IDM UID
Version created on/Version Status
External Reference

Expert's support of design review of the ITER Water Detritiation System

Technical Specification

Approval Process			
	Name	Action	Affiliation
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Document Security: level 1 (IO unclassified) RO: Sergey Beloglazov			
Read Access	No limitation		

1. Background

ITER (International Thermonuclear Experimental Reactor) is established to construct and operate fusion reactor using deuterium-tritium plasma. During ITER operation, including maintenance campaigns, tritiated water will be generated by various sources, which lead to accumulated amounts that are much in excess of the amounts that can be periodically discharged as effluent. Furthermore, effluents discharge from ITER are likely be limited to tritium concentration of 74 MBq/m^3 or smaller. Because of this, tritiated water will have to be stored, and then processed on site.

According to the ITER rules design shall undergo through several design reviews. This specification is for conceptual design review. Review shall be performed by ITER staff from different departments. External experts are invited to provide an independent input to the review.

2. Design description

ITER Water Detritation System (WDS) consists of two parts: the tritiated water holding tanks for temporary storage of tritiated water and the water detritiation system itself for processing such water.

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The WDS shall be based on Combined Electrolysis Catalytic Exchange (CECE) technology. This technology includes converting tritiated water to gaseous hydrogen, detritiation of this hydrogen and discharge it to the atmosphere within the given release limits.

The total capacity of the WDS was evaluated for processing the amounts of tritiated water, which will be generated during normal operation, including maintenance. In case of accidental/incidental events leading to the generation of large amounts of tritiated water by operation of the tritium confinement systems, large holding tank(s) shall be available to store the water until it can be processed. The capacity of the tanks is determined by the throughput of the Detritiation System needed to recover from the accident/incident, and the time in which the recovery shall take place.

Based on CECE technology, the WDS admits tritiated water from the holding tanks and converts it to gaseous hydrogen using an electrolysis process. This hydrogen is fed to the Liquid Phase Catalytic Exchange (LPCE) column(s), in which it is detritiated and then discharged to the environment. The detritiation process is arranged in a counter flow mode and promoted by a hydrophobic catalyst and an inert packing material. The LPCE column therefore needs to be packed both with hydrophobic catalyst and with inert packing material.

The arrangement for column packing with catalyst and inert packing to be used for ITER WDS shall be based on proven record of testing relevant to the ITER application and quality control database for the catalyst/packing already employed. Catalyst and inert packing must be commercially available.

To allow the detritiation process to occur, the LPCE column shall also be fed with fresh water. The operating temperature of the LPCE column lies in the range 40 ºC to 80 ºC. The optimum catalyst operation temperature is determined by the catalyst characteristics.

The WDS is designated for processing of water which will be produced in normal operations of the atmosphere Detritiation Systems as part of tritium confinement at ITER. It should also process water which would be generated as a result of recovery from incident/accident events. In this respect, the WDS presents a final stage of the tritium confinement. Holding tanks shall provide the capacity for storing large quantities of tritiated water, and acting as an intermediate stage for the movement and blending of the tritiated water to the WDS. Accordcing to iTER safety classification, the WDS operation does not present a safety important function; temporary non-availability of WDS does not compromise tritium confinement. However, safety related instruments are Safety Importance Class components (SIC). For example, the tritium on-line and real-time hydrogen monitor (monitoring hydrogen discharge from LPCE), is SIC since its purpose is to monitor the WDS integrity.

The electrolysis process, which converts tritiated water to gaseous hydrogen, produces also an oxygen stream. This stream will contain traces of water vapour and tritiated hydrogen. Therefore the oxygen stream shall be decontaminated and discharged through the atmosphere Detritiation System. It is foreseen to use electrolysers of Solid Polymer Electrolyte type.

The hydrogen stream generated by the electrolyser shall be split into two streams. One part shall be fed to the Isotope Separation System (ISS) for further tritium enrichment; the other part shall be fed to the LPCE column for detritiation prior to discharge to the atmosphere. The hydrogen stream, depleted of tritium in the ISS, shall not be discharged directly from the ISS, but shall be returned to the LPCE for further detritiation prior to discharge to the atmosphere.

The water detritiation and holding tanks system shall provide the following:

- Various tanks to ensure sufficient storage capacity for the tritiated water produced during normal operations, including maintenance, and accidental/incidental events involving tritium release
- Chemical purification of tritiated water waste prior to processing
- Chemical purification of fresh water to the level of purity needed for the process
- Electrolysis process for the conversion of tritiated water to gaseous hydrogen and oxygen
- Counter-current catalytic isotopic exchange process for the detritiation of gaseous hydrogen
- Arrangement for gaseous oxygen to be detritiated prior to its discharge through the atmosphere Detritiation System
- Chemical purification of hydrogen to be fed to the ISS
- Safe discharge of decontaminated hydrogen.

One or more LPCE columns and electrolysers will be needed to meet requirements for the WDS throughput. A modular approach has to be employed. The WDS modules shall each, to the largest extend possible, be of the same design. Provisions shall be made for installation of the modules in stages.

The isotopic composition of the feed tritiated water influences the design and operation of the LPCE column. For ITER operation, it is expected that some streams of hydrogen, to be discharged to the atmosphere Detritiation System, will contain deuterium much above the natural level. This deuterium will be collected as water, which contains all three hydrogen isotopes (protium, deuterium and tritium), and then fed to the WDS system. Because WDS prevents heavy hydrogen isotopes (tritium and deuterium) to be released with the stream of decontaminated hydrogen, deuterium will be accumulated in the electrolysers in a similar way to tritium. Therefore the WDS shall be designed with provisions to provide the required overall detritiation factor for processing water containing all three isotopes.

3. Deliverable

The duration of this contract is expected to be about 3 weeks.
An expert is required to participate in the design review of the WDS conceptual design.
Prior the design review, the expert shall:

- Review documents and drawings provided by ITER
- Asses concept of WDS in respect to technical feasibility, operability and safety
- Identify inconsistency between set of requirements and design
- Identify points of concept which need improvement

It is expected that review of the documentation package will take about 5 working days. This work shall be performed remotely. The access to the documentation will be provided by ITER.

The expert shall attend the design review on 30th and 31st of March 2011, and provide support to the design review evaluation panel within 2 weeks after the design review.

The report format is established by ITER. The chairman of the design review panel is in charge of the report.

4 Profile of expert

External expert shall meet the following requirements:

- possess hands-on knowledge and experience in design and operation of full-scale or pilot-scale water detritiation facility based on CECE technology
- have a proven record of publications or list of projects on the subject
- be familiar with safety aspects of WDS facility design and operation
- be familiar with nuclear regulations applicable to WDS facility design and operation.