
# AIR SHIPMENT OF SPENT NUCLEAR FUEL FROM ROMANIA TO RUSSIA

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## ABSTRACT

Romania successfully completed the world's first air shipment of spent nuclear fuel transported in Type B(U) casks under existing international laws and without shipment license special exceptions when the last Romanian highly enriched uranium (HEU) spent nuclear fuel was transported to the Russian Federation in June 2009. This air shipment required the design, fabrication, and licensing of special 20-foot freight containers and cask tiedown supports to transport the eighteen TUK-19 shipping casks on a Russian commercial cargo aircraft. The new equipment was certified for transport by road, rail, water, and air to provide multi-modal transport capabilities for shipping research reactor spent fuel. The equipment design, safety analyses, and fabrication were performed in the Russian Federation and transport licenses were issued by both the Russian and Romanian regulatory authorities. The spent fuel was transported by truck from the VVR-S research reactor to the Bucharest airport, flown by commercial cargo aircraft to the airport at Yekaterinburg, Russia, and then transported by truck to the final destination in a secure nuclear facility at Chelyabinsk, Russia. This shipment of 23.7 kg of HEU was coordinated by the Russian Research Reactor Fuel Return Program (RRRFR), as part of the U.S. Department of Energy Global Threat Reduction Initiative (GTRI), in close cooperation with the Rosatom State Atomic Energy Corporation and the International Atomic Energy Agency, and was managed in Romania by the National Commission for Nuclear Activities Control (CNCAN). This paper describes the planning, shipment preparations, equipment design, and license approvals that resulted in the safe and secure air shipment of this spent nuclear fuel.

## INTRODUCTION

In June 2009 Romania became the world's first country to transport spent nuclear fuel (SNF) by air in Type B(U) shipping casks under existing international laws and without shipment license special exceptions. This safe and secure transport was completed with the support of multiple international organizations.

### GTRI and RRRFR Programs

The United States (US) Department of Energy (DOE) National Nuclear Security Administration (NNSA) created the Global Threat Reduction Initiative (GTRI) to help reduce and protect vulnerable nuclear and radiological material at civilian sites worldwide. In cooperation with the International Atomic Energy Agency (IAEA) and the Rosatom State Atomic Energy Corporation (Rosatom), NNSA created the Russian Research Reactor Fuel Return Program (RRRFR) as part of GTRI to assist with the transfer of Russian-origin highly enriched uranium (HEU) research reactor

fuel from participating countries to the Russian Federation (RF). By the end of May 2010, RRRFR had transported over 1339 kg of HEU to Russia and more shipments are planned for the near future.

Romania Participation in GTRI and RRRFR

In April 2003, the National Commission for Nuclear Activities Control (CNCAN) started planning with NNSA for HEU fresh and spent nuclear fuel shipments to both the United States (US) and Russia. On 21 September 2003, after 4 months of preparations, Romania shipped fresh HEU to Russia making Romania the 2nd country to ship HEU under the RRRFR Program. Planning began in September 2004 to return HEU type S-36 spent nuclear fuel assemblies to Russia from the VVR-S research reactor located near Bucharest. Comprehensive cooperative actions resulted in the successful air shipment of the HEU spent fuel on 29 June 2009. CNCAN also helped return other HEU nuclear fuel to the US under another GTRI program, not discussed in this paper. Romania has clearly demonstrated its commitment to nuclear nonproliferation by becoming the 3rd RRRFR country and the 14th GTRI country to eliminate all HEU.

## AIR SHIPMENT PREPARATIONS

Project Planning Meetings

Forty-five planning meetings were conducted in Romania, the Russian Federation, the US, Bulgaria and IAEA headquarters in Austria to prepare for the spent fuel air shipment. These meetings assured that the multiple international partners understood the actions needed to meet the shipment schedule. Special focus meetings were also conducted to assure that legal requirements were met, IAEA guidelines were implemented, European Commission (EC) requirements were satisfied, Romanian institutions were informed, and lessons learned from other RRRFR shipments were incorporated into the Romanian plans.

Transport Options

Four SNF shipment options with various transport modes (rail, river, sea, and air) were investigated for Romania (see Table 1). After considerable discussions, careful review by Russian authorities, and the design of specialized air shipment equipment, the air transportation option was accepted by all parties. The actual shipment used Russian TUK-19 casks secured inside freight containers that were transported in one AN-124-100 commercial cargo aircraft (see Figure 1) owned and operated by the Volga-Dnepr Airlines Company.

**Table 1. Romania SNF Transport Options**

| Option | Transportation Modes |
|---|---|
| 1 | Terrestrial 1: Railway |
| 2 | Terrestrial 2: Railway + Danube River Barge |
| 3 | Terrestrial 3: Railway + Sea Vessel |
| 4 | Air |


**Figure 1. AN-124-100 Commercial Cargo Aircraft**

Specialized Equipment

Prior to the air shipment decision, TUK-19 casks were only shipped in railcars so new equipment was required to transport the casks by air. A new container was designed and certified in accordance with International Organization for Standardization (ISO) rules for standard size 20-foot ISO freight containers to hold 1, 2, or 3 TUK-19 casks. Compliance with ISO rules assured the cask containers could be handled by transportation carriers worldwide. Cask tiedowns were designed to secure the casks inside the containers. The ISO containers and cask tie-downs were fabricated and certified in Russia for road, rail, water, and air transport. Volga-Dnepr assisted to assure the equipment would meet all Russian and international air transportation requirements.

A shielded transfer cask was also designed and fabricated to load the spent fuel assemblies in the TUK-19 casks. This was not required for air shipment but was required for cask loading. Additional equipment details may be found in the References [1,2,3,4].

International Partners

International partner participation, calculated as a percentage of the total project cost, is presented in Figure 2 by country and in Figure 3 by organization. CNCAN organized international meetings in Romania in cooperation with IAEA, NNSA, EC and the Russian institutions (see Figure 4).

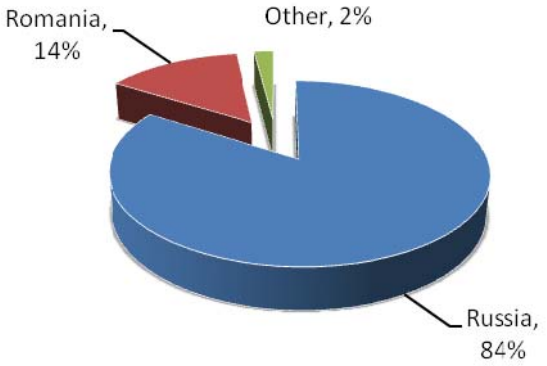


**Figure 2. Cost Distribution by Country**

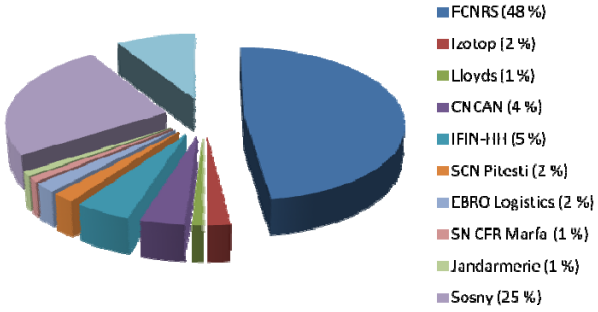


**Figure 3. Direct Partners Involvement**


**Figure 4. Examples of Meetings Organized in Romania**

Facility Modifications

The VVR-S reactor hall and site were modified to support the cask loading and transportation activities. The facility operator, the Horia Hulubei National Institute for Physics and Nuclear Engineering (IFIN-HH), added equipment inside the reactor hall, upgraded the reactor hall access, replaced the reactor hall flooring, improved the site access roads, and installed supplemental security fences. Facility modification details may be found in the References [1,2,3,4,5].

## LEGAL FRAMEWORK

The spent fuel air shipment complied with national regulations in Romania and Russia and also international safety standards and guides developed by IAEA and EC.

Romanian Regulations

The Regulatory framework for SNF shipments in Romania was defined by:

- Law on the Safe Deployment of Nuclear Activities, no. 111/1996 republished;
- CNCAN regulations;
- Other regulatory documents (guides, licensing requirements, etc.).

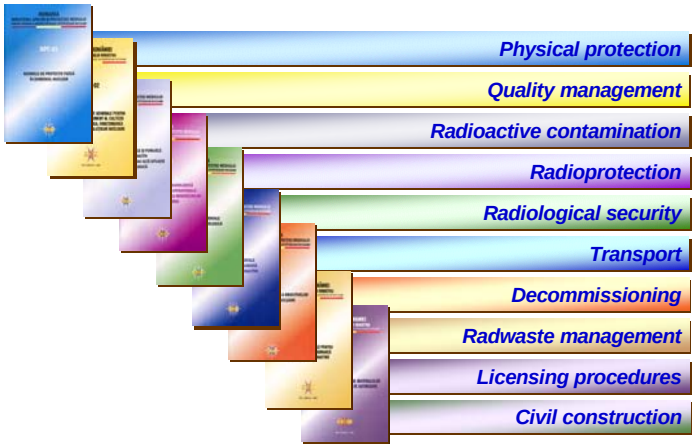


**Figure 5. CNCAN Regulations for the SNF Air Shipment**

CNCAN is the State Competent Authority on nuclear and radiation safety for transportation of nuclear materials and radioactive substances in Romania. The CNCAN regulations applied to the SNF air shipment are shown in Figure 5.

Russian Federation Regulations

The Regulatory framework for SNF shipments in Russia was defined by:

- Federal Law № 317, 01 December 2007,"On the State Nuclear Energy Corporation "Rosatom";
- Governmental Decree № 751, 15 September 2009, Amendments to the Governmental Decree № 204, 19 March 2001, "On the State Competent Authority for Nuclear and Radiation Safety in the Transport of Nuclear Materials, Radioactive Substances and Products Thereof";
- Russian NP-053-04, "Safety Regulations for Transportation of Radioactive Materials," 2004;
- Other regulatory documents (guides, licensing requirements, etc.).

The Rosatom State Atomic Energy Corporation is the State Competent Authority on nuclear and radiation safety for transportation of nuclear materials and radioactive substances in Russia.

International Regulatory and Legal Basis for SNF Shipments

The air shipment also complied with the following international documents:

- IAEA TS-R-1, "Regulations for the Safe Transport of Radioactive Material" and other related IAEA safety standards and guides;
- European Commission Directives and Regulations:
  - The EURATOM Treaty;
  - European Directive 2006/117 "On the Supervision and Control of Shipments of Radioactive Waste and Spent Fuel";
  - Council Regulation (EC) No 1334/2000 "Setting Up A Community Regime for the Control of Exports of Dual-use Items and Technology";
  - Commission Recommendation 2008/956/Euratom of 4 December 2008 "On Criteria for the Export of Radioactive Waste and Spent Fuel to Third Countries";
  - Commission Regulation (Euratom) No 302/2005 of 8 February 2005 "On the Application of Euratom Safeguards".
- International conventions and treaties:
  - Non-Proliferation Treaty;
  - Convention on Physical Protection of Nuclear Material;
  - Vienna Convention on Civil Liability for Nuclear Damage, as amended;
  - Safeguards Agreement between Romania and IAEA.
- Bilateral government-to-government agreements:
  - "Agreement Between the Government of the United States of America and the Government of the Russian Federation Concerning Cooperation for the Transfer of Russian-produced Research Reactors Nuclear Fuel to the Russian Federation", signed on 27 May 2004;
  - "Agreement Between the Nuclear Agency of Romania and the National Commission for Nuclear Activities Control of Romania and the Department of Energy of the United States of America Concerning Cooperation in the Area of Countering the Proliferation of Nuclear Materials and Technologies", signed on 19 July 2004;
  - "Agreement Between the Government of Romania and the Government of the Russian Federation Concerning Cooperation for the Transfer of Research Reactor Irradiated Nuclear Fuel to the Russian Federation", signed on 18 February 2009.

## SNF AIR SHIPMENT LICENSING STEPS

The spent nuclear fuel air shipment licensing steps used by the Competent Authorities from Romania and Russia can be summarized as follows:

1. Rosatom issued a combined B(U)F package design and shipment certificate for air shipment of the VVR-S HEU spent fuel in TUK-19 casks (RUS/3104/B(U)F-96T). The license was in compliance with TS-R-1, NP-053-04 and the 2007 Administrative Regulation of the Federal Atomic Energy Agency on execution of the state function "Issue of Certificates for Transportations of Radioactive Materials and Keeping Register of the Certificates." The period from license application submittal to final certificate approval took 254 days (36 weeks).

2. CNCAN reviewed the Russian package design and shipment certificate and issued a validation of type approval in compliance with TS-R-1 and CNCAN regulations. The review considered compliance with Romanian requirements for nuclear safety, strength, thermal safety, emergency preparedness, accidents, physical protection, and transport safety.

3. CNCAN issued transport authorizations for air and road carriers. The carriers were evaluated for nuclear material transport capabilities, equipment technical aspects, existence of related authorizations and permits from other institutions (i.e. road and air safety authorities), personnel sufficiency and training, compliance with international regulations for transport of Class 7 dangerous goods, and radioprotection plans.

4. CNCAN issued a spent nuclear fuel shipment certificate for road and air. CNCAN evaluated the shipment preparedness prior to issuing this certificate, including the existence of licensed carriers, routes, schedule, physical protection and emergency preparedness.

5. Romania issued Export Licenses from CNCAN and the National Agency for Control of Exports (ANCEX). Control of the exported material during shipment was considered prior to issuing these licenses, including reviews of the safeguards plan, Russian import license, responsible organizations, foreign trade contract, and content characteristics of each exported item.

6. CNCAN approved the Quality Control Plan for fabrication of the transfer cask and auxiliary equipment in Romania by the Institute for Nuclear Research at Pitesti (SCN Pitesti). CNCAN reviewed the design, quality assurance plan and fabrication procedures for this approval.

7. CNCAN approved the Radiological Safety Authorization for the transfer cask. CNCAN reviewed the design, quality of the fabrication process, radiological test results, functionality test results and operating procedures for this approval.

8. CNCAN approved the Radiological Safety Authorization for the specialized ISO freight containers. CNCAN reviewed the design, quality of fabrication process, functionality test results, operating procedures, and existing certificates issued by other authorities (Russian Maritime Register) for this approval.

9. CNCAN issued IFIN-HH Management and operator personnel licenses. CNCAN reviewed the management of RRRFR program activities, personnel responsibilities, training, knowledge of operating procedures, and reactions in case of critical situations. The IFIN-HH Director for Nuclear Safety, the SNF Loading Team Leaders, and all involved IFIN-HH operators were licensed after written exams, interviews and practical exams.

10. CNCAN approved the reactor core loading plan. Seventy (70) HEU spent fuel assemblies (SFA) were to be loaded in casks in the VVR-S reactor hall but the reactor hall spent fuel cooling pond had only 60 places available. To save time, the remaining 10 fuel assemblies, stored in the Away from Reactor Spent Fuel Storage Building, were transported into the reactor core for temporary storage then moved into the reactor hall cooling pond for cask loading. CNCAN reviewed the reactor core loading scheme, the condition of the fuel transfer system, nuclear safety issues, existing procedures, and experience of operators for this approval.

11. CNCAN issued a Spent Nuclear Fuel Loading Permit. CNCAN reviewed the existence of all required previous authorizations, licenses, approvals and permits, preparedness for loading the SNF in TUK-19 casks and the overall shipment preparedness for this permit.

## AIR SHIPMENT

The licensing process was completed as planned and on 29 June 2009, 23.7 kg of HEU SNF contained within 6 ISO containers (see Table 2) were loaded into an AN-124-100 aircraft at the Henri Coanda Airport in Bucharest (see Figure 6). A few hours later the SNF arrived in the Russian Federation after flying the route shown in Figure 7 to a refueling stop then continuing to the final destination airport in Yekaterinburg, Russia. This route avoided all transit countries and all major population areas. The casks were unloaded and transported by truck to the final destination in a secure facility in Chelyabinsk, Russia. The entire spent nuclear fuel air shipment was completed without delays and under very good safety and security conditions.

**Table 2. SNF Air Shipment Data**

| HEU Amount | Shipment Date | Assembly Type and Enrichment | No. of Assemblies | No. of Casks | No. of ISO Containers |
|---|---|---|---|---|---|
| 23.7 kg | 29 June 2009 | S-36 (36.6%) | 70 | 18 (TUK-19) | 6 |

**Figure 6. AN-124-100 Airplane During SNF Loading at Henri Coanda Airport, Bucharest**


**Figure 7. SNF Air Shipment Route**

## CONCLUSIONS

- Romania demonstrated its commitment to nuclear nonproliferation goals by participating in the GTRI and RRRFR programs and becoming free of all highly enriched uranium.
- In 2003 Romania was the 2nd RRRFR country to ship HEU nuclear materials.
- Air shipment of 27.3 kg of HEU spent nuclear fuel to Russia in a Type B(U) cask on 29 June 2009 was completed safely, securely, and on schedule.
- Romania was the world's first country to ship spent nuclear fuel by air in Type B(U) casks in accordance with international laws and without special exceptions for the transport licenses.
- Romania is the 3rd RRRFR country and the 14th GTRI country to eliminate all HEU.

## ACKNOWLEDGEMENTS

Work was supported by the U.S. Department of Energy Office of National Nuclear Security Administration under NNSA Contract DE-GI52-03NA99602 and DOE Idaho Operations Office Contract DE-AC07-05ID14517.

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