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Specification study for the development of an isolation valve for helium cooled fusion reactor

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1. Introduction

Helium is one of the coolants of fusion breeder blanket cooling systems and a helium cooled test breeding blanket system is being developed in Korea to study tritium breeding technology in fusion reactors. The helium cooled ceramic reflector (HCCR), which is one of the helium cooled test breeding blankets, has been being developed in Korea for the ITER TBM program [1, 2, 3] and the key components of the helium cooling system (HCS), such as a high speed and high compression helium circulator, a high efficiency recuperator, are developed for the HCCR test breeding system (TBS) of the TBM program [4, 5]. In present, it is required to install isolation valves in the HCS pipe lines to protect the ITER Machine from the high pressure and high temperature of helium coolant during break out of the helium coolant of the [6].

2. Determination of the Isolation Valve

The specifications of the isolation valve are studied and determined for the HCCR HCS of the ITER project.

2.1 Operating and design conditions

Operating and design conditions of the isolation valve are the same as the conditions on the inlet and outlet of the HCS pipes for HCCR TBM because the valve will be installed at these pipes. Therefore, the operation (design) condition are 500 (550) C of temperature and 8.0 (10.0) MPa of pressure with 1.14 (1.5) kg/s of helium coolant flow [6].

2.2 Pressure drop

In present, the overall pressure drop margin of the HCS is too tight. Therefore, preferably the pressure drop by the isolation valve should be minimized. For this reason, the pressure drop of the isolation valve has been set below 0.01 MPa, and the isolation valve, with lower pressure drop as possible, will be developed.

2.3 Leakage rate

Although very small amount, tritium is contained in the helium coolant of HCS during operation. Therefore, very strict leakage conditions are required to prevent radioactive materials leaking into the environment. In addition, the isolation valve is defined as the vacuum boundary of ITER Machine, so it also required very strict external leakage criterion, VQC 1 ($1x10^{-10}$ Pam^3s^{-1}) class according to the ITER Vacuum Handbook [7].

2.4 Size and shut down (closing) time

The isolation valve should be closed as soon as possible to protect the ITER Machine and Tokamak Building in case of LB-LOCA of HCS accident, so the closing time is preferably shorter. However, the closing time is limited by its installation space because shorter closing time is required larger valve actuator size. Unfortunately, the space, on which the valve is installed, is very limited, so the isolation valve size shall be within 1 m of diameter and 1.5 m of height. Therefore, the closing time is set to be less than 3 seconds at this moment, but it may be lower through optimization design to be studied.

2.5 The other considerations

The isolation valve to be installed and to be operated in the ITER building, where is high neutron flux, high radioactive and high electro-magnetic environment. Therefore, materials of the valve should be considered as tritium compatibility and as low activation (Co/Ta/Nb controlled) materials. Since the valve will be installed in very limited spaces, it should be designed considering the maintenance in such small space [6].

3. Isolation valve development plan

The isolation valve will be developed with an valve specialized company, KOVAL Co. in Busan, and KAERI through a government support project, called 'New Product Development Project under Purchase Conditions.' KOVAL, based on experience of other isolation valve development (Fig. 1), will be in charge of design, manufacturing, and testing of the valves, while KAERI will conduct thermal-hydraulic analysis, structural analysis, and seismic analysis on the valve design by KOVAL. The target design parameters are listed in Table I.

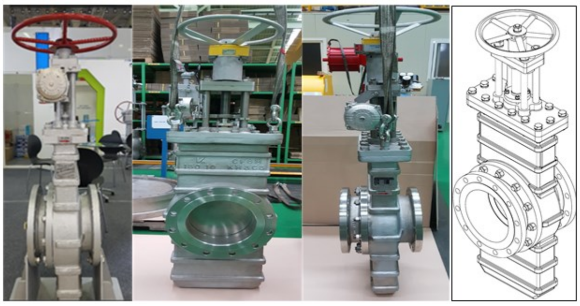

Fig. 1. The TSIV (Tank Safety Isolation Valve) developed by KOVAL

Table I: Specifications for key components

Design parameters	Unit	Target values
Design pressure	MPa	10
Design temperature	℃	550
Leakage rate	$Pa.m^3/s$	Less than 10^{-10}
Pressure drop	MPa	Less than 0.01
Closing time	Seconds	Less than 3
Seismic	G	More than 0.2

4. Conclusions and future works

Development of the isolation valve is required to protect the ITER Machine from the high pressure and high temperature of helium coolant during LB-LOCA event of the HCS. In this paper, the specifications; 1) operating and design conditions, 2) pressure drop, 3) leakage rate, 4) size and closing time, and 5) the other considerations of the isolation valve, are presented. The isolation valve for the ITER HCCR HCS will be developed by cooperation between KOVAL Co. and KAERI through a government support project over the next two years.

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