Available online at www.sciencedirect.com

ScienceDirect

Physics Procedia 67 (2015) 107 – 110

Physics Procedia

25th International Cryogenic Engineering Conference and the International Cryogenic Materials Conference in 2014, ICEC 25–ICMC 2014

Current status of the modifications of the former HERA cryogenic plant for the XFEL facility

H. Wilhelm[a]*, B. Petersen[b], T. Schnautz[b]

[a] *Linde Kryotechnik AG, Daettlikonerstrasse 5, 8422 Pfungen, Switzerland*
[b] *Deutsches Elektronen Synchrotron DESY, Notkestrasse 85, 22607 Hamburg, Germany*

Abstract

The Hadron-Electron-Ring-Accelerator (HERA) at the German Electron Synchrotron (DESY) in Hamburg, Germany, was in operation between 1990 and 2007. The required cooling capacity for the superconducting magnets was provided by a cryogenic system consisting of three identical helium refrigeration plants. Due to the implementation of the X-ray free electron laser European XFEL, two of the existing HERA refrigeration plants have been adapted to the new heat load requirements of the XFEL-linac. A 2 K cooling loop of approximately 2.6 kW comprising a string of four cold compressors has been included into the existing refrigerator system. Efficient operation for 17.5 GeV beam load, for future up-grade options, and high turn down ability during partial load operation are key features of this modified cryoplant. A stepwise commissioning concept has been applied in order to compensate any changes in the overall XFEL project schedule. Another challenge was to revamp, install and commission the XFEL cryoplant under continuous operation of the third cryoplant, which is still providing refrigeration power for the FLASH-linac and other consumers.

Peer-review under responsibility of the organizing committee of ICEC 25-ICMC 2014

Keywords: liquefier; cold compressor; recooling bypass; commissioning

* *Corresponding author*. Tel.: +41-52-304-0523; fax: +41-52-304-0550
E-mail address: Hanspeter.wilhelm@linde-kryotechnik.ch

Peer-review under responsibility of the organizing committee of ICEC 25-ICMC 2014
doi:10.1016/j.phpro.2015.06.019

1. Introduction

The Hadron-Electron-Ring-Accelerator (HERA) at the German Electron Synchrotron (DESY) in Hamburg, Germany, was in operation between 1990 and 2007. The required cooling capacity for the superconducting magnets was provided by a cryogenic system consisting of three identical helium refrigeration plants, which all were connected at their cold end to one valve box. Fig. 1 provides a simplified schematic overview of the cryogenic plant for the HERA application.

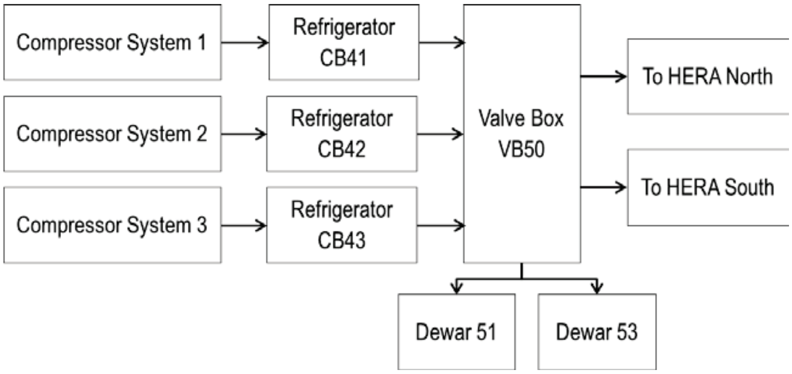

Fig. 1. Simplified block diagram of the cryogenic plant for HERA during 1990-2007.

For the X-ray free electron laser European XFEL, scheduled for operation in 2015, Linde Kryotechnik has been awarded a contract for its economical plant concept [1]. It is based on two of the former HERA compressor systems, their coldboxes and a new distribution and a new cold compressor box. Fig. 2 shows the simplified block diagram of the XFEL cryoplant. Compressor system 2, coldbox 42 and valve box 50 are not part of the XFEL process, and continue to serve FLASH and other consumers. For the XFEL cryoplant, coldboxes 41 and 43 are connected at their cold end to one distribution box, connecting and redistributing flows between the dewar, the coldboxes and the cold compressor box CB44. This cold compressor box comprises four serially connected cold compressors and a full flow cold compressor bypass for startup and turndown operation. In the subsequent chapters, the main features as well as the current status of the project shall be presented.

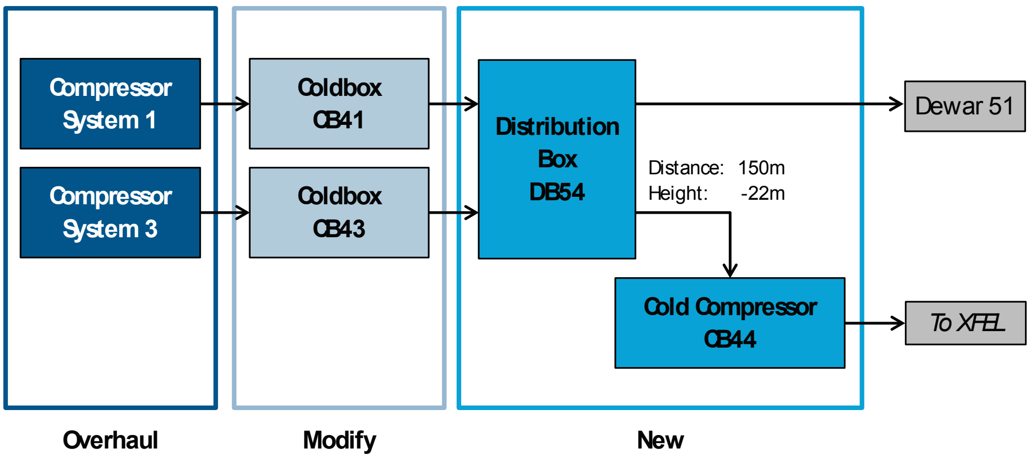

Fig. 2. Simplified block diagram of the cryogenic plant for XFEL.

2. Compressor overhaul and coldbox 41/43 modification

As another 15 years of continuous operation of the compressor systems and the coldboxes 41/43 were required by DESY, the compressor systems were completely overhauled. Starting in summer 2011, the overhauling of the compressor system included dismantling and revision of compressors, motors and pumps, exchange of all sealings of any flanged connections, control valves, other armatures, renewal of coalescing elements and drying adsorbent, painting of the reassembled pipework and a complete pressure and leak test.

Besides the general overhauling of the warm pipework at the coldboxes 41 & 43, major modifications on the coldbox internals were conducted: 50% of all cold piping was modified, the LN2 precooling heat exchanger was removed, the turbines were rearranged and turbine flow parts were optimized due to the changed liquefaction process.

Another key issue was to transfer DESY's 17 years operational experience, which has been collected in several dedicated program routines for e.g. compressor startup, stop and coldbox pump down. Due to the intense modification of the refrigeration process, continuous control loops were completely re-designed, but transient operations, such as automated preparation prior to coldbox startup or after coldbox stop, plant stop, evacuation routines etc. were adapted and transferred into the XFEL controls.

3. Distribution and cold compressor box

Fig. 3 shows the process flow diagram of the cold compressor box CB44, which comprises four cold compressors in series with a total pressure ratio of 45.83, a phase separator and a compressor bypass, designed for complete re-cooling at full flow conditions. This configuration enables quick startup and pump down of the compressor string without connected suction side, connecting the suction line at any pressure between 1100 and 24 mbar as well as excellent turndown capacities.

Compressors, coldboxes 41 and distribution box 54 are located in building 54, whereas the cold compressor box will be located in the XFEL shaft building (XSE) and will be connected to the distribution box by a transfer line of approximately 150 m length.

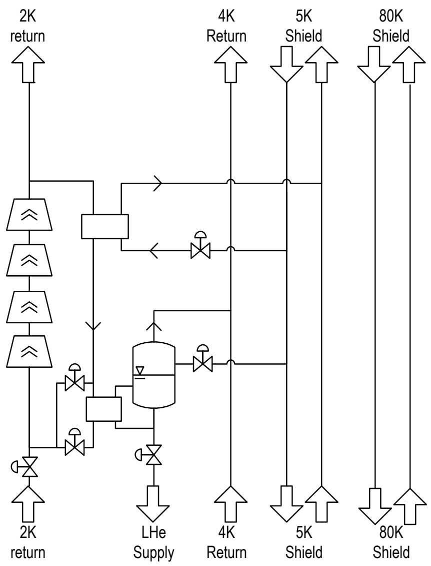

Fig. 3. Process flow diagram of cold compressor box CB44.

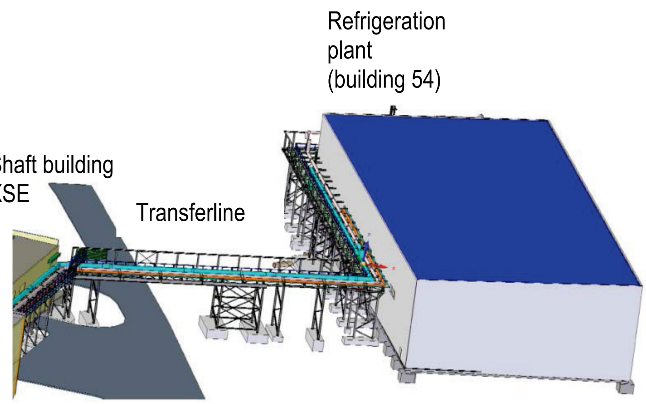

Fig. 4. Isometric view of the cryogenic transfer line, the refrigeration plant building and XFEL shaft building.

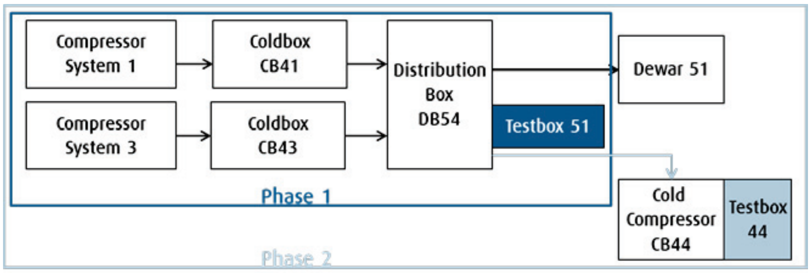

Fig. 5. Commissioning phases.

A stepwise commissioning concept has been applied, in order to compensate for any changes in the overall XFEL project schedule and optimize commissioning time for the cold compressors, as illustrated in Fig. 5.

In Phase 1, coldboxes 41 & 43 were commissioned together with the distribution box and a test box, comprising bypasses from supply to return lines and heaters for simulating the required cryogenic loads. From August to November 2013 the specified operation cases and control functionalities were successfully commissioned, and the refrigeration plant could be prepared for Phase 2.

In Phase 2, the cold compressor box CB44 is temporarily installed at close proximity to the Distribution Box DB54. Test box 54 is dismantled, a temporary transfer line (CXTRL) and another test box including the required heaters are installed. Since April 2014 cold compressor commissioning is ongoing, and functional tests have been completed. Initial operation of the cold compressor string proves the expected rapid start-up and flexibility of the system with further tests to follow in the coming weeks.

Fig. 6. Temporary transfer line connecting DB54 and CB44.

Fig 7: CB44 with mounted test box.

4. Status & conclusion

Compressor system, cold boxes 41 & 43 as well as distribution box 54 have been commissioned successfully. The commissioning of the cold compressors in the Phase 2 configuration will continue until September 2014. Initial operation of the cold compressor string was conducted successfully in the past weeks reaching 30 mbar suction pressure starting from warm, atmospheric conditions within 12 working days only and achieving pump down time of less than 20 minutes, started from cold atmospheric conditions. Final control parameter settings and plant acceptance tests will be performed with the cold compressor box placed at its final location in winter 2014/2015.

References

[1] Blum, L, Petersen, B., Schnautz, T., 2012. Modification and Extension of the Hera Plant for the XFEL Experiment, Proceedings of the twenty-fourth international Cryogenic Engineering Conference, Fukuoka, Japan, 445-449.