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摘要集

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The ESS accelerator cryoplant status

作者： xilong wang[1]

合作者： John Weisend [2]; Philipp Arnold [2]

[1] *ESS ERIC*

[2] *E*

相应作者： xilong.wang@esss.se

The European Spallation Source (ESS) is a neutron-scattering facility being built with extensive international collaboration in Lund, Sweden. The ESS accelerator will deliver protons with an average beam power of 5 MW to the target at 2.0 GeV, with a nominal current of 62.5 mA. The superconducting part of the accelerator is about 300 meters long and contains 43 cryomodules. The ESS accelerator cryoplant (ACCP) will provide the cooling for the cryomodules and the cryogenic distribution system that delivers the helium to the cryomodules. The ACCP will cover three cryogenic circuits: Bath cooling for the cavities at 2 K, the thermal shields at around 40 K and the power couplers thermalisation with 4.5 K forced helium cooling. The installed cooling capacities of the ACCP are 3050 W at 2 K circuit, 9.0 g/s liquefaction rate at 4.5 K and 11380 W at 40-50 K circuit. The open competitive bid for the ACCP took place in 2014 with Linde Kryotechnik AG being selected as the vendor. Almost all the components, including warm compressor system, cold box system, liquid helium storage tank and ambient heaters have been delivered to the ESS site starting in July 2017. The installation work is well under way and final commissioning of the plant is expected in April 2019. The overall project status, the progress, the challenges and lessons learnt will be addressed in the talk.

1

LHC Cryogenics Operation: main achievements of Run 2 from low to high energy beam

作者： Gerard FERLIN[1]

合作者： Benjamin Bradu [1]; Krzysztof Brodzinski [1]; Laurent Delprat [1]

[1] *CERN*

相应作者： gerard.ferlin@cern.ch

After completion of the first major maintenance works performed during the Long Shutdown period (LS1, 2013-14), the LHC came back to operation with beam in April 2015. With the progressively increased beam energy scheme, the operational margins on the cryogenic capacity were drastically reduced. The non-isothermal 4.5-20 K dynamic thermal load, intercepted by the Beam Screens system (BS), is about in average 30% higher than the design value. This imply a high-level optimization of the cryogenic plants and the use of advanced process control system to drive the 585 cooling loops dedicated to the BS temperature control. The presentation will summarize the evolution of the global LHC cryogenic system configuration as well as the operational adaptation scenario. The main encountered issues and applied mitigation approaches will be developed. Finally, the benefits and remaining issues from the Run 2 (2015-2018) will be presented.

2

LHC Cryogenics availability and helium inventory management during Run 2 (2015-2018)

作者： Laurent Delprat[1]

[1] *CERN*

The year 2018 is the last operational year of Run 2 period, which has seen increased beam-induced heat loads due to increased beam energy from 4 TeV to 6.5 TeV. Despite constraints of the operational conditions, extensive experience gained through the whole run period allowed to maintain a high level of availability as well as reducing helium losses. The key operation performance indicators of the LHC cryogenic system for Run 2 will be presented, emphasizing on the global cryogenic availability to physics. Aspects regarding hardware reliability will be discussed, focusing on the impact of the LHC cryogenic system configurations adopted for Run 2.
From the helium management point of view, several actions have been undertaken ensuring a close follow-up of the inventory and reducing significantly the losses. The presentation will cover the LHC helium storage management including the overview of Run 1 to Run 2 statistics. Finally, in the view of Long Shutdown 2 (LS2) preparation, the externalized helium storage strategy allowing flexibility for maintenance and consolidations works will be addressed.

3

Cryogenic safety considerations for Vertical Test Facility for qualifying high-β SRF cavities for the European Spallation Source.

作者： Louis Bizel-Bizellot[1]

合作者： Marco Liffredo [2]; Shrikant Pattalwar [1]

[1] *STFC*

[2] *Criotec Impianti S.p.A.*

相应作者： louis.bizel-bizellot@stfc.ac.uk

A dedicated cryogenic infrastructure has been installed at STFC Daresbury Laboratory to qualify and deliver 84 high-beta SRF cavities for the ESS (European Spallation Source) under construction at Lund, Sweden. In order to meet the delivery schedule and optimise the test process efficiently a large 1.6 m diameter, 3.5 m tall liquid helium cryostat has been developed. RF tests are conducted on 3 cavities at 2K in one cool-down. There are 3 cryogenic circuits operating at 50K, 4.2K and 2K designed to handle a maximum helium mass flow rates of 4g/s. Considering large internal (beam pipe) and external surface areas of the cavities under test the pressure relief system has been designed very carefully. Various limiting scenarios and associated safety scheme are presented in detail in this paper.

4

Performance degradation of helium refrigerator for cryogenic hydrogen system at J-PARC

作者： Tomokazu Aso[1]

合作者： Hideki Muto [1]; Hiroshi Takada [1]; Katsuhiro Aoyagi [1]; Makoto Teshigawara [1]; Shoichi Hasegawa [1]

[1] *JAEA*

相应作者： aso.tomokazu@jaea.go.jp

At the 1-MW spallation neutron source of Japan Proton Accelerator Research Complex (J-PARC), a cryogenic hydrogen system including a helium refrigerator has been in operation to generate a

liquid-hydrogen-circulation flow (20 K, 1.4 MPaG, 185 g/s) as a cold-neutron-moderator. The helium refrigerator has a refrigeration power of 6 kW at 17 K under an operating pressure of 1.5 MPaG and a flow rate of 270 g/s.
Since January 2015, a pressure drop gradually increased between heat exchangers and an adsorber (ADS) in the helium refrigerator, forcing us to stop the operation in 2016 because its cooling performance was degraded. To investigate the cause of the performance degradation, impurities accumulated in helium gas was measured with some devices such as a gas chromatography and a quadrat mass spectrometer. However, no significant amount of impurities was observed. It was also measured that the oil contamination at outlet of the oil separator was around 10 ppb, which was design value. By cleaning inside of the heat exchangers and replacing ADS with new one, the refrigerator performance could be restored. The amount of oil extracted through the cleaning was c.a. 150 g, that is equal to the amount estimated after the operating period of 18,000 h with an oil contamination rate of 10 ppb. As a result of dismantling the replaced ADS, we found that oil was locally accumulated in membranous form onto the felt at the helium entrance side. This might cause the pressure drop because the frozen oil during cooling down obstructed helium flow. The felt is generally used for retaining the active charcoal inside ADS. However it played a role of an oil filter in this case. This phenomenon was confirmed by an elementary test using cold nitrogen gas flow, too. There are still some doubtful relation between the pressure drop and the performance degradation at the heat exchanger. Actually, the pressure drop at the ADS was c.a. 7-8 times of magnitude higher than that at the heat exchangers. However, it would be too early to conclude that large pressure drop at the ADS deteriorates the performance of heat exchanger. We are still making effort to investigate the cause.

5

The LHC Cryogenics availability calculation tool

作者： Laurent Delprat[1]

合作者： Thomas Ytterdal [1]

[1] *CERN*

相应作者： laurent.delprat@cern.ch

The operation of the LHC accelerator requires a large cryogenic infrastructure composed of eight independent cryogenic plants at 4.5 K, eight units at 1.8 K and the associated cryo-distribution, supplying each ring sector and using a variety of equipment with over 3’500 operating conditions to manage.
Specific conditions must be set in order to allow beams to circulate, and ones that are even more restrictive are required to maintain the beams and allow for physics production. These conditions define the availability of LHC cryogenics.
Meeting the requirements for physics imposes to maximize this availability: constant attention is required on cryogenics and its operational margins as well as reliable and efficient tools to ensure its close follow-up.
This presentation will describe the LHC cryogenic system architecture and get back to the definition of LHC cryogenics availability, as it was set during its initial start-up in 2008. We will explain how the availability is calculated, considering different definition criteria and taking into account operational margins.
We will highlight the optimization and automating of the availability calculation tool, allowing more precise statistics production in less time.
Finally, we will discuss ongoing work to use this new tool in collecting early warning signals data during operation, thus allowing to even more improve the overall availability of the LHC cryogenic system.

6

Operation Status of KEK Accelerator Cryogenic Systems

作者： Hirotaka NAKAI[1]

合作者： Hirotaka SHIMIZU [1]; Kazufumi HARA [1]; Kota NAKANISHI [1]; Teruya HONMA [1]; Yuuji KOJIMA [1]

[1] *KEK*

相应作者： hirotaka.nakai@kek.jp

There are three cryogenic systems for superconducting RF cavities of superconducting accelerators in the Accelerator Laboratory of KEK. One is the 4.5K large-scale helium cryogenic system for the SuperKEKB accelerator. Others are 2K superfluid helium cryogenic systems for the Superconducting RF Test Facility (STF) and the compact Energy Recovery Linac (cERL). Brief description and operation status of these cryogenic systems will be presented. Future plan for unification of control systems for these cryogenic systems will also be introduced.

7

Operational Experience of Helium liquefier at TIFR, Mumbai, INDIA

作者： KADAYAM VENKATRAMAN SRINIVASAN[1]

[1] *TATA INSTITUTE OF FUNDAMENTAL RESEARCH, MUMBAI*

Low temperature facility (LTF) of Tata Institute of Fundamental Research, (TIFR) Mumbai, India, has been operating and maintaining helium liquefiers, nitrogen generators for about six decades. For the past ten years, helium is liquefied using Linde make, L280 Model helium liquefier. LTF caters an annual liquid helium consumption of 125000 liquid liters by the above helium liquefier. Liquid helium is dispensed to about 45 research laboratories including dilution refrigerator, adiabatic de-magnetization, NMR spectrometers, SQUID ' s, PPMS, VSM, STM, Nano electronics, Point Contact Spectroscopy, Photo Electron Spectroscopy, Mossbauer Experiments, Nuclear Atomic Physics / Beam hall experiments and many homemade setups. Many systems are kept at 4.2K continuously. TIFR has a large network of helium gas recovery piping (~1.75 km) and our recovery rate is about 80% to 90%.
Since its installation in June 2008, LTF has carried out many preventive & breakdown maintenance including critical component like turbine. The paper will present our experience in helium liquefier operation and maintenance, highlighting aspects such as: like cryogenic valve seat leakage, non-functional turbine, increasing mother dewar pressure, prolonged dewar neck frosting etc., which were successfully tackled in-house at our facility. The paper will also brief about the various automation and other modifications carried out for the operational smoothness.

8

The cryogenic control system of 40 T hybrid magnet

作者： Ming Fang[1]

合作者： JunJie Li [1]; ZhengRong Ouyang [1]

[1] *High Magnetic Field Lab, CAS*

相应作者： fangming4230@hmfl.ac.cn

The cryogenic system is one of the key components for 40 T hybrid magnet for cooling the external cooling-shields, internal cooling-shields, outsert superconducting coil, current lead and the cryogenic distribution valve box of the hybrid magnet. Considering the complexity of the cryogenic system, a safe and stable control system is required. The control system is based on Siemens S7-300 PLC, with Siemens WinCC as the host computer monitoring software. Four experiments over the past two years have demonstrated the safety, stability and efficiency of this control system. This paper describes the network structure, hardware configuration, software structure, auxiliary system and future development direction.

9

Design of the 1.8 K helium cooling test platform for CICC

作者： Shuai Zhang[1]

合作者： JunJie Li [1]; ZhengRong OuYang [1]

[1] *High Magnetic Field Laboratory,CAS*

相应作者： maxzhang@hmfl.ac.cn

The superfluid helium (He II) cooled superconducting (SC) magnets show substantially better stability performance than normal helium cooled SC magnets. The thermal-hydraulics characteristics of the 1.8 K pressured helium need to been specified for the design of He II cooled SC magnet. The 1.8 K He II Cable-in-Conduit Conductors (CICC) Test Platform structure design and test procedure design have been finished. In this paper, the details of the test platform structure and the experimental procedure are presented. The test platform will make contribute to the design of the He II cooled SC magnets.

10

Reliability and management strategy of the cryogenic and utility systems for SRF test facility at the RISP

作者： KI WOONG LEE[1]

合作者： HEE CHUL PARK [1]; HYUN CHUL Jo [1]; HYUN MAN JANG [1]; JAE HEE SHIN [1]; SUNGWOON YOON [1]; TAE KYUNG KI [1]

[1] *Institute for Basic Science*

相应作者： kwlee@ibs.re.kr

Superconducting radio frequency test facility, cryogenic system, cryomodule, cavity, maintenance, helium leak

Summary:

The Rare Isotope Science Project (RISP) had completed the installation of the cryogenic system at the Superconducting Radio Frequency Test Facility (SRF TF) in June 2016. The commissioning was successfully completed for 6 months. The TF is being used in order to test SRF cavities, cryomodules and SC magnets which will be applied to RISP’ s accelerator. In 2017, the performance tests of cryomodules, superconducting cavities, superconducting magnet and SCL demo were conducted 18 times. We have experienced numerous trials and gotten the know-how at cryogenic systems for performance tests. This presentation introduces the problems that occurred in cryogenic and utility systems of the SRF TF during the performance tests and how the systems are modified and maintained. Causes of the problems are analyzed and solutions that we find out are applied to the SRF TF. The current status are presented and management process of the SRF TF are discussed in order to operate that efficiently and safely. In addition, helium inventory and management method are introduced. Our management process that we set up to increase reliability and maintainability will be applied to new SRF TF.

11

Operational record of the KSTAR helium refrigeration system

作者： Dong-Seong PARK[1]

合作者： Jae Joon Joo [1]; Nak-Hyung SONG [1]; Nam-Won KIM [1]; Sang-Woo KWAG [1]; Yaung-Soo KIM [1]; Yong-Bok CHANG [1]; Young Ju Lee [1]; kyungmo moon [2]

[1] *National Fusion Research Institute*

[2] *n*

相应作者： dspark@nfri.re.kr

The nuclear fusion research is in progress for the next generation energy source in many countries. The Korean large fusion device whose name is Korea Superconducting Tokamak Advanced Research (KSTAR) is made of Nb3Sn and NbTi superconductor and it is necessary to cool down to liquid temperature. In order to proper operation of the KSTAR superconducting (SC) magnets, a Helium Refrigeration System (HRS) with an exergetic equivalent cooling power of 9 kW at 4.5 K was installed and commissioned in 2008.
After then, the KSTAR device was ready for the first campaign and has been operated successfully since 2008 and the HRS has presented sufficient cooling power for last 9 years.
During the campaign period of KSTAR, the HRS has experienced several abnormal events such as utilities failure and equipment failures. In this presentation will show the result of operation, maintenance, failures, repair, system modification as well as the reliability of the KSTAR HRS.

Summary:

The helium refrigeration system (HRS) of Korea Superconducting Tokamak Advanced Research (KSTAR) with an equivalent cooling power of 9kW at 4.5K has been operated since 2008. The cryoplant for superconducting (SC) fusion device is designed and constructed to cope with pulsed thermal load that is more severe operating condition than the accelerator cryoplant. During over 30,000 operation hr from 2008 to 2017, the KSTAR HRS faced a few abnormal events. Even though the abnormal events while operation, the KSTAR HRS has demonstrated sufficient performance and reliability thanks to superior design of equipment and professional effort of operating personnel. During the maintenance period of KSTAR, there were a lot of efforts in order to increase system reliability and efficiency. Thanks to these efforts, the KSTAR HRS present excellent system availability and it is ready for the KSTAR campaign in 2018.

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Study on Heat Transfer of 4.5K Supercritical Helium Coiled Subcooler

作者： Shuai Zhang[1]

合作者： JunJie Li [1]; ZhengRong OuYang [1]

[1] *High Magnetic Field Laboratory,CAS*

相应作者： oyo@ipp.ac.cn

Helium forced flow cooling was demonstrated as a reliable way for superconducting (SC) magnets. For the large Cable-in-Conduit Conductors (CICC) in high magnetic field, supercritical helium forced flow cooling is utilized. A coiled sub-cooler for 4.5 K supercritical helium, which is the vital component of the system, has been designed and manufactured to supply required helium for the SC magnet. The coiled sub-cooler installed in the valve box has been tested during the experiment process of SC magnet. In this paper, the design details and the heat transfer performance of the coiled

sub-cooler are presented. The analysis of test results reflects the design principles for the coiled sub-coolers.

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Regulating of Gas impurity in Helium Refrigeration System at a Reactor CNS

作者： Xiaohua LAN[1]

合作者： Cong LIU [1]; Zi WANG [1]

[1] *Institute of Nuclear Physics and Chemistry, CAEP*

相应作者： lanlan212@yeah.net

Helium is widely used at reactor cold neutron source cryogenic system(CNS). It is well known that gas purity control is very important in an expansion-turbine-based helium refrigerator.High levels impurities such as nitrogen,hydrogen or organics can cause to process faults.What's more,high hydrogen concentration will trigger the reactor.It's owing to the hydrogen concentration monitoring in CNS is used to estimate the hydrogen leakage inside moderator chamber.Usually,the hydrogen and organics comes from compressor oil degradation and oxidation.These unexpectable gas always be detected by gas chromatography during one thousand operating hours after change new compressor oil.The impurities mostly are condensed in adsorber inside Cold-box. Nevertheless,they are overload for available liquid nitrogen adsorber. Methods are found to remove the hydrogen and other compounds in helium completely.Systems operating safety are ensued.In this paper,we will share the valid experience in the cryogenic system.

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Modification of the KSTAR 9kW HRS

作者： Jae Joon Joo[1]

合作者： Dong-seung Park [2]; Kyung Mo Moon [2]; Nak Hyung Song [2]; Nam Won Kim [2]; Sang Woo Kwag [2]; Seok Ho Hong [2]; Yang Soo Kim [2]; Yong Bok Chang [2]; Yong Ju Lee [2]

[1] *NFRI*

[2] *National Fusion Research Institute*

相应作者： jjjoo@nfri.re.kr

The Helium Refrigeration System (HRS) of Korea Superconducting Tokamak Advanced Research (KSTAR) has been successfully operating since 2008. The KSTAR HRS is the complex system that equipscontains various components such as rotating machines, sensors, heat exchangers, valves, and so forth.etc Meanwhile, tThere have beenwere several abnormal events due to the component failures, abnormal pressure variations on the supercritical helium (SHe) circuits, control system faults, black out, and so on. Among them, the turbine that most important key component was shut down due to a fault in the temperature sensor. In addition, pressure and flow fluctuations occurred in PF [Poloidal Field] coil and TF [Toroidal Field] coil circuit. We have been successful in solving related problems in an effective way. This Poster will present describe the modification of the KSTAR 9kW HRS.

Summary:

- The KSTAR HRS is the complex system that equipscontains various components such as rotating machines, sensors, heat exchangers, valves, and so forth.

- The turbine that most important key component was shut down due to a fault in the temperature sensor
- Due to frequent failure of the thermal well type temperature sensor, the specification of the sensor was changed and used as the redundancy sensor to obtain stable results
- The pressure fluctuations shortened the life span of HRS equipment and had an adverse effect on the KSTAR experiment.
- Through the analysis of the temperature and pressure of each circuit, the heat penetration inside the circuit was traced to remove the related elements, and the pressure fluctuation phenomenon disappeared.
- In this way, the problems that occur in various equipment are corrected and the equipment are operated stably.

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Development of cool-down control logic and its application result of KSTAR campaign in 2016,2017

作者： Kyung mo Moon[1]

合作者： Dong Seong Park [1]; Jae Joon Joo [1]; Nak Hyung Song [1]; Nam Won Kim [1]; Sang Woo Kwag [1]; Yaung Soo Kim [1]; Yong-Bok Chang Yong-Yong-Bok [1]; Young Ju Lee [1]

[1] *National Fusion Research Institute*

相应作者： kmmoon@nfri.re.kr

Korea Superconducting Tokamak Advanced Research (KSTAR) is fully superconducting (SC) magnet tokamak which consists of 30 magnets and is made of Nb3Sn and NbTi superconductor.

To keep the superconducting (SC) magnet coils of the KSTAR Tokamak at proper operating conditions, other cold components such as SC bus-lines, thermal shields, magnet structures, and current leads should be kept in their respective cryogenic temperatures as well as coils.

The Helium Refrigeration System (HRS) with an exegetic equivalent cooling power of 9kW at 4.5K is dedicated to cool down and keep the KSTAR SC magnets in cryogenic temperature.
Cool down process which is to be run after making a vacuum state of the KSTAR is one of the important procedures that requires a lot of manpower and time.

The largest part of Cool down process is flow control of the KSTAR cold components through the manual operation of HRS Cool down valves.
In order to improve the efficiency of it, the need of developing the Control logic has raised its head and then the work commenced in 2015, after which the device was for the first time applied in the campaign in 2016.
This poster will describe development study of KSTAR cool-down control logic for the helium refrigeration system and its application result of KSTAR campaign in 2016, 2017.

Summary:

The designing of control logic for entire KSTAR cooling circuit including helium refrigeration system, helium distribution system and KSTAR SC magnets system shall be required for system stability, reliability and efficiency.
During the KSTAR cool-down period in 2016, 2017, the stable and reliable operation of control logic based on optimization philosophy was demonstrated.

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Construction and Application of the 2nd KSTAR Cryo-plants

作者： Young-Ju Lee[1]

合作者： Dong Seong Park [1]; Jae Joon Joo [1]; Kyoung Mo Moon [1]; Nak Hyung Song [1]; Nam Weon Kim [1]; Sang Woo Kwag [1]; Yaung Soo Kim [1]; Yeong Bok Chang [1]

[1] *National Fusion Research Institute*

相应作者： lordlee@nfri.re.kr

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Summary:

The old cryoplant (1 kW @ 4.5 K), which was used for the tests of the KTSAR cryogenic components from 2002, was installed into the KSTAR building for the operation of the new cryogenic facilities such as in-vessel cryopumps, supersonic molecular beam injector, pellet injection system, 2nd neutral beam injector, and the other technical experimental components. Before the installation, there have been maintenances in the warm compressor station, electrical power supply, oil-filter, and so on. In 2015, new 3rd distribution box was constructed for the cryogenic components mentioned above. From 2016, the cryoplant started operation for the plasma experiments. Recently, 2nd neutral beam injector started installation and preparing commissioning of the cryopanel in the beam injector. Details of constructions and application results will be presented.

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Capability of the cryogenic system in SRF Test Facility of RISP

作者： Hyun Chul Jo[1]

合作者： Hee Cheol Park [2]; Hyun Man Jang [3]; Jae Hee Shin [3]; Ki Woong Lee [4]; Sung Woon Yoon [3]; Tae Kyung Ki [3]

[1] *I*

[2] *Institute for Basice Science*

[3] *Institute for Basic Science*

[4] *Institue for Basic Science*

相应作者： olights@ibs.re.kr

accelerator, cavity, cryogenic system, cryomodule, RISP, SRF, test facility

Summary:

A first SRF test facility (TF) of rare isotope science project (RISP) was launched in 2016. RISP’s accelerator, RAON, consists of 104 cryomodules (347 cavities), 13 LTS triplet magnets, and 7 HTS magnets, and the cryomodules, cavities, and magnets will be tested in the SRF TF. A cryogenic system, which consists of a helium liquefier, distribution system, recovery system and warm pump system, provides 4.5 K liquid helium, and gives support to produce 2 K superfluid helium for cavity and cryomodule tests. 6 cavity tests and 7 cryomodule tests were successfully supported during 2017 and performances of them are evaluated. This paper describes the test procedures and our capability as SRF TF. We outline all components of the cryogenic system and explain how tests are conducted in details. Currently, a new SRF TF is under construction to increase capability of cryogenic tests. In 2019, our capability will be 13 cavity tests and 5 cryomodule tests for 1 month and it will do the major role in order to establish successfully RISP’s accelerator.

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Overcoming challenges while building cryogenic infrastructure

作者： Rossi Carolina Mendez Cordero[1]

合作者： Ronald Dekker [2]; Ruud van der Woude [1]

[1] *Demaco Holland bv*

[2] *D*

相应作者： rm@demaco.nl

Superconducting magnets must be cryogenically cooled. The magnet cold mass is immersed in a pressurized bath of superfluid helium and operated at very low temperatures (approximately 1.9 K). The distribution of helium at pressures above atmospheric pressure is a significant engineering challenge. The secret lies in the use of reliable and efficient cryogenic infrastructure like for instance multiple helium transfer lines, cryostat, valve boxes and others.

An efficient cryogenic system has to overcome design challenges (i.e., heat load of various origins within the system, pressure drop, mechanical stability, space constraints etc.), manufacturing challenges (i.e., correct sequence of building up the equipment, testing inside out, material traceability and components certificates), logistic challenges (i.e., procurement of valves, raw materials, temperature, pressure and flow sensors) and installation challenges (i.e., special tools for placing the hardware and confined spaces for performing welding and testing activities). The key goals are to reaffirm and refine the reference solutions from previous cryogenic projects. Demaco has designed, manufactured, tested and installed cryogenic infrastructure over the last thirty years.

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General cryogenic maintenance policy and recent updates for CERN equipment

作者： Frederic FERRAND[1]

合作者： Philippe GAYET [1]; Sigrid KNOOPS [1]

[1] *CERN*

相应作者： frederic.ferrand@cern.ch

- Maintenance policy for cryogenic equipment at CERN integrated in the Computerized Maintenance Management Software
- Review of recent changes of maintenance approach for specific piece of equipment
- Input of failure maintenance and breakdown analysis for maintenance and consolidations
- Implementation of the updated strategies for Long Shut Down 2 of LHC in 2019-2020

Summary:

CERN operates several large cryogenic systems including those serving the LHC machine complex and its associated detectors, together with the Cryogenic Test Facilities and Cryogenic Distribution services of smaller size. For this large spectrum of cryogenic systems, maintenance and consolidation policies are being standardized to reduce downtime and thus improve availability.
In this talk, emphasis will be given to failures observed in the past years of operation and actions taken, either to prevent or to mitigate new risks of occurrence. We will share recent review of the general maintenance plan demonstrating its adaptation towards an improved overall reliability and considering its implementation for execution during the Long Shut Down 2 of LHC scheduled in 2019-2020.

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Radiation control of J-PARC superconducting neutrino cryogenic facility

作者： Yasuhiro Makida[1]

合作者： Hirokatsu Ohhata [1]

[1] *KEK*

相应作者： yasuhiro.makida@kek.jp

1. Introduction
2. Operation History
3. Tritium Detection
4. Require Ways of Maintenance

Summary:

A neutrino superconducting beam line in J-PARC, which transports 30 GeV proton beam from a main ring to a neutrino production target, has operated since 2009 with an integrated time of about 40000 hours. The power of the proton beam increased gradually from 20 kW in 2009 to 485 kW now. During a design study on the superconducting magnet system, it was predicted that helium-3, which is slightly included in helium supply, becomes tritium by radio activation from the proton beam. So inspections, whether the refrigerant helium having tritium or not, have been carried out during worming up beyond 25 K. No tritium could be detected until 2011, when the beam power had been lower than 200 kW, but a few ten Bq/ℓ tritium (Hydrogen - Tritium type) has been detected since end of 2012 beam time. Despite that the detected values are extremely smaller than allowable HT value of 7000 Bq/ℓ for human health according to relevant regulations, some ways of maintenance, which need discharge helium, became burdensome, because the radiation safety manager restricts helium discharge or diffusion without radiation check and require air at working area to be exhausted into a chimney stack line including radiation monitor.
We would like to hear ways of maintenance under the same situation in other facilities.

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Installation and commissioning of JT-60SA Cryoplant

作者： Christine HOA[1]; pascal Roussel[2]

合作者： François BONNE [3]; Jerome LEGRAND [4]; Koji KAMIYA [5]; Manfred WANNER [6]; Pascal FEJOZ [7]; Sylvain GIRARD [7]; Takaaki ISONO [5]; Valérie LAMAISON [7]

[1] *Univ. Grenoble Alpes, CEA INAC SBT*

[2] *CEA Grenoble*

[3] *Univ Grenoble Alpes, CEA INAC SBT*

[4] *AIR LIQUIDE ADVANCED TECHNOLOGIES*

[5] *QST Naka*

[6] *F4E Garching*

[7] *CEA IRFM*

相应作者： pascal.roussel@cea.fr

The cryogenic system of JT-60SA is a French voluntary contribution to the joint European - Japanese project, a superconducting tokamak presently under assembly at Naka, Japan. This fusion experiment is part of the Broader Approach agreement between Europe and Japan in order to support ITER and to investigate advanced plasma scenarios.
The contract for this cryoplant was concluded with Air Liquide Advanced Technologies (AL-aT) company in December 2012 and the successful reception tests were completed at the end of 2016 in close collaboration between the French atomic and alternative energies commission (CEA), Fusion for Energy (F4E) and the National Institutes for Quantum and Radiological Science and Technology (QST) in Naka, Japan.
In 2017 another cool down of this 9.5 kW equivalent at 4.5K cryoplant was performed by the Japanese operators. The installation and the commissioning of the plant will be presented, with a focus on the main characteristic of this cryoplant: the heat load smoothing control will be detailed. First lesson learnt from the commissioning will be discussed and shared with the cryogenic community.

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Operation of large capacity helium turbine with eddy current brake in EAST helium refrigerator

作者： bao fu[1]

合作者： shanshan LI [1]

[1] *IPP*

相应作者： fubao@ipp.ac.cn

Abstract. The helium turbine is the core part of helium refrigerator. In order to ensure the refrigeration capacity and reliability，the helium turbines with eddy current brake were operated in EAST cryogenic system. The helium turbines with eddy current brake and Rotor Cooling Circuit (RCC circuit)，whose total braking capacity can be reached 10 kW. The turbines rotors are supported by fully dynamic radial gas bearings. And the thrust gas bearing is static gas bearing combined with dynamic bearing, in order to increase the thrust bearing capacity. Up to now，the eddy current brake turbines with large capacity have been performed for many times in EAST cryogenic system. The operation process, measurement and control design of the turbines were introduced in this paper. The test results show that the application of eddy current helium turbine’s start-up，running process and shut down process are very easy to operate , the efficiencies are high and the protection system is very well.

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Status of EAST 3.5 K subcooling helium cryogenic sytem

作者： 志刚朱 [1]

[1] 中国科学院等离子体物理研究所

相应作者： zzg@ipp.ac.cn

To obtain high operating current and magnetic fields of Experimental Advanced Superconducting Tokomak (EAST), it is a good choice to lower the operating temperature of the toroidal field (TF) coils. Beside 4.5 K refrigeration mode, the EAST helium refrigerator has the ability to provide a refrigeration capacity of 1050W at 3.5 K, based on warm compression with cold recovery. It consists of liquid helium Dewar, counter-flow heat exchanger, J-T valve, oil ring pump and so on. The oil ring pump was converted from the SKA303 series liquid ring pump, in particular shaft sealing to decrease the risk of air in-leaks. The EAST sub-cooling helium system was tested twice in cool-down experiments. It took only about one hour to cool down from 4.5 K to 3.5 K. The presentation will give an overview of this subcooling helium system and its last operation performance.

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Operation Present Status and Maintenance strategy of the Upgraded Cryogenic System for EAST Tokamak

作者： Qiyong ZHANG[1]; Zhiwei Zhou[1]

合作者： Bao FU [2]; Liangbing HU [2]; Linhai SHENG [2]; Ping ZHU [2]

[1] *Institute of Plasma Physics, Chinese Academy of Sciences*

[2] *Institute of Plasma Physics Chinese Academy of Sciences*

相应作者： zzw@ipp.ac.cn

The cryogenic system is one of the critical sub-systems for EAST (Experimental Advanced Superconducting Tokamak) installation, which is used to provide the proper cooling power for the superconducting magnets and its other cold components. It was designed and built by the institute of Plasma Physics Chinese Academy of Sciences itself, and performed its first commissioning in 2005. At present, it is putting into operation for the fourteenth cool-down experiment. In order to promote the refrigeration efficiencies and reliability, the EAST cryogenic system was upgraded gradually from 2012 to 2015, replacing new helium screw compressors and new dynamic gas bearing helium turbine expanders with eddy current brake to improve the original poor mechanical and operational performance. The totally upgraded cryogenic system has successfully coped with various normal operational modes during cool-down and 4.5 K steady-state operation under pulsed heat load from the tokamak in the latest several experimental campaigns. In this report, the upgraded EAST cryogenic system and its new control network will be introduced in detail, and its operation present status which shows a high reliability and low fault rate after upgrade will also be presented. The system maintenance strategy and some future necessary work to meet the higher reliability requirement for future uninterrupted long-term experimental operation will also be proposed in the end.

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Liquid Nitrogen System for Cryogenic Permanent Magnet Undulators

作者： Shuhua Wang[1]

合作者： Li Wang [1]; Ming Li [1]; Qiaogen Zhou [1]; Yiyong Liu [1]; Yuefeng Liu [1]

[1] *Shanghai Institute of Applied Physics, Chinese Academy of Sciences*

相应作者： wangshuhua@sinap.ac.cn

The cryogenic permanent magnet undulator (CPMU) is one new-type undulator with advantages such as higher magnetic performance compared with conventional undulators at the same magnetic period and gap. Shanghai Institute of Applied Physics (SINAP) has been studying the related technologies and developing the CPMU, and apply the CPMUs for the future SSRF upgrade and the XFEL projects in China. A subcooled liquid nitrogen circulation system based on a conventional semi open-cycle cooling system is adopted to cool the CPMU. Flow chart of subcooled liquid nitrogen loop system and result of the on-line test are given in this paper. During operation, the subcooled liquid nitrogen supplying temperature is at the range between 77.2K and 78.5K, and pressure fluctuation is lower than ±1kPa, which can meet the operation requirements of CPMU.

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Experimental study of helium liuqefier

作者： 建成汤 [1]

[1] 北京中科富海低温科技有限公司

相应作者： jctang@fuhaicryo.com

Helium liquefier/refrigerator plays an important role in high energy physics reserch. This report will present a 40L/h hleium liquefier developed by TIPC (Technical Institute of Physics and Chemistry of the Chinese Academy of Sciences) and Fullcryo (Beijing Sinoscience Fullcryo). The cryogenic system will be introduced. Some recent study resluts will be shown in this presentation.

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Liquid Nitrogen System for Cryogenic Permanent Magnet Undulators

作者： Shuhua Wang[1]

合作者： Li Wang [1]; Ming Li [1]; Qiaogen Zhou [1]; Yiyong Liu [1]; Yuefeng Liu [1]

[1] *Shanghai Institute of Applied Physics, CAS, Shanghai 201204, China*

相应作者： liuyuefeng@sinap.ac.cn

The cryogenic permanent magnet undulator (CPMU) is one new-type undulator with advantages such as higher magnetic performance compared with conventional undulators at the same magnetic period and gap. Shanghai Institute of Applied Physics (SINAP) has been studying the related technologies and developingthe CPMU, and apply the CPMUs for the future SSRF upgrade and the XFEL projects in China. A subcooled liquid nitrogen circulation system based on a conventional semi open-cycle cooling system is adopted to cool the CPMU.

Summary:

Flow chart of subcooled liquid nitrogen loop system and result of the on-line test are given in this paper. During operation, the subcooled liquid nitrogen supplying temperature is at the range between 77.2K and 78.5K, and pressure fluctuation is lower than ±1kPa, which can meet the operation requirements of CPMU.

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Operation experience of cryogenic system and cryomodules for the superconducting linear accelerator at IUAC, New Delhi.

作者： Tripti Sekhar Datta[1]

合作者： Anup Choudhury [1]; Joby Antony [1]; Manoj Kumar [1]; Santosh Kumar Sahu [1]; Soumen Kar [1]; Suresh Babu [1]

[1] *Inter University Accelerator Centre. New Delhi. India*

相应作者： tsdatta59@gmail.com

The superconducting linear accelerator as a booster of 15 UD pelletron accelerator is commissioned and operating for more than three years. The acceleration is achieved by a series of 97 MHZ superconducting quarter wave bulk niobium cavities at 4.2 K. In the first phase, accelerator was partly commissioned with first linac cryomodule, superbuncher, rebuncher cryostat along with 500 W capacity CCI make helium refrigerator. In the second and final phase two more linac cryomodules with eight cavities each were installed in beam line. New helium refrigerator of Linde make LR 280 along with the additional section of liquid helium distribution line were integrated with existing liquid helium distribution network. The cooling philosophy for five beam line cryomodules with the new refrigerator was modified to have faster cooling rate of 20 –25 K of the cavities against earlier 8- 10 K/hr in the critical zone of 150- - 70 K. Pressure fluctuation in the helium vessel of cavities was reduced significantly to avoid frequent breaking of RF locks. The parallel liquid helium filling to each Cryomodule is managed by VME based software CADS. Performance of new cryogenic system and the cryomodules during beam acceleration run will be discussed.

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Numerical simulation study on the static performance of a gas bearing for the helium turbo-expander

作者： Shanshan Li[1]

合作者： Bao Fu [1]; Qiyong Zhang [1]; Zhiwei Zhou [2]

[1] *Institute of Plasma Physics Chinese Academy of Sciences*

[2] *Institute of Plasma Physics, Chinese Academy of Sciences*

相应作者： lss@ipp.ac.cn

As the heart of cryogenic refrigerators, the helium turbo-expander affects the stable operation of cryogenic systems. The supporting component of the turbine is bearing, the mechanical properties of which are directly related to the reliability and safety of the turbine. For the helium turbo-expander, the operating speed is high and the temperature of the working wheel is low. So it is necessary to choose the gas bearing, which has the performances such as light, non-polluting and cryogenic operation. In this paper, CFD numerical simulation method is used to study the bearing rotor system and analyze the bearing performance. Finally, the results were verified by experiments.

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Stable operation of the 2K cryogenic system at Peking University

作者： Jiankui HAO[1]

[1] *PKU*

相应作者： jkhao@pku.edu.cn

A 2K cryogenic system was constructed for DC-SRF injector and 2x9-cell cryomodule of the Peking University Free Electron Laser (PKU-FEL) facility. A stability of the helium pressure better than ±0.1 mbar and total refrigeration capacity of 65 W at 2K temperature has been reached with stable operation. A vertical test system for superconducting cavities was set up based on the 2K cryogenic system. A total cooling capacity of 200 W is got with the upgrade of the 2K pumping system. Vertical tests of superconducting cavities have been carried out successfully.

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Cryogenic System for the SCLF Cryomodule Test Facility

作者： Jiuce Sun[1]

合作者： Lei Lei [2]; Lei Zhang [2]; Shuhua Wang [3]; Xiongzhong Deng [2]; Zhengrong Ouyang [4]

[1] *S*

[2] *ShanghaiTech University*

[3] *Shanghai Institute of Applied Physics, Chinese Academy of Sciences*

[4] *High Magnetic Field Laboratory,Chinese Academy of Sciences*

相应作者： sunjc@shanghaitech.edu.cn

The Shanghai Coherent Light Facility (SCLF), a quasi-continuous wave hard X-ray free electron laser facility, is currently under construction. The linear accelerator of SCLF project will consist of about 78 cryomodules. All superconducting components within the cryomodules, i.e., the cavities and magnets are supposed to be tested before the Cryomodule assembly. The assembled complete Cryomodules have also to be qualified afterwards. Moreover, the superconducting undulators (SCU), which are planned to be implemented in SCLF, also generates the similar test requirements before installation in the tunnel. In response to these demands, a cryogenic test facility (CTF) is being built within SCLF project. In this paper, the design specification, process analysis, system scope, conceptual layout, description of single compotes, and test schedule of the cryogenic system for the CTF will be introduced.

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RF Heat Load Compensation for the European XFEL

作者： J. Penning[1]

合作者： B. Schoeneburg [1]; M. Clausen [1]; O. Korth [1]

[1] *DESY*

相应作者： joerg.penning@desy.de

The European XFEL consists mainly of three parts: The superconducting linac, the undulator sections to produce light and of course the experiments. The linac operates at 2K using cold compressors. We show how to stabilize cryogenic operation by compensating heat load changes introduced by the RF system by reducing the power in the associated heaters. This includes the basic calculations and an overview of our robust runtime environment.

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LHC cryogenics control system at CERN: 10 years' experience.

作者： Marco Pezzetti[1]

[1] *CERN TE-CRG*

相应作者： marco.pezzetti@cern.ch

Since 2008, the CERN cryogenic system for the Large Hadron Collider accelerator installed on five cryogenic islands feeding a 26.7-km circumference ring deep underground tunnel is in operation.

The LHC cryogenic operation support has brought new challenges and opportunities. Several consolidations and upgrades have been undertaken in the cryogenics process control system in order to maintain a high reliability: analysis, consolidation, upgrade including R2E (Radiation to Electronics) campaign, cold compressors refurbishment and massive usage of automatic advanced generators applied to classical industrial controls architecture, have been performed. The achieved work has allowed an improved expertise of the support team as well as in the technical quality of the applied solutions. This paper will describe the gained experience dealing with this large cryogenic process control system and its electrical associated system.

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Registration

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Welcome remarks

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LHC Cryogenics Operation: main achievements of Run 2 from low to high energy beam

相应作者： gerard.ferlin@cern.ch

Session 1 / 37

Commissioning and first operation of the XFEL cryogenic system

相应作者： tobias.schnautz@desy.de

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Challenges of parallel installation and commissioning activities at ESS

相应作者： philipp.arnold@esss.se

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Coffee break， Poster Up

Session 2 / 40

Cryogenic activities at IHEP

相应作者： lisp@ihep.ac.cn

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The Operational Experience of e-Linac Cryogenic System at TRIUMF

相应作者： akovesh@triumf.ca

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Lunch time

Session 2 / 43

Operation Status of KEK Accelerator Cryogenic Systems

相应作者： hirotaka.nakai@kek.jp

Session 3 / 44

Introduction of the 2nd KSTAR cryo plants and application

相应作者： lordlee@nfri.re.kr

Session 3 / 45

Operation Present Status of the Upgraded Cryogenic System for EAST Tokamak

相应作者： zzw@ipp.ac.cn

Session 3 / 46

Operational Record of the KSTAR Cryoplant

相应作者： dspark@nfri.re.kr

Session 3 / 47

Installation and commissioning of JT-60SA Cryoplant

相应作者： pascal.roussel@cea.fr

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Thermal behavior of the cryogenic system during quench protection tests of the superconducting magnet of a hybrid magnet

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Coffee break

Session 4 / 50

LHC cryogenics control system at CERN: 10 years' experience

相应作者： marco.pezzetti@cern.ch

Session 4 / 51

Ten years operation experience and current status of BEPCII cryogenic system

相应作者： zhangzhuo@ihep.ac.cn

Session 4 / 52

Operation experience of cryogenic system and cryomodules for the superconducting linear accelerator at IUAC

相应作者： tsdatta59@gmail.com

Session 4 / 53

Operating status of BES Superconducting Magnet

相应作者： liuzx@ihep.ac.cn

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Cryogenic refrigeration system revamp project at the Paul Scherrer Institute

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Discussion

Session 5 / 56

Radiation control of J-PARC superconducting neutrino cryogenic facility

相应作者： yasuhiro.makida@kek.jp

Session 5 / 57

Operation of CSNS cryogenic system

相应作者： hekun@ihep.ac.cn

Session 5 / 58

LHC Cryogenics availability and helium inventory management during Run 2 (2015-2018)

相应作者： laurent.delprat@cern.ch

Session 5 / 59

The Application and Commissioning Tests of Refrigeration System in Cold Neutron Source Device in CARR

相应作者： lijianlong1220@163.com

Session 5 / 60

Performance degradation of helium refrigerator for cryogenic hydrogen system at J-PARC

相应作者： aso.tomokazu@jaea.go.jp

Session 6 / 61

General cryogenic maintenance policy and recent updates for CERN equipment

相应作者： frederic.ferrand@cern.ch

Session 6 / 62

ADS injector I 2K cryogenic system

相应作者： gerui@ihep.ac.cn

Session 6 / 63

ADS injector II cryogenic system

相应作者： niuxiaofei@impcas.ac.cn

Session 6 / 64

Cryogenic Infrastructure

相应作者： rm@demaco.nl

Session 7 / 65

Accelerator Cryoplant Status at European Spallation Source ERIC

相应作者： xilong.wang@esss.se

Session 7 / 66

Cryogenic safety considerations for Vertical Test Facility for qualifying high-β SRF cavities for the European Spallation Source

相应作者： louis.bizel-bizellot@stfc.ac.uk

Session 7 / 67

Operational Experience of Helium liquefier at TIFR, INDIA

相应作者： kvsrini2006@gmail.com

Session 7 / 68

Operation Status Analysis of the Cryogenics Equipment and Helium Comprehensive Support System

相应作者： stonewall@163.com

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Take the shuttle bus at the door of the IHEP Main building

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Banquet (Great Mansion Restaurant)

Session 8 / 71

Progress of helium refrigerator in TIPC

相应作者： liqing@mail.ipc.ac.cn

Session 8 / 72

Cryogenic system at Peking University

相应作者： jkhao@pku.edu.cn

Session 8 / 73

Cryogenic System for the SCLF Cryomodule Test Facility

相应作者： sunjc@shanghaitech.edu.cn

Session 8 / 74

Cryogenic refrigeration system revamp project at the Paul Scherrer Institute

相应作者： ute.probst@linde-kryotechnik.ch

Session 9 / 75

RF Heat Load Compensation for the European XFEL

相应作者： joerg.penning@desy.de

Session 9 / 76

Experimental study of helium liuqefier

相应作者： jctang@fuhaicryo.com

Session 9 / 77

The LHC Cryogenics Availability Calculation Tool

相应作者： laurent.delprat@cern.ch