

SUMMARY

“Conceptual design of the five Auxiliaries Cold Boxes (ACB), the Cold Compressor Box (CCB), the Thermal Shield Cooling system (TSCS) of ITER project”

Introduction to the Cryogenic system

ITER is a thermonuclear experimental reactor based on a large superconducting magnet and cryopump systems. Therefore the ITER machine requires a large cryoplant and cryodistribution system to cooldown the systems and to remove heat loads at 4.5 K and 80 K in steady state as well as transient operation. The cryodistribution system is located in the tokamak building while the cryoplant is installed in a dedicated building.

The cryodistribution consist of five Auxiliary Cold Boxes (ACB) one Compressor Cold Box (CCB) supplying 43 cold boxes interfacing the cryogenic users and two Thermal shields Valve Box (TCVB) (Figure 1). The cryogenic power distribution is achieved via a complex system of multi-pipe cryogenic transfer lines.

- The first cooling loop distributes the cold power to the magnet system. This part gathers 26 Cold Termination Boxes (CTB), 3 Cold Valves Boxes (CVB) and 4 Auxiliary Cold Boxes (ACB). It includes independent 4.5 K supercritical helium primary loop dedicated to each magnet subsystem as the Central Solenoid (CS), the Poloidal Field (PF), the Toroidal Field (TF) and the Structures (Str).
- The second cooling loop is dedicated to the cooling and regeneration of the cryopumps system used to produce high vacuum in the plasma vessel, the cryostat vessel and the beam line vessels of the Neutral Beam Injection (NBI) system. Only one ACB and one primary supercritical helium loop are used to supply 14 CVB interfacing the cryopumps, NBI and the Pellet Injection System with the cryodistribution.
- The third cooling loop supply the thermal shield system, via the two TCVB part of the TSCS system.

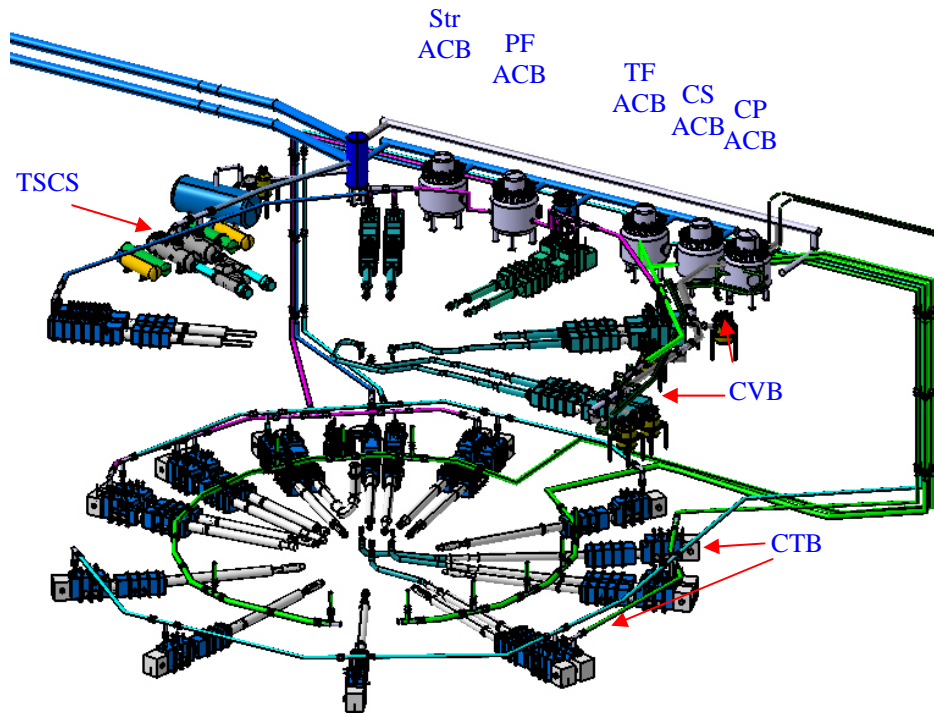


Figure 1: General layout of the ITER cryogenic distribution and cryolines in the tokamak building

Subject of this Technical Specification

This technical specifications details requirements, information and deliverables for the tendering of the conceptual design of the 5 **Auxiliaries cold boxes** (called **ACB**), one **Compressor Cold box** (called **CCB**) and the 2 **Cooling Thermal Shield systems** (called **TSVS**) for the ITER cryogenics system which are required for the distribution and control of the cryogenic fluids to the users.

This note includes all the technical specifications and requirements for the 5 ACBs, CCB and TSVS. The contractor shall review the requirements, perform the conceptual design and provide the design description, supply the thermal mechanical calculations and assembly strategy.

Scope of work

The contractor shall provide CAD and Engineering personnel with cryogenic engineering experience, cryogenic material expertise, cryogenic design know-how and expertise. The contractor shall or review:

- routing, layout, installation, P&ID of cryolines and cryodistribution components
- Studies of the internal layout of the ACB's, CCB and TSVS in order to optimize and identify interfaces and requirements.
- Studies of the U-bend Box (UB), Water cooling box (WA) and Electrical Heater boxes (EH)
- The thermal-mechanical calculations and verification to support design and layout.

-The Technical Design Report relating to the conceptual design.

Documents in computer-readable form

All documentation supplied to ITER shall in their final version be made available in computer-readable form.

-Microsoft Office Word 2003 for text documents

-Microsoft Office Excel 2003 for lists

-Microsoft Office Project 2003 for planning

-CATIA V5 R17 for engineering drawings

-ANSYS V11 for Finite Elements calculation

Units to be used in all documentation

The units of physical values in any documentation shall be according to the International Standard of Units (SI).

All property data for Helium given in any documents shall be compatible with the NIST (National Institutes of Standards and Technology) Technical Note 1334 by R.D. Mc Carty.

Normal temperature and pressure (NTP) are defined as 273K and 0.1013MPa (1.013 bar)

All pressure values are given as absolute pressure with respect to vacuum.

General description of the work

All ACBs are located at the upper level of the tokamak building. In the Process Flow Diagram (PFD see Annex 1) ACBs and CCB are situated between the collector and the valves boxes of the users. A compact design is required due to buildings constraints (see cross section of the cryodistribution area in annex).

Each ACB contains one circulating pump for supercritical helium (SHe), one or two bath(s) with boiling liquid helium working at two different levels of temperature, one or two supercritical helium flow heat exchanger(s) (note that at this time these two options are under discussion but the PFD and the P&ID will be frozen at the kick-off meeting), a set of cryogenic valves to control the supply and return helium flow (during cool down, test modes, normal operation, warm up) and also to isolate the tokamak cryostat from the ACB in order to reduce the accidental releases of cold gas helium in case of piping failure.

There is one entrance port from the ACB common manifold between ACBs and the collector and there are two or three identical exit ports towards the cryolines supplying the users. Vacuum barriers are installed on these 3 or 4 connections.

Two identical TSCS (or only one, note that at this time this option is under review and shall be frozen at the kick-off meeting of this task), shall provide full redundancy for the cooling system of the thermal shield; this system shall be composed by two identical 80K Cold Valve Box (TCVB), two identical U-Bend Box (UB), two identical Water Cooler (WA), two identical Electrical Heater (EH).

Design requirements

All components shall be of a high industrial quality standard, all pipes shall have multi-layer insulation and the ACB and CCB system shall be vacuum insulated with active thermal shield and be equipped with vacuum barriers, the TCVB shall be vacuum insulated and be equipped with vacuum barriers.

Performances

The valves boxes ACB, the CCB and the TCVB shall be designed to guarantee a minimum heat load into the cold piping by using a vacuum enclosure, an active thermal shield (not for TCVB) and multi-layer insulation.

Applicable documents

ITER standards

ASME is selected as main code following the Pressure Equipment Directive PED 97/23/EC

Design and Manufacturing:

vessels: ASME Section VIII Div. 2

piping ASME B 31.3, Category M

pumps ASME B73.1M / B73.2M

valves ASME B16.34

supports ASME Section VIII Div.2

bellows: ASME B31.3, Appendix X/EJMA

International standards

Others recent harmonized EU standards, which are in conformity with PED.

EN 1252-1:1998 Cryogenic vessels - Materials - Part 1: Toughness requirements for temperatures below -80 C

EN 1626:1999 Cryogenic vessels - Valves for cryogenic service

EN 1797:2001 Cryogenic vessels - Gas/material compatibility

EN 12434:2000 Cryogenic vessels - Cryogenic flexible hoses

EN 13371:2001 Cryogenic vessels - Couplings for cryogenic service

EN 13458-1:2002 Cryogenic vessels - Static vacuum insulated vessels - Part 1: Fundamental requirements

EN 13458-2:2002 Cryogenic vessels - Static vacuum insulated vessels - Part 2: Design, fabrication, inspection and testing

EN 13458-3:2003 Cryogenic vessels - Static vacuum insulated vessels - Part 3: Operational requirements

EN 13648-1:2002 Cryogenic vessels - Safety devices for protection against excessive pressure Part 1: Safety valves for cryogenic service

EN 13648-2:2002 Cryogenic vessels - Safety devices for protection against excessive pressure Part 2: Bursting disc safety devices for cryogenic service

EN 13648-3:2002 Cryogenic vessels - Safety devices for protection against excessive pressure

Quality assurance

The organisation conducting these activities should have an ITER approved QA Program or an ISO 9001 accredited quality system.

Prior to commencement of the task, an Implementation Plan ([ITER Contractor Implementation Plan \(22MFMW\)](#)) must be submitted for IO approval giving evidence of the above and describing the organisation for this task; the skill of workers involved in the study; any anticipated sub-contractors; and giving details of who will be the independent checker of the activities.

Documentation developed as the result of this task shall be retained by the performer of the task or the DA organization for a minimum of 5 years and then may be discarded at the direction of the IO. The use of computer software to perform a safety basis task activity such as analysis and/or modelling, etc shall be reviewed and approved by the IO prior to its use, it should fulfil IO document on Quality Assurance for ITER Safety Codes ([Quality Assurance for ITER Safety Codes \(258LKL\)](#)).