



SAFETY TRAINING LEAFLET 06 CARBON DIOXIDE

AIGA 009.06/26

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1 Introduction

1.1 Safety leaflets

Safety training leaflets summarise the basic operational safety knowledge which needs be known by employees working in the gas industry.

Refer to AIGA 009 *Safety Training of Employees* for the various combinations of leaflets which define the scope of safety training for a variety of specific jobs.

Each leaflet addresses a specific topic as identified in the title.

1.2 Comprehension tests

There is a comprehension test for each leaflet, included in **Appendix 1**.

Each test comprises several questions. To pass the test it is suggested that the employee should score 75% at the first attempt. Incorrect answers should be discussed to confirm understanding.

Appendix 2 includes the list of correct answers.

2 Carbon dioxide

2.1 Carbon dioxide specific properties

- Carbon dioxide, (CO₂) can be produced, stored or used in any of the three different physical states (gas, liquid, solid) in which a substance can exist, solid carbon dioxide is usually designated as “dry ice”.
- The following diagram summarizes the physical state of carbon dioxide when pressure and temperature vary.

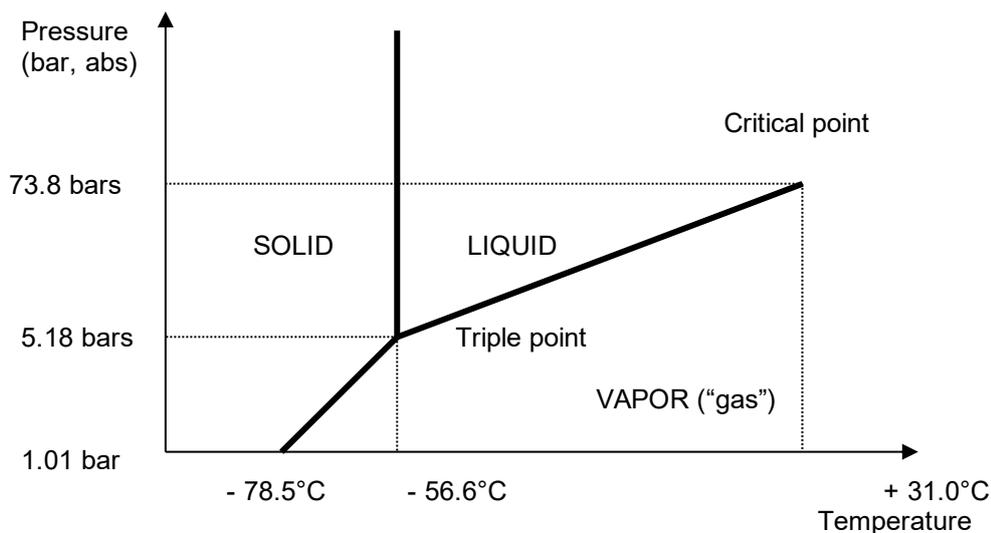


Figure 1 Carbon dioxide pressure-temperature diagram

- Note that:
 - liquid carbon dioxide can exist only when temperature is below 31°C

- when liquid carbon dioxide pressure drops below 4.18 bar (5.18 bar. abs) and/or its temperature drops below -57°C , solid carbon dioxide is formed.
- Hazardous conditions can be created when carbon dioxide temperature and/or pressure are not properly controlled
- Carbon dioxide is hazardous as it can generate low temperature (cryogenic burns), ice plugs (overpressure and striking objects) and hazardous atmospheres: with increasing exposure time and concentration over 3% in air, vital functions such as breathing are affected. Over 10% in air, loss of consciousness happens in one minute and would result in death if prompt action is taken.
- Carbon dioxide concentration in the air that we breathe must be kept below 5000ppm TLV-TWA, usual concentration in ambient air is around 400ppm. Higher concentrations can be tolerated for short exposure time (see below).
- In potentially exposed working places where room ventilation is less than 6 volume changes per hour, carbon dioxide concentration shall be monitored in addition to oxygen concentration monitoring. Severe physiological effects occur over 30000 ppm (TLV-STEL Ceiling). Specific Threshold Limit Values depend upon local regulations and can vary from one country to another.

2.2 Production of liquid carbon dioxide

- Low (negative gauge pressure) at plant inlet booster suction can cause air pollution of the plant feed stream. This requires monitoring the possible oxygen contamination of the plant feed stream when it contains flammable substances. Also, raw gas supply process or equipment could be damaged by negative gauge pressure.
- You must know the maximum (and sometimes minimum) allowed concentrations of plant feed stream components and what to do if limits are exceeded.
- Low temperature and high pressure are potential hazards which require adequate operating and maintenance practices, do not perform tasks that you have not been trained to undertake.
- Relatively large quantities (several tonnes) of ammonia (NH_3) are used in the liquid carbon dioxide production process. Ammonia is a hazardous material (toxic and corrosive) which requires stringent operating, maintenance and emergency procedures that personnel must know and follow.
- The smell of ammonia is characteristic, and we can smell a few ppm in the air that we breathe. Ammonia leaks are not acceptable and once detected they shall be reported immediately. Ammonia leaks shall be repaired as soon as possible by properly trained and qualified personnel.
- Ammonia is highly soluble in water, but it releases heat. The pH of ammonia solutions is high. Ammonia solutions shall be treated as hazardous waste.
- Protective clothing and breathing apparatus (appropriate canisters and Self-Contained Breathing Apparatus) are available and maintained in a ready to use condition at dedicated locations in the plant. You must know those locations.
- Personnel require to be trained to use breathing apparatus and to wear protective clothing.
- Only approved relief valves can be used for liquid carbon dioxide service.

- Ammonia is a toxic, corrosive and flammable gas. Eye wash, emergency showers and suitable firefighting devices are available, and you must know where they are located and how to use them.

2.3 Liquid carbon dioxide storage and transfer

- Liquid carbon dioxide storage tanks are registered pressure vessels, you must know what the marks on the identification plate mean. Tank pressure monitoring and control is critical, operating instructions shall be understood and followed, uncontrolled deviations shall be reported immediately.
- Pressure relief devices protect storage tanks against overpressure hazards, you must know their set points. Only relief devices designed for liquid carbon dioxide service can be used.
- Storage tanks are often equipped with a low-pressure alarm that is set at a pressure above 8 bar.
- It is hazardous to overfill liquid carbon dioxide storage tanks. Level of liquid carbon dioxide in a storage tank must be monitored.
- On liquid carbon dioxide lines, there shall always be a pressure relief valve between two valves.
- During transfer of liquid carbon dioxide, ice plugs can be generated inside the piping or flexible hose when transfer procedures are not followed. This can lead to serious incidents caused by overpressure, low temperature, high velocity pieces of dry ice and whipping hoses.
- Liquid carbon dioxide pressure shall be kept above 8 bar until flexible hoses are drained.
- Flexible hoses shall be coupled to safety lines secured at both ends (trailer or truck at one end and storage tank at the other end).
- A liquid carbon dioxide release in the atmosphere generates a thick cloud consisting of condensed moisture and dry ice crystals. Do not expose yourself to the cloud and try to get out of the cloud.

2.4 Carbon dioxide cylinders filling

- Contamination of carbon dioxide cylinders with moisture is hazardous as it causes corrosion which in turn can cause cylinders to fail, sometimes violently.
- Carbon dioxide is filled in liquid state under pressure in the cylinders. It is hazardous to overfill cylinders as they can consequently burst. Each cylinder shall have a legible tare weight indication (total weight = tare weight + weight of filled carbon dioxide).
- Cylinders shall be emptied prior to tare weight check. In case of a difference between tare weight and actual weight the cylinder shall be inspected.
- The quantity of carbon dioxide in a cylinder can only be measured by weight and not by pressure.
- Weighing scales used to fill carbon dioxide cylinders shall be certified by a third party and frequently checked using test weights.
- You must know how to stop the cylinder filling process in case of an emergency.

- Most carbon dioxide cylinders are fitted with valves with built-in bursting discs. Make sure you know how to identify those valves and what to do in case a bursting disc blows out...(Go away and wait until cylinder is empty .. no more gas blowing).
- When not connected to the filling rack, cylinders shall be capped and secured.
- Before de-valving cylinders, vent slowly and weigh the cylinder to make sure that no liquid is left.

2.5 Dry ice manufacturing, storage and handling

- A dry ice production press is hazardous: high pressure and low temperature liquid carbon dioxide feed, high speed moving mechanical parts, hydraulic flexible hoses at very high pressure...
- Wear your personal protective equipment as required, for example hard hat, glasses, gloves and shoes.
- The ground around a hydraulic press could be oily and slippery. Oil leaks shall be contained in order to avoid pollution of soil and water (surface and underground). You must know the local waste management procedure.
- Report oil leaks so that maintenance can be performed to repair the leak.
- Moving and cutting tools (press, saw, packaging machine) are fitted with protective devices to avoid hand injuries, make sure that these protections work properly and do not by-pass them!
- Dry ice is cold (about -78°C) you must wear adequate safety gloves to handle it.
- Dry ice sublimates into carbon dioxide vapour, this can lead to asphyxiation in confined spaces such as small closed workshops, sawing and packaging section, storage containers and closed transport vehicles or storage area. Both oxygen and carbon dioxide concentrations may need to be monitored in case of marginal ventilation (less than 6 room volumes per hour). Make sure that you know how to check that atmosphere monitoring devices operate properly.
- When storing dry ice products in transport containers, do not put your head inside the container.

2.6 Procedures

- Refer to and learn the site standard operating and maintenance procedures. When you do not know, ask questions and do not take chances.

Appendix 1 – CARBON DIOXIDE – Test Questions

Tick the correct answer (s) or write in the blank spaces as requested.

1. The most important safety characteristic of carbon dioxide is that it is:

A. Flammable	C. Oxidising agent
B. Concentration must be kept below 5000 ppm	D. Asphyxiating

2. Which of the following risks can be caused when using and transporting Dry Ice?

A. Chemical asphyxiation	C. Fire
B. Cryogenic burns	D. Oxygen deficiency

3. Carbon dioxide is heavier than air.

A. True	B. False
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4. Which of the following items are the two main hazards when transferring liquid carbon dioxide

A. Spillage of product	C. Fire
C. Whipping hoses	D. Toxicity

5. Tick the correct statements

A. Filling process must be controlled by weight
B. Carbon dioxide gas can cause chemical asphyxiation
C. The filling of carbon dioxide is controlled by a pressure gauge
D. Carbon dioxide could be filled in any compressed gas cylinder

6. Tick the two main safety hazards of ammonia.

A. Toxic	D. Corrosive
B. Oxidising	E. Toxicity
C. Inert	F. Heavier than air

7. Storage tanks are often equipped with a low pressure alarm set not below 8 bar, to prevent the production of dry ice

A. True	B. False
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8. Tick the correct statements

A. Cylinders must be emptied prior to tare weight
B. In cylinders product is in phase liquid and gas
C. Concentrations over 3% carbon dioxide in air affects breathing
D. When filling carbon dioxide there is a risk of fire

Appendix 2 – CARBON DIOXIDE – Test Answers

1. B and D
2. A, B and D
3. A
4. A and C
5. A and B
6. A and D
7. A.
8. A, B and C