# OUTLINE OF FRESH MOX FUEL TRANSPORTATION IN JAPAN AND DEVELOPMENT STATUS OF TRANSPORTATION CASK FOR LWR


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## ABSTRACT

In Japan, the operation of JNFL (Japan Nuclear Fuel Ltd.) MOX fuel fabrication plant for LWR (J-MOX plant) will be started in March 2016, and the preparatory work by JNFL is proceeding with steady steps. The introduction of the MOX fuel into the LWRs in Japan is aimed from the viewpoint of the policy on nuclear energy, and it is in progress certainly.

MOX fuels are transported from J-MOX plant in Rokkasho to the LWR plants in Japan. The transportation cask is type B(M) package. The transportation cask for JNFL MOX fuel (J-MOX cask) is designed to increase the volume of contents as much as possible within the handling restriction of the cask in J-MOX plant.

J-MOX casks consists of two types designed for BWR and PWR fuels, which are of about 6m in length × about 2.4m in diameter including the shock absorber, and of about 24 tons in weight including the contents. The capacity of the J-MOX cask for BWR is 12 MOX fuel assemblies; 8×8 type or 9×9 type, and J-MOX cask for PWR is 4 MOX fuel assemblies; 17×17 type.

BWR fuel is loaded in the fuel holder with fuel tightening function before loaded into the cask. On the other hand, the fuel holder is not necessary for PWR because the cask tightens the fuel directly.

As characteristics of J-MOX cask, multistage cylindrically shaped shock absorbers are used to absorb impact from all direction. Propylene Glycol water solution is used as a neutron shielding material in the lateral of the cask. Helium gas is filled inside the cask to improve conductivity of decay heat during transportation.

Safety analysis is performed by a proven analysis code for B(M) package licensing.

It is scheduled to apply for design approval by the Japanese Authority in the near future, and the transportation test using the dummy fuel will be executed before actual transportation.


## INTRODUCTION

The J-MOX plant is the first commercial MOX fuel fabrication plant in Japan which is constructed in Rokkasho village, Aomori prefecture, and is the indispensable facility in order to complete the nuclear fuel cycle in Japan. The J-MOX plant is adjacent to JNFL Rokkasho Reprocessing Plant (RRP), JNFL aims to start construction from October 2010 and to start commercial operation from March 2016, and has been applying the reviewing of design and construction methods by the government and also has been performing preparatory work for construction now. Japanese electric power companies also published the plan to introduce MOX fuel into the 16~18 LWRs in whole country by fiscal year 2015, and the commercial operation using a few MOX fuels from overseas has already begun in some nuclear power plants. It is expected that full-scale MOX fuel transportation starts in Japan after the J-MOX plant begins commercial operation. In this report, the outline of fresh MOX fuel transportation for LWRs in the future and development status of MOX fuel transportation cask in Japan are described.

## THE OUTLINE OF FRESH MOX FUEL TRANSPORTATION IN JAPAN

Bird's-eye view of the J-MOX plant is shown in Figure 1. MOX fuel for each domestic BWR and PWR is manufactured in the J-MOX plant. The maximum fabrication capacity of the plant is 130 tons-Heavy Metal per year, this is determined as a capacity to fabricate whole of MOX powder obtained from RRP to MOX fuel in the plant. There are 56 commercial LWRs including under construction, and the introduction of MOX fuel into 16~18 LWRs among them is being advanced by Japanese electric power companies now. The MOX fuel fabricated in the J-MOX plant will be transported toward these nuclear power plants.(See Figure 2.)

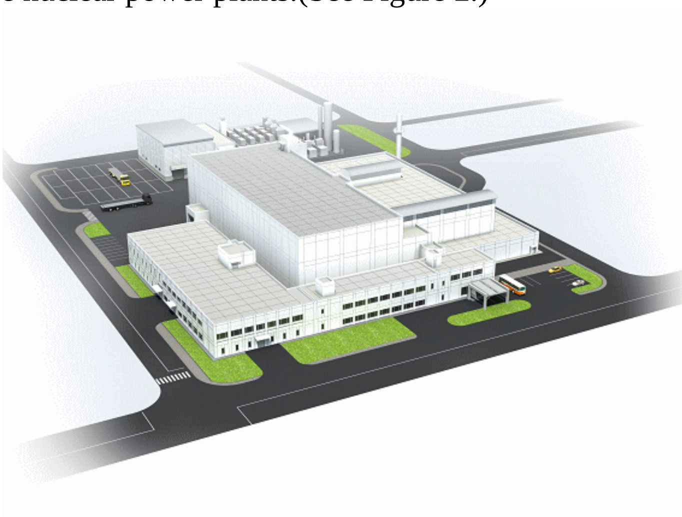

**Figure 1. Bird's-eye view of the J-MOX plant**

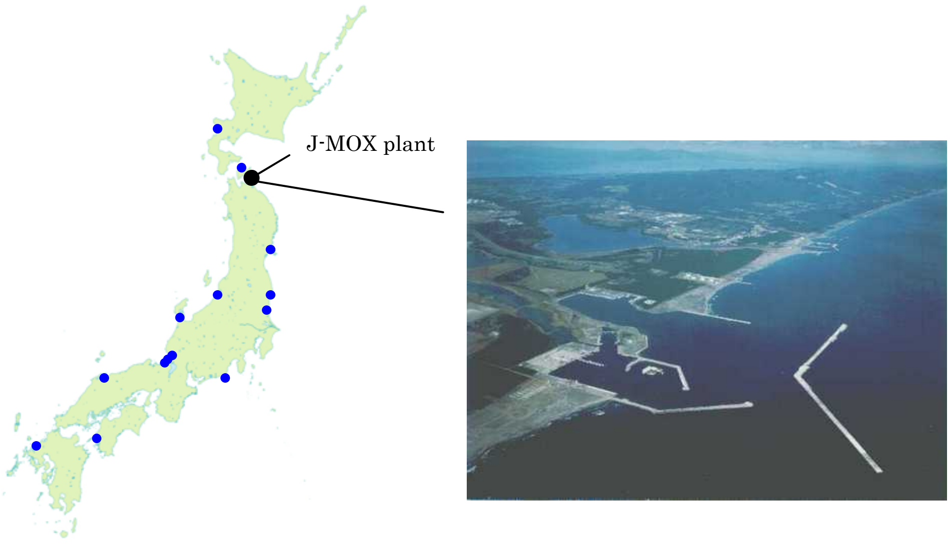


**Figure 2. Location of the J-MOX plant and nuclear power plants in Japan**

MOX fuel transportation will be performed as sea transportation. First of all, the MOX fuels are packed into the transportation cask which is designed for J-MOX transportation (hereafter referred to as J-MOX cask) in the J-MOX plant. The J-MOX casks contained the MOX fuels are transported to the nearest port through JNFL site, are transshipped to the transport vessel there, and are transported to each nuclear power plant by sea. Afterwards, the MOX fuels are delivered at pre-determined place in the nuclear power plant. The empty casks are sent back to the J-MOX plant by road or by sea. Although the details of domestic MOX fuel transportation plan will be investigated in near future, it is expected that about several-time MOX fuel transportations are performed per year after the J-MOX plant operates. Necessary correspondences about physical protection during transportation are studied by relevant parties now.

## DEVELOPMENT STATUS OF THE J-MOX CASK

The J-MOX cask which will be used to domestic MOX fuel transportation as mentioned above is in the final phase of detail designing by Nuclear Fuel Transport Co., Ltd. (NFT) Development status of the J-MOX cask is described as follows.

<u>The outline of the J-MOX cask</u>

J-MOX cask is designed as two types of special cask for each BWR and for PWR, therefore the J-MOX cask for BWR is hereafter described as J-MOX(B) cask, and the J-MOX cask for PWR is described as J-MOX(P) cask.(See Figure 3. and Figure 4.) The outline of the specifications of each type of the J-MOX cask is shown in Table 1. Each type of the cask is designed to as lightweight cask whose gross weight becomes less than 30 tons.

**Table 1. The outline of the specifications of the J-MOX(B) cask and J-MOX(P) cask**

| | J-MOX(B) cask | J-MOX(P) cask |
|---|---|---|
| Package | Type B(M)-fissile | Type B(M)-fissile |
| Contents | 8×8BWR / 9×9BWR | 17×17PWR |
| Heavy-Metal weight | Less than 176kg per an assembly | Less than 475kg per an assembly |
| Capacity | 12 BWR-MOX fuels with fuel holder | 4 PWR-MOX fuels |
| Pu-f content | Less than 6.1 wt% | Less than 9.1 wt% |
| Heat generation | Less than 5,760W | Less than 7,640W |
| Weight*1 | About 24 ton | About 24 ton |
| Size*2 | About 2.4m diameter× about 6.2m length | About 2.4m diameter× about 5.9m length |
| Note | Under development | Under development |

*1 Including contents and shock absorbers, and not including transportation frame.
*2 Including shock absorbers.

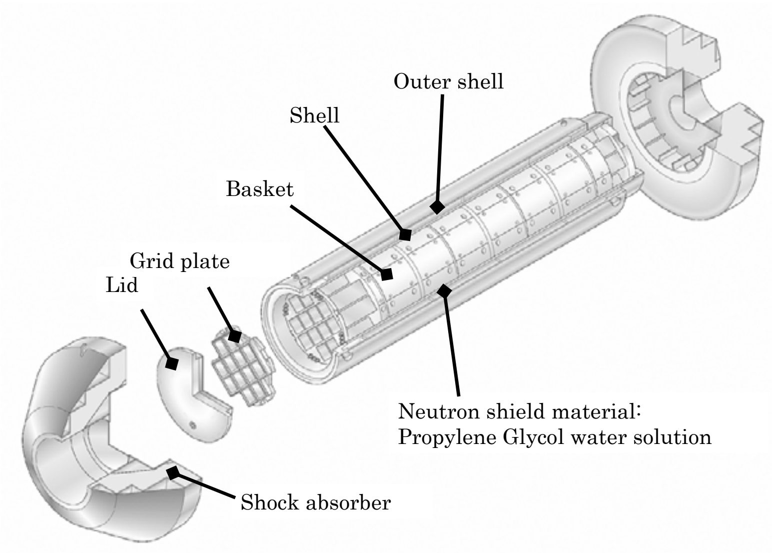


**Figure 3. J-MOX cask for BWR (J-MOX(B) cask)**

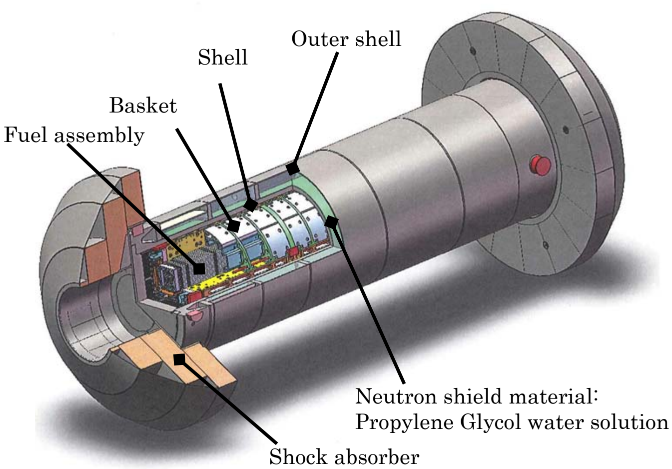


**Figure 4. J-MOX cask for PWR (J-MOX(P) cask)**

Development of the J-MOX cask

The J-MOX cask is designed to meet each requirements described as follows.

1) Safety requirements
   ・To meet technical standards provided in domestic laws established according to IAEA regulations.
2) Requirements from securing fuel integrity.
   ・To tighten MOX fuel in the cask in order to prevent from vibration during transportation.
3) Other requirements
   ・To meet the requirement based on the weight limit of the J-MOX plant.

The outline of safety design

The safety design of the J-MOX cask is almost the same between the J-MOX(B) cask and the J-MOX(P) cask. The outline is shown below.

1) Shock absorbers design

   The multistage-cylindrical shape, which have four-tiered cylindrical balsa wood internally, is adopted to the shock absorbers used for the top and bottom part of the J-MOX cask. Such design was developed to comply with both requirements, decreasing the impact acceleration from each direction and saving its weight. The drop test using a 1/2 sized dummy cask is planned in fiscal year 2011 in order to confirm the validity of this design.

2) Shielding design

   The resin is used in the lid and the bottom part of the basket, and Propylene Glycol water solution is used in the side of the cask between shell and outer shell as a neutron shielding material. Propylene Glycol water is superior to resin in the viewpoint of its low specific gravity and it contributes to save the weight of the cask.

3) Decay heat removal design

   The decay heat removal performance is improved by using aluminum base alloy as the components of the basket (aluminum block), and by filling inside the cask with the helium gas. Moreover, the decay heat removal performance is improved by painting the surface of the outer shell, because the radiation performance is improved.

4) Subcritical design

   The borated stainless steel (B-SUS) is used for the main part of the basket as a neutron-absorbing material, the subcritical performance of the cask is secured with keeping the geometrical position of each MOX fuel.

The outline of design to secure fuel integrity

It is necessary to tighten MOX fuel in the cask appropriately in order to prevent the MOX fuel from the abnormal vibration during transportation and to secure its integrity. The outline is shown below.

1) Fuel tightening method of the cask

   The fuel holder is used for the J-MOX(B) cask. The MOX fuel is loaded into the fuel holder, afterward the fuel holder is inclined to 45 degree and loaded into the cask, as shown in Figure 5. The fuel holder has fuel packing function and fuel tightening function, and it prevents MOX fuel from the vibration during transportation and handling. And as shown in Figure 6., the fuel holder is pushed toward the gravitational direction by taper key, as a result, the fuel holders including MOX fuels are stabilized against the vibration of the vertical direction and the horizontal direction.

   On the other hand, the fuel holder is not used for J-MOX(P) cask, as shown in Figure 7., MOX fuel is held directly by the fuel tightening systems which are installed in the cask. The fuel tightening systems are placed in the side and lid of the cask respectively, and tighten MOX fuel to the radial direction and axial direction by spring method.

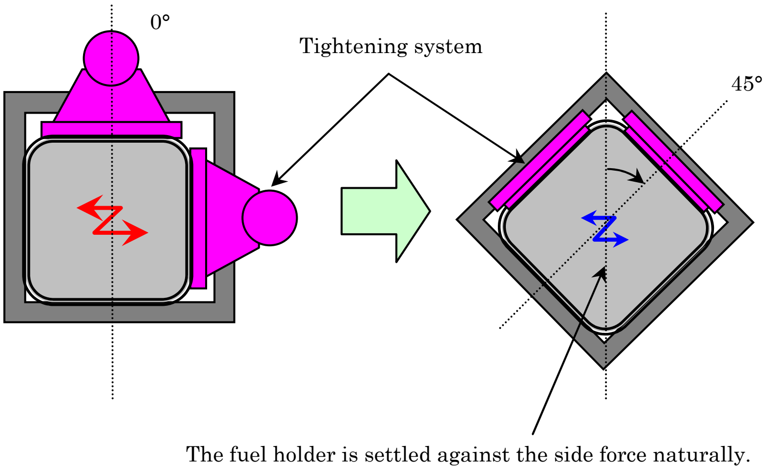


**Figure 5. Fuel tightening system design for BWR**

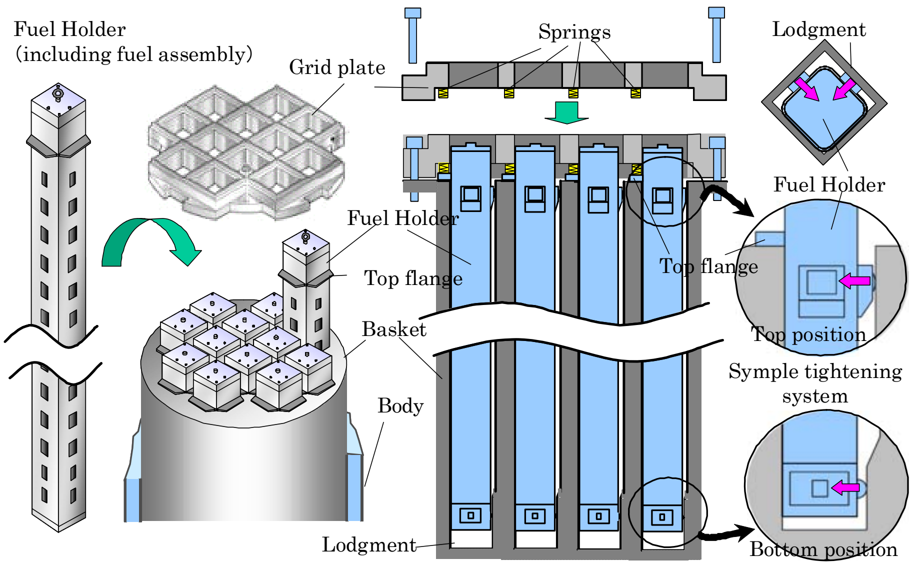


**Figure 6. Fuel holder locking method of the J-MOX(B) cask**

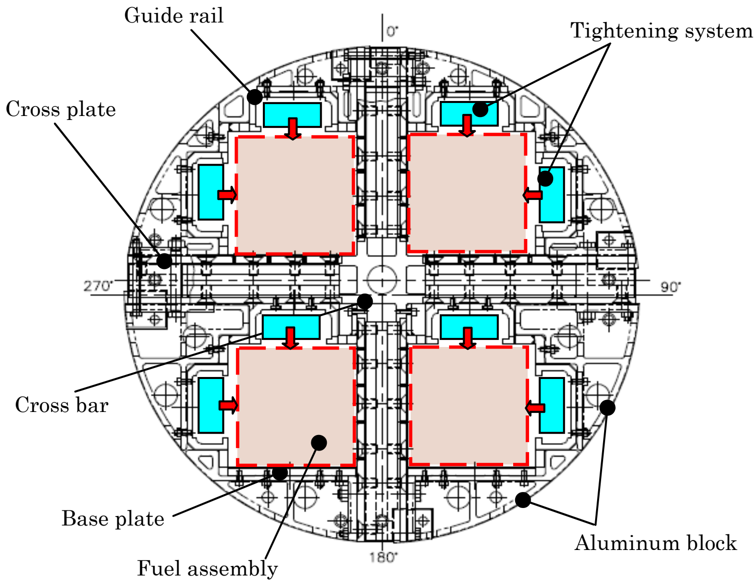


**Figure 7. The outline of the fuel tightening system for the J-MOX(P) cask**

2) The validation test of fuel integrity.
   A transportation test using the first-built J-MOX(B) and J-MOX(P) cask will be performed in order to confirm fuel integrity under real transport condition during the trial operation of the J-MOX plant.

The outline of weight design

The J-MOX cask is especially considered to reduce its weight. It is necessary to make its gross weight 30ton or less when the cask is lifted up by crane in the J-MOX plant from the viewpoint of the crane capability. Each type of the J-MOX cask is designed to be about 24 tons as weight of the package, even though the transportation frame (about 2.8 tons) and the hoisting attachment (about 1.3 tons) are included, the gross weight of each cask does not exceed 30 tons, it complies with the requirement from the J-MOX plant.

## CONCLUSIONS

JNFL would like to advance any preparation of the J-MOX plant in order to operate the plant as smoothly as possible. And also would like to ensure the security of the MOX fuel transportation in the future, cooperating with NFT, surely to deliver integral MOX fuels, and to contribute to progression of nuclear fuel cycle business in Japan.

## ACKNOWLEDGMENTS

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