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New concept for the Interim Storage Facility for Spent Fuel Dual Purpose Casks

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Abstract

The interim storage facility for spent fuel becomes more important and necessary for nuclear fuel management in the world year and year. For this porpose, various storage system are suggested using dual purpose casks or canister systems. Concerning the facility for dual porpose casks, open site or with building or simplified roof are proposed.

The main purpose of this new concept is to prevent the turnover of a cask during earthquake and to prepare an easy way of reduction of site boundary dose rates. This can be applied because a dual purpose cask itself is very strong for any accident and then any special structual strength is not needed for the facility. Also, this concept is very flexible for expanding storage capacity because this concept is moduler structure which is prefabricated at shop and assembled at the storage site. The cost is also able to be reduced by prefabrication. Portal crane is used for moving a cask to the module rack. The devices to monitor the pressure between double lids and surface temperature of a cask for checking the soundness of the cask are easily installed inside the module rack for storage period. Any fixed device is installed by a portal crane into the storage area and then the module rack is fixed on the floor by bolts. The shielding panel is prepared in order to reduce both of direct and skyshine dose rates by neutron and gamma ray at site boundary. All assembling parts of module rack is manufactured at the shop and transported to the storage site, then all parts are assembled at the storage site by using a portal crane.

Introduction

The spent fuel generated from the operation of a nuclear power plant is stored in the NPP site or in the interim storage facility in the world. There are many type of storage system of metal cask, but one good solution is presented in this paper, especialy in case of small scale facility is required.

Feature of this new concept for storage facility of spent fuel dual purpose cask

As shown in Fig. 1, this facility is made by a small unit called module rack and can be expanded easily.

The main features of this concept are as follows;

- Required no building
- Easy to expand storage capacity of metal casks
- All components can be pre-fabricated at the shop.
- Advantage in case of small-scale storage at the NPP site
- Easy to dismantle and dispose it when the site is closed
- Very flexible for layout of facility

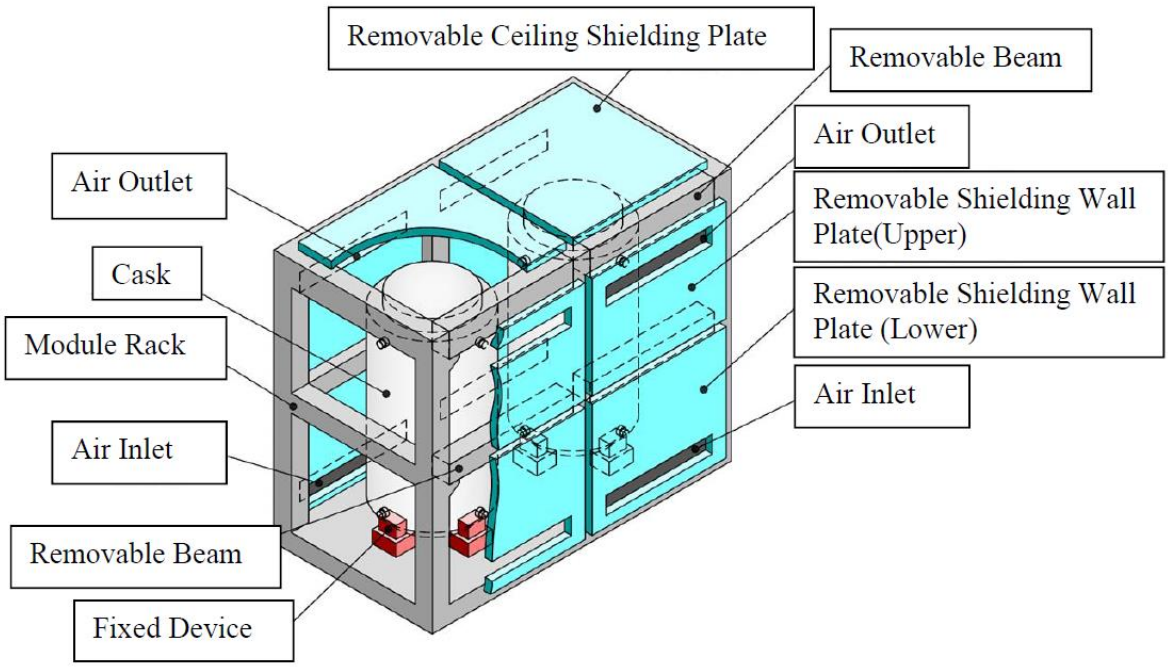

Fig. 1 Bird eye view of new concept for storage facility of dual purpose cask

Outline of new concept for cask storage facility

1. Layout of the facility

Fig. 2 and fig. 3 shows the plot plan and sectional plan of an interim storage facility for spent fuel dual purpose casks as an example. The capacity is 42 casks. The casks stored on vertical position. The transfer of a cask is carried out by a portal crane. The cask passes the center of module racks. When the cask transported in a horizontal position by the vehicle, the cask is vertically lifted by the portal crane in the Receiving Area. The pressure between double lids and surface temperature of a metal cask is monitoring in the Monitoring Room.

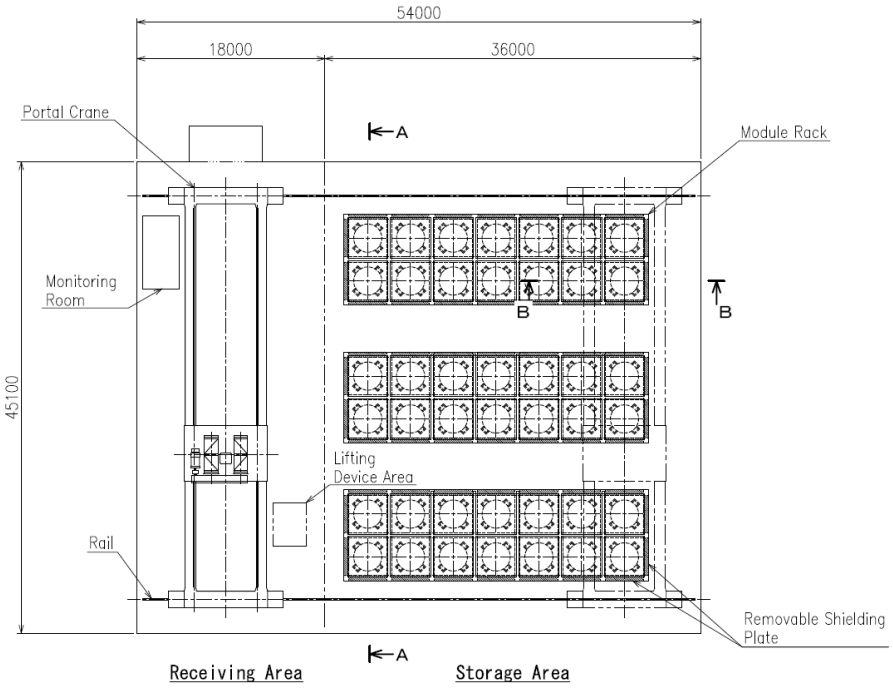

Fig. 2 Example of interim storage facility for dual purpose cask (Plot plan)

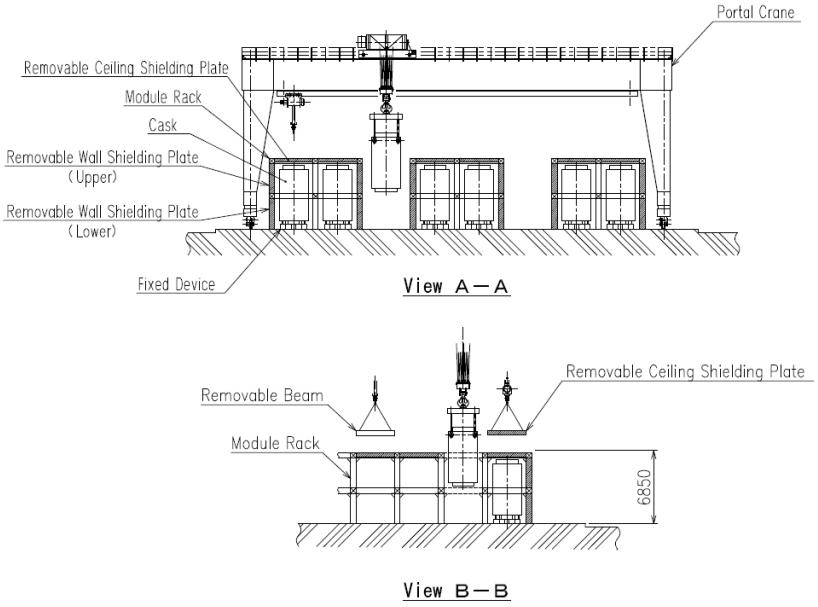

Fig. 3 Example of interim storage facility for dual purpose cask (Section plan)

2. Handling Flow

An example of handling flow of this facility is shown in Fig. 4.
A cask transfers to the line of module racks by using the portal crane. Before that time the needed module racks are already settled.
Following procedure is planned.

① A cask is moved into the space for the cask position in a rack. At this time front beam and Removable Shielding Plate are not set yet.
② The cask is set on to the Fixed Device
③ Removable Beam is attached to the Module Rack by using the portal crane, then the Removable Beam is fixed by bolts.
④ Removable Ceiling Shielding plate is attached to the Module Rack by using the portal crane, then the Ceiling Removable Shielding Plate is fixed by bolts.
⑤ Removable Wall Shielding plates (Upper and Lower) are attached to the Module Rack. by using the portal crane, then the Removable Wall Shielding Plates are fixed by bolts.

Based on this simple procedure, the settlement of a storage cask is completed.

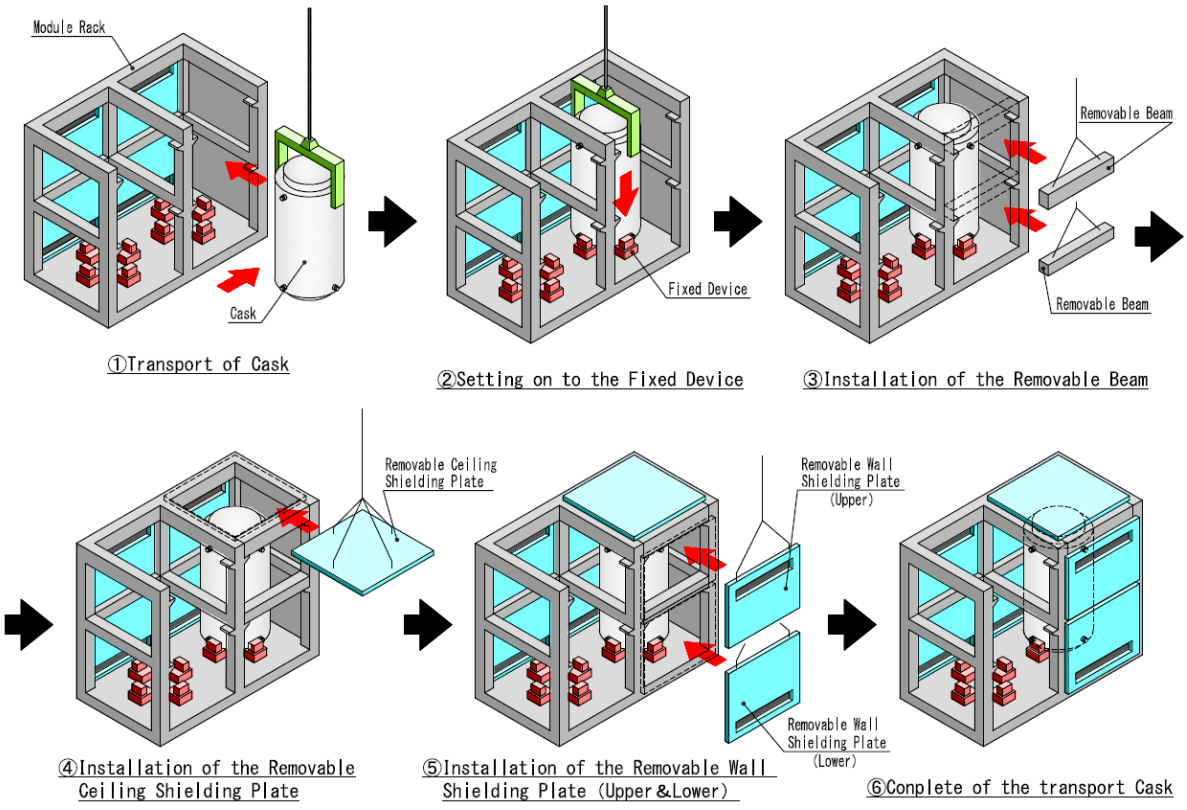

Fig. 4 Handling Flow for settling a cask

3. Countermeasure for Seismic accident

Concept of countermeasure for seismic accident is shown in Fig. 5.
The metal cask is not fixed by any bolts on the floor but it is put on a fixed device. The fixed device is fixed on the floor by bolts and it prevents a metal cask to move horizontally. The enough depth of the fixed device also prevents a metal cask to be jumped out from the device by the vertical acceleration of earthquake.
Square pipes of the module racks also are fixed by bolts to the floor and prevent a metal cask to turnover by horizontal acceleration of earthquake if a metal cask swings by earthquake.

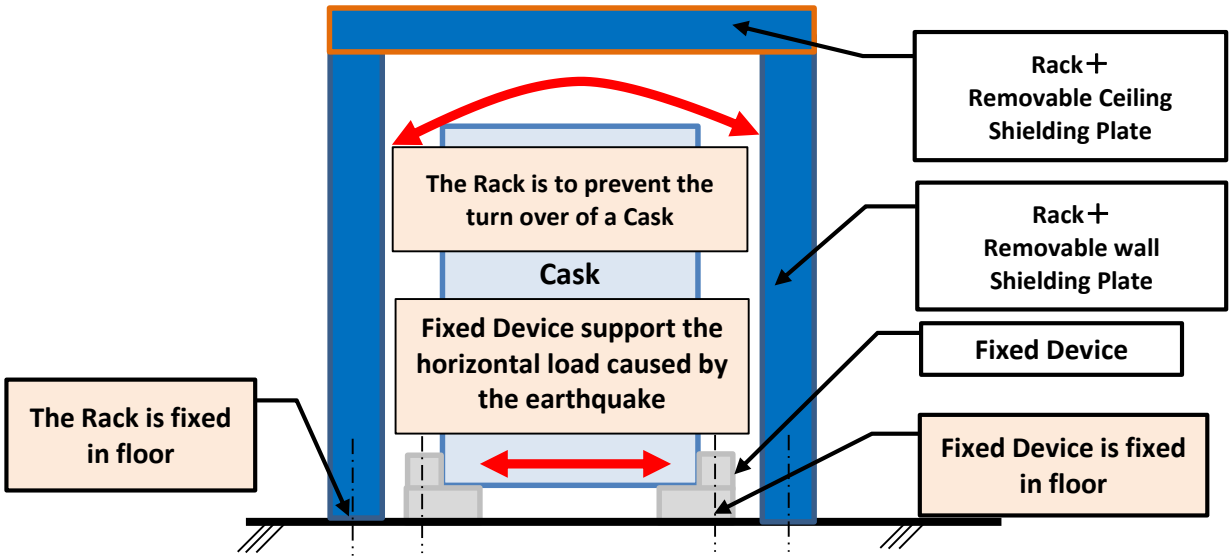

Fig. 5 Concept of countermeasure for Seismic accident

4. Shielding

The module rack equipped with the Removable Shielding Plate whch is prepared in order to reduce both of direct and skyshine dose rates by neutron and gamma ray at site boundary.This Shielding plate is made by stainless steel and neutron shielding material as shown in Fig. 6
In addition, putting neutron shield material inside of rack pipe is effective for reducing dose rates.
The dose rate at site boundary can be controlled by changing shielding design of rack structure.
Fig.7 shows calculation model for boundary dose rare calculation by MCNP Code.
This calculation condition is as follows;

1) Neutron is only considered for this calculation.
2) The value of 0.1 mSv/h is used for this calculation as a dose rate at 1 m from cask surface.
3) The open part of shielding plate as like an air inlet and outlet is not considered.

Fig.8 shows an example of results of boundary dose rare calculation by MCNP Code.
This result shows that shielding plate is effective of reducing boundary dose rates, also neutron shielding material inside of rack pipe is effective of reducing boundary dose rates.

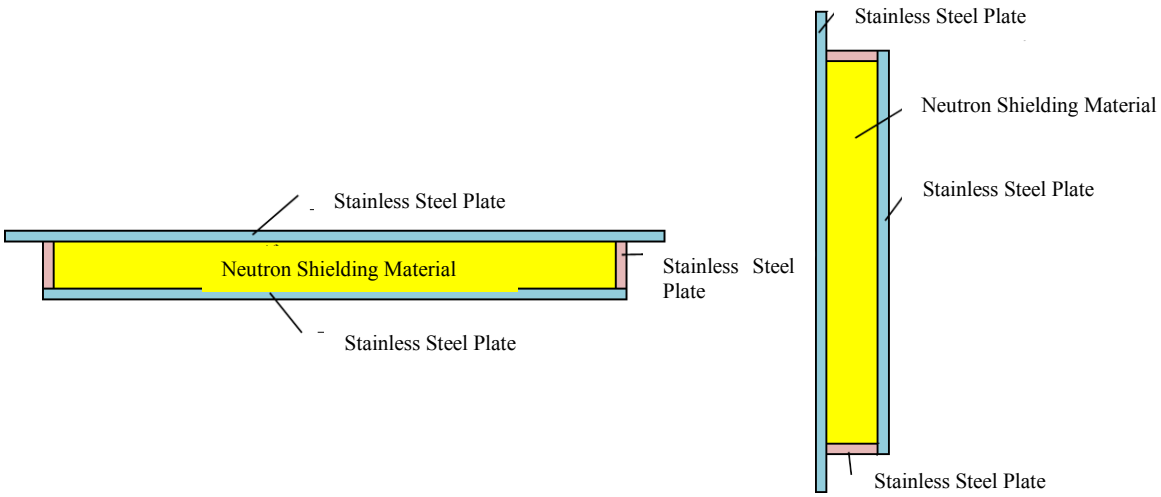

Fig. 6 Removable Shielding Plate for module rack

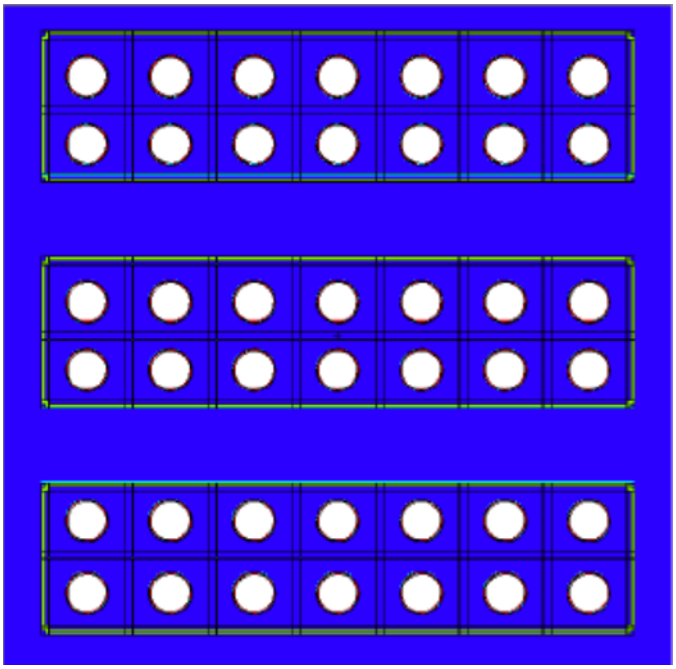

Fig.-7 Shielding model by MCNP Code

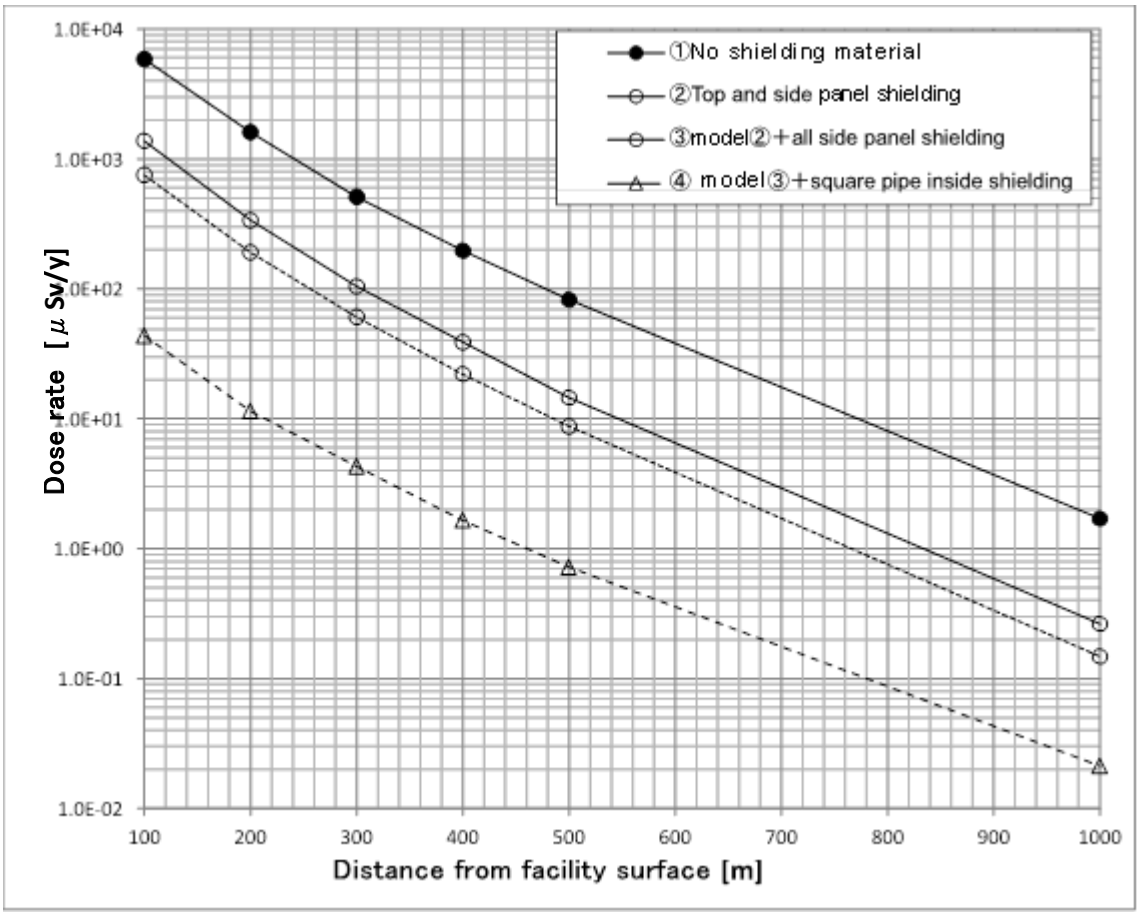

Fig.-8 Dose rate calculation result for distance from facility surface

5. Heat Removal

This concept does not have any special equipment for heat removal. Natural air convection is used for decay heat removal of a metal cask. Air inlet opening is designed at the lower part of side panel. Air outlet is also set up at upper part of the side panel as shown in Fig. 9.
On the other hand, air inlet and air outlet become the opening, so streaming measures are necessary.

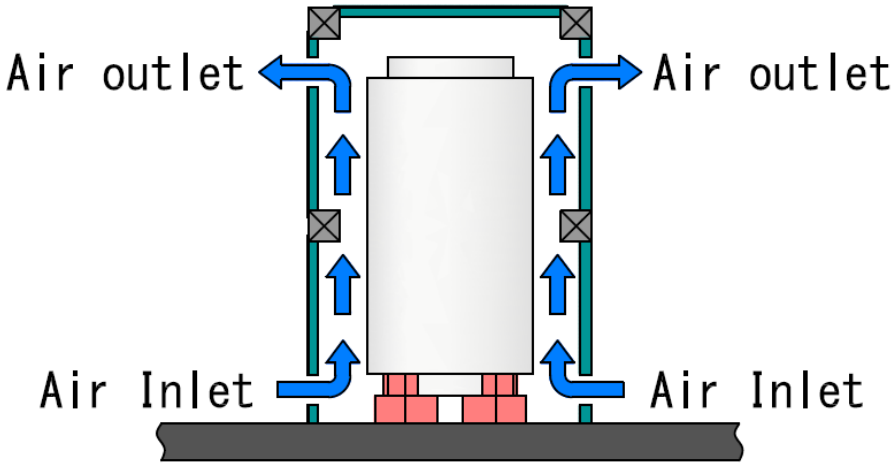

Fig. 9 Concept of Heat Removal

Conclusions

This new concept for the interim storage facility for spent fuel dual purpose casks can provide very economical and easy construction facility, flexible expansion, preventing a tumble of cask and easy reduction of dose rates at site boundary are features of the concept.
Basic safety function, such as shielding, heat removal, and structure toughness for seismic accident is confirmed by the calculation.
The further study for this concept is needed in order to develop more concrete design on a specific site condition. Also material investigation for shielding material is required to reduce a total cost of this facility.

Hopefully this concept will be used at actual NPP site or storage site in near future.