

§ 4. A Study on the System of Tritium Recovery from a Liquid Blanket of a Fusion Reactor

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A liquid blanket was applied to the conceptual design of FFHR-II because of advantages of a self-cooled, simple structure. The molten salt blanket showed good performances of low MHD effect, $TBR > 1$ with the addition of Be, low induced radioactivity, low tritium inventory and low reactivity with oxygen or water vapor. However, there were few design studies on tritium recovery from the molten salt blanket. In the present study, we investigated the tritium recovery system as a design study of the NIFS collaboration work of FFHR-II.

Necessary conditions imposed on the tritium recovery from the molten salt blanket are as follows; (1) all tritium generated in the blanket (1.8 MCi/day) is transferred by a Flibe coolant and is recovered by a tritium removal system under a steady-state operation, (2) permissible tritium leak to the environment should be less than 10 Ci/day that was tentatively set in the present study, (3) simple apparatus and easy to operate, (4) operation over the melting temperature, (5) high operation safety and to use materials compatible with HF and (6) operation under a low oxygen impurity condition. Additional assumptions for the design are; (7) no isotope effect in physical properties, (8) no decomposition of Flibe by a $V \times B$ force. We here focused on whether or not tritium can be recovered by a permeation window, a counter-current He-Flibe extraction tower and a vacuum disengager that are in a realistic scale [1-3].

Fig. 1 shows a typical configuration of a plasma chamber, a blanket, tritium recovery system and a heat exchange consisting a fusion reactor system. The tritium generation rate was estimated 1.8 MCi/day. Most of them is removed by the tritium recovery system and others inevitably leak through walls of tubing lines, the tritium recovery system and the heat exchanger. If there was no barrier for the tritium leak, the leak rate was estimated 35 kCi/day. Since the value was huge, it was impossible to lower the tritium leak rate below 10 Ci/day without any tritium barrier. On the other hand, if the

heat exchanger and the tritium recovery system are surrounded by a stagnant Flibe (or Flinak) layer, the tritium leak rate became 1.6 Ci/day. The rate was within the permissible level. If there is other reliable tritium barriers, e.g. alumina film, with a degradation factor of 10^6 , it will be also effective. A by-pass system can decrease a flow rate of Flibe passing through the tritium recovery system, and therefore it can make their size small. However, it was found to be not good from a view point of tritium leak. We needed to lower all the tritium level in Flibe coolant down to the permissible level.

Even if we used any of the three recovery systems, the most serious tritium leak occurred at the secondary coolant loop of the heat exchanger. The rate was 34 kCi/day and was thousand times higher than the permissible level. It is necessary to develop a new concept to enclose tritium in the secondary loop. The largest tritium inventory source was 34 kCi/ton in a stainless-steel structural material. That in Flibe was much smaller than it. We need to search for a new material with low inventory.

References

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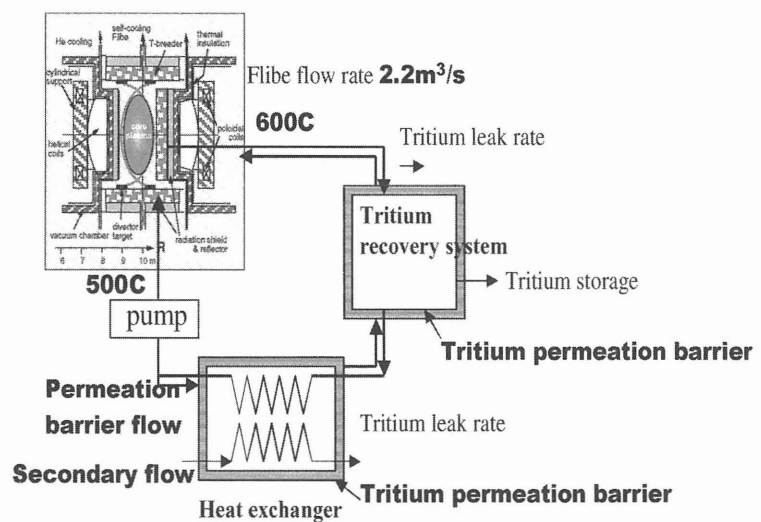


Fig. 1 A liquid blanket (Flibe) loop system

Table 1 Tritium recovery rate and tritium leak rate with or without by-pass or tritium permeation barrier

	(1) $\alpha = 1$ (no by-pass)	(2) $\alpha = 1$ (Flibe barrier)	(3) $\alpha = 0.1$
T generation rate in blanket	1,800kCi/day	1,800kCi/day	1,800kCi/day
T concentration in Flibe	5×10^{-4} wppm (1kPa)	5×10^{-4} wppm (1kPa)	5×10^{-3} wppm (10kPa)
In T recovery system	1,765kCi/day	1,766kCi/day	1,441kCi/day
T leak through line from blanket to TRS	1kCi/day	1Ci/day	10kCi/day
T leak through secondary flow	34kCi/day	34kCi/day	340kCi/day
T Leak from heat exchanger	10Ci/day	10Ci/day	9kCi/day
T leak through line from HX to blanket	10Ci/day	10Ci/day	30Ci/day
T inventory in sus 316	8kCi/ton	8kCi/ton	30kCi/ton