COOLING WATER DISTRIBUTION SYSTEM OF THE FOUR (4) ELECTRON CYCLOTRON UPPER LAUNCHERS

This technical note concerns the upcoming business opportunity related to the design for the cooling water distribution system of the four (4) electron cyclotron upper launchers. Tentative launch time of the procurement procedure is June 2014. Work starts from the beginning of conceptual design and finishes at the end of detailed design. Design tasks consist of cooling components both inside (partially) and outside of the ITER vacuum vessel. The system that is envisioned comprises of interfacing ITER service systems, manifold structures, distribution piping, flow regulation systems as well as functional specification for cooling control system. The cooling water distribution system will cool components distributed over a distance of 20 meters.

Introduction

Electron Cyclotron (EC) Upper Launcher (UL) is housed in ITER Tokamak building. EC UL consists of First Confinement System (FCS) – the first segment of the evacuated waveguide line – and Launcher, as shown in Figure 1. The interface of the FCS and Launcher is at the launcher closure plate. At the other end of the FCS, the waveguide line segment ends at the diamond window, about 16 meters outside from the Launcher closure plate. The closure plate separates components into in-vessel (inside ITER vacuum vessel) and ex-vessel (outside ITER vacuum vessel) -components.

System description and functions

The four cooling water distribution systems of the EC UL mm-wave components are placed behind 4 ITER vacuum vessel upper ports; port numbers 12, 13, 15 and 16, where upper launchers are installed and essentially provide sharing or coolant flow to launcher components (mm-wave and structural) from ITER cooling water interfaces. Mm-wave components are generally the components interacting with propagated mm-power through the First Confinement System and Launcher into the plasma, such as mirrors, waveguides, miter bends and couplings. Structural components include sections of the port plug structure, the front part of the launcher (Blanket shield module and First wall panel) and the internal shields.

The main functions of the cooling water distribution system are:

- Cooling and thermal control of the in-vessel components subjected to thermal power derived from ohmic losses, plasma heating and plasma neutron flux; maximum extracted power is in the range of 150 kW for mm-wave and 430 kW for structural components.
Cooling and thermal control of the ex-vessel mm-wave components and auxiliaries subjected to thermal power derived by ohmic losses; maximum extracted power is in the range of 100 kW.

Figure 2: Illustration of the in-vessel (black left), ex-vessel (red and blue) and transmission line (black right) segments of the Electron Cyclotron Upper Launcher waveguide lines.

The cooling water distribution can be divided into in-vessel and ex-vessel cooling systems (Figure 2). The two systems are subject to different design requirements and functions. The requirements are based on system functions and to ITER component classification which includes the classification for: Quality, Safety, Seismic, Vacuum, Tritium and Remote Handling (RH).

Cooling arrangement:

- Ex-vessel components are cooled with water of Component cooling water system 1 (CCWS-1, sole-user interface).
- In vessel components are cooled with water of Primary Heat Transfer System (PHTS, multi-user interface) or CCWS-1 (sole-user interface).

The first system is for the cooling and thermal control of ex-vessel mm-wave components in the Interspace and Port cell areas where components are under atmospheric pressure and at near room temperature.

Figure 3: Illustration of the in-vessel mirrors. Four sets of 2 mirrors direct the mm-beam propagation into the plasma.
The second system is for the cooling and thermal control of in-vessel components under vacuum, neutron flux radiation and plasma heating (Figure 3). It is under higher ambient temperature in the range of about 100 degrees in Celsius. In deuterium-tritium operation of ITER, tritium permeation through plasma facing walls into the cooling loop and activated corrosion content management need to be taken into account.

In-vessel component wetted surfaces are in general constructed of copper (Pure or CuCrZr) and stainless steel (AISI 316 variants). The erosion and corrosion issues over the lifetime of the cooling water distribution system need to be included in the engineering consideration.

Both in-vessel and ex-vessel components are under strong static and time varying magnetic fields caused by plasma and magnet coils of ITER. Instrumentation of both systems is located in port cell. System interfaces for coolants and gaseous mediums are located in Port cell.

Ionizing radiation is present in interspace and port cell. All components housed in port cell or interspace inside the space reservation of port plug remote handling transfer cask trajectory volume need to be cleared for each port plug removal. All maintenance activities foreseen for the cooling water distribution system are planned to be done through manual or semiautomatic operations. The worker exposures during maintenance activities are subject to ALARA.

Power supply for the cooling plant is provided by ITER steady state electrical network (SSEN). Cooling plant sub-system control unit (1 per port) will be used to manage control signals of each of the EC UL cooling plant.

Design Interfaces

Coordination activities linked to this work include management of interfacing design teams within and outside F4E (appointed by F4E). To clarify technical design interfaces that the cooling circuit design team need to foresee with others, see the following description and illustration (Figure 4). First set of interfaces are the mm-wave components and structural components that the cooling water distribution system will serve. Second set of interfaces is the service systems that are necessary to allow functionality of the cooling water distribution system.

For EC UL ex-vessel components, the interfaces are at the components. However, for design of the in-vessel piping and components the technical design interface will be at the port plug back-end. The circuit design team will be responsible of performing the thermo-hydraulic design of the in-vessel circuits (mm-wave and structural), and the component design team covers mechanical design of the circuits inside the vacuum vessel. Therefore, even a certain degree of task overlap is expected as the cooling circuit design team will conduct circuit analyses for the in-vessel piping and the components (mm-wave and structural) to demonstrate the overall system compliance although their routing and characteristics are the responsibility of the component design team.

![Figure 4: Boundaries of the Supply for EC UL Cooling Plant design.](image-url)