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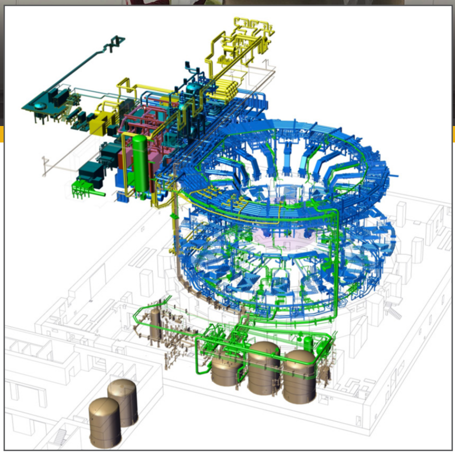
# Tokamak Cooling Water System

*The vacuum vessel primary heat transfer system (VV PHTS) volume control tank has been delivered to the ITER site. Photo: ITER Organization*



*Tokamak cooling water system design. Image: US ITER*

*Assembly is complete for this primary pump of the vacuum vessel heat transfer system. Photo: US ITER*

## U.S. Contribution

US ITER is responsible for the design, fabrication, acceptance testing, and delivery of the tokamak cooling water system.

## Overview

The tokamak cooling water system, the primary source of cooling for ITER, has the capacity to remove 1 GW of heat from client systems. Major industrial equipment is used to transfer the heat through the distribution system to an interface with the secondary cooling system, which is being provided by India.

The tokamak cooling water system is designed to cool client systems, such as the first wall blanket assembly, vacuum vessel, divertor, and neutral beam injector. Supporting operations are designed to meet functional requirements, including baking of in-vessel components, chemical and volume control of water provided to client systems, draining and drying for maintenance, and support for leak detection and localization. The system interfaces with the majority of ITER plant systems, including the steady state electrical supply, plant control systems, radioactive waste, and the tokamak building. Classified as safety important for the confinement of radioactivity, the system is comprised of more than 100 major industrial pieces of equipment operating with maximum design temperatures of 400 °C (gas) and maximum pressure of 5 MPa (water @ 240 °C) and must withstand an N16 gamma radiation source in excess of $10^{+17}$ γ/s, an N17 neutron source in excess of $10^{+13}$ n/s and magnetic fields to 125 millitesla (mT).

## Status

Final design is complete. Hardware including tanks, pumps, heat exchangers, electrical instrumentation and controls, and other components are at various stages of fabrication, with delivery of many components complete. Fabrication and deliveries will continue into 2030.

*Drain tanks produced by Joseph Oat Corporation in Camden, NJ, were the first U.S. components installed in the tokamak complex. Photo: US ITER*

## Safety functions

Confinement of radioactivity
Maximum tritium content: 0.32 mg/m$^3$
Maximum activated corrosion products: 7.8 GBq/m$^3$
Removal of decay heat in case of a loss of off-site power
Low flow pump on Class III-safety power
Small heat exchanger on safety chilled water CHWS-H1

## Equipment

**Heat Exchangers:** Heat transfer capacities from less than 1 MW to more than 200 MW

**Heaters:** Providing over 9 MWe of heating capacity

**Compressor:**
2 MW nitrogen compressor to blow out and dry client systems

**Pumps:** Ranging from small transfer pumps to 3 MW main pumps, with total pumping power 30 MW

**Normal and Safety Drain Tanks (4):**
231,600 L volume (10 m x 6 m diameter), 73,500 kg dry weight

**Neutral Beam Injector Drain Tank:**
101,300 L volume (5 m x 6 m diameter), 47,400 kg dry weight

**Pressurizers (3):**
Largest is 60 m$^3$ Volume, with a design pressure of 5.0 MPa

**Nuclear Grade Piping:**
More than 36 km of stainless-steel piping, ranging from small bore to DN500

**Nuclear Grade Valves:**
3,200 valves ranging from small bore to DN500

**Piping and equipment supports:**
Attached to steel plates embedded in concrete

## Technical Description

**Total installed heat removal capacity:** 1,000 MW (thermal)

**Max coolant operating temperature:**
126° C (plasma), 240° C (water baking), 400° C (gas baking)

**Max design pressure:** 5.0 MPa

**Cooling water inventory:** more than 1,000,000 L

## *Contributors include*

### US ITER contracts

Hayward Tyler (Colchester, VT, U.S.)

Howden Compressors (Renfrew, Scotland)

Industrias Eléctricas Soler (IES) (Barcelona, Spain)

Inovoal (Houston, TX, U.S.)

Optimex (Fleurieux sur l'Arbresle, France)

Precision Fabrication and Cleaning (Cocoa, FL)

Termomeccanica (La Spezia, Italy)

Vahterus Oy (Kalanti, Finland)

### Contracts Supporting US ITER Arrangements

CNPEC/Marimatsu (Shanghai, China)

CNPC/Hailu (Shanghai, China)

Doosan Babcock Limited/Doosan Heavy Industries and Construction (Seoul, South Korea)

Energy Steel (Rochester Hills, MI, U.S.)

Institute of Plasma Physics of the Chinese Academy of Sciences in consortium with Harbin Boiler Company Ltd. (China)

KEPCO/Doosan Heavy Industries and Construction (Seoul, South Korea)

Korea Hydro & Nuclear Power Company (Gyeongsangbuk-do, South Korea)

Porvair Filtration Group (Fareham, United Kingdom)

Procon Systems S.A. (Badalona, Spain)

TRILLIUM Flow Technologies (Saint-Victoret, France)

VELAN GmbH (Willich, Germany)

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