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Current Status of the Russian Research Reactor Fuel Return Program

October 2019

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Changing the World's Energy Future

Idaho National Laboratory

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October 6-9, 2019

Zagreb, Croatia

— PERMANENT THREAT REDUCTION —

MATERIAL MANAGEMENT AND MINIMIZATION

CONVERT, REMOVE, DISPOSE

Program Goal

The primary goal of NNSA M3's Russian Research Reactor Fuel Return (RRRFR) program is to advance nuclear nonproliferation objectives encouraging eligible countries to convert their research reactors from highly enriched uranium (HEU) to low enriched uranium (LEU) fuel and eliminating stockpiles of HEU.

The RRRFR program supports the removal, consolidation, and disposal of HEU and plutonium from civilian sites worldwide. Each kilogram of this dangerous material that is removed reduces the risk of a terrorist acquiring a sufficient amount of material for use in a nuclear weapon.

Program History

- Based on the success of the Foreign Research Reactor Spent Nuclear Fuel Acceptance program, which removes eligible U.S.-origin research reactor fuel to the United States for management and disposition, the U.S. Department of Energy began work on a similar effort in Russia.

- Trilateral discussions among the United States, Russia, and the IAEA, initiated in 1999, identified more than 20 research reactors in 16 countries that have Russian/Soviet-supplied HEU fuel:
  - Belarus, Bulgaria, China, Czech Republic, DPRK, Germany, Hungary, Kazakhstan, Latvia, Libya, Poland, Serbia, Romania, Ukraine, Uzbekistan, and Vietnam.

- In 2000 the IAEA Director General sent a letter to 16 countries asking for their willingness to return spent HEU fuel to the Russian Federation. 14 countries responded positively to the Director General's letter.

International Interest

14 countries agreed to participate

2 countries did not respond

Legal Framework Development

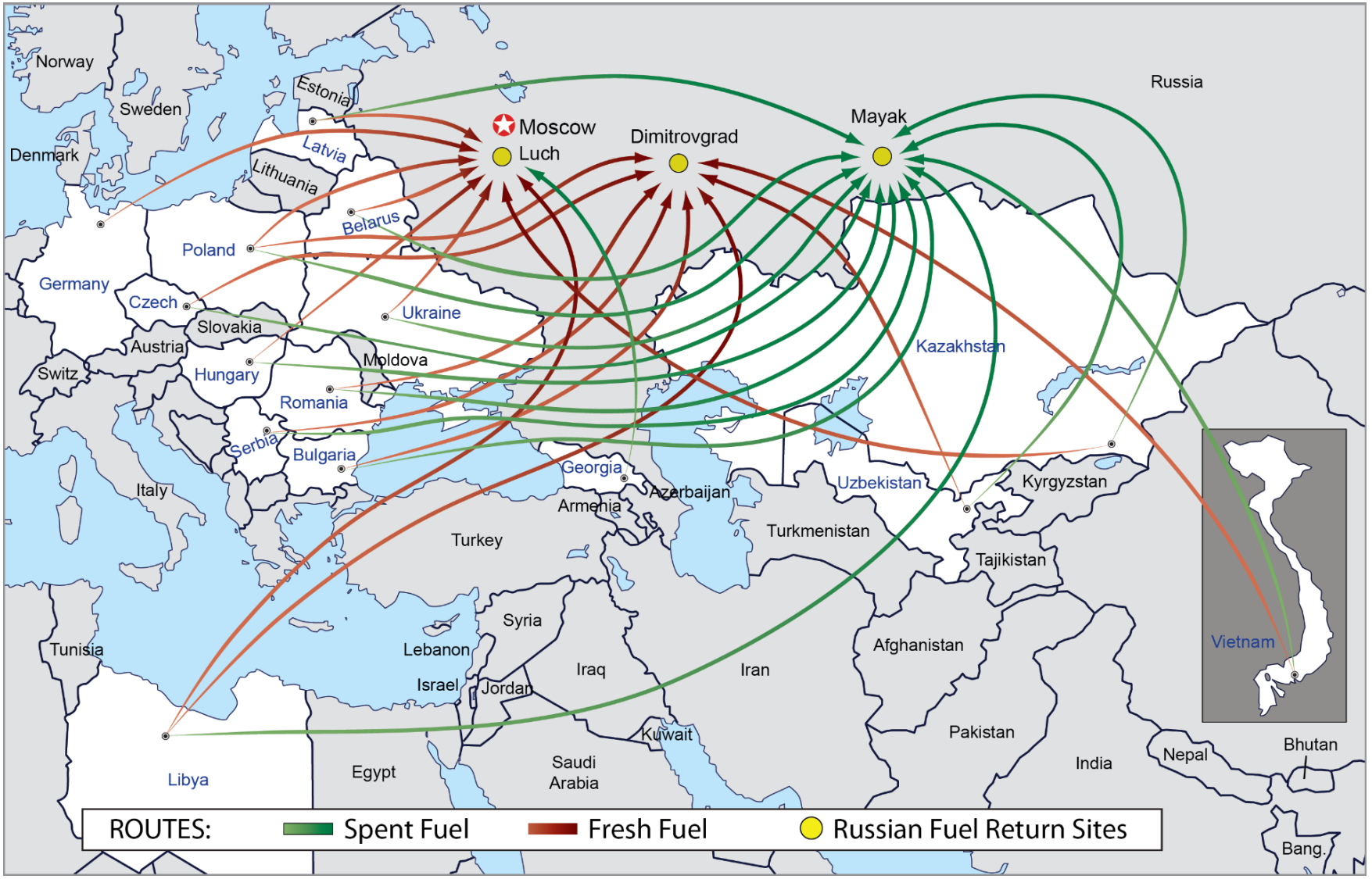
- In May 2004, the United States and the Russian Federation signed a Government-to-Government Agreement Concerning Cooperation for the Transfer of Russian-produced Research Reactor Nuclear Fuel to the Russian Federation.

- This agreement established the legal framework necessary for cooperation between the United States and the Russian Federation for the return of Russian-supplied research/test reactor fuel from eligible countries.

Program Achievements

- To date, the RRRFR program has completed sixty-three successful operations to repatriate to Russia almost 2,300 kg of Russian-origin HEU fresh and spent fuel:
  - 25 shipments of HEU fresh fuel were conducted from fourteen countries: Serbia, Romania (2 shipments), Bulgaria, Libya (2 shipments), Czech Republic (4 shipments), Uzbekistan, Poland (3 shipments), Germany, Vietnam, Hungary (2), Ukraine (4 shipments), Belarus, Kazakhstan, and Latvia.
  - 38 shipments of HEU spent fuel were conducted from fourteen countries: Uzbekistan (7 shipments), the Czech Republic (2 shipments), Latvia, Bulgaria, Hungary (2 shipments), Romania, Ukraine (2 shipments), Libya, Kazakhstan (4 rail shipments + 5 air shipments), Belarus, Serbia, Vietnam, Georgia, and Poland (8 shipments).
- All Russian-origin HEU has been completely removed from 12 countries: Bulgaria, the Czech Republic, Georgia, Hungary, Latvia, Libya, Poland, Romania, Serbia, Ukraine, Uzbekistan, and Vietnam.

Russian-origin Fuel Return Shipments



UPCOMING HEU REMOVALS

Upcoming Efforts

HEU Removal from IVG.1M in Kazakhstan (IVG spent fuel)

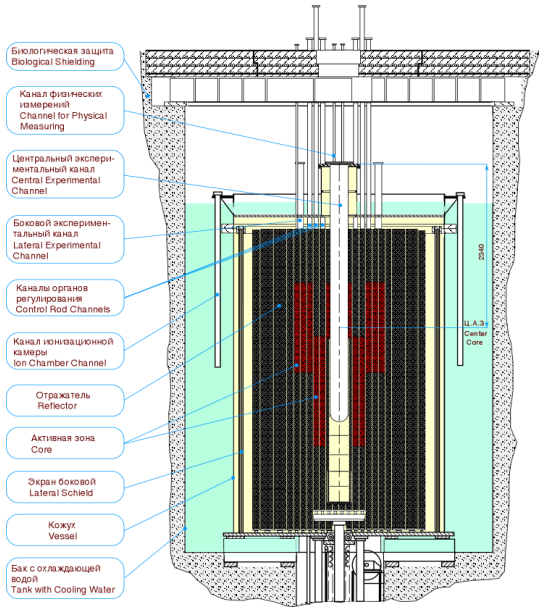
- IVG.1M reactor belongs to the National Nuclear Center of Kazakhstan and is located at the Baikal-1 site near Kurchatov City.
- Feasibility study on possible conversion of the IVG.1M reactor to LEU fuel was completed in 2013.
- Two LEU lead test assemblies for IVG.1M reactor were delivered to Kazakhstan in 2014; the test of IVG LEU fuel assemblies started on October 17, 2017.
- As of today almost 90% of the testing is completed.
- LEU fuel irradiation testing should be completed in November 2019.
- PIE is scheduled for 2020 and conversion of IVG.1M reactor is scheduled for 2021.
- Upon successful conversion the HEU spent fuel which is currently in the reactor core will be returned to Russia in 2022(5.1 kg of U235).

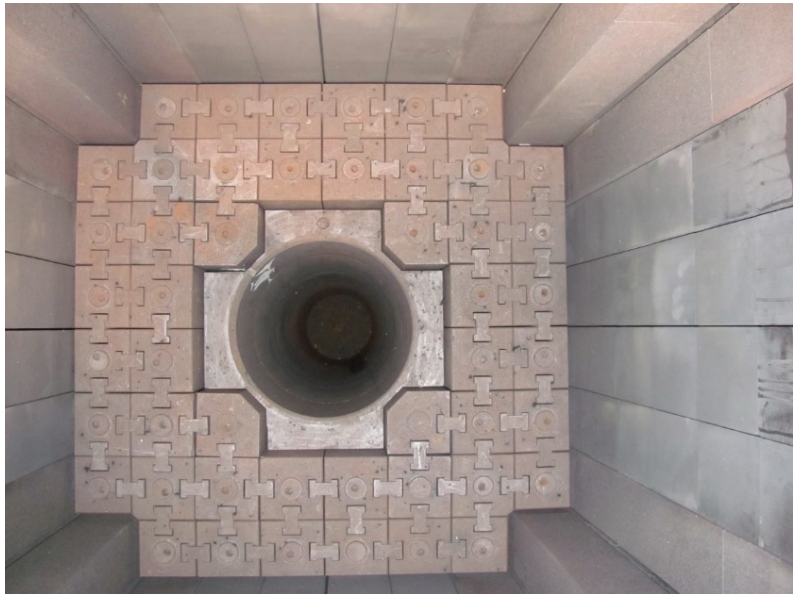
Experimental LEU fuel assemblies were transported to “Baikal-1” site and loaded into IVG.1M core

Upcoming Efforts

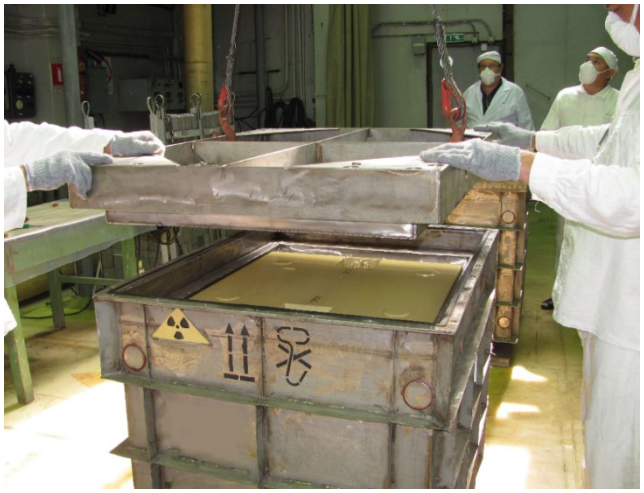
HEU Removal from IGR reactor in Kazakhstan (IGR fresh fuel)

- IGR reactor also belongs to the National Nuclear Center of Kazakhstan.
- Feasibility study on possible conversion of the IGR reactor was completed in 2013.
- LEU lead test graphite fuel for IGR reactor was fabricated and delivered to Kazakhstan in 2014; the test of IGR LEU fuel will be conducted in IGR and VVR-K reactors.
- Fresh HEU fuel from IGR reactor (2.5 kg) will be down-blended at Ulba Metallurgical plant in 2020.

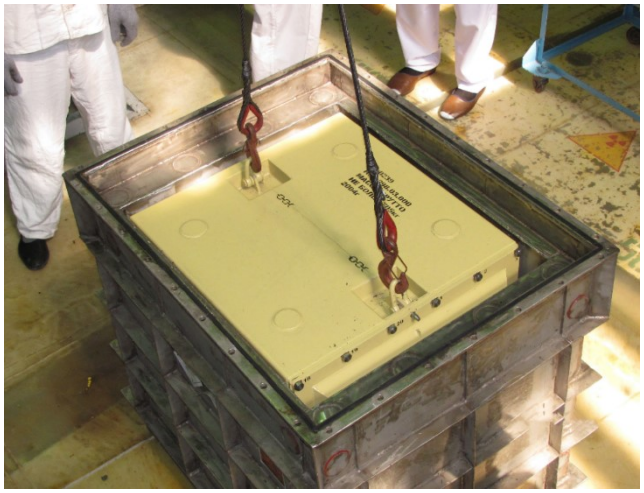




Packaging and Transportation

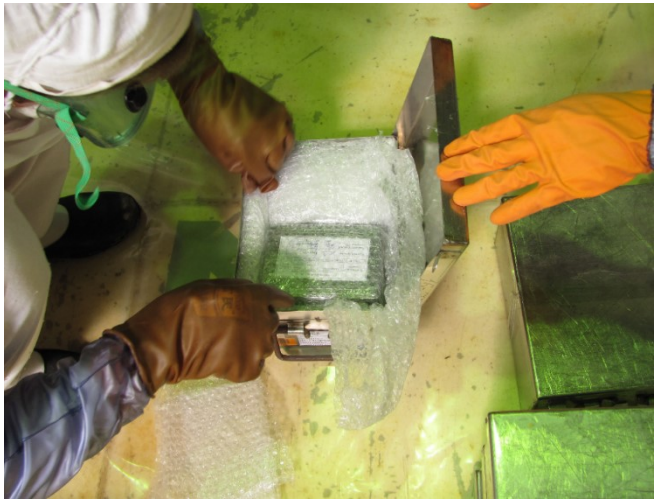


Removal of outer casing lid of TUK-39M1



Removal of internal casing of TUK-39M1

Cells with box-containers for NM in internal casing of TUK-39M1

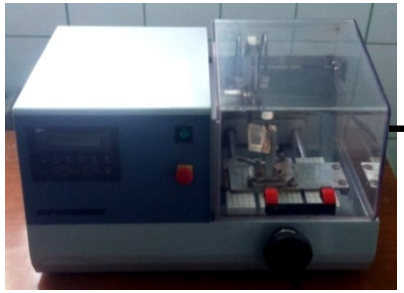


Box-container from TUK-39M1 with two graphite blocks

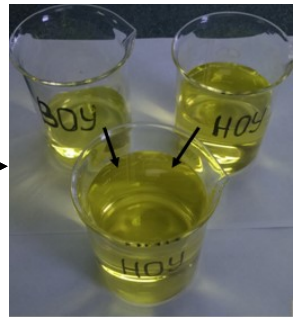
Development of IGR Fuel Down-Blending Technology

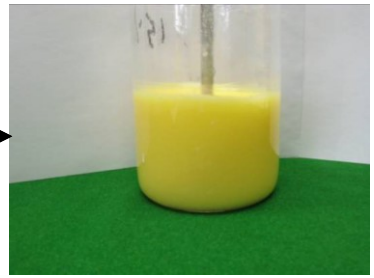
Graphite-HEU blocks down-blending process

Fragmentation and grinding → Temperature oxidation → Dissolution → U_{235} adjustment → Extraction of U → Sedimentation → Calcining → U_3O_8 powder








IGR Fresh Fuel Down-Blending

Временный участок переработки ВОУ.
Short term EUP conversion site.

IGR irradiated fuel

Down-blending and permanent disposition of IGR irradiated fuel

- The irradiated HEU fuel from the IGR reactor which is currently in storage (7 kg of U235) will be down-blended at NNC, Kazakhstan
- NNC just completed a feasibility study on final disposition of the IGR slightly irradiated fuel in Kazakhstan.
- The down-blending technology for irradiated IGR fuel will be developed by NNC and Ulba by the end of next year.
- The same down-blending technology will be used later for IGR spent fuel in the core.

Belarus Spent Fuel Removal
Joint Institute for Power and Nuclear Research

Project Facts:

- Shipment was conducted in October 2010
- 105 intact PAMIR assemblies + 6 canisters of PAMIR / IRT fuel assemblies were shipped (42 kg of HEU)
- 4 SKODA VPVR casks were used for the shipment
- To accept PAMIR reactor spent fuel the reprocessing technology at Mayak was modified.
- 44 kg of fresh HEU Pamir fuel were also removed from Belarus in 2010.

HEU Fresh Fuel in Belarus

- Sosny Institute, Belarus
  - HEU in different forms
  - Up to 90% enrichment

HEU Fresh Fuel Removal from Belarus

- At the present time JIPNR has three main nuclear facilities:
  - Sub-critical assembly Yalina (converted to LEU fuel)
  - Critical assembly Hyacinth (can be loaded with UZrCN LEU fuel)
  - Critical assembly Crystal (HEU fuel was discharged)

- Current activities:
  - Preparations completed for UZrCN LEU fuel irradiation test in the SM-3 reactor in Dimitrovgrad, Russia. The irradiation test will be conducted up to 40% burn-up.
  - Ten UZrCN fuel pellets will be delivered to INL for additional fuel examination in January 2020.
  - Preparations started for modification of the Hyacinth and Crystal critical assemblies at JIPNR-Sosny into fast critical assemblies which will be used UZrCN LEU fuel.

HEU Spent Fuel Removal from Germany

- 191.4 kg of HEU spent fuel are stored in CASTOR MTR2 spent fuel casks at the Ahaus Interim Storage Facility in Germany.
- The HEU fuel elements are from the Rossendorf facility near Dresden.
- The material was packaged in the 18 CASTOR MTR2 casks between 30 May 2005 and 13 June 2005.
- Spent fuel can be shipped to Mayak in three shipments by truck to the German port, then by vessel to the port of Murmansk, and then by rail to the Mayak facility.

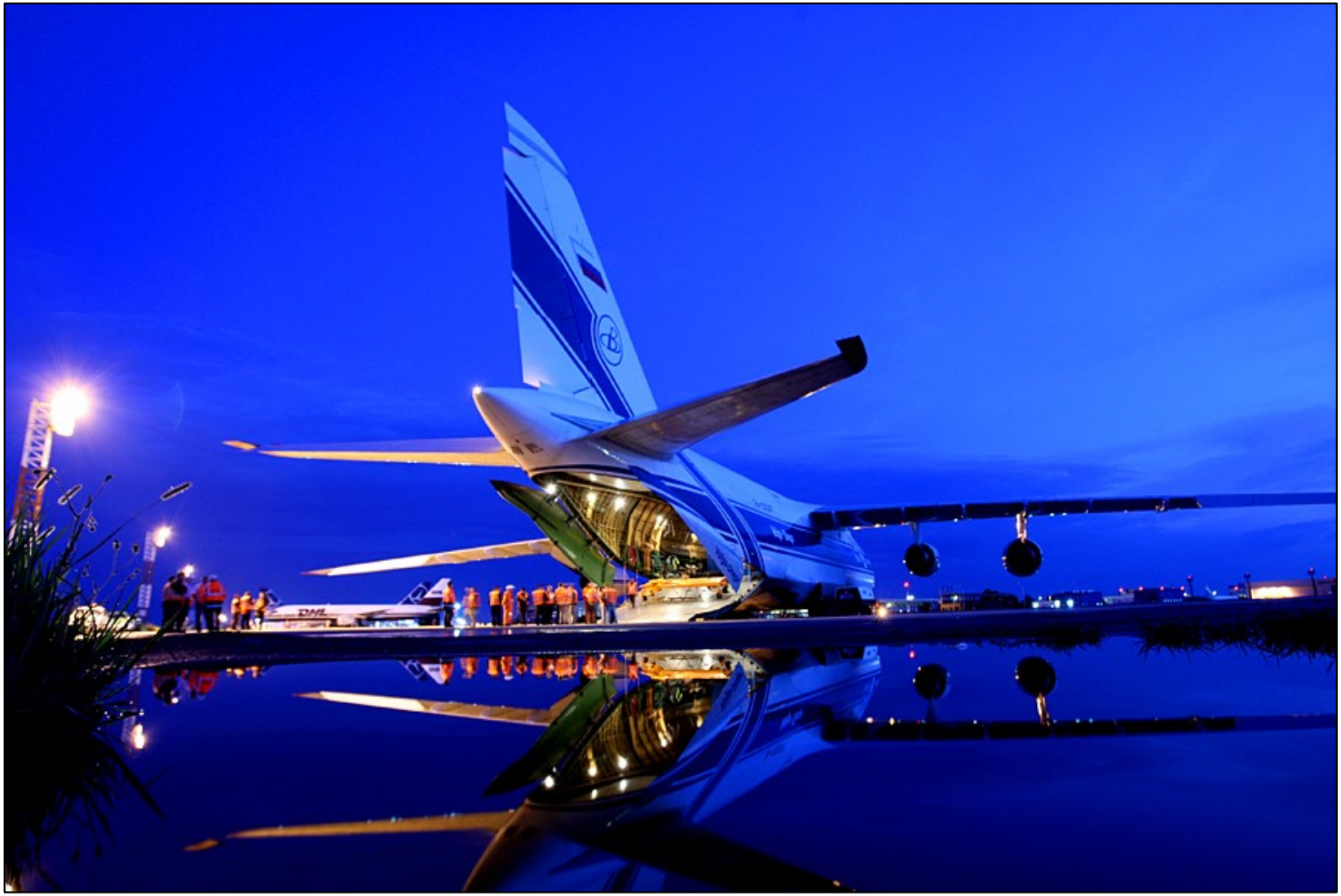
VKTA specialists use a tailored mobile transfer station for transferring the irradiated fuel elements from the storage pond into the CASTOR casks

Russian-origin HEU in China

- China has approximately 1 metric ton of civilian HEU, about 240 kg of which is Russian-origin.
- In 2000 the IAEA DG sent a letter to China proposing to return Russian-origin HEU to Russia. China did not respond.
- The Nuclear Power Institute of China (NPIC) has converted its two HEU research reactors to LEU fuel:
  - The 125 MWt High Flux Experimental and Test Reactor (HFETR) was converted to LEU fuel in 2007.
  - The 5 MWt Min Jiang Test Reactor (MJTR) was converted to LEU fuel in 2007.
- China currently has three research reactors that utilize HEU: the **CEFR Prototype Fast Power reactor**, a Zero Power Fast Critical assembly, and the MNSR reactor in Shenzhen.
- The China Experimental Fast Reactor (**CEFR**) had an initial load of Russian-supplied HEU fuel.

Russian-origin HEU Fuel in DPRK

- The IRT-2000 reactor at the Yongbyon Center, which has a power of 8 megawatts-thermal (MWt), was supplied by the former Soviet Union in 1963.
- The reactor started with 10% enriched fuel and later was converted to 36% and then to 80% enriched fuel.
- Most of the Russian supplied HEU has been fully used.
- In total, about 42 kilograms of Russian-origin HEU are in the irradiated fuel.
- North Korea is not believed to have any fresh Russian-origin HEU fuel.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