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Dealing with the Legacy of US and Russian Nuclear Defence Programmes - AREVA's Contributions

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Introduction

During more than forty years of US and Russian defence programmes, very large quantities of fissionable nuclear materials were produced. In a broad non-proliferation initiative, the US and Russian governments have entered into various agreements which are fulfilling President Eisenhower's challenge in 1953 to "diminish the potential destructive power of the world's atomic stockpiles" by harnessing the valuable energy content of these potentially dangerous materials and converting them into "abundant electrical energy" supplies.

AREVA was incorporated on 3 September 2001 and is comprised of two core businesses: Nuclear Power and (electrical) Connectors. In 2002, AREVA had total revenues of €8.3 billion: Nuclear Power contributed €6.58 billion and Connectors (through FCI) €1.72 billion. AREVA has over 50 000 employees in more than 30 countries. AREVA has two primary Nuclear Power subsidiaries: COGEMA and Framatome ANP.

AREVA plays a major role in all phases of the nuclear fuel cycle: through COGEMA at both the front end (uranium, conversion and enrichment) and the back end (dry spent fuel storage systems, transportation, reprocessing, recycling and production of mixed oxide (MOX) fuels). AREVA's Framatome ANP is the world's leading company for the design and construction of nuclear power reactor systems (PWR and BWR), and provider of fuel fabrication and engineering and reactor services to operators of nuclear reactors.

Due to the scope of AREVA's activities in the nuclear power arena and the depth of AREVA's technological expertise, the company is uniquely qualified to play a central role in the processing and management of nuclear materials, particularly those made redundant by the United States and Russia following the end of the Cold War.

This Paper describes four programmes in which AREVA is making an important contribution to non-proliferation initiatives by transforming the US and Russian Cold War weapons legacy into useful commercial materials.

The four programs are:

- Purchase of the Russian highly enriched uranium¹ (HEU) UF₆ feed component;
- MOX design and build to treat surplus US weapons plutonium;
- Blended Low Enriched Uranium (BLEU) programme to treat off-specification US HEU; and
- UNH Crystals Program to process US HEU.

HEU Feed Material Purchase Agreement

Background

The history of the Russian HEU deal is long and complex, so only a very brief summary of the events leading to the signing of the commercial HEU natural feed component agreement is provided. The US–Russian Government HEU Agreement evolved from the START I Treaty of 1991, which mandated mutual cuts in the US and Russian strategic weapons delivery systems, with the attendant reductions in weapons stockpiles.

On 18 February, 1993, representatives of Presidents Clinton and Yeltsin signed an agreement that provided for Russia to sell 500 tonnes of HEU to the United States over a 20 year time period beginning in 1993. In May 1993, certain principles were agreed upon between US Department of State and MINATOM for the purchase and sale of HEU, including an understanding that Russia would blend the HEU to low enriched uranium² (LEU) assay of 4.4 w/o U²³⁵ suitable for commercial power reactors.

On 14 January, 1994, the United States Enrichment Corporation (USEC) and Techsnabexport (TENEX), as executive agents for the United States and Russia respectively, concluded a commercial contract to implement the HEU Agreement over a 20 year period. Under the terms of the implementing contract, USEC purchases the enrichment portion of the Russian LEU and sells it to its customers. USEC transfers to TENEX a quantity of natural uranium equal to the natural uranium component of the LEU.

Initially, the Government HEU Agreement included purchase of the natural uranium component as well as the SWU. But according to a 1993 amendment to the US-Russia Suspension Agreement related to dumping of Russian uranium, restrictions were placed on Russian imports into the US, including the sale of the HEU feed component. The USEC Privatization Act, dated 26 April 1996, set out

¹ HEU is uranium that has been enriched 20 w/o U²³⁵ or greater

² LEU is uranium that has been enriched to less than 20 w/o U²³⁵

a schedule of annual quotas for HEU feed and limited USEC's role as executive agent to purchase of just the enrichment component.

Due to a prolonged period of historically low uranium prices during the 1990's, and to limited open demand for uranium, especially in the United States, it was extremely difficult for the Russians (TENEX and affiliates) to sell the HEU feed component delivered at USEC.

Prior to 1997, the US government made two substantial purchases of HEU feed material to support the US-Russian Government HEU Agreement to avoid inflicting severe damage on the uranium and domestic conversion industry, but without any clear means of selling the material into the commercial market. The lack of a predictable revenue stream for the Russians from the HEU feed threatened to unravel the entire deal.

HEU Feed Material Purchase Agreement

With the sale of the HEU feed component in limbo, AREVA/Cogema and two other companies involved in the supply of uranium (Cameco and RWE Nukem) entered into protracted negotiations with TENEX beginning in 1997 and ending in early 1999. The discussions eventually culminated in an agreement on 24 March 1999 among Cameco, COGEMA, RWE Nukem and TENEX, providing for purchase of the HEU feed component from TENEX by the three so-called Western Companies.

The 1999 commercial agreement with TENEX granted the Western Companies exclusive options to purchase quantities of up to 70% of the annual feed component under defined pricing conditions. Under an important amendment to the HEU feed material Agreement, on 26 November, 2001, the Western Companies agreed to convert the options into firm commitments to purchase quantities of natural uranium at least equal to their respective US quota allocations each year from 2002 through 2013.

In total, the Western Companies agreed to buy from TENEX about 60% of the HEU uranium feed component delivered to TENEX during the period 1999-2013. The 40% of the feed component retained by TENEX is sold by TENEX or returned to Russia as part of a monitored inventory in Russia, or it is used for dilution of HEU.

AREVA's contribution to the US-Russian HEU Government Agreement

To date, the Western Companies have agreed to purchase approximately 60 000 tonnes U as UF₆. The quotas for AREVA from 2002 to 2013 are approximately 20 400 t U. These firm purchase commitments will guarantee predictable revenue to the Russian Federation and provide predictable supplies to the Western Companies.

It is important to mention that the HEU feed purchases will be supported by AREVA's commercial activities in Europe, requiring from now to the end of the contract in 2013, significant physical flows of natural UF₆ from North America to Europe. We believe that European customers will also support this important

non-proliferation initiative through commitments to purchase HEU feed material from AREVA.

Prospects for HEU Feed Purchases

From AREVA's perspective, the continued success of the programme will depend on AREVA's ability to effectively market the HEU feed component:

- To help secure the entire HEU agreement, thus decreasing the proliferation risks associated with surplus military grade material inventories, and
- To maintain a stable uranium market allowing existing mines to survive and possibly competitive new mines to be developed.

US Mixed Oxide Fuel Fabrication Facility

Background

The United States and the Russian Federation signed a bilateral agreement in September 2000 committing both countries to reductions in nuclear weapons stockpiles. The United States and Russia each agreed to dispose of 34 tonnes of surplus weapons plutonium, leading to two parallel projects, one in the US and one in Russia.

One way to dispose of surplus military plutonium is to capture the energy potential of the plutonium by converting it into MOX fuel and to irradiate the fuel in commercial power reactors. The resulting spent fuel would ultimately be placed safely in a geologic repository.

MOX is a nuclear fuel containing about 95% uranium oxide and 5% plutonium oxide and has been used routinely in many European plants since the end of the 1960's.

In May 1998 the US Department of Energy (DOE) issued a "Request for Proposals" for the conversion of its surplus weapons grade plutonium into commercial MOX fuel assemblies.

Three nuclear industry leaders - the Duke Energy Group, COGEMA Inc. and Stone & Webster - joined forces to respond to the request, forming the DCS (Duke COGEMA Stone & Webster) LLC. DCS was awarded a contract by DOE in March 1999.

Scope of programme

The scope of the US MOX project includes the design and construction of a facility in the United States to dispose of surplus military (weapons grade) plutonium. DOE contracted with DCS for full-scope services from DCS, including:

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- design, licensing, construction, operation and deactivation of a MOX fuel fabrication facility (MFFF);
 - design and qualification of the commercial MOX fuel assemblies; and
 - irradiation of the MOX fuel in commercial nuclear plants.

The MFFF will be owned by the US government and will be located at the DOE Savannah River Site (SRS) in South Carolina. The life cycle project cost is estimated to be US\$2.2 billion.

The MOX fuel will be irradiated in Duke Power's McGuire and Catawba nuclear reactors in North and South Carolina. The plant will be regulated by the US Nuclear Regulatory Commission and be subject to safeguards verification by the International Atomic Energy Agency.

AREVA's contribution

AREVA participates in the project through two of its subsidiaries: COGEMA, Inc., a member of the DCS consortium, and Framatome ANP, Inc., one of the major subcontractors to the project.

COGEMA is a world leader in design, construction and operation of MOX fuel fabrication facilities. It has operated the very successful Melox facility in Marcoule (France) since 1995. Melox is the facility on which the design for the US and Russian MFFFs is based. As a member of the DCS team, COGEMA, Inc. provides the MOX facility expertise, bringing to bear the unique qualifications of COGEMA's Treatment, Recycling, Engineering, Logistics, Mechanics and Information Services business units.

Duke Engineering & Services (DE&S) and Framatome ANP, Inc. were both subcontractors to DCS at project inception. With the merger of DE&S into Framatome ANP, Inc. last year, Framatome ANP, Inc. is now responsible for:

- providing the MOX fuel design, based on its extensive experience with US power reactors; and
- contributing to the design, licensing and operation of the MFFF.

Progress to date

DCS submitted an "MFFF Construction Authorization Request" to the NRC in February 2001 and has since then answered a number of requests for additional information from NRC. The Construction Authorization is expected in the fall of 2003.

The Final Design of the MFFF is about 85% complete. The DCS team is looking forward to the completion of the design phase and to undertaking construction of the facility.

In December 2002, DOE and MINATOM (the Russian Ministry for Atomic Energy) agreed to replicate the MFFF in Russia, but with the design adapted to Russian specifications. The Russian project will be developed in parallel with the US MFFF; financing is being finalized.

Project status

The overall schedule of the US MOX project is currently being re-evaluated to maintain concurrency with the Russian MOX project.

Blended Low-Enriched Uranium Project

Background

In 1995, the US government declared as surplus 174 tonnes of highly enriched uranium (HEU) from its nuclear weapons programme, including about 40 tonnes of uranium referred to as “off-specification”, which does not meet "commercial grade" criteria.

In July 1996, the US DOE issued the Disposition of Surplus Highly Enriched Uranium Final Environmental Impact Statement (EIS) Record of Decision (ROD) that considered alternatives for disposition of the surplus HEU. The ROD stated that the surplus HEU should be down-blended to LEU, and to the extent practicable, its economic value should be recovered by using the LEU as reactor fuel.

In 1997, the DOE and Tennessee Valley Authority (TVA) agreed to pursue a joint programme to investigate the use of “off-spec” HEU as a source of low-enriched uranium for TVA’s reactors.

The off-specification HEU material was characterised and detailed analyses of the constituents reported by the DOE’s HEU Disposition Program Office in June 1998:

U²³⁵ enrichment averaging between 55 and 66 w/o,
U²³⁶ content between 20 and 28 w/o,
U²³⁴ content less than 1.3 w/o, and
U²³² content as high as 20 ppb.

The off-specification material can be down-blended with fresh natural uranium to lower the enrichment of the HEU from 55-66 w/o U²³⁵ to less than 5 w/o U²³⁵, and also to reduce the other constituents (U²³⁶, U²³⁴, U²³²) to acceptable levels.

In April 2001, an interagency agreement between the DOE and TVA for the Off-Spec Fuel Project was finalized; the US government Savannah River Site (SRS) was authorized to participate in the down-blending programme; and contracts between TVA, AREVA’s Framatome ANP, Inc. and Nuclear Fuel Services (NFS) were concluded to process 33 tU of HEU, by blending it to assays suitable for nuclear fuel, initially for TVA's Browns Ferry nuclear plants.

The turnkey project includes design, construction, licensing, operation, and decommissioning of facilities dedicated to the Blended Low-Enriched Uranium programme called "BLEU".

AREVA's Role in the BLEU Programme

DOE's surplus HEU materials will be down-blended by NFS in Erwin, Tennessee, and by SRS in South Carolina. NFS and SRS will each process approximately one-half of the off-spec HEU materials currently released to the BLEU Programme. 16 tU of HEU will be treated by solvent extraction and blended at SRS and 17 tU of HEU will be down-blended (some also purified by SX) at NFS.

Framatome ANP, Inc. will receive the equivalent 33 tU of DOE HEU supplied in the form of down-blended low enriched uranyl nitrate (LEUN) solution from SRS and NFS.

Framatome ANP, Inc. is responsible for the design, construction and operation of the BLEU Conversion Complex (BCC) which consists of a 240 000 gallon Uranyl Nitrate Storage Building, Oxide Conversion Building and effluent treatment facilities, all located on NFS property.

LEUN will be gradually withdrawn from the storage tanks and converted into UO₂ powder in the adjacent Oxide Conversion Building. Process effluent will be treated and prepared for transfer and subsequent burial as low level waste at the designated DOE Nevada Site.

The UO₂ powder produced by the BLEU conversion complex will be shipped, as it is produced, to the Framatome ANP, Inc. manufacturing facility in Richland, WA and will be stored until needed to produce a reload fuel batch. The UO₂ powder will be prepared and pressed into fuel pellets in a dedicated facility at Richland.

Project Status

- The LEUN storage facility is complete and receiving uranyl nitrate shipments from SRS.
- The oxide conversion facility is under construction and will begin producing UO₂ powder in the summer of 2004.
- Pellet production and fuel-assembly fabrication will begin in late 2004. The first reload of fuel-assemblies will be delivered to the TVA by mid-January 2005.

The BLEU Programme provides a cost effective method for utilizing surplus HEU as fuel in TVA's commercial reactors and for DOE avoiding the substantial disposal cost by other methods.

Annual deliveries of fuel assemblies will continue for about 12 years, containing approximately 462 t U of BLEU pellets – enough for 10 to 12 fuel reloads – over the project life of approximately 15 years.

Uranyl Nitrate Crystals Programme

Background

In conjunction with the privatisation of USEC, 50 tU of the 174 tU of HEU identified by the US Government as surplus weapons materials was transferred by DOE to USEC.

USEC contracted with BWXT to down-blend this HEU material to feed acceptable for commercial nuclear fuel fabrication activities. The process at BWXT results in down-blended material in the form of uranyl nitrate hexahydrate (UNH) crystals. The blended crystalline product must meet American Society for Testing and Materials (ASTM) commercial uranium specifications.

Since the HEU material provided to BWXT varied somewhat in composition, the level of down-blending required to meet commercial ASTM specifications results in various final isotopic assays. Typically the UNH crystals are classified as low assay (nominally 2.75 w/o U^{235}) or as high assay (nominally 4.00 w/o U^{235}) materials.

AREVA's Role in the UNH Programme

AREVA's role in the UNH crystals programme, through Framatome ANP, Inc., includes receiving and storing the UNH material, verifying weights and material assays, and converting the material to UO_2 powder meeting Framatome ANP's internal UO_2 powder specifications.

UNH crystals contained in specialized transportation packages are delivered by truck to the Framatome ANP, Inc. Richland, WA facility with each truck shipment containing approximately one tonne of uranium.

Under contract with USEC, Framatome ANP, Inc. is substituting UNH crystals in lieu of standard uranium hexafluoride (UF_6) gas feedstock for part of the production of UO_2 powder at Richland. This is being achieved by dissolving the UNH crystals in water and subsequently employing the wet (ammonium diuranate, or ADU) conversion process at the Richland facility to produce powder.

The ADU process is currently employed for waste recycling activities at Richland, since the dry conversion process introduced in 1998 has become the primary production process for UO_2 powder.

To facilitate successful implementation of the UNH crystals programme at Richland, Framatome ANP, Inc. converted an existing warehouse for storage of the UNH material, performed detailed criticality analyses to permit safe handling and storage of the materials, and designed special handling and dissolution

systems. The receipt and use of the UNH crystals along with UF₆ gas feedstock must be properly coordinated to ensure product quality is maintained and contract commitments are met.

Project Status

The UNH crystals programme contract began in 2000 and consisted of two phases:

- During Phase 1, methods and procedures were established to receive, store, and initially process 25 tU of UNH crystals. Phase 1 of the programme was completed in December 2000.
- During Phase 2, which began in July 2001, Framatome ANP, Inc. will receive an additional 250 tU of crystals for processing over a five period.

This programme is operating smoothly and, through close cooperation with USEC and BWXT, additional efficiencies are anticipated. Over the five year project life Framatome ANP, Inc. will have received and processed UNH crystals material equivalent to two full BWR cores.

Conclusions

Given AREVA's prominent position throughout the nuclear fuel cycle, perhaps it was inevitable that AREVA would find itself playing a central role in the disposition and management of weapons materials. We are proud to be participating in these non-proliferation initiatives, which in a very tangible way are responding to President Eisenhower's challenge in 1953 to "diminish the potential destructive power of the world's atomic stockpiles."