THE LINDE GROUP

Safety advice.

Cryogenic liquefied gases.

Properties

Cryogenic Liquefied Gases are also known as Refrigerated Liquefied Gases or Deeply Refrigerated Gases and are commonly called Cryogenic Liquids. Cryogenic Gases are cryogenic liquids that have been vaporised and may still be at a low temperature.

Cryogenic liquids are used for their low temperature properties or to allow larger quantities to be stored or transported. They are extremely cold, with boiling points below -150°C (-238°F). Carbon dioxide and Nitrous oxide, which both have higher boiling points, are sometimes included in this category. In the table you may find some data related to the most common Cryogenic Gases.

	Helium	Hydrogen	Nitrogen	Argon	Oxygen	LNG	Nitrous Oxide	Carbon Dioxide
Chemical symbol	He	H_2	N_2	Ar	O_2	CH_4	N2O	CO_2
Boiling point at 1013 mbar [°C]	**-269**	**-253**	**-196**	**-186**	**-183**	**-161**	**-88.5**	**-78.5****
Density of the liquid at 1013 mbar [kg/l]	0.124	0.071	0.808	1.40	1.142	0.42	1.2225	1.1806
Density of the gas at 15°C, 1013 mbar [kg/m^3]	0.169	0.085	1.18	1.69	1.35	0.68	3.16	1.87
Relative density (air=1) at 15°C, 1013 mbar *	0.14	0.07	0.95	1.38	1.09	0.60	1.40	1.52
Gas quantity vaporized from 1 litre liquid [l]	748	844	691	835	853	630	662	845
Flammability range	n.a.	4%–75%	n.a.	n.a.	n.a.	4.4%–15%	n.a.	n.a.

Notes: *All the above gases are heavier than air at their boiling point; **Sublimation point (where it exists as a solid)

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Hazards

Cold Burns – Skin and Eyes

Cryogenic liquids are extremely cold and will cause severe and immediate cold burns to the unprotected skin or eyes.

Any direct contact with cryogenic liquids, uninsulated pipes or equipment will cause cold burns and tissue damage, the cold burn itself is similar to that of a burn from a hot source and will destroy tissue. A jet of cryogenic gases may also freeze the skin or eyes.

Cold Embrittlement

Certain types of rubbers, plastics and carbon steels, will at cryogenic temperatures become brittle so that very little stress may already cause the material to fail. Metals such as stainless steels, aluminium, brass, copper, and certain types of plastics do not have a brittle transition and may remain ductile at low temperatures. Therefore, it is important to choose a material suitable for the product and temperature.

Humidity/ Moisture

The cold nature of cryogenic liquids or gases may cause freezing of any humidity or moisture present in vessels, pipes or equipment which could cause blockages due to the formation of ice, safety valves, pressure gauges, instrument lines or stop valves etc. from operating correctly.

Pressure Build-up and Rupture

If a cryogenic liquid is trapped in a container, high pressures of pipes or equipment can build up very rapidly. This is due to the cryogenic liquid being vaporised into a gas by the absorption of thermal energy from the warmer surroundings. Without proper venting or installing pressure-relief devices correctly, the pressure build-up may lead to a catastrophic rupture or failure of the equipment.

Oxygen Deficiency

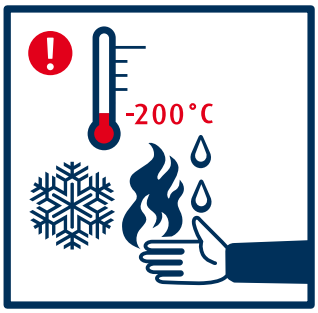
When inert cryogenic liquids evaporate, such as liquid Nitrogen, liquid Argon, or liquid Helium, one litre of liquid produces approximately 690 to 850 litres of gas. These large volumes of gas can very quickly lead to oxygen deficiency unless there is adequate ventilation. See the relevant Safety Advice “Oxygen deficiency”.

Oxygen Enrichment

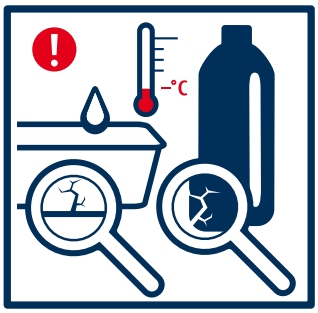
When liquefied oxygen evaporates, one litre of liquid produces approximately 850 litres of gas. These large volumes of gas can very quickly lead to oxygen enrichment unless there is adequate ventilation. See the relevant Safety Advice “Oxygen enrichment”.

Flammability

When flammable cryogenic liquids evaporate, such as liquid Hydrogen, or LNG, one litre of liquid produces approximately 630 to 850 litres of gas. These large volumes of gas can very quickly lead to a flammable atmosphere unless there are adequate controlling measures in place e.g. monitoring systems, shut-off devices and ventilation.

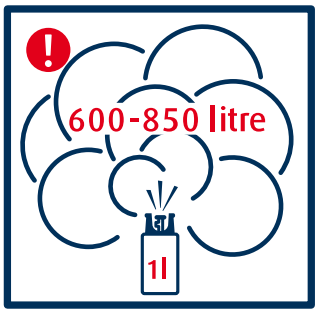


Naked or insufficiently protected parts of the body coming into contact with cryogenic liquefied gas may cause serious cold burns.



Materials, e.g. most plastics, ferritic steels are embrittled due to the effects of low temperatures.

The cold nature of the cryogenic liquefied gas may cause freezing of any moisture or humidity which may cause failure of safety valves or pressure gauges.



One litre of liquid gas produces approximately 600 to 850 litres of gas.

Precautions

- Ensure containers are properly labelled to identify the cryogenic liquid inside
- Do not mix different cryogenic liquids or change the use of containers without a recognised procedure
- Decanting cryogenic liquids must only be done by trained operators using approved procedures
- Use Personal Protective Equipment (PPE) suitable for very low temperature to protect skin and eyes
- External pockets, trousers or overalls tucked into boots must be avoided
- Remove any metallic jewellery or watches on the hands and wrists as, if they come into contact with cold gases, the metallic parts can freeze to the skin
- Do not permit smoking or open flames in any area where Oxygen, Hydrogen or LNG is stored, handled or used
- To avoid oxygen deficiency or enrichment while working in a confined area, a permit to work must be used
- To avoid flammable or explosive atmospheres while working in a confined area, a permit to work must be used
- Only materials suitable for cryogenic temperatures and the product must be used in contact with cold temperature liquids or gases
- Do not dispose of cryogenic liquids via drains
- Users must ensure that cryogenic liquids are never trapped in a closed system, and that suitable relief systems are provided
- Do not use a plug or any other device that would interfere with venting of gas from a protective device
- Vessels, pipes, and equipment must be thoroughly dried to remove moisture before cryogenic liquids or gases are introduced

Emergency

Cryogenic liquefied gases may be flammable, oxidiser or asphyxiant in high concentrations. Leaks should be approached when a self contained breathing apparatus is worn. Exposure to a fire may cause containers to rupture/explode. Damaged containers should be handled only by specialists

Spill or leak

1. For Oxygen, keep combustible materials, wood, paper, hydro carbons, asphalt etc. away from the spilled material
2. For flammable gases, all ignition sources should be removed
3. Do not touch or walk through spilled products
4. Stop leaks, if possible
5. Do not direct water at the spill source of the leak or any protective devices
6. Use water spray or fog to reduce or divert a vapour cloud
7. Prevent cryogenic liquids or gases from entering into waterways, sewers, basements or other confined areas
8. Allow spilled cryogenic liquids to evaporate
9. Isolate the area until the cryogenic liquid or gas has dispersed

First aid

1. Inhalation: remove victim to uncontaminated area and fresh air
2. Skin or eye contact with cryogenic liquid: in case of frostbite or cold burn, spray with or place in lukewarm water for at least 15 minutes. Do not remove adhered clothing. Apply a sterile dressing. Obtain medical assistance. Immediately flush eyes thoroughly with lukewarm water for at least 15 minutes

Fire

1. Use an extinguishing medium suitable for the type of fire
2. Remove containers to safe area, if safe to do so
3. Cool containers with water from a protected position. Exposure to a fire may cause containers to rupture.
4. Do not direct water at the source of a leak or any protective devices.
5. Advise the Fire Services of the location of containers and their contents

Refer to the relevant Safety Data Sheet for further information / Contact your local Linde supplier for specific questions.

Proper clothes and personal protective equipment e.g. gloves and safety shoes must be worn.

Permission to enter a confined space shall be given only after the issue of an entry permit.

Cylinders exposed to fire must be cooled from a protected position.

The safety data sheet informs users about chemical and physical properties of a material and its generic use, provides advice on the safe handling, storage, transport, use and disposal of the material, provides information about the health effects, exposure control, environmental effects and emergency procedures.