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Nuclear Fuel Material Transportation in Japan

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1. Introduction

While Japan has not blessed with rich energy resources, it is essential for Japan to ensure energy security in order to sustain economic growth and social activities.

To secure stable energy supply, establishing nuclear fuel recycling has a vital role in using and developing nuclear power.

Therefore, it is essential and increasing its importance in the field of nuclear fuel cycle on safe and smooth transport among various nuclear fuel recycling facilities, enrichment plants, re-conversion plants, fuel fabrication plants, reprocessing plants, etc.

In the nuclear fuel recycle policy of Japan, using plutonium thermal, that burns plutonium in the form of mixed oxide fuel(MOX fuel) with uranium in a Light Water Reactor, has been positively considered with views to utilize plutonium generated by spent fuel reprocessing and to achieve more effective use of uranium.

Japanese government has a principle not to maintain excess plutonium and from this point of view, plutonium thermal use is the best way of utilizing plutonium.

Japanese government, based on the cabinet approval "Promotion Plan for Developing Nuclear Fuel Cycle, Feb.4 1997", requested governors of three prefectures, Fukui, Fukushima and Niigata , where nuclear power plants are located, to accept implementing plutonium thermal use at those power plants and to assist it.

When local governments and local communities accept it, plutonium thermal use would be promoted and it would be lead to a large amount of MOX fuel transportation.

But the implementation of plutonium thermal use has been postponed, as it was opposed at the resident referendum held in Kariha-mura village, Niigata prefecture on May 2001.

2. Status of Nuclear Power Plants and Nuclear Fuel Cycle Facilities in Japan

1) Nuclear Power Plants

As of the end of July 2001, nuclear power generating capacity totaled about 45,000 megawatts (MW) in Japan, with 51 commercial power reactors in operation. And nuclear power accounted for about 35% of total generated electricity in Japan.

There are 10 units of the commercial power reactors under construction or at the stage of preparation. If those reactors are included, there will be 61 units in all, total generating capacity of about 57,000 MW.

2) Status of Nuclear Fuel Cycle Facilities

There are 2 units of enrichment plants, one unit of re-conversion plant and 4 units of fuel fabrication plants in Japan.

Almost all of nuclear fuel materials such as uranium hexafluoride (UF_6) or uranium dioxide(UO_2) powder used in Japan are imported from abroad, and are processed in these nuclear fuel cycle facilities.

The reprocessing plant is under construction with the aim of starting operation on and after July 2005, and spent fuel reception pools have been completed at present.

Meanwhile, the low-level radioactive waste(LLW) burial facility and the high-level radioactive waste(HLW) management facility are both located in Rokkasho-mura village, Aomori prefecture.

The LLW burial facility has been in operation since 1992, and the HLW facility, in which vitrified residue canisters returned from France are kept, has been in operation since 1995.

3. Status of Nuclear Fuel Cycle and Nuclear Fuel Material Transportation

1) Outline

Table 1 shows the amount of nuclear fuel materials transported for nuclear power plants and nuclear fuel cycle facilities from 1996 to 2000.

The amount of fresh fuel transported (tons of uranium) has been decreasing since 1996 due to reduction of initial core fuel for new power plants and promotion of high burn-up fuel.

Table 1 Amount of Transportation of Nuclear Fuel

(Unit: tons of uranium)

		1996		1997		1998		1999		2000	
		T	Q	T	Q	T	Q	T	Q	T	Q
Fresh fuel	UF_6	50	720	52	704	34	418	32	534	32	387
	UO_2 etc	79	747	74	745	83	731	70	556	66	475
	Fuel Assemblies	77	1217	51	825	66	1101	65	902	64	1085
Fresh fuel Subtotal		206	2684	177	2274	183	2259	167	1992	162	1947
Spent fuel		22	199	9	127	6	69	10	107	8	102
HLW(Unit : tons)		1	20			1	30	1	20		
Others		27	1.6	23	2.7	10	0.3	12	0.2	9	

T: Number of transportation Q: Total quantity

NOTE

1.This table shows nuclear fuel materials transported subject to confirmation by code, which are type A

2.UF_6 refers to enriched uranium hexafuoride,
UO_2 refers to uranium dioxide, uranium trioxide and other uranium oxides,
Fuel Assemblies refers to bundles of UO_2 fuel and MOX fuel,
HLW refers to high-level radioactive waste,
Others refers to LLW (low-lever radioactive waste) etc.

2) Transportation of Nuclear Fuel Materials and Fuel Assemblies

Uranium for nuclear fuel used at nuclear power plants is mainly imported in either form of uranium hexafluoride (UF_6) or uranium dioxide (UO_2) powder from abroad, and is transported overland from ports to respective nuclear fuel fabrication plants.

Imported UF_6 is changed into enriched UO_2 through the enrichment process and the reconversion process, and finally becomes fuel assemblies at fuel fabrication plants.

Such nuclear fuel materials and fuel assemblies are regularly transported among fuel cycle processing plants and nuclear power plants.

Those materials and assemblies are mainly transported by land using trucks or trailers, but some fuel assemblies are carried by ship depending upon the location of the nuclear power plant.

3) Transportation of MOX Fuel

The first shipment of MOX fuel, mixture of uranium and plutonium oxides fuel, for commercial use in a light water reactor was carried out from July to October 1999, and the second shipment was accomplished by sea in 2001.

4) Transportation of Spent Fuel

In August 1999, transportation of spent fuel to the reprocessing plant of Japan Nuclear Fuel Ltd. located in Rokkasyo-mura Village, Aomori prefecture was carried out for the first time, and calibration test of burn-up monitors was conducted.

After the agreement on safety assurance of the facility and preservation of environment around was concluded among local governments and Japan Nuclear Fuel Ltd. which operates the plant, several shipments of spent fuel have been conducted by the ship of exclusive use since December 2000.

5) Transportation of LLW

Low-level radioactive waste produced from operation and periodical inspection of nuclear power plants is packed in drums mixed with cement, asphalt or other materials after reducing its capacity by burning.

After temporary storage in exclusive storage houses, these filled drums are contained in shock-resistant containers and sent to the LLW burial site of Japan Nuclear Fuel Ltd. (JNFL) located at Rokkasyomura Village, Aomori prefecture

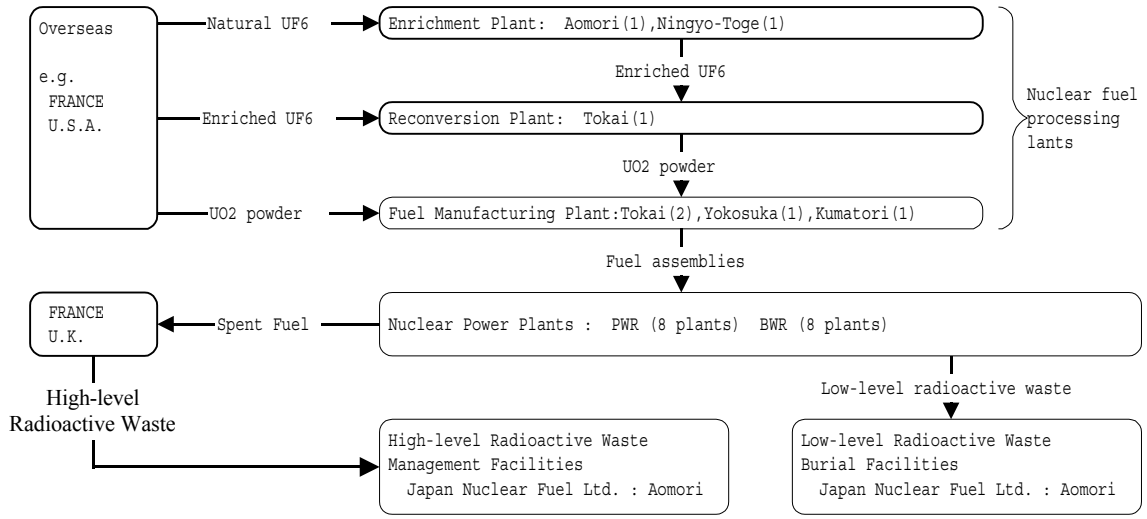
6) Transportation of HLW

Liquid waste with high level radioactivity generated from reprocessing of spent fuel is melted and mixed together with glass which is extremely stable and they are poured into stainless steel canister for hardening.

These canisters have been transported several times, as it is arranged that high-level radioactive waste generated from reprocessing plants in abroad is to be returned back to Japan.

Throughout those shipments, canisters of HLW are contained in the transport packagings conforming to IAEA Regulations for the Safe Transport of Radioactive Materials (ST-1), and the packages are transported by ship which compiled with IMO's SOLAS Convention and INF code (international regulations concerning safe maritime transportation of Irradiated Nuclear Fuel).

Fig.1 Current Situation of Major Transportation of Nuclear Fuel Materials



4. Measures for Safe Transport

1) Improvement of Quality Assurance

The importance of quality assurance was emphasized after the exposure of data falsification of resin, neutron shield material of spent fuel packagings in October 1998.

After that, the special committee of competent authority on this subject recommended several countermeasures for improvements shown below, and these measures have been conducted by competent authorities and licensees.

(Licensee's Countermeasures)

- To audit manufacturers and its subcontractors concerning packagings
- To implement quality assurance program such as ISO9000
- To verify technical ability of manufacturers when applied new technology
- To study the fabrication process and inspection method concerning key material for safety, among concerned parties.
- To verify inspection result and data, and shall witness inspection or test if necessary.

(Competent Authority's Countermeasures)

Competent authorities shall check items shown below in order to verify licensee's performance deeper than before and to make licensee's countermeasures more efficient.

- To examine licensee's quality control system on manufacturing packagings
- To examine manufacturing process of packagings

2) Safety Study

To ensure safe transportation of radioactive materials, it is necessary not only to establish strict standards but also to promote a systematic safety study based on the progress in technology and the study results achieved so far. For this purpose, safety studies are being conducted in research institutes throughout Japan. (Table 2 shows some examples.)

Table2 Safety study on radioactive material transportation

Area of Study	Theme	Research Institute
Sealing and Criticality	Study for high performance radiation shield	National Maritime Research Institute
Structure, material, heat/fire resistance	Study on Integrity of Transport and Storage Cask against transport regulation after long-term storage	Central Research Institute of Electric Power Industry (CRIEPI)
	Demonstrative analysis of safety on packaging of nuclear fuel material	Japan Atomic Energy Research Institute
Others	Evaluation of transport system for radioactive wastes produced from decommissioning of nuclear plants	CRIEPI

5. Japanese Competent Authority and Regulation System

1) Competent Authority

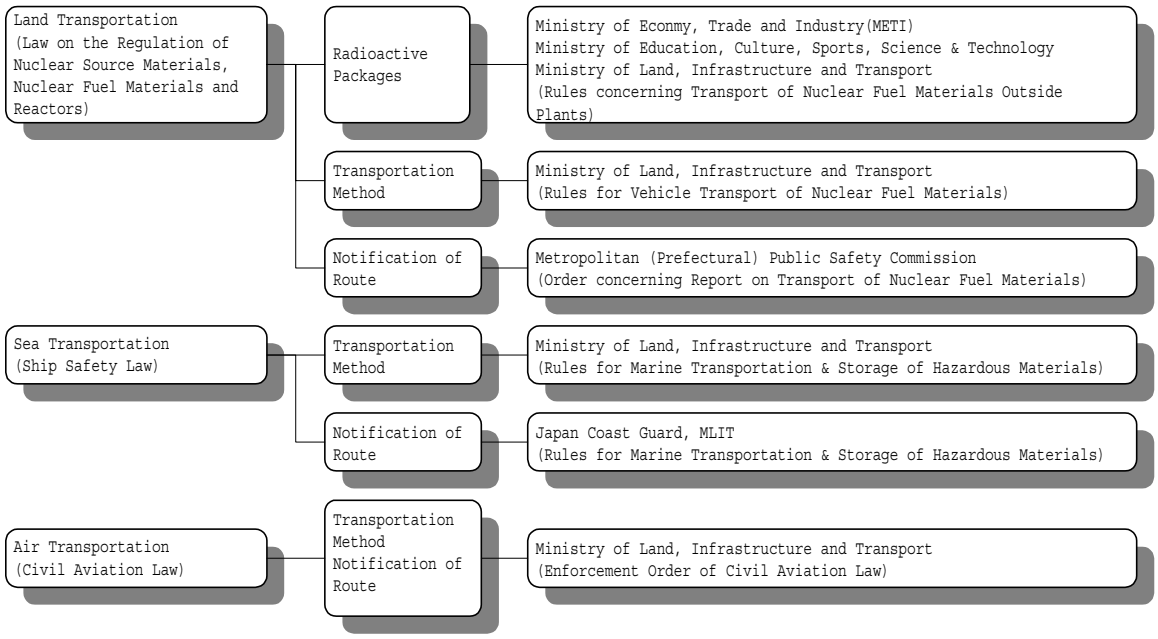
In accordance with the reform of Japanese administrative authorities on January 6, 2001, competent authorities for transportation of radioactive materials have been changed.

Through the above development, control for transportation of nuclear fuel materials used in commercial nuclear power plants is executed currently for land transportation under “Law on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors (Reactor Regulation Law)” by Ministry of Economy,

Trade and Industry (METI) , Ministry of Land, infrastructure and Transport (MLIT) and Public Safety Commission , for marine transportation under "Ship Safety Law" by MLIT and Japanese Coast Guard, and for air transportation under "Civil Aviation Law" by MLIT, respectively. (See figure below)

Meanwhile, the authorities concerned with transportation of nuclear materials, "Ministry of Economy, Trade and Industry", "Ministry of Land, Infrastructure and Transport", "Japanese Coast Guard", "Ministry of Education, Culture, Sports, Science and Technology", "National Police Agency" and "Fire Defense Agency" , hold coordinating meetings periodically to discuss about countermeasures for safe transport and established safety measures to be taken in case of an accident in February 1984.

Fig.2 Radioactive Material Transport Mode and Regulation Assignment



2) Regulation System

a. Safety Regulation on Land Transportation

Ministry of Economy, Trade and Industry (METI) executes standards concerning safe transport of nuclear fuel packages including "Rules concerning Transport of Nuclear Fuel Materials Outside Plants" under Reactor Regulation Law, and verifies that nuclear fuel packages comply with the safety standards specified in the rules upon each occasion of such transport.

These safety standards are established according to the regulations set up by the IAEA so that safety is ensured not only during normal transport but also incase of erroneous cargo handling or traffic accidents.

Upon confirmation of nuclear fuel materials, strict review is executed by METI to verify that the design of packages complies with the safety standards, then design approval is given to those recognized as complying. Then, it is confirmed that the individual transport container are fabricated to the approved design and maintained accordingly, finally, approval for packages will be issued.

After all these procedures, it is verified, upon each transportation, that the nuclear fuel materials housed comply with the approved design specifications and they are housed in the approved containers before any transport certificate is issued by respective authority.

On the other hand, Ministry of Land, Infrastructure and Transport (MLIT) established safety standards

concerning transportation methods including methods of loading nuclear fuel packages onto vehicles, signs to be put up on vehicles and the maximum package per vehicle in the order of MLIT, "Rules for Vehicle Transport of Nuclear Fuel Materials" under Reactor Regulation Law.

b. Safety Regulation on Marine Transportation

For marine transportation, basically the same safety control system is applied as for land transportation. Ministry of Land, Infrastructure and Transport (MLIT) has established safety standards concerning nuclear fuel packages and methods of transportation including methods of loading onto the ship in the order of MLIT, "Rules concerning Marine Transportation and Storage of Hazardous Materials" under Ship Safety Law .

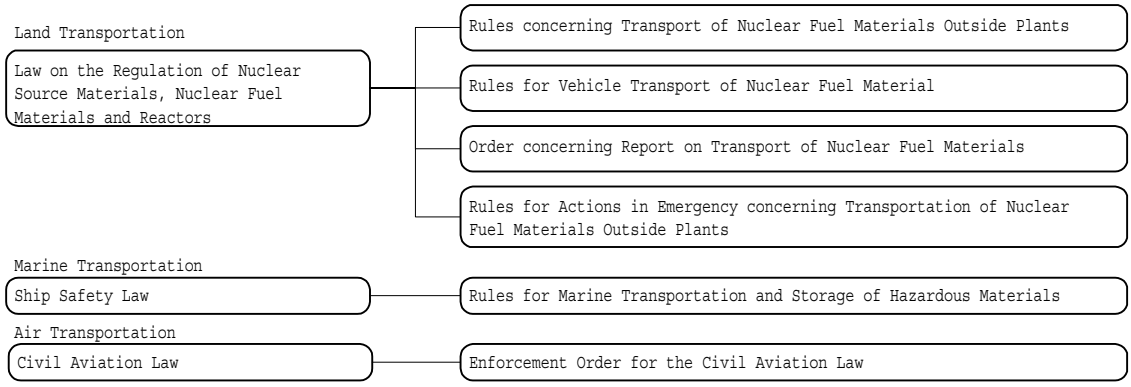
If it is recognized that the shipment is to be handled subject to Ship Safety Law, MLIT verifies, upon each occasion of loading, that the subject packages and the transportation method concerned comply with these safety standards.

As these safety standards for nuclear fuel packages are basically the same as those for nuclear fuel packages to be handled by land transportation, those nuclear fuel packages to be seamlessly handled through land and marine transportation are regarded as those verified by MLIT as stipulated by Ship Safety Law if they have been verified by Ministry of Economy, Trade and Industry (METI) under Reactor Regulation Law.

c. Safety Regulation on Air Transportation

Safety standards for air transportation of nuclear fuel materials are set out in rules such as the order of Ministry of Land, Infrastructure and Transport, "Enforcement Order for the Civil Aviation Law" under Civil Aviation Law.

Fig.3 Code System concerning Transportation of Nuclear Fuel Materials



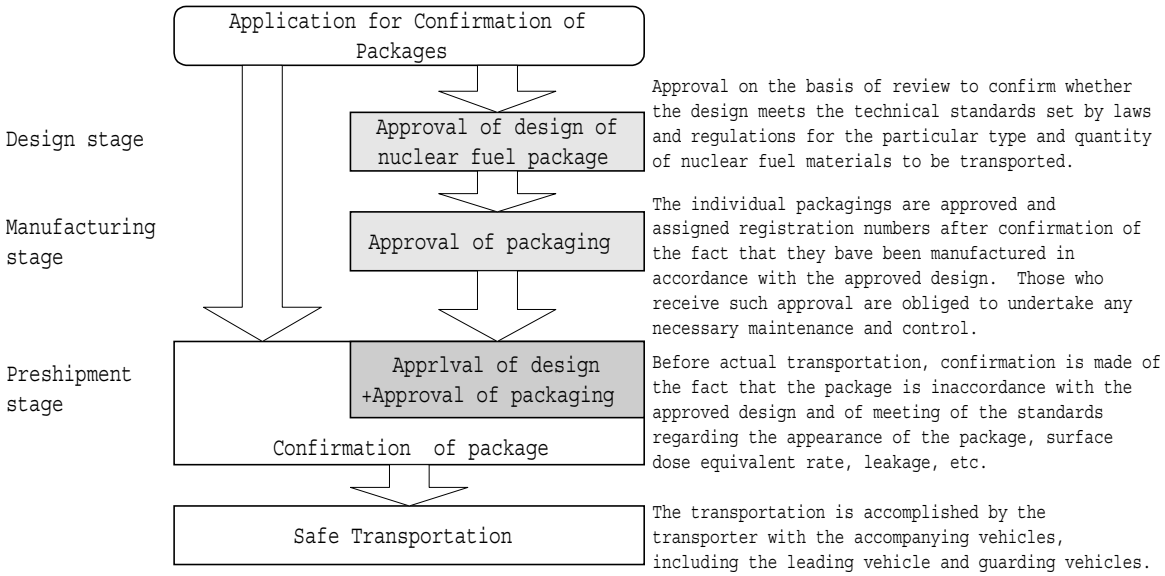
3) Approval System in Japan

Japanese regulation system has not only approval of package design, same as IAEA Regulation's approval of package design, but also "Package Approval". On each shipment competent authority examine that each package meet regulation code. Examining items are shown below.

- Package design shall meet regulation standards
- Each packaging shall fulfill approved package design
- Each Package shall meet regulation standards (contents, radiation level, contamination etc.)

Licensees could get approval of package design and approval of each packaging beforehand. With those approvals, licensees do not have to submit documents explaining package's conformity to regulation and could be approved by a approval organization designated by competent authority. "Approval of packaging" requires that each packaging is manufactured in accordance with approved package design and maintained in good condition.

Fig.4 Flow Chart of Confirmation of Packages
(the case of Land Transportation)



6. Adoption of 1996 Edition of IAEA Safe Transport Regulations to Japanese Regulations

In order to enhance safety regulation, laws concerning transportation of nuclear fuel materials through discussion by the Radiation Council, which were enforced after April 1, 1979, complying with "Guidelines for Safety Standards for Transport of Radioactive Materials" established in January, 1975 by the Atomic Energy Commission subject to the "Regulation for Safe Transport of Radioactive Materials (1973)" issued by the International Atomic Energy Agency (IAEA).

This effort was followed by amendment of the laws subject to the IAEA's "Regulation for Safe Transport for Radioactive Materials (1985)", which amendment formed the former regulations.

Japanese competent authorities revised domestic regulations based on laws for transport of radioactive materials by June 15 in accordance with 1996 edition of Regulations for the Safe Transport of Radioactive Material (ST-1), and those regulations have become effective since July 1, 2001.

The revision was examined by both Nuclear Safety Committee and Radiation Council.

Japanese competent authorities will continue to participate in the ongoing work of revising 1996 edition of IAEA transport regulation.

7. Implementation of mandated requirements of the INF Code under the SOLAS Convention since 2001

Up to the end of 2000, Japan had made an effort to ensure ship's safety by issuing order imposing necessary requirements equivalent to the INF Code as well as additional domestic regulations.

Recognizing the situation of INF Code becoming mandatory from the beginning this year and the revision of safety regulation policy on maritime transport after critical accident occurred in Japan, INF Code and additional requirements were incorporated into Ship Safety Law and its regulation, which entered into force on January 1, 2001. Thus, Japanese competent authority has strengthened safety measure for maritime transport, in terms of hull constructions and onboard equipments of ships carrying irradiated nuclear fuel etc. as well as shipment approval system.