DEVELOPMENT OF NEW TRANSPORTATION SYSTEM FOR NATURAL UF_6

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INTRODUCTION

Up to date, Natural Uranium Hexafluoride (hereinafter called as to UF_6) is transported from overseas uranium conversion plants to Tokyo port by a liner ship, and then to Rokkasho uranium enrichment plant of Japan Nuclear Fuel Limited (hereinafter called as to JNFL) at Rokkasho-Mura in Aomori prefecture by land. According to the JNFL schedule for expanding the capacity of their uranium enrichment plant, the need for feed material (UF_6) has increased. The current transportation equipments for 48Y cylinder used for the above transportation system consist of flat rack container, cylinder saddles, valve protector and fire protection covers (meeting to the requirement of 800℃, 30 minutes of IAEA '96), and have to be handled respectively at the time of shipment. Therefore, it was supposed that the current transportation system (hereinafter called as to "current system") could not cope with the increasing need of the transportation in the near future.

Considering this situation, the "current system" was modified to the new transportation system (hereinafter called as to "new system") where all equipments are integrated into a single transportation unit. The design condition of this modification is as follows;

- Increase of receiving operation capacity at Rokkasho uranium enrichment plant is expected.
- More effective operations than with the "current system" are expected in overseas conversion plants, and the conformity with the overseas handling system is ensured.
- Mixed loading with the "current system" is possible.
- Conformity with the package requirements and the safety during transportation are

ensured.

It was confirmed from a result of the analysis and the demonstration test that the transportation is carried out safely, and also confirmed from a result of transportation experience that the "new system" conforms to the inland and overseas transportation system and has more effective operativity than the "current system".

STRUCTURE OF NEW TRANSPORTATION SYSTEM

Fig.1 as attached, shows the bird's eye view of the "new system" integrated with valve protector, heat resistance caps, special shutter, flat rack container etc. which are now handled respectively in the "current system". The weight loaded with filled 48Y cylinder is approximately 20 tons, and the size is 6.1m length x 2.4m width x 2.1m height: these are in conformance to the specification of the "current system", too.

· Valve protector

The shape and material of the valve protector are the same as the shape and material (ASTM A516 Grade-60) used for the current equipment. Valve protector installed inside of the heat resistance cap is fixed to the cylinder valve by sliding the supporting structure. Fig.2 shows an overview of the valve protector.

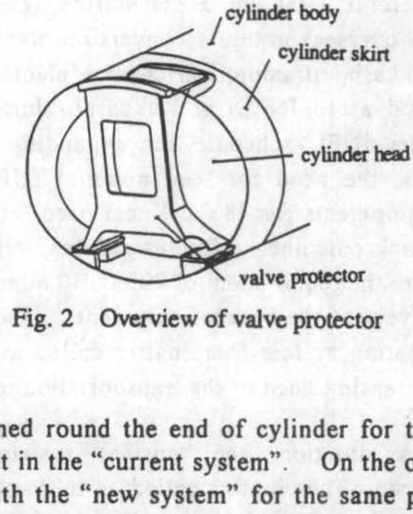

Fig. 2 Overview of valve protector

· Heat resistance cap

The fire protection cover is fastened round the end of cylinder for the purpose of protecting the valve in fire accident in the "current system". On the other hand, the heat resistance cap is equipped with the "new system" for the same purpose as the "current system". The heat resistance cap is equipped with the valve protector inside of it, and the valve protector is fixed to end of cylinder at the time of setting the heat resistance cap to the cylinder. The heat resistance cap has a cylindrical structure covered with insulation materials (two layers of ceramic cloth and one layer of blanket).

· Supporting frame of heat resistance cap

The supporting frame of heat resistance cap made of stainless steel holds a heat resistance cap inside of it. At the time of loading and unloading of 48Y cylinder, the whole aspect of the cylinder can be seen by sliding the supporting frame in the longitudinal direction on the rail of the container. The above sliding can be operated by hand easily.

· Special shutter

At the time of setting the supporting frames on the exact position after loading of 48Y cylinder on the container, the both ends of the cylinder can be covered by the supporting frames, and the whole aspect of the cylinder can be covered by closing the shutters.

· Special container

The special container is a flat-rack type equipped with the cylinder saddles. The container is in conformity to the ISO requirement and the guideline of Japanese Ministry of Transport (JMOT) regarding the tie down of radioactive material's package.

Fig 3 shows the procedure of loading and unloading of the "new system". Unloading procedure is reverse of loading procedure. Although the operation of the "current system" was complicated because of respective handling of container, frames, fire protection covers and valve protector, the operation of "new system" is easier by integrating these equipments into one unit.

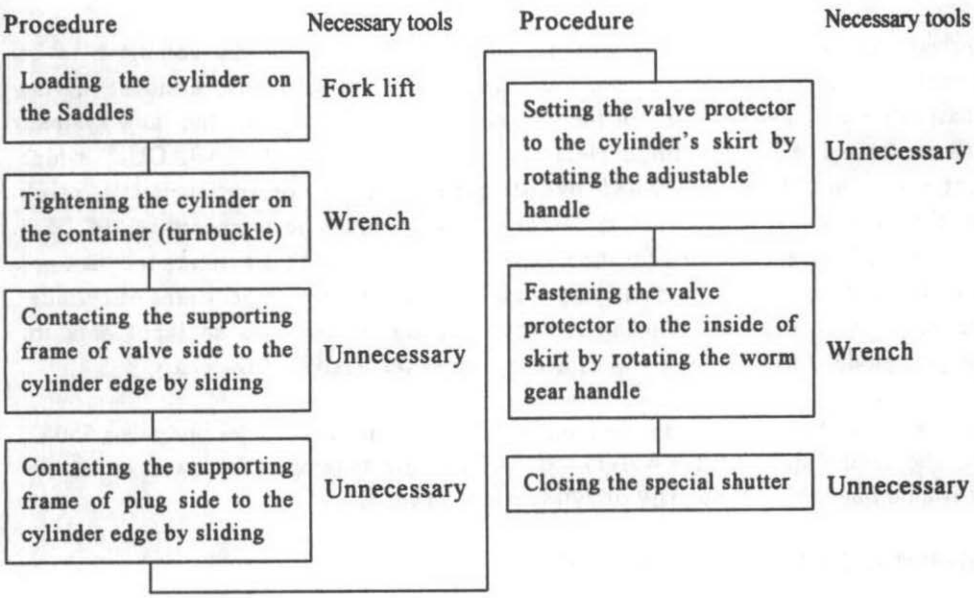

Fig.3 The Handling Procedure of New Transportation System

STRENGTH ANALYSIS OF NEW TRANSPORTATION SYSTEM

The structure strength analysis of the following equipments of the "new system" was performed.

- Beam supporting the load of cylinder
- Fixing bolts of the above mentioned beam
- Welded parts of cylinder reinforcement rings
- Tie down equipment

Under the normal condition the working loads are defined based on the guideline of JMOT regarding the radioactive materials transportation and under the accidental condition based on the governmental guidance of JMOT.

Normal condition: Acceleration 2G of vertical direction, 2G of fore and aft direction, and 1G of transverse direction work on a new transportation system at once.

Accidental condition: Acceleration 10G of fore and aft direction works on a new transportation system

Evaluation criteria are as follows ;

Normal condition : $\sigma_y/1.3$ for tension and bend, $\sigma_y \times 0.6$ for shear

Accidental condition : σ_B for tension and bend, $\sigma_B \times 0.6$ for shear

Here, σ_y is design yield strength, and σ_B is design tensile strength.

As a result of analysis, all stress were less than the criteria, and so the strength were ensured to be enough.

THERMAL ANALYSIS OF NEW TRANSPORTATION SYSTEM

Thermal analysis of the "new system" was performed under the condition to be exposed to a fire at 800℃ for 30 minutes assuming a fire accident during transportation. The analysis for the UF6 filled cylinder loaded on the "new system" was performed using the finite element analysis general code "ABAQUS" which conformity had been confirmed by comparing the demonstration test's result mentioned below. Three analysis models to determine the temperatures of UF6, cylinder and valve were used for the analysis. First of all the maximum temperature of UF6 was determined under analysis model 1, and then the temperatures of cylinder and valve were determined using the result of the model 1 as an input data for analysis model 2 and 3. Fig.4 as attached, shows the analysis flow chart.

As a result of the analysis, the maximum temperature of the cylinder body was 550℃, and the temperature of the valve was 144℃. Each temperature was under the allowable one, and the integrity of cylinder was ensured.

THERMAL DEMONSTRATION TEST

The thermal demonstration test for the "new system" was performed under the condition to be exposed to a fire at 800℃ for 30 minutes for the purpose of studying the heat resistance performance of 48Y cylinder loaded on the "new system". Steel shots of 2mm average diameter as a mock of the content of 48Y cylinder were used instead of UF6.

The result of the demonstration test is as follows;

• Table 1 shows the maximum temperature and the time to attain this temperature of each point, and also the maximum temperature obtained by the demonstration test for the "current system" as a comparison data.

Table 1

Measuring point	After 30 minutes	Maximum temperature (℃)	Time to attain max. temperature (minutes)	Max. temperature in current system (℃)
Center of cylinder body	502.6	502.6	0	695.3
Edge of cylinder body	240.0	267.8	25.2	227.1
Valve	130.0	212.1	60.0	185.5
Surface of heat resistance cap	687.0	687.0	0	771.7

• Soap tests of valve, plug and welded parts were carried out after the demonstration test, and no leak was confirmed without foaming.

• The maximum temperature of the cylinder surface was approximately 500℃ less than approximate 700℃ of the maximum temperature in case of the "current system", and this indicates the heat shielding effect of the shutter and the supporting frame at the time of a fire accident. However, some temperature increase of approximate 40℃ at the cylinder body edge and approximate 20℃ at valve was found. This would be caused by the air convection generated in a gap between the heat resistance cap and the cylinder. The existence of a gas is inevitable to enable the heat resistance cap to be set to the cylinder easily by one operation. On the other hand, in case of the "current system", as the fire protection cover is fastened round the cylinder directly, there is no gap between the cover and the cylinder

EXPERIENCE OF TRANSPORTATION BY THE NEW TRANSPORTATION SYSTEM

Fig.5 as attached, shows a comparison of the transportation mode between the "current system" and the "new system". In the "current system", necessary containers and equipments are separately sent to the conversion plants or the overseas ports, and also necessary fire protection cover is fastened round the cylinder at the exporting port just before sea transportation to Japan. This is a complicated mode. In the "new system", as necessary equipments are integrated into one unit, the

management for shipment and the handling of the unit has become easy to do and the effective operation has become possible.
It was confirmed that the "new system" conforms to the handling and transport system of both conversion plants of France and Canada and also the handling system of JNFL, and can improve the operativity by 2 to 3 times in comparison with the "current system".

The transportation by the "new system" was commenced in 1996 from Comurhex of France, and 100 pcs of UF6 filled cylinder were transported from Comurhex via Cameco of Canada in 1997. Twice shipments per year are scheduled to be executed from 1999 by the "new system", and it is expected that the effect of increasing the transportation efficiency becomes conspicuous.

100 pcs of the "new system" equipments were shipped to Montreal in Canada by chartered ship in 1997, and 50 pcs of those were unloaded and transported by trailer to Cameco, and after being loaded with 50 pcs filled 48Y cylinders on trailer, those equipments returned to Montreal port. The anchorage period at the port was about 4 days. Then the chartered ship shipped to Fos port in southern France to load more 50 pcs filled 48Y cylinders of Commulex. At Fos port the remaining 50 pcs of the "new system" were unloaded and transported to Commulex by wagon, and after being loaded with the filled cylinders on wagon, returned to Fos port. The anchorage period at the port was about 11 days. After that, 100 pcs of new equipments loaded with filled cylinders were shipped to Mutsu Ogawara port and unloaded, and transported to Rokkasho enrichment plant by 9 trailers. The anchorage period to load again the empty "new system" on the ship was 4 days.

CONCLUSION

It was confirmed from a result of mechanical strength analysis, thermal analysis and thermal demonstration test that for the new transportation the tie down system strength is satisfactory and meets the requirements of IAEA 1996 to be exposed to a fire at 800℃ for 30 minutes. It was also confirmed that the operation efficiency, the operativity and the safety are improved remarkably in operation and transportation at overseas, Mutsu Ogawara port and JNFL enrichment facilities.

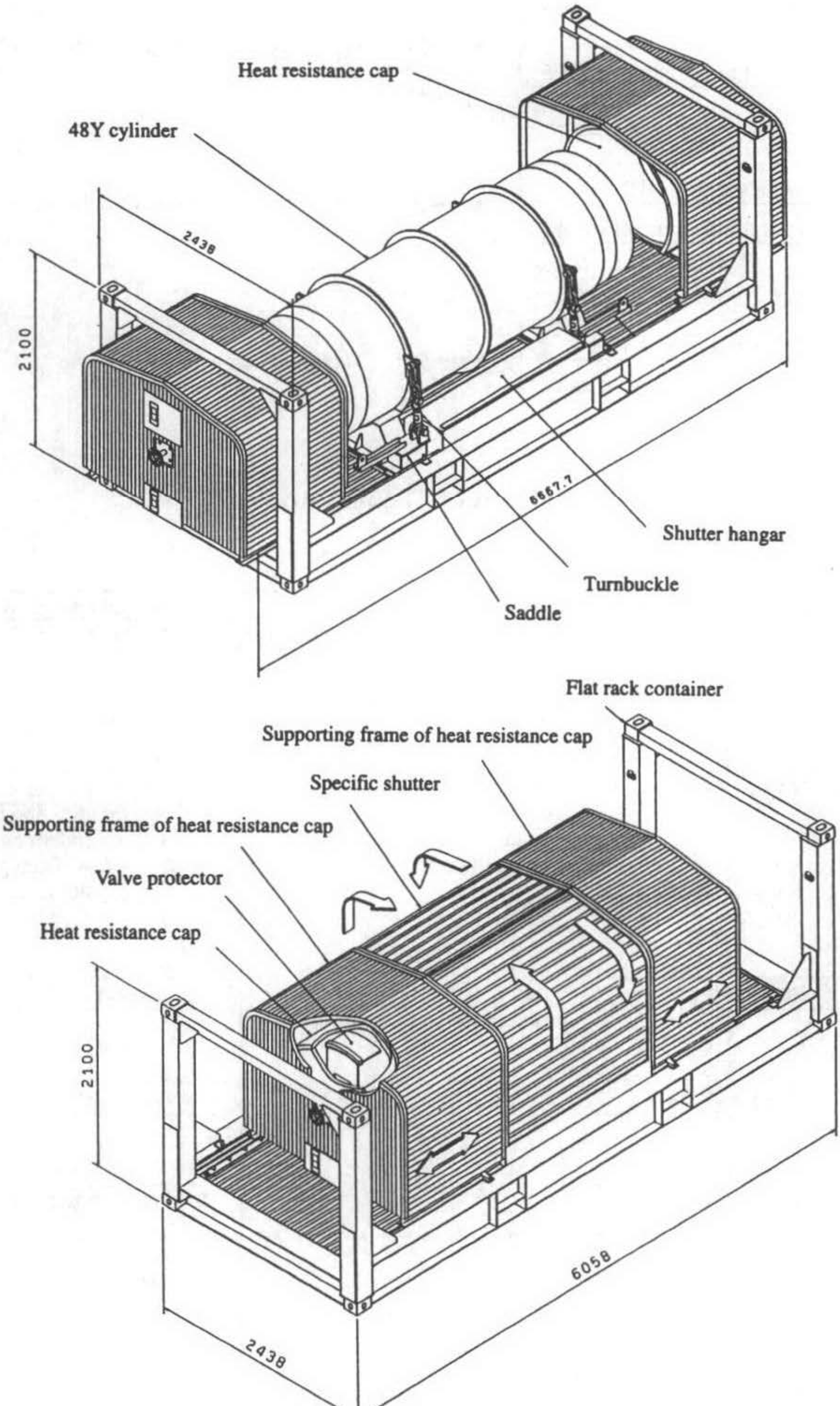

Fig. 1 Bird' s Eye View of the New Transportation System

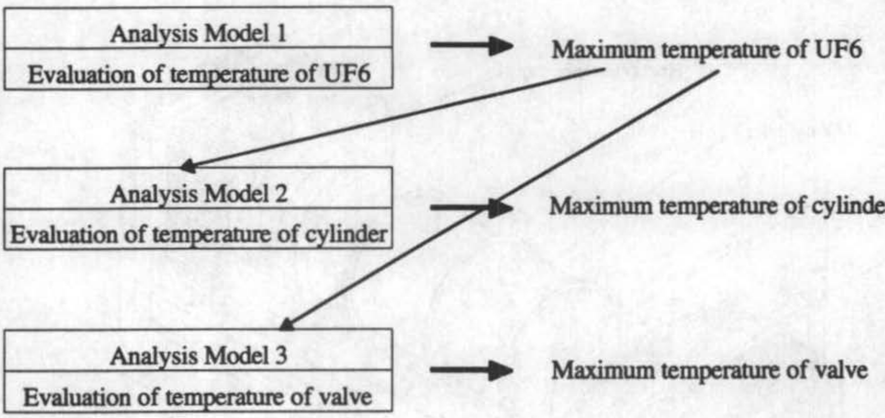

Fig.4 Flow Chart of Thermal Analysis

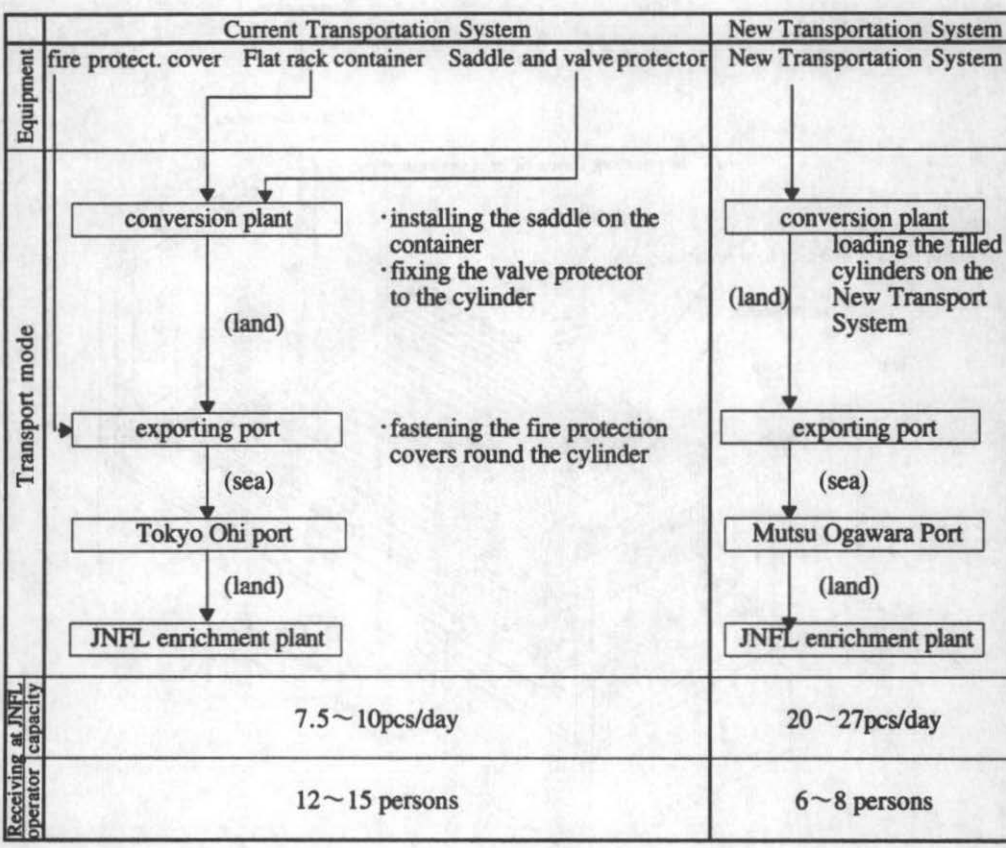

Fig. 5 Comparison of the transportation mode