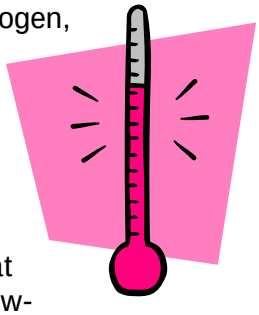
Cold Embrittlement

What is cold embrittlement?

Cold embrittlement is a condition that occurs when a material is subjected to temperatures that make it less resilient, and therefore more brittle.



It is therefore a potential hazard when handling our liquid products such as nitrogen, oxygen or argon. The temperatures of these products are very low; liquid nitrogen, for example, is -195°C, liquid oxygen is -183°C and liquid argon is -185°C at atmospheric pressure. A similar risk exists with any extremely cold gas or with dry ice, which can form if carbon dioxide has a sudden drop in pressure below 60 psig.

The potential for material to become brittle depends on the type of material that is subjected to these low temperatures. Some materials, such as carbon and low-alloy steels will become brittle at low temperatures and therefore susceptible to damage ranging from cracking to shattering or disintegration of equipment. Other materials, such as stainless steels, aluminium, brass, copper or high-nickel alloys may be used at very low temperatures without becoming brittle.

What are the potential consequences?

When a material becomes brittle, the consequences can be very serious. If the brittle material is subjected to an impact or an equivalent shock (ex. rapid pressurization) the combination could potentially lead to a catastrophic failure under certain conditions.

Equipment failure can cause serious damage or injury. It may also interrupt the availability of the gas supply, and therefore create an additional hazard, such as stopping the flow of oxygen to a hospital.

It is important to keep in mind that any product released due to cracking or to more serious equipment failure, may have dangerous inherent properties. Oxygen or flammable gases released into the atmosphere could accelerate fires, while asphyxiants such as nitrogen or argon may produce an oxygen-deficient atmosphere, creating a serious risk of injury or death: anoxia[1].

What are the best means of prevention?

For customers using product at very low temperatures, the following steps can minimize the risk of material becoming brittle:

a) First, when handling gas products at very low temperatures (cryogens or dry ice), always wear appropriate protective clothing. Not only can the product make certain materials brittle, but it can also cause serious cold burns to exposed skin or eyes.

b) Ensure that all equipment that comes in contact with the product can withstand very low (cryogenic) temperatures. Check with your supplier that equipment such as vessels, buffer tanks, piping, flexible hoses or transfer vessels are appropriately rated. Any non-metallic materials that are likely to come into contact with cryogenic products must also be evaluated before use.

c) Connect liquid cylinders only to approved equipment, even if you are using the vapour phase.

d) Ensure that any pressurized equipment is being operated at the correct pressure rating and according to the manufacturer's operating instructions.

e) If a cylinder of carbon dioxide has a significant, rapid drop in pressure (below 60 psig), avoid suddenly re-pressurizing it, as the material may have become brittle and might explode.

f) Inspect liquid cylinders regularly for leaks or frost spots, and send any damaged or malfunctioning cylinders to a qualified repair facility.

g) If liquid spills onto a surface or equipment, repair or replacement may be required. Consult the supplier or a qualified repair facility.

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[1] More information can be found in the "Anoxia" brochure, published by Air Liquide Canada, 2006.

Further information can be found in Compressed Gas Association pamphlet: CGA P-56 "Cryogenic Vaporization Systems – Prevention of Britle Fracture of Equipment and Piping"