

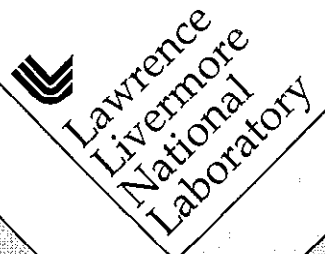
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# U.S. Transparency Monitoring of HEU Oxide Conversion and Blending to LEU Hexafluoride at Three Russian Blending Plants

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# U S. TRANSPARENCY MONITORING OF HEU OXIDE CONVERSION AND BLENDING TO LEU HEXAFLUORIDE AT THREE RUSSIAN BLENDING PLANTS

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## Abstract

The down-blending of Russian highly enriched uranium (HEU) takes place at three Russian gaseous centrifuge enrichment plants. The fluorination of HEU oxide and down-blending of HEU hexafluoride began in 1994, and shipments of low enriched uranium (LEU) hexafluoride product to the United States Enrichment Corporation (USEC) began in 1995. U S transparency monitoring under the HEU Purchase Agreement began in 1996 and includes a permanent monitoring presence

U S transparency monitoring at these facilities is intended to provide confidence that HEU is received and down-blended to LEU for shipment to USEC. The monitoring begins with observation of the receipt of HEU oxide shipments, including confirmation of enrichment using U S nondestructive assay equipment. The feeding of HEU oxide to the fluorination process and the withdrawal of HEU hexafluoride are monitored. Monitoring is also conducted where the blending takes place and where shipping cylinders are filled with LEU product. A series of process and material accountancy documents are provided to U S monitors.

## BACKGROUND

Negotiation of the HEU Purchase Agreement (February 1993) and subsidiary agreements is reviewed by Bieniawski, *et al* [1]. The Agreement called for transparency measures to be implemented, but left specification of the transparency measures to future agreements. The Protocol (March 1994) established a framework of transparency measures and allowed Russia's Minatom to begin processing HEU under the Agreement, however, agreement on Annexes to the Protocol sufficient to allow implementation of transparency measures was not achieved until April 1996 [1,2].

## THE RUSSIAN FLUORINATION AND BLENDING PROCESS

There are three facilities that have been involved with the fluorination and blending of HEU subject to the Agreement. (1) The Ural Electrochemical Integrated Enterprise (UEIP) developed the Russian HEU fluorination and blending process [3] and was Minatom's designated site for all of the fluorination and blending in the initial agreements. The UEIP is Russia's oldest and largest gaseous-centrifuge uranium enrichment plant, and is located at Novouralsk (formerly Sverdlovsk-

44) in the Ural Mountains, north of Yekaterinburg (2) The ElectroChemical Plant (ECP) in Zelenogorsk (formerly Krasnoyarsk-45), Russia, located east of Krasnoyarsk in south-central Siberia, is another of Russia's four gaseous centrifuge enrichment plants. The ECP began receiving HEU oxide from the SChE in December 1995 and began fluorination and blending operations in January 1996 (3) The Siberian Chemical Enterprise (SChE) located in Seversk (formally Tomsk-7)

There are three separate processes

**Fluorination:** The first step is direct fluorination of HEU (90% enrichment) oxide ( $U_3O_8$ ) with fluorine gas at a temperature of a few hundred degrees Celsius, followed by desublimation of solid HEU hexafluoride, and then a resublimation/desublimation cycle for purification purposes, with sampling by desublimation from the primary gaseous HEU hexafluoride stream

**Blending:** The second step is the gaseous blending, at ambient temperature and pressures less than 1 psia, of HEU hexafluoride and 1.5% enriched uranium hexafluoride blend stock, using critical-flow orifices to control the blending ratio. The HEU hexafluoride gas is generated by desublimation from the containers of HEU hexafluoride produced in the fluorination process. The 1.5% enriched blend stock comes directly from holding tanks filled directly from the gaseous centrifuge plant. The diameters of the critical-flow orifices and the uranium hexafluoride gas pressures are chosen to give the proper blending ratio to produce whatever enrichment ordered by USEC, from 3.5% to 5% enriched. The blended product is desublimed from the blending equipment into process cylinders. While the process is conceptually simple, it is complicated by the four-kilometer separation of the blending point from the 1.5% blendstock feed point and the LEU product withdrawal point.

**Product Transfer:** The LEU hexafluoride is melted in the process cylinders, about two metric tons of liquid LEU hexafluoride is poured into an USEC 30B shipping cylinder, and three samples are taken, one for UEIP analysis, one for shipment to USEC, and one for any referee analyses required to settle disputed analyses.

UEIP processing of HEU to LEU began with receipt of the first shipments of HEU oxide from the Siberian Chemical Enterprise (SChE) in July 1994, and the conversion and blending of one metric ton of HEU to LEU in September and October 1994. Then, following placement of USEC's initial order under the Agreement, regular HEU-LEU production began early in 1995, leading to the arrival of the first shipment of LEU from HEU at USEC's Portsmouth Gaseous Diffusion Plant in June 1995.

## IMPLEMENTATION OF TRANSPARENCY MONITORING

The Annexes governing monitoring rights at the fluorination and blending facilities (UEIP, ECP and SChE) allow monitors to observe

- storage of HEU oxide in shipping containers received from the oxidation facilities SChE and MPA, weighing of HEU oxide containers, and inspection of containers and documentation,
- feeding of HEU oxide into the fluorination process, which consists of opening the container and pouring the contents down a chute into the fluorination reactor,
- withdrawal of HEU hexafluoride containers and samples, tare and gross weighing of containers, and inspection of containers,
- weekly inspections of the blending equipment, application of U.S. seals to flow-controlling

orifice plates, reading of HEU hexafluoride and LEU hexafluoride gas pressures to determine mass-flow rates, sampling the three gaseous uranium hexafluoride (HEU and 1.5% LEU inputs, and blended LEU output), and

- installation of filled process cylinders and empty 30B cylinders into the LEU product transfer equipment, sampling, weighing and sealing (with USEC security seals) of filled 30B cylinders and samples, and inspection of cylinders and documentation
- At UEIP, monitors are also allowed to perform blind sampling and analysis of samples taken from the blendpoint piping to confirm the U-235 enrichment of material flowing in these pipes. This procedure can be performed up to four times per year. This method of determining the enrichment of the contents of the pipes is to be replaced by continuous NDA monitoring of the blending facility pipes later this year. This equipment will also be installed at the blendpoint of ECP. The current Agreement also allows such equipment to be installed at the blend area of SChE.

The U.S. monitoring rights also allow for the observation of measurement of flow-controlling orifices and exchange of the orifice plates in the blending facility pipes.

Currently, UEIP no longer receives purified oxide from the oxidation facilities. It currently receives HEU hexafluoride from SChE. Monitoring at UEIP currently is allowed starting from the HEU hexafluoride storage area.

The U.S. Department of Energy opened a Permanent Presence Office (PPO) at Novouralsk, Russia, on August 15, 1996, as permitted by Annex 3 to the Protocol, to monitor HEU-to-LEU processing at the UEIP. The PPO has operated continuously since then, with the exception of a one-month holiday recess in December 1997 and January 1998. Teams of three or four monitors reside in hotel-like accommodations, with an adjacent office, located just outside the closed city of Novouralsk. Monitoring at the UEIP is normally conducted daily, on normal work days, during the daytime shift, although limited off-hours monitoring is also permitted. During the first six months of PPO operation, the permanent presence monitors witnessed the receipt of approximately two metric tons of HEU oxide from the SChE, including 12 containers with U.S. seals which had been applied at SChE during bimonthly U.S. special monitoring visits to SChE [4]. A Permanent Presence Office has contributed greatly to overall confidence that HEU was being downblended to LEU.

One important feature of U.S. monitoring at UEIP has been the use of U.S. portable sodium-iodide detectors for gamma-ray measurements to confirm the enrichment of HEU oxide and hexafluoride in containers. This has added significantly to U.S. confidence that HEU oxide is being converted to HEU hexafluoride, since monitors are able to observe containers documented to contain HEU oxide, some of them with U.S. seals applied under the observation of U.S. monitors at the SChE oxidation plant, take an NDA measurement to confirm that the material in the container was HEU and then watch it be fed to the fluorination process, then later make another measurement to confirm that the material declared to be HEU hexafluoride withdrawn from the fluorination process was indeed HEU.

Another important right, scheduled for implementation in 1998, is the right to install U.S. monitoring equipment in the blending facility to continuously monitor the flow and enrichment of HEU and LEU hexafluoride in the three blending pipe lines. The U.S. equipment designed for this

purpose is described elsewhere [5-7], and should significantly improve U S confidence that the declared quantity of HEU is blended to LEU

## CONCLUSIONS:

Special monitoring of the three blending facilities is taking place. In addition, the Permanent Presence Office at UEIP has been in operation for almost two years. Working relationships between the U S monitors and their Russian plant hosts have been quite good. The good quality of working relationships is a bona fide contributor to overall confidence that the Russian plants are processing HEU as declared.

## REFERENCES

[1] Bieniawski *et al*, this volume

[2] Mastal *et al*, this volume

[3] V F Kornilov, A P Knutarev, G S Soloviev, V V Raev, V V Klimovskikh and S L Tjutrumov, "Method for the Production of Low Enriched Uranium Hexafluoride from Highly-Enriched Metallic Uranium," United States Patent Number 5,492,462, February 20, 1996

[4] Benton *et al*, this volume

[5] Mattingly *et al*, this volume

[6] March-Leuba *et al*, this volume

[7] Wyatt *et al*, this volume

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## **Outline**

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- The Russian down-blending process and sites
- Goal of U.S. transparency monitoring
- U.S. monitoring activities
- The U.S. DOE Permanent Presence Office
- Transparency provides confidence



## Three separate processes



- **Fluorination**
  - Receipt of HEU oxide shipments
  - Loading of HEU oxide into fluorinators
  - Direct fluorination with fluorine gas and desublimation of  $\text{HEUF}_6$  into 6-liter cylinders
  - Withdrawal and weighing of six-liter cylinders
- **Blending**
  - Receipt of HEU hexafluoride shipments
  - Sublimation of HEU hexafluoride from 6-liter cylinders
  - Mixing with 1.5% enriched  $\text{UF}_6$  blend stock
  - Critical-flow orifices and pressure regulation control blending ratio
  - Desublimation of blended product
- **LEU Product Transfer**
  - Liquid transfer from process tanks into USEC 30B cylinders
  - Sampling and weighing of product and samples

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## Goal of U.S. Monitoring at Russian Fluorination and Blending Plants



*To ensure "that the declared quantity of HEU is blended down to low enriched uranium (LEU)"*

- Protocol on HEU Transparency Arrangements, signed March 18, 1994

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## U.S. Monitoring of the Fluorination Process



- 1 - Where HEU oxide is received and stored**
  - Inspect containers, serial numbers, U S and Russian seals
  - Observe weighing and check against shipping documents
  - Observe confirmation of enrichment with U S portable NDA equipment (NaI gamma spectrometer)
- 2 - Where HEU oxide is fed into the fluorination process**
  - Inspect containers, serial numbers, U S and Russian seals
  - Observe feeding of HEU oxide to the fluorination process
- 3 - Where HEUF<sub>6</sub> containers are withdrawn from the fluorination process and stored**
  - Inspect containers, serial numbers, U S and Russian seals
  - Observe weighing and check against shipping documents
  - Observe confirmation of enrichment with U S portable NDA equipment (NaI gamma spectrometer)

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## U.S. Monitoring of the Blending Process



- 1 - Where HEUF<sub>6</sub> is received and stored prior to blending**
  - Inspect containers, serial numbers, U S and Russian seals
  - Observe installation and removal of HEUF<sub>6</sub> containers in feed stations at ECP
- 2 - Where HEUF<sub>6</sub> is blended with 1 5%-enriched blend stock to produce LEU with enrichment ordered by USEC**
  - Observe measurement of critical-flow orifice diameters and installation and sealing, with U S seals, of orifice plates on HEU and blend stock pipes
  - Read gas pressures before and after orifice plates to indicate flow
  - Request and observe sampling of UF<sub>6</sub> gas in pipes with blind analysis in UEIP analytical lab (UEIP only)
  - Future continuous monitoring of enrichment and flow in blending facility pipes by U S monitoring equipment

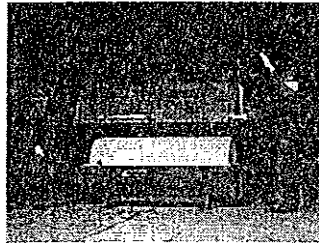
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## U.S. Monitoring of LEU Product Transfer



- Inspect containers, serial numbers, U.S. and Russian seals
- Observe the installation and removal of containers
- Observe the sampling of filled USEC 30B cylinders
- Observe the weighing and sealing, with U.S. and Russian seals, of USEC 30B cylinders and sample containers



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## U.S. Monitoring of Russian MC&A Documents



- **Way Bills for HEU shipments**
  - information for each container and total shipment weights
- **Analytical reports for HEU oxide, hexafluoride and wastes**
  - U purity and  $^{235}\text{U}$  enrichment
- **Analytical reports of  $^{235}\text{U}$  enrichment in blending pipes**
- **Shipping certificates for LEU product**
  - analytical results for U isotopes and impurities vs ASTM spec
  - seal numbers, gross, tare, net and uranium weights
- **Monthly and annual material processing summaries**
  - For each enrichment beginning and ending inventory, amounts received and shipped, amounts into and out of the blending process, and amounts written off as lost

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## Growth of Russian HEU Down-Blending



Year	Plant	HEU Fluorinated	HEU Blended	LEU Shipped	HEU in LEU
1995	UEIP	10	8	186	6
1996	UEIP	7	6	243	7
	ECP	7	7	128	5
1997	UEIP	4	9	179	7
	ECP	8	8	180	7
	SChE	10	5	122	4

- Quantities are in metric tonnes of uranium
- 1995 totals include 1 MT fluorinated and blended in fall of 1994
- 1998 processing at UEIP, ECP and SChE at increased rates

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## Growth of U.S. Monitoring Activities



### 1995

- Familiarization visit leading to implementing Annex at UEIP

### 1996

- 21 weeks of U S monitoring at UEIP
  - » Special Monitoring Visits in February and March
  - » Permanent-presence monitoring started August 15, 1996
- Familiarization visit leading to implementing Annex at ECP

### 1997

- 49 weeks of U S monitoring at UEIP
  - » Permanent-presence monitoring January 1 - December 10
  - » Special Monitoring Visit in February
- Four Special Monitoring Visits to ECP
- Familiarization visit leading to implementing Annex at SChE

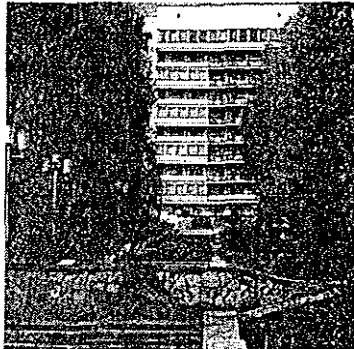
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## U.S. DOE Permanent Presence Office Novouralsk (UEIP), Russia



- 22 months of operation since August 15, 1996
  - » Continuous except for one-month holiday closure
- Staffed by 2-4 U.S. monitors on overlapping two-month assignments



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## Current U.S. Monitoring Activities



### 1998 to date ( through July)

- Monitoring fluorination at ECP and SChE
- Monitoring blending at UEIP, ECP and SChE
- 28 weeks of U.S. monitoring at UEIP
  - » Permanent-presence monitoring from January 15, 1998 through present
- Four Special Monitoring Visits to ECP
- Three Special Monitoring Visits to SChE

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## **HEU transparency builds confidence that the goals of the Agreement are being met**



- **Two years of HEU transparency monitoring**
  - Monitors have noted increased cooperation as both sides gain experience
- **We have confidence that HEU is being blended to LEU**
  - Permanent presence with daily access at UEIP
  - More accessible blending systems at ECP and SChE are assessed during 5-day Special Monitoring Visits
- **Monitoring of HEU fluorination process provides confidence that HEU throughput is consistent with declared quantities of HEU blended**
  - Visual observation of containers and process
  - NDA confirmation of enrichment of HEU
- **Future continuous monitoring of  $UF_6$  enrichment and flow in blending systems will increase confidence**

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