

Contract for the Design, Fabrication, Installation and Commissioning of the Helium Refrigerators for ITER

SUMMARY

Purpose

The purpose of the Contract is the design, fabrication, installation and commissioning of the helium refrigerators for the ITER machine components.

Background

ITER overall programmatic objective is to demonstrate the scientific and technological feasibility of fusion energy for peaceful purposes. The principal goal is to produce significant fusion power amplification (tenfold the energy input).

The ITER machine requires high magnetic fields to confine and stabilize the plasma. The magnets require cooling with supercritical helium at an inlet temperature of 4.2 to 4.5 K and the possibility of enhanced cooling at 3.8 K. All magnets are surrounded by a large cylindrical cryostat and an actively cooled silver-coated thermal shield cooled between 80 and 100 K. Cryogenics is also required for the evacuation of the cryostat insulation vacuum and the Torus vacuum as well as the pumping of the fusion reaction ashes. The required high pumping rates and vacuum is achieved via large cryosorption panels cooled at 4.5 K.

Cryogenic components and equipment will be procured from China, the European Union, India, Korea and the United States of America. The ITER Organization in Cadarache is responsible to define the conceptual design, coordinate and integrate the work of the Domestic Agencies, commission and operate the machine. In addition the ITER Organization in Cadarache will directly procure the liquid helium refrigerators from one of the 7 parties.

The key design requirement for the ITER cryogenic system and in particular for the helium refrigerators is to cope with large dynamic heat loads deposited in the magnets due to magnetic field variation and neutron production from deuterium-tritium fusion reaction. At the same time the system must be able to cope with the regular regeneration of the cryopumps to 80 K as well as higher temperature regeneration at 470 K.

The basic duties are the cooldown of the cryopumps in order to pump the cryostat and torus and the gradual cooldown and fill of the magnet system and thermal shields. Once at nominal operating temperatures, the cryogenic system has to maintain the magnets and cryopumps at these operating conditions over a wide range of operating modes. It has also to accommodate resistive transitions and fast discharges of the magnets and limit the time to recover back to nominal operating conditions. Additionally the system must ensure high flexibility and reliability of operation together with low maintenance requirements.

The ITER cryogenic system consists of two main sub-systems: the cryoplant and the cryodistribution.

The cryoplant is composed of helium and nitrogen refrigerators combined with an 80 K helium loop. Storage and recovery of the 24 t helium inventory is provided in warm and cold (80 K) gaseous helium tanks.

The three helium refrigerators will supply the required cooling power via an interconnection box providing interface to the cryodistribution system and redundancy of operation between refrigerators during faulty scenarios. One of the helium refrigerators is fully dedicated to the cryopump system for the cooling of the cryopumps prior to cooling the cryostat. It

accommodates regular variations of liquefaction and refrigeration loads for cryopumps operation. The other two refrigerators are used for the magnets system and provide partial redundancy for stand-by operation while keeping the refrigerator size within industrial standards.

Two nitrogen refrigerators provide cooling power for the thermal shields and HTS leads cooling as well as 80 K pre-cooling of the helium refrigerators.

The refrigerators and the whole cryoplant which comprise the dryers, gas medium pressure storage for 24 t of helium, liquid helium and liquid nitrogen, purification system, will make use of state-of-the-art technology adapted to large dynamic loads and parallel refrigerators' operation. Presently two large units of about 25 kW for the magnets and a smaller one of 15 kW for the cryopumps and small users shall be installed in order to minimize costs and improve efficiency. Staged installation for the various phases of the machine operation will be adopted instead of uncertainty factors and margins. The requirements and loads for the refrigeration system will be therefore constantly checked and validated before committing to an upgrade.

In addition the cryoplant system will be designed to ensure high flexibility and reliability in line with machine operation requirements as well as low maintenance of equipments for reduced shutdowns.

A non exhaustive list of features and requirements for the helium refrigerators is:

- ✓ Two stages compressors
- ✓ (Switchable) online dryers for moisture
- ✓ Bypass valves and heaters for reception test
- ✓ Gas management valves
- ✓ Return from current leads
- ✓ Possibility to recover gas of approx. 5 bar line from 470 K box
- ✓ Helium recovery from quench tanks (to be defined)
- ✓ LN2 pre-cooling for gradual cool down and normal operation
- ✓ Switchable 80 K absorbers
- ✓ Switchable 20 K absorbers
- ✓ Phase separator to reach SHe to 4.6 K

The helium refrigerators have to be fully automatic. The hardware (PLC's etc...), and software will be a part of the supply which also include the master controller for the whole cryogenic system (phase sequencer).

The supply shall also include all the required documentation and spare parts.

The Tenderer, awarded and having signed the Contract shall be denominated as the Contractor.

Scope of work

The contractor shall design, fabricate, install and commission the helium refrigerators and provide the necessary documentation, spares and controls.

A non exhaustive list of deliverable is:

- 1) Detailed engineering design of the helium refrigerators
- 2) Manufacturing of the helium refrigerators and factory testing's
- 3) Packing and Shipping
- 4) Final assembly and installation of the helium refrigerators at ITER site Cadarache
- 5) Warm commissioning
- 6) Cold commissioning and acceptances tests for the refrigerators
- 7) Fully automated control system
- 8) Documentation, operating procedures and spare parts

Estimated Duration and Timetable

The duration of the Contract will be approximately 5 years from the date of the signature, plus options for additional spares and a possible upgrade of the cooling capacity or an additional refrigerator. The ITER Organization explicitly reserves the right to decide whether or not to extend the Contract for the options and upgrades.

The tentative timetable of the applicable Call for Tender procedure is as follows:

Call for Pre-qualification	July 2010
Call for Tender	1 st quarter 2011
Tender submission	2 nd quarter 2011
Contract placement	3 rd quarter 2011

Experience

The potential tenderers shall have proven experience in the following areas:

- ✓ Design, manufacturing, installation and commissioning of helium refrigerators with a 4.5 K equivalent cooling power of at least 15 kW
- ✓ Design and programming of controls for complex cryogenic system
- ✓ In-house technology and expertise for helium expansion turbo machines with gas or magnetic bearing
- ✓ be certified ISO 9001:2000/ISO 9001:2008, ISO 14001, OHSAS 18001
- ✓ have designed and built in the past following EN or ASME and CE certifications

Candidature

Participation is open to all legal persons participating either individually or in a grouping (consortium) which is established in an ITER Member State. A consortium may be a permanent, legally-established group or a grouping, which has been constituted informally for a specific tender procedure. All members of a consortium (i.e. the leader and all other members) are jointly and severally liable to the ITER Organization.