REFRIGERATED CO_2 STORAGE AT USERS' PREMISES

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EIGA

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1 Scope

This recommendation represents the minimum requirements and the practice for design, construction, installation, operation, and maintenance of refrigerated liquefied CO_2 storage at users' premises.

Vessels with capacity ranging from 1 ton to 100 tons at pressure between 10 to 25 bar are considered.

This document contains information on the principal hazards arising from the bulk storage of liquid carbon dioxide and gives general advice on precautionary measures and control techniques which experience has shown to be appropriate

This information applies to user's storage installations where liquid carbon dioxide is delivered in road tankers and transferred to a storage vessel.

It will help the EIGA companies to prepare their own document.

In this publication bar shall indicate gauge pressure unless otherwise noted - i.e.(bar,abs) for absolute pressure.

2 Properties of carbon dioxide

Name: Carbon dioxide - also called carbonic acid gas or CO_2.

A MSDS is available at the gas supplier. A short summary of the properties of carbon dioxide is given below.

2.1 Physical Properties and Handling

2.1.1 Gaseous state

At normal temperature (+15 °C) and atmospheric pressure CO_2 has a density of 1,87 kg/m^3 and is 1,5 times heavier than air. It is a colourless and odourless gas (with a slightly pungent odour at high concentrations) and spreads along the ground collecting in low -lying areas such as pits and cellar.

Carbon dioxide is classified as a non toxic gas but it does start to affect breathing at concentration of about 1% with affects becoming more serious with increasing concentrations (see Appendix B-Physiological Effects).
Carbon dioxide is a non flammable gas.

2.1.2 Liquid state

Carbon dioxide can exist as a liquid below the critical temperature of 31 °C and above the so called triple point with a temperature of (-56,6) °C and 4,18 bar (see P-T-Diagram – Appendix A).

Carbon dioxide is transported, stored and handled in liquid form, either at ambient temperature (in cylinders or not insulated storage tanks at a pressure of 45 - 65 bar) or refrigerated (in transportable vessels and storage tanks) at a temperature range of -35 °C to -15 °C and a pressure of 12 to 25 bar. The carbon dioxide, in this state, is a liquid at its boiling point.

Below the triple point carbon dioxide can only exist in the solid and gas phase.

Therefore liquid carbon dioxide cannot exist at atmospheric pressure. When the liquid CO_2 is depressurised below the triple point pressure of 4,18 bar to atmospheric pressure it is transformed to dry ice and gas. When the liquid CO_2 is released to the atmosphere a dense white fog of powdery solid carbon dioxide particles and vapour is produced.

2.1.3 Solid state (Dry ice)

The expansion of liquid carbon dioxide to atmospheric pressure is used to produce CO_2 - snow at a temperature of -78,5 °C. The “snow“ is pressed to “dry ice” blocks or pellets.
Dry ice is handled in insulated containers.

2.2 Chemical Properties

Carbon dioxide does not support combustion. When dissolved in water, carbonic acid (H_2CO_3) is formed. The pH - value of carbonic acid varies from 3,7 at atmospheric pressure to 3,2 at 23,4 bar. The carbonic acid is corrosive and provides the biting taste of soda water; it reacts in alkaline solutions producing carbonates. It has very few vigorous reactions with other substances except under conditions of high temperature and pressure in the presence of reactive substances such as sodium and magnesium. For this reason carbon dioxide should not be used as a fire extinguishing agent for reactive metals like sodium and magnesium.

3 Quick information on design and construction of pressure vessel for refrigerated liquefied CO2

3.1 Design

The vessels should be designed in accordance with the appropriate code or standard and the national regulations in force in the country of use. If no such codes or standards exist, then suitable international standards should be used. The low temperature use shall be taken into consideration.

The vessels must be certified by a suitable authority or a competent person as required by the country of construction or use for:

- Design pressure
- Test pressure
- Minimum/maximum design temperatures
- Maximum CO_2 capacity
- Maximum permitted mechanical loading on vessel supports

The design pressure shall be equal or higher than the maximum working pressure.

The maximum capacity is the total capacity less the necessary gas space to ensure that the relief valves are discharging gas under all the conditions.

Storage vessels for liquid CO_2 shall be provided with a suitable device which prevents overpressurisation above the maximum design limits of the vessel and should be provided with a device to prevent overfilling.

Storage vessels for liquid CO_2 should be made with resilient steel at low temperature in accordance with the National Regulations.

All piping, valves and fittings must be made from materials suitable for use with carbon dioxide at the designed pressure and temperature conditions. The filling conditions (pressure, temperature, flow rate) should be taken into account. They must be constructed to standards permitted by the country of use.

Provision should be made where required for expansion, contraction and vibration.

All additions or alterations to the storage vessel must be made in accordance with the rules and regulations that apply in the country of use. Advice should be obtained from the carbon dioxide supplier or a recognised equipment supplier.

3.2 Relief Valves

Selection and sizing of relief valves should be in accordance with national or international standards. The rules and regulations for the connection of the relief valves (that means directly to the vessels or indirectly by means of a change over valve) are different from country to country.

The capacity of relief valves should take into consideration the maximum heat input through the insulation and electrically or steam heated vaporisers if installed inside the vessel.

It is normal practice for each bulk storage vessel to be equipped with two suitable sized relief valves directly connected with the gas phase.

A properly sized 3-way valve selector valve is recommended. This allows for periodic maintenance and valve testing without removing the vessel from service.

If a three-way valve is installed to accommodate two pressure relief devices operating, either simultaneously or alternatively, then the size of the valve, regardless of the position of the actuating device, shall be such that the vessel is adequately protected. The three-way valve should be provided with a position indicator showing which relief devices are “on line”.

In some installations there is one valve only to evacuate heat in case of fire, plus eventually two valves which can be mounted on a three-way valve properly sized.

The installation of relief valves should be such that dirt or moisture cannot accumulate on the valve seat.

In some countries regulations ask for special calculations for the capacity of relief valves which also include the possible excessive heat input if the insulation has been damaged in case of fire.

If for any reason the tank has to be installed inside a building, calculation factors may be changed, compared to normal outdoor installation.

3.3 Pipework

Attention should be paid to any part of the system in which liquid carbon dioxide may be trapped and which may lead to excessive pressure if the temperature then rises. All piping, in which liquid carbon dioxide may be trapped, shall be equipped with suitable sized safety relief valves: these safety relief valves should be set to discharge within the design pressure of the part of the system they protect.

If ball valves are used, it must be ensure that no internal overpressure is developed when closed (e.g. a self relief valve, a pilot hole, etc.).

All pipework from the pressure vessels, except those for safety devices, must have shut off valves which shall be located as close to the vessel as practicable.

Supplier should be involved in any modification of withdrawal lines to prevent back feed contamination.

3.4 Equipment

The storage tanks are designed for a CO_2 pressure ranging normally from 15 to 25 barg corresponding at temperatures approximately from (-30°C) to (-15°C). In order to maintain pressures, the tanks are insulated and, at times, provided with a refrigeration system.

The refrigeration unit removes heat from the contents by condensing carbon dioxide vapour, which results in a corresponding decline in pressure. The refrigeration evaporator coil is installed in the vapour space of the vessel. The refrigeration system automatically operates to maintain a pre-set maximum pressure.

The refrigeration units contain refrigerants (CFC, HCFC, HFC etc.). Many of them will be not permitted in future and have to be exchanged with approved refrigerants.

The refrigeration units need maintenance regularly

Each storage vessel shall be equipped with a device for indicating the contents of liquid carbon dioxide (e.g. level , weigh scale, etc.)

3.4.1 Static non-vacuum insulated cryogenic vessels

To maintain carbon dioxide's low temperature, vessels have to be insulated.

The insulation can be:

- A layer (normally from 100 mm to 200 mm) made of polyurethane foam, a vapour-proof seal and, eventually, clothed with a protective metal cladding, i.e. aluminium (see Appendix D).
- The tank consists of two vessels: an outer vessel and an inner vessel.

The outer vessel has a durable protective coating to guard against corrosion; the inner tank is made of steel resisting to low temperature.

The insulation is made filling up with perlite and with the addition of molecular sieve absorber the space between the inner and the outer vessel. (see Appendix E).

These vessels are normally equipped with a suitable refrigeration unit to maintain the desired operating pressure during period of low usage or increased heat input.

The refrigeration unit is switched on and off automatically by means of pressure switches to keep the pressure (and temperature) of the liquid CO_2 within the design limitations.

3.4.2 Static vacuum insulated cryogenic vessels

These tanks consist of two vessels: an outer vessel and an inner vessel (see Appendix F).

The outer vessel has a durable protective coating to guard against corrosion; the inner tank is made of steel resisting to low temperature.

In these vessels the insulation is made creating vacuum between the inner and the outer vessel and filling up it with perlite and with the addition of molecular sieve absorber.

Normally they are not equipped with a refrigeration unit.

4 Operating conditions

4.1 Pressure monitoring

The vessels may be fitted with alarms to give warning if abnormally high or low pressure conditions in the storage vessel occur. In some countries this device is mandatory to monitor pressure and temperature.

4.2 Safety and control devices

Periodical testing of safety relief valves is recommended, carry out a periodical check test of all safety relief valves with a frequency of not greater than three years.

Pressure relief devices on vessels and piping should always be vented through suitable pipework to a safe place in the open air.

Vent lines should be properly designed and sized, so that any back pressure in them is compatible with the ability of the pressure relief device to relieve the vessel safely in accordance with the design standard.

Any excess pressure in the CO_2 bulk storage vessel should be investigated immediately and it is suggested to contact the owner or the supplier of the storage tank.

4.3 Transfer of liquid carbon dioxide from bulk road tanker to storage tank

Road tankers are equipped with safety devices, transfer pump(s), and pipe work for transferring liquid carbon dioxide into or out of the storage tank.

Connections between the CO_2 - tanker and storage vessel are made with flexible reinforced hoses.

If there is a gas balance line between CO_2 tanker and CO_2 storage tank, this hose may be connected either to the gas phase of the vessel or to an overfilling tube, installed inside the storage vessel which prevents overfilling of the vessel by returning liquid CO_2 to the tanker.

A Try Cock valve should be used, to prevent overfilling of the storage tank. The try cock valve indicates the liquid level in the storage tank, when it is reached during the filling operation, and shall stop the filling operation (manually or automatically).

The transfer pumps shall be stopped immediately if the tank pressure reach the maximum allowable working pressure, if no devices are installed to prevent overpressurisation and overfilling.

All hoses used in carbon dioxide service shall be designed for the maximum working test and bursting pressure according to the standards and regulations of the country of use. In accordance with such regulations the hoses may have to be re-tested at certain intervals.

The interior surface of the hoses must be compatible with carbon dioxide to avoid swelling, blistering, shrinking, or other forms of deterioration.

The hoses should have an effective protection to prevent accumulation of dirt or humidity (water): e.g. hose caps.

The flexible hoses required for the transfer are normally carried by the delivery tanker. However, if hoses have been supplied to the user and are retained on the customers premises, then they should be regularly inspected and tested by a competent person.

The procedure for off - loading of the tanker should be agreed between the customer and the supplier.

Pressurising and purging procedures are very important in order to avoid dry ice plug development.

4.4 CO2 - vaporisers

Carbon dioxide may be used by the customer in liquid or gaseous form. If carbon dioxide gas is required, the storage vessel may be equipped with a vaporising system. The vaporiser should be capable of providing an adequate supply of carbon dioxide vapour and/or maintaining the pressure in the storage vessel within its design limitations.

Where internal electrically heated vaporisers are used, special attention should be given to fail safe devices to cut off the electricity supply to the heater elements when overheated or when the upper limit of the setpressure is reached.

Where hot water or steam is used to vaporise liquid CO_2, following devices should be installed in addition to a direct reading temperature :

- A low temperature audible alarm pre-set at an appropriate temperature setting.
- An extra-low-temperature trip which automatically closes the valve installed on the liquid CO_2 supply line to the vaporiser.

If external heated vaporisers are used, a trip is recommended on the gas outlet or on the heating unit to safeguard the customer's installation against liquid carry over.

Users should be aware of the dangers of partially closing any valve on a steam supply line to a vaporiser, causing the vaporiser water temperature to fall dangerously low.

All vaporizers system shall have a safety shut of system. These systems assure, that no liquid phase will be transferred to the user point.

5 Hazards of carbon dioxide

5.1 Substantial release of carbon dioxide

Any substantial release of carbon dioxide is potentially hazardous especially inside a poorly ventilated building. Enclosed low - lying areas, where CO_2 gas could accumulate in high concentration, are particularly hazardous because the gas is slow to disperse unless the spaces are well ventilated.

More details about physiological effects are found in Appendix B.

Emergency procedures at a substantial release of CO_2 should be established including an evaluation of the need of self-contained breathing apparatus and a recommendation to inform the supplier as soon as possible.

In case of a substantial release of carbon dioxide in confined areas, evacuate all personnel as soon as possible. Never enter such areas before they are properly ventilated.

When confined spaces must be entered before they are properly ventilated, the person entering such areas must be well trained and wear self - contained air breathing apparatus.

Canister respirators give no protection in atmospheres containing dangerous concentrations of carbon dioxide. A second, also well trained person should be connected with a rope to the person entering the gas filled area, for rescue purposes.

Substantial releases of carbon dioxide may occur through:

- Failure of pipework containing carbon dioxide.
- Tearing away of the flexible hoses through movement of the road tanker while the hoses are still connected between road tanker and storage vessel.
- Release from a relief valve.
- Inadvertent opening of a drain or vent valve while the system contains CO_2.
- Failure of connections, e.g. flexible hoses, flanges etc.
- Failure of a regulating device resulting in gas release through the body vent holes.

5.2 Low pressure in storage vessel

When compressed gas is allowed to expand or liquid to evaporate, the temperature of the system falls. Should larger quantities of carbon dioxide gas be rapidly lost from the storage vessel either accidentally or through automatic or manual relief, or excessive withdrawal of CO_2 the temperature in the vessel could fall below the minimum permitted operating temperature.

If the temperature falls to the "triple point" (4,18 bar at -56,6 °C) solid CO_2 forms in the tank.

If the pressure is reduced to atmosphere pressure, the temperature of the dry ice will be -78,5°C. At this temperature most carbon steels if not thermally treated may become brittle and fail if highly stressed.

Under normal conditions the pressure should remain above 10 bar .

Should the pressure fall below, the customer should stop withdrawal to avoid dry ice formation and contact the gas supplier immediately.

If the pressure reaches 4 bar there is probably dry ice in the tank. The supplier must be informed and take actions.

5.3 Low temperature of product: extreme cold

The snow produced from leaks of liquid carbon dioxide is extremely cold (- 78,5 °C) and may cause frost bite if touched with bare hands. If carbon dioxide snow comes into contact with the eyes it may cause severe eye injury.

Touching of pipes and connections containing liquid carbon dioxide may cause frost bite.

Where there has been a major release of gas, the atmosphere will be very cold and visibility is likely to be limited. These factors can make escape or rescue difficult.

5.4 Flailing hoses and tow away accidents

If a hose connection fails during the transfer of liquid carbon dioxide, the hose may flail and endanger people and equipment in the vicinity.

The use of safety slings during filling, securing each end of the hose to fixed points on the tanker and the storage tank is recommended.

A system to prevent tow - away accidents should be used so that the road tanker cannot be moved while hoses are still connected.

5.5 Dry ice plugs in pipes and hoses

Dry ice plugs can be formed inside hoses and piping when liquid carbon dioxide pressure is decreased below its triple point pressure of 4,18 bar . The dry ice can be compacted into a plug which can trap gas. The pressure behind or within a plug may increase as the dry ice sublimes until the plug is forcibly ejected or the hose or pipe ruptures. A dry ice plug may be ejected from an open end of hose or pipe with enough force to cause serious injury to personnel, both from the impact of the dry ice plug and/or the sudden movement of the hose or pipe as the plug ejects.

Liquid carbon dioxide must be purged from the hose or pipe before reducing the pressure below 5 bar . This can be done by supplying carbon dioxide vapour to one end of the hose or piping system to maintain the pressure above the triple point while removing the remaining liquid from the other end.

If dry ice plug is suspected the supplier should be informed and take actions.

6 Precautions

6.1 Siting of the storage vessel

Open-air locations are recommended where-ever practicable to avoid problems in maintaining suitable and adequate ventilation.

For more detail recommendation see Appendix C “Code of Practice for Bulk Liquid CO_2 Storage Installations on User's Premises”.

6.2 Inspection and maintenance

The person in control of the installation (this may be the owner or the supplier) is responsible for making positive arrangements to ensure the proper maintenance, examination and inspection of the carbon dioxide installation, whether he owns it or has it on lease or on loan. Maintenance work should be directed by a responsible person who is able to authorise, necessary repairs or the shutting down

of the plant if necessary. Maintenance work on carbon dioxide plants should be subject to a permit-to-work system which is designed to take account of the nature of the work to be done and any hazard that may be encountered during such work.
The installation should be inspected regularly by a well trained operator and a procedure should be established whereby the operator reports defects such as leaks, mechanical damage, missing end caps, damaged filling connections, damaged insulation, suspect of faulty instruments, missing pipe supports, or obstructed access or exit, to a responsible person so that they can be corrected.

Special attention should be paid to the condition of the fixed connector at the unloading point (where wear can be severe).

The carbon dioxide pressure system should be subjected to a comprehensive external examination, at least once a year by a competent person or authority who should submit a written report to a responsible person with authority to arrange for remedial work or to withdraw the plant from service.

6.3 Periodic inspection

Periodic inspection should be made by a competent person or authority following the standards and regulations of the individual countries

The frequency, scope and nature of the examination should be agreed with the competent person or that prescribed by the authorities.

6.4 Operator protection

Operators, handling uninsulated pipelines or connections, should wear personal protective equipment as they are likely to come into contact with cold pipes or hoses when discharging liquid CO_2 or with dry ice or with cold gas.

7 Placard posted on the tank

A placard with basic safety information should be posted on the tank. It can vary from company to company but it should contain some basic information as following.

7.1 General information

Notices should be clearly displayed and visible particularly at access point, to indicate the following as a minimum:

- Liquid Carbon Dioxide
- Authorised Persons Only
- Asphyxiant Hazards.

Wherever possible, symbols should be used and supported by written notices as necessary.

In order to facilitate control of an emergency, a sign should be displayed showing:

- Gas supplier's name and local address
- Gas supplier's local telephone number
- Phone number of the local emergency service.

This information should also be available at a control point.

7.2 Identification of Contents

The storage tank should be clearly labelled "LIQUID CARBON DIOXIDE". The connection fittings of multistorage installations or long filling lines should be clearly marked with the gas name or the symbol in order to avoid confusion.

7.3 Legibility of notices

All displayed warning signs and labels should be legible, visible and up-to-date at all times.

7.4 Operating instructions

Operating instructions and safety data sheets should be provided by the CO_2 supplier and should be available and understood before commissioning the installation. These instructions should be kept legible and up-to-date.

They should include a clearly set out operating procedure and a drawing of the installation. Valves should be identifiable immediately.

The instructions should indicate the operating limits of the system regarding the pressure.

A notice indicating to inform immediately the carbon dioxide supplier and/or tank owner if during the operation of the installation an excursion out side the safe operating limits of the system (e.g. overpressure/underpressure, mechanical damage etc.) occurs should be written.

8 Training of personnel

All personnel directly involved in the commissioning, operation and maintenance of liquid carbon dioxide storage systems should be trained.
The training should cover, but not necessarily be restricted to, the following subjects for all personnel:

- Potential hazards of carbon dioxide
- Site Safety Regulations
- Emergency Procedures
- Use of personal protective equipment including breathing sets where applicable.
- Monitoring equipment.
- First-aid treatment for cryogenic burns.

It is recommended that the training be carried out under a formalised system and that records be kept of the training given and some indications of the results obtained in order to show where further training is required.
The training programme should make provision for refresher courses on a periodic basis, or on changes of site personnel.

9 Emergency procedures

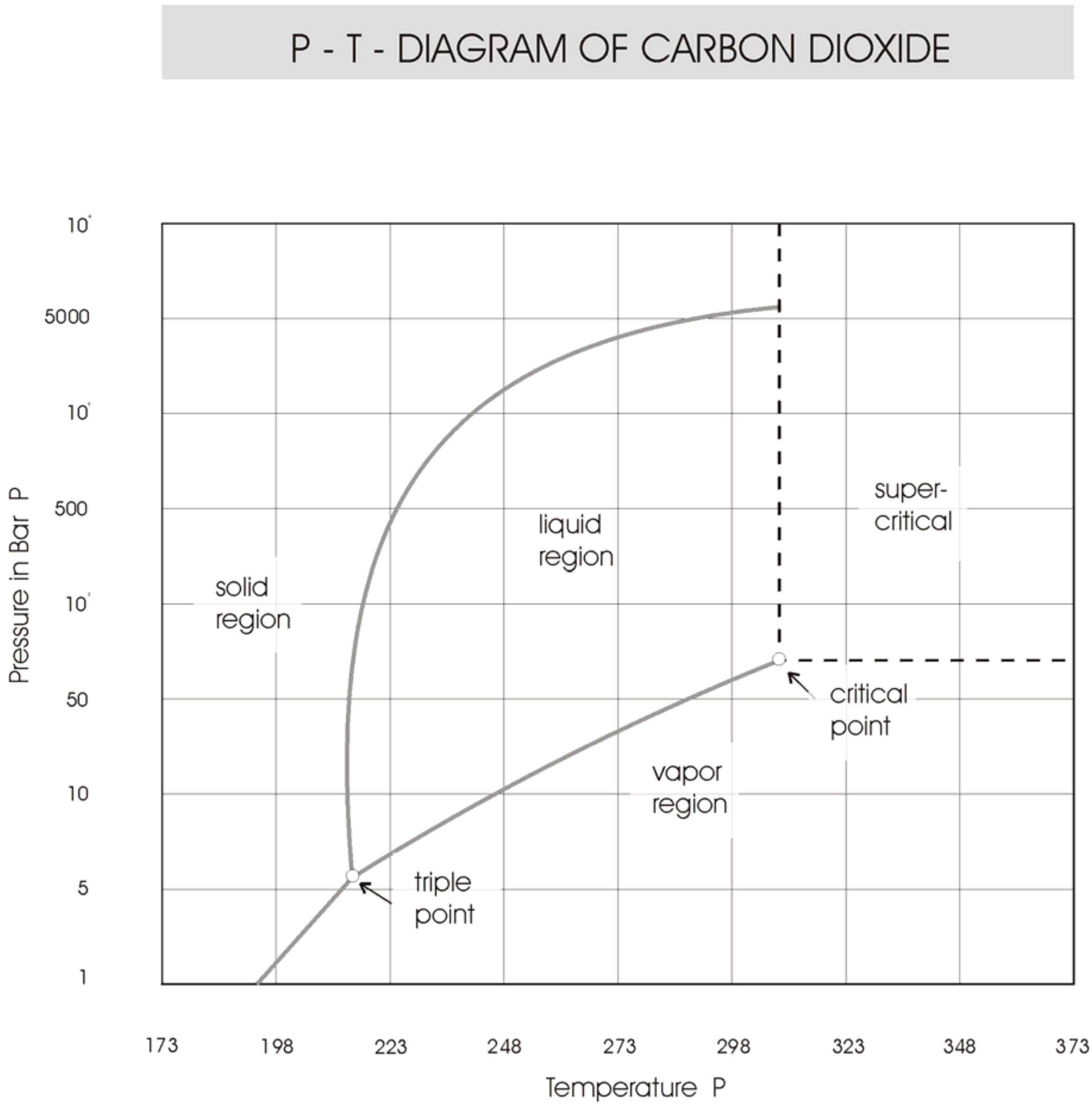
Emergency procedures should be prepared by the site operator to include the event of a major carbon dioxide release.

Local emergency services should be party to the preparation of the emergency procedures. Works employees likely to be affected should know the actions required to minimise the adverse effects of a spillage. Consideration should be given to the carrying out of practical exercises.

The following are the guidelines which could be used for formulating emergency procedures:

- Raise the alarm
- Summon help and emergency services
- Evacuate all persons from the danger area. Do not attend to rescue unless safe to do so
- Isolate the source of carbon dioxide where safe to do so
- Alert Public to possible dangers from vapour clouds and evacuate when necessary
- Notify the gas supplier.

APPENDIX A: P-T-Diagram of carbon dioxide



Triple point: T_t =-56,6°C (216,55K) P_t =5,18 bar abs.

Critical point: T_c =31°C (304,15K) P_c =73,83 bar abs.

APPENDIX B: PHYSIOLOGICAL EFFECTS OF CARBON DIOXIDE

Carbon Dioxide is classified as a non-flammable, non-toxic liquefied gas. It is normally present in atmospheric air at a level of approximately 350 parts per million (0.035 %). It is a normal product of metabolism being held in bodily fluids and tissues where it forms part of the bodies normal chemical environment. In the body it acts in the linking of respiration, circulation and vascular response to the demands of metabolism both at rest and in exercise.

The effects of inhaling low concentrations of carbon dioxide are physiological reversible but in high concentrations the effects are toxic and damaging.

NB The effects of carbon dioxide are entirely independent of the effects of oxygen deficiency.

The oxygen content in the atmosphere is therefore not an effective indication of the danger. It is possible to have an acceptable low oxygen content of 18% and a high carbon dioxide content, being 14 % very dangerous.

Individual tolerances can vary widely, dependent on the physical conditions of the person and the temperature and humidity of the atmosphere, but as a general guide, the effects of inhaling varying concentrations of carbon dioxide are likely to be as follows:

Concentrations By Volume - Likely Effects

1-1,5% Slight effect on chemical metabolism after exposures of several hours.

3% The gas is weakly narcotic at this level, giving rise to deeper breathing, reduced hearing ability, coupled with headache, an 0increase in blood pressure and pulse rate.

4-5% Stimulation of the respiratory centre occurs resulting in deeper and more rapid breathing. Signs of intoxication will become evident after 30 minutes exposure.

5-10% Breathing becomes more laborious with headache and loss of judgement.

10-100% When the carbon dioxide concentration increases above 10%, unconsciousness will occur in under one minute and unless prompt action is taken, further exposure to these high levels will eventually result in death.

The recommended exposure limit for carbon dioxide is 5.000 parts per million (0,5%) by volume, calculated on an 8 hour time weighted average concentration in air.

Depending on regulations in individual countries carbon dioxide concentration peaks up to 30000 parts per million (3%) in air are allowed, where by the duration of exposure is between 10 minutes and 1 hour.

Cardiac or respiratory defects are likely to increase the hazards of inhalation.

Wherever any doubt exists, the recommended exposure limit of 5000 parts per million carbon dioxide in air should be regarded as the maximum level of the individual concerned.

APPENDIX C: Code of practice for bulk liquid CO_2 storage installations on users' premises

III.1 Siting

Open-air locations are recommended where-ever practicable to avoid problems in maintaining suitable and adequate ventilation.

III.1.1 Open air location

When the storage vessel is sited in the open air:

- Suitable weather protection will be required for the refrigeration unit, together with the electrical installation and the control instruments.

- Full weatherproof cover will be necessary where the insulation and cladding of the vessel or the weighing equipment provided are unsuitable for external use without such protection.

- The installation should be protected against the risk of accidental damage (e.g. suitable guard rails or other protection must be provided where necessary).

- Appropriate steps should be taken to minimise the fire hazard from adjacent installations or activities.

- The outlets from each relief valve should discharge in a safe location.

III.1.2 Enclosed location

When the storage vessel is to be sited within an enclosed area, then account must be taken of the possible release scenario.

- Wherever practicable, the area occupied by the vessel should be isolated from any other occupied parts of the same building.

- The area must then be provided with suitable means of exit and adequate ventilation at floor level.

- The installation of a detector for CO_2 concentration with alarm is recommended.

If, in any circumstances, the vessel has to be sited within an occupied working area, then additional precaution should be considered, including:

- Piping the connections for liquid and gaseous CO_2 balancing to a suitable open air loading point.

- Piping the outlets from each relief valve separately to a safe high level discharge point in the open air.

III.2 Basements, pits, trenches

Attention should be given to any openings, pits and trenches which would enable CO_2 to enter and accumulate in any enclosed areas below ground level.

In such circumstances storage vessel should be sited as far away as is practicable from any enclosed areas below ground level which are of sufficient size to allow entry of persons.
If, however, siting of a storage vessel away from such areas is impracticable, then the areas below ground level must be provided with adequate forced ventilation.

III.3 Tanker access and unloading

- The liquid transfer area shall be designated a “No Parking” area and should be level.

- Storage vessels. filling connection and equipment controls shall be located such that adequate safe access to the CO_2 unloading area is available for the delivery vehicle.

- Access to the installation should be forbidden to all unauthorised persons. Warning notices should support this.

- A road tanker, when in position for filling from or discharging to the installation, shall be in the open air and not be in a walled enclosure from which the escape of heavy vapour is restricted. The installation should be so designed that authorised persons should have easy access to and exit from the operating area at all times. Kerbs, barriers or bumper blocks shall be provided to prevent damage to any part of the installation by the tanker or other vehicles.

- The use of safety cables on high pressure CO_2 flexible connections is recommended.
- The liquid transfer area should normally be located adjacent to the fill coupling of the installation and be positioned in such a way that it facilitates the movement of the tanker in the case of an emergency.

- The liquid transfer area should normally be located such that CO_2 transfer connections can be made with the single standard length flexible hoses carried by the vehicle.

- The extension of the high pressure flexible connections by interconnecting more than two standard length hoses is not recommended. If extended filling connections cannot be avoided, special provisions should be followed, see company instructions.

- The tanker driver must be able to move freely between the tanker and the storage installation at all times, to maintain proper control of the pumping operation, and to ensure that the correct quantity of CO_2 is transferred, and to avoid overfilling the storage vessel

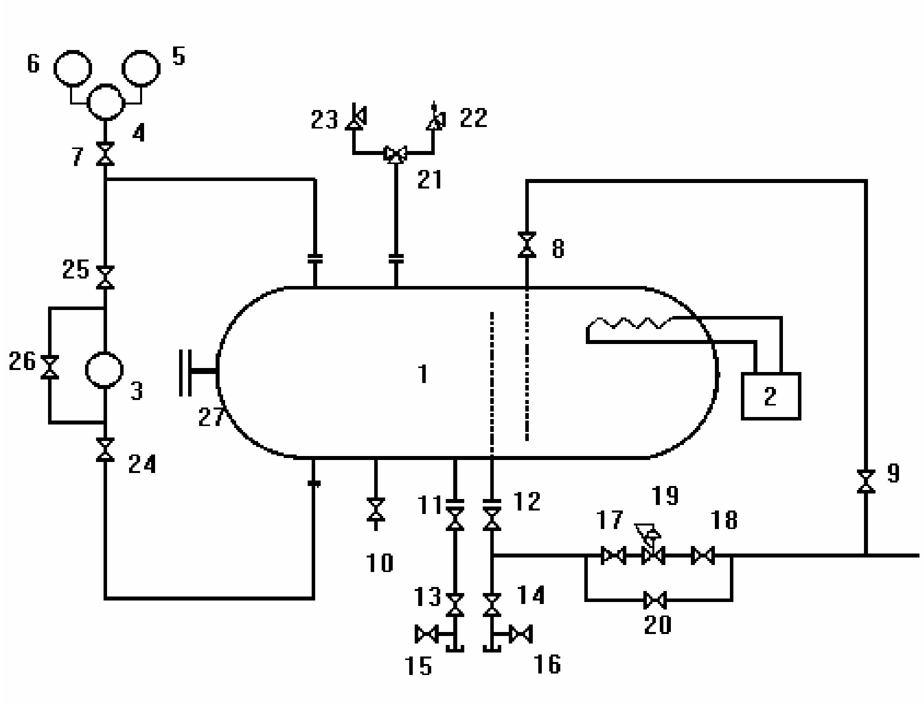
- The access route for the vehicle must also be left unobstructed such that in the event of a fire or other emergency in the vicinity of the storage installation, the vehicle can be disconnected and moved to a safe place with the minimum of delay.

III.4 Electrical equipment

All electrical equipment and wiring should be installed and maintained in accordance with the appropriate code or standard and the national regulations in force in the country of use.

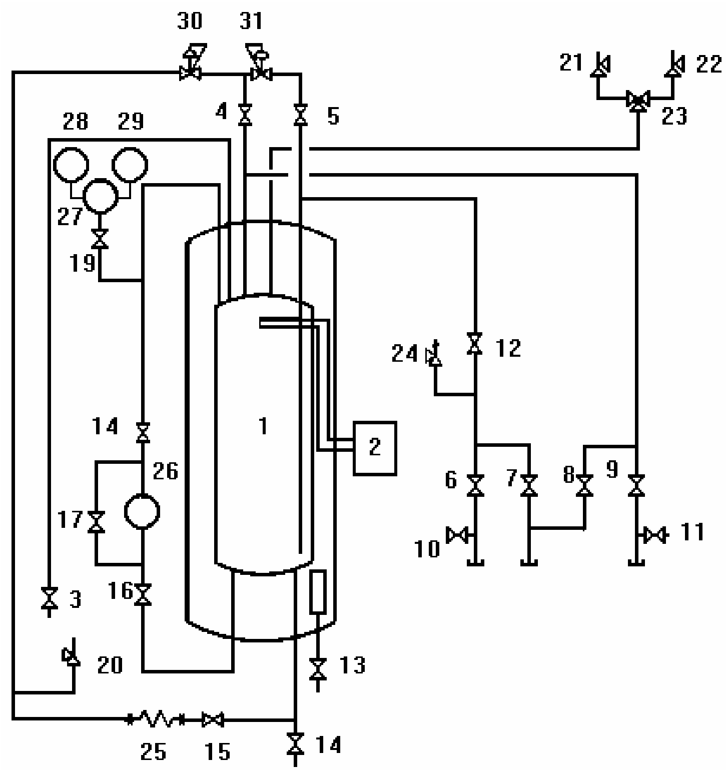
All electrical equipment on the storage installation must be properly earthed. Also all conductive material forming part of the installation, including the vessel itself, shall be earth bonded.

APPENDIX D: Polyurethane insulated Storage tank



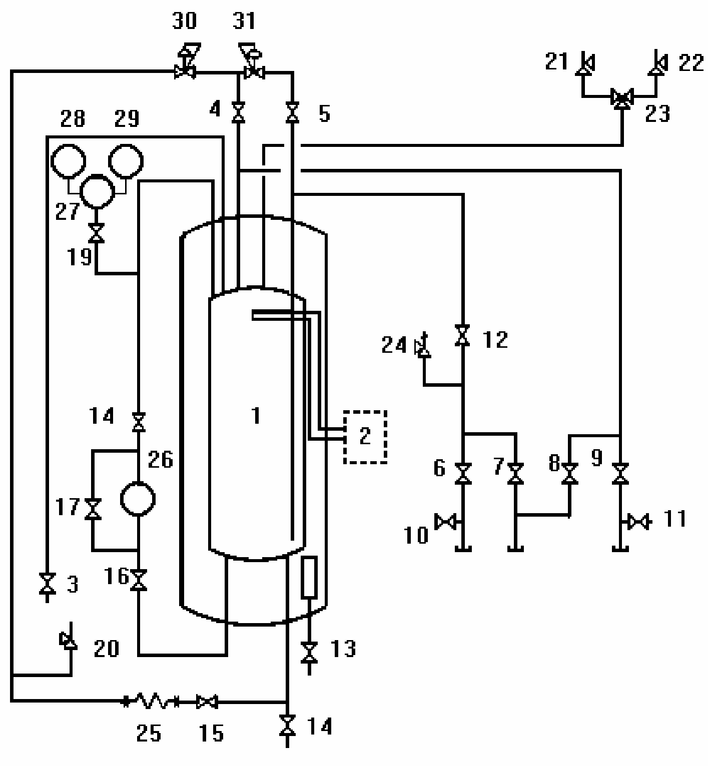
1. **Pressure vessel**
2. **Refrigeration unit**
3. **Level indicator**
4. **Pressure gauge**
5. **Low pressure switch**
6. **High pressure switch**
7. **Pressure gauge shut valve**
8. **Shut-off valve**
9. **Shut-off valve**
10. **Shut-off valve**
11. **Shut-off valve**
12. **Shut-off valve**
13. **Shut-off valve**
14. **Shut-off valve**
15. **Liquid vent valve**
16. **Gas vent valve**
17. **Shut-off valve**
18. **Shut-off valve**
19. **Pressure regulator**
20. **By-pass valve**
21. **Change-over valve**
22. **Relief valve**
23. **Relief valve**
24. **Shut-off valve**
25. **Shut-off valve**
26. **Shut-off valve**
27. **Man door**

APPENDIX E: Perlite insulated storage tank



1. **Pressure vessel**
2. **Refrigeration unit**
3. **Overflow shut-off valve**
4. **Shut-off valve**
5. **Shut-off valve**
6. **Shut-off valve**
7. **Shut-off valve**
8. **Shut-off valve**
9. **Shut-off valve**
10. **Liquid vent valve**
11. **Gas vent valve**
12. **Shut-off valve**
13. **Vacuum probe valve**
14. **Liquid vent valve**
15. **Shut-off valve**
16. **Shut-off valve**
17. **Shut-off valve**
18. **Shut-off valve**
19. **Manometer shut-valve**
20. **Relief valve**
21. **Relief valve**
22. **Relief valve**
23. **Change-over valve**
24. **Relief valve**
25. **Pressure building coil**
26. **Level indicator**
27. **Pressure gauge**
28. **High pressure switch**
29. **Low pressure switch**
30. **Pressure building regulator**
31. **Pressure building regulator**

APPENDIX F: Vacuum insulated Storage tank



1. **Overflow shut-off valve**
2. **Pressure vessel**
3. **Refrigeration unit**
4. **Shut-off valve**
5. **Shut-off valve**
6. **Shut-off valve**
7. **Shut-off valve**
8. **Shut-off valve**
9. **Shut-off valve**
10. **Liquid vent valve**
11. **Gas vent valve**
12. **Shut-off valve**
13. **Vacuum probe valve**
14. **Liquid vent valve**
15. **Shut-off valve**
16. **Shut-off valve**
17. **Shut-off valve**
18. **Shut-off valve**
19. **Manometer shut-valve**
20. **Relief valve**
21. **Relief valve**
22. **Relief valve**
23. **Change-over valve**
24. **Relief valve**
25. **Pressure building coil**
26. **Level indicator**
27. **Pressure gauge**
28. **High pressure switch**
29. **Low pressure switch**
30. **Pressure building regulator**
31. **Pressure building regulator**