Proceedings of the 17th International Symposium on the Packaging and Transportation of Radioactive Materials
PATRAM 2013
August 18-23, 2013, San Francisco, CA, USA

The Global Threat Reduction Initiative (GTRI), Russian Research Reactor Fuel Return (RRRFR) Program, Return of Highly Enriched Uranium (HEU): Air Shipment of Energetic Radionuclides

Authors:

Stanley D. Moses (ORNL[1])
Igor Bolshinsky (INL[2])

August 15, 2013

Abstract

U.S. President Barak Obama has spearheaded an international effort to strengthen global nuclear materials security and prevent nuclear terrorism. In 2010, he convened the leaders of 47 nations in Washington, DC, for the first global Nuclear Security Summit. There, 29 countries pledged more than 50 specific commitments to secure or eliminate nuclear materials, and prior to a second summit held Seoul in 2012, already roughly 90 percent of those national commitments had been completed. A third Summit is scheduled to take place in the Netherlands in 2014.

The United States Department of Energy (USDOE) National Nuclear Security Administration (NNSA) manages the Global Threat Reduction Initiative (GTRI) to reduce and protect vulnerable nuclear material located at civilian sites worldwide, both domestic and foreign. Both GTRI and RRRFR work closely with IAEA and the Russian Federation (RF) State Corporation for Atomic Energy (Rosatom) to safely and securely transport this material. By the end of 2013, the RRRFR Program will have completed 53 shipments of former Soviet Union fresh or spent highly enriched uranium (HEU) from fourteen (14) countries back to the Russian Federation for recovery and reuse. In like manner, by the end of 2016, the complementary USDOE/NNSA Foreign and Domestic Fuel Return Program will have completed over 50 shipments including 1,824 kilograms of HEU from 28 countries and an additional 1,077 kilograms of HEU from countries of origin for HEU from states other than the US or RF.

Introduction to GTRI and RRRFR Programs

The United States Department of Energy (USDOE) National Nuclear Security Administration (NNSA) manages the Global Threat Reduction Initiative (GTRI) to reduce and

[1] US Department of Energy, Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee, USA

[2] US Department of Energy, Idaho National Laboratory (INL), Idaho Falls, Idaho, USA

protect vulnerable nuclear material located at civilian sites worldwide. In cooperation with the International Atomic Energy Agency (IAEA), NNSA created the Russian Research Reactor Fuel Return (RRRFR) Program as a part of GTRI, to reduce nuclear proliferation risks by assisting with the transfer of Russian-origin highly enriched uranium (HEU) research reactor fuel from participating countries back to the Russian Federation. The United States (US) and the Russian Federation (RF) signed an agreement in 2004 to assist countries with the RRRFR shipments of HEU nuclear fuel to Russia. RRRFR works closely with IAEA and the Russian Federation State Corporation for Atomic Energy (Rosatom) to safely and securely transport this material.

Summary of GTRI Accomplishments

By the end of 2013, the RRRFR program will have completed 54 shipment operations to repatriate to Russia (Fig. 1) approximately 2.2 MT of Russian-origin HEU fresh and spent nuclear fuel in the following countries:

– Twenty-four (24) shipments of HEU fresh fuel will have been conducted from 13 countries (Fig. 1): Serbia, Romania, Bulgaria, Libya, Latvia, Czech Republic, Uzbekistan, Poland, Germany, Vietnam, Hungary, Ukraine, and Belarus.

– Twenty-five (29) shipments of HEU spent fuel were conducted from Uzbekistan, the Czech Republic, Latvia, Bulgaria, Hungary, Romania, Ukraine, Libya, Kazakhstan, Belarus, Serbia, and Poland, Vietnam.

All Russian-origin HEU has been removed from seven countries: Bulgaria, Latvia, Libya, Romania, Serbia, Ukraine, and Vietnam.

By the end of 2012, the USDOE Domestic and Foreign Fuel Return Programs completed shipments (Fig. 2) from thirty-nine (39) countries to return US origin fuel to either the Savannah River National Laboratory (South Carolina, USA) or the Idaho National Laboratory (Idaho Falls, Idaho). The countries include:

- Argentina, Australia, Bangladesh, Brazil, Canada, Chile, Columbia, Congo, Denmark, Germany, Ghana, Greece, Indonesia, Iran, Iraq, Italy, Jamaica, Japan, Mexico, Netherlands, Nigeria, Pakistan, Peru, Philippines, Portugal, Romania, Slovenia, South Africa, South Korea, Spain, Sweden, Switzerland, Syria, Taiwan, Thailand, Turkey, United Kingdom, Uruguay, and Venezuela

All US-origin HEU has been removed from fifteen (15) locations: Brazil, Chile, Columbia, Denmark, Greece, Mexico, Philippines, Portugal, Slovenia, South Korea, Spain, Sweden, Taiwan, Thailand, and Turkey.

Countries Participating in RRRFR

RRRFR Program has moved fresh and spent HEU fuels from the 14 countries and 16 institutes and/or research reactors (Table 1). There are several countries where the HEU was located in multiple locations. The chart also gives the types of fuels removed from the respective locations.

Table 1. Countries and Material Type Participating in RRRFR Program

City, Country	Material Type
Minsk, Belarus	IRT-3M, Pamir, U-Oxide
Sofia, Bulgaria	IRT-2M
Prague, Czech Republic	IRT-2M, IRT-3M
Dresden, Germany	WWR-M2, U-metal, U-oxide
Budapest, Hungary	WWR-SM, WWR-M2
Almaty, Kazakhstan	WWR-TS
Riga, Latvia	EK-10, IRT-2M, IRT-3M
Tripoli, Libya	IRT-2M
Warsaw, Poland	WWR-SM, WWR-M2, MR, oxide
Belgrade, Serbia	TWR-S
Bucharest, Romania	EK-10, S-36, IRT-2M
Kiev, Ukraine	WWR-M2, WWR-M5
Sevastopol, Ukraine	S-36
Kharkiv, Ukraine	U-material
Tashkent, Uzbekistan	IRT-2M, IRT-3M
Dalat, Vietnam	WWR-M2

In addition to the Soviet-origin HEU fuel assemblies listed above that were returned to Russia, the GTRI program also assists research reactors that want to continue operating with low enriched uranium (LEU) fuel. As part of the compensation package for the respective countries, LEU fuel (atom-for-atom trade) was shipped from TVEL, Luch, or Areva to research reactors when the HEU fuel was removed. Countries where LEU was shipped include Belaurs (from Luch), Czech Republic, Hungary, Kazakhstan, Libya, Poland (from Areva), Ukraine, Uzbekistan, and Vietnam.

Facilities in Russia where the material is transported

The majority of the nuclear fuel was sent to one of three facilities in the Russian Federation (see location of facilities in Fig. 1) based on the material recovery plan. Unirradiated (or fresh fuel -FF) went to one of two facilities, either the Joint Stock Company "State Scientific Center – Research Institute of Atomic Reactors" (JSC "SSC RIAR") a part of integrated JSC Atomenergoprom (full name Joint Stock Company Atomic Energy Power Corporation) located in Dimitrovgrad, Russian Federation or to the Federal State Unitary Enterprise "Scientific Research Institute Scientific Industrial Association (FSUE "SRI SIA "LUCH") in Podolsk, Russian Federation. Twelve (12) shipments managed by Sosny R&D Company went to RIAR and twelve (12) shipments managed by LUCH went to LUCH. One (1) shipment will be sent directly to TVEL [location] where it will be used to fabricate LEU fuel. Both facilities participate in the Russian-USA material consolidation and conversion (MCC) program to receive former Soviet Union HEU materials removed from reactor locations both foreign and domestic to the Russian Federation, locate the materials at either LUCH or RIAR, and to convert the HEU material (from whatever form) to LEU oxide. The oxide material is down blended to less than 20 weight percent ^{235}U, and is used for domestic research reactor LEU fuel fabrication or for domestic commercial fuel nuclear power production.

All 29 shipments of irradiated fuel (or spent nuclear fuel-SNF), were transported to the Mayak Production Association (MPA) at Ozersk, Russian Federation where it was entered into the RT-1 processing facility and the remaining fissile material is recovered and reutilized.

Transport Mode

RRRFR program utilized all modes of transportation in shipping the fresh and spent nuclear fuel. Virtually all sites moved the fuel (both fresh and spent) from their storage locations by highway to the next transportation transfer point.

All of the HEU fresh fuel was transported by truck to the nearest airport where it was loaded into an exclusive use air cargo plane (owned and operated by Volga-Dnepr). The packagings where marked and labeled in accordance with IAEA standards (IAEA TS-R-1[3]), the

[3] IAEA SAFETY STANDARDS SERIES No. TS-R-1, Regulations For The Safe Transport of Radioactive Material 2009 Edition, International Atomic Energy Agency, Vienna, Austria, 2009

respective country of origin, and the Russian Federation rules and regulations for transportation of dangerous goods. The plane transported the fuel to an airport nearest either RIAR or LUCH where it was transferred to trucks and transported to the respective storage sites. Depending on the amount of packagings and distance traveled, the airplane used to ship fresh fuel was either an AN-12 or IL-76 (Figs 3 and 4).

The spent fuel was ship by various combinations of modes of transport. If the country of origin and Russia shared a border, then the shipment was loaded onto rail and transported directly to Mayak (Fig. 5). On several occasions, transit agreements were made and rail was used even when the countries did not share a boarder (e.g.-Uzbekistan). Otherwise, all the remaining shipments that have been made used trucks or rail to transport the SNF to the nearest seaport where the casks (Fig. 6) inside ISO containers were loaded onto a Category 3 vessel under contract to the USDOE/NNSA. One such vessel (Fig. 6) was used to transport spent nuclear fuel from Gydina, Poland to Murmansk, Russian Federation (Fig. 7). At Murmansk, the SNF was transferred to rail and transported to Mayak.

Recently, an ORNL-Sosny R&D Company effort has resulted in the certification of a unique TYPE C [TUK-145/C (RUS/3166/CF-96)] package to air ship highly active materials (such as spent nuclear fuel). The TUK-145/C completed loading/unloading operational tests with and without semi-truck and trailer, into and out of an AN-124-100 (Fig. 8, at Vostochny Airport [ULY], Ulyanovsk, Russian Federation) to demonstrate capability, test loading operations, establish time requirements, and assess overall handling techniques. A shipment of SNF from Vietnam to Russia (Mayak) was recently completed as the first use of the TUK-145/C package. A second TUK-145/C package has been fabricated and will be ready this fall that will allow for twice the number of fuel assemblies to be shipped.

Packagings

All of the HEU and LEU fresh fuel was shipped in either the TK-S14, TK-S15, or TK-S16 packagings (Figs 9 and 10, respectively) that are certified in the Russian Federation as well as the country of origin. TK-S14 and TK-S15 are same external packaging with eleven (11) or seven (7) fuel assembly internal tubes. These packages are certified to ship fissile, Type B quantities of ^{235}U, although, many of the shipments were actually shipped as either Type A quantities or even the lesser low specific activity, because there was limited amount of nuclear material in the package.

RRRFR Program has used two Type B, Spent Nuclear Fuel casks exclusively to ship spent fuel to Russia. The program initially used the TUK-19 cask (Fig. 11), which has a content of 4 IRT type fuel assemblies or 12 WWR type fuel assemblies (depending on the activity and thermal heat of the contents). A number of the shipments utilized the special TUK-5 rail cars if there was a contiguous border and the rail cars were delivered to the nearby railhead for transfer. A special ISO intermodal 20-ft freight container (Fig. 11) was developed to hold 1, 2, or 3 TUK-19 casks. The ISO containers with the TUK-19 packagings are easily transferred between

highway, rail, and vessel transport.

There were several air shipments of the TUK-19 casks in the ISO packagings under air shipment of Type B quantity of highly active material in accordance with IAEA TS-R-1 standards. The shipment limited the number of fuel assemblies in each cask.

It was realized early in the program that there were not enough TUK-19 packages to support the RRRFR Program schedule as agreed under the US and RF Presidents at several Summits. Under a USDOE NNSA-IAEA contract, a higher capacity cask (SKODA[CZ/048/B(U)F-96], VPVR/M Type B, Fig. 12) cask was developed and certified in Czech Republic, Russian Federation, and subsequently in each of the countries where it has been used. Sixteen VPVR/M casks were built and all have been used in shipments of spent fuel.

As mentioned above and described in a separate paper later in this conference, a package to air ship spent fuel was designed, fabricated, tested, and utilized to ship SNF. The TUK-145/C is a combination of the VPVR/M casks (without the impact absorbers) completely surrounded by titanium over pack or energy absorbing container (EAC) deigned to absorb the energies of the hypothetical accident conditions (air crash).

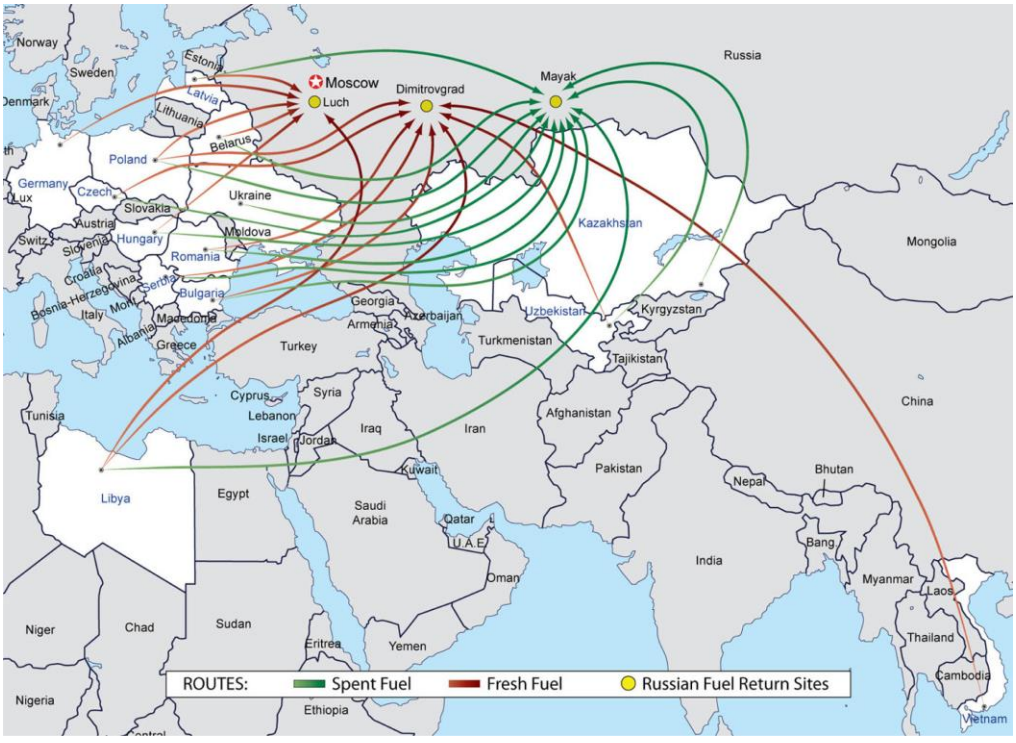

Figure 1 – RRRFR HEU Fuel Locations and Russian Receiving Facilities for Fresh and Spent Fuel Shipments

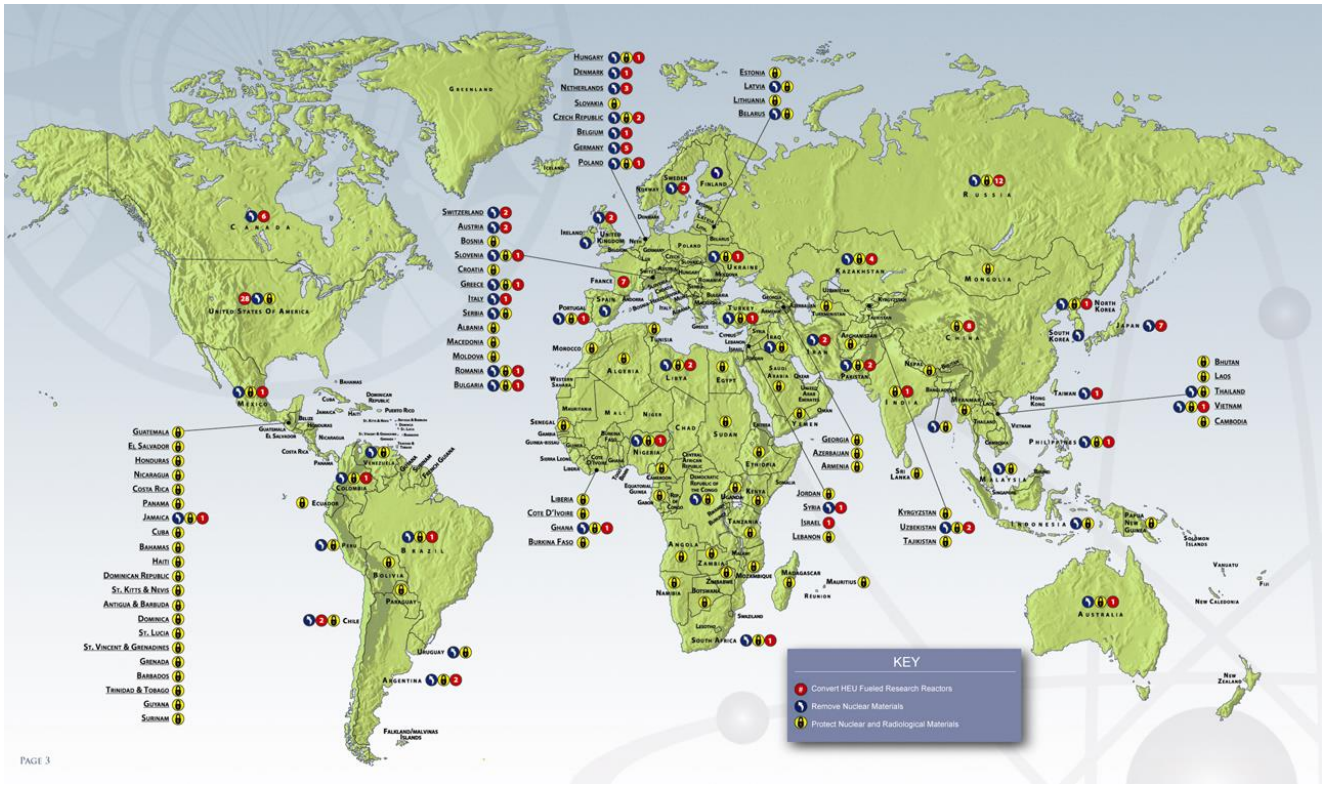

Figure 2 – US Foreign Fuel Locations and US Receiving Facilities for Spent Fuel Shipments

Figure 3 – HEU Fresh Fuel Loading (Tripoli, Libya) - AN-12

Figure 4 – HEU Fresh Fuel Loading (Kharkiv, Ukraine) – IL-76

Figure 5 – TUK-19 Spent Fuel Casks loading into a TUK-5 Rail Car (Riga, Latvia)

Figure 6 – Michael Dudin Category 3 Vessel Transporting Spent Nuclear Fuel

from Gdynia, Poland to Murmansk, Russian Federation

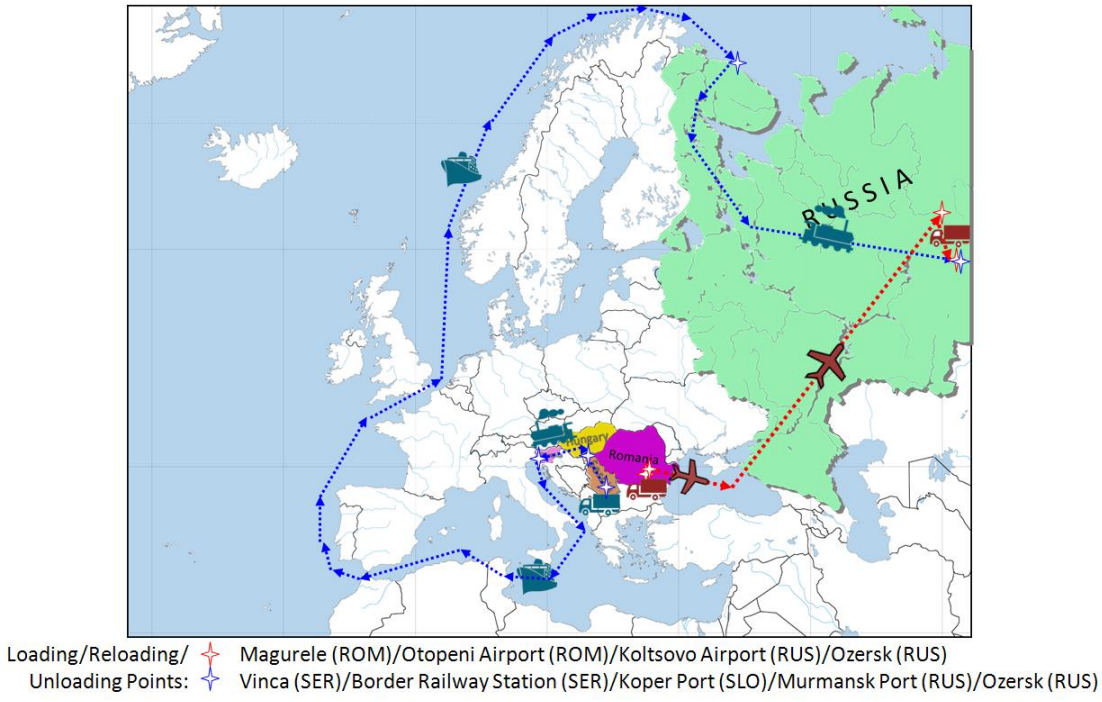

Figure 7 – Transportation Route for Spent Nuclear Fuel from Vinca, Serbia to Mayak, Ozersk, Russian Federation

Figure 8 – TUK-145/C on Low-Boy truck/trailer loading into AN-124-100

Figure 9. TK-S15 Packaging

Figure 10. TK-S16 Packaging in IL-76 (Kharkiv, Ukraine)

Figure 11. TUK-19 Spent Nuclear Fuel Casks in 20-FT ISO Containers

Figure 12. SKODA VPVR/M Cask (Type B) Loading into 20-FT ISO Container