ASCO
All about CO_2



GENERAL INFORMATION
and
SAFETY INSTRUCTIONS
TRANSLATION

Version 0.0

ascoco2.com



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1 INTRODUCTION

These ASCO instructions will support and accompany you in the familiarization, installation and also in the commissioning of your ASCO quality product. In addition, these operating instructions contain important information for the safe, seamless and efficient operation of your product.

Please ensure that all instructions are observed precisely and, in the order, described in order to prevent danger and damage and to guarantee the longest possible product life.

In addition to these technical operating instructions and the safety instructions, the local legal regulation for safety and work instructions must also be followed. Whenever you use your ASCO product, the operating instructions must be to hand.

ASCO reserves the right to make technical changes at any time without prior notice.



NOTE

The information and advice contained in these operating are drawn up and checked with all possible care and in line with our best knowledge and instructions. Nevertheless, these instructions do not make any claim to absolute accuracy and completeness. If errors are present despite everything, we will be glad to accept your notes and suggestions.
In the framework of legal possibilities, the authors and publishers do not accept any liability whatsoever for damage resulting from incorrect or incomplete information and the consequences of this.

If anything is unclear, the German version of the instructions will apply as a reference document.

2 WHAT IS CO_2?

Carbon dioxide is the combination of two atoms of oxygen joined with a single atom of carbon. Its chemical formula CO_2 is almost as well-known as that of water, H_2O, and it is frequently referred to by its formula rather than its name.

In nature's chain of life, the mutual dependence of plant and animal life is maintained though the link of carbon dioxide. Every time we breathe, we release this gas, which plants need for life. Though the process of photosynthesis, the plants separate the carbon from the oxygen. In turn, plants release the pure oxygen, which we need to survive. We reverse the process, and by combining the oxygen with carbon from the foods we eat, produce carbon dioxide again.

CO_2 is a colourless, inert gas approximately 1½ times heavier than air and 0.03 % is present in the earth's atmosphere. It smells slightly pungent, has a sweet biting taste (soda water) and is highly stable (difficult to separate).

It is produced in varying amounts by the common process of combustion of fuels high in carbon content. The most common source of fuel for combustion is oil which, when mixed with the correct proportion of air, burns to produce around 15 % CO_2 in the flue gases of a CO_2 plant. After combustion has taken place, the CO_2 can be separated from the flue gases and, though a simple process, made available for the many commercial purposes to which it can be applied.

CO_2 can exist in three forms:

- in gaseous form: for the beverage and food industries
- in liquid form: in a storage tank under pressure
- in solid form: called dry ice (for cooling, blasting etc.)



Gaseous CO_2 can be liquefied under pressure provided its temperature is below 31 °C (87.8 °F), this temperature being referred to as the CRITICAL POINT. If compressed and cooled below the critical point, a colourless fluid, approximately the same density as water, is produced.

CO_2 will remain in the liquid form as long as its temperature remains below the critical point but will return to the gaseous state if its temperature rises above this point, regardless of the pressure applied.

Liquid CO_2 can be stored indefinitely at high pressure or low pressure as follows:

2.1 HIGH PRESSURE CO_2

High pressure liquid CO_2 is produced by compressing the gaseous CO_2 in multistage compressors to pressures in the neighbourhood of 69 bar (1000.8 psi) pressure, then cooling it to around 18 °C (64.4 °F). It is customarily filled into specially constructed steel cylinders. Like water, liquid CO_2 can be weighed, and this is the normal form of measuring it.

2.2 LOW PRESSURE CO_2

Low pressure liquid is an alternative method of storing CO_2 and is produced either by expanding high pressure CO_2 to a lower pressure or by refrigeration. It is held in specially constructed storage tanks, heavily insulated and equipped with refrigeration units to hold the internal tank pressure at or below 21 bar (304.6 psi) and -18 °C (-64.4 °F) temperature. Pressure switches are incorporated to control the refrigeration units and safety mechanism and electrical alarms are fitted to release the tank pressure and raise an alarm in the event of refrigeration malfunction.

Low pressure liquid CO_2 (sometimes referred to as “bulk”) is transported to one place from another in insulated road tankers or trailers (or, in some countries, by rail tank wagons), the liquid being simply transferred from mobile to static tank by pumping or gravity feed.

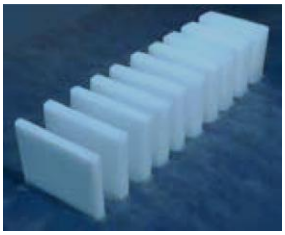
Unlike water, carbon dioxide cannot exist in the open air in liquid form. It must be held under pressure or refrigeration (or a combination of both) to remain in the liquid state.

2.3 SOLID CO_2 (CUSTOMARILY KNOWN AS “DRY ICE”)

Dry ice is the product of processing liquid CO_2. If the pressure of liquid CO_2 is suddenly released, a proportion of that liquid will change to the solid state (becoming dry ice “snow”) and the remainder will revert to gas (revert gas). When the snow is compressed under hydraulic or mechanical action, blocks or pellets of dry ice are formed. The revert gas (gaseous CO_2) can be readily reclaimed and converted back to liquid by recompression and reliquefication, thence returned to the dry ice block machine or pelletizer for further processing.

The temperature of dry ice is -79 °C (-110.2 °F) and in the atmosphere it will pass directly from the solid to the gaseous stage, leaving no moisture or trace of its presence except the cold.





3 CO_2 IS OUR LIFE

Many generations - and individual lifetimes! - of experience have perfected ASCO‘s ability to provide the most complete and best matched CO_2 system available.

From the CO_2 production or recovery plant to storage, dry ice blasting, cylinder filling, dry ice making and even dry ice wrapping, it‘s all ASCO. This ability to provide matched components benefits ASCO clients as they can comfortably develop and grow their business without changing suppliers.

Having the largest range of CO_2 and dry ice components also enables ASCO customers to make full use of the versatile nature of CO_2 and its vast number of uses, thus gaining maximum value from the product. For example, a soft drink bottler could easily develop an extra cash flow business from surplus CO_2 (or excess plant capacity) by adding ASCO dry ice equipment and / or cylinder filling gear to supply CO_2 to other users.

ASCO‘s website provides details of their most up to date CO_2 and dry ice plants. All ASCO equipment is space efficient, designed for easy operation maintenance and engineered for maximum reliability and life. Component materials are selected to balance capital cost and plant longevity and from the flue gas oxygen sensor on the plant to the level indicator on the CO_2 storage tank all controls are effective, logical, clear, and linked to a PLC.

ASCO‘s technology, combined with a wide range of CO_2 equipment, makes it easy for their clients to mix and match components and thus tailor their CO_2 / dry ice system from the one shop.

Significant new ASCO CO_2 plant sales to Africa, South America and the Middle East indicates that many bottlers, brewers and merchant CO_2 companies prefer working with a single supplier and that supplier is ASCO. Let our life add life to your business.

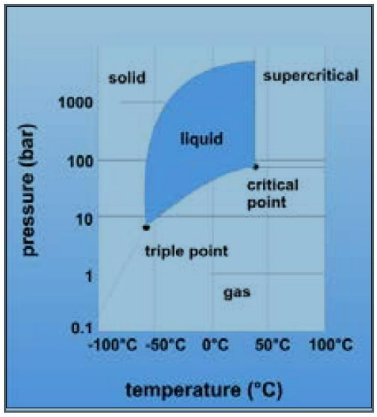
From liquid CO_2 into dry ice

Carbon Dioxide has 3 physical states of gas, liquid and solid which depend on temperature and pressure.

The relationship between the 3 states is shown on the pressure-temperature phase diagram beside.

Where does CO_2 come from?

CO_2 is derived from several sources including combustion of carbonaceous fuels, fermentation, natural wells, and as a by-product of industrial processes such as ethylene oxide and bioethanol production and ammonia synthesis.



CO_2 phase diagram

3.1 THE SOLID STATE (DRY ICE)

Below the triple point (5.18 bar (75.1 psi), -56.6 °C (-69.9 °F) CO_2 can only appear in its solid and gaseous state. Dry Ice is the common trade name for solid CO_2. At atmospheric pressure it has a temperature of approx. -79 °C (-110.2 °F). The solid CO_2 changes directly into its gaseous state. This evaporation (sublimation) does not leave any residues. Dry ice is non-toxic, non-inflammable, inert, without smell and bacteriostatic. It is white and has a density of approx. 1'500 kg/m^3 in its compact state. Dry ice is an ideal refrigerant which qualifies especially well for various applications. It has a high cooling capacity, and heat transfer is very high when in direct contact with the cold material.



Dry ice slices and blocks



16 mm (0.630 in) pellets



3 mm (0.118 in) pellets

ASCO has the best range of dry ice machines for dry ice production.

3.2 THE LIQUID STATE

Within a temperature range between -56.6 °C (-69.9 °F) and 31 °C (87.8 °F) and pressure greater than 5.2 bar (75.4 psi) and less than 74 bar (1073.3 psi) respectively CO_2 is in its liquid state except at very high pressures. This means that, below 5.2 bar (75.4 psi), CO_2 exists only in its solid or gaseous state. At 5.2 bar (75.4 psi) and -56.6 °C (-69.9 °F) all three states (solid, liquid and gas) are present. This is called the triple point.

The critical point of CO_2 lies at a temperature of approx. 31 °C (87.8 °F) and a pressure of approx. 74 bar (1073.3 psi). Normal CO_2 liquid can only be formed at temperatures below 31 °C (87.8 °F). Above the critical point there is no physical difference between the liquid and gaseous phase. This supercritical state is also called „Fluid“. The liquid state is important for the storage and transportation of CO_2 as well as during cooling and freezing applications. During release of the liquid CO_2 to atmosphere a temperature of -79 °C (-110.2 °F) is reached. This is associated with a high cooling capacity due to the evaporation heat which is extracted from the environment when releasing the liquid CO_2.



Horizontal CO_2 storage tank



Vertical CO_2 storage tank



ISO container for transportation of CO_2

3.3 THE GASEOUS STATE

CO_2 gas has a density of approx. 1.9 kg/m³ (0.119 lb/ft³) at atmospheric pressure and 15 °C (59.0 °F). CO_2 has many unique and beneficial features which make it valuable in the preservation of packaged food, in explosion and fire protection, in pest control and as protective gas in inert-gas-welding. In all these applications it is important for the CO_2 gas to drive out and replace the atmospheric oxygen. Moreover, CO_2 gas is used for enriching the atmosphere in greenhouses, in storing fruits and vegetables and for pH control when treating potable and wastewater.



CO_2 for beverage carbonation



CO_2 fumigation in pest control

4 DRY ICE BLASTING

4.1 CLEANING IN THE INDUSTRY

In industrial processes pollution, impurities of all kinds, adhesion of contaminants on machines, casting moulds etc. in different concentrations do exist and can have impact on the environment. The reliability of production related equipment, the quality of the products and the safety for personnel are very important issues.

Plant managers and all other personnel in charge are therefore looking worldwide for new cleaning technologies which are quality improving, cost saving and at the same time environmentally safe. In today's world the classical cleaning methods don't always meet the cleaning needs or have considerable drawbacks.

Some examples:

- High pressure cleaning and the use of solvents and other toxic chemicals increase disposal costs dramatically.
- Tedious manual labour (i.e. scraping, scrubbing) results in a lot of man-hours and is thus very expensive.

Cleaning with dry ice offers you a perfect, environmentally safe alternative.

4.2 THE TECHNOLOGY

The ASCOJET uses little pellets of carbon dioxide as blasting media. Liquid carbon dioxide (CO_2) is expanded in a production unit into carbonic snow which is extruded under high pressure through a die. That way we produce hard and identical shaped CO_2 pellets (approx. 3 mm [0.118 in] diameter). The dry ice pellet has a temperature of approx. -79 °C (-110.2 °F) and has a very special feature.

The impact of kinetic energy transforms the dry ice immediately from solid to gaseous state. This fact is used with the dry ice cleaning technology.
In the ASCOJET the dry ice is transported by compressed air to the blasting gun. In this gun, the CO_2 pellets are accelerated to a maximum speed of 300 m/s (984 ft/s) and shot at the surface to be treated.

4.3 CLEANING ACTION OF DRY ICE PELLETS

The cleaning action of carbon dioxide is based on two principles i.e. thermo-shock and kinetic energy.

- Thermo-shock:
  CO_2 pellets have a temperature of approx. -79 °C (-110.2 °F) and every material has a different shrinking factor. Therefore, the adhesion between contaminant and substratum will loosen.
- Kinetic energy:
  To remove the contaminant a little extra energy is needed. This energy is supplied by the pellets themselves. The pellet penetrates the contaminant and when it hits the base surface, it turns immediately from solid to gaseous state (=sublimation). This produces an increase in volume (factor 500) by which the kinetic energy is converted to a lateral release which acts as a "gas wedge" that lifts the contaminant. In some applications thermo-shock is more important (i.e. bitumen, resins, glues) in others the kinetic energy (i.e. coatings).

4.4 THE BENEFITS

Dry ice blasting has several important advantages towards other cleaning methods.

4.5 DRY ICE BLASTING

Reduces waste	Since dry ice sublimates in the atmosphere at the impact on a surface and the only waste left is the removed contaminant - if not recyclable.
Gentle action	Dry ice pellets have the hardness of chalk. The surface structure is not changed resp. the treated surface is not damaged.
Dry	Cleaning is performed dry. Since the pellets sublimate immediately on impact no residues of the blasting agent remain.
Fast	As this cleaning method causes no secondary contamination many applications can be carried out directly on the object. Costly standstill times can thus be minimised.
Safe	As this cleaning method requires no chemical or other environmentally harmful agent, it increases the safety of the cleaning work, and the personnel are not exposed to additional hazards.
Compactness & mobility	The ASCOJET is designed out of a user's point of view. It is light, mobile, with minimized maintenance, reliable and easy to operate.

4.6 CLEANING WITH DRY ICE PELLETS AND SAND (ADDITIVE)

In order to improve the properties of the dry ice blasting, the ASCOJET has devices that combine these advantages with the additional use of an abrasive blasting agent.
This combined blasting procedure can be used on the one hand to deal with very severe and stubborn dirt, and on the other hand also for applications where a form of cleaning in which a small amount of the material is removed is desired.

4.7 COMBINED BLASTING

Reduced waste	The waste (removed dirt and the abrasive blasting agent) are kept to an absolute minimum.
Gentle action	Since it is possible to choose between pure dry ice blasting and combined blasting, the gentle action of dry ice pellets can be used optimally as before.
Powerful	Use in combination with an abrasive blasting agent means that the performance of the blasting operation can be massively increased.
Pre-treatment	Frequently the cleaned surfaces need to be pre-treated for the next process step (roughening). When use is combined with an additive in addition to the action dry ice alone, this pre-treatment can be done in one work step.

4.8 APPLICATIONS

Wherever oil, grease, resin, adhesives, paint, ink, bitumen, wax and other pollutants have to be removed.

Dry ice pellets are non-toxic, non-conductive and are described to be non-abrasive. Therefore, this technology has a broad range of applications in all kinds of industries.

- food processing
- plastic processing
- nuclear decontamination
- petrochemicals
- foundries
- chemicals
- printing
- textiles
- automotive



NOTE

The list does not claim to be complete, as new potential applications are continuously being discovered.

5 SAFETY NOTES

5.1 DRAWING AND SYMBOLS

Many accidents on and with machines are caused by failure to observe the manufacturer's instructions and the safety notes. International signs and symbols draw attention to the hazard situations in the working environment. You will find the following symbols, among others, in the instruction manual of your ASCO product.



DANGER

Describes a hazard with a high degree of risk.
If these instructions are not followed, this will result in death or serious injury (leading to disability).



WARNING

Describes a hazard with a medium degree of risk.
If these instructions are not followed, this may result in death or serious injury (leading to disability).



CAUTION

Describes a hazard with a low degree of risk.
If these instructions are not followed, this may result in slight or moderate injury.

Note, user tips, minor material damage at the most:



NOTE

Designates general instructions with subsequent action.
User tips and recommendations for work are given, which have no effect on the health and safety of personnel but do require certain behaviour or action.

…Highlights useful tips and recommendations plus information for efficient and fault-free operation.



NOTE

Describes general notes.
Practical user tips and work recommendations are given which do not, however, have any effect on the safety and health of staff.

...highlights useful tips and recommendations plus information for efficient and fault-free operation.

Instructions designed to prevent serious damage to property:

	**CAUTION**
	Describes a potentially damaging situation. If these instructions are not followed, material damage will result. … indicates a potentially damaging situation which may lead to material damage if these instructions are not followed.

5.2 CO_2 SAFETY NOTES

CO_2 data sheet

Name	Carbon dioxide
Chemical formula	CO_2
Molecular weight (at 0 °C [32.0 °F] and 101.3 kPa [14.7 psi])	44.011 g/mol [97.03 lb/kmol]
Molecular volume	22.263 m^3/kmol [786.2 ft^3/kmol]
Specific gas constant	0.1889 kJ/(kg/K) [0.0451 BTU/(lb·°F)]
Gas density (at 0 °C [32.0 °F] and 101.3 kPa [14.7 psi])	1.977 kg/m^3 [0.123 lb/ft^3]
Relative gas density (at 0 °C [32.0 °F] and 101.3 kPa [14.7 psi], air = 1 kg/m^3 [0.06243 lb/ft^3])	1.529 kg/m^3 [0.095 lb/ft^3]
Triple point	-56.6 °C [-69.9 °F] at 5.18 bar [75.1 psi]
Gas colour	Colourless
Reaction under normal conditions	Stable molecules, can be used as inert gas
Odour	Odourless
Taste	Neutral, slightly acidic
Toxic classification	Non toxic

Solid CO_2 (dry ice)

Sublimation temperature	-78.9 °C [-110.0 °F] (194.25 K) at p= 0.9807 bar [14.2 psi]
Latent heat of the sublimation	573.02 kJ/kg [246.3 BTU/lb] (enthalpy of the sublimation)

The following safety notes refer to the handling of carbon dioxide in its three aggregate conditions:

1. Gaseous CO_2
2. Liquid CO_2
3. Solid CO_2 (also known as "dry ice")

5.3 FREEZE INJURIES



DANGER

Dry ice has a temperature of approx. -79 °C [-110.2 °F] and it can lead to freeze burns if it comes into contact with inadequate protective clothing. Dry ice must not be taken orally under any circumstances. Keep away from children!



CAUTION

Metallic parts, such as CO_2 pipes, may only be touched if appropriate protective clothing is being worn. Frozen metal parts can give freeze burns if they come into contact with the skin. Unprotected skin can "stick" to froze parts.

5.4 DANGER OF CARBON DIOXIDE POISONING

Please ensure that your ASCO quality product is always set up in a well-ventilated area.



WARNING

An increase in carbon dioxide concentration in the ambient air affects breathing.

The carbon dioxide can no longer be discharged from the blood or the alveoli, and this means there is no space for oxygen in the blood which leads to a toxic reaction.
This effect of the carbon dioxide is described as poisoning. The effect of carbon dioxide poisoning is completely independent of the effects of a lack of oxygen. **The content of oxygen in the atmosphere is thus not an effective indication of danger.** It is definitely possible to have an acceptably low oxygen concentration of 18 % in the ambient air and an increased carbon dioxide concentration at the same time which signifies a dangerous situation.

The individual tolerance values can vary strongly depending on the physical condition of the people and the temperature and air humidity ratios of the atmosphere, but the effects mentioned below will generally occur if various carbon dioxide concentrations are inhaled.

1 - 1.5 %	Light effect on the chemical metabolism following exposure over several hours.
3 %	In this concentration the gas has a weak narcotic effect and it causes deeper and quicker breathing and poorer hearing ability along with headache, increased blood pressure and a quicker pulse.
4 - 5 %	Stimulation of the breathing centre and resultant deeper and quicker breathing. After 30 minutes exposure the appearance of poisoning becomes apparent!
5 - 10 %	Breathing becomes more of an effort with headache and loss of judgement!
10 - 100 %	If the carbon dioxide concentration goes above 10 %, loss of consciousness will occur in less than 1 minute - and if no immediate measures are taken, further exposure to such high values can result in death.

The effects of inhaling carbon dioxide in low concentration are physiologically reversible but in higher concentrations the effect is toxic and damaging!



WARNING

Heart and breathing defects can increase the danger of carbon dioxide poisoning.

ASCO CARBONDIOXIDE LTD supplies appliances for continuous monitoring of the ambient air in the danger area. These display the current CO_2 concentration and give an acoustic warning when the set highest concentration values are reached.



NOTE

ASCO CARBONDIOXIDE LTD expressly recommends the use of a CO_2 warning device. In accordance with local regulations the room will be ventilated following reaching the alarm threshold and or the appliance and the tank switched off.

5.5 RISK OF ELECTRIC SHOCK



DANGER

Risk of electric shock. Service works, maintenance and deinstallation may only be performed on de-energized equipment and with disconnected power plug.



WARNING

Changes on the electrical installation on your own are prohibited.
Changes on the electrical installation, on the program or on its parameters can cause serious damages to the machine and its environment.
Any change on the control or at the program which is not performed by an ASCO-technician leads to a loss of warranty.

5.6 QUALIFICATION OF OPERATOR



WARNING

It is mandatory that operators are trained by an authorized person (operating company or manufacturer) in the following issues:

- Safe handling of dry ice and / or liquid / gaseous CO_2
- Operation of ASCO equipment
- Safety precautions / safety equipment
- Protective clothing



WARNING

A qualified personnel for maintenance and repair is a skilled and trained engineer or technician for:

- Mechanical engineering
- Electrical engineering
- Hydraulics engineering
- Refrigeration engineering

5.7 INTERACTING MACHINE PARTS



CAUTION

Many ASCO appliances are mechanically driven machines. Moving parts present a corresponding danger.

The service openings as well as the side and rear walls must always be closed during operation so that moving parts cannot be reached. Please ensure that these lids are always fitted before the machine is commissioned.

5.8 FURTHER SAFETY MEASURES AND INFORMATION



WARNING

Dry ice "sublimates", i.e. it goes directly over into a gaseous state without becoming liquid, therefore do not store in hermetically sealed containers. Please observe that 1 kg (2.205 lb) of dry ice at 1 bar (14.5 psi) ambient pressure corresponds to a volume of approx. 0.5 m^3 (17.66 ft^3) CO_2 gas.

Generally, it is assumed that all CO_2 liquid pipes are pressurised. After the end of production the pipes must be emptied or depressurised. It must be ensured that all pipes are resealed again in order to prevent ingress of damp.

Please ensure that your ASCO product is always installed on a level industrial floor. Ventilate the production areas.



WARNING

Many ASCO appliances are hydraulic driven machines. Oil leakage together with condensed water caused by cold machine components may lead to a slippery floor.



CAUTION

In order to avoid accidents with "shooting" pellets on start up, it must be ensured that the pellet ejection area is completely clear. While the plant is in operation, never look directly at the pellet exit.



CAUTION

If the tank and the appliance are switched off together, the pipe safety valve can react under certain circumstances.

5.9 OVERPRESSURE IN PIPES

If two shut off valves are connected on a CO_2 liquid pipe, a safety valve must always be installed between the valves. If liquid CO_2 is trapped in the pipe between two shut-off valves, then the pressure in the pipe, triggered by the rapid expansion of CO_2 due to heating, can increase very quickly.



WARNING

For this reason there is a danger of damage to persons or material damage as the pipe or the hose could burst in the worst-case scenario.

- Therefore, it is extremely important that a safety valve is fitted anywhere where liquid CO_2 can be trapped.
- In addition, it is recommended to fit a discharge vent valve so that CO_2 can be released when required.

NOTE

Additional machine-specific safety precautions can be found in the main section of the operating manual.

5.10 PROTECTIVE CLOTHING



CAUTION

In order to avoid the danger of injury, wearing protective clothing is obligatory. Leather gloves must be worn. Rubber gloves are not sufficient.



WARNING

When operating the ASCO equipment safety shoes for industrial use must always be worn.



CAUTION

Suitable safety goggles must be worn at all times when operating ASCO machines.



WARNING

Approved hearing protection must always be worn when operating the ASCO equipment or if you are in the vicinity of the machines.

5.11 CO_2 CLASSIFICATION

	Solid	Liquid
UN number	1845	2187
Hazardous goods class	none	22

5.12 INFORMATION FOR SAFE OPERATION

Storage and transport	Liquid CO_2 is stored at temperatures between -28 °C (-18.4 °F) and -17 °C (1.4 °F), depending on the storage pressure.
Danger of fire/explosion	CO_2 is not flammable and it is used as a fire extinguishing agent.

5.13 EFFECTS ON HEALTH



DANGER

Swallowing solid or liquid CO_2 causes serious internal burns. Swallowing larger amounts of gaseous CO_2 causes intestinal irritations due to the formation of bad carbonic acid compounds!



WARNING

Gaseous CO_2 causes light eye irritations through the formation of bad carbonic acid compounds. Liquid and also solid CO_2 cause serious freeze burns and can lead to blindness.

5.14 FIRST AID

Swallowing	Get medical assistance **IMMEDIATELY**.
Eyes	Rinse the eye with plenty of warm water and get medical assistance **IMMEDIATELY**.
Skin	Sprinkle the skin with warm water for at least 15 minutes and get medical assistance **IMMEDIATELY**.
Inhalation	In the case of fainting, move victim to a well-ventilated area **IMMEDIATELY**. **TAKE CARE: DO NOT EXPOSE YOUR- SELF TO DANGER.** Get medical assistance **IMMEDIATELY**. If breathing stops, give artificial respiration **IMMEDIATELY** and get medical assistance.