Current Status of Nuclear Materials Transportation in Japan

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1. Introduction

Some 30 years have passed since the development and utilization of nuclear power began on a full scale. During that time, the nuclear power generation of Japan has achieved a rapid growth. As a result, the frequency and quantity of nuclear fuel transports in Japan has showed a tremendous increase.

Also, a plan for constructing nuclear fuel cycle facilities, consisting of enrichment, reprocessing and radioactive waste storage facilities is being implemented, and it is consequently expected that a variety of transport modes will also be developed.

One of the basic principles relating to nuclear fuel transportation in Japan is to protect workers and the public from the exposure as low as reasonably achievable (ALARA) in order to assure safe transport of nuclear fuel. Japan has regulated package design and shipment based on this principle of safety.

2. Current Status of Safety Regulations for Nuclear Fuel Transport

2.1 Nuclear power generation and nuclear fuel transport in Japan

As of the end of November, 1988, there were 35 nuclear power plants in operation (with a total of 27,881 MW), while 14 plants were under construction (13,665 MW). In addition, there are four nuclear power plants (4,362 MW) are under consideration for construction, making a total of 53 power plants with a capacity of 45,908 MW.

The number of nuclear material transports in relation to the power plants during 1983 ~ 1987 are shown in Table 1.

Table 1 The Amount of Nuclear Fuel Material Transported for Nuclear Power Plants

Item		1983		1984		1985		1986		1987	
		Number of Transportation (time)	Total Quantity (U-ton)	Number of Transportation (time)	Total Quantity (U-ton)	Number of Transportation (time)	Total Quantity (U-ton)	Number of Transportation (time)	Total Quantity (U-ton)	Number of Transportation (time)	Total Quantity (U-ton)
Fresh fuel	UF_6	29	526	39	730	34	601	36	599	35	556
	UO_2	95	683	111	689	83	697	91	547	76	629
	Fuel Assembly	50	792	67	1,094	48	745	59	1,047	55	861
Spent fuel		31	385	27	396	36	488	44	485	51	527

(Notes) 1. Data which confirmed for the application based upon the regulations
2. The amount of spent fuel transported to foreign countries was 460 tU in 1987.

2.2 Current status of safety regulations relating to nuclear fuel transport in Japan

Regulations relating to nuclear fuel transport in Japan are governed by the Law for Regulation of Reactors, by Maritime Safety Law and by Aviation Law. The technical standards for nuclear fuel transport are stipulated in ministerial ordinances and notifications based on these laws. The contents of these technical standards are mainly based on the 1973 IAEA Transport Regulations.

For implementation of regulations, when fissile packages or BM or BU type packages are to be shipped, confirmation of safety is required by law. This confirmation is divided into three phases, i.e., (1) design approval for nuclear fuel packages, (2) packaging approval (registration), and (3) shipment confirmation (confirmation of packages and the method of transport).

2.2.1 Design approval

Science and Technology Agency (STA) and Ministry of Transport (MOT), the competent authorities of Japan, carry out the safety examinations, with the help of advisory committees (consisting of experts in the fields as structure, material, heat, containment, shielding and criticality), related to safety analysis of the package. The term of validity of a certification for the package design is three years. The certification can be extended by following the appropriate procedures.

2.2.2 Packaging approval (registration of packaging)

Before using packagings, the applicant must obtain the packaging approval of the competent authorities who examine the results of inspections carried out according to inspection manual, defined in advance, which consists of an inspection method and the relevant criteria, concerning to material, dimensions, welding, pressure, heat conduction, shielding etc. The competent authorities carry out inspections as necessary during manufacture and at the time of the completion of the packaging. The term of validity of a certification for packaging approval (registration) is three years. This certification can also be extended.

2.2.3 Shipment confirmation

(a) Confirmation of the safety of a package

The competent authorities examine, prior to each shipment, whether the contents meet the approved design specification and are in the approved packaging. Before the shipment,

inspection (as necessary) such as measurements of surface dose rate and sealing performance are carried out by inspectors from the competent authorities. Only then is the confirmation certificate issued for the package.

(b) Confirmation of the safety of a transportation method

In addition to the procedure detailed in (a), the MOT carries out a safety inspection of the method of fastening the package on the conveyance being used (vehicle, vessel, aircraft, etc.), of the structure and equipment of the conveyance and the method of radiation exposure control. The confirmation certificate is then issued for the relevant transport method.

2.3 Incorporation of the IAEA 1985 Transport Regulations into Japanese regulations

The technical aspects of Japanese regulations related to the transport of radioactive materials are based on the 1973 IAEA Transport Regulations. Specific measures are now being taken by the Nuclear Safety Commission of Japan to incorporate the 1985 IAEA Transport Regulations.

The 7th SAGSTRAN of IAEA decided the period of incorporating the 1985 IAEA Transport Regulations to be prolonged until January 1991. Therefore, the period of incorporation of the IAEA 1985 Transport Regulation into Japanese regulations is now reconsidering.

3. Overview of Recent Nuclear Materials Transport and Related Safety Regulations

In Japan, construction of uranium enrichment plant, private reprocessing plants and low-level radioactive waste storage facilities at Rokkasho-mura, Aomori Pref. is currently implemented for the establishment of nuclear fuel cycles.

(1) Transportation relating to low-level radioactive waste storage facility

The total number of commercial nuclear power plants now in operation in Japan is 35 with a capacity of 27,881 MW as of November, 1988. These plants are located at 15 sites. The low-level radioactive wastes produced from these plants are stored in the storage houses constructed in each site. The total number of low-level radioactive waste drums stored at nuclear power plants throughout the nation is approximately 450,000 as of the end of March, 1988. Each power plant has dealt with an increasing number of radioactive waste by expanding the storage houses. However, to realize land disposal of these low-level radioactive waste, a plan is being implemented to construct a low-level radioactive waste disposal facility at Rokkasho-mura, Aomori Pref. The maximum disposal capacity of this facility will be initially about 40,000 m^3 (equivalent to 200,000 drums (200 ι /drum)), and its capacity will be gradually expanded, and the final disposal capacity is expected to reach about 600,000 m^3 (equivalent to about 3,000,000 drums (200 ι /drum)). For transportation to this facility, radioactive waste are to be transported by sea from the exclusive-use port or the nearest port of each power plant site to Mutsu Ogawara Port near the low-level radioactive waste disposal facility and then transported by truck from that port to the disposal facility. The transport capacity is expected to be initially about 25,000 drums/year, and normally 50,000 drums/year.

The Ministry of Transport formulated technical standards relating to exclusive-use ships for the transportation of low-level radioactive wastes, as a notice issued by the Director of the Maritime Technical Safety Bureau on November 18, 1988.

Specifically, these standards stipulate requirements concerning hull construction, such as stability at the time of damage, storage of cargo, etc., as well as requirements concerning ship equipment, such as lashing of cargo, radiation measuring devices, drainage, fire

prevention, lifesaving, power supply, navigation, communications equipment and engines, to secure safety in the transportation of low-level radioactive wastes by sea.

(2) Transportation relating to commercial uranium enrichment facility

With regard to the balance between the demand and supply of uranium enrichment, Japan is currently receiving enrichment services amounting to about 3,000 tons SWU/year from the United States under the Japan-U.S. Atomic Energy Cooperation Agreement, and has a contract of being supplied with about 6,000 tons SWU/year around 2000. Moreover, Japan is to receive enrichment services totalling about 18,000 tons SWU from Eurodif Corp., an international joint venture centering around France, for 25 years from 1980.

Thus, enriched uranium needed to operate nuclear power plants in Japan is secured until the first half of the 1990s. To meet the subsequent new demand, the portion equivalent to this will be produced domestically from a standpoint of establishing independent nuclear fuel cycles. As part of this, a commercial uranium enrichment facility with a final enrichment capacity of 1,500 tons SWU/year is under construction at Rokkasho-mura in Aomori Pref., which is expected to start operation around 1991. For transportation in relation to this facility, the natural uranium which is imported from foreign countries will be shipped by container ship, and then shipped to the enrichment facility by vehicle.

Also, the product of enriched uranium will be shipped to fabrication facility.

(3) Transportation relating to private reprocessing plants

Reprocessing of spent nuclear fuel is currently dealt with by reprocessing at the reprocessing plant of the Power Reactor and Nuclear Fuel Development Corporation (PNC) as well as by the reprocessing commission agreement with British Nuclear Fuel Fuels plc (BNFL) and Compagnie Générale des Matiéres Nucleaires (COGEMA). Also, in the water pools of nuclear power plants and the Tokai Reprocessing Plant, spent fuel totalling about 2,000 tons as of March, 1987 is safety of 0.7 ton U/day. Tokai reprocessing plant entered into full-scale operation in January, 1981, and processed spent fuel of 392 tons in total from September, 1977 to June, 1988, including test running period. On the other hand, a private reprocessing plant is to be constructed at Rokkasho-mura in Aomori Pref., which is expected to start operation in the middle of 1990, with a processing capacity of 800 ton U/year.

For transportation relating to this, spent fuel is to be shipped from the exclusive-use port or the nearest port of each power plant site to the reprocessing plant, in the same way as the transportation of low-level radioactive wastes.

(4) Transportation relating to returned waste

Among waste which is generated on the occasion of reprocessing in foreign countries, the radioactive waste to be returned to Japan (hereinafter called "returned waste") will be received and stored within the site of a private waste management enterprise's facility at Rokkasho-mura, Aomori Pref.

To receive the returned waste, it is necessary to ensure not only that these waste possess adequate properties from the standpoint of safety but also that safety is secured for transportation and storage as well.

Because of this, the Radioactive Materials Safety Transport Advisory Committee of the Nuclear Safety Commission of Japan has carried out, since 1984, study on the safety of packages in which the returned waste are contained, with respect to the items for evaluating the safety of packages to be supposed a reasonable design, which are required from the standpoint of transport standards regulated in the Japanese laws based on the IAEA Transport

Regulations, and published its report in September, 1987. This report reveals a prospect that it will be possible to safely transport the returned waste. When such transport is actually carried out in the future, the specifications of the returned waste will be given more concrete form and also the packages which meet these requirements will be developed. In actual transportation, therefore, safety examination will be conducted anew based on the packages containing specific returned waste under the safety regulations based on the laws and ordinances, and the safety relating to their transportation will be confirmed.

4. Safety Research

Safety research on the transport of radioactive materials is carried out based on the "Annual Program for Safety Research on Nuclear Facilities, etc." formulated by the Nuclear Safety Commission, in addition to research by private companies and participation in international research cooperation. An outline of these research activities will be described hereunder.

4.1 Research based on the Annual Program for Safety Research on Nuclear Facilities etc.

(1) Research on structure and materials

To obtain information on the structural strength of nuclear fuel transport packages, the characteristics of materials in use, etc., research is carried out on the impact resistance of packages at the Mechanical Engineering Laboratory (MITI); research is carried out on evaluating the low-temperature brittleness of metal materials for packages at the National Research Institute for Metal (STA); research is carried out on evaluating the safety of ductile cast iron casks at the Central Research Institute of Electric Power Industry; research is carried out on the structural strength of returned waste packages at the Ship Research Institute (MOT).

In the area of research concerning the impact resistance of packages, experiments and analyses were conducted on secondary impacts at oblique drop of packages by use of scale models, and the extent of damage given to the main body and shock absorber when oblique angles were changed widely was examined, obtaining a conclusion with respect to the drop posture which affects the safety of packages.

Also, regarding the dynamic collapse test on light weight packages which was newly required in the 1985 IAEA Transport Regulations, a series of experiments and analyses were conducted by use of typical test bodies and as a result, useful information on test methods were obtained. In the area of research concerning materials used in the packages, various information such as static material characteristics, dynamic fracture toughness including the fracture toughness of carbon steel and spheroidal graphite cast iron, etc. which are required to evaluate the low-temperature brittleness of these materials are being obtained.

In the area of research on cast iron packages, material tests were conducted using full-scale wall thickness cast iron casks, thus obtaining useful basic data required to carry out structural evaluation for large full-scale packages in the future.

In the area of research on the structural strength of returned waste packages, basic data on collapse strength and vibration were obtained with respect to high, medium and low-level packages.

(2) Research on heat and fire resistances

To obtain information on the heat and fire resistances of packages, research is carried out on evaluating the thermal behavior of a UF_6 package at the Power Reactor and Nuclear Fuel Development Corporation. Also, at the Fire Defense Research Institute (FDA),

research is carried out on evaluating the behavior of a package during a tunnel fire accident.

In the research on evaluating the thermal behavior of a UF_6, the cylinder simulated from the UF_6 package was filled with UF_6, and thermal test was conducted, thus obtaining basic data for estimating the thermal transfer behavior and change in the phase of UF_6.

Also, in the research on evaluating the behavior of a package during a tunnel fire accident, fire test was conducted using liquid fuel in the model tunnel, and precious data were obtained.

(3) Research on containment

To obtain information on the containment of packages, basic research was carried out on the leakage behavior of radioactive materials in the package at the Mechanical Engineering Laboratory (MITI) and as a result, basic data for establishing equations for evaluating the leakage flow in the molecular flow domain and information on the validity of a dual containment system were obtained.

(4) Research on shielding and criticality

To obtain information on the shielding and criticality of packages, research is carried out on the shielding safety of packages at the Japan Atomic Energy Research Institute. At the Ship Research Institute (MOT), research on radiation shielding in the transportation of spent fuel by ship and research on radiation shielding in the transportation of returned waste by ship, as well as research on evaluating the safety of mass transportation of various radioactive waste by ship in Japan are carried out. In the research on shielding safety, gamma ray built-up coefficients using spot-decay nuclear integral codes were computed, and a data library for mono-layer heavy elements was completed.

In the research on radiation shielding in the transport by ship, basic data on evaluating the shielding performance of neutron shielding resin layer on the surface of the TN-12A type cask and the optimum loading of low-level radioactive wastes are obtained.

(5) Research on the characteristics of contents

To obtain basic data on the chemical reaction speed between the content (UF_6) and sea water (or water) at the time of an accident when the UF_6 package sinks under the water, the characteristics of products, diffusion behavior, etc., research is carried out on the behavior of UF_6 under accident conditions at the Power Reactor and Nuclear Development Corporation; data for confirming the condition of reaction between UF_6 and sea water are being obtained by pouring sea water in the package in which solid UF_6 is placed.

(6) Development of safety analysis codes for packages

Packages are designed in various ways according to the types and quantities of nuclear fuel substances to be transported, and various analyses including their structural strength calculation, thermal calculation, etc. are required.

Because of this, at the Japan Atomic Research Institute, thermal and structural safety analysis code systems for packages were developed, in addition to analytical code systems for making a detailed analysis.

Moreover, the development of simple analysis codes for making a prompt analysis of sensitivity for studying safety was started, and analysis codes for calculating the

deformation of a shock absorber when the package with shock absorber was dropped and subjected to shocks and the acceleration of the package were developed.

(7) Research on safety for air packages

To establish safety evaluation for packages which withstand air accidents, research on plutonium air transport packages was carried out at the Power Reactor and Nuclear Fuel Development Corporation, and high-speed impact test, high-temperature long-term fire resistance test, etc. were conducted, obtaining precious information on shock absorbing mechanism, heat resistance behavior, etc.

4.2 Current status of research by private companies

To cope with the transportation and temporary storage of reactor dismantled waste materials, spent fuel, etc., measures are being taken to develop methods for material evaluation and non-destructive inspection of cast iron casks and establish manufacturing methods for mass supply of packages.

Also, with an increase in the degree of burn-up of light water reactor fuel in the future, highly enriched fuel will be used. To evaluate the critical safety of packages realistically and rationally, therefore, measures are being taken to establish a critical safety evaluation method considering a burn-up credit (change in reactivity owing to combustion).

Regarding demonstration tests, the Central Research Institute of Electric Power Industry is to carry out, at the request of the Japanese Government, demonstration tests on the safety of returned waste packages under a 7-year program from 1986 to 1992, during which time tests on the characteristics of high-level radioactive waste solid bodies, design and fabrication of packages, safety demonstration tests on packages and overall evaluations will be carried out. Also, regarding demonstration tests on the reliability of spent fuel packages, a series of tests had been completed by 1987, the results of tests on packages for demonstration tests under ordinary test conditions, tests under special test conditions and pressure resistance tests are compiled.

4.3 Participation in IAEA CRP

Japan is participating in the Coordinated Research Program (CRP) implemented by the IAEA. The CRP which is currently implemented relates to a "radiation protection in transport accidents involving radioactive materials", which was started under the 3-year program from 1987. The first meeting for coordination of research activities was held in Tokyo in September, 1987 at the request of the IAEA Secretariat, and the progress of research in various countries was reported and coordination and confirmation were made with respect to the overall program.

Meanwhile, Japan decided also to participate in the new CRP, namely, "Development of Probabilistic Safety Assessment Techniques Related to the Safe Transport of Radioactive Materials".

5. Conclusion

Regulations relating to nuclear fuel transport in Japan carried out by STA and MOT, and incorporation of the 1985 IAEA Transport Regulations will be planned before January 1991.

A plan for constructing nuclear fuel cycle facilities consisting of enrichment, reprocessing and radioactive waste storage facilities in Rokkasho-mura in Aomori Pref. is being implemented and it is consequently expected that a variety of transport mode will be developed.

Safety Research in Japan on the transport of nuclear fuel and also international research cooperation are being carried out over a wide range.