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Development of ITER tritium transport package

Sanghoon Lee[a,*], Min-Soo Lee[a], Ju-Chan Lee[a], Woo-Seok Choi[a], Ki-Young Kim[a], Je-Eon Jeon[a], Ki-Seog Seo[a], Wataru Shu[b], Glugla Manfred[b]

[a] Korea Atomic Energy Research Institute, Daedeok-daero 1045, Yuseong-gu, Daejeon, Republic of Korea
[b] ITER Organization, Route de Vinon sur Verdon, 13115 Saint Paul Lez Durance, France

HIGHLIGHTS

- A new tritium transport package has been developed for tritium supply to ITER.
- Functional, interfacial, regulatory requirements of the package are described.
- Design concepts and important features of the package are described.
- Structural and thermal safety of the package is demonstrated using analyses.

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ABSTRACT

For tritium supply to the fusion reactor of ITER (International Thermonuclear Experimental Reactor; the way to new energy) [1], tritium needs to be transported from tritium production sites, mainly the CANDU type reactor sites to the Tritium Plant building of ITER. Korea Atomic Energy Research Institute (KAERI) was commissioned the work of developing the transport package for tritium by ITER organization and the first stage of the development has been finished. The developed package was designed to carry 70 g of tritium and classified as a type B(U) package, which should comply with the requirements stipulated in IAEA regulations for the transportation of radioactive materials [2]. The package is composed of a storage vessel, a containment vessel, an overpack and an aluminum liner, which is a unique feature of the package. The aluminum liner between the storage vessel and the containment vessel is for containment control under the repetitive use of the package. The package has enough pressure resistance for 5 years in-site storage and the structural and thermal integrity under the hypothetical accident conditions has been demonstrated through a series of analyses.

1. Introduction

ITER is the next generation fusion machine with the fuel of deuterium and tritium [1]. The transport of large amounts of tritium is an important issue from the viewpoints of fuel supply and safety. For the shipment of tritium to the ITER site, a transport container needs to be developed and licensed per the radioactivity and amounts of its radioactive contents. It is an ITER requirement to transport tritium as metal tritide, which has been considered to be the safest way for tritium transport. There are not many available licensed packages on the market today. Examples are the WSRC (Westinghouse Savannah River Company) Hydride Transport Vessel (HTV) [3–5], which can be loaded with up to 18 g tritium in uranium tritide powder and JAERI (Japan Atomic Energy Research Institute) Type B(U) package with capacity up to 25 g tritium in ZrCo tritide material. JAERI (now Japan Atomic Energy Agency) has proposed a 250 g capacity tritium transport package for future fusion reactors. The design utilizes ZrCo to form the metal tritide to store the tritium [6].

The tritium will be transported from the tritium production sites, mainly the CANDU type reactor sites to ITER Tritium Plant building. According to the tritium supply plan derived from the operation and experiment plan of ITER, it is necessary to develop a large capacity tritium transport package, which is licensed for international transportation. In 2009, KAERI was commissioned the work of developing the tritium transport package by ITER Organization and the first stage of the development has been finished. The interfaces of the package with related equipments/facilities were identified and the basic design and preliminary safety analyses were successfully performed. This paper describes the design requirements, basic design and the structural and thermal evaluation results of the developed package under the hypothetical accident condition.

* Corresponding author at: Nuclear Fuel Cycle waste Treatment Research Division, Korea Atomic Energy Research Institute, Daedeok-daero 989-111, Yuseong-gu, Daejeon 305-353, Republic of Korea. Tel.: +82 42 868 2242; fax: +82 42 861 1567.
E-mail address: shlee1222@kaeri.re.kr (S. Lee).

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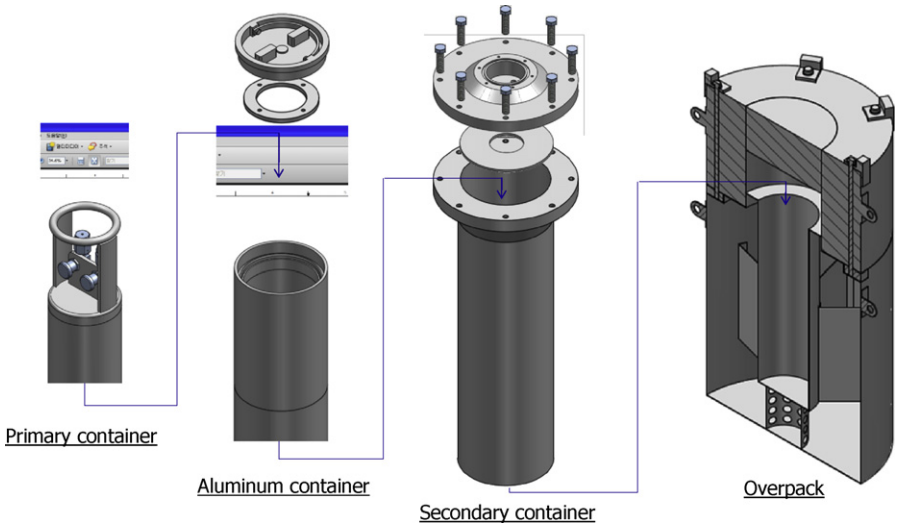

Fig. 1. Conceptual drawing of ITER tritium transport package.

2. Design requirements and speicifications

2.1. Design requirements

The design requirements of the ITER tritium transport package can be classified into three categories: functional requirements, interfacial requirements, and safety/regulatory requirements. The functional requirements given by the ITER Organization are as follows:

- The capacity of the package is 70 g and tritium should be stored in the form of metal hydride for safe transportation [7].
- Tritium would be loaded into and deloaded from the package with appropriate means.
- The package would be stored in fully loaded state for up to 5 years.
- The package would be reused and should provide additional contamination control for repetitive use.

The interfacial requirements of the package are as follows:

- The package should be equipped with appropriate interfacial apparatus such as valves and connectors compatible with equipments in both ITER Tritium Plant building and tritium production sites. More specifically, it should have proper interface with the dismantling vault, calorimeter, storage system and load-in/load-out glovebox of storage and delivery system (SDS) of ITER Tritium Plant and the tritium handling equipments of production sites.
- The package should be sized so that the modification of equipments currently in operation such as the glovebox at the tritium production sites would be minimized.

Lastly, the safety/regulatory requirements of the package are as follows:

- The package design should comply with the IAEA regulation for safe transportation of radioactive materials.
- Also domestic regulations of countries related with the transportation like France should be considered.

The design of SDS is under way by ITER Korea and some of the designs of the above-mentioned equipments have not been fixed yet. For the tritium production sites, we have considered the Tritium Removal Facility at Wolseong site (WTRF) as a reference for the interface of the package. Currently, the tritium is collected in the Tritium Gas Handling and Storage System (TGHS) of WTRF, which is located in a nitrogen glovebox. Since WTRF is a facility currently in operation, many interfacial apparatus of the tritium transport package were designed to be compatible with WTRF glovebox and other relevant equipments and it will be reflected in the design of SDS in the future.

2.2. Design of developed package

The proposed design of the ITER tritium transport package consists of four parts: the primary container (storage vessel), the aluminum container (contamination control vessel), the secondary container (containment vessel) and the overpack. (Fig. 1) The materials used for the containers are listed in Table 1. Mainly stainless steel is used for the containers except the aluminum container. Balsa wood is considered for shock absorbing material of the overpack. The overall weight of the package is about 120 kg.

The design criteria of each part are described more in detail in the subsequent sections.

2.2.1. Primary container

The function of the primary container is to provide the confinement of tritium and together with its inlet and outlet path. It is designed to withstand the pressure buildup by the tritium decay for 5 years including the time spent for transportation. The detailed functional requirements and design features are as follows: It should confine 70 g of tritium as a form of metal tritide, and sustain its integrity at least for 5 years. It should resist high pressure developed by He-3, the tritium decay product, for 5 years without any release of it. It must be equipped with adequate inlet and outlet lines for the tritium absorption and desorption together with their

Table 1
Materials used in the package.

Parts		Material	Specification
Primary container	Body	Stainless steel	SA240 Type 316L
Aluminum container	Body, lid	Aluminum	A 95083
Secondary container	Body, lid	Stainless steel	SA240 Type 304
	Bolts	High strength steel	SA193 Gr. B7
Overpack	Shell	Stainless steel	SA240 Type 304L
	Shock absorber	Wood	Balsa wood
	Bolts	Stainless steel	SA240 Type 304
	Thermal fin	Copper	C10200