GSI Helmholtzzentrum für Schwerionenforschung GmbH

Document Title

Common Specification Refrigerator

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Abstract

This document describes the refrigerators, which will supply liquid and gaseous helium at subatmospheric temperatures for FAIR which are part of the common cryogenic system.

FAIR Division/Group/Supplier
GSI-MT-Department

Prepared by:
Kauschke

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1. Purpose and classification of the document

This document gives in overview on the demands for refrigerator and liquefier at FAIR site which belong towards the common system. In the further document liquefier are covered by the term refrigerator.
Not covered by this document is any refrigerator that is dedicated towards a special user and is not operated by the common systems.

2. Scope of the technical System

2.1. System Overview

As given in Figure 1 the refrigerator part of the cryogenic system consists of

- the cold box (system),
- cold and warm storage for helium,
- cold storage for nitrogen,
- the compressor station,
- and the piping in between the components and the supply point for various media and the cryogenic system.

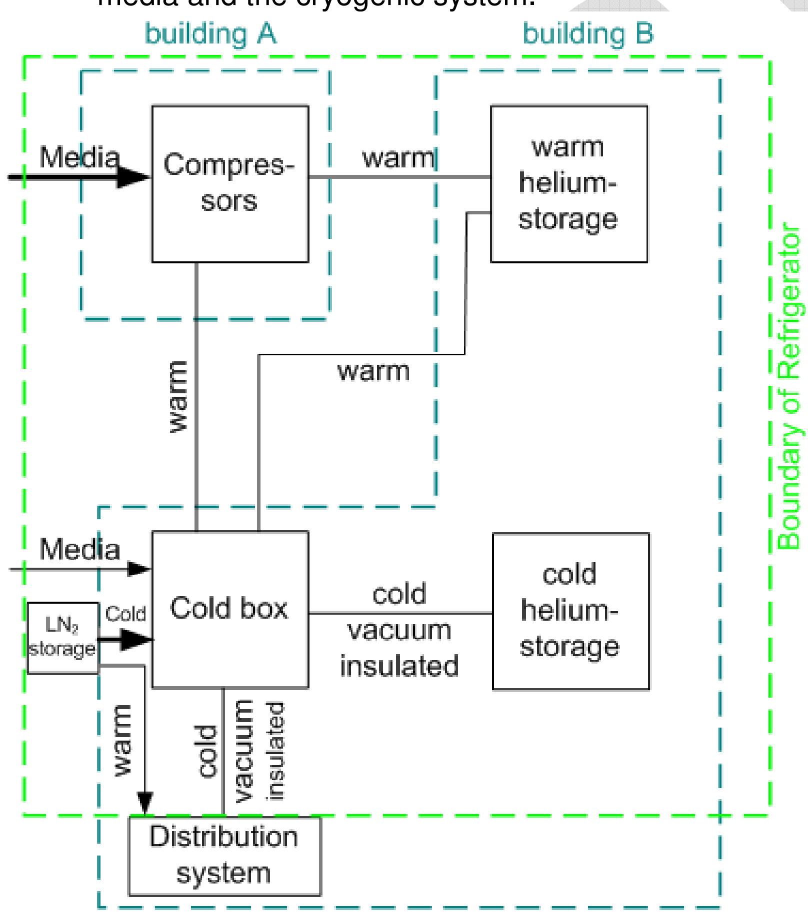

Figure 1: Schematic boundary/ limitation of the refrigerator part in the cryogenic system

2.2. Limits of the System and environment

Each building or cryogenic area has a transfer point for the supply of various media as compressed air or cooling water. The supply up to this dedicated transfer point for the media in the building is not part of the refrigerator neither part of the cryogenic system. The piping from this transfer point within the cryogenic area is part of the refrigerator.
The components of the refrigerator mainly the compressor station and the rest may be placed in different buildings, in Figure 1 exemplary called building A and B. The warm piping it self between these buildings is part of the refrigerator. The supply route/line building itself will be provided by FAIR. Within the compressor station the power convertor between 20kV and the operating voltage of the compressor motors is supplied by FAIR. All cabling towards the frequency convertor and further belongs towards the refrigerator.
For the liquid helium supply in open dewars, the boundary is at the door of the building; the dewars and the transportation utilities do not belong to the refrigerator. Also the equipment for returning the helium gas will be provided by others. The return line for gaseous helium from the main experimental area is provided by FAIR sites.
The interface towards the control system is specified in [1].

2.3. Basis of concept

At FAIR there will be a closed loop refrigeration system for some users and an open dewar helium supply for smaller users.
There will be at least two closed cycle systems, which consist at minimum of one refrigerator each. Each of these cooling cycles/ refrigerators has it dedicated users, but even so the distribution system is designed in such a way that the cold helium may be shifted between the plants. Each refrigerator is a complete closed system and can by operated by itself without connection towards the distribution system. During shut down the helium is stored in warm and cold storages. Approx. 80% of the helium is stored warm in medium pressure tanks. The rest will be stored into liquid storages, with separate small recoolers. This liquid helium capacity may also been taken in account for short term over-load. Therefore the warm storages are mounted close to the compressor station, and the cold once next to the cold-box.
The compressor station will house all compressors for the closed loop part. To minimize the redundancy all refrigerator has to be designed to the same pressure heads.

3. Technical Specifications

The refrigerators have to provide helium at operating parameters given in [3] with an additional margin for the distribution system given in the detailed specification. The refrigerators, the distribution system and the users will be operated via a common control system. Therefore the control algorithms for the operation of the refrigerator have to be documented in a special defined format [1]. All components (especially compressor skits, turbines) have to be provided inherently safe.

All components have to be provided with a proven MTBM of at least 12 month or they have to be equipped with an exchange devise which can take over operation during maintenance without interruptions in the operation.

3.1. Efficiency

At the design heat load the refrigerator should show maximum electrical power consumption which is given in the detailed specification.
For the closed loop refrigerators in addition for part load conditions of the refrigerator the following efficiency has to be achieved. The maximum ratio for the power consumption based on the power consumption used at 100% design load is given in the following diagram. The part load is only seen in the 4-5K range. The load on the 50-80K level only drops about 5% in respect to the maximum.

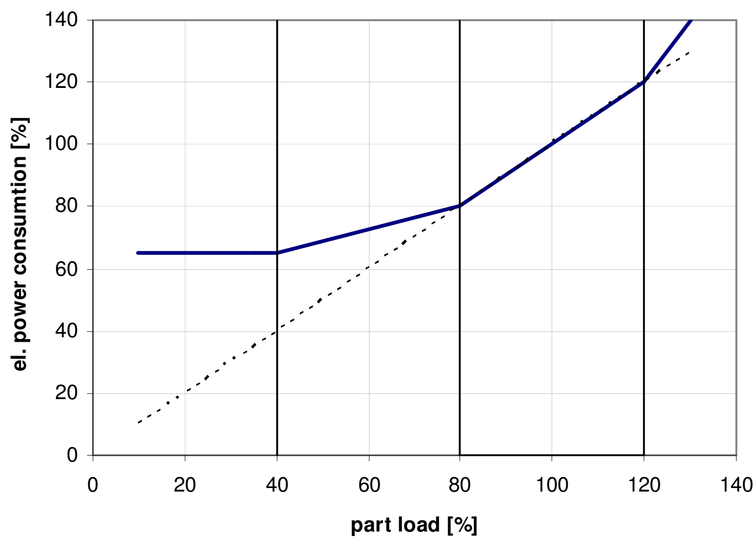

Figure 2: Requested maximal power consumption for the refrigeration process in respect of the requested heat load

As the efficiency of the total cooling loop is requested,

a) one refrigerator may be replaced by two individual machines providing different temperature levels. (i.e. one nitrogen plant for the shield cooling, a helium plat for the low temperature level, whereby the nitrogen is only allowed in the refrigerator, as a refrigerant in the user only helium is allowed.)
b) or the heat exchanger may be designed in that way, that two flow channels for different mass flow rates are realized (“Two plants in one box”).

For the combination of two plants the exemplary power consumption is given in the following figure. The second design point is at 20% of the total heat load.

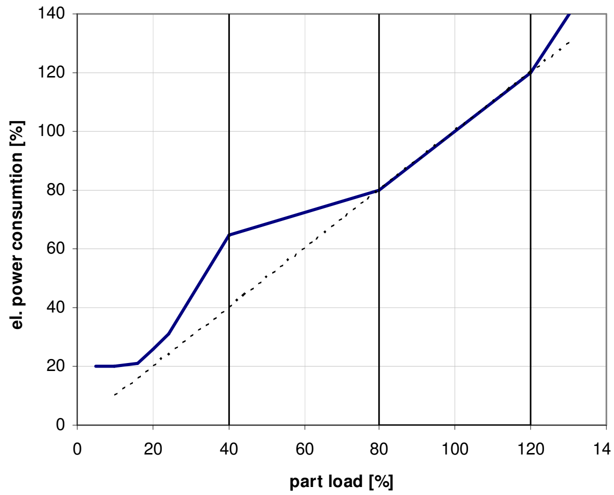

Figure 3: Exemplary combined power consumption for the refrigeration process in respect of the requested heat load

3.2. Compressor station

As the building requirements for process compressors are different than the normal technical building the compressors for the closed loop system are housed in one building together with the redundancy and the one common recovery compressor for the system.
This main compressor station will consist of screw compressors with a variable speed control. For the regular operation there are 10 compressors are foreseen in the building with a maximum power of 10 MW. In addition for the full refrigerator system there are two redundant compressors, one for the low pressure and one for the high pressure level. To make use of the redundancy the cabling must be as flexible as required to connect every frequency convertor to the redundant compressor.
The recovery compressor is independent from the refrigerator operation. The recovery compressor will bring the evaporating helium from the distribution system into the warm storages for helium gas. The control system of this recovery compressor has to be independent from the refrigerator control system. The total load for the recovery system is 500kW.
For the independent open cycle liquefier the compressor will be outside the building on a separate foundation.

4. Quality Assurance, Tests and Acceptance

The suppliers for the refrigerator have to follow the quality assurance, tests and acceptance described in the technical guideline referenced in [2].
In addition the efficiency of the refrigerator will be tested.
After commissioning:
A test heat load up to 25% of the design heat load will be applied. The refrigerator should not excite the efficiency given in Figure 2 for more than 5%.

After the distribution system and the users are connected a second evaluation of the efficiency will take place at the design load.
If the power consumption exceeds the requested efficiency the additional energy costs for the next ten years have to be covered by the supplier. If the supplier reaches an efficiency 5% below the requested one the 50% of the saved energy costs will be remitted for the next 10 years.

5. Documentation

The suppliers for the refrigerator have to follow the quality assurance, tests and acceptance described in the technical guideline referenced in [2].

6. Warranty

The specifications from the FAIR General Specifications [4] shall apply.

I. Attached Documents

II. Related Documentation

[1] Common Specification Control System F-CS-LS-01e ACS v10.doc
[2] Common Specification Cryogenic F-CS-K-03e Cryogenic v1.0.doc
[3] F-TG-K-50.0e Cryogenic Operation Parameter 20110228.doc
[4] FAIR-XXXXX-EF-0012 v.1, FAIR General Specifications

III. Document Information

III.1. Document History

Version	Date	Description	Author	Review / Approval
0.1	yyy-mm-dd	Draft version	Author Name	review comment, approver
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1.0				