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THE RUSSIAN URANIUM ENRICHMENT INDUSTRY TODAY AND TOMORROW

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Russian approach to the development and implementation of centrifuge enrichment technology

The industrial centrifuge technology in Russia has been under development for over 40 years.

It is well-known that separative power of the centrifuge machine is determined by the circular speed of the rotor=s outer wall and by the length of the working chamber of the rotor (Slide 1).

$$E = \alpha V^n L$$

At the maximum, the value of n is equal to 4, but in reality this value depends on the parameters of the internal gas dynamics in the rotor. Under the high circular speed of the outer wall of the rotor, the value of n approaches 2. Considering this fact, it is clear that an increase in the circular speed of the outer wall of the rotor is always a more effective way to increase separative power than an increase of the length of the centrifuge machine. This is why Russian designers have opted for the creation and development of sub-critical centrifuge machines with multi-layer positioning of those machines in an aggregate unit containing 20 machines each (Slide 2).

In order to achieve a high circular speed of the rotor, it is necessary to use materials that have a high unit strength in the tangent direction, and a high unit rigidity in the axis direction. As progress in development of such materials has been achieved, development of the Russian centrifuge machines has followed along with other technology advances such as improvement of the supporting bearings, electrical connectors as well as the system of technological control.

There are seven generations of the sub-critical centrifuge machines that have been developed over the years (Slide 3).

The separative power of a single centrifuge machine has increased approximately 8 times while the costs per separative work unit ("SWU") have decreased approximately 6 times without changes in size of the 20-unit aggregate machine assembly.

The comprehensive system of quality control of the raw materials, components, manufacturing process and operation of the gas centrifuge machines, as well as a

system of technical control during the entire life of these machines, was developed in Russia. These systems have allowed the Russian enrichment industry to achieve an exceptionally high durability of the gas centrifuge machines. Operational life has been extended from 10 years for the first generation machines to 25-30 years for the machines of the later generations.

The initial multi-layer design of the 20-machines aggregate unit is being kept and these aggregate units are situated in the manufacturing buildings also in multi-layered fashion. This design allows for the replacement of aggregate units equipped with gas centrifuges of the older generation with gas centrifuges of the latest generation, while keeping all technological utilities as well as structural elements, such as supporting columns, intact. As a result, capital costs of the machine replacement is kept down while the new generations of the Russian centrifuge machines are being installed. Along with such replacement, there is a constant upgrade and modernization of the energy support and automatic control systems. These measures are aimed at increasing the durability of the overall operations.

Utilization of the Russian uranium enrichmnet capacity

At the present time, there are three generations of gas centrifuge machines operating at four enrichment facilities, which are parts of the Ministry of Atomic Energy of the Russian Federation (AMinatom@). These are the fifth, sixth and seventh generation centrifuge machines. The installed enrichment capacity is approximately 20 million SWU which is allocated between the four facilities as follows (in %) (Slide 4):

UEIP, Novouralsk	-	48
ECP, Zelenogorsk	B	29
SCP, Seversk	B	14
AEIP, Angarsk	B	9

Russian share of world installed enrichment capacity is nearly 35% (Slide 5) including 76% of the world gas centrifuge capacity.

In the year 2000, practically all Russian enrichment capacity was used for the production of fuel for Russian built nuclear reactors (including those in Russia, CIS and in Eastern Europe), SWU and EUP export and fulfilment of the HEU agreement. Therefore, at present the existing installed enrichment capacity of Minatom is fully utilized.

Outlook for the future

Future development of enrichment capacity in Russia is fully determined by the prospective development of the nuclear generation industry. The beginning of the new century has seen a positive change in the public perception toward nuclear energy.

Together with the previously announced strategy for development of nuclear energy in the Asia-Pacific region, Russia adopted a specific program in 2000 titled AStrategy for Development of the Nuclear Energy in Russia in the First Half of the XXI Century.@ That program calls for increasing the installed capacity of nuclear power plants 1.5 times by 2010, and doubling it by 2020.

In November 2000, the European Commission approved the Green Book titled ATowards a European Strategy for the Security of Energy Supply.@ That program supports the development of the next generation of nuclear reactors.

There are some positive developments related to the nuclear energy in the US. There is a growing opinion that maintaining nuclear energy in the US is not only a viable option but rather a vital part of US energy and environmental policy. In May 2001, President Bush announced a comprehensive energy plan that promotes dependable, affordable and environmentally sound production and distribution of energy for the future. Vice President Cheney called for a change in public perception toward nuclear energy in his appearance on MSNBC news channel on March 21, 2001.

In August 2000, the Ministry chamber of Minatom of Russia considered and then adopted a basic program titled AModernization of the enrichment capacity for the period of up to 2010.@ The program sets the following main goals for the Russian uranium enrichment industry (Slide 6):

1. Securing supply of nuclear fuel for domestic Nuclear Power Plants to achieve goals set by the program for development of the Nuclear Energy Industry of the Russian Federation for the period of up to 2010;

2. Implementation of Minatom=s obligations under the Agreement signed between the Governments of the Russian Federation and the United States of America concerning the disposition of highly enriched uranium extracted from nuclear weapons (HEU Agreement);

3. Strict fulfillment of all existing and future contracts to supply uranium enrichment services and low enriched uranium to foreign customers. Such export material will be in full compliance with the applicable international quality standards.

The achievement of these main goals will be possible through the replacement of the aging fifth generation machines with the new and effective gas centrifuge machines of the seventh generation. In practice, such modernization process has been ongoing since the end of 1997. These four years of experience in operating the first modernized units, which are equipped with the seventh generation centrifuges, shows that the designer=s estimations and operation personnel=s expectations for the new gas centrifuges= effectiveness and durability have been fully justified.

The modernized units have twice the separative capacity of the fifth generation machines with practically the same operating costs. This means that per unit operating costs for the new units have decreased two times. The program for development of the uranium enrichment capacity of Minatom of Russia considers continuation of the scientific-research and design-test work aimed at creation of the gas centrifuge machines of the next generation, including a switch to the super-critical centrifuge machines, while keeping existing dimensions of the 20-machines aggregate unit.

We are confident that centrifuge technology is far from exhausting its potential to increase the effectiveness of enrichment facilities, and the overall uranium enrichment business. Therefore, this technology will continue to increase competitiveness of the nuclear generation industry.

There is also research that is being conducted in Russia focused on laser uranium enrichment technology. We believe that this work should be continued in order to develop a technology alternative to the centrifuges for the years after 2030-2040.

Thank you for your attention.