Japanese Version Transport/Storage Packaging "TN24"

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INTRODUCTION

Since 1983, Kobe Steel has been engaged jointly with the French company Transnucleaire in the development of "TN24", a dry-type transport and storage packaging for irradiated fuel elements. This report describes the packaging, which has been adapted for use in domestic power stations using BWRs on the basis of the results of this development.

BACKGROUND

Transnucleaire's design experience on the TN12/17 transport packaging and Kobe Steel's technologies and expertise in manufacturing and quality assurance have resulted in the "TN24," a high-efficiency transport/storage packaging capable of containing up to 24 , 28 or 32 PWR fuel elements. In 1985, drop tests on a 2/5 scale model demonstrated the soundness of the packaging under accident conditions. In 1986, a prototype model was manufactured following successful research, and after various cold tests had been carried out in Japan, this prototype model was sent to the U.S.Idaho National Engineering Laboratory for storage tests with irradiated fuel elements loaded.

FEATURES OF THE PACKAGING

The "TN24" transport/storage packaging has the following features :

- The main body, lid, and bottom plate have an extremely solid structure since their main structural material is forged carbon steel.
- The inner space of the main body is dry and filled with a helium atmosphere to maintain the temperature of irradiated fuel elements at a sound level.
- A metallic double gasket is used for the containment system to maintain good leak-tightness for a long period of time.
- The basket has high storage efficiency and a high anti-criticality capability thanks to its borated aluminum alloy "egg-crate" structure.

In the Japanese "TN24" packaging, the design was modified and the following functions have been provided:

- There are two size of packagings. One packaging can contain 52 BWR fuel elements and the other 37 BWR fuel elements for each 4-year cooling.
- The containment system has two lids, each of which has metal double gasket. The pressure between these two lids is monitored as a check on their soundness.
- The second lid incorporates a neutron shielding layer for vertical direction, while the bottom plate incorporates a neutron shielding layer for possible horizontal storage.
- A silicone resin based neutron shielding material developed by Kobe Steel is used, which ensures both a high shielding capability and long-term heat resistance.
- In its horizontal position, the packaging is placed on a dedicated storage frame which has a high earthquake resistance.

DESIGN REQUIREMENTS

The Japanese "TN24" packaging was designed to meet the following design requirements.

(1) Storage Packaging is required to have the following safety functions and structural strength.

- Heat removal

The decay heat of spent fuels shall be removed in a proper way so as to maintain the integrity of these fuels and structural elements having safety functions and structural strength.

- Containment

Radioactive materials contained in spent fuels shall be sealed in a proper way so as to protect residents living in the neighborhood of the facility site and workers handling radioactive materials against radiological exposure.

In the concrete, maintaining negative inner pressure throughout the design storage period so that leakage of radioactive materials in the packaging toward the exterior can be regarded as virtually impossible.

- Shielding

Radiation emitted by spent fuels shall be shielded in a proper way so as to protect residents living in the neighborhood of the facility site and workers handling radioactive materials against radiological exposure.

In the concrete, the dose equivalent rate of less than 2 mSv/h at the packaging surface and less than 100 μ Sv/h at one meter from surface under normal condition. Under conditions caused by any assumed abnormal event, the dose equivalent rate of less than 10mSv/h at one meter from the packaging surface.

- Prevention of criticality

Spent fuels shall be prevented from reaching criticality in any assumed cases.

In the concrete, the standard effective multiplication factor for neutrons of less than 0.95, taking into account possible error in the calculation results of the effective multiplication factor for neutrons.

(2) Packaging is mainly used for storing spent fuels for long periods but is also used for transport in the power plant site. Therefore packaging should be designed to permit correct long storage and transportation of spent fuels.

(3) In order to ensure constant and sufficient containment for long periods, two lids, each of which has metal double gasket should be provided and the containment should be monitored by measuring the pressure in the space between these lids.

(4) Packaging should be designed to store spent fuels in the horizontal position.

(5) Packaging should be optimized to meet specific site requirements (weight or dimension limits, fuel size or irradiation characteristics, etc.).

OUTLINE OF DESIGN

The specification and configuration of the Japanese "TN24" packaging, which was designed in accordance with the design requirements described in the above item are shown in Table 1 and Fig. 1, 2 respectively.

The following design considerations were given for heat removal, containment, shielding and prevention of criticality respectively.

(1) Heat Removing Structure

- Spent fuels are contained in the basket of a compartment structure inside the packaging. Aluminum alloy with good heat transfer properties is used for the basket.
- The inner space of the packaging is filled with helium gas, which has high thermal conductivity.
- Heat transfer plates are provided to improve heat conduction in a neutron shielding layer with lower thermal conductivity.

(2) Containment Structure

- Metallic double gaskets that are supposed to have high durability against heat and corrosion are used for the seal of lids and penetration holes.
- The main body is a solid structure ; the lid is a double containment structure consisting of a double, primary and secondary lid.

  Therefore, the containment boundary has the first containment boundary which consists of the main body, the primary lid, the penetration hole of primary lid, and their seals ; as well as the second containment boundary which consists of the main body, the primary lid, the secondary lid, penetration holes of the both lids, and their seals.
- The pressure barrier is created through negative pressure inside the packaging and positive pressure in between the lids.
- By monitoring the pressure between the two lids with a pressure sensor, the integrity of the containment function can be monitored. If leakage is created by either of the double containment seals, the deterioration of the containment function will be detected by monitoring the pressure decrease between the double lids. Even in this case, negative pressure inside the packaging is maintained so that the gas inside the packaging is not released directly into the air.

  The detail of the containment structure is shown in fig.3.

(3) Shielding Structure

- Gamma radiation shielding is mainly constructed of the forged carbon steel of the main body, lid and bottom plate.
- Neutron shield is constructed of Kobesh-a silicone resin-based neutron shielding material developed by Kobe Steel, which ensures both a high shielding capability and long-term heat resistance.
- Neutron shield is installed in the bottom plate and secondary lid because the packaging is stored in the horizontal position.

(4) Criticality Prevention Structure

- The lattice construction of the basket holding the spent fuel supports the spent fuel in a fixed geometric configuration.
- An aluminum alloy with inserts of boron which effectively absorbs neutrons is used as the basket material.

CONCLUSION

It is expected that the Japanese dry-type storage packaging "TN24" with these features will soon be put to practical use in Japan in view of its high storage efficiency and high degree of safety.

TABLE 1 Specification of Japanese version "TN24"

	Version A	Version B
CONTENTS		
Assembly	BWR	BWR
Fuel Elements	52	37
Thermal Power	app. 30kW	app. 20kW
DIMENSIONS (mm)		
Cavity Diameter	app. 1500	app. 1200
Cavity Length	app. 4500	app. 4500
Fuel Compartment Sections	app. 150×150	app. 150×150
External Diameter	app. 2400	app. 2200
Length during Storage	app. 5600	app. 5600
MASSES(kg)		
Body	88,000	76,000
Primary Lid	4,000	3,000
Secondary Lid	5,000	4,000
Basket	3,000	2,000
Shock Absorbing Cover	6,000	5,000
Fuel Assembly	14,000	10,000
Total during Transport	120,000	100,000
Total during Storage	115,000	95,000

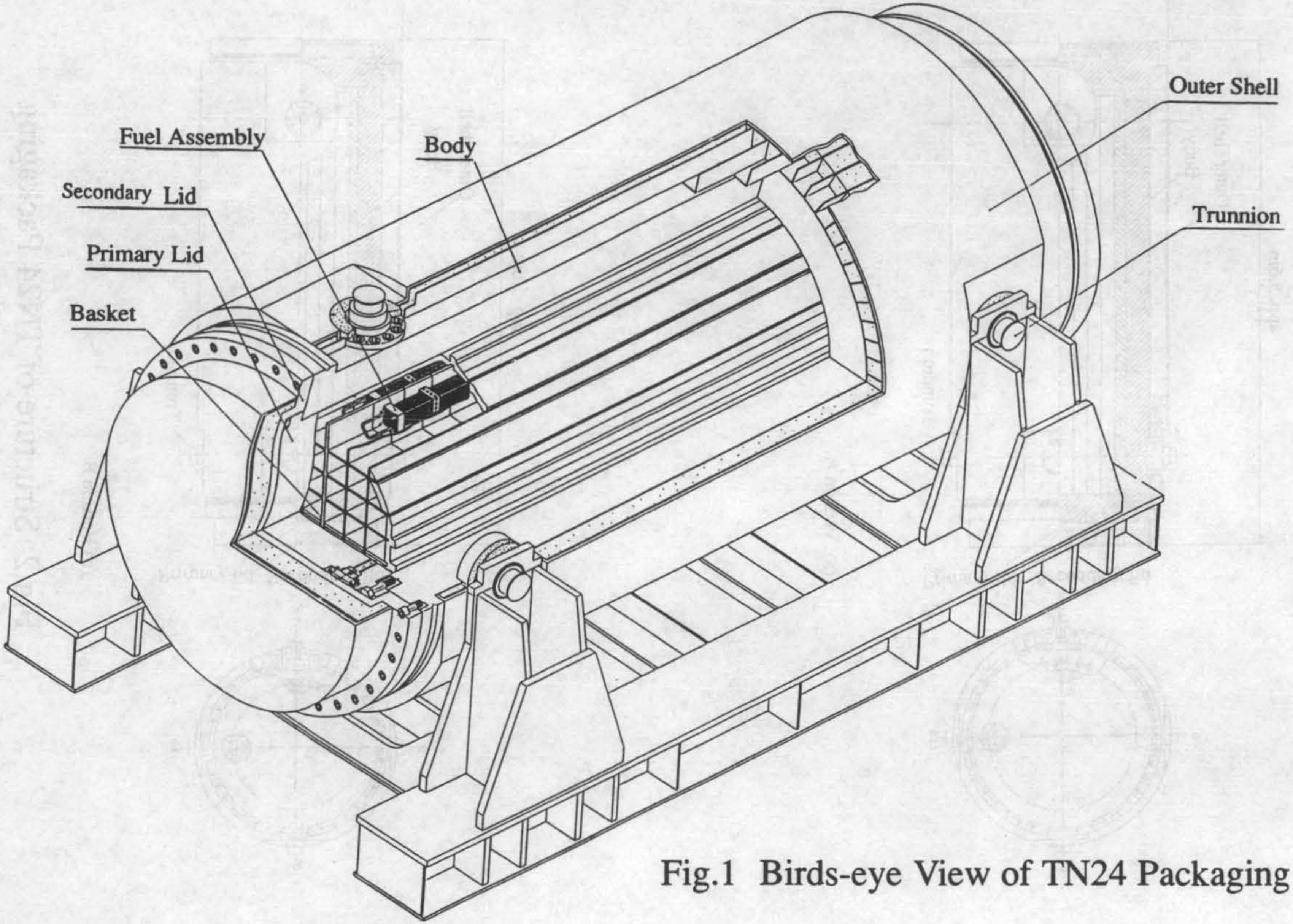
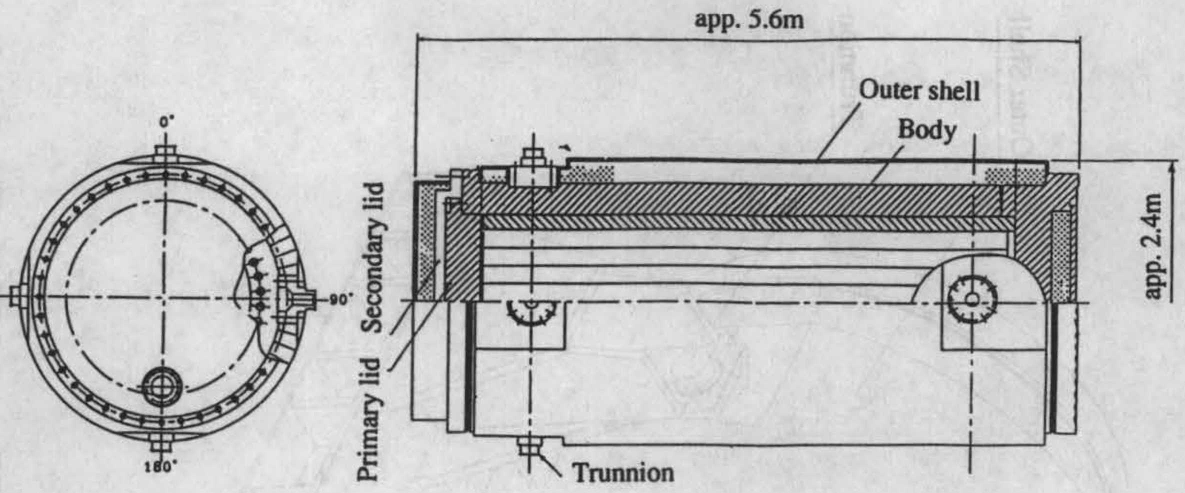
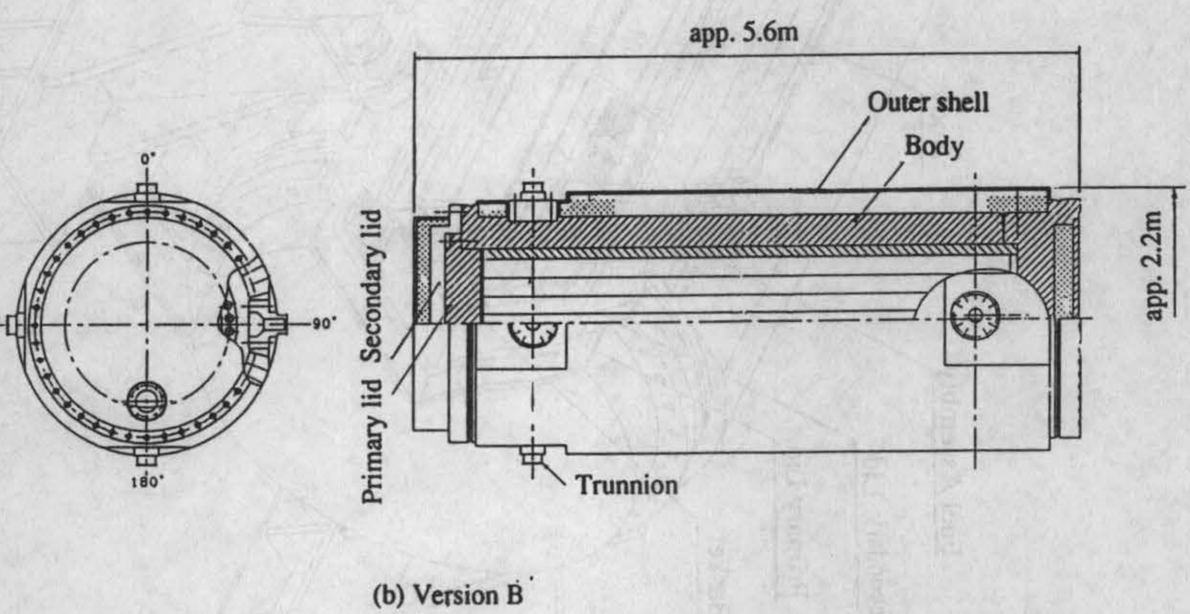


Fig.1 Birds-eye View of TN24 Packaging



(a) Version A



(b) Version B

Fig.2 Structure of TN24 Packaging

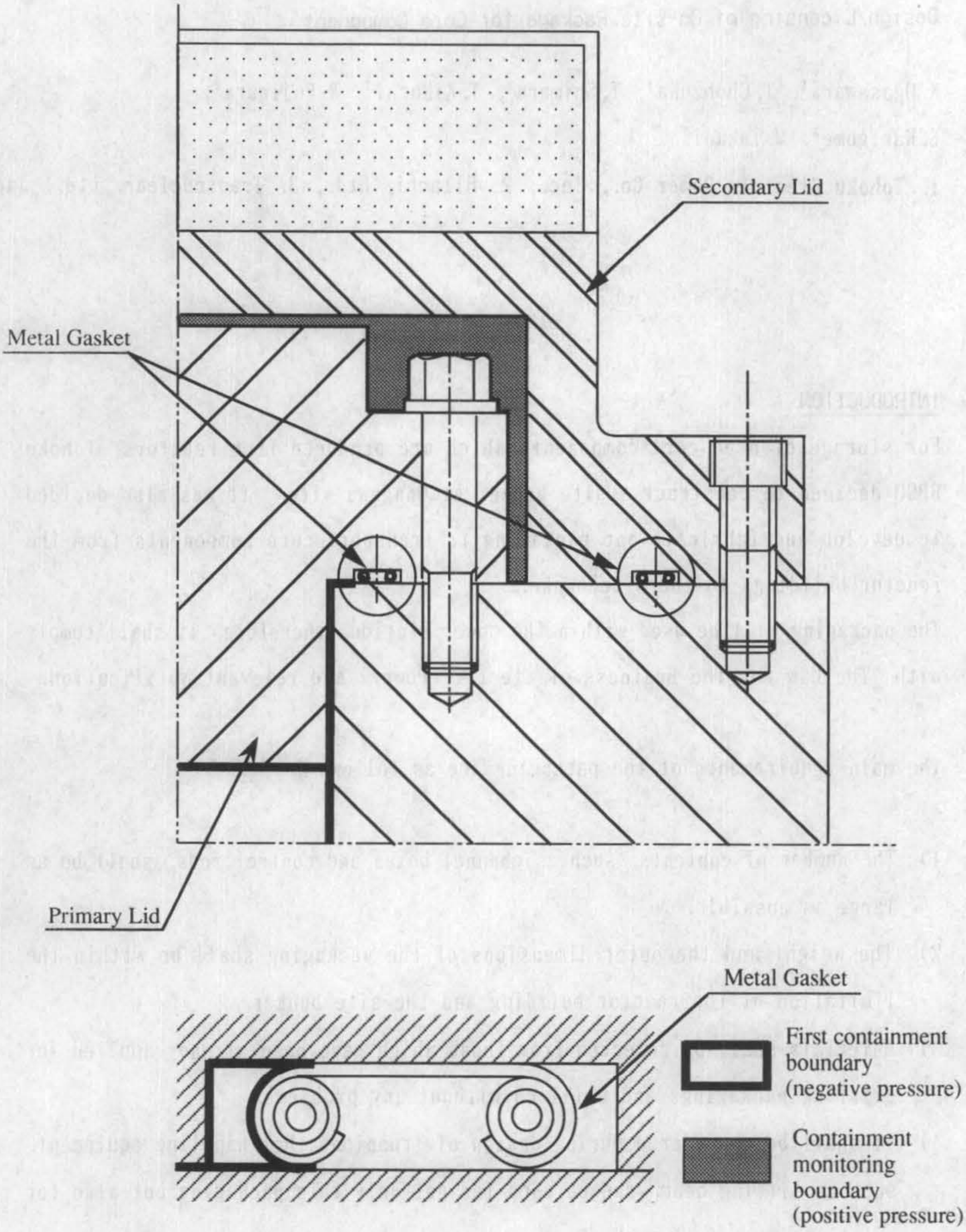


Fig.3 Detail of Containment Part of TN24 Packaging