Rules for handling liquid helium cryostats

1. Introduction

When working with He-cooled cryostats, the following rules must be observed for safety reasons and to minimise consumption:

Cryostats:

The cryostats must be connected in accordance with the operating instructions of the manufacturer. The entire setup with helium can, transfer pipe, cryostats, any helium pump and exhaust pipe may only be put into operation together with the beamline manager.

By connecting a helium balloon, it must always be visible that the can is under slight overpressure. If a helium pump is used to pump through the helium, it must be helium-tight and equipped with an oil separator at the exhaust.

Helium return line:

A helium recirculation line is permanently installed in the FS laboratories which collects the helium exhaust gas and directs it to the DESY gas service. The exhaust line or the outlet of the helium pump is connected to this line via a non-return valve and a pressure relief valve. The exhaust pipes of the helium cans can also be connected here. Make sure that the exhaust pipe is tightly closed when not in use and that no air is pumped into it. A gage measures the air content of the helium. When the helium is contaminated, it is then blown into the hall instead of being sent to the gas service.

Order of Helium cans:

Qualified persons (e.g. beamline engineers/beamline staff, who are trained in the use of cryogenic gases) ask the “Gasabrufberechtige” (Technical Hall Service) to order the liquid helium required by the user. It takes about a week from order to delivery. The hall service only forwards the order if he has ensured that the customer is a Qualified Person* and trained in the use of helium. This means that the present rules for handling helium are accepted and signed. On delivery, the cans are provided with name tags and only the cans procured under one's own name may be used. The customer is responsible for the proper handling of the jug.

2. Special properties of liquid helium

Liquid helium has a boiling temperature of 4.21 K at 1 bar. All other gases are only present in the solid phase at this temperature and pressure. The critical point for helium is 2.275 bar and 5.201 K. As the following table shows, helium has the lowest evaporation heat of all gases:

ΓHe = 2,56	kJ/ltr	at 1 bar
ΓH2 = 31,56	kJ/ltr	at 1 bar
ΓN2 = 160,82	kJ/ltr	at 1 bar
ΓO2 = 243,25	kJ/ltr	at 1 bar

The density of liquid helium at the boiling pressure of 1 bar and the corresponding boiling temperature of 4.21 K is only 125.2 g/ltr.
The density of helium vapour at the specified boiling pressure of 1 bar is 16.66 g/ltr.
The density of helium at the critical point (2.275 bar and 5.021 K) is still 69.64 g/ltr.
In contrast, the density of helium at 1 bar and 15 °C is only 0.167 g/ltr.

Liquid helium in a dewar is a boiling liquid. Since the external environment is much warmer, a small amount of heat energy flows constantly into the dewar, evaporating the liquid helium inside. This so-

called evaporation loss is 1-2 percent per day. But there is another reason for the evaporation of helium.

If the pressure of a boiling liquid is lowered, the temperature also drops. The relationship between boiling pressure and boiling temperature is described by the vapour pressure curve. The reduction in temperature associated with the reduction in vapour pressure leads to the evaporation of a certain proportion of the liquid helium. A drop of the air pressure, e.g. by 50mbar (approaching thunderstorm) leads to an irreversible liquid helium loss of 1.25 % of the liquid helium quantity in the dewar.

If, for example, the dewar is stored at a pressure of 1.2 bar and has to be depressurized in order to insert the siphon, an irreversible loss of at least 5% of the liquid content will occur.
Due to the relatively low density ratio of liquid helium and cold helium vapour, a 5-fold greater loss can easily occur in practice due to the entrainment of liquid droplets.

3. Conclusions to be drawn from the special properties of helium

(a) A helium dewar shall not be locked for an extended period of time. Depending on the degree of filling, the pressure could theoretically rise to a value of more than 800 bar. This is not possible in practice, because the Dewar will burst at much lower pressures. By the way, the pressure in the dewar can only increase to values of 7.5 bar by evaporating the helium alone without warming up.

b) No liquid can be taken from the Dewar with a pressure > 2.275 bar, only cold gas.

c) If possible, liquid helium should be stored at a low overpressure. The closer the pressure is to the critical pressure, the greater the evaporation loss.

d) The exhaust pipe should be as long and angled as possible, because liquid helium acts like an extremely absorbent cryogenic pump. This means that other gas molecules can also enter a cold helium dewar in the opposite direction to the outflowing helium gas. There they freeze and collect in the neck tube or on the bottom of the can.

e) If a helium dewar is frozen in the neck, i.e. if the boiling liquid has no connection to the environment, there is a danger of explosion. These high pressures can build up. In this case it is absolutely necessary to contact the Technical Emergency Service (2500). The neck of the dewar must be reopenend as quickly as possible, i.e. within 3-5 hours (mechanically or with dry gaseous helium).

(f) Protective work clothing
Solid shoes, cryo-gloves and safety glasses (protective shield) can protect against possible injuries, especially "burns" on the hands or on the cornea of the eyes etc.

***Qualified Person (= requester in gas order form “Lagerabrufschein”)**
A Qualified Person is a person who, through his or her vocational training, professional experience and prompt professional activity, has the necessary specialist knowledge for handling gases. These can be the responsible persons (e.g. beamline manager) or persons determined by them, e.g. beamline engineers or other persons. In addition to their qualification, they must have appropriate training in gas safety ("Lindeschulung" or MEA6 training).
Qualified Persons are allowed to request gases via the “Gasabrufberechtigte”. The Qualified Person concerned is named on the label of the gas cylinder as the customer. Starting with the transfer from the delivery box to its destined gas cabinet, the customer named on the label is responsible for the safe handling of the gases. They also instruct the users in the use of the gases and gas fittings

Safety Instruction: Use of helium cryostats

I hereby certify that I was briefed in the use of helium cryostats.

Trainer:

Date	Name	Signature