Tritium Safety Assessment on High Temperature Liquid Blanket for Fusion-Based Hydrogen Production Reactor FDS-III

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The fusion-based hydrogen production reactor FDS-III is designated to exploit the potential advanced application of fusion energy in the production of hydrogen, which is studied by the Fusion Design Study (FDS) Team in ASIPP (Institute of Plasma Physics, Chinese Academy of Sciences). An innovative high temperature liquid (HTL) blanket concept is proposed in FDS-III to achieve LiPb outlet temperature of about 1000℃ for high efficient production of hydrogen, which include the multilayer flow channel inserts in the liquid LiPb channels, the Reduced Activation Ferritic/Martensitic steel as the structural material and helium gas cooling the first wall and blanket structures. Considering the radioactivity of the tritium and the high toxicity of HTO, particular care and adequate mitigation measures are to be applied in the FDS-III blanket system in order to keep the tritium environmental release in normal operation less than the allowable level i.e. 1g/yr.

In this manuscript, a tritium analysis model for the entire FDS-III blanket system was developed, which included the HTL blanket and major components of the auxiliary system. The tritium safety assessment on HTL blanket system was done for the normal operation. Based on the established model, tritium permeation, inventory and extraction in HTL blanket were calculated by using the Tritium Analysis Software (TAS) developed by FDS Team, in which various factors were considered, such as the flow velocities of liquid LiPb and helium gas coolants, tritium permeation barrier, plasma driven tritium implantation, tritium extraction from both LiPb and helium, helium leakage rate from the cooling system and so on.

The results show that most of the tritium releasing into the environment will permeate through the heat exchanger as HTO. And a reasonable compromise among the various requirements could be found to keep the tritium release from FDS-III blanket system under safety guide line, based on technologically achievable requirement for tritium permeation barriers, tritium extraction from LiPb and the capability of helium coolant purification.

Key Words: Fusion reactor; Tritium safety; FDS-III