Tritium Release Under Unlikely and Extremely Unlikely Loading Condition of the HCCR TBS at PD-1 Phase

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1. Introduction

Korea has developed a Helium Cooled Ceramic Reflector (HCCR) TBS which will be installed to the ITER [1]. It consists of two major loops, which are HCS (Helium Cooling System) and TES (Tritium Extraction System) (Fig. 1). And these systems should demonstrate safety in various operating situations. Tritium is one of the most highly permeable molecule on earth, therefore, tritium permeation takes place from HCCR TBS. This paper presents a tritium release input data set of unlikely and extremely unlikely loading condition for the HCCR TBS, assumption of the estimation and boundary conditions.

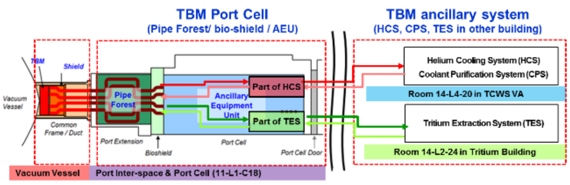

Fig. 1. Schematic Diagram of HCCR TBS.

2. Assumptions

To estimate the tritium release under unlikely and extremely unlikely loading condition followings were assumed.

-Tritium production is given by neutronics calculation. (No extra tritium flux from plasma)

-Continuous back to back plasma pulse with duty factor 0.25.

-Steady state condition (instantaneous tritium diffusion to the purge gas isotropically)

-Averaged tritium generation rate (constant over the time and uniform in the TBM volume)

-Transport mechanism through structural materials is bulk diffusion.

-Tritium concentration in space is constantly zero to estimate conservative release rate.

-Averaged temperature and pressure for each region

3. ITER Loading Conditions

ITER loading conditions are categorized into the following four classes based on the expected frequency of occurrence.

Table 1. ITER Loading Conditions

Category	Description
I	Operational Loading Conditions
II	Likely Loading Conditions
III	Unlikely Loading Conditions
IV	Extremely Unlikely Loading Conditions

4. Boundary Conditions

Boundary condition of this estimation is given in the Table 2.

Table 2. Summary of boundary condition

Tritium Production Rate	25.9 mg/day (continuous back to back with duty 0.25)
PI/PC Volume	280.264 m^3
TCWS VA Volume	500 m^3 (considering occupied by HCCR HCS/CPS)
TES Pipe Thickness	3.68 mm
HCS Pipe Thickness	8.56 mm (Vertical shaft pipe thickness 8.56 mm)
BZ Pipe Thickness	4.0 mm
N-DS at PI/PC	40 m^3/h
HVAC at TCWS	1 Vol/hr, i.e. 500 m^3/h

5. Results

Fig. 2 is pipe length and operational temperature information of each room which HCCR-TBS is allocated. Design of HCCR-TBS is evolving and this data reflects recent update of PD-1 phase.

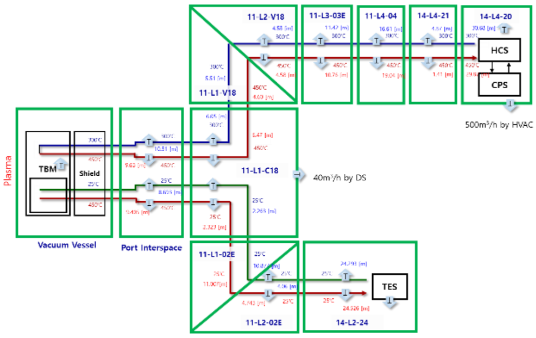

Fig. 2. Pipe length and temperature of HCCR-TBS.

6. Results

This result is outcome of input data set for the ITER Connection Pipe System Design Document, which contains total activity(Bq) of each location and amount of tritium(mg) for unlikely and extremely unlikely loading conditions of the HCCR TBS. At the PD-1 stage, it is conservatively assumed that tritium in pipes completely releases during unlikely and extremely unlikely loading. Amount of tritium highly depends on operating temperature of pipes in each room.

Table 3. Summary of tritium total activity

TBS sub-system	Function	Rooms	Total Activity (Bq) / Amount of tritium (mg) for unlikely and extremely unlikely loading conditions
HCS	Inlet	11-L1-C18	2.71E+09/7.53E-03
		11-L1-V18	2.46E+09/6.86E-03
		11-L2-V18	2.05E+09/5.71E-03
		11-L3-03E	5.11E+09/1.42E-02
		11-L4-04	7.43E+09/2.07E-02
		14-L4-21	2.18E+09/6.07E-03
		14-L4-20	1.37E+10/3.82E-02
	Outlet	11-L1-C18	2.29E+09/6.39E-03
		11-L1-V18	1.63E+09/4.54E-03
		11-L2-V18	1.62E+09/4.52E-03
		11-L3-03E	3.81E+09/1.06E-02
		11-L4-04	6.75E+09/1.88E-02
		14-L4-21	5.00E+08/1.39E-03
		14-L4-20	1.06E+10/2.95E-02
TES	Inlet	11-L1-C18	2.04E+10/5.68E-02
		11-L1-02E	9.80E+10/2.73E-01
		11-L2-02E	3.66E+10/1.02E-01
		14-L2-24	2.19E+11/6.10E-01
	Outlet	11-L1-C18	2.09E+10/5.83E-02
		11-L1-02E	9.92E+10/2.76E-01
		11-L2-02E	4.27E+10/1.19E-01
		14-L2-24	2.21E+11/6.15E-01

7. Conclusion

Total activity and tritium amount have been estimated. Design of the HCCR TBS is evolving, therefore, this input data set will be revisited at PDR and FDR phase.

8. Acknowledgement

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REFERENCE

[1] D.W. Lee, et. al., “Current Status and R&D Plan on ITER TBMs of Korea,” Journal of Korean Physical Society, 49 S340-S344 (2006).