TECHNICAL SPECIFICATION FOR THE SUPPLY OF THE TORUS CRYOPUMP HOUSINGS TO THE ITER ORGANISATION

INFORMATIVE APPENDIX APB3_A

TCPH SYSTEM DESCRIPTION

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1. LOCATION

The external rectangular envelope (Shell) of the six Torus Cryopump Housings (TCPH) connect with and are located outboard of the Cryostat Lower Ports 4, 6, 10, 12, 16 and 18, to which they are joined by welded connections. The inner cylindrical regeneration volume of each Torus Cryopump Housing incorporates a cylindrical double bellows at their inboard end and these are connected to the VV Port Extension at the aforementioned lower port locations. At their outboard ends, the Torus Cryopump Housings protrude through penetrations in the cylindrical bioshield and terminate in the Lower Port Cells at their Cryopump Flanges.

Note: All pictures shown in this document are for reference only.

2. SYSTEM FUNCTIONAL REQUIREMENTS

The TCPH provides a vacuum environment to avoid excessive thermal loads from being applied to the Torus Cryopump components located within their vacuum volume that are being operated at cryogenic temperatures, by gas conduction and convection.

The TCPH constitute radiological confinement since they form the vacuum volume into which the Torus Cryopumps regenerate hydrogen isotopes including tritium.

The TCPH are SIC-1 class components since the free vacuum volume is large enough to limit the maximum hydrogenic concentration to 1.5 mol/m^3 to mitigate deflagration hazards.

The TCPH are of robust rigid construction to handle all design basis loads adequately for SIC-1 components

The Torus Cryopump Housings has penetrations for connecting the elements of systems outside the Cryostat to the corresponding elements inside the Vacuum Vessel (such as water cooling pipes, diagnostic, pellet and gas injection systems, and pumping ducts for the Torus Cryopumps).

The TCPH have flanged connections at their outboard ends in the lower port cells to facilitate remote removal and replacement of complete torus cryopumps.

The TCPH incorporate features to allow docking of a remote handling cask in the port cells to enable remote removal and replacement of complete torus cryopumps while preserving radiological confinement and ionizing radiation shielding integrity during remote handling of the torus cryopumps.

Each TCPH incorporates cylindrical double bellows connecting their inner cylindrical regeneration volume to the VV Port Extension in order to compensate for the mutual displacements between the VV Port Extension and Torus Cryopump Housings, which are mechanically anchored to the Cryostat, occurring under design basis events (thermal, seismic, thermo-hydraulic, electro-magnetic). The bellows are double to prevent perforation of a single bellows from tritiating the Cryostat and internals since the pumping duct pressure is several orders of magnitude higher than the cryostat pressure during plasma discharges.

The TCPH are a SIC-1 component.

The TCPH have a Seismic Classification of: SC1(SF)

The TCPH have a Quality Classification of: QC 1

The TCPH have a Tritium classification of: TC 1A

The TCPH have RH Classification of: non-RH

The TCPH have a Vacuum Classification of: VQC-1A

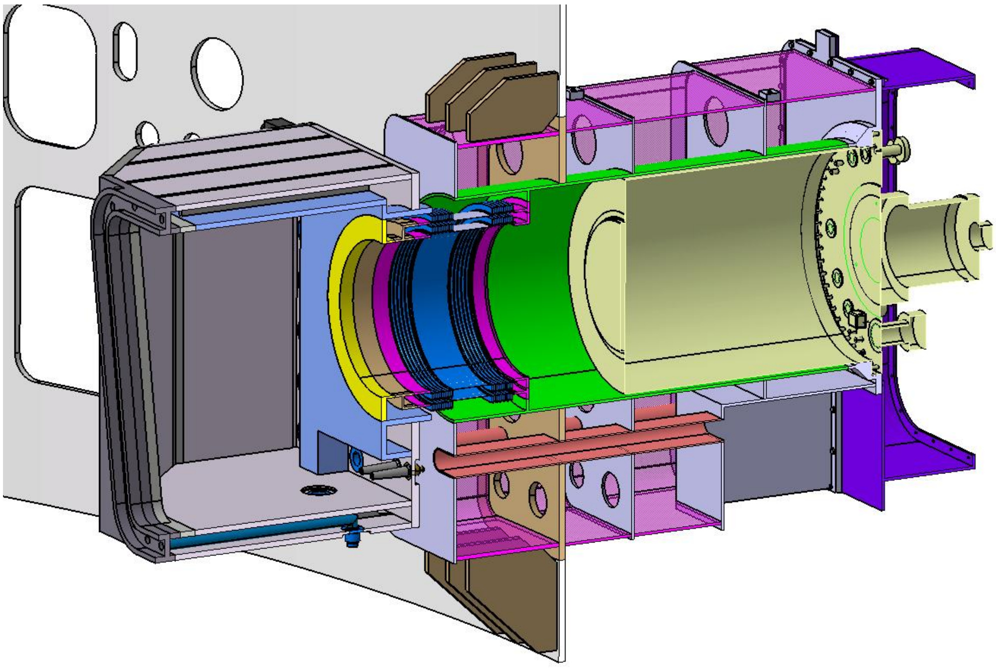
The TCPH have an ESPN classification of: not applicable

The TCPH have a PED Classification of: not applicable

3. SYSTEM DESCRIPTION

The TCPH is a vacuum vessel, with its axis horizontal and has two separate vacuum volumes, an inner and an outer. The inner cylindrical volume (Inner Cylinder) of each TCPH houses a Torus Cryopump, which is secured to the housing by a bolted flange at the outboard, port cell end, the necessary vacuum seal being provided by a double metallic seal ring assembly integral with the bolted flanged connection. The outer vacuum volume (Shell) is rectangular in cross section with radiused corners. It envelopes the inner cylindrical vacuum volume and is joined to it by ribs (Vertical Plates) which are welded to both the inner and outer vacuum volume walls. Each Torus Cryopump Housing fits into the Cryostat Vessel through a corresponding rectangular penetration in the Cryostat wall, to which it is welded. The inboard end of the cylindrical inner vacuum volume connects with a cylindrical double bellows, the other end of which connects to the VV Port Extension. The interspace of each double bellows assembly incorporates pipes to supply tracer gas to, or to evacuate, the interspaces for detection of vacuum leaks in either the inner or outer bellow elements.

In order to eliminate variants of the TCPH design, a single uniform design is used, capable of accommodating all design boundary conditions, including the worst case (port 12).



4. TORUS CRYOPUMP HOUSING COMPONENTS

The main components that form the full Torus Cryopump Housing are as follows: The inner cylindrical vacuum volume (Inner Cylinder), including the flanged connection mating with the Torus Cryopump flange; the outer rectangular vacuum volume (Shell); the ribs joining the Inner Cylinder to the Shell; the double cylindrical bellows connecting the inner cylindrical vacuum volume to the VV Port Extension, including the bellows interspace monitoring pipes.

The mass of each TCPH is 15.8 t

The overall dimensions of each Torus Cryopump Housing are: W=2700; H=3330; D=3490

Inner Cylinder

The Inner Cylinder is 1640 mm outside diameter, 20 mm wall thickness, 3150 mm long and of mass 2626 kg.

Cryopump Flange

The Cryopump Flange is 2700 mm wide by 3140 high (excluding dowel lugs used for locating the Torus Cryopump during insertion into the Inner Cylinder) and has a maximum thickness of 340 mm. The connection interface of the Housing Flange is machined to tolerances compatible with the metallic double vacuum seal. The Cryopump Flange incorporates remote handling sockets which facilitate docking of the Torus Cryopump remote handling equipment during remote maintenance operations.

Shell

The TCPH Shell is segmented axially into such that the width increases towards the outboard. The shell elements are fabricated from 20 mm thick plate material, with corner external radii of 150 mm and vary in external width from 1900 mm to 2580 mm with a constant external height of 3020 mm.

Vertical plates

Five Vertical Plates join the Inner Cylinder to the Shell elements having holes through which the Inner Cylinder pass and engage with the Vertical plates, the outer profiles of which connect with the segments of the Shell. The Vertical plates are welded to the Shells and to the Inner Cylinder. The Vertical Plates have penetrations to allow passage of services including such as diagnostics, and pellet and gas injection systems. The width of the Vertical Plates varies from 1940mm to 2620 mm with a constant height of 3060 mm. All Vertical Plates are from 20 mm thick plate material and their mass varies from 585 kg to 675 kg.

Wall flange

The single Wall Flange of each TCPH is used to connect the Inner Cylinder to the Shell, where the Shell penetrates the Cryostat Vessel wall, to which it is welded. To provide reinforcement at this location, where the mass of the Torus Cryopump Housing (including Torus Cryopumps and all systems passing through it) is transferred to the Cryostat wall, the Wall Flange has the same radius of curvature and thickness as the cryostat wall for good abutment. The Wall Flange has holes to allow penetration of the services passing through it (diagnostic, and pellet and gas injection systems) and additionally for the pipes used to monitor the interspace of the cylindrical double bellows between the Inner Cylinder of the Torus Cryopump Housing and the VV Port Extension. There are three variants of Wall Flange, with penetration holes to suit the services passing through the particular Torus Cryopump housing, and mass of each Wall Flange is 1697 kg to 1712 kg. The envelope dimensions are 2140 mm linear width, 3220 mm height, 50 mm wall thickness.

TCPH Ribs

Welded ribs reinforce the junction between the TCPH and their Cryostat wall penetrations. The ribs are 50 mm thick and there are three variants weighing 93, 100 and 154 kg. The Ribs are welded to each Torus Cryopump Housing Shell where it protrudes into the Cryostat, and the Cryostat wall.

TCPH Double Bellows

The double bellows connects the inboard end of the Inner Cylinder to the outboard end of the VV Port Extension. The bellows compensate for the mutual displacements between the VV Port Extension and TCPH (which are mechanically anchored to the Cryostat), occurring under design basis events (thermal, seismic, thermo-hydraulic, electro-magnetic).

TCPH Temporary Flange

The Torus Cryopump Temporary Flange is fitted to the TCPH Cryopump Flange to maintain radiological confinement during maintenance of the Torus cryopumps. It is fabricated from 20 mm plate material and the mass is 1684 kg.

5. TCPH Assembly

The Torus Cryopump Housings are SIC-1 because the pressure boundary constitutes radiological confinement for the tritium that is pumped during plasma discharges and dwell periods and also since they contain flammable hydrogen isotopes in quantities that could pose a deflagration hazard.

Shipment

The ITER site has a transport limitation of 9m×9.1m×19m (W×H×L). Therefore the Torus Cryopump Housings may be fabricated in India and transported to the ITER site in packages that conform to this size limit.

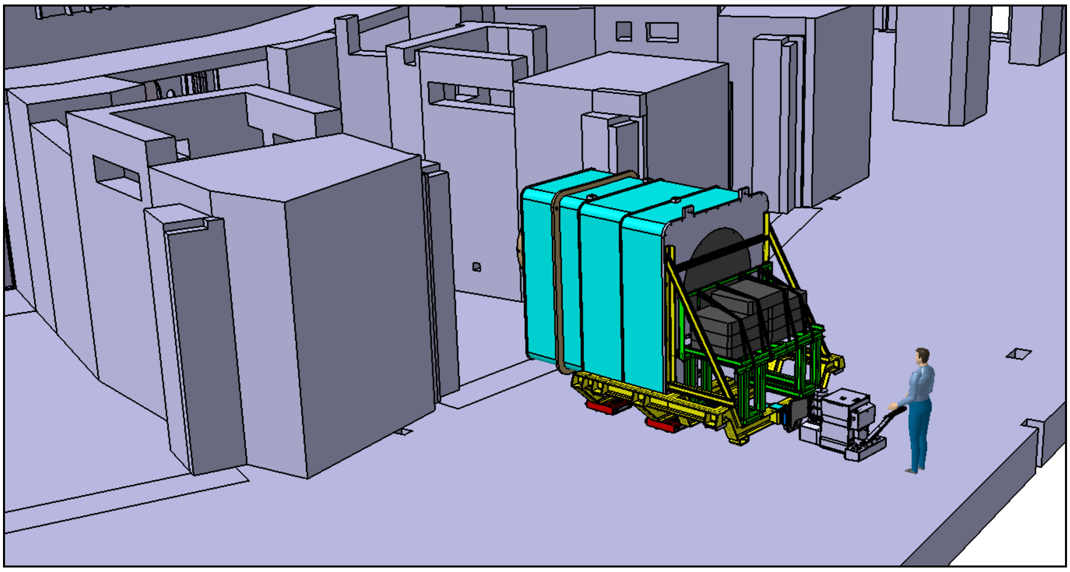
The transported components must be packed in accordance with the requirements of the ITER Vacuum Handbook to prevent damage or contamination, especially by seawater, during transportation. Those parts shipped by sea will be cleaned in accordance with the requirements of the ITER Vacuum Handbook prior to the commencement of assembly to the ITER machine.

On-site Fabrication

When the TCPH are delivered at the ITER site, they are unpacked, inspected and tested in accordance with the requirements of the ITER QC system and the ITER Vacuum Handbook, prior to acceptance or non-acceptance.

For each TCPH assembly to the ITER machine, there are two elements that have to be custom machined to compensate for as-built positional and profile tolerances of the abutments between the TCPH and the ITER machine. These abutments are (i) where the Wall Flange is welded to its mating penetration in the Cryostat wall and (ii) where the double bellows is welded to the VV Port Extension. To compensation for toroidal and vertical misalignment of the VV Lower Port Extension opening and cryostat opening, the Wall Flange is supplied with a 120 mm trim allowance which is custom machined based on a survey of the as-built position and profile of the VV Port Extension abutment and the TCPH penetration in the Cryostat wall, at each of the six TCPH locations. For the double bellow assemblies, radial misalignment of the VV Lower Port Extension and Cryostat openings is compensated for by the VV Port Extension Adaptor. This element is custom machined based on a survey of the as-built position and profile of the VV Port Extension abutment and the TCPH penetration in the Cryostat wall.

Assembly to the ITER machine



1) The TCPH will be driven inside the Building 11 through the TO-11-L1-08 to the TKM lift and then transferred to B1 in front of the Lower Port Cell of interest.

2) The TCPH, mounted on the handling tool, is driven, using the Master Tug, to the Building 11 lift (through the temporary opening at L1). Then it is driven within B1 to position it in front of the Lower Port Cell.

3) The Skidding Systems are installed under the Handling Tool

4) TCPH and Handling Tool mounted on Skidding System

5) Installation of the Lateral Beam and Horizontal Jacks

6) TCPH and Handling Tool on Lateral Beams and Jacks

7) Transfer of load to the Skidding System

8) Skates and Master Tug are removed

9) TCPH ready for final approach

10) Radial movement of TCPH and Handling Tool

11) Survey operation

The fiducials located on the external envelop of the TCPH will be used to position it accurately in the cryostat opening.

12) The TCPH is welded to the Cryostat opening from inside the Cryostat

13) TCPH Handling Tool removed

14) TCPH Counterweight removed

15) Final approach from the internal bellows side

16) Assembly of custom machined VV Port Extension Adaptor

17) Welding of double bellows assembly

Following a positional and profile survey, the VV Port Extension Adaptor is custom machined to match with the VV Port Extension interface and Bellows interface.

After qualification and acceptance of the VV Port Extension Adaptor, the internal bellows flange will be welded to the VV lower port extension, from the inside of the VV Lower Port Extension.

19) Welding of TCPH ribs

After all preceding welds are accepted, the TCPH ribs are welded (following rib welding and acceptance, the surrounding pipes are welded)