

The ASCO logo features a stylized blue symbol of three horizontal lines of varying lengths to the left of the word "ASCO" in a bold, blue, sans-serif font.

All about CO₂

GENERAL INFORMATION
and
SAFETY INSTRUCTIONS
TRANSLATION

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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	
	<p>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 in spite of everything we will be glad to accept your notes and suggestions.</p> <p>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.</p>

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

2 WHAT IS CO₂?

Carbon dioxide is the combination of two atoms of oxygen joined with a single atom of carbon. Its chemical formula CO₂, is almost as well-known as that of water, H₂O, 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 through the link of carbon dioxide. Every time we breathe we release this gas, which plants need for life. Through 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.

CO₂ 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 % CO₂ in the flue gases of a CO₂ plant. After combustion has taken place, the CO₂ can be separated from the flue gases and, through a simple process, made available for the many commercial purposes to which it can be applied.

CO₂ 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 CO₂ can be liquefied under pressure provided its temperature is below 31 °C, 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.

CO₂ 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 CO₂ can be stored indefinitely at high pressure or low pressure as follows:

2.1 HIGH PRESSURE CO₂

High pressure liquid CO₂ is produced by compressing the gaseous CO₂ in multistage compressors to pressures in the neighbourhood of 69 bar pressure, then cooling it to around 18 °C. It is customarily filled into specially constructed steel cylinders. Like water, liquid CO₂ can be weighed, and this is the normal form of measuring it.

2.2 LOW PRESSURE CO₂

Low pressure liquid is an alternative method of storing CO₂ and is produced either by expanding high pressure CO₂ 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 and -18 °C 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.

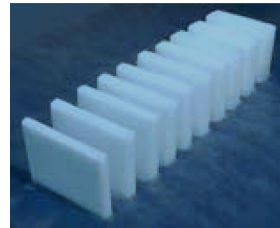
Low pressure liquid CO₂ (sometimes referred to as “bulk”) is transported to one place from another in insulated road tankers or trailers (or, in some countries, by rail tank wagons), the liquid being simply transferred from mobile to static tank by pumping or gravity feed.

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 CO₂ (CUSTOMARILY KNOWN AS “DRY ICE”)

Dry ice is the product of processing liquid CO₂. If the pressure of liquid CO₂ 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 CO₂) can be readily reclaimed and converted back to liquid by recompression and reliquefaction, thence returned to the dry ice block machine or pelletizer for further processing.

The temperature of dry ice is -79 °C 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 CO₂ IS OUR LIFE

Many generations - and individual lifetimes! - of experience have perfected ASCO's ability to provide the most complete and best matched CO₂ system available.

From the CO₂ 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 CO₂ and dry ice components also enables ASCO customers to make full use of the versatile nature of CO₂ 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 CO₂ (or excess plant capacity) by adding ASCO dry ice equipment and / or cylinder filling gear to supply CO₂ to other users.

ASCO's website provides details of their most up to date CO₂ 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 CO₂ storage tank all controls are effective, logical, clear, and linked to a PLC.

ASCO's technology, combined with a wide range of CO₂ equipment, makes it easy for their clients to mix and match components and thus tailor their CO₂ / dry ice system from the one shop.

Significant new ASCO CO₂ plant sales to Africa, South America and the Middle East indicates that many bottlers, brewers and merchant CO₂ companies prefer working with a single supplier and that supplier is ASCO. Let our life add life to your business.

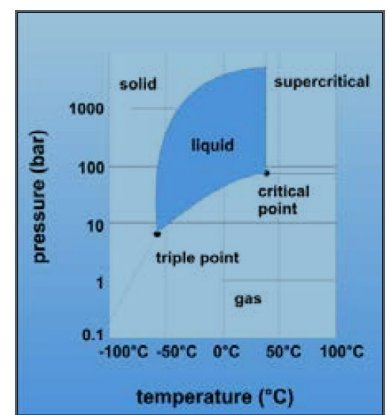
From liquid CO₂ into dry ice

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 CO₂ come from?

CO₂ is derived from a number of 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.



CO₂ phase diagram

3.1 THE SOLID STATE (DRY ICE)

Below the triple point 5.18 bar, - 56.6 °C CO₂ can only appear in its solid and gaseous state. Dry Ice is the common trade name for solid CO₂. At atmospheric pressure it has a temperature of approx. -79 °C. The solid CO₂ 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/m³ 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 (5/8 in) pellets



3 mm (1/8 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 and 31 °C and pressure greater than 5.2 bar and less than 74 bar respectively CO₂ is in its liquid state except at very high pressures. This means that, below 5.2 bar, CO₂ exists only in its solid or gaseous state. At 5.2 bar and - 56.6 °C all three states (solid, liquid and gas) are present. This is called the triple point.

The critical point of CO₂ lies at a temperature of approx. 31 °C and a pressure of approx. 74 bar. Normal CO₂ liquid can only be formed at temperatures below 31 °C. 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 CO₂ as well as during cooling and freezing applications. During release of the liquid CO₂ to atmosphere a temperature of -79 °C 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 CO₂.



Horizontal CO₂ storage tank



Vertical CO₂ storage tank



ISO container for transportation of CO₂

3.3 THE GASEOUS STATE

CO₂ gas has a density of approx. 1.9 kg/m³ at atmospheric pressure and 15 °C. CO₂ 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 CO₂ gas to drive out and replace the atmospheric oxygen. Moreover, CO₂ gas is used for enriching the atmosphere in greenhouses, in storing fruits and vegetables and for pH control when treating potable and waste water.



CO₂ for beverage carbonation



CO₂ 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 molds 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 (CO₂) 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 CO₂ pellets (approx. 3 mm diameter). The dry ice pellet has a temperature of approx. -79 °C 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 CO₂ pellets are accelerated (max. 300 m/s) and blasted upon the surface to be cleaned.

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:
CO₂ pellets have a temperature of approx. -79 °C 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 sublime 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
	Indicates an immediate threat of danger. Failure to heed the information will result in death or severest bodily injury (invalidity).


	! WARNING
	Indicates a possibly dangerous situation. Failure to heed the information can result in death or severest bodily injury (invalidity).

	! CAUTION
	Indicates a possibly dangerous situation. Failure to heed the information can result in damage to property as well as minor or medium injuries to body.

Note on useful tips to avoid property damages:

	NOTE
	Indicates general information, user tips and suggested hints on work which, however, do not affect the safety and health of the personnel. ...emphasizes useful tips and suggestions as well as information for efficient and disturbance-free operation.

Note on prevention of major property damages:

	! CAUTION
	Indicates a possibly dangerous situation. Failure to heed the information can result in damage to property. ... indicates a possibly dangerous situation which may result in damage to property if it is not avoided.

5.2 CO₂ SAFETY NOTES

CO₂ data sheet

Name	Carbon dioxide
Chemical formula	CO ₂
Molecular weight (at 0 °C and 101.3 kPa)	44.011 g/mol
Molecular volume	22.263 m ³ /kmol
Specific gas constant	0.1889 kJ/(kg/K)
Gas density (at 0 °C and 101.3 kPa)	1.977 kg/m ³
Relative gas density (at 0 °C and 101.3 kPa, air = 1 kg/m ³)	1.529 kg/m ³
Triple point	-56.6 °C at 5.18 bar
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 CO₂ (dry ice)



Sublimation temperature	-78.9 °C (149.25 K) at p = 0.9807 bar
Latent heat of the sublimation	573.02 kJ/kg (enthalpy of the sublimation)

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

1. Gaseous CO₂
2. Liquid CO₂
3. Solid CO₂ (also known as "dry ice")



5.3 FREEZE INJURIES

	 DANGER
	<p>Dry ice has a temperature of approx. -79 °C 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!</p>

	 CAUTION
	<p>Metallic parts, such as CO₂ 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 frozen parts.</p>

5.4 DANGER OF CARBON DIOXIDE POISONING

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

	 WARNING
	<p>An increase in carbon dioxide concentration in the ambient air affects breathing.</p>


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 CARBON DIOXIDE LTD supplies appliances for continuous monitoring of the ambient air in the danger area. These display the current CO₂ concentration and give an acoustic warning when the set highest concentration values are reached.



	NOTE
	ASCO CARBON DIOXIDE 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
	<p>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.</p>

5.6 QUALIFICATION OF OPERATOR

	 WARNING
	<p>It is mandatory that operators are trained by an authorized person (operating company or manufacturer) in the following issues:</p> <ul style="list-style-type: none"> ▪ Safe handling of dry ice and / or liquid / gaseous CO₂ ▪ Operation of ASCO equipment ▪ Safety precautions / safety equipment ▪ Protective clothing



	 WARNING
	<p>A qualified personnel for maintenance and repair is a skilled and trained engineer or technician for:</p> <ul style="list-style-type: none"> ▪ Mechanical engineering ▪ Electrical engineering ▪ Hydraulics engineering ▪ Refrigeration engineering



5.7 INTERACTING MACHINE PARTS



	 CAUTION
	<p>Many ASCO appliances are mechanically driven machines. Moving parts present a corresponding danger.</p>



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
	<p>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 1kg of dry ice at 1 bar ambient pressure corresponds to a volume of approx. 0.5 m³ CO₂ gas.</p> <p>Generally it is assumed that all CO₂ 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.</p> <p>Please ensure that your ASCO product is always installed on a level industrial floor. Ventilate the production areas.</p>



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

	 CAUTION
	<p>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.</p>


	 CAUTION
	<p>If the tank and the appliance are switched off together, the pipe safety valve can react under certain circumstances.</p>

5.9 OVERPRESSURE IN PIPES


If two shut off valves are connected on a CO₂ liquid pipe, a safety valve must always be installed between the valves. If liquid CO₂ is trapped in the pipe between two shut-off valves, then the pressure in the pipe, triggered by the rapid expansion of CO₂ due to heating, can increase very quickly.


	 WARNING
	<p>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.</p>


- Therefore it is extremely important that a safety valve is fitted anywhere where liquid CO₂ can be trapped.
- In addition it is recommended to fit a discharge vent valve so that CO₂ 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 CO₂ 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 and -17 °C, 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 causes 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.