

Extent of Tritium Contamination of Helium Circuit in a Fusion Reactor- probable scenarios

Wednesday, October 24, 2018 8:30 AM (4 hours)

In the presently available fusion reactors, cryogenic helium is an integral part for cooling the magnets in order to achieve super conductivity. Some of the fusion reactors use tritium as a nuclear fuel along with deuterium, in which a part of tritium is proposed to be bred through lithium blanket covering the first wall of plasma. Since fusion reactors have very small burn up efficiencies (~ 0.3 to 2 % only), a very small amount of fuel is consumed and majority of the unburnt fuel is required to be pumped out and is reprocessed for subsequent cycles. Due to the magnetic and neutronic environment prevailing inside the fusion reactor, for the evacuation of the vacuum vessel, cryo-pumps are the suitable choice as compared to other available options. Cryo-pumps provide cooled surface of charcoal as an adsorber bed to trap the gaseous molecules. The adsorber beds are cooled down to 5K with the help of cryogenic liquid helium being supplied from the cryo-plant with an intermediate cold box in order to provide better controllability. The contamination of cryogenic helium with tritium arises in the cryo-pumps and may be extended to the cryo-plant. Thus are possible scenarios where the hand-shaking of tritium with cryogenic helium is possible thereby posing a threat to cryogenic plant safety depending on the extent of tritium contamination of cryogenic fluid and hence is required to be analyzed while designing the system. The tritium impact on cryo-plant design in the presently available tokamaks (such as ITER, etc.) has not been taken into consideration in the design as the amount of tritium permeated through stainless steel to cryogenic helium, through cryo-pumps, is not substantial. But for future fusion reactors where the amount of tritium to be handled would be substantial, the threat can't be evaded. This leads to open a new area of research in the context of design of cryo-plants for future fusion reactors.

The present study throws light on the possible scenario and mechanism of tritium diffusion along with the extent of contamination and its validation through available experimental data. This study will also be helpful for design of the cryo-plants for future fusion commercial reactors.

Country or International Organization

India

Paper Number

FIP/P3-35

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Session Classification: P3 Posters

Track Classification: FIP - Fusion Engineering, Integration and Power Plant Design