

Long-term Operation of Wolsong Tritium Removal Facility (WTRF)

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1. Introduction

Wolsong TRF(Tritium Removal Facility) operated by Korea Hydro & Nuclear Power Co., LTD(KHNP) has been in operation for about 18 years since it started operation in 2007. As the second facility worldwide, there were some equipment failures and shutdowns during initial operations due to reliability and lack of experience; however, with the accumulation of operating and maintenance experience as well as improvements in operational management techniques, it is now being stably operated, significantly reducing the concentration of tritium in heavy water and the environmental release of tritium. Contrary to early concerns, Wolsong TRF is fully delivering on expectations regarding its operation, which positively contributed to Korea's KHNP winning the contract for constructing Cernavoda TRF in Romania.

2. Overview

The objective of TRF operation is to reduce tritium emission to the environmental release and minimize tritium dose to the workers in Wolsong CANDU reactors.

The construction period of Wolsong TRF was from January 2003 to June 2007, taking approximately 53 months.

Design Capacity of Wolsong TRF is as follows.

Table 1: Design Capacity

Parameter	Design Value
Heavy Water Feed Rate	100 kg/hr
Tritium Extraction Efficiency	$\geq 97\%$
Tritium Purity By-product	$\geq 99\%$
Design Service Life	40 years
Design Availability Target	80 %

2. General Facility Description

Tritium is primarily produced in heavywater 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 tritium removal, or detritiation, process is made up of three parts.

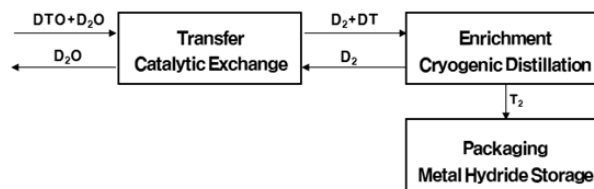
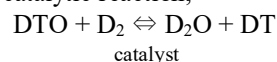


Fig. 1. Detritiation Process

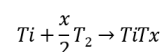
The first part, or “front-end”, involves the transfer of tritium from a heavy water molecule to a deuterium molecule with catalytic reaction,



This process uses a self-developed LPCE (Liquid Phase Catalytic Exchange) columns.

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 . Helium refrigerator is used for cryogenic cooling.

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.



4. Operating Performance

4.1. Tritium Removal of Reactor(Moderator)

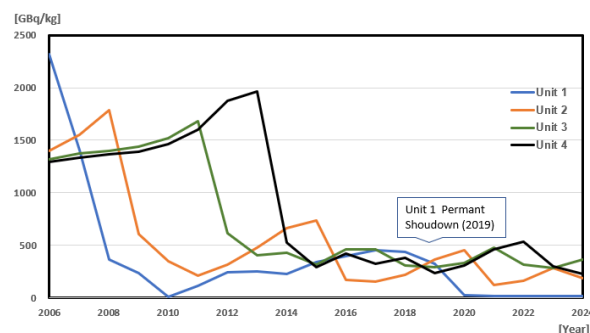


Fig.1. Tritium Activity Trend of Moderator

After TRF treatment of each reactor, the tritium concentration was significantly reduced.

4.2. Tritium Emission

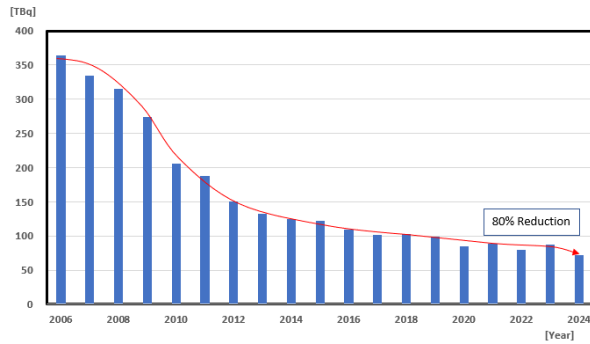


Fig.2. Airborne Tritium Emission Trend

After TRF operation, tritium emission in the air decreased by approximately 80%.

5. Operating Effectiveness

5.1 Reduce exposure dose to workers and emission to environment

As the concentration of tritium in the reactor heavy water was dramatically reduced, working conditions for workers were improved and emissions to the environment were reduced.

5.2 Enhance trust of public about nuclear

Trust in nuclear energy has increased, and awareness is shifting towards safer and more environmentally friendly power plant.

5.3 Take advantage of the tritium as potential resource

Stored tritium as a byproduct can be used as fusion fuel, in industrial, medical and research area.

Tritium sales begun in 2024, and decayed helium-3 also have a potential value as a resource. Furthermore, cooperation in the tritium field is taking place in the construction of nuclear fusion reactors.

5.4 TRF construction export

The contract for the construction of the Cernavoda TRF in Romania was signed with KHNP in 2023, and construction is currently underway.

6. Conclusion

The Wolsong TRF has been operating stably for approximately 18 years since its launch in 2007, and has reduced the tritium concentration in the heavy water reactor.

The construction, testing and operating experiences of Wolsong TRF will be valuable in constructing and operating the Romania's Cernavoda TRF. Additionally, the safely stored tritium and helium-3 at Wolsong TRF will be used for future rare resource utilization purposes.

REFERENCES

- [1] Wolsong TRF Safety Analysis Report, 2015
- [2] Wolsong TRF Operation Report, 2024