THE CURRENT STATE OF THE RUSSIAN REDUCED ENRICHMENT RESEARCH REACTORS PROGRAM

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SUMMARY

The report presents the current state of the Russian reduced enrichment research reactors program.

During the last year after the 16-th International Conference on Reducing Fuel Enrichment in Research Reactors held in October, 1993 in Oarai, Japan, the conclusive stage of the Program on reducing fuel enrichment (to 20% in U-235) in research reactors was finally made up in Russia.

The Program was started late in 70th and the first stage of the Program was completed by 1986 which allowed to reduce fuel enrichment from 80-90% to 36%.

The completion of the Program current stage, which is counted for 5-6 years, will exclude the use of the fuel enriched by more than 20% from RF to other countries such as: Poland, Czeck Republick, Hyngary, Roumania, Bulgaria, Libya, Viet-Nam, North Korea, Egypt, Latvia, Ukraine, Uzbekistan and Kazakhstan.

In 1994 the Program, approved by RF Minatom authorities, has received the status of an inter-branch program since it was admitted by the RF Ministry for Science and Technical Policy.

The Head of RF Minatom central administrative division N.I.Ermakov was nominated as the Head of the Russian Program, V.G.Aden, RDIPE Deputy Director, was nominated as the scientific leader.

The Program was submitted to the Commission for Scientific, Technical and Economical Cooperation between USA and Russia headed by Vice-President A.Gore and Prime Minister V.Chernomyrdin and was given support also.

The Secretary of US Department of Energy Mrs. H.O'Leary has noted in her letter addressed to the Minister for Atomic Energy Mr. V.N.Mikhailov that "A joint effort by the United States and Russia to minimize the use of HEU in civil reactors would help implement one of the key objectives of the January 14, 1994 Summit Joint Statement on Nonprolifiration... We believe this is a promising area for U.S.-Russian cooperation in nonprolifiration".

In his reply Mr. V.N.Mikhailov has expressed his gratitude to Mrs. H.O'Leary for the support rendered to the proposals on developing cooperation between US DOE and Minatom of Russia in the field of reducing fuel enrichment in research reactors.

Working contacts were maintained on the problem of reduced enrichment with Argonne National Laboratory.

A group US specialists visited Russia in November, 1993 aiming at getting familiar with Russian institutes potentialities to implement the Program. The specialists have visited Research and Development Institute of Power Engineering (RDIPE) in Moscow, All-Russia Scientific Research Institute Inorganic Materials (VNIINM) in Moscow, Novosibirsk Plant of Chemical Concentrates (NZHK) in Novosibirsk, RDIPE Ekaterinburg Branch in Zarechny, Sverdlovsk Region, Machinery building Plant, (MSZ) in Electrostal, Moscow Region. The Russian and American parties have presented a number of scientific and technical reports which demonstrated the achievements in the development of high density fuel (UO_2, U_3Si, U_3Si_2, U-Zr-Nb, U_6Fe), technology for manufacturing fuel elements and fuel assemblies as well as possibilities of fuel elements and fuel assemblies reactor tests and their post-reactor studies under RDIPE Ekaterinburg Branch conditions.

Sharing opinion between Russian and US specialists enabled to specify some propositions of the Russian Program.

The Program final stage content, which will take place during 5-6 years is briefly presented below.

Having in mind a necessity to switch the research reactors as soon as possible to the fuel with 20% enrichment in U-235 the Program stipulates three principle stages in the work:

- develop fuel elements and assemblies of the VVR-M2, IRT-3M, MR types with fuel based on uranium dioxide but with higher uranium density in comparison with the one reached so far;
- develop high density fuel;
- develop fuel elements and fuel assemblies of the VVR-M5, IRT-3M, IVV-10 types with high density fuel.

Such a structure of the Program is aimed at the first stage at switching the research reactors to 20% enriched fuel with the use of uranium dioxide. Then as the high density fuel is being developed it will be possible to replace in some reactors the fuel based on uranium dioxide with the high density fuel, that will allow to improve experimental possibilities of the reactors in service.

It is substantial that the works under all three stages are being carried out in parallel.

The first stage of the Program envisages implementation of the below basic works.

Development of design:

- develop working design documentation on fuel elements and assemblies models in the first turn for reactor service life time tests and ampule devices to study fuel, as well as for tests on determining design limits for fuel elements damage in emergency modes;
- issue a quality assurance program;
- carry out thermal-hydraulic and neutronics calculations of reactor cores under normal and transient conditions.

Development of technology:

- develop a fabricational steps to manufacture of fuel elements;
- develop and manufacture tools;
- technological experiments using a high density compound with uranium dioxide under factory conditions;
- develop techniques and equipment to ensure fuel elements quality monitoring.

In-pile tests:

- develop a program for in-pile tests, technical justification on tests safety and a program on postirradiation examinations;
- manufacture fuel elements and assemblies models for in-pile tests;
- carry out in-pile tests and postirradiation examinations;
- investigations to determine fuel elements destruction threshold energy;
- study the behavior of exposed and unexposed fuel elements as similating severe accidents.

Development of core technical design:

- justify the taken decisions;
- issue the core technical design materials;
- issue materials on safety analysis and justification.

Organization of production:

- fabricate test samples of fuel elements and assemblies, carry out factory tests and tests for reception, organization of their production;
- fabrication of fuel elements and assemblies for two demonstration-type cores.

Trial operation of two demonstration cores.

The second stage of the Program stipulates implementation of the following general works:

- analyze the results of the own investigations previously fulfilled, foreign information on high density fuel, choose fuel types for further investigation;
- assess fuel swelling and determine alloying additions stabilizing fuel crystal structure;
- fabricate fuel samples and compositions on their basis;
- investigate their physical, mechanical and technological characteristics;
- study interactions in the "fuel-coolant" system under pre-reactor and reactor conditions;
- run in-pile tests and postirradiation examinations;
- analyze test and examinations results, choice of fuel.

The third stage of the Program covers the following key works.

Development of design materials including thermal-hydraulic and neutronics calculations of cores in stationary and emergency modes.

Development of technology:

- issue a quality assurance program;
- work out a technology process to fabricate fuel granules;
- organize a test allotted work to fabricate fuel;
- fabricate fuel granules;
- work out a fabricational steps to manufacture fuel, calculate technological parameters, develop and manufacture tools, carry out technological experiments on fabricating fuel elements under industrial conditions;
- create technology and organize a test allotted work to reprocess fuel production wastes;
- develop techniques and equipment to monitor fuel elements quality.

In-pile tests:

- develop a program on in-pile tests, technical justification of tests safety and a program postirradiation examinations;
- fabricate fuel elements and assemblies models for reactor service lifetime tests and for tests aimed at determining fuel elements design-basis destruction limits in accident modes;
- carry out reactor and post-reactor investigations;
- investigate the behavior of exposed and unexposed fuel elements as imitating severe accidents.

Issue materials on core technical projects.

Organization of production:

- fabricate fuel elements and assemblies test samples, carry out factory and formal acceptance tests, organization of their production.

Develop a program to transport fuel from the countries having reactors built with the ex-USSR assistance.

The following works have already been fulfilled by the present time:

- working design documentation on fuel elements and assemblies models with fuel based on uranium dioxide has been developed;
- a test ampule fuel assemblies design has been worked out;
- preliminary thermohydraulic and neutronics calculations have been made;
- according to the Program, fabrication steps for manufacturing fuel elements have been developed at the first stage, technological conditions have been calculated and tools developed and ordered; the first technological experiments for fabricating fuel elements of the IRT- and MR-types have been carried out;
- there have been made analyses and preliminary selection of high-density fuel type such as U_3Si (x%Al), U_3Si (x%Nb, y%Zr), U_3Si_2, U+x%Zr+y%Nb, U_6Fe.

The preliminary neutronics calculations have shown that to maintain the same extent of the reactor fuel burnup as the one of the fuel with 36% enrichment in uranium-235 when uranium dioxide with 20% enrichment ~~in~~ uranium-235 is used as fuel, some design changes need to be made in the existing fuel elements. These changes mainly concern the thickness of fuel elements cladding and fuel meat.

To reduce the nomenclature of fuel elements produced by the plant-producer (NZHK) there have been decided that fuel assembly of the IRT-2M type should be excluded from the Program and that only fuel assembly of the IRT-3M type should be developed. These fuel assemblies have equal external dimensions, however a fuel assembly of the IRT-3M-type has much more developed surface for heat transfer (by a factor of 1.8), which allows either a higher reactor power or a larger thermal reserve.

To provide for necessary loading of uranium-235 the thickness of fuel elements in the IRT-3M fuel assembly has been increased. The thickness of cladding remains unchanged.

For technological reasons the maximum density for uranium was taken to be up to about 4 g/cm^3. It means that if the density of UO_2 is equal to 10.2 g/cm^3, than the volume fraction of uranium dioxide in fuel element core does not exceed 40%.

The first fuel elements of the MR and IRT types have been fabricated.

It is necessary to mention that this Program may be optimized in the course of its implementation. The full completion of the entire program depends on the amount of funds which may be allocated for the Program.

In conclusion it would be desirable to note that Russian Program has been given support at the governmental level. At present the matters of interaction between RF Minatom and US DOE within the framework of the Program in are under consideration of the Commission on Scientific, Technical and Economical Cooperation.