THE LINDE GROUP

Safety Advice. 16 – Handling refrigerated liquefied nitrogen in transportable cryogenic receptacles.

Preliminary note

Low-temperature liquid nitrogen (LIN) is frequently transported and stored in transportable cryogenic receptacles. Such receptacles can be closable pressure vessels suitable for excess pressure or open Dewar vessels that are not pressurized.
To avoid accidents during the handling of transportable LIN cryogenic receptacles, certain properties of low-temperature liquid nitrogen must be considered and appropriate precautions taken.

Activity	Dangers	Precautions
Handling of cryogenic nitrogen (LIN) 	**Oxygen deficiency** When it vaporizes, 1 litre of LIN produces approx. 700 litres of gaseous nitrogen. When the concentration of nitrogen increases in the air, the concentration of oxygen decreases, i.e. there can be an oxygen deficiency that cannot be detected by the human sense organs. Persons in contact with an atmosphere deficient of oxygen (less than 17% vol. O2) may become unconscious suddenly without any warning and may suffocate. This risk is seldomly present in the open air. However, this danger must be remembered in rooms with LIN equipments, in particular with open cryogenic receptacles.	Cryogenic receptacles filled with LIN should only be transported in vehicles if • they are approved for road transportation, • they are secured in the vehicle so that they cannot fall over, • the loading area is open or ventilated. Rooms with LIN cryogenic receptacles must be sufficiently ventilated. Mechanical ventilation with defined incoming and outgoing airflows is to be preferred. The outlets for outgoing air must be located in the lower region of the room as vaporizing nitrogen is cold and heavier than air and thus spreads mainly at floor level. Inlets and outlets for air should not be closed. The rooms can be fitted with an automatic warning device for oxygen deficiency, the sensors being located in the lower region of the room. Alternatively, staff can wear oxygen deficiency warning devices. Such warning devices should be chosen depending on the local circumstances and the operating conditions.
Handling of cryogenic nitrogen (LIN)	**Pressure** LIN automatically absorbs heat from its surroundings and changes into the gaseous state. The vaporization of LIN in an enclosed space causes the pressure to increase. If the pressure	Cryogenic receptacles that do not have any marks indicating the permissible internal excess pressure should only be filled without pressure. The filling pipe or hose must be inserted loose into the container opening and the liquid nitrogen must flow out freely into the container. The filling opening or a second opening must remain partially open during filling so that the vaporizing nitrogen can escape.

Activity	Dangers	Precautions
	cannot be released, the part of the equipment concerned can burst.	Non-pressurized containers containing LIN should only be closed with a loose lid or plug to allow pressure equalization with the surrounding atmosphere. Cryogenic receptacles that are suitable for internal excess pressure have appropriate markings. They are usually filled through a pipe with a secure screw connection. The preliminary pressure with which the liquid is fed into the cryogenic receptacle should not exceed the permissible internal excess pressure. No water should be allowed to enter the cryogenic receptacle containing LIN so that the container does not become blocked by ice. Pipe sections carrying LIN that can be shut off must have a safety valve. LIN should not drain into the ground in large quantities. The vaporizing nitrogen can become enclosed in the ground due to the formation of ice and it may then expand explosively.
Umgang mit tiefkalten Stickstoff (LIN) 	Cold Refrigerated liquefied nitrogen has a temperature of approx. -196°C (boiling point at an ambient pressure of 1 bar absolute). If the refrigerated liquid comes into contact with human skin, cold burns can occur. Large cold burns can be life-threatening. Some materials have reduced ductility and toughness at low temperatures, i.e. they become brittle and can break and are thus not suitable for LIN. Materials that are cooled by LIN shrink. If such a cooling object is clamped securely, it is prevented from shrinking. In this case the material can break. Air condenses on parts of machinery that contain LIN and that are not insulated (e.g. pipes on LIN tanks). Condensate drips become enriched with oxygen - because the nitrogen content vaporizes again. If this oxygen-enriched condensate penetrates into a flammable solid (e.g. wood or organic insulation material), there is an increased risk of fire.	When handling LIN directly (e.g. filling procedures), personal protection should be worn (dry clothes covering the entire body, closed safety shoes, gloves, goggles). Cryogenic receptacles with LIN should be transported so that they cannot fall over or down. A load safeguard is required during every transportation. Equipment that is intended for the direct handling of LIN must be made of cold-resistant material (e.g. non-rusting, austenite steel = stainless steel, copper, aluminium). Organic materials such as wood, plastic, rubber are unsuitable. LIN should not leak on concrete floors because concrete is damaged by the cold. The floor around filling sites can be protected with a trough made of stainless steel in which LIN drips can collect and vaporize. The floor beneath uninsulated parts of LIN equipment must be made of nonflammable material in order to exclude the risk of fire as a result of oxygen enrichment.

Activity	Dangers	Precautions
Handling of cryogenic nitrogen (LIN) 	Filling LIN	Unless automatic, the filling of LIN into cryogenic receptacles must be carried out under constant surveillance and must be stopped at the right time so that no liquid leaks into the room or into the open air. Filling can be controlled by a safety switch consisting of a dead-man's switch and a solenoid valve in the filling pipe. The solenoid valve only allows a flow of LIN to the cryogenic receptacles as long as the dead-man's switch is pressed at regular intervals. Stationary cryogenic receptacles can have an automatic level control to reliably prevent overfilling. For filling procedures written operating instructions from the employer must be present that include information on handling LIN safely and avoiding dangers and hazards to health. When these operating instructions are written, the operating instructions of the cryogenic receptacle manufacturer should be taken into account. The latter contains information on the intended use and the proper maintenance of the cryogenic receptacles. Staff who fill containers with LIN must be informed of the contents in the operating instructions.
Transport in vehicles	Transport accidents	Transport of LIN in cryogenic vessels is only allowed when: – the vessel is designed and approved for transport by road – the vessel is firmly secured against traffic incidents – the load space of the vehicle is sufficiently ventilated.

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