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FABRICATION TECHNOLOGY FOR STORAGE AND / OR TRANSPORT CASKS BASED ON WIDE AND LONG-TIME FABRICATING EXPERIENCE

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ABSTRACT

Kobe Steel, Ltd. (KSL) started fabricating TN12 transport casks used for spent fuel transportation in 1978. After that, various types of spent fuel transport casks have been continuously fabricated. Additionally, TN28VT transport casks used for radioactive vitrified waste and another various transport casks for radioactive waste or neutron source had been fabricated since 1994. Concerning dry storage casks, KSL and TN International (TN-I, former TNP) initiated co-developments of materials and casks from 1983. And KSL delivered TN24 dry storage casks to the domestic nuclear power plant in 1995 for the first time in Japan. KSL also has fabricated and delivered TN-68 and TN-40 / TN-40HT dry storage casks to the nuclear power plant in the United States since 2001.

At the beginning, KSL had performed not only the basic design but also safety analysis, however the work of safety analysis has been transferred to Transnuclear, Ltd. (TNT) now.

Based on design and fabrication technology cultivated in many years of experience, KSL and TNT are advancing the development of new type casks such as TK type cask for the domestic nuclear power plant.

INTRODUCTION

KSL has participated in fabrication of the various types of casks and completed more than 260 casks in the past 35 years as shown in Table 1. (22 casks are under construction.)

KSL has many in-house fabricated materials such as steel plates, forged materials, welding materials, neutron shielding materials and neutron absorbers used for main parts of casks. Furthermore, KSL has performed many verification tests such as drop test to develop new type casks. In terms of fabrication, KSL has designed and fabricated the casks with good manufacturing efficiency with TNT by incorporating cutting, bending, welding, and assembly technology based on a lot of fabricating experience.

Outlines of fabrication process for storage and / or transport casks based on wide and long-time fabricating experience are described in this paper.

*) Present affrication is Transnuclear, Ltd. (TNT) in Japan.

Table 1 Fabrication achievements in the past 35 years

TYPE	Q'TY	REMARKS
TN12/1, TN12/2 and TN13/2	55	Spent fuels and MOX
TN17/2 and TN17/3	24	Spent fuels
TN-BRP and TN-REG	2	Spent fuels
JRC-80Y-20T	2	Spent fuels
TN24 Prototype and TN24	21	Spent fuels
TN28VT	8	High level wastes
CAST IRON CASK	16	High level wastes
MUTSU	12	Nuclear ship
NFT-38B	6	Spent fuels
NFT-32B	7	Spent fuels
NFT-22B	3	Spent fuels
NFT-12B	3	Spent fuels
IN-SITE CASK	1	Solid wastes
TN-68	47	Spent fuels
NUHOMES-32PT	25	Spent fuels
TN-40 and TN-40HT	30	Spent fuels
TN843	(12) **	RAW
TNG3	(10) **	Spent fuels
Total	284	**) ( ) : Under construction

AUTHORIZATION AND FABRICATION OF VARIOUS TYPES OF TN CASK

TN12 transport casks designed by TN-I and used for spent fuel transportation from nuclear power plant in Japan to nuclear fuel reprocessing plant in France were fabricated in 1981 as the first cask fabricated by KSL.

TN12 could contain 12 PWR spent fuels. During transportation, the casks were maintained to dryness state. Outer view of TN12 is shown in Fig.1. The overall height of the cask is approx. 6.5 m, its outer diameter is approx. 2.5 m and its total weight is approx. 115 ton.

When TN12 casks started to be fabricated, the end user of electric power company needed to acquire the design approval. Hence, the safety analysis was required to certify the safety of cask. The work of making the safety analysis report for the Japanese authorities was quite a new experience for KSL. Based on the safety analysis report for the French authorities, KSL established the analysis method in conformity with the regulation of Japanese technical standard and completed the safety analysis report. Through this experience, KSL has made progress in design technique and accumulated the knowledge about the safety functions such as heat removal, containment for radioactive material, shielding of gamma ray and neutron radiation and sub-criticality. KSL also accumulated the knowledge of structural design to maintain the safety function in any cases of operations.

As for the fabrication of TN12 casks, there were many complicated works such as copper fin welding, resin installation, orifice assembling and many required test such as thermal test, hydrostatic test and helium leak test. KSL accumulated not only the knowledge of fabrication technique but also the know-how to control the work schedule and the quality control for materials and cask parts.

After that, KSL could perform safety analysis and fabricate TN12A transport casks, TN12B transport casks and TN17 transport casks without pause. TN12A could contain 12 PWR spent fuels, TN12B could contain 32 BWR spent fuels and TN17 that was smaller than TN12 could contain 17 BWR spent fuels. These types of cask were the improved type of TN12.
Furthermore, TN28VT transport casks used for radioactive vitrified waste and another various transport casks for radioactive waste or neutron source had been fabricated since 1994.
KSL makes full use of wide experience and tackles the difficult fabrication of the new type cask such as TN843 transport cask and TNG3 transport cask.
TN843 can contain 36 compacted waste canisters while the TN28VT could contain 20 compacted waste canisters.
TNG3 designed by TN-I to transport PWR or BWR spent fuels will be used in nuclear power plants and in the recycling plant in France.

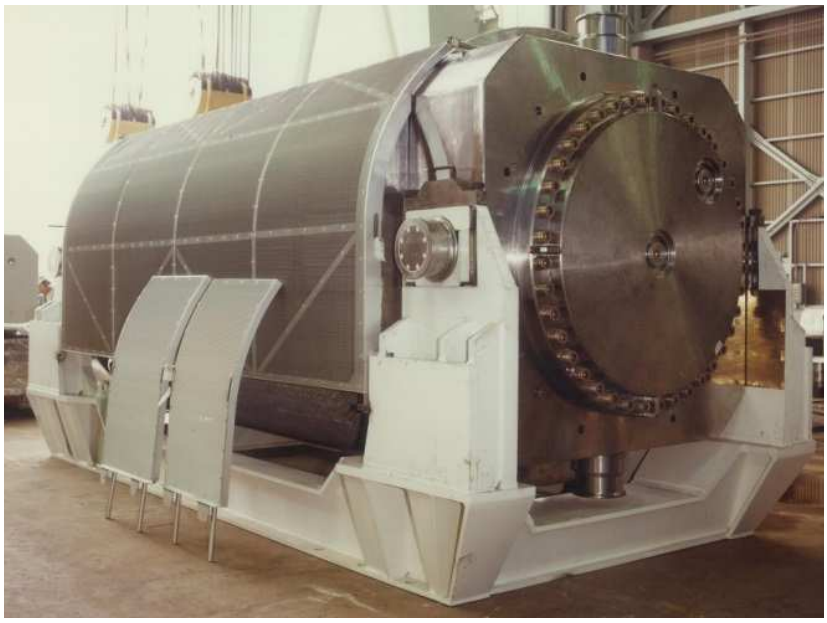

Figure 1　Outer view of TN12 cask

DESIGN AND FABRICATION OF CASK FOR EXPERIMENT NUCLEAR FUELS

JRC-80Y-20T transport cask used for experimental nuclear fuel transportation to Japan Atomic Energy Research Institute were designed and fabricated by KSL at the same time as the fabrications of the various types of TN cask. Outer view of JRC-80Y-20T is shown in Fig.2. Although JRC-80Y-20T is a small type of cask and its weight is only approx. 20 ton, many kinds of nuclear fuels can be installed by changing the basket. Many ideas were applied to JRC-80Y-20T such that the radiating fins attached around cask body for heat removal were also used for shock absorber when 9m drop test was required in regulation. The design of JRC-80Y-20T was the first and original design of cask for KSL and it was licensed as one of the few BU type of transportation cask.

Figure 2　Outer view of JRC-80Y-20T cask

DESIGN AND FABRICATION OF NFT CASK

NFT casks are mainly used for transportation of spent fuels from nuclear power plant to reprocessing plant in Japan. These casks were developed and designed under the direction of Nuclear Fuel Transport Co., Ltd. (NFT) and the electric power companies. There are six types of NFT cask, 4 types for BWR fuels (NFT-38B, NFT-32B, NFT-22B and NFT-12B) and 2 types for PWR (NFT-14P and NFT-10P) and KSL mainly contributed to the design of BWR type of NFT cask. Outer view of NFT-38B cask which is representative is shown in Fig.3.

NFT cask is wet type cask, therefore water is installed in its cavity during transportation.

Figure 3　Outer view of NFT-38B cask

DESIGN AND FABRICATION OF DOMESTIC CASK

As for storage cask, KSL started the development in corporate with TN-I in 1983. Based on TN cask that had a lot of achievements of transportation, KSL performed the basic design of cask with considering storage condition and after 2 years of research and development including 9m drop test with 2/5 scale model. KSL completed the detailed design of TN24 cask as storage and transportation cask. In 1990's, TN24 cask was a candidate for spent fuel storage cask in Japan. Toward the practical use of dry storage cask for spent fuels, KSL fully cooperated to prepare the rules and regulations for it. As a result, TN24 was approved as the first dry storage cask in Japan. In 1995, KSL fabricated nine TN24 casks and delivered to the domestic nuclear power plant for the first time in Japan. In addition, after 18 years, KSL fabricated another eleven TN24 casks and delivered to the same plant in 2013. The casks had been delivered in 1995 suffered the Tsunami in the Great East Japan Earthquake in 2011. However these casks have been continuously operating restored with the spent fuels after replacement of the metallic gasket of secondary lid.

FABRICATION OF CASK USED IN USA

KSL fabricated one proto type of TN24 and delivered to Idaho National Engineering Laboratory (INEL, latter Idaho National Engineering and Environmental Laboratory) in the United States for verification test of the safety of spent fuel dry storage cask. INEL performed the many kinds of useful tests and the valuable test results were published [1] [2].

KSL started fabricating TN-68 spent fuel dry storage casks [3] and TN-40 / TN-40HT spent fuel dry storage casks [4] and delivered to nuclear power plant in the United States in 2001.

Outer view of TN-68 is shown in Fig.4. TN-68 could contain 68 BWR spent fuels. The overall height of the cask is approx. 5.5 m, its outer diameter is approx. 2.5 m and its total weight is approx. 85 ton.

Storage appearance of TN-40 is shown in Fig.5. TN-40 / TN-40HT could contain 40 PWR (14×14) spent fuels. The overall height of the cask is approx. 5.1 m, its outer diameter is approx. 2.7 m and its total weight is approx. 86 ton.

These casks mainly consist of inner shell, gamma shield shell, lid, trunnions, neutron shielding, outer shell and fuel basket. These casks were assembled the inner shell into the shield shell with shrink fitted. The shield shell was surrounded with aluminum square tubes installed in neutron shielding that was mainly composed of polyester resin. The fuel basket consists of stainless square tubes, stainless support bar, aluminum plates, borated aluminum plates (poison plates) and basket rails including aluminum insert. Aluminum plates with poison plates and stainless steel bars were put between each stainless square tube. The stainless square tubes were fixed by fusion welding to stainless support bars. Vent port, drain port and over pressure port were established with cover, bolts and metallic gasket in lid. Lid was assembled to the cask body with bolts and metallic gasket after basket installation. TN-68 cask and TN-40 / TN-40HT cask have similar structure. After installation of spent fuels, the casks were maintained to dryness state in its cavity and stored in the open air.

Figure 4　Outer view of TN-68 cask

Figure 5　Storage appearance of TN-40 cask

SHORT TERM FABRICATION

KSL had a lot of fabricating achievements of TN-68. KSL had experience completing TN-68 about 10 months from acceptance the order to completion of the shipping preparation. (Production period was only about 6 months.)

KSL has many in-house fabricated materials such as steel plates (used for inner shell, lid, and outer shell), forged materials (used for shield shell and shell flange), welding materials and neutron shielding materials used for main parts of casks. In addition to the above, controlling the suitable dimensions based on wide fabricating experience (such as shrink fit dimension, basket assemble dimension, etc), controlling the efficient welding conditions (such as welding bevel and welding parameters), using jigs and cooperation with Areva group enable to fabricate the cask in a short time.

DEVELOPMENT OF MATERIALS USED FOR CASK

KSL proceeds to develop the materials to design a high performance cask for over thirty years. Especially KSL has developed the materials to secure criticality safety and shielding safety. KSL could make the heat-resistant and high-performance neutron shielding resin called for *Kobesh*^{TM}. There are four types of *Kobesh*^{TM} such as silicone rubber type, ethylene-propylene rubber type, titanium hydride type and polypropylene type. Silicone rubber type that has excellent heat resistance is used for storage cask and was sold overseas. As for ethylene-propylene rubber type, it is candidate for neutron shielding of new type cask (TK type cask) because of high-performance of neutron shielding. In terms of criticality safety, KSL established the fabrication method of borated aluminum plate used for basket in 1995. Accelerated test was performed for these materials to confirm that the efficiency of these materials had been secured after long term storage. KSL evaluated the safety of these materials in accordance with the test results. The borated aluminum plates with in-house fabricated are also used for domestic storage cask.

DEVELOPMENT OF CASK

Considering recycling efficiency and low cost fabrication, KSL developed the new type cask called KATS [5]. Structure of KATS is shown in Fig.6. Lead block is used for gamma ray shielding and resin block is used for neutron shielding. Using mass-produced lead blocks and resin blocks enable KSL to short the fabrication term and recycle these materials easily if the cask is scraped in the future. If the lead is poured and bounded with the inner shell and the outer shell, the special surface treatment for the lead shall be performed to get a good thermal transfer path. As for KATS, no heat transfer ability is required for the lead because the copper fins connect inner shell and outer shell to remove thermal heat of spent fuels to outside of the cask. This is the advantage of KATS.

After completion of TN24 project, KSL started developing the various type of TK cask such as TK-69 and TK-26 [6], etc. as advanced casks with TNT and TN-I. TK type cask is based on TN24 design and a lot of experience of designing and fabricating the dry storage casks in 1997. Structure of TK-69 is shown in Fig.7. TK-69 can contain 69 BWR spent fuels and TK-26 can contain 26 PWR spent fuels. Design concept of TK-69 and TK-26 is the same and these casks have been improved with the safety and economy using developed the materials.

KSL established TNT as the subsidiary company in partnership with TN-I in 1984. At the beginning, KSL had performed the basic design and safety analysis independently or with TN-I, but these works has been transferred to TNT since 2002. TNT also plays an important part of engineering and sales in Asian area. KSL and TNT are advancing the development of new type casks such as TK type cask for the domestic nuclear power plants.

SUMMARY

KSL has been accumulating the knowledge of design and fabrication technology through the successful achievements of designing and fabricating the various type of cask. KSL also has many

in-house fabricated materials used for casks. Therefore, KSL learn to fabricate various casks in short lead time.

Considering the current market situation and customer needs, KSL will proceed to develop the cask and the materials based on wide and long-time fabricating experience with Areva group.

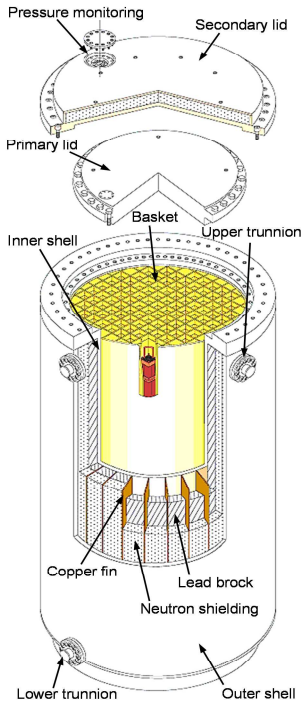

Figure 6 Structure of KATS

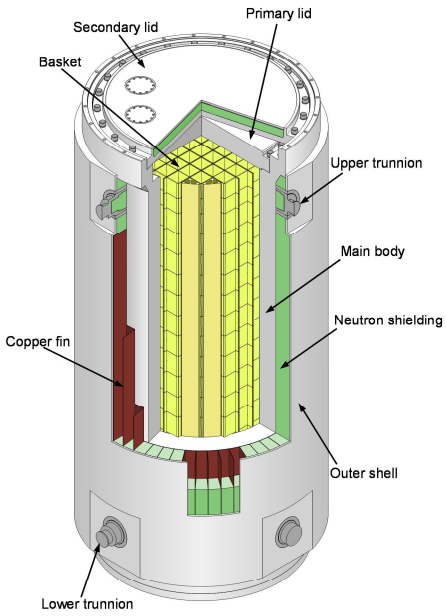

Figure 7 Structure of TK-69

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