from pressurised systems that are not designed for high temperature operation.

5.1.1.1 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. Refer to EIGA Safety Information 02: “Handling of Gas Cylinders at and after Fire/Heat Exposure” for further recommendations

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. The EIGA SI 02, *Handling of Gas Cylinders during and after Exposure to Heat or Fire* includes recommendations for customers and Fire Brigades [3].

5.1.2 Follow-up actions

It is recommended that the Gas suppliers 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 container

Leakage from a container can arise from seven possible sources, as follows: (see figure 1)

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 (valve seat pass-through leak). 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 diaphragm and in the case of an O-ring seal valve, failure of the O-ring seal. Leaks of this nature can not be cured by tightening the gland nut. Typically, 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 typically 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 may be referred to as a 'safety relief device' in some other parts of the world. Types of pressure relief device in use include one or more of the following types:

- '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.

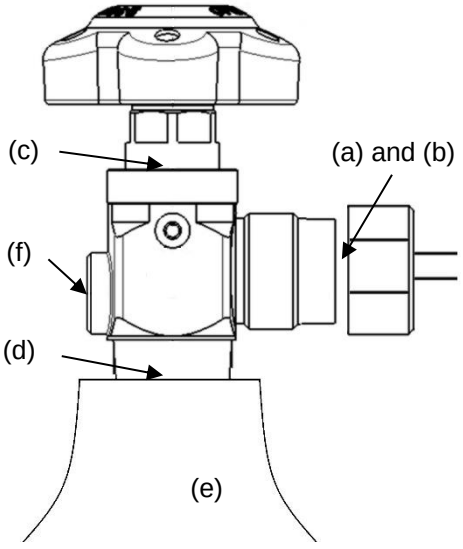
- 'bursting disc' type - this consists of a metallic disc designed to rupture at a predetermined pressure and is intended to protect the cylinder from over-pressurisation arising from any cause. Once the disc has ruptured, the entire cylinder content will be discharged. Very small leaks from this type 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.

g) From the flange between the pressure drum or portable tank and its cover on which the valve(s) are threaded - this may be due to:

- the bolts being tightened insufficiently
- damage to the gasket
- mechanical damage during handling

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.



(a) Connection between the valve outlet and the user's equipment.

(b) From the valve outlet (valve seat pass-through leak)

(c) From the valve gland or packing.

(d) From the joint between the valve and the cylinder (neck-leak).

(e) From the cylinder body itself.

(f) From a pressure relief device which may be fitted to some cylinder valves

Figure 1 - Container leak sources

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 or damaged seat) 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, O-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:

- An external 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 main role of the Gas supplier's Representative should be to provide guidance on the nature of the gases involved, the hazards that may arise and to support the Public Emergency Services. 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 supplier's 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 supplier's 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. Typically no action is 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 down (typically down to the temperature of a domestic freezer) in order to reduce the internal pressure and 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 Container 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 argon, carbon dioxide, nitrogen, oxygen and 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 risk 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 not oxygen there is a risk of oxygen depletion in the atmosphere, particularly if the release is in a confined or poorly ventilated area. (see AIGA 008, *Hazards of Oxygen Deficient Atmospheres*) [4]

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) Typically flammable cryogenic gases are not 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 usually 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 container (tube trailer, battery vehicle, bundle & drum)

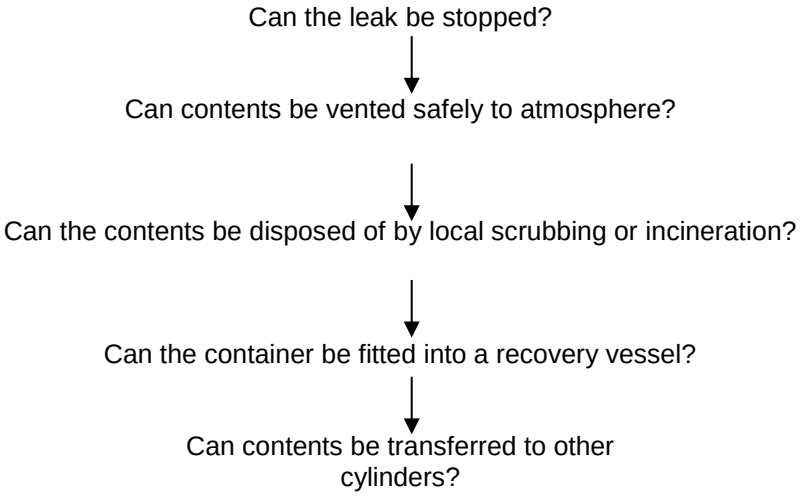
Generally, the same principles apply as for emergencies involving cylinders; however the consequences may be much more severe. Some of the emergency equipment used for smaller cylinders may not be appropriate (e.g. cylinder recovery vessels) and other specialised equipment and a specific emergency team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



The recommended methods for the disposal of common products are listed in Annex 1 of AIGA 083, *Disposal of Gases [5]*.

6.1 Cylinder neck leaks

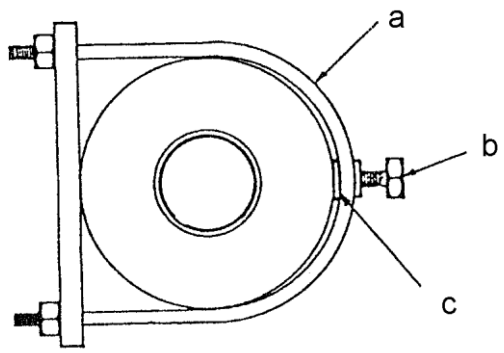
Attempting to tighten valves into a cylinder under pressure (particularly high pressure) is potentially dangerous and should be avoided. For repair refer to section 6.11.

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 suck back 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

Figure 2 - Temporary seal

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, O-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 (evaluate if safe to do so; not recommended for flammable gases)
- 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.

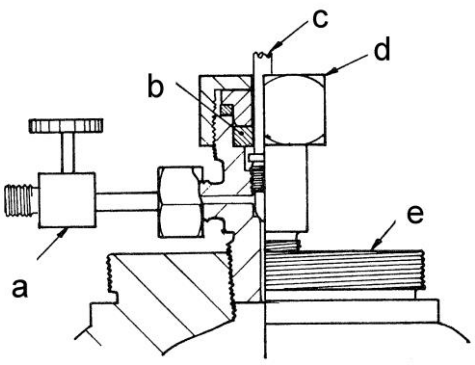
6.6 Valve seat leaks

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.

If this is not possible refer to section 6.11.



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

Figure 3 - Valve parts

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 replaced 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 and at a temperature at which the vapour pressure of the liquefied gas is below atmospheric pressure to avoid the ingress of air and moisture inside the container.

b) rotating or moving the cylinder - where the leak is from the liquid phase (i.e. liquefied gas is escaping and then vaporizing 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 vaporize to several hundred times their liquid volume.

6.11.2 Decanting contents

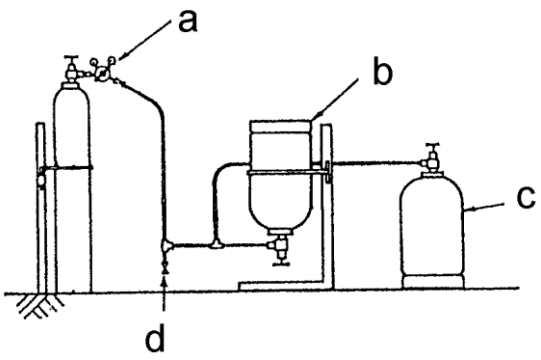
a) Compressed gas content: Sequentially decanting the contents of the leaking cylinder into several evacuated cylinders can significantly reduce the pressure in the leaking cylinder.

   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 should be inverted and if a 90º eductor tube is fitted, the cylinder should be laid horizontally so that the eductor tube is dipping into the liquid phase). It will 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

Figure 4 - Pressurising leaking cylinder

- 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 Emergency abatement of gas leaks

Emergency 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:

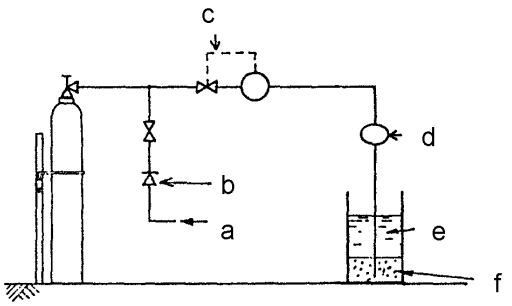
- activated charcoal (for many gases)
- moist soda lime (for many acidic gases)

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 Emergency 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.

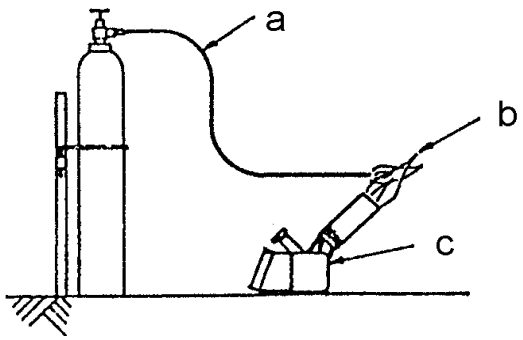
b) To temporary scrubbers: A simple kind of gas scrubber for using on-site can be made up from a plastic hose leading to the bottom of a suitable open topped vessel containing shingle (to improve the gas/liquor contact) and a suitable acid/alkaline or other liquor. This method is recommended where absorbent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

Figure 5 - Temporary Scrubber

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 shall be located in a safe position away from combustible material. In the case of liquefied gases, suck back of air should be avoided



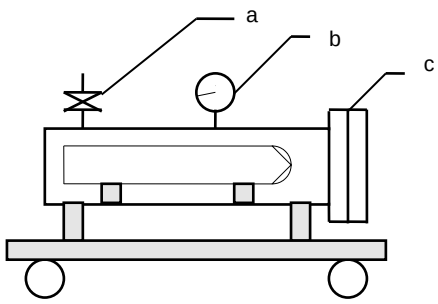
a - Metal pipe
b - Blow lamp flame
c - Blow lamp (Kerosene or gas)

Figure 6 - Burner

Appendix B lists products to which the above disposal methods can be applied. Additional information regarding disposal methods can be found in the AIGA 083. [5]

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/vent valve
b - Pressure gauge
c - Flange

Figure 7 - Recovery vessel

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 shall not be placed in cylinder recovery vessels.

Leaking cylinders containing gases or mixtures that are pyrophoric are allowed provided the leaking gas is not ignited and the risk of ignition during transport has been assessed.

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 periodically checked.

- open the vent to equilibrate pressure inside and outside.

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 A.

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

7.1.1 Hardware

- PPE see section 7.2.2
- 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
- Gas detectors (Oxygen, Flammable gas, Toxic gas)
- Camera
- Smartphone and charger/battery
- Warning tape

7.1.2 Access to information

Tablet or Smartphone to access digital information

- Safety Data Sheets (SDS)

- Gas data information (book or software)
- maps
- AIGA 083 [5]
- Useful telephone numbers (e.g. Hospitals, Public emergency services, National poisons centre etc.)

Hard copies of some documents might be useful in some cases (no battery or connection of the device)

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, vermiculite)
Temporary cylinder cap scrubber
Small gas burner

7.2.2 Personal Protective Equipment (PPE)

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

Selected PPE items shall be conform to the recommendations from the SDS for the gases that will be handled and maintained in good condition.

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

Additional protective equipment may be required for specific gases. (e.g. 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 systems
- portable gas detectors
    - oxygen detector
    - flammable gas detectors
    - specific gas detectors (e.g. toxic gases, hydrides)
- thermal imaging camera for incidents with flammable gases
- test kit for water quality (puffer bottle)

8 Emergency response personnel

8.1 Selection of personnel

It is desirable that all personnel involved in emergency response should have 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).
- physical 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

Gas supplier 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 shall 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 shall be performed. The risk assessment is to be updated every time circumstances and operational parameters change.

- Minimum two fully equipped persons are required when tackling cylinder emergencies (typically one to act as back-up)
- Members of the Emergency Response Team must be physically fit and have specific medical surveillance. 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 shall be considered.

9 References

[1] European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR), www.unece.org

[2] The Regulation concerning the International Carriage of Dangerous Goods by Rail (RID), www.otif.org

[3] EIGA Safety Information 02, *Handling of Gas Cylinders during and after Exposure to Heat or Fire,* www.eiga.eu

[4] AIGA 008, *Hazards of Oxygen Deficient Atmospheres,* www.asiaiga.org

[5] AIGA 083, *Disposal of Gases,* www.asiaiga.org

10 Other references

AIGA 025, *Pressure receptacles with blocked or inoperable valves*, www.asiaiga.org

EIGA Doc 106, *Environmental Issues Guide*, www.eiga.eu

The Emergency Response Guidebook (ERG 2020)

https://www.phmsa.dot.gov/hazmat/erg/emergency-response-guidebook-erg

Fundamentals of Emergency Management

https://training.fema.gov/is/courseoverview.aspx?code=IS-230.e

Appendix A - Salvage pressure receptacle for Class 2

Salvage pressure receptacle 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.

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

The transport regulations of ADR allow the use of a salvage pressure receptacle [1]:

- *Chapter 1.2 defines a salvage pressure receptacle as* a pressure receptacle with a water capacity not exceeding 3000 litres into which are placed damaged, defective, leaking or non-conforming pressure receptacle(s) for the purpose of carriage e.g. for recovery or disposal l;
- *Section 4.1.1.20 regulates the use of a salvage pressure receptacle and*
- *Section 6.2.3.11gives design and approval requirement for a salvage pressure receptacle*
- *Section 5.2.1.3 requires marking of the salvage pressure receptacle with the word "SALVAGE".*

This note details the general requirements to transport a salvage pressure receptacle for class 2 (and the receptacle it contains) in accordance with ADR [1]. 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 pressure receptacle 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 pressure receptacle 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 pressure receptacle 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 pressure receptacle (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 pressure receptacle may not exceed the design pressure of the salvage pressure receptacle.

The marking and labelling of the salvage pressure receptacle and documentation shall comply with the relevant section of the current ADR for the product concerned [1].

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

Appendix B - List of gases with emergency disposal methods

EIGA SDS	Usual Name	Chemical formula	CAS Registry Number	Paragraph 6.11.4
Not listed	Air	Mixture	Mixture	a
001	Acetylene (dissolved)	C_2H_2	74-86-2	c or a
002	Ammonia	NH_3	7664-41-7	b
003	Argon	Ar	7440-37-1	a
005	Arsine	AsH_3	7784-42-1	b
006	Boron trichloride	BCl_3	10294-34-5	b
007	Boron trifluoride	BF_3	7637-07-2	b
008	Bromochlorodifluoromethane (R12B1)	$CBrClF_2$	353-59-3	a
009	Bromomethane	CH_3Br	74-83-9	a
010	Bromotrifluoroethylene (R113B1)	C_2BrF_3	598-73-2	a
011	Bromotrifluoromethane (R13B1)	CF_3Br	75-63-8	a
012	1,2-Butadiene	C_4H_6	590-19-2	c
013	1,3-Butadiene	C_4H_6	106-99-0	c
075	iso-Butane (R600a)	C_4H_{10}	75-28-5	c or a
014	n-Butane	C_4H_{10}	106-97-8	c
076	Iso-Butene	C_4H_8	115-11-7	c
016	trans-2-Butene	C_4H_8	624-64-6	c
018	Carbon dioxide	CO_2	124-38-9	a
019	Carbon monoxide	CO	630-08-0	c
020	Carbonyl fluoride	COF_2	353-50-4	b
021	Carbonyl sulphide	COS	463-58-1	b
022	Chlorine	Cl_2	7782-50-5	b
023	Chlorine pentafluoride	ClF_5	13637-63-3	b
024	Chlorine trifluoride	ClF_3	7790-91-2	b*
025	Chlorodifluoroethane (R142b)	$C_2H_3ClF_2$	75-68-3	a
026	Chlorodifluoroethylene (R1122)	C_2HClF_2	359-10-4	a
027	Chlorodifluoromethane (R22)	$CHClF_2$	75-45-6	a
028	Chloroethane	C_2H_5Cl	75-00-3	a
029	Chloromethane	CH_3Cl	74-87-3	a
Not listed	Chloropentafluoroethane (R155)	C_2HF_5Cl	76-15-3	a
031	Chlorotetrafluoroethane (R124a)	C_2HF_4Cl	2837-89-0	a
032	Chlorotrifluoroethane (R133a)	$C_2H_2F_3Cl$	75-88-7	a
033	Chlorotrifluoroethylene (R1113)	C_2ClF_3	79-38-9	a
034	Chlorotrifluoromethane (R13)	$CClF_3$	75-72-9	a
035	Cyanogen	C_2N_2	460-19-5	c
036	Cyanogen chloride	CNCl	506-77-4	b
037	Cyclobutane	C_4H_8	287-23-0	c
038	Cyclopropane	C_3H_6	75-19-4	c
039	Deuterium	D_2	7782-39-0	c or a
040	Diborane	B_2H_6	19287-45-7	b
Not listed	Dibromodifluoromethane (R12B2)	CBr_2F_2	75-61-6	a
041	Dichlorodifluoromethane (R12)	CCl_2F_2	75-71-8	a
042	Dichlorofluoromethane (R21)	$CHCl_2F$	75-43-4	a
043	Dichlorosilane	SiH_2Cl_2	4109-96-0	b
Not listed	Dichloromethane (R30)	CH_2Cl_2	75-09-2	?

EIGA SDS	Usual Name	Chemical formula	CAS Registry Number	Paragraph 6.11.4
045	Difluoroethane (R152a)	$C_2H_4F_2$	75-37-6	a
046	1,1-Difluoroethylene (R1132a)	$C_2H_2F_2$	75-38-7	a
130	Difluoromethane (R32)	CH_2F_2	75-10-5	?
Not listed	Digermane	Ge_2H_6	13818-89-8	c
048	Dimethyl ether	C_2H_6O	115-10-6	c
047	Dimethyl amine	C_2H_7N	124-40-3	b
087	2,2-Dimethyl-propane (Neopentane)	C_5H_{12}	463-82-1	c or a
049	Dimethylsilane	$(CH_3)_2SiH_2$	1111-74-6	c
050	Disilane	Si_2H_6	1590-87-0	c
051	Ethane	C_2H_6	74-84-0	c
052	Ethyl acetylene	C_4H_6	107-00-6	c or a
054	Ethyl amine	C_2H_7N	75-04-7	b
053	Ethyl methyl ether	C_3H_8O	540-67-0	c or a
055	Ethylene	C_2H_4	74-85-1	c or a
056	Ethylene oxide	C_2H_4O	75-21-8	c
057	Fluorine	F_2	7782-41-4	b
058	Fluoroethane	C_2H5_F	353-36-6	a
059	Fluoromethane	CH_3F	593-53-3	a
060	Germane	GeH_4	7782-65-2	c
Not listed	Germanium tetrachloride	$GeCl_4$	10038-98-9	b
138	Germanium tetrafluoride	GeF_4	7783-58-6	b
Not listed	1,1,2-Trichloro-1,2,2- trifluoroethane (R113)	$C_2Cl_3F_3$	76-13-1	?
061	Helium	He	7440-59-7	a
062	2H-Heptafluoropropane (R227ea)	C_3HF_7	431-89-0	a
131	Hexafluoro-1,3-Butadiene	C_4F_6	685-63-2	?
063	Hexafluoroacetone	C_3F_6O	684-16-2	a
065	Hexafluoroisobutene	$C_4H_2F_6$	382-10-5	a
066	Hexafluoropropene (R1216)	C_3F_6	116-15-4	a
067	Hydrogen	H_2	1333-74-0	c or a
068	Hydrogen bromide	HBr	10035-10-6	b
069	Hydrogen chloride	HCl	7647-01-0	b
Not listed	Hydrogen cyanide	HCN	74-90-8	b or c
070	Hydrogen fluoride	HF	7664-39-3	b
071	Hydrogen iodide	HI	10034-85-2	b
072	Hydrogen selenide	H_2Se	7783-07-5	c
073	Hydrogen sulphide	H2S	7783-06-4	c or b
074	Hydrogen telluride	H_2Te	7783-09-7	c
Not listed	Iodine pentafluoride	IF_5	7783-66-6	?
077	Krypton	Kr	7439-90-9	a
078	Methane	CH_4	74-82-8	c or a
079	3-Methyl 1-butene	C_5H_{10}	563-45-1	c or a
081	Methyl acetylene	C_3H_4	74-99-7	c or a
082	Methyl amine	CH_5N	74-89-5	b
083	Methyl mercaptan	CH_4S	74-93-1	c
084	Methyl silane	CH_3SiH_3	992-94-9	c
080	Methyl vinyl ether	C_3H_6O	107-25-5	c or a
Not listed	Natural gas	Mixture	Mixture	c

EIGA SDS	Usual Name	Chemical formula	CAS Registry Number	Paragraph 6.11.4
086	Neon	Ne	7440-01-9	a
088	Nitric oxide	NO	10102-43-9	b or a
089	Nitrogen	N_2	7727-37-9	a
090	Nitrogen dioxide (Dinitrogen tetroxide)	NO_2 (N_2O_4)	10102-44-0	b
091	Nitrogen trifluoride	NF_3	7783-54-2	a
Not listed	Nitrogen trioxide	N_2O_3	10544-73-7	b
092	Nitrosyl chloride	NOCl	2696-92-6	b
093	Nitrous oxide	N_2O	10024-97-2	a
094	Octafluorobutene (R1318)	C_4F_8	360-89-4	a
095	Octafluorocyclobutane (RC318)	C_4F_8	115-25-3	a
Not listed	Octafluorocyclopentene	C_5F_8	559-40-0	?
096	Octafluoropropane (R218)	C_3F_8	76-19-7	a
132	Octafluorotetrahydrofuran	C_4F_8O	773-14-8	?
097	Oxygen	O_2	7782-44-7	a
Not listed	Pentacarbonyl iron	$Fe(CO)_5$	13463-40-6	c
137	Pentafluoroethane	C_2HF_5	354-33-6	?
099	Phosgene	$COCl_2$	75-44-5	b
100	Phosphine	PH_3	7803-51-2	c or b
101	Phosphorus pentafluoride	PF_5	7647-19-0	b
102	Phosphorus trifluoride	PF_3	7783-55-3	b
103	1,2-Propadiene	C_3H_4	463-49-0	c
104	Propane (R290)	C_3H_8	74-98-6	c or a
105	Propylene (R1270)	C_3H_6	115-07-1	c or a
Not listed	Propylene oxide	C_3H_6O	75-56-9	c
106	Selenium hexafluoride	SeF_6	7783-79-1	c
107	Silane	SiH_4	7803-62-5	c
Not listed	Silicon tetrachloride	$SiCl_4$	10026-04-7	b
108	Silicon tetrafluoride	SiF_4	7783-61-1	b
109	Stibine	SbH_3	7803-52-3	c
112	Sulfuryl difluoride	F_2O_2S	2699-79-8	?
113	Sulphur dioxide	SO_2	7446-09-5	b
110	Sulphur hexafluoride	SF_6	2551-62-4	a
111	Sulphur tetrafluoride	SF_4	7783-60-0	b
Not listed	Tetracarbonyl nickel	$Ni(CO)_4$	13463-39-3	c
Not listed	Tetrachloromethane	CCl_4	56-23-5	?
133	Tetrafluoroethane (R134a)	$C_2H_2F_4$	811-97-2	a
114	Tetrafluoroethylene (R1114)	C_2F_4	116-14-3	a
Not listed	Tetrafluorohydrazine	N_2F_4	10036-47-2	?
116	Tetrafluoromethane (R14)	CF_4	75-73-0	a
Not listed	Trichlorofluoromethane (R11)	CCl_3F	75-69-4	a
Not listed	Trichlorosilane	$SiHCl_3$	10025-78-2	b
118	Trifluoroethane (R143a)	$C_2H_3F_3$	420-46-2	a
119	Trifluoromethane (R23)	CHF_3	75-46-7	a
122	Trimethylamine	C_3H_9N	75-50-3	b
138	Trimethylboron	$B(CH_3)_3$	593-90-8	b
121	Trimethylsilane	$C_3H_{10}Si$	993-07-7	c
123	Tungsten hexafluoride	WF_6	7783-82-6	b

EIGA SDS	Usual Name	Chemical formula	CAS Registry Number	Paragraph 6.11.4
124	Vinyl bromide	C_2H_3Br	593-60-2	c
125	Vinyl chloride	C_2H_3Cl	75-01-4	c
126	Vinyl fluoride	C_2H_3F	75-02-5	c
127	Xenon	Xe	7440-63-3	a