Safety Advice. 24 – Supplying Gases to Supra Conductive Magnets.

1. Introduction

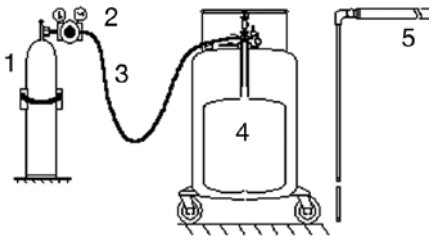
The Supra Conductive Magnets are used at hospitals in magnetic resonance imaging of patients (MRI) and when analyzing the structure of chemical compounds with nuclear magnetic resonance (NMR) spectroscopy. The supra conduction needs a temperature of very close to –273 °C which in turn requires that the magnet is cooled by liquid helium. Liquid nitrogen is occasionally used to pre-cool the magnet at startups. Furthermore, gaseous helium is commonly used to pressurize the transportable cryogenic receptacle (liquid container) at the transfilling but recent development at Linde has resulted in a container with internal pressurization system.

2. Responsibility

Each Linde Gas operative unit supplying gases to MR magnets shall ensure that the personnel involved in this has a good knowledge of the risks and needed precautions to carry out the work safely. The intention of this paper is to serve as a guideline for the parts of the work instructions and / or information material describing the risks and the precautions, which are developed in each local operative unit. Note that it is needed to complete this paper with a description of the equipment, tansfilling procedure and other local circumstances depending on the used dewar, MR machine, etc. These instructions address mainly supply of gases to the medical application MRI but can also be used at the other MR applications.

3. Supply of Liquid Helium

Below please find the typical system for filling liquid helium into the MR. A transfer siphon must be introduced in the LHe container and the container must be pressurized with gaseous helium. Note that the introduction of the siphon requires an appropriate room height. Some Linde dewars are equipped with a new Linde system where the dewar has a permanently installed submerged pipeline with a coupling for connection to the LHe transfer line. In this case, there is no need for a considerable free space above the dewar. Furthermore, this new development of liquid containers can also offer an internal helium pressurization system which eliminates the need of the gaseous helium cylinder and the corresponding installation.



1, 2, 3: System for pressurization of the liquid helium container
4: Liquid helium container
5: Vacuum insulated filling siphon

3.1. Liquid Helium and Nitrogen Containers

The liquid helium as well as the liquid nitrogen occasionally used, are delivered in cryogenic containers with a weight of between 100 and 500 kg. It comprises of a stainless steel inner container encased within an outer stainless steel shell. The typical insulation system between the inner and outer containers consists of multi-layer insulation and high vacuum. The inner shell is, for liquid helium containers, fixed to the outer shell mainly by the neck – a very sensible design required to minimize the heat losses. The container is non-magnetic which allows the use near a strong magnetic field.

3.2. Handling of the Liquid Containers

- The container must be handled with care to avoid any damage of it. If it is inclined too much, bumped too hard or otherwise exposed to too high forces, the neck can crack. The liquid container will then loose its insulation properties and must be taken out of service.
- Gloves and eye protection must be used to avoid injuries if the safety valve would release the gas. Safety shoes shall be used to protect from foot injuries.
- The container is equipped with wheels to facilitate the handling. Ensure that the wheels and the floor are in good condition.
- The wheels should be locked when the container is parked for transfilling or any other reason.
- When the container is transported in an elevator, no person should accompany the container in the elevator. A sign "Do not enter" should be placed on the container to prevent other persons to enter the lift.

3.2. Handling of the Gas Cylinders

- Safety shoes shall be used when transporting cylinders to protect from foot injuries. Gloves are recommended.
- Gas cylinders with a size of 20 litres or more should be transported by using a cylinder cart.
- Secure gas cylinders to prevent them from falling.
- Ensure that the cylinder valve is closed and leakproof. Put on the valve cap.

For further advice see Safety Advice 7, "Safe Handling of Gas Cylinders and Cylinder Bundles".

4. Gas Properties and Risks

The liquid helium has a temperature of –269°C and the liquid nitrogen –196°C. The three main risks are discussed below.

4.1. Respiratory Hazards

The two gases helium and nitrogen are colorless, odorless, non-toxic and non-flammable but will, when released, decrease the oxygen concentration in air. The oxygen concentration must not be below 19 % in the working area and if it reaches 15 % the physical and intellectual efficiency is reduced. At concentrations below 10 % there is a risk of immediate fatal injury. The asphyxiation effect takes place rapidly and without any clear signs that could alert the victim.
In areas where a considerable gas release could be expected, it should be considered to install alarms for oxygen deficiency and ventilation failures. Note, that the low temperature of the gases results in a rapid evaporation at room temperature.
If the transfilling is carried out by only one person present, a mobile alarm for low oxygen content in the air shall be carried. For further information see Linde Gas Safety Advice 3, "Oxygen Deficiency".

Low temperature warning

4.2. Cold Burn Hazards

Cryogenic liquid gases or cold vapor can produce effects on the skin similar to burns. The severity will vary with the gas, the temperature and the time. Naked or insufficiently protected parts of the body coming in contact with un-insulated pipes or equipment will stick by virtue of the freezing of available moisture and the flesh will be torn in removal.
To avoid cold burn, eye protection and gloves shall be used when there is a risk to get in contact with the cold gas. Gloves and suitable protective clothing shall also be used when handling the cold equipment.
For further information on the hazards and first aid actions when handling liquid gases, see Linde Gas Safety Advice 1, „Handling of Cryogenic Liquefied Gases".

4.3. Gas Expansion Hazards

If the cryogenic liquid gas becomes sealed off in a section of the transfer line or hose and is left to evaporate, the pressure will increase considerably. The pressure usually will exceed the bursting pressure of the system and a sudden burst will occur which might result in serious injuries.
The MR equipment and the liquid container are equipped with safety valves to ensure that any excessive pressure can be released.

5. Risk Caused by the Magnetic Field

The magnet generates a very strong magnetic field which can violently move metallic things (if magnetic) so rapidly, that a person if hit by a heavy object can be fatally injured. The magnetic field will attract all magnetic material (carbon steel, etc.), not only big objects as gas cylinders, fire extinguishers, tools, etc. but also ball pens, clips, metallic objects in the body, etc..
The MR has been used for many years and the experience shows there is no health effects of being in the vicinity of such magnetic field. Nevertheless, the following precautions must be taken:

- Personnel exposed for the strong magnetic field should previously have gone through a medical examination.
- Persons using pacemaker, defibrillators, hearing aids or other devices as well as persons with metallic screws or plates in the body should not be exposed for the high magnetic field.
- Person with heart arythmi, blood deficiencies and some spasm diseases as well as pregnant women shall not be exposed for the high magnetic field.
- Safety shoes shall not have any magnetic parts.
- Credit cards, security cards, electronic circuits, etc. will loose the magnetic information if exposed to the strong field.
- Transfilling of liquid helium must not take place when the MRI is in use.
- Gas cylinders made of steel must not be used or stored in the MR room or otherwise close to the magnet. It has happened that, at an emergency, an aluminium cylinder was brought into the MRI room and an incident occurred while the cylinder regulator partly was made of magnetic steel.
- Magnetic materials, including tools and pencils, must not be brought into the MR room.
- Any emergency equipment, which should be brought into the MRI room must be made of non-magnetic material and clearly marked accordingly.
- The transfilling must be done according to the manual of the MRI producer.

6. Other Risks

- During the transfilling, the liquid helium container shall be pressurised by gaseous helium. The transfer must be stopped before any gaseous and warm helium reaches the coil creating a risk of quench. If this occurs, the resistance and temperature of the coil will suddenly increase and generate huge amounts of gaseous helium causing a risk of asphyxiation.
- If the external surface of pipes and other equipment reaches cryogenic temperatures, the surrounding air will condense and there is a risk of oxygen enrichment.
- Air ingress in the connections and pipes of the dewar should be prevented to avoid the risk of ice plugs and / or contamination.

7. References

- Safety Advice 1, "Handling of Cryogenic Liquefied Gases"
- Safety Advice 3, "Oxygen Deficiency"
- Safety Advice 7, "Safe Handling of Gas Cylinders and Cylinder Bundles"
- Liquid helium – essential for research, technology and medicine. Publ. No 8769/9

The Safety Advices are available at the SEQ Service Notes database. The publication 8769/9, available in English and German, can be ordered from bernd.vogler@linde-gas.com.

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