ISBN: 978-3-95450-207-3 doi:10.18429/JACoW-MEDSI2018-TUPH30

ALBA SYNCHROTRON LIGHT SOURCE LIQUEFACTION HELIUM PLANT

M.Prieto†, Y. Nikitin‡, C. Colldelram§, J. Casas#
ALBA Synchrotron Light Source, 08290 Cerdanyola del Vallès, Spain

Abstract

ALBA is a 3rd generation Synchrotron Light facility with: 8 operational Beam Lines (BLs), a 2nd BL of Phase II under construction and 3 first Phase III BLs in design phase. Some user experiments require Liquid Helium (LHe) as a coolant. The resulting LHe consumption at ALBA is about 650 l/week.

Thus far the vaporized helium, which results from the refrigeration of experiments and equipment, has been released into the atmosphere without being reused. Due to the increasing price of LHe, ALBA agreed with ICN2 (Catalan Institute of Nanoscience and Nanotechnology) to invest in a Liquefaction Helium Plant. Internal staff has carried out the project, installation and pressure equipment legalization of the plant, which is located in a new 80 m^2 construction. Under operation the plant allows recycling up to 24960 litres of LHe per year, which is an 80% of the helium consumed at ALBA, by making the gaseous helium undergo through 3 main stages: recovery, purification and liquefaction.

The plant, unique in Catalonia, will entail cost savings about 77% and will reduce vulnerability to supply disruptions. ICN2 will benefit from a part of the production due to their initial investment.

SIGNIFICANCE OF RECYCLING HELIUM

Due to the fact that helium is an inert gas and it has a really low boiling-point (-268.93 ºC) [1], it is used in a wide range of applications.

Once gaseous helium is released into the atmosphere there is no economical way to recovery it, because most of it escapes into the space; leading to a very low and relatively constant atmosphere helium concentration of only 5.2 ppm [2], which is too low so as to separate it from air. By contrast, the highest helium content is in a few natural gas fields around the globe.

Owing to the balance between increasing demand and helium availability, helium is a finite non-renewable resource. Thus, gaseous helium should be recovered.

OPERATION

So as to meet ALBA's liquid helium demand, the plant subjects the vaporized helium to 3 stages: **recovery**, **purification** and **liquefaction**.

† mprieto@cells.es
‡ ynikitin@cells.es
§ ccolldelram@cells.es
# jcasas@cells.es

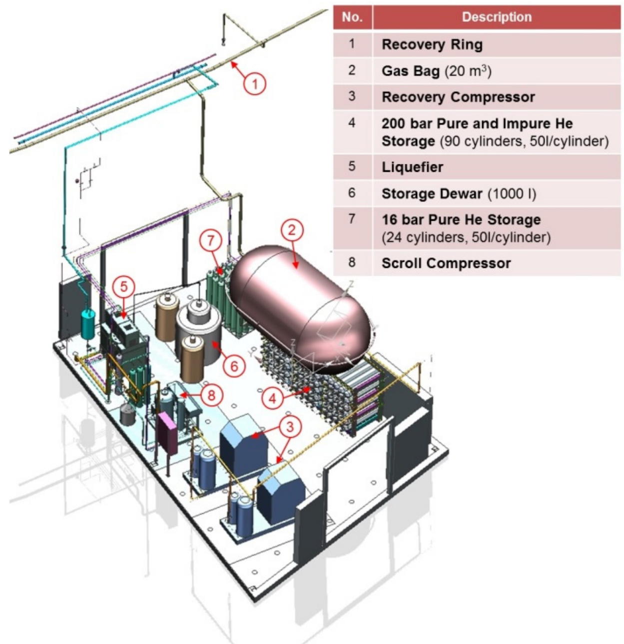

Figure 1: Liquefaction Helium Plant (LHeP) equipment identification.

Recovery

The **recuperation** initiates when the vaporized helium, which results from the thermal exchange between the liquid helium and the beamlines' components to cool, is slightly heated and inserted in the 400 m perimeter **recovery ring** that carries the gaseous impure helium to a **20 m^3 gas balloon.** The helium warm-up is vital prior to being introduced into the recovery ring in order to avoid damaging the canvas, which composes the 20 m^3 gas bag, because it cannot handle extreme temperatures. The helium stored in the balloon is compressed up to 200 bar by the **recovery compressor** for the purpose of saving space as well as averting the bag's collapse. The resulting 200 bar helium is stored in the **200 bar impure helium storage** (see Fig. 1 and Fig. 2).

Purification

Prior to liquefying this gas, it must be purified by the **liquefier**'s internal purifier (see Fig. 2) that is capable to clean helium gas with up to 10 % air impurity. Thus, once the 200 bar storage contains a reasonable amount of impure helium, the **purification** commences starting the **liquefier** up.

The liquefier's purifier works as long as it is cooled below pre-set temperatures, which can solely be reached by circulating cold pure helium through it. The required pure helium is sucked of the **16 bar pure helium storage**,

ISBN: 978-3-95450-207-3 doi:10.18429/JACoW-MEDSI2018-TUPH30

which is at room temperature. So this reserve's content (16 bar pure helium) must be chilled before flowing through the purifier, otherwise, this pure gas would not be able to cool the purifier down. In order to decrease pure helium's temperature, the liquefier:

- can optionally use liquid nitrogen so as to speed the cooling up,
- removes heat using the main heat exchanger and,
- carries out consecutive expansions of this gas (see Fig. 2).

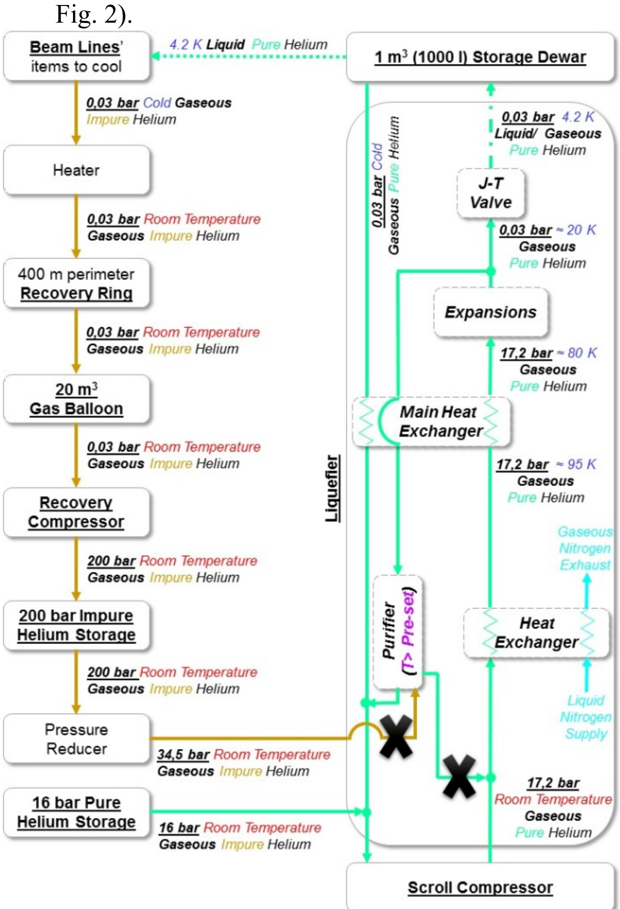

Figure 2: Plant's flow diagram when liquefier's internal purifier is not cooled below pre-set temperatures.

Therefore, before going through the successive expansions, the pure helium has to be compressed by the **scroll compressor** that delivers 17.2 bar to the liquefier where the gas is cooled (by means of the above-mentioned processes). As it is shown in Fig. 2, the resulting 17.2 bar cold pure helium stream flows though the liquefier's purifier so as to hit its pre-set temperatures. Hereafter the liquefier stops sucking the gas of the 16 bar pure helium storage and starts working with the gas of the 200 bar impure helium storage with the aim of starting the plant's final stage: the **liquefaction**.

Liquefaction

As it is shown in Fig. 3, the sucked 200 bar impure helium is led to the liquefier's internal purifier so as to remove its impurities. Then, the purified helium undergoes the different expansions that take place inside the liquefier and gets colder. The cold pure helium eventually is subjected to a final expansion that takes place inside in the Joule-Thomson (J-T) valve, where the gas cools below -268.93 ºC, that is to say, 4.2 K. The resulting liquid/gas mixture flows through into the **1000 l storage Dewar**, but the gaseous portion comes back into the liquefier so as to be cooled and liquefied.

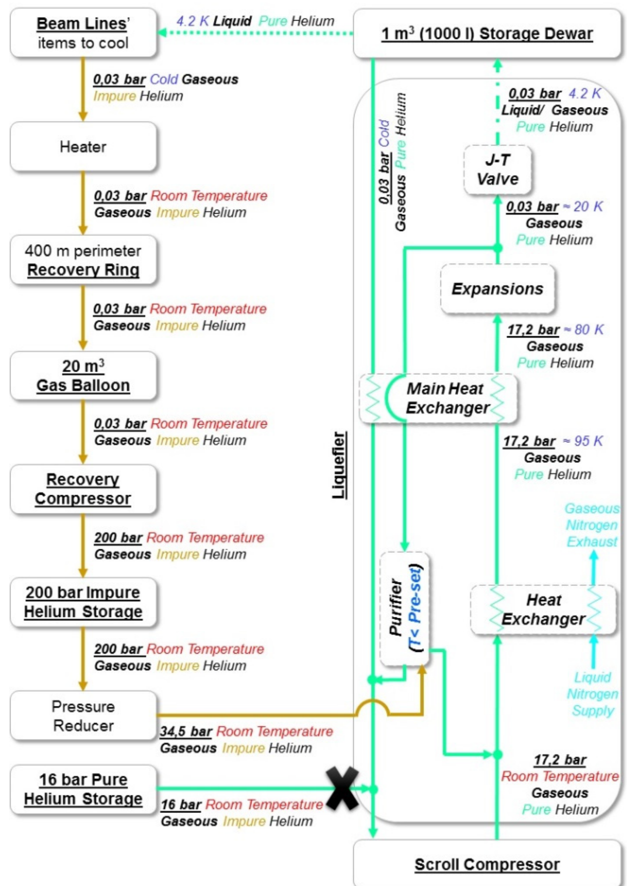

Figure 3: Plant's flow diagram when liquefier's internal purifier is cooled below pre-set temperatures.

PRODUCTION MANAGEMENT

Taking into account that the plant's liquid helium production is about 24 l/h, the strategy plan is to store the recovered gaseous helium in the 200 bar impure helium storage for two weeks. After that, 3 days will be spent to liquefy helium so as to ensure the liquid helium demand for a week.

BENEFITS

The plant allows recycling up to an 80% of the helium consumed at ALBA and implies cost savings about 77%.

Consequently, in institutions than use a significant amount of liquid helium, recovery and re-liquefaction of helium not only entail significant long-term returns but

ISBN: 978-3-95450-207-3 doi:10.18429/JACoW-MEDSI2018-TUPH30

also reduce vulnerability to supply disruptions. For instance, ALBA's Liquefaction Helium Plant can ensure from now on enough helium for 2 weeks without any new supply.

Despite the economic benefit and the fact that ALBA owns the single liquefaction helium plant in Catalonia, **ALBA will not supply liquid helium to external companies**. Nonetheless, a percentage of its production will be delivered to ICN2 as a result of their investment on the plant.

Last but not least, ICN2 also contributed money to the plant's training that has already been performed by a field service supervisor. This course entailed the installation check, commissioning and the plant's operation modes training.

ACKNOWLEDGEMENT

The author appreciates the technical advice and support as well as the superb installation task to ALBA's workshop chief, José Ferrer, and his crew. An example of their outstanding work is the 400 m perimeter ring, which has about 100 weld beads.

REFERENCES

[1] LINDE, http://www.lindeus.com/en/products_and_supply/helium/index.html

[2] B.M. Oliver, J. G. Bradley, "Helium concentration in the Earth's lower atmosphere", *Geochemica et Cosmochimica Acta*, vol. 48, Sept. 1984, p. 1759-1767.