Comparison of Tritium Removal Facility Characteristic

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1. Introduction

Wolsong Tritium Removal Facility(TRF) operated by Korea Hydro & Nuclear Power(KHNP) in Korea has been operating for about 18 years since 2007. There are currently two TRF worldwide that are operational, and one TRF under construction. The first commercial operation TRF is the DTRF at the Canadian Darlington nuclear power plant, which started running in 1990. The second facility to be built was the Wolsong TRF in Korea, which began operations in 2007. Currently, there is another TRF being constructed in Romania's Cernavoda nuclear power plant with a construction contract signed with KHNP in June 2023, aiming for completion in 2028. This presentation aims to compare the characteristics and differences of these three facilities.

2. General Facility Description

Tritium is primarily produced in heavy-water-moderated power reactors by neutron capture of deuterium nuclei in the heavy water moderator and coolant. The concentration of tritium in the reactor moderator and coolant systems increases with time of reactor operation. The overall objective of TRF is to reduce the amount of tritium contained in the moderator and heat transport systems and also reduce occupational and public tritium exposures from operation of the CANDU reactors.

The tritium removal, or detritiation, process is made up of three parts.

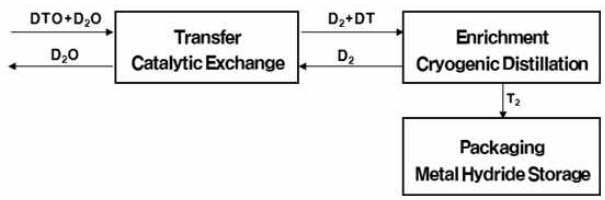

Fig. 1. Detritiation Process

The first part, or "front-end", involves the transfer of tritium from a heavy water molecule to a deuterium molecule,

$$DTO + D_2 \Leftrightarrow D_2O + DT$$
catalyst

A number of alternative processes can be used for this "front-end" process.

The second part of the process is termed the "enrichment" stage. This stage concentrates the tritium by low temperature distillation (cryogenic distillation) of the D_2/DT mixture, to produce streams of essentially pure D_2 and T_2.

The third part of the process is the measurement and packaging of the concentrated T_2 for secure, long-term storage. the T_2 removed from the detritiation process is reacted with titanium metal at room temperature, to form a stable metal tritide

3. Comparison of TRF Characteristic

The typical design differences in the TRF process are as follows

Table 1: Design Differences

	DTRF(Canada)	WTRF(Korea)	CTRF(Romania)
D_2O Feed Rate	360 kg/hr	100 kg/hr	40 kg/hr
Catalyst Type	VPCE**	LPCE* (Separated Bed)	LPCE* (Mixed Bed)
No. of Catalyst Column	8	2	3
Tritium Removal Rate	97%	97%	99%
No. of CD*** Column	4	4	4
Refrigerator	Hydrogen	Helium	Helium
Tritium Storage	Ti-tritide	Ti-tritide	Ti-tritide
Tritium Purity in Storage	≥ 99%	≥ 99%	≥ 99%
Operation Year	1990	2007	2028 (Planned)

* LPCE : Liquid Phase Catalytic Exchange
** VPCE : Vapor Phase Catalytic Exchange
*** CD : Cryogenic Distillation

3.1 DTRF(CANADA)

The DTRF was constructed as a large-scale facility to remove tritium from CANDU reactors at Darlington Nuclear Power Plant and other Ontario Power Generation(Pickering, Bruce). The catalytic process applies an vapor catalytic exchange(VPCE) technique and the refrigeration system uses hydrogen refrigerator.

3.2 WTRF(KOREA)

The WTRF was constructed with capacity to remove tritium from four reactors at Wolsong Nuclear Power Plant. The catalytic process applies a liquid phase catalytic exchange(LPCE, separated bed with packing and catalyst layer) technology and uses helium refrigerators.

3.3 CTRF(ROMANIA)

The CTRF is being built with the capacity to remove tritium from two reactors at Cernavoda. The catalytic process uses liquid phase catalytic exchange(LPCE, mixed bed with packing and catalyst layer) technology and uses helium refrigerators. the goal of the CTRF's tritium removal rate is more than 99%.

4. Conclusion

The operation of tritium removal facilities contributes to safe plant operations by reducing worker's radiation exposure and environmental releases through lowering tritium activity. Additionally, safely stored tritium has high value as a rare resource and can be used as fuel for future nuclear fusion reactor. The technology for handling and storing tritium also helps in research on tritium fuel cycles and storage and delivery systems for similar nuclear fusion process.

REFERENCES

[1] Wolsong TRF Safety Analysis Report, 2015
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