Overview of Blanket Cooling Manifold System

Task 3: Manifold Chimney Pipes

Task 5: Upper Port Manifolds

Task 6: Branch Pipes and Coaxial Connectors

Task 4: Lower Port Manifolds

Main function: to supply cooling water to the Blanket Modules (BM’s) and to contribute to neutron shielding
Overview of Blanket Cooling Manifold System

- About 6.5 km of 316L stainless steel pipes (OD = 48.3 x 2.7 mm, 60.3 x 2.7 mm).
- Not ESPN, Seismic Class 2, Remote Handling Class 3.
- General pipe shape tolerance: +/- 2.5mm over 8m pipe length.
- Challenges: no leaks (100% RX + PT on pipe welds, high EM loads (supports electrically insulated from pipes with alumina coating), high thermal loads (thermal conductivity pipe-support optimized).

- **2000 pipe supports: Three pipe support design options:**
  1. Hot Radial Pressing (HRP) = specialized process developed by ITER-F4E, requires pipe welds on each side.
  2. Bolted Design (only inboard) = High strength Alloy 718, number of pipe welds could be reduced w.r.t. HRP.
  3. Welded Clamshells = Clamshells pressed against pipes and welded; number of pipe welds could be reduced; Design validation ongoing.
Overview of Blanket Cooling Manifold System

Task 1 and Task 2: Inboard and Outboard Bundles

Chimney Pipes (Task 3)  Upper Port Pipes (Task 5)

Prototype HRP support

HRP Support Design: coated pipe placed inside steel block and submitted to high pressure and temperature in vacuum oven.

Welded Support Concept

Prototype bolted support

Task 1 (10° Vacuum Vessel sector)
Overview of Blanket Cooling Manifold System

Task 3: Chimney Pipes

V-Band Flanges are welded to the outer bulkhead stubs to provide a testing interface to facilitate the progressive leak and pressure testing of the MA during installation.

In all 18 Ports.
40 Chimney Pipes per Port (20 inlet, 20 outlet).
Pipes are bended, no supports, no coating, no welds.
V-Band Flanges are components out-of-the-shelf (COTS - no installation required).

The pipe ends at this interface are evenly distributed in relation to the port wall, to allow access for orbital cutting and welding tools for installation and future maintenance. Sufficient flexibly of the Chimney pipes mitigates the need for customized pipe ends at this joint.
Task 4: Lower Port Pipes

The 60.3 and 73mm diameter pipes, divided into two sub-lengths, are supported along the length of the Lower Port Stub Extension by four individually mounted sliding supports (bolted type) per pipe. An alumina applied coated provides electrical isolation between pipe and each support. Grey pipes are from Alloy 625.
The vessel end of each upper port pipe features an over-size pipe end boss. The machining of these bosses both internally and externally is required to achieve the weld-fit with the Inboard or the Outboard bundles. Required position of pipe ends will be provided in due time. All supports are of the bolted type.
Branch pipes delivered with over-size pipe end bosses. Customization of bosses NOT included in scope.
**HRP Support Design:** based on standard SS 316L modules bonded to the pipe by Hot Radial Pressing and welded together to form multi-pipe supports.

- **Standard Module**
- **Extensions, attachment, legs**
- **Module with shielding**

Weld root passes to be visually inspected.
DESCRIPTION OF BCM SUPPORT DESIGNS

Manufacturing of HRP Support Design:

Tools, pipe and support prepared

Tools and tube and support assembled

Module ready to be welded

Modules in vacuum oven

**Thermal cycle**

- Temperature (°C)
- Time (min)

![Graph showing thermal cycle](image_url)
HRP Support Design: Bundle Prototype with HRP supports
DESCRIPTION OF BCM SUPPORT DESIGNS

Bolted Support Design:

Supports 1 & 2
Supports 3 & 4
Supports 5 & 6
Supports 7 & 8
Supports 9
Support 10
Support 11
Support 15
Support 16
Welded Support Design:

Design consists of two half clamshells in SS 316L pressed against the pipe. Alumina is applied on pipe or on clamshells.

* TIG weld
Welded Support Design:

Clamshells coated with alumina + copper

Pipe uncoated

* TIG weld
Welded Support Design:

- Clamshells are positioned around pipe and pressed with predefined preload.
- Preload is maintained during welding.
- TIG welding with filler material and argon gas.
- Weld root passes to be visually inspected.
- Modules can be assembled as HRP modules.
Welded Support Bundles

Once the half clamshells are welded around the pipes, they can be handled and welded as any HRP modules. Weld root passes to be visually inspected.
Manufacturing Pipe Bundles using specifically designed Jigs
Manufacturing Jig for Pipe Bundles:
Manufacturing of Pipe Bundles
Correction of pipe alignment and pipe welding
Welding of Monoblocks Side by Side
Factory Acceptance tests:

- Hydraulic Pressure Test;
- Dimensional and visual examination (Geometrical shape and tolerances);
- Hot and Cold Helium leak test;
- Functional alignment test;
- Functional Electrical Insulation test;
- Final Cleaning for packaging.
MANUFACTURING OF PIPE BUNDLES

- Enclosure bag
- Gasket not expanded
- Moving plate
- Gasket expanded
- Tube to fit
- Local seal at welded joint