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SPECIALIZED TECHNICAL SERVICES AT ESS

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Abstract

The European Spallation Source (ESS), a world class lab for neutron science currently under construction in Lund, Sweden requires a number of technical services that extend across the various project areas (accelerator, target and neutron science). These services include: cryogenics, vacuum and technical electrical and cooling systems. This effort constitutes more than 70 million Euros of construction cost. Rather than have separate support groups in each of the project areas, ESS has created a Specialized Technical Services group within the Accelerator Division to provide these services. This approach permits standardization, development of synergies and improved communication. The STS group also provides cryomodule testing to the accelerator project.

This paper describes the scope of work, current design status and future plans for Specialized Technical services at ESS.

INTRODUCTION

The European Spallation Source (ESS) is a world class lab for neutron science currently under construction in Lund, Sweden [1]. The technical part of ESS can be divided broadly into 3 project areas: the accelerator that produces the proton beam, the target that converts the protons into neutrons via spallation and the instruments that enable the neutron science. All three of these areas require services in cryogenics, vacuum and technical cooling and electrical support.

The Specialized Technical Services (STS) Group provides this support to all areas of ESS. These services were centralized within a single group to allow standardization, improved communication and the development of synergies. STS also provides testing of the elliptical cavity cryomodules and, via our collaborators at Uppsala University, testing of the spoke cavity cryomodules.

CRYOGENICS

Accelerator Cryogenics

The accelerator, based on superconducting RF technology is the principal user of cryogenics at ESS. The 146 SRF cavities contained in 43 separate cryomodules operate at 2 K. In addition, each cryomodule has a 40 K thermal shield. The cooling for these cryomodules will be provided by the Accelerator Cryogenic Plant (ACCP) that has a capacity of 3kW at 2 K, 10.8 kW at 40 K and 9 g/s liquefaction capacity for power coupler cooling.

The ACCP is connected to the cryomodules via a cryogenic distribution system that permits independent warm up and cool down of each cryomodule. A conceptual design of the distribution system including a typical connection to the cryomodules is shown in Figure 1.

Preliminary industry studies have been carried out for the ACCP. A detailed technical specification had been written and a request for proposals released. The ACCP will be ordered in Q1 2015. The ACCP and cryogenic distribution system will be fully installed and commissioned by the end of 2018.

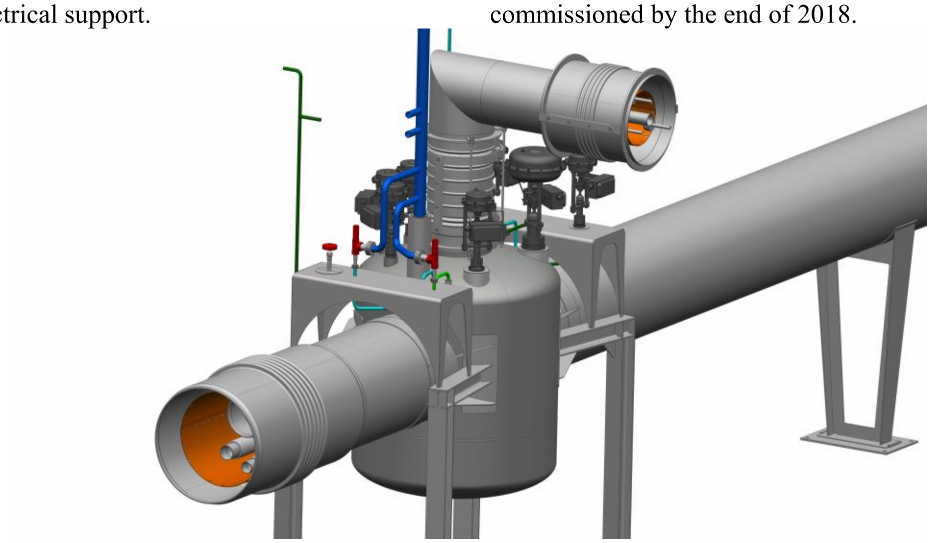

Figure 1: Conceptual Design of ESS Cryogenic Distribution System.

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Target Cryogenics

The cryogenic system for the target supports the supercritical Hydrogen in the neutron moderators surrounding the target. These moderators operate at 20 K. The design of the moderators and the hydrogen loop is the responsibility of the Target Division. STS provides supercritical helium at a nominal temperature of 16 K that serves as a heat sink for the hydrogen loop. The moderator design has recently been optimized and the current capacity required for the target moderator cryoplant (TMCP) is 20 kW @ 16 K. The TMCP will be ordered in 2015 and commissioned in 2018.

Test & Instruments Cryogenics

Neutron instruments at ESS will require up to 5000 l per month of LHe, both for the instruments themselves and for the cryogenic sample environment. This is provided by the Test & Instruments Cryoplant (TICP). The TICP will also provide the cooling for the cryomodule test stand at Lund and this application sets the capacity of the plant at 76 W at 2 K, 422 W at 40 K plus 0.2 g/s of liquefaction for coupler cooling. When operated in pure liquefaction mode this plant will produce more than the required 5000 l per month. All LHe sent to the instruments is returned as warm gas, purified and reliquefied. The TICP will be ordered in 2015 and commissioned in mid 2017.

Additional details of the ESS cryogenics system may be found in [2].

VACUUM SYSTEMS

Vacuum is used throughout ESS, including in the accelerator beam line, the neutron guides, surrounding the target, as part of the cryogenic insulation system and in the instruments themselves. Depending on the application, the vacuum levels range from 10^{-10} to 10^{-2} mbar. Portable cleanrooms will be required for the interconnection of some of the accelerator components. In the ESS all vacuum activities are located in the STS group allowing for standardization and economies of scale. Activities to date include: holding a vacuum standardization workshop with ESS collaborators, production of a detailed vacuum handbook, conceptual and in some cases detailed design of vacuum components. Figure 2 is a conceptual design of the Low Energy Differential Pumping Unit that connects the beam line vacuum between the normally conducting front end linac components and the cryogenic superconducting cryomodules.

ELECTRICAL AND COOLING SUPPORT

This activity provides the engineering and organizational link between site utilities, provided by Conventional Facilities Division, and the technical customers (accelerator, target and instruments) throughout the ESS project. Work here includes development of grounding systems to prevent electromagnetic interference between technical systems, modelling of the site electrical system, collection of site – wide uninterruptable power requirements, gathering of water cooling requirements and developing systems that provide that cooling from site utilities.

Challenges in this area include: the requirement for heat recovery by using the Lund district heating systems as the ESS heat sink, the need for low conductivity water in certain systems and the potential for some water systems to contain tritium necessitating separate isolated loops.

Significant work has been done to date in requirements definition and conceptual design. Figure 3 shows a conceptual layout of the cooling water system for the normally conducting front end of the accelerator.

TEST STANDS

The ESS cryomodules contain the superconducting RF cavities that provide the bulk of the beam acceleration. There are three different families of cryomodules: spoke cavity, medium β elliptical and high β elliptical. All cryomodules are tested at full power and at the nominal cryogenic temperatures prior to installation. The spoke cavity cryomodules are expected to be tested at Uppsala University and the elliptical cavity cryomodules will be tested at the ESS site. The STS group is responsible for the design, installation and operation of the ESS test stand and provides assistance in the coordination of the Uppsala tests. Cryomodule testing activities and data analysis will involve ESS, Uppsala and the in-kind partners that are responsible for the design and production of the cryomodules. In addition, in-kind partners will assist the testing program with their expertise. STS is also responsible for the set up of test stands for the testing of ESS klystron and modulator prototypes. Figure 4 shows the layout of the ESS cryomodule test stand. This stand is scheduled to be in operation by the end of 2017.

STAFFING

There are currently 16 people in the STS group including scientists, engineers and designers in a variety of technical disciplines. This number is expected to more than double by 2018 as technicians, cryoplant operators and additional engineers are added. In addition, there are generally one to two graduate students in the group working on topics in cryogenics and vacuum systems.

SUMMARY

Significant work in Specialized Technical Services (cryogenics, vacuum, electrical, cooling and test stands) has been done at ESS consistent with the project schedule. Having a single point of contact at ESS for these disciplines improves communications and allows for standardization and the development of synergies.

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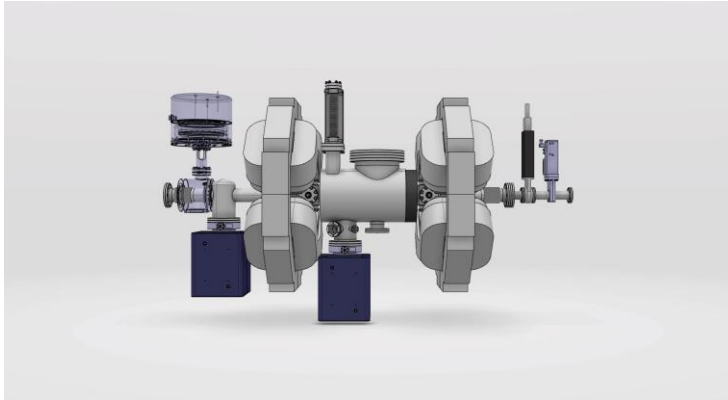

Figure 2: Conceptual Design of Low Energy Differential Pumping Unit.

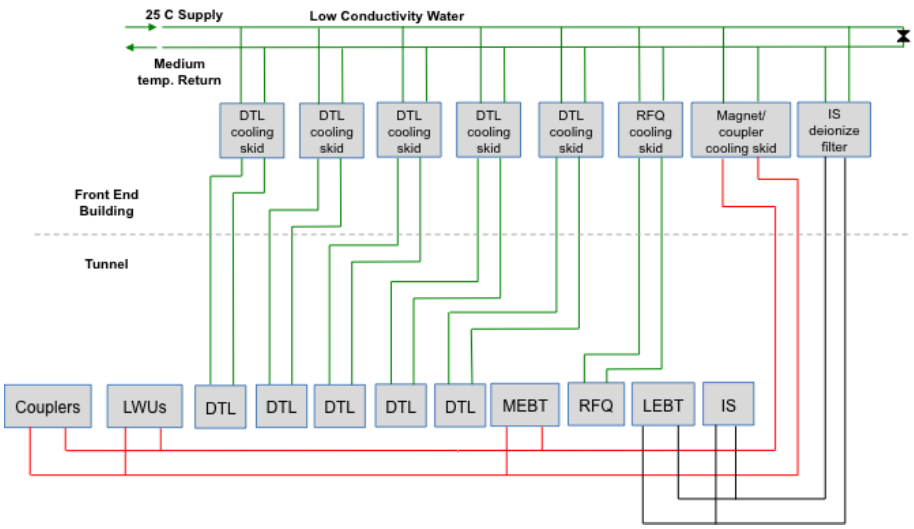

Figure 3: Water Cooling System Schematic for the ESS Linac Normal Conducting Front End.

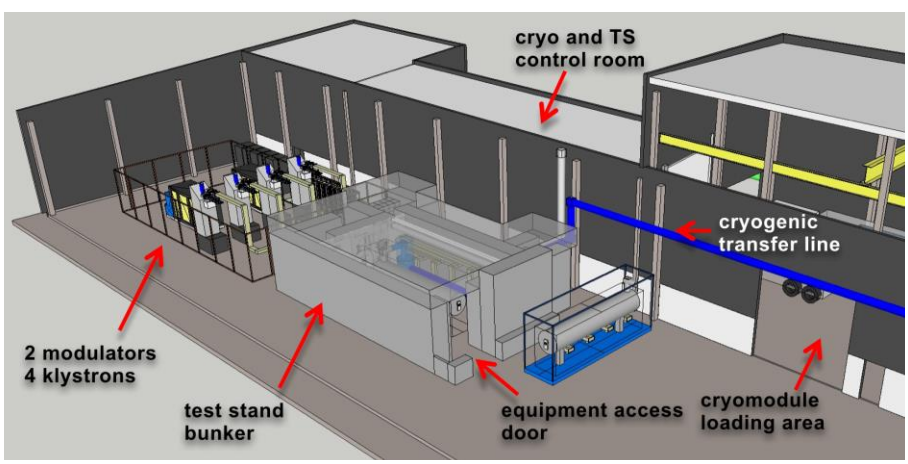

Figure 4: ESS Cryomodule Test Stand.

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