SANDIA REPORT
SAND2008-1981
Unlimited Release
Printed March 2008

Summary Report on Transportation of Nuclear Fuel Materials in Japan: Transportation Infrastructure, Threats Identified in Open Literature and Physical Protection Regulations

John R. Cochran, Yuichiro Ouchi, James P. Furaus and Michelle Marincel

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550

Sandia is a multiprogram laboratory operated by Sandia Corporation,
a Lockheed Martin Company, for the United States Department of
Energy under Contract DE-AC04-94AL85000.

Sandia National Laboratories

Issued by Sandia National Laboratories, operated for the United States Department of Energy by Sandia Corporation.

NOTICE: This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government, nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors, or their employees, make any warranty, express or implied, or assume any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represent that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government, any agency thereof, or any of their contractors or subcontractors. The views and opinions expressed herein do not necessarily state or reflect those of the United States Government, any agency thereof, or any of their contractors.

Printed in the United States of America.

Available to DOE and DOE contractors from
U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831

Telephone: (865) 576-8401
Facsimile: (865) 576-5728
E-Mail: reports@adonis.osti.gov
Online ordering: http://www.osti.gov/bridge

Available to the public from
U.S. Department of Commerce
National Technical Information Service
5285 Port Royal Rd.
Springfield, VA 22161

Telephone: (800) 553-6847
Facsimile: (703) 605-6900
E-Mail: orders@ntis.fedworld.gov
Online order: http://www.ntis.gov/help/ordermethods.asp?loc=7-4-0#online

SAND2008-1981
Unlimited Release
Printed March 2008

Summary Report on Transportation of Nuclear Fuel Materials in Japan: Transportation Infrastructure, Threats Identified in Open Literature, and Physical Protection Regulations

John R. Cochran
Materials Transportation Security / Risk Assessment Department
Sandia National Laboratories
Albuquerque, New Mexico 87185

Yuichiro Ouchi
Nuclear Materials Management Office of
Nuclear Nonproliferation Science and Technology Center of
Japan Atomic Energy Agency

James P. Furaus
International Safeguards and Systems Engineering Department
Sandia National Laboratories
Albuquerque, New Mexico 87185

Michelle Marincel
Materials Transportation Security / Risk Assessment Department
Sandia National Laboratories
Albuquerque, New Mexico 87185

Abstract

This report summarizes the results of three detailed studies of the physical protection systems for the protection of nuclear materials transport in Japan, with an emphasis on the transportation of mixed oxide fuel materials[1]. The Japanese infrastructure for transporting nuclear fuel materials is addressed in the first section. The second section of this report presents a summary of baseline data from the open literature on the threats of sabotage and theft during the transport of nuclear fuel materials in Japan. The third section summarizes a review of current International Atomic Energy Agency, Japanese and United States guidelines and regulations concerning the physical protection for the transportation of nuclear fuel materials.

[1] The draft of this Summary Report was completed in June, 2005 and this final report reflects conditions as they existed in 2005.

Acknowledgment

This work was funded by the Japan Atomic Energy Agency.

Contents

This page intentionally left blank.

1. Introduction and Scope

Japan is one of the world's major industrial democracies and Japan relies on other countries for 80% of its energy supply. To increase energy independence, while reducing the emission of greenhouse gases, the Government of Japan (GOJ) has embarked on an ambitious program to expand the use of nuclear power. Expanding the use of nuclear power requires the GOJ to address many technical, economic, political and social challenges. One of these challenges is to insure the physical protection of the transport of nuclear fuel materials.

Japan Atomic Energy Agency (JAEA) and Sandia National Laboratories (SNL) have undertaken a cooperative study and training program focused on the GOJ's system for physical protection of the transportation of nuclear fuel materials, with an emphasis on mixed oxide (MOX) fuel materials. This collaborative effort is funded by JAEA and the work scope is defined in "Action Sheet" 61 signed by the United States Department of Energy / National Nuclear Security Administration and JAEA.

The Action Sheet 61 work is divided into four tasks. This report summarizes the Task 1 findings. The results of Tasks 2, 3, and 4 will be addressed in subsequent reports. Under Task 1, SNL and JAEA collected and analyzed baseline data on Japan's nuclear fuel materials transportation system. This Task 1 baseline data is documented in the three detailed reports listed below:

1. "Overview of Transportation Infrastructure for Nuclear Fuel Materials" – This report reviews the infrastructure for the transportation of nuclear fuel materials in Japan with an emphasis on the transportation of mixed oxide fuel materials. This JAEA-internal report was prepared by Yuichiro Ouchi.
2. "Threats Identified in the Open Literature Review" - The literature review report summarizes baseline data from the open literature on the threats of sabotage and theft during the transportation of nuclear fuel materials. The full report, titled *Open Literature Review of Threats Including Sabotage and Theft of Fissile Material Transport in Japan*, is published as SNL report SAND2005-0414.
3. "Physical Protection of Transportation Regulations and Requirements Review" – This report reviews current United States (U.S.) government, GOJ, and International Atomic Energy Agency (IAEA) guidelines and regulations concerning the physical protection of the transportation of nuclear fuel materials, with an emphasis on transportation of MOX fuel materials. The full, JAEA-internal report is titled *Review of Physical Protection Regulations Governing Transport of Fissile Material*.

This report, the fourth report developed under Task 1, summarizes the resulted of the three detailed reports listed above[2].

[2] The draft of this Summary Report was completed in June, 2005 and this final report reflects conditions as they existed in 2005.

This page intentionally left blank

2. Japan's Nuclear Power Plants and Fuel Cycle Facilities

2.1 Commercial Nuclear Power Plants

In Japan, 52 conventional light water reactors (LWRs) operate at 16 commercial nuclear power plants (NPPs) of December 2003[3][4]. All of the NPPs are located at coastal sites (Figure 2-1). Additionally, there are several research reactors such as the experimental Fast Breeder Reactor (FBR) "Joyo," the developmental FBR "Monju," and other research reactors at universities.

2.2 Nuclear Fuel Cycle Facilities

There are two uranium enrichment plants, one reconversion plant, and four fuel fabrication plants for commercial LWRs. There are also two reprocessing plants, of which one is currently under construction in Rokkasho-mura, Aomori-prefecture and another is in operation in Tokai-mura, Ibaraki-prefecture. The location of these facilities is shown in Figure 2-2. Nuclear fuel materials used by commercial NPPs are mainly transported by sea in cargo ships from abroad in the form of uranium hexafluoride (UF_6), uranium oxide powder (UO_2, U_3O_8), or fuel assemblies. Most of these materials are unloaded at the Port of Tokyo, and then transported by land from the port to each facility.

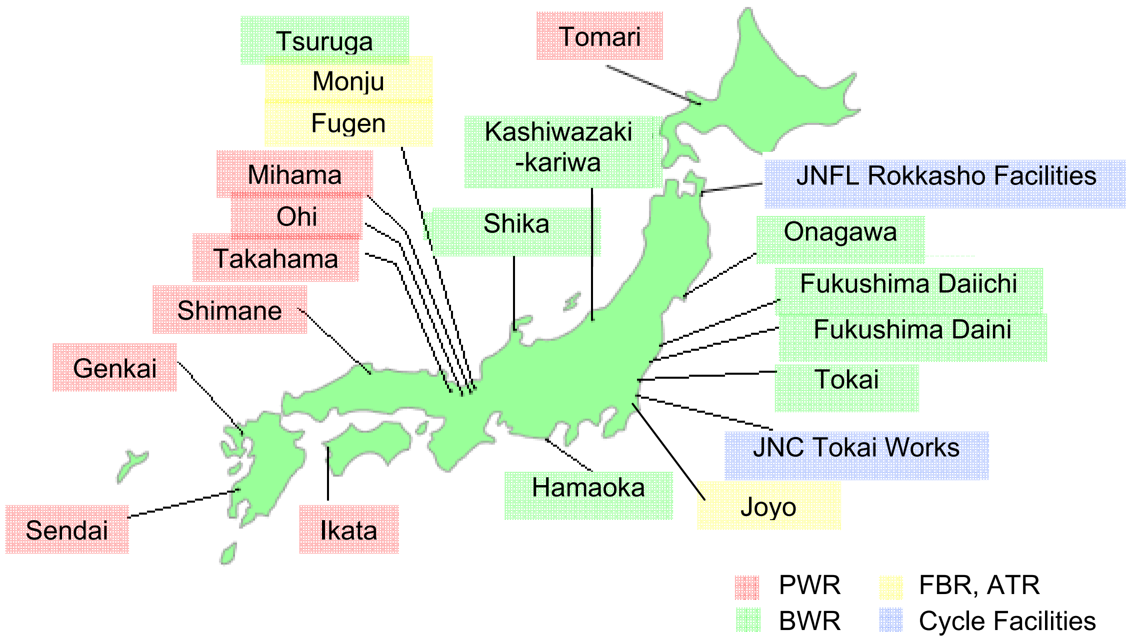
Several of these facilities are operated by the Japan Nuclear Fuel Limited (JNFL) in Rokkasho-mura. These facilities include the Low-level Radioactive Waste (LLW) Disposal Center (LLW Center) and the Vitrified High-Level Waste (HLW) Storage Center (HLW Center), as well as the Rokkasho Reprocessing Plant (RRP), which is currently under construction. The storage pool of the RRP has already accepted significant quantities of spent nuclear fuel assemblies from the commercial NPPs.

2.3 Mixed Oxide Fuels

The production of electricity in each of the 52 conventional LWRs decreases the Uranium-235 (U-235) content in the uranium fuel pellets and increases the content of fission "by-products" such as Strontium-90. At the same time, some of the non-fissionable U-238 in the uranium fuel pellets is converted to plutonium by neutron capture. After about three years of operation, the U-235 content has decreased, and the fission by-products have increased to the point where reactor criticality can not be maintained and the fuel rods are removed and managed as spent nuclear fuel. Spent fuel (SF) from uranium fuel pellets typically contains about 1% plutonium. The 1% plutonium in the SF is composed of about two-thirds Plutonium-239 (Pu-239) and about one-third other isotopes of plutonium such as Pu-240 and Pu-241.

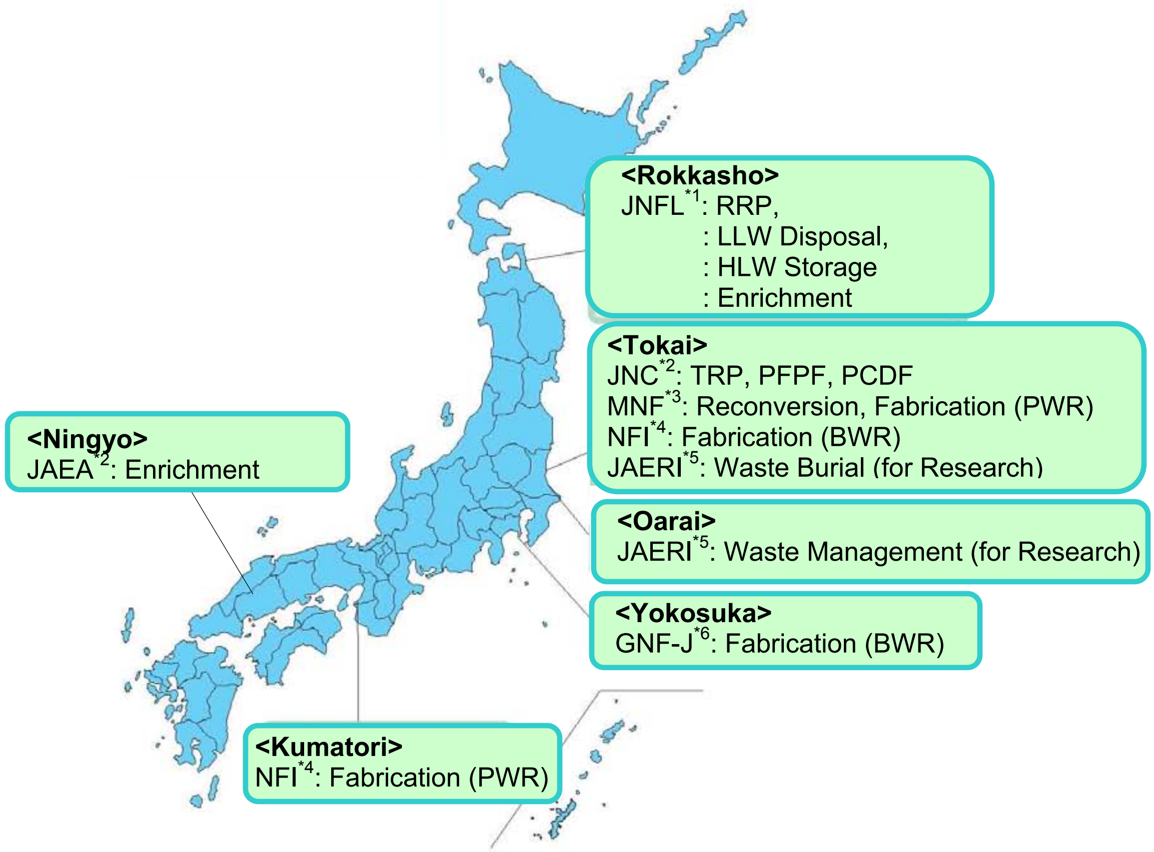
---

[3] The U.S. has about 104 conventional LWRs operated at 65 NPPs.
[4] The draft of this Summary Report was completed in June, 2005 and this final report reflects conditions as they existed in 2005.



Electric Power Co. (EPCO)	Name of NPP	Reactor Type	Operational
Hokkaido EPCO	Tomari	PWR	2
Kansai EPCO	Mihama	PWR	3
	Ohi	PWR	4
	Takahama	PWR	4
Chugoku EPCO	Shimane	PWR	2
Shikoku EPCO	Ikata	PWR	3
Kyushu EPCO	Genkai	PWR	4
	Sendai	PWR	2
Tohoku EPCO	Onagawa	BWR	3
Tokyo EPCO	Kashiwazakikariwa	BWR	7
	Fukushima Daiichi	BWR	6
	Fukushima Daini	BWR	4
Hokuriku EPCO	Shiga	BWR	1
Chubu EPCO	Hamaoka	BWR	4
Japan Atomic PCO	Tokai Daini	BWR	1
	Tsuruga	BWR	1
		PWR	1
	Total		52

Figure 2-1 Location of Commercial NPPs



*1) JNFL: Japan Nuclear Fuel Limited
*2) JNC: Japan Nuclear Cycle Development Institute
*3) MNF: Mitsubishi Nuclear Fuel Co., Ltd
*4) NFI: Nuclear Fuel Industries, Ltd
*5) JAERI: Japan Atomic Energy Research Institute
*6) GNF-J: Global Nuclear Fuel Japan Co., Ltd

Figure 2-2 Location of Nuclear Cycle Facilities (as of 2005)

Some countries utilize the "once through" cycle in which the SF will be disposed in a geologic repository. Other countries recycle the fissionable plutonium from the SF and create new fuel pellets that can be used in conventional LWRs to produce more electricity. The new fuel is composed of oxides of plutonium and oxides of uranium ($PuO_2 + UO_2$) and the mixture of oxides is known as MOX fuel. MOX fuel pellets contain about 7% fissionable Pu-239 rather than 4% fissionable U-235 in the uranium fuel pellets. Utilizing MOX fuel in a conventional LWR (1) recycles an important source of energy from the SF, (2) reduces the amount of radioactive waste that must be disposed, (3) reduces the amount of U-235 that must be mined, milled, and enriched, and (4) reduces Japans dependence on imported energy. Figure 2-3 shows a photograph of a fuel pellet used in a conventional LWR and a fuel pellet used in a FBR. The fuel pellets are placed in fuel rods and the fuel rods are combined into fuel assemblies.

MOX is widely used in conventional LWRs in Europe. Typically, about one-third of the fuel assemblies in a conventional LWR will be composed of MOX fuel and two-thirds of the fuel assemblies will be composed of conventional U-235 fuel. The use of one-third MOX fuel and two-thirds U-235 fuel does not alter the engineering or operational characteristics of a conventional LWR. Japan plans to utilize MOX fuel in about one-third of its commercial LWRs by 2010. The use of MOX in conventional LWRs is also known as "Pu-thermal."

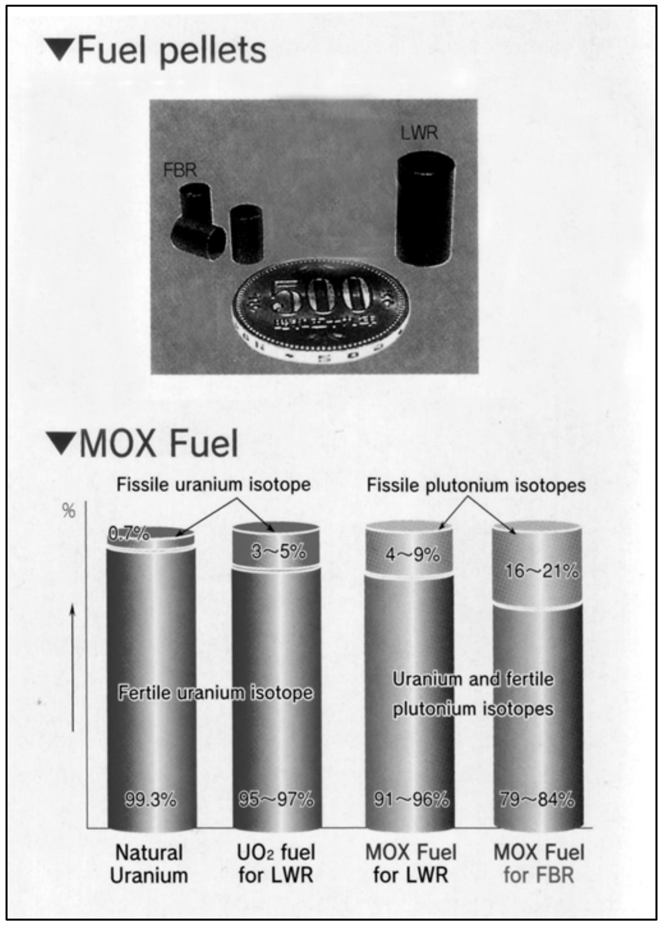


Figure 2-3 Uranium and MOX Fuel Pellets
(from undated JAEA Brochure)

MOX fuel can also be used in a FBR. The FBR is specifically designed to utilize fast (high-energy) neutrons to fission the MOX fuel. There are design differences between a FBR and a conventional LWR. The FBR contains MOX fuel assemblies and a "blanket" of uranium assemblies. Over longer time periods, the FBR creates more plutonium (through neutron capture) than is fissioned. In Japan, Monju is a prototype FBR for establishment of commercial FBR technology. The MOX fuel used in a FBR contains about 16 – 21 % plutonium, rather than the 7% plutonium typically used in MOX in a conventional thermal spectrum LWR. Because a FBR produces more plutonium that is consumed, the recycling of plutonium from a FBR will greatly reduce Japan's dependence on foreign energy sources.

In the FBR cycle in Japan, MOX fuels are fabricated in JAEA's Tokai Works in Tokai-mura, Ibaraki-prefecture. The Tokai Works includes the Plutonium Fuel Production Facility (PFPF) and the Tokai Reprocessing Plant (TRP) (Figure 2-4). The TRP is accepting some SF assemblies from commercial NPPs and all of the SF assemblies from the Advanced Thermal Reactor "Fugen." The MOX fuels produced at the PFPF are used in the FBRs Monju and Joyo.

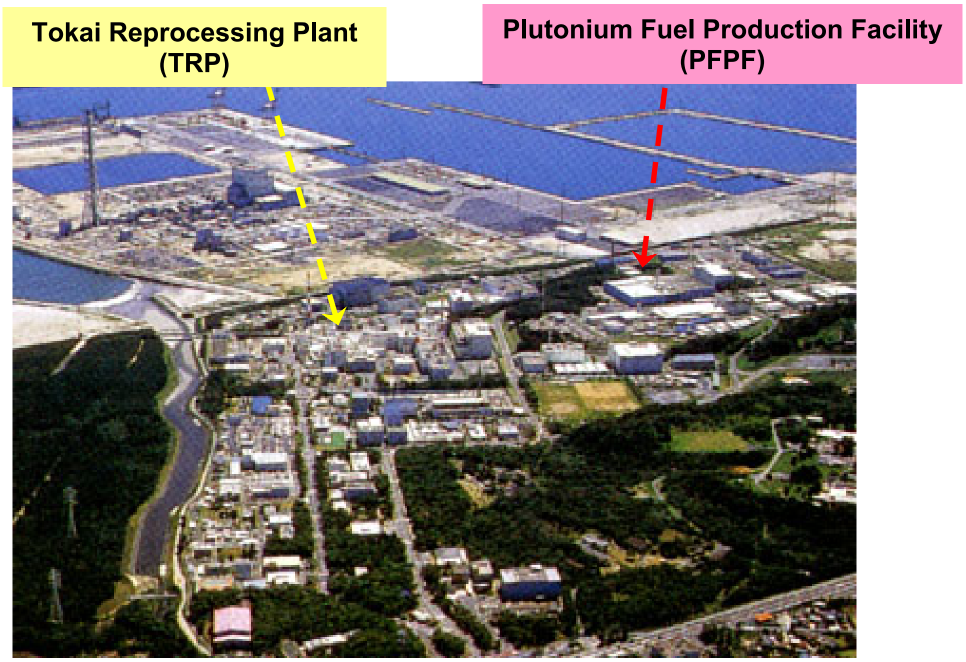


Figure 2-4 JAEA's Nuclear Cycle Facilities in Tokai Works

Remark: A port seen at the upper part of the picture is the Port of Hitachinaka that is currently under construction.

Note: The image was taken from the website of the Nuclear Power Division, Village Office of Tokai-mura, Ibaraki. [http://www.vill.tokai.ibaraki.jp/as-tokai/01jigyosyo/j02cycle.htm]

This page intentionally left blank.

3. Overview of Transportation Infrastructure for Nuclear Fuel Materials

3.1 Schematic of the Movement of Nuclear Fuel Materials in Japan

Figure 3-1 shows a schematic of the main domestic and international transport of nuclear fuel materials in Japan[5]. Nuclear fuel materials used by commercial NPPs are transported by sea in cargo ships from abroad in the form of UF_6, uranium oxide powder (UO_2, U_3O_8), and fuel assemblies.

Formerly, most SF assemblies from commercial NPPs were transported by ship to overseas reprocessing plants. Overseas reprocessing was completed in December 2000. The majority of the SF assemblies are currently transported and stored in the RRP, and the minority of the SF assemblies are transported and stored at the TRP. HLW generated by the overseas reprocessing plants is returned to the HLW Center of JNFL. A part of the plutonium recovered from the overseas reprocessing of Japanese SF was transported by sea from a foreign reprocessing plant to Japan at the end of 1992. This recovered plutonium was, and will be used, to create MOX fuel for the FBR Monju.

[5] The draft of this Summary Report was completed in June, 2005 and this final report reflects conditions as they existed in 2005.

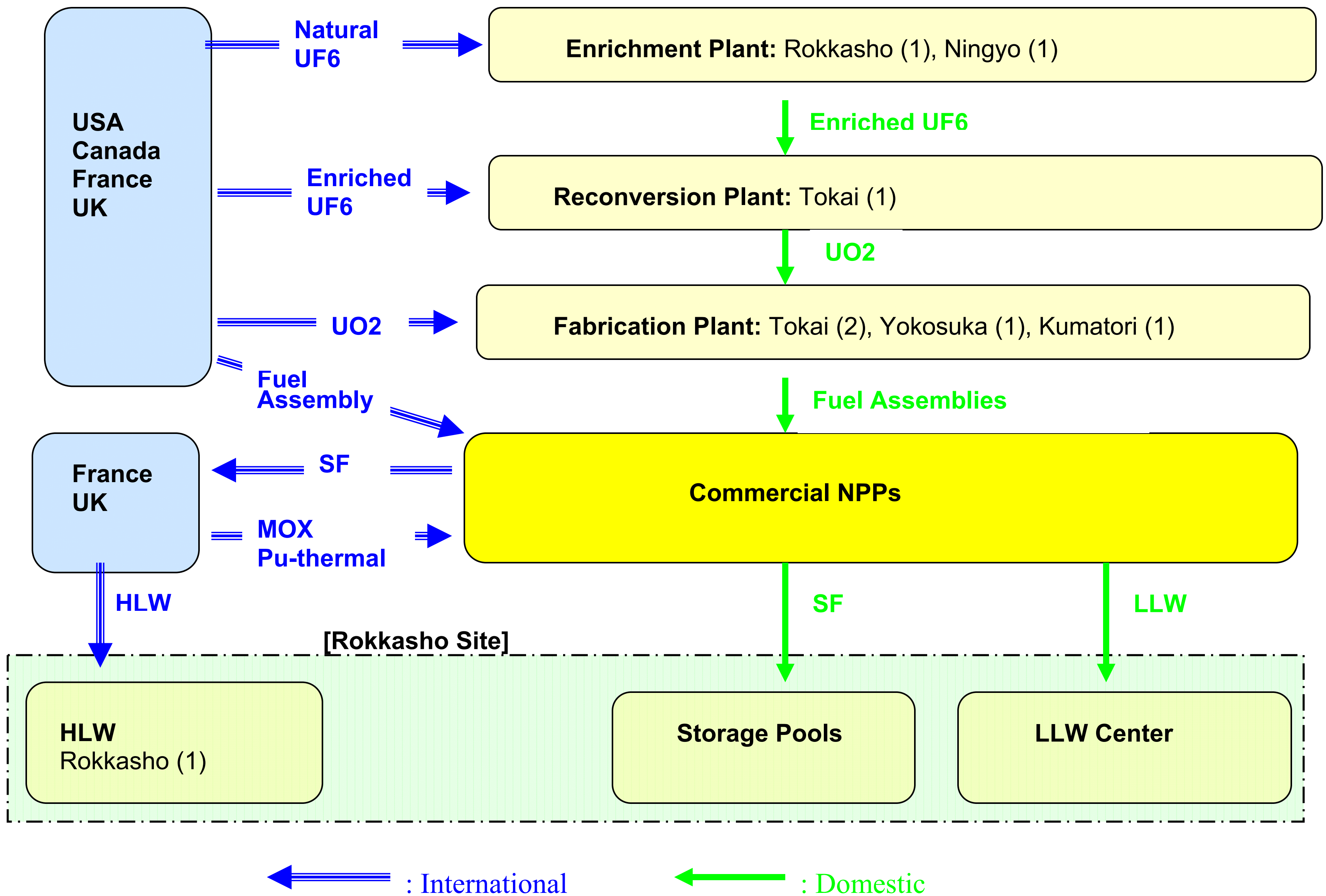


Figure 3-1 Schematic of Current Transport Nuclear Fuel Materials for Commercial NPPs (as of 2005)

3.2 Transport of MOX Materials for FBR Cycle

Currently, MOX fuel materials are transported for the FBR cycle. Figure 3-2 shows a schematic of the main domestic and international transport of nuclear fuel materials for the FBR cycle. The PFPF, which is operated by Tokai Works of JAEA in Tokai-mura in Ibaraki-prefecture, is producing MOX fuel for the FBR Joyo in Oarai-cho in Ibaraki and for the FBR Monju in Tsuruga-shi in Fukui-prefecture.

Transport of MOX fuel assemblies to FBR Joyo began in November 1976 and transport operations to the FBR Monju began in September 1992. Those assemblies are transported by land from the PFPF to each reactor. Monju suspended operations due to the sodium leak accident in 1995, but operations are expected to resume in the near future. The restart of Monju will require transportation of many MOX fuel assemblies from PFPF to Monju.

The ATR Fugen in Tsuruga-shi, Fukui-prefecture terminated operation in March 2004 and decommissioning activities are under way. Sea transport of SF from Fugen to the TRP currently takes place on a regular basis. Also, sea transport of SF from the FBR Monju is expected to take place in the future.

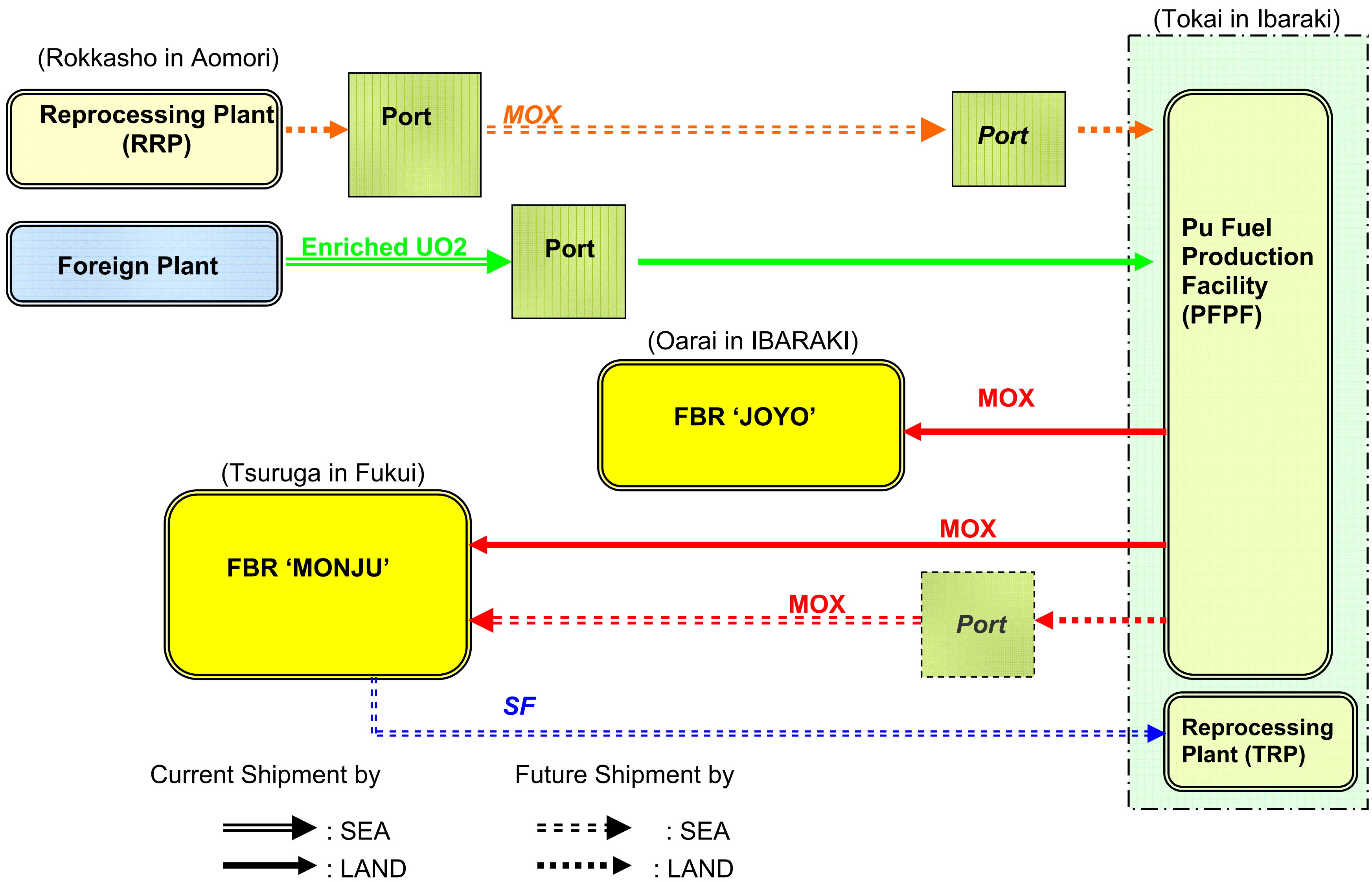


Figure 3-2 Schematic Flow of Current and Future Transport for FBR Cycle (as of 2005)

3.2.1 Transport of MOX Fuel Assemblies for Joyo

MOX fuel is currently produced at the PFPF and transported by land on a public road in a commercially-operated truck under contract by JNC to the FBR Joyo in Oarai-cho, Ibaraki-prefecture, which is approximately 30 km away. The transport operations meet IAEA requirements for transport of Category I quantities. In transporting by land, a package called "TN-9121/B" is used. The package meets the Type B(M)F technical standards and requirements specified in IAEA regulations (Figure 3-3).

Package Name	TN-9121/B
Type	B(M)F
Dimensions	4 m L x 0.6m W
Weight	0.71 tons

Figure 3-3 MOX Fuel Package for FBR Joyo

3.2.2 Transport of MOX Fuel Assemblies for MONJU

Transport operation for the prototype FBR Monju in Tsuruga-shi, Fukui-prefecture began in 1992. Over 200 assemblies were transported by land from PFPF before Monju suspended operations due to the sodium leak in 1995. In transporting MOX fuel by land, a package called "MONJU-F" is used; the package meets technical standards for Type B(U)F (Figure 3-4).

Package Name	MONJU-F
Type	B(U)F
Dimensions	5 m L x 0.6 mW
Weight	2.3 tons

Figure 3-4 MOX Fuel Package for FBR Monju

MOX fuel assemblies are transported in a convoy of trucks, with escort cars, and guard cars. The convoy takes an approximately 600 km route to Monju using public roads. These transport operations meet IAEA requirements for the physical protection of the transportation of Category I quantities.

3.2.3 Transport of Enriched UO2 Powder from a Foreign Plant

As fuel for FBR Joyo, UO_2 powder with an enrichment of approximately 20 wt% U-235 is transported from a foreign plant. The first shipment took place in 2002. Subsequent shipments are expected to take place on a regular basis. The transport operation will be for Category II quantities. In transporting from a foreign plant, a package called "FS-47" is used. The package was designed to use to transport PuO_2 powder from a foreign plant to Japan. The exclusive container is also used to transport the UO_2. The containers are transported by rail and sea to the port in Japan. From the Port the containers are transported by land in trailers to the PFPF in Tokai.

3.2.4 Future Plan to Transport MOX Powder from Rokkasho to Tokai

In the future, JAEA plans to begin procuring MOX powder from RRP for making MOX fuel for Monju and Joyo. If Monju and Joyo operate as planned, they will need approximately 1.6 tons of heavy metal in MOX (50% UO_2 + 50% PuO_2) per year. A cask for the transport of the MOX powder from RRP to the PFPF is currently being designed to hold tens of kg of MOX powder (PATRAM, 2004). Figure 3-5 shows the initial structure of the new cask.

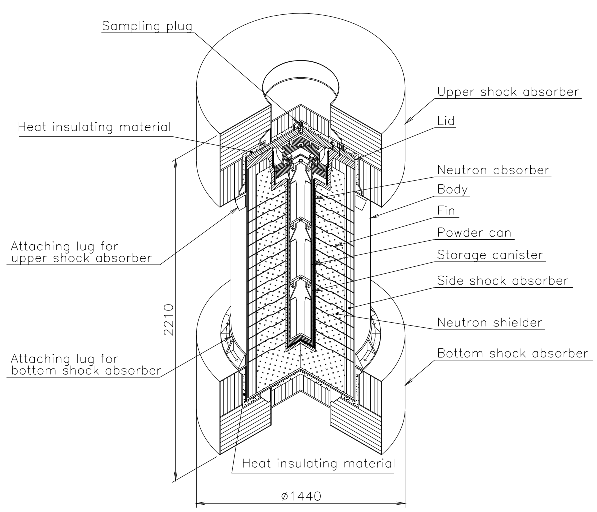


Figure 3-5 Schematic Structure of the New Package under Design

3.3 Typical Land Transport Operations for MOX Materials

Transport Convoy

In transporting MOX fuel materials by land, a convoy of several truck/trailers and accompanying vehicles is organized to insure safe and secure transport operations. The escort car and guard car are accompanied in the front and behind the transport vehicles.

Transport Control Center

The Transport Control Center at the shipper's site is staffed by one responsible person, one person in charge of the transport monitoring system, and several communications personnel, to monitor the entire transport operation from departure to arrival of the convoy. Contact between the convoy and the Center takes place at predetermined fixed points along the route, as well as whenever something out of the ordinary happens. The Center relays both the routine and occasional information received from the convoy to the receiver's site.

Transportation Monitoring System

The Transport Control Center constantly tracks the location of the convoy during transport using a monitoring system such as a global positioning system (GPS) that allows monitoring the convoy. The system tracks the location of the convoy and allows the convoy to send textual information to the Center. Furthermore, a specialist accompanying the convoy is equipped with a visual device that allows transmission of images from the convoy to the Center.

Emergency Response

The Transport Control Center is responsible for managing normal transport operations; however, an Accident Task Force takes control in the event of emergency. The Accident Task Force consists of the head of the Center and a total of eight teams, including an Information Team, a Security Control Team, and an Onsite Response Team. The Onsite Response Team includes personnel of a backup transport operation group, who are dispatched to the site of the emergency if required by circumstances. The backup operations personnel and their equipment are always ready during the transport operations.

4. Threats Identified in the Open Literature

4.1 Introduction

The open literature was reviewed to gather information on possible threats of sabotage and theft during the transportation of nuclear fuel materials in Japan[6]. This literature review was intended to aid in the development of a design basis threat (DBT) for the AS 61 Task 2 work. A DBT is defined by the IAEA as the attributes and characteristics of potential insider and/or external adversaries who might attempt unauthorized removal or sabotage of nuclear material.

Information from the open literature was categorized according to the schema in *The Design and Evaluation of Physical Protection Systems* by Mary Lynn Garcia. According to Garcia, adversaries can be categorized into three broad groups: outsiders, insiders, and outsiders working in collusion with insiders. Outsiders might include terrorists, criminals, or extremists. Ideological, economic or personal reasons are motivations that might prompt adversaries. An insider is defined as anyone that possesses knowledge of operations or security systems and has unescorted access to facilities or security interests. Insiders can be passive, or active, nonviolent, or violent. Insiders can have the same motivations as outsiders.

4.2 Demographics

Japan has a relatively homogeneous population with 99% of the estimated 127,000,000 people being ethnic Japanese people. One percent of the population is of non-Japanese origin, including:

- 511,262 Koreans,
- 244,241 Chinese,
- 182,232 Brazilians,
- 89,851 Filipinos, and
- 237,914 people of other origins.

The religious preferences show that 84 percent of the population practice both Shinto and Buddhism, 0.7 percent practice Christianity and the balance practice various other religions.

4.3 Outsider

4.3.1 Terrorist Threat

[6] The draft of this Summary Report was completed in June, 2005 and this final report reflects conditions as they existed in 2005.

Red Army, Chukaku-Ha, and Seikijuku

Known terrorist groups in Japan comprise the Red Army, Chukaku-Ha, Seikijuku, and Aum Shinrikyo. The Red Army's goals were to overthrow the Japanese government and ignite global revolution through violent, guerrilla means. The Red Army split into three factions: the Yodo Group, the Japanese Red Army, and the United Red Army operating in North Korea, Lebanon, and Japan, respectively. Each faction eventually adopted a local doctrine. The Yodo Group adopted the philosophy of the North Korean leader in 1969, Kim Jong Il; the Japanese Red Army adopted the philosophy of the Palestinian struggle for liberation; and the United Red Army sought the overthrow of Japan's monarchy. They incited global fear and intimidation though their terrorist activities but were not successful on a large scale.

Chukaku-Ha, the Middle Core Faction or Nucleus, sought to demonstrate frustration with Japan's imperialism, the imperialism of the West, and the Gulf War through violent protests with rudimentary rockets and incendiary devices. Seikijuku, or Sane Thinkers School, a right-wing group, seeks to protect and reinstate the role of the Emperor in Japan.

Aum Shinsen

Aum Shinsen no Kai was formed in 1984. It was headed by Chizo Matsumoto, more commonly known as Shoko Asahara, "the one who has attained supreme truth." Asahara was the self-proclaimed guru and holy man. Young Japanese, including academically-able scientists, medical doctors, and engineers, willingly at first, pledged complete obedience and devotion to the guru. They gave up their lives and assets to feed the organization's need for membership and 300 million to one billion U.S. dollars' worth of assets. At the time of the infamous subway attack in 1995, Aum Shinrikyo's membership totaled an approximate 19,000 people.

Only after the defeat of twenty-five of the members running in the 1990 Japanese general election did Asahara begin to preach that Aum Shinrikyo was being attacked by biological and chemical weapons in an attempt to justify the acquisition of similar weapons.

None of these biological weapons programs were successful, though Aum executed nine biowarfare pseudo-attacks. The first involved venting botulinum toxin from a van as the van drove through Tokyo, Narita International Airport, and other locations. According to police reports, the second and third incidents in 1993 consisted of a failed aerosolization of a veterinary inoculation anthrax strain on top of an eight-story building.

The Aum technical expertise was much more adept with chemical synthesis than it was with bioweapon development. They successfully concocted numerous chemical agents including nerve agent VX, tabun, soman, mustard, hydrogen cyanide, phosgene, and sarin. Aum's release of 12 liters of Sarin in1994 at the Matsumoto Castle in Matsumo City exposed 600 people, hospitalizing 58 residents and killed seven people.

While preparation for the subway attack were underway in 1995, Aum members firebombed several buildings in Tokyo, and the attackers they left fake fliers from a rival sect in order to try to keep Aum away from the blame and confuse police. Aum Shrinkyo attacked Tokyo's subway system the morning of March 20, 1995. Five attackers punctured a total of eight of eleven bags of sarin before exiting the subway cars. Throughout the course of the day, *5,510 casualties reported to medical centers* of which 4,470 were psychogenic patients and 54 were critically or severely wounded. The gassing resulted in 12 fatalities, and widespread fear in Japan, as well as the rest of the world.

After Aum Shinrikyo's attack on the Tokyo subway, the government arrested over 200 elite members of Aum and put the cult under surveillance. According to the United States Embassy in Japan, in July 2001 several Russian Aum Shinrikyo followers were arrested under the suspicion of a plan to bomb the Imperial Palace in Tokyo in order to free Asahara and take him to Russia. Asahara was sentenced in February 2004, and subsequently received the death penalty for crimes associated with the 1995 subway attack.

At its peak, Aum Shinrikyo was a well established organization with millions of U.S. dollars in monetary resources, substantial amounts of weapons, and a membership of thousands of people in Japan with intellectual and technical capability.

Japan's Support of U.S. in Iraq and al-Qaeda

Examination of the external terrorist threat must take into consideration the international relations. Japan supported the U.S. in its war on terrorism and war in Iraq. Such alliances may make Japan a target for both international and domestic terrorists. The 2004 Madrid train bombings exemplify the actions of terrorists against countries that support U.S. policy.

Seven people with suspected links to al-Qaeda were arrested in Japan at the beginning of June, 2004 including a Frenchman, Lionel Dumont, who traveled, lived, and worked in Japan several times for over a year beginning in 2002 with a false passport and without arousing suspicion of Japanese authorities and employers, even though he had been placed on the world's most wanted list in 1999. Another member of al-Qaeda, an Algerian, Ahmed Ressam, was linked to plans to plant a bomb in the Los Angeles airport in 2000, and was convicted in the U.S. In light of these events, Japan has begun to reduce the number of illegal immigrants. In 2003, 50,000 foreigners were deported, and Japanese authorities aim to deport another half of its illegal immigrant population of 250,000.

North Korean Abductions

Japan holds several grievances against North Korea including the kidnappings of 11 Japanese in the early 1980s, which continue to hamper progress towards improving relations. The chairman of the Democratic People's Republic of Korea, Kim Jong-Il admitted abduction of the 11 Japanese at the September 17, 2002 Japan-North Korea summit meeting. Throughout a series of Japan-North Korea Normalization and Six-Party Talks, Japan has continued to reiterate the importance of the unconditional release of the eight family members of those abducted, and an inquiry into the indefinite whereabouts of the other ten abducted Japanese. Japan has stated that the resolution of this issue is essential for all other issues to be determined.

North Korean Missiles and Nuclear Weapons

The *Council on Foreign Relations* contends that Japan is vulnerable to an attack from North Korea, due to its close proximity and good relations with the U.S. The possibility was made very clear when North Korea launched a long-range Taepodong Missile over the Japanese islands in August 1998 as well as the testing and deployment of medium-range Nodong missiles capable of reaching Japan.

Under the terms of the 1994 Agreed Framework, the U.S. supplied light-water reactors to North Korea in response to North Korea freezing its graphite-moderated reactors and other nuclear activities. However, on December 31, 2002, North Korea refused inspection by the IAEA of its nuclear facilities. On January 10, 2003, North Korea announced its abandonment of the Non-Proliferation Treaty and the Security Council of the United Nations discussed the matter soon afterwards. North Korea, at the April 23-25, 2003, Three-Party Talks with the U.S., China, and Republic of Korea, declared that all spent fuel rods had been reprocessed and used in the fabrication of nuclear weapons.[7] Relations between Japan and North Korea remain strained.

North Korean Boats

In 2001 and 2002, Japanese officials became increasingly alarmed by the encroachment of espionage and drug-running ships believed to be of North Korean origin into Japanese waters. The ships often releasing smaller boats that in turn launched rubber rafts to ferry agents to and from the Japanese coast. The agents were believed to have relied primarily upon the approximately 200,000 Korean residents of Japan who identify themselves as North Korean citizens. The agents are also believed to have used threats against family members in North Korea as a means of coercion. In December 2001, Japanese coast guard patrol boats chased and exchanged fire with one suspected North Korean spy ship disguised as a Chinese fishing boat. The confrontation ended when the mystery boat sank inside China's exclusive economic zone. North Korean cigarettes and a badge of the deceased leader Kim Il-Sung were found as some of the evidence of the ship's origin. *Dozens of automatic weapons, a surface to air missile launcher and an underwater scooter capable* of carrying three people were found in the sunken ship, along with ten bodies.

4.3.2 Criminal Threat

While the crime rate has risen in recent years, it is still well below the threshold of concern for western countries. The Japan National Police Agency reported a total of 2,790,000 penal code crime cases known to the public in Japan in 2003. Of this number,

- 13,658 were felonious offences,
- 2,263,000 were larceny offences,
- 78,759 were violent offences,

[7] On 9 October, 2006, North Korea detonated a small nuclear weapon, and in February 2007 North Korea agreed to seal its only nuclear reactor in exchange for fuel oil, as a first step in abandoning its nuclear weapons program.

- 74,754 were intellectual offences, and
- 13,034 were moral offences.

Total percentage of crimes committed, by nationality in 2003 were as follows:

- 74.5% were Asian,
- 17.7% South American,
- 2.2% North American,
- 2% European
- 1.8% Russian,
- 0.9% African, and
- 0.8% Oceanian.

4.3.3 Anti-Nuclear Threat

The third component of the design basis threat is antinuclear individuals and groups. Japan has been the area of operations of a number of antinuclear groups including Greenpeace, Citizens' Nuclear Information Center, No Nukes Asia Forum, Green Action, Plutonium Action Hiroshima, BUND, Plaintiffs Against Nuclear Fuel Cycle Facilities, People of Fukui Opposing Nuclear Power, and Stop the Monju. Several large, international antinuclear organizations such as Greenpeace, Citizens' Nuclear Information Center, and BUND have been especially active and persuasive due to their monetary and membership resources. The recent foci of their protests have been nuclear reprocessing technology, transportation of MOX fuel, and possible nuclear proliferation issues that could result thereof. Examples of demonstrations include Greenpeace boarding the British-flagged ship Pacific Swan in order to hang a "stop plutonium" sign on it as it passed through the Panama Canal.

4.4 Insider

The insider threat includes the threats of disgruntled, coerced, psychotic, and criminal employees. The disgruntled employee threat has been almost unthinkable in Japan, given the history of Japan's employment system. The Japanese have historically viewed their employment by a specific company as a relationship where loyalty and trust are essential and training, teamwork, and hard work are methodologies for success. Life-long employment and keiretsu are both expressions of the same thing—the view of Japanese society as the extension of the family. Despite the prevalence of mutuality of company-employee relationships, only 30 to 40 percent of companies honor lifetime employment.

One in ten Japanese corporations reported corporate crime from 2001 to 2003, and much more crime is believed to occur undetected. Asset misappropriation is reported to be the highest fraud practiced, while cybercrime and product piracy and counterfeiting comprise the concerns for the near future. Threats of the employee being forced into cooperating via blackmail and the psychotic employee must also be considered in determining the insider threat, along with the threat of the criminal employee.

5. Physical Protection of Transportation Guidelines and Regulations

5.1 Introduction

As a part of the Task 1 activities of Action Sheet 61, SNL and JAEA collected and analyzed IAEA guidelines and Japanese and U.S. regulations concerning the physical protection of the transportation of nuclear fuel materials, with an emphasis on transportation of mixed oxide fuel materials[8]. This collection and analysis task was conducted in 2005.

5.2 International Atomic Energy Agency Recommendations

The IAEA states that "The transport operation is probably the most vulnerable to attempted theft or sabotage of nuclear material." The IAEA's recommendations for reducing this vulnerability with the physical protection of nuclear materials during transportation are given in *Physical Protection of Nuclear Material and Nuclear Facilities* (INFCIRC/225/Rev. 4). Guidance to assure consistent and rigorous application of the recommendations is provided by the IAEA's *Guidance and considerations for the implementation of INFCIRC/225/Rev.4, The Physical Protection of Nuclear Material and Nuclear Facilities* (IAEA-TECDOC-967 (Rev.1)).

With respect to the issue of transporting nuclear materials, the *Convention on the Physical Protection of Nuclear Material (INFCIRC/274 Rev.1*) obligates parties to make specific arrangements and meet defined standards of physical protection for international shipments of nuclear material, as well as cooperate in the recovery of stolen nuclear material.

Generally, a physical protection system is designed to be effective against the Member State's DBT. The DBT is defined by the IAEA as the attributes and characteristics of potential insider and/or external adversaries who might attempt unauthorized removal or sabotage of nuclear material.

The IAEA recommends a graded approach in which the physical protection measures are matched to the "value" of the nuclear asset. In implementing the graded approach, the IAEA categorizes fissile materials into Categories I, II, and III quantities, with Category I quantities requiring the greatest protective measures.

IAEA recommendations for shipping Category I quantities by road include vehicles that are specially designed to resist attack and equipped with a vehicle disabling device so that an adversary cannot drive a captured vehicle away. Each load vehicle should carry a guard, and a corresponding escort vehicle should be manned with one or more guards. Radio communications must be maintained at all times. For shipments of Category I nuclear material quantities by rail, sea, or air, the IAEA recommends that "exclusive use" freight trains, transport ships, or cargo planes be employed.

---

[8] The draft of this Summary Report was completed in June, 2005 and this final report reflects conditions as they existed in 2005.

Member States are encouraged to use armed guards to the extent that laws and regulations permit. If the guards are not armed, other compensatory measures must be applied. An adequately sized, equipped, and trained response force must be available to deal with emergencies. There must be enough detection, delay, and communication that the responses force can arrive in time to prevent the theft or sabotage.

5.3 Japanese Regulations

For safe transport of radioactive materials, Japan incorporated the IAEA Regulations for the Safe Transport of Radioactive Material (IAEA transport regulations) and has implemented safety regulations in conformity with the IAEA Transport Regulations. For maritime and air transport, Japan is a contracting party to the International Convention for the Safety of Life at Sea (SOLAS Convention) and the Convention on International Civil Aviation (ICAO Convention). Legally binding international transport regulations in accordance with these conventions are incorporated into the Japanese relevant legislations. These conventions adopt the IAEA Transport Regulations through the UN Recommendations on the Transport of Dangerous Goods that are bases of regulations for international transport. Japanese law and regulations for sea transport and air transport are consistent with the IAEA Transport Regulations. Also, the Japanese regulations for land transport have been established in conformity with the IAEA Transport Regulations from the view-point of ensuring safe transport as well as consistency in modes of land, sea and air transport.

For physical protection of nuclear material, Japanese regulations for physical protection of nuclear material transports are established within the framework of international rules that include the Convention on the Physical Protection of Nuclear Material, bilateral agreements on nuclear energy cooperation with other countries, and the IAEA guidelines. The common international guideline for the physical protection of nuclear materials during use, storage and transportation is the IAEA's INFCIRC/225. Revision 4 of INFCIRC/225 has been issued by the IAEA, and currently competent authorities are discussing the incorporation of Reversion 4 recommendations into Japanese laws. This regulation review was completed in 2005.

Relevant organizations for regulations for nuclear facilities, etc. are:

- Ministry of Economy, Trade and Industry (METI) in charge of regulations for nuclear power stations, nuclear fuel cycle facilities such as commercial reactors, fabrication and reprocessing plants, etc.,
- Ministry of Education, Culture, Sports, Science and Technology (MEXT) with jurisdiction over regulations for test and research nuclear reactors, using facilities for nuclear fuel materials and radioisotopes, etc. METI and MEXT are also responsible for the package requirements.
- Ministry of Land, Infrastructure and Transport (MLIT) has responsibilities for conveyance for land, sea, and air transport. This organization has jurisdiction over the conveyances requirements.
- Organizations for jurisdiction over regulations mainly for emergency response, accidents, security, etc. are the Japan Coast Guard (JCG) and the National Police Agency (NPA).

The Japanese regulatory system uses a graded categorization system that is basically the same as the categorization system of the IAEA's INFCIRC/225. In addition, the Japanese system identifies specific nuclear materials to be protected (SNMPs). The Japanese laws for transport of nuclear materials are separately established for each transport mode:

- *Ship Safety Law* for maritime transport,
- *Civil Aviation Law* for air transport, and
- *Reactor Regulation Law* for land transport.

The Ship Safety Law, the Civil Aviation Law and their subordinate regulations, which are administered by MLIT, regulate requirements for safe and secure transport by sea and air, respectively.

For land transport, the Reactor Regulation Law is jointly administered by three ministries – METI, MEXT and MLIT. These ministries share responsibilities corresponding to their regulatory scope. Under the Reactor Regulation Law, requirements for safe and secure transport of nuclear materials are provided with subordinate regulations that include:

- *Regulation Concerning Transport of Nuclear Fuel Materials Outside Plants* – prescribes the safety standards and the technical requirements for the nuclear material package used outside nuclear facilities.
- *Regulation of Vehicle Transport of Nuclear Fuel Material* – prescribes the safety regulation of matters regarding all conveyances, including methods of loading nuclear materials packages into land vehicles.
- *Order Concerning Report on Transport of Nuclear Fuel Materials* – prescribes advance notification requirements regarding the transport route and date/period.

The Reactor Regulation Law and its subordinate safety regulations for land transport define many safety measures that also enhance physical protection. Examples of these measures include:

- Preparation and approval of a transportation plan,
- Emergency preparedness,
- Technical standards for the packages (e.g., Type BM and Type BU packages),
- Requiring locks and seals,
- Prescribing handling locations isolated from unrelated persons,
- Requiring carrying documents,
- Minimizing the total transport time and the trans-shipment frequencies,
- Control of detail information about shipments,
- Notification of the Local (Prefectural) Safety Commission and issuance of a "Shipment Certificate" according to requirements in the *Order Concerning Report on Transport of Nuclear Fuel Materials,*
- Designation of a "Transport Control Center" where the supervisor can communicate with the person responsible for conveyance under the shipment, and
- Establishing dedicated communications between each transport vehicle, the escort car, and the Transport Control Center and emergency preparedness.

In addition to the safety requirements, the Reactor Safety Law sets physical protection requirements for protection of shipments containing SNMPs which correspond to Category I or II, or the irradiated SNMPs. These physical protection measures are not performance-based using a DBT, but are feature-based. Many of the current, required physical protection features are identical to the required safety features (e.g., Transport Control Center, emergency preparedness, and communications). There are additional security requirements such as:

- The use of a transport convoy that includes the person who is responsible for control and command for physical protection. Guards must also accompany the transport convoy.
- The use of hardened locks attached to packages containing nuclear material. Seals are also attached to the package to ascertain if the packages have been tampered.
- Notification of the Public Safety Commission. The licensee must notify the Public Safety Commission about the formation of the vehicles, the allocation of guard's car, arrangements of the guard personnel, and communication with the competent authorities. The transport certificate must be received by licensee from the Public Safety Commission before the transport can begin.

5.4 United States Regulations

Regulations governing transportation of nuclear fuel materials in the U.S. are also complicated. Control of the production and use of fissile materials is delegated to the U.S. Nuclear Regulatory Commission (NRC) and the U.S. Department of Energy (DOE). The U.S. NRC is responsible for regulating commercial nuclear fuel cycle activities, and the U.S. NRC may delegate their licensing authorities for by-product, source, and less-than-critical quantities of special nuclear materials (SNMs) to "Agreement States." There are relatively few commercial shipments of Category 1 quantities of special SNMs in the U.S. The U.S. DOE is responsible for regulating U.S. "atomic energy defense" transportation activities related to the U.S. nuclear weapons program. There are a significant number of U.S. DOE shipments of Category I quantities of SNMs.

The U.S NRC's 10 CFR 73.1(a) states that physical protection systems (PPSs) to protect formula quantities of strategic SNMs transport shall be designed to protect against a DBT (a formula quantity of strategic SNMs is the same as an IAEA Category I quantity). Since 1977, the U.S. NRC has required that PPSs be designed to protect against a DBT. The NRC's DBT for protection of formula quantities of strategic SNMs is defined in 73.1(a)(1) for radiological sabotage and in 73.1(a)(2) for theft of strategic quantities of SNMs. The DBT provides an objective measure to design and evaluate the effectiveness of PPSs.

The U.S. NRC's DBT for radiological sabotage includes the following general characteristics:

- A determined violent, external, assault of several persons:
  - with military training and skills,
  - with passive insider assistance (e.g., insider provides information),
  - with active insider assistance (e.g., disable alarms and participates in violent attack),
  - with suitable weapons, including hand-held automatic weapons having long-range accuracy,
  - with hand-carried incapacitating agents and explosives for entry or for destroying transporter, or container integrity,

  - with a four-wheel-drive land vehicle used to transport personnel and their hand-carried equipment,
- An internal threat of an insider, including an employee (in any position), and
- A four-wheel-drive land vehicle bomb.

The U.S. NRC's DBT for theft of formula quantities for strategic SNMs is the same as the DBT for radiological sabotage, but more rigorous in the following areas:
- The determined violent, external, assault is by "a small group of several persons," rather than "several persons."
- The small group of several people has the ability to operate as two or more teams.
- The small group has detailed knowledge of nuclear power plants and facilities, and
- The small group has items and false documentation to facilitate theft of SNM.

Additionally, there are two classified U.S. NRC documents that list potential weaponry, tactics, and capabilities of the terrorist group described in general terms above.

The U.S. NRC's DBT was first upgraded in 1993 after the first attack on the World Trade Center, and a vehicle intrusion into the Three Mile Island nuclear power plant. The DBT was upgraded again in April 2003 in response to the September 11, 2001 terrorist attacks. On September 11th, a total of 19 attackers, operating in four coordinated but separate teams, attacked the U.S. The attacks required significant technical training and over a year of preparation. The attacks of September 11th led to a significant rethinking of the threats that nuclear security systems must be designed to address. The U.S. Government Accountability Office, citing others, states that the U.S. nuclear power industry has invested about $1 billion in security upgrades since September 11th, 2001.

In addition to requiring that a transportation PPS be designed against the DBT, the NRC also required a PPS to meet general performance objectives of 10 CFR 73.20 for formula quantities of strategic SNMs and the performance capability requirements of 10 CFR 73.25. Examples of general performance objective for a PPS include:
- A design with sufficient redundancy and diversity to ensure maintenance of the capabilities.
- A testing and maintenance program.

Examples of performance capability requirements for "in-transit" PPSs of strategic SNM include:
- Preplanning itineraries,
- Tracking the movement of materials,
- Detection and delay systems,
- Establishment of liaisons with local law enforcement authorities for assistance en route, and
- Assurance that a single adversary action cannot destroy the capability to notify law enforcement forces of the need for assistance.

In addition to the DBT, the general performance objectives requirements and the performance capability requirements, the U.S. NRC's 10 CFR 73.26 requires transportation PPS for formula quantities of strategic SNMs to include systems, components and procedures. Examples of these include:

- Security arrangements must be pre-approved by the U.S. NRC,
- The transportation shall include armed escorts, armed response personnel, a movement control center, and communications with local law enforcement authorities,
- Armed escort personnel must be qualified for duty in accordance with Appendix B of 10 CFR 73. Armed escorts shall requalify at least every 12 months,
- Armed escorts and armed response force personnel armament shall include handguns, shotguns, and semiautomatic rifles, as described in Appendix B of 10 CFR 73,
- All transfers of strategic SNM shall be protected by at least seven armed escorts. Each of the seven armed escorts shall be capable of maintaining communication with each other,
- Shipments made by sea shall be on container-ships. The strategic SNM container(s) shall be loaded into exclusive use cargo containers conforming to American National Standards Institute (ANSI) Standard MH5.1—"Basic Requirements for Cargo Containers" (1971) or International Standards Organization (ISO) 1496, "General Cargo Containers" (1978).

The U.S. NRC has other requirements for the transport of irradiated reactor and the transport of SNM of moderate or low strategic significance. Specific diagrams, armaments, and other information on PPS features must be protected as required in the U.S. NRC's 10 CFR 73.21 "Requirements for the protection of safeguards information."

The U.S. DOE is responsible for regulating U.S. atomic energy defense transportation activities and the U.S. DOE frequently transports Category 1 quantities of SNM. The U.S DOE implements its authority through a set of Directives, DOE Orders and regulations. The most relevant of these is DOE Order 470.1, *Safeguards and Security Program.* A revised version of DOE Order 470.1 (DOE O 470.1A) is available.

In general terms, the DOE's uses a graded approach, which means that the highest level of protection is given to activities and materials whose theft and/or compromise would seriously affect national security. DOE PPSs must be based on the results of vulnerability and risk analyses designed to provide graded protection in accordance with an asset's importance. To determine the appropriate level of protection against risk, DOE must consider the nature of the threat, the vulnerability of the potential target, and the potential consequences of an adversarial act. The protection strategies identified in draft DOE O 470.1A include:
- denial of access,
- denial of task,
- containment, and
- containment with recapture.

The DOE's DBT, details on implementation of DOE O 470.1, and DOE's Adversary Capabilities List are classified. However, the U.S. Government Accountability Office's (GAO's) 2004 report titled *NUCLEAR SECURITY: DOE Needs to Resolve Significant Issues Before It Fully Meets the New Design Basis Threat* (GAO-04-623) provides unclassified insights into the DOE's physical protection system. Relevant exerts from the GAO's report are presented in the full, JAEA-internal report *Review of Physical Protection Regulations Governing Transport of Fissile Material*.

Distribution List:

6	Nuclear Material Management Office Nuclear Nonproliferation Science and Technology Center Japan Atomic Energy Agency 2-4 Shirane, Shirakata, Tokai-mura, Naka-gun Ibaraki, 319-1195 JAPAN	
Attn:	Mr. Takafumi Kitamura, Deputy Director (3) Mr. Yuichiro Ouchi, Assistant Principal Engineer (3)	
1	MS0718	Ken Sorenson, 6774
1	MS0719	David Miller, 6765
1	MS0719	John Cochran, 6765
1	MS1361	John Matter, 6754
1	MS1374	David Betsill, 6721
	MS0899	Technical Library, 9536 (electronic copy)