# Current Status and Future Trends of the Russian RERTR Program

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# Topics

- Introductory remarks
- Current status of the program; main directions of the work
- International co-operation
- Nearest tasks and future trends

# The Russian RERTR Program

**The Program started at the end of 70's**

***The final goal of the program was formulated as:***

***to minimize and in perspective to eliminate using of HEU in fuel elements and assemblies that supplied to foreign research reactors with the minimum of penalties for the experimenters***

# The Russian RERTR Program

- Later officials, scientists and engineers have begun political and scientific discussion about reducing enrichment in Russian domestic reactors
- Also later the return of fresh and spent HEU fuel was an important objective of our work

# Features of the Russian RERTR Program

- Practically only one material are used for the fuel meat - uranium dioxide
  - In aluminum matrix
  - In copper matrix (in high-flux reactor SM)
- Tube type of fuel elements is the main type though in Russia there several research reactors that use pin type elements

# International Co-Operation

**Joint Statement Secretary Abraham and Minister Rumyantsev**

**September 16, 2002**

**"…one of the important area of joint co-operation that could lead to reduction of HEU is:**

**.**

**work on accelerated development of LEU fuel for both Soviet-designed and United States-designed research reactors"**

# Current Status

## *Basic directions of the work:*

- **The completion of the development of the fuel elements and assemblies on a basis of traditional fuel type - uranium dioxide**
- **The development of the fuel on a basis of U-Mo alloy**
- **The development of pin type fuel elements on a basis of uranium dioxide and U-Mo alloy**

# The main types of fuel assemblies manufactured at JSC NCCP for research reactors built-up according to the former USSR projects:

## VVR-M2

three- tube FA with external FE of hexahedral cross section.

Consumers – **Hungary, Ukraine, Vietnam**

## IRT-2M (3M)

four (eight)-tube FA with FEs of box section.

Consumers – **Uzbekistan, Czech Republic**

## MR

six-tube FA with FE of round section with inner rib.

Consumer– **Poland**

# Current Status:
# works on uranium dioxide

- Fuel assemblies of **WWR-M2** type with LEU were developed and qualified for foreign research reactors that use such type of fuel assemblies;

- These assemblies are ***ready*** for the supply to several operating foreign research reactors and reactors that are planned now for construction

MINATOM of RUSSIA

# Current Status: works on uranium dioxide

- Fuel assemblies of IRT-4M type with LEU were developed and irradiated in the reactor in Uzbekistan;

- At the end of this year these assemblies will be qualified and also will be ready for the supply to foreign research reactors

# Current Status:
# works on uranium dioxide

**The development of fuel assemblies of MR type on the base of uranium dioxide was not successful despite of several attempts to increase the density of dioxide in the fuel meat**

# Current Status:
# Works on U-Mo Fuel

**Main players in the development of U-Mo fuel for research reactors in Russia:**

On the traditional Russian tube type fuel – tube type fuel - **RDIPE, NCCP, and IPPE;**

On the development of pin type fuel – **VNIINM and NCCP** in collaboration with the **U.S. RERTR program**

# Development of U-Mo fuel

- Uranium-molybdenum alloys for the application in the nuclear industry were developed in Russia by the A.A.Bochvar Institute – VNIINM at the end of 50th years
- These alloys were successfully used in the First Nuclear Power Plant in Obninsk and in the Bilibino Nuclear Power Plant
- The fuel in these reactors was the uranium - molybdenum alloy (with 9% of molybdenum) dispersed in a magnesium matrix

# Development of U-Mo fuel

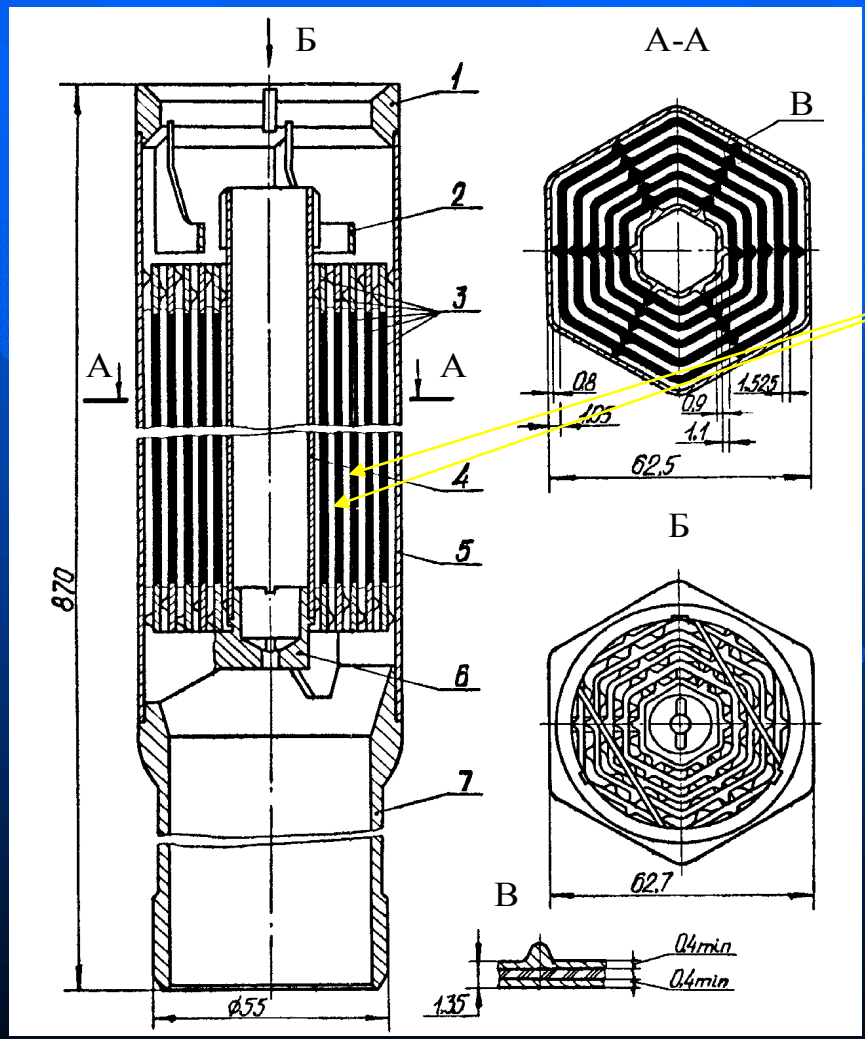
- Alloys of the system U-Mo are well enough investigated in Russia;
- An additional purposeful researches of the alloys developed earlier is necessary to adapt these alloys for to use in fuel elements of research reactors;

# Development of U-Mo fuel

- The development of U-Mo fuel continues in two directions:
  - traditional tube type fuel elements;
  - new pin type fuel elements;
- The full scale elements and mini pins were developed and are fabricated

# IVV-2M type fuel assembly with two inner experimental fuel elements (U-Mo)

## *(fabricated by NCCP and IPPE)*




Experimental fuel elements

# Irradiation Tests

- In the period from October 31, 2001 to April 21, 2002, the irradiation tests of two combined fuel assemblies was carry out in the reactor IVV-2M of the Sverdlovsk Branch of RDIPE (now it is the Institute of Reactor Materials)
- The tests were carried out up to planned average burnup in the experimental fuel elements of 40% and 60% respectively

# Results of postirradiation examinations of IVV-2M experimental FA

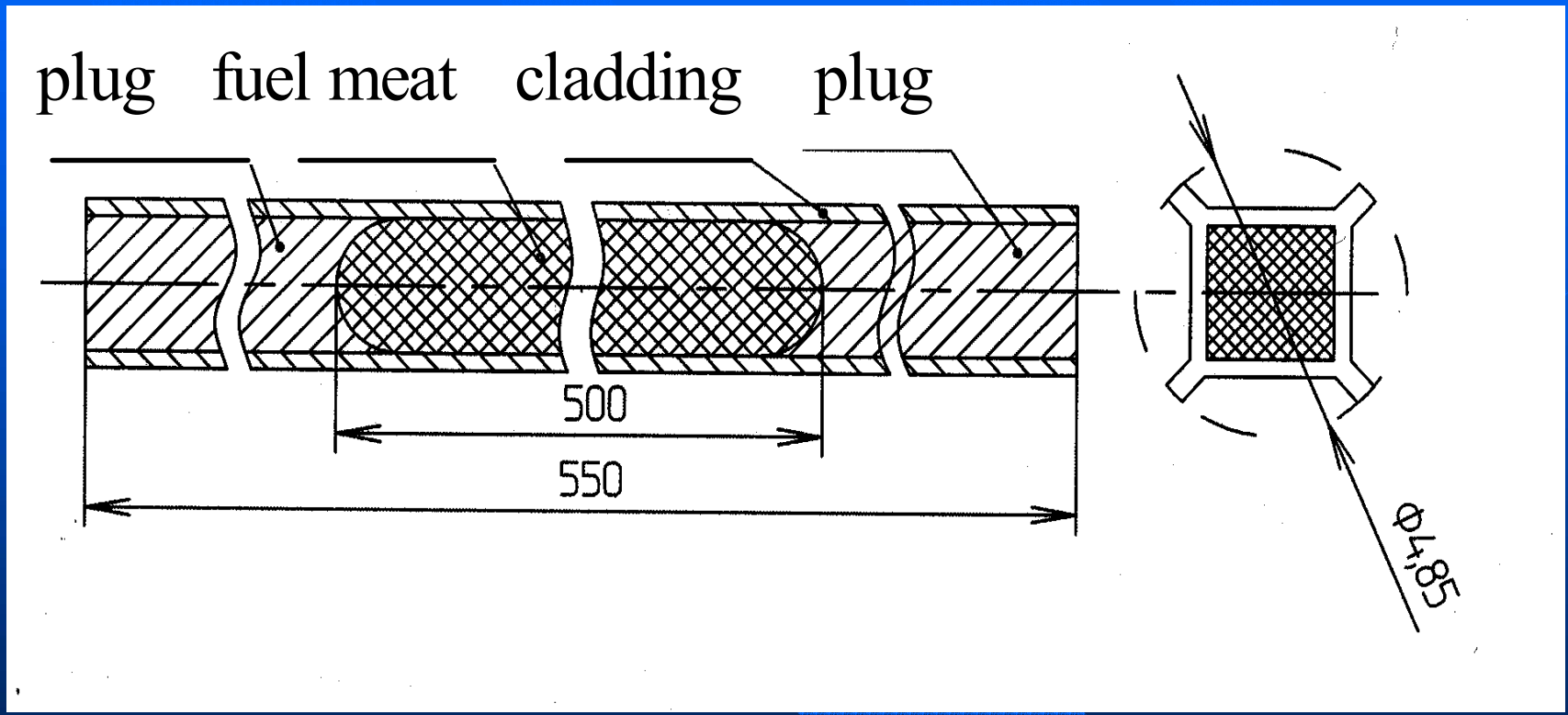
***Conclusion of the expert group that was investigated irradiated fuel elements***

**The results of analysis of the activity of the coolant and leaktightness tests of the experimental fuel element with burnup of 40% *do not suggest precise conclusion* about evident loss of tightness of the U-9%Mo alloy based fuel elements**

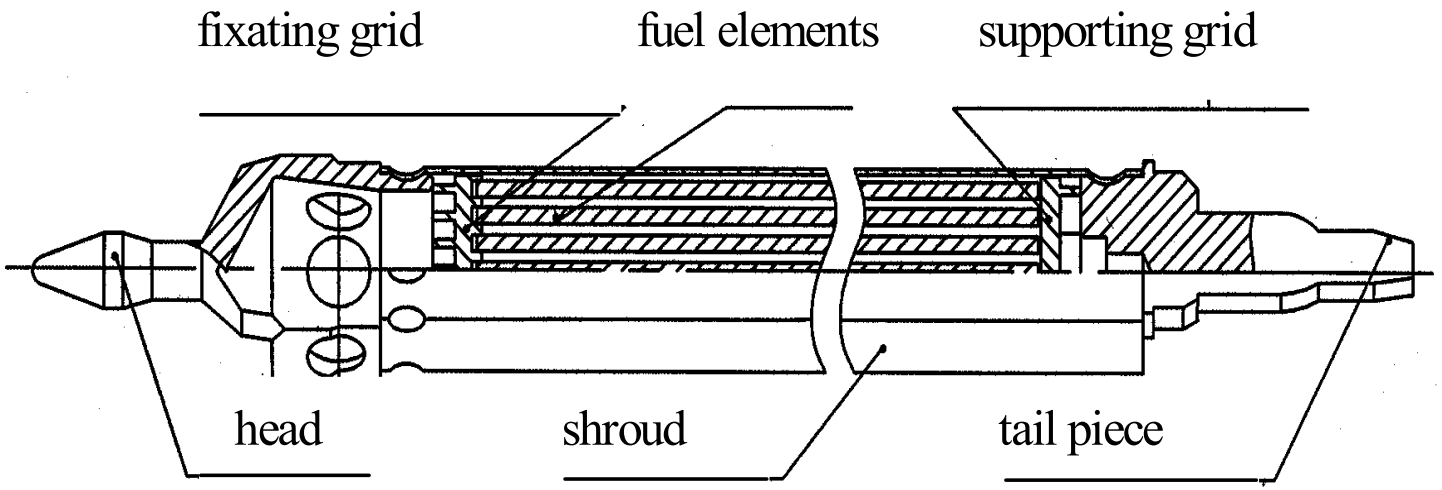
# Pin Type Fuel

- The technology of the fabrication of pin type fuel elements was developed
- The experimental fuel elements and asssemblies are fabricated
- Irradiation tests are begun

# Pin Type Fuel Element

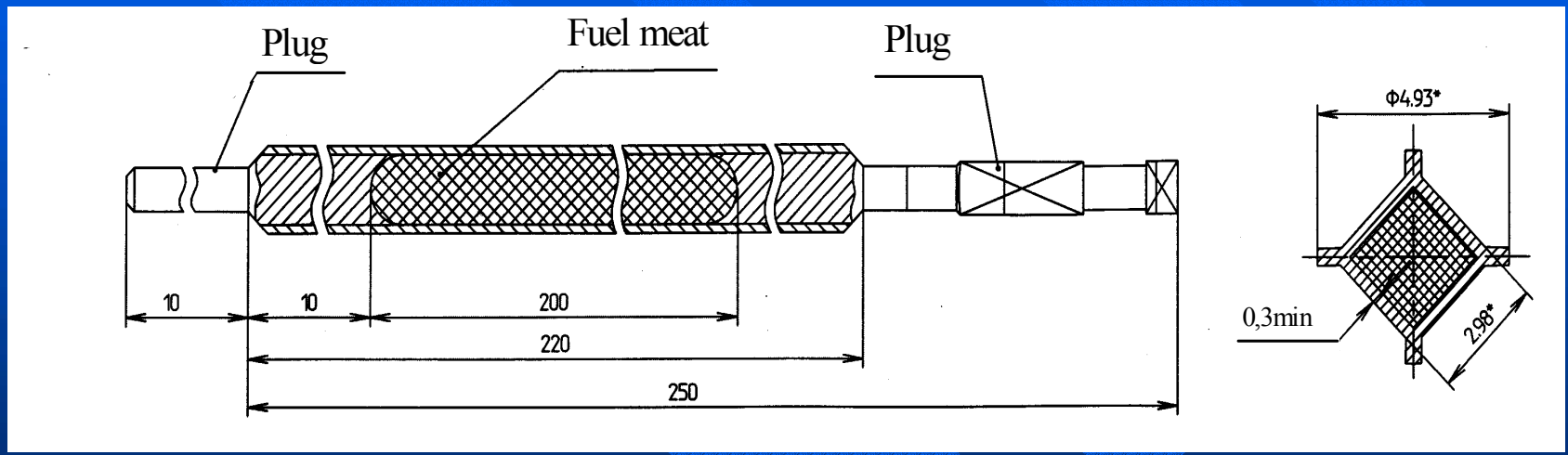


# Fuel Assembly of VVR type with uranium dioxide and U-Mo fuel *(fabricated by VNIINM and NCCP)*



# Pin type mini-fuel element

## *(fabricated by VNIINM)*



# Irradiation Tests

- Irradiation tests in reactors WWR-M and MIR of pin type fuel elements and assemblies are begun recently (reports will be presented at next sessions of the Meeting)

# Domestic Reactors

- Several domestic Russian research reactors such as WWR-M, IR-8, MIR, PIK and others were investigated from the point of view of reducing of enrichment;
- There is an intensive discussion about possible ways of reducing enrichment;
- The international co-operation is the important stimulus during this discussion

# Shipment of fresh and spent HEU from foreign research reactors to Russia

- Problems of the repatriation of the fresh and spent HEU fuel from foreign research reactors do not concern directly to the RERTR program but these tasks are very closely connected with each other;
- Unfortunately at the start of the program the sufficient attention was not paid on this problem; by this reason now it is necessary to apply significant efforts to decide it;

# Shipment of fresh and spent HEU from foreign research reactors to Russia

- There are more than 20 sites in Eastern European countries, former Soviet republics and another countries that have big amount of Russian origin HEU in fresh and spent form;
- The new Russian legislation opens the possibility for the shipment of SNF to Russia for temporary storage and reprocessing of the fuel; this year practically all so-called under law acts were signed by the Government of Russia

# Fuel Repatriation to Russia

- First result of international cooperation in the field of repatriation of research reactor HEU from foreign countries to Russia was achieved in August 2002 when the fresh fuel from research reactor in Yugoslavia was shipped to Russia for the safe storage and subsequent blending;
- In September 2003 the fresh fuel from Romania was shipped to Russia where the fuel will down-blended and used for nuclear power plant fuel fabrication

# Future Plans
# Nearest Goals

- Conversion of reactor in **Uzbekistan** and shipment of SNF from the site of this reactor to Russia
- Return of fresh and spent fuel from sites of foreign research reactors; first successful results are important but the main amount of fuel is not in the fresh form but in the spent form
- Continuation of investigations of the possibility of conversion of Russian domestic reactors to LEU

# Future Plans

## Nearest Goals

### Dioxide fuel

## Qualification of IRT-4M fuel assemblies

# Future Plans

## Nearest Goals

### U-Mo fuel

**postirradiation tests of fuel elements in FA of IVV-2M type with 60% burnup**

# Future Plans

## Nearest Goals

## U-Mo fuel

This year the Novosibirsk Chemical Concentration Plant will fabricate two full scale fuel assemblies of IRT-3M tube type with fuel U-9%Mo+Al of 19.7 % enrichment of U - 235 and the density of U in the fuel meat – 5.4 g/cm$^3$ for the irradiation tests in research reactors

# Future Plans

## U-Mo fuel

**It is contemplated that the qualification of the tube type fuel elements IRT-3M and fuel assemblies IRT-3M with the U-Mo fuel will be accomplished in 2006**

# Future Plans

## U-Mo fuel

**The irradiation of a full-sized U-Mo pin-type fuel assembly containing 5.3 g U/cm$^3$ is scheduled to begin this year in the reactor WWR-M and be completed in the 2006.**

# Future Plans

Irradiation of mini rods with fuel meat densities of 4 and 6 gU/cm$^3$ and containing both atomized and HD powders were began this year in the MIR reactor at Dimitrovgrad; following the end of the irradiation in 2004 and a suitable cooling period, postirradiation examinations will be performed.

# Future Plans

- Development of MR type fuel assemblies on the base of U-Mo fuel
- Study of other aspects of elimination of the use of HEU in research reactors

# CONCLUSION

- The Russian RERTR program was created 25 years ago and during these years Minatom of Russia actively supported program despite of many difficulties
- Successes of the program deal with development of the fuel on the base of uranium dioxide but this fuel has reached the definite limit and work on the development of this fuel will be finished in coming years;

# CONCLUSION

**US DOE-RF MINATOM co-operation have an important role in the progress of the program both in the development of new fuel elements and assemblies and in the import of fresh and spent fuel of research reactors to Russia**

# Best congratulations on the case of XXV anniversary of the RERTR Program!