STATUS AND PROGRESS OF THE RERTR PROGRAM IN THE YEAR 2003*

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ABSTRACT

One of the most important events affecting the RERTR program during the past year was the decision by the U.S. Department of Energy to request the U.S. Congress to significantly increase RERTR program funding. This decision was prompted, at least in part, by the terrible events of September 11, 2001, and by a high-level U.S./Russian Joint Expert Group recommendation to immediately accelerate RERTR program activities in both countries, with the goal of converting all the world's research reactors to low-enriched fuel at the earliest possible time, and including both Soviet-designed and United States-designed research reactors.

The U.S. Congress is expected to approve this request very soon, and the RERTR program has prepared itself well for the intense activities that the "Accelerated RERTR Program" will require.

- Promising results have been obtained in the development of a fabrication process for monolithic LEU U-Mo fuel. Most existing and future research reactors could be converted to LEU with this fuel, which has a uranium density between 15.4 and 16.4 g/cm^3 and yielded promising irradiation results in 2002. The most promising method hinges on producing the monolithic meat by cold-rolling a thin ingot produced by casting. The aluminum clad and the meat are bonded by friction stir welding and the cladding surface is finished by a light cold roll. This method can be applied to the production of miniplates and appears to be extendable to the production of full-size plates, possibly with intermediate anneals. Other methods planned for investigation include high temperature bonding and hot isostatic pressing.

- The progress achieved within the Russian RERTR program, both for the traditional tube-type elements and for the new "universal" LEU U-Mo pin-type elements, promises to enable soon the conversion of many Russian-designed research and test reactors. Irradiation testing of both fuel types with LEU U-Mo dispersion fuels has begun. Detailed studies are in progress to define the feasibility of converting each Russian-designed research and test reactor to either fuel type.

The plan for the Accelerated RERTR Program is structured to achieve LEU conversion of all HEU research reactors supplied by the United States and Russia during the next nine years. This effort will address, in addition to the fuel development and qualification, the analyses and performance/economic/safety evaluations needed to implement the conversions.

In combination with this over-arching goal, the RERTR program plans to achieve at the earliest possible date qualification of LEU U-Mo dispersion fuels with uranium densities of 6 g/cm^3 and 7 g/cm^3. Reactors currently using or planning to use LEU silicide fuel will rely on this fuel after termination of the FRRSNFA program, because it is acceptable to COGEMA for reprocessing. Qualification of LEU U-Mo dispersion fuels has suffered some unavoidable delays but, to

accelerate it as much as possible, the RERTR program, the French CEA, and the Australian ANSTO have agreed to jointly pursue a two-element qualification test of LEU U-Mo dispersion fuel with uranium density of 7.0 g/cm^3 to be performed in the Osiris reactor during 2004.

The RERTR program also intends to eliminate all obstacles to the utilization of LEU in targets for isotope production, so that this important function can be performed without the need for weapons-grade materials.

All of us, working together as we have for many years, can ensure that all these goals will be achieved. By promoting the efficiency and safety of research reactors while eliminating the traffic in weapons-grade uranium, we can prevent the possibility that some of this material might fall in the wrong hands. Few causes can be more deserving of our joint efforts.

INTRODUCTION

This will be a special meeting for the RERTR program. It was just over twenty-five years ago that the program started, and this is the twenty-fifth time that scientists from many countries come together to exchange information about their activities related to the program and to coordinate their efforts. A quarter of a century marks an important milestone for the program, and encourages us to reflect on the meaning of what we do, on the progress that we have jointly accomplished, on friendships started long ago, and on what we should do next. Largely for this reason, it is appropriate to hold this year's meeting in Chicago, where the entire effort began, and where the first meeting of the program was held twenty-five short years ago. Much has changed during this time, both in the program and in Chicago, but I believe that you will agree with me that some things have not changed. A picture of that first RERTR meeting of long ago still hangs in my office and several people depicted in that picture are here today, somewhat older and much wiser, but sharing with the more recent members of our team the same spirit of excitement and determination to succeed that they had at that first meeting.

The RERTR Program was established in 1978 at the Argonne National Laboratory (ANL) by the Department of Energy (DOE), which continues to fund the program and to manage it in coordination with the Department of State (DOS) and the Nuclear Regulatory Commission (NRC). The primary objective of the program is to develop the technology needed to minimize and eventually eliminate use of high-enriched uranium (HEU) for civilian applications worldwide. Most of the civilian HEU is used in research and test reactors, and the RERTR program concentrates on the use of low-enriched uranium (LEU) in these reactors, instead of HEU, and on making the conversion feasible without significant penalties in experiment performance and in economic or safety aspects.

Close cooperation with international organizations has been the cornerstone of the RERTR Program since its beginning. This cooperation and the high quality of the technical contributions that many partners have brought to the overall effort are to be credited for much of the progress that the program has achieved.

Just like the RERTR program, Chicago and Argonne National Laboratory have grown more mature, bigger, and more diverse, during the 25 years that have passed since that first meeting. I hope that you will appreciate and enjoy these changes. I also hope that all of you, including those who can remember the program and the city from many years ago and those whose memories are more recent or are visiting here for the first time, will find that Chicago and ANL are friendly and exciting places to be and that they, as well as the RERTR program, welcome you with open arms.

OVERVIEW OF THE PROGRAM STATUS IN 2002

By November 2002, when the most recent International RERTR Meeting was held [1], many important results had been achieved in the fuel development area:

1. The qualified uranium densities of the three main fuels which were in operation with HEU in research reactors when the program began had been increased significantly with LEU (UAl_x-Al, from 1.7 g/cm^3 to 2.3 g/cm^3; U_3O_8-Al from 1.3g/cm^3 to 3.2 g/cm^3; and $UZrH_x$, from 0.5 g/cm^3 to 3.7 g/cm^3). A new LEU fuel type, based on U_3Si_2-Al had been developed, qualified, and licensed [2] with uranium densities up to 4.8 g/cm^3. This fuel type had been widely accepted and was fabricated routinely for more than twenty research reactors by several international fuel fabricators.

2. The effort to develop new advanced LEU fuels with higher effective uranium loadings had been restarted in 1996 after a pause of about six years. Five batches of samples (RERTR-1, -2, -3, -4, and -5), each containing 32 microplates formed with a variety of promising fuel materials, had been irradiated between 1997 and 2001 in the Advanced Test Reactor (ATR) in Idaho. Postirradiation examinations of these samples had indicated very promising behavior of U-Mo alloy particles dispersed in an aluminum matrix, with Mo content between 6% and 10% and uranium densities up to 8-9 g/cm^3. Two RERTR-4 miniplates, containing monolithic LEU U-Mo fuel with uranium density of 15.6 g/cm^3 and irradiated to up to 75% burnup, had yielded excellent preliminary results.

3. The back-end of the research reactor fuel cycle had become a very important issue for research reactor operators. While reprocessing studies at the Savannah River Site (SRS) had concluded in 1983 that the RERTR fuels could be successfully reprocessed there, these results had been rendered moot by the end of reprocessing operations at SRS and by the expiration of the Off-Site Fuel Policy at the end of 1988. A Record of Decision [3] had been issued in 1996 for a new DOE policy allowing, until May 2009, the return of spent research reactor fuel elements of U.S. origin irradiated before May 13, 2006. Implementation of this policy through the U.S. Foreign Research Reactor Spent Nuclear Fuel Acceptance (FRRSNFA) Program had been very successful. By November 2002, 4,576 MTR elements had been received at SRS and 961 TRIGA elements had been received at INEEL under that program, for a total of 5,537 elements.

4. Many reactors using or planning to use LEU silicide fuel intended to have their spent fuel reprocessed after termination of the FRRSNFA Program, but the closure of the UKAEA Technology reprocessing plant at Dounreay, U.K., had created a potential problem. The COGEMA plant in La Hague, France, which was the main remaining site where research reactor fuel could be reprocessed, had indicated that, unlike Dounreay, it could not accept silicide fuel. Thus, development and qualification of LEU U-Mo fuel, which COGEMA had indicated it could accept, had become deeply intertwined with the back-end of the research reactor fuel cycle.

5. Qualification of LEU U-Mo dispersion fuel with uranium densities of up to 6 g/cm^3 was planned to occur through irradiation of test elements fabricated by BWXT using atomized powder produced by KAERI. Beginning of elements irradiation in the HFR-Petten, originally scheduled to occur in the spring of 2001, had been postponed to late 2003 because of problems linked to patents obtained by KAERI in 1999-2000 and covering the use of spherical U-Mo particles in research reactor fuels. BWXT was to fabricate two elements with uranium density of 6 g/cm^3, with approximately half of the plates containing spherical powder and the rest containing comminuted powder produced by AECL. Two other LEU U-Mo dispersion fuel elements with uranium density of 7 g/cm^3 were to be fabricated by the CNEA using both spherical powder and hydride/dehydride powder produced by the CNEA. Irradiation of these four elements in the HFR-Petten was expected to begin in September 2003 and qualification was expected in October 2005. These qualification activities were planned to occur in close cooperation with a parallel French fuel development program [4] concentrating on the qualification of LEU U-Mo fuel with uranium density of 8 g/cm^3.

6. The feasibility of using LEU instead of HEU in fission targets dedicated to the production of ^{99}Mo for medical applications had been the object of intensive studies for several years. Procedures had been developed for dissolution and processing of both LEU silicide targets and LEU metal foil targets, and for both acidic and basic processes. In particular, four metal foil targets of a new annular design had been irradiated at BATAN, showing that (1) aluminum can be used for target tubes and (2) uranium foils with nickel, zinc, or aluminum fission-recoil barriers can be removed from the target. The acidic chemical process to be used in combination with this target had been demonstrated and was ready for a final test to be conducted at BATAN. However, this final demonstration was on hold because of the international situation caused by the September 11, 2001, attacks.

7. Extensive studies had been conducted, with positive results, on the performance, safety, and economic characteristics of LEU conversions. These studies included many joint study programs for about 41 reactors from 23 countries.

8. The end of the Cold War had enabled a new cooperation between the RERTR program and several Russian institutes with the goal of converting to LEU many Russian-designed research reactors still operating with HEU. Active cooperation with various components of the Russian RERTR program was in progress and included conversion studies, safety analyses, fuel development, and fuel tests needed to establish the technical and economic feasibility of converting Russian-supplied research and test reactors to the use of LEU fuels. Irradiation of LEU UO_2-Al fuel assemblies in the WWR-M reactor at the Petersburg Nuclear Physics Institute in Russia had been concluded successfully and several analytical studies had been conducted to investigate the feasibility of converting to the use of LEU fuels a number of HEU research reactors of Russian design.

9. Thirty-eight HEU research reactors had been converted to LEU fuels, or were in the process of converting. In addition, LEU fuels were planned for the new Ongkharak TRIGA reactor in Thailand, the new MAPLE1 and MAPLE2 reactors in Canada, the new Jules Horowitz Reactor in France, the new China Advanced Research Reactor in China, and the new Replacement Research Reactor in Australia.

10. The events of September 11, 2001, had changed greatly the importance assigned by the U.S. Government to the goals of the RERTR program and the urgency with which those goals were to be pursued. On September 16, 2002, following up on the conclusions reached by Presidents Bush and Putin at their May 2002 Summit meeting, U.S. Secretary Abraham and R.F. MINATOM Minister Rumyantsev had issued a joint statement [5] announcing that their Joint Expert Group had recommended that both countries should commit themselves to the "accelerated development of LEU fuel for both Soviet-designed and United States-designed research reactors." The RERTR program had prepared and submitted to the Department of Energy proposals, plans, and schedules consistent with this recommendation.

PROGRESS OF THE RERTR PROGRAM IN 2003

The main events, findings, and activities of the RERTR Program during the past year are summarized below.

1. Consistent with the greater emphasis of the U.S. Government on non-proliferation goals caused by the September 11, 2001, attacks and with the September 16, 2002, joint statement by U.S. Secretary Abraham and R.F. Minister Rumyantsev of a recommendation to accelerate "development of LEU fuel for both Soviet-designed and United States-designed research reactors," the U.S. Department of Energy requested Congress to authorize and appropriate a significant increase in RERTR program funding. This additional funding, amounting to approximately 50% of existing RERTR funding, is to be used for the "Accelerated RERTR Program" and to be assigned to tasks strictly related to the conversion of U.S.-designed and R.F.-designed research reactors for which adequate LEU fuels are not yet available. The U.S. Congress has not yet completed work on the bill appropriating the funding requested for the Accelerated RERTR Program, but it is expected to do so very soon at the end of the ongoing Continuing Resolution. Meanwhile, the RERTR program has prepared itself for the many activities required by the accelerated program.

2. Monolithic LEU U-Mo fuel, contained in two miniplates that were irradiated with promising results to up to 75% burnup in RERTR-4, is considered to be the most promising fuel material for conversion of several U.S.-designed research reactors that cannot be converted today. The same fuel can also be used, with some fabrication modifications, in the conversion of Russian-designed research reactors. Therefore, a large fraction of the 2003 RERTR fuel development effort was dedicated to the development of a fuel fabrication process that could be used to produce fuel elements containing monolithic U-Mo. Since the very different ductilities of U-Mo and aluminum preempt co-rolling and co-extrusion of meat and clad, this effort was divided in two separate tasks: production of the monolithic fuel meat and metallurgical bonding of the aluminum clad to the fuel meat.

3. After testing several alternative processes, a promising method to produce monolithic U-Mo fuel meat for fuel plates with the desired characteristics was developed [6]. This method is based on casting of thin ingots, followed by cold rolling. This method is suitable for the production of miniplates and appears to be extendable to the production of full-size fuel plates with the possible addition of intermediate annealing steps.

4. Also after testing several alternative processes, a promising method[6] to bond an aluminum clad to a monolithic U-Mo meat was developed. This method is based on the use of friction stir welding (FSW), followed by a light cold rolling pass. Alternative methods that are

planned to be explored further are based on high temperature bonding and on hot isostatic pressing (HIP).

5. Efforts to qualify U-Mo dispersion fuels with uranium densities in the 6-7 g/cm^3 range have continued. There are encouraging signs that the problems caused by the patents issued to KAERI and covering any use of spherical U-Mo particles in research reactor fuels will be resolved soon in a manner consistent with RERTR goals, but meanwhile the program continues to pursue qualification of fuel plates containing both spherical and non-spherical powders. The spherical particles were produced by KAERI, and the non-spherical particles are being produced by AECL by comminution and by CNEA by the hydride-machine-dehydride (HMD) method[7]. Production difficulties have slowed powder production at AECL and shipping difficulties have slowed powder production at CNEA. It now appears that both types of non-spherical powders will be produced by November, 2003. This means that the data needed to qualify this fuel type through irradiations in the HFR-Petten reactor will become available around the end of 2006.

6. To compensate at least in part for this slippage, the RERTR program, the French Commissariat à l'Énergie Atomique (CEA), and the Australian Nuclear Science and Technology Organization (ANSTO) have agreed to jointly pursue a two-element qualification test of LEU U-Mo dispersion fuel with uranium density of 7.0 g/cm^3 to be performed in the Osiris reactor during 2004. Contracts are currently being negotiated to fund this work.

7. Interpretation of irradiation results of U-Mo dispersion fuels was based in the past on the assumption that the interaction phase between U-Mo particles and aluminum matrix was a mixture of $(U\text{-}Mo)Al_3$ and $(U\text{-}Mo)Al_4$. However, this assumption cannot account for all the aluminum known to be present in the miniplates of the RERTR-2 and RERTR-3 tests. More detailed examination [8] of the experimental data, and additional experimental data provided by the CEA, have provided strong evidence that the interaction phase contains $(U\text{-}Mo)Al_7$, a previously unexpected compound that is very rich in aluminum. The formation of this new compound has been included in the PLATE [9] and DART [10] codes, and has resulted in much better agreement between the results of these codes and the experimental RERTR-2 and RERTR-3 results.

8. Cooperation with various components of the Russian RERTR program has continued [11]. The WWR-M LEU UO_2-Al tube-type fuel with uranium density of 2.5 g/cm^3 that was successfully irradiated in the WWR-M reactor at the Petersburg Nuclear Physics Institute (PNPI), is now qualified for use in four Russian-designed research reactors. Fuels under development for conversion of the other Russian-designed research reactors concentrate on the use of LEU U-Mo dispersion fuel. Seventy-two mini-elements of the "universal" LEU U-Mo pin-type fuel design[12] developed by the A. A. Bochvar Institute for Inorganic Materials (VNIINM) are currently under irradiation in the MIR-M1 reactor [13] at the Russian Institute of Atomic Reactors (RIAR), Dmitrovgrad, and one full-size assembly of the same fuel type is under irradiation testing at PNPI [14]. A second full-size assembly containing UO_2 dispersion fuel is also being irradiated at PNPI for comparison purposes. A tube-type design, developed by the Novosibirsk Chemical Concentrates Plant (NZChK) has been irradiation-tested in the IVV-2M reactor in Zarechniy and post-irradiation examinations are in progress. Both fuel types are candidates for irradiation testing in the WWR-SM reactor in

Uzbekistan. Extensive calculations and evaluations have been performed to study the applicability of both fuel types to the conversion of Russian-designed research reactors. [15, 16]

9. Significant progress was achieved on several aspects of producing ^{99}Mo from fission targets utilizing LEU instead of HEU. This activity is conducted in cooperation with several other laboratories including the Indonesian National Nuclear Energy Agency (BATAN), the Argentina Comisión Nacional de Energía Atómica (CNEA), MDSN/AECL/SGN (Canada), and the Australian Nuclear Science and Technology Organization (ANSTO). The final demonstration planned to take place at BATAN is still on hold because of the international situation, but significant progress was achieved in cooperation with CNEA [17] and MDSN/AECL/SGN [18, 19].

10. Several joint studies are in progress to facilitate reactor conversions or to improve utilization of LEU fuel in converted reactors. Conversion studies have continued for the HFR-Petten reactor[20] in the Netherlands and preparations for joint studies are under way, in anticipation for the Accelerated RERTR Program, to study the conversion feasibility of the Massachusetts Institute of Technology Reactor (MITR-II), the Advanced Test Reactor (ATR), and the National Bureau of Standards Reactor (NBSR). A joint study with the Technical University of Munich, to assess the feasibility of reducing the enrichment of the FRM-II fuel, is scheduled to begin immediately after the conclusion of this meeting.

11. To date, twenty research reactors have been fully converted to LEU fuels outside the United States, including ASTRA (Austria), BER-II (Germany), DR-3 (Denmark), FRG-1 (Germany), IAN-R1 (Colombia), IEA-R1 (Brazil), JMTR (Japan), JRR-4 (Japan), NRCRR (Iran), NRU (Canada), OSIRIS (France), PARR (Pakistan), PRR-1 (Philippines), RA-3 (Argentina), R2 (Sweden), R2-0 (Sweden), SAPHIR (Switzerland), SL-M (Canada), THOR (Taiwan), and TRIGA II Ljubljana (Slovenia). Eleven research reactors have been fully converted in the U.S., including FNR, GTRR, ISUR, MCZPR, OSUR, RINSC, RPI, ULRR, UMR-R, UVAR, and WPIR. Seven foreign reactors, GRR-1 (Greece), HOR (Netherlands), La Reina (Chile), MNR (Canada), SSR (Romania), TR-2 (Turkey), and TRIGA II Vienna (Austria), have been partially converted. (ASTRA, DR-3, GTRR, ISUR, MCZPR, SAPHIR, and UVAR were shut down after conversion).

PLANNED ACTIVITIES

1. The highest priority of the RERTR program during the next few years, contingent on DOE guidance and funding, will be given to implementing the recommendation reached by the Joint Expert Group and described in the Abraham/Rumyantsev joint statement. In doing so, the RERTR program plans to exploit to the fullest extent the excellent results recently obtained by fuel development activities both in the U.S. and Russia. This will entail aggressive development of LEU U-Mo fuels, in both dispersion and monolithic forms, for conversion of research reactors supplied by the U.S. and Russia.

2. Qualification of LEU U-Mo dispersion fuel with uranium densities of 6 g/cm^3 and 7 g/cm^3 will continue to be pursued. Conclusion of this activity is now scheduled to occur in late 2006, with important intermediate results to be obtained in 2005 from the Osiris irradiations.

3. Development, testing, and qualification of monolithic LEU U-Mo fuel will be pursued very aggressively, building on the promising results obtained during the previous year. Our goal will

be to achieve qualification of this fuel by the end of 2008 and conversion of all U.S. research reactors by the end of 2012. Without the Accelerated RERTR Program, achievement of these goals had been planned to occur, respectively, two and five years later.

4. Development, testing, and qualification of both monolithic and dispersion LEU U-Mo fuel for conversion of Russian-designed research reactors will also be pursued very aggressively, under the Accelerated RERTR Program and in cooperation with the Russian RERTR program, with the goal of achieving conversion of all Russian-designed research reactors also by the end of 2012.

5. As qualification of these fuels proceeds with the strong impetus provided by the Presidential Summit and the joint Abraham/Rumyantsev statement, the fuels will also be used in the conversion of all other research reactors worldwide, with the cooperation of the many partners of the RERTR program. The main goal will be to ensure that by 2012 no HEU will be needed to support operation of research reactors anywhere.

6. In parallel with fuel development and reactor conversion activities, the RERTR program plans to continue its cooperative efforts with all international isotope producers, medical and otherwise, to ensure that HEU ceases to be needed also for this important purpose.

SUMMARY AND CONCLUSION

One of the most important events affecting the RERTR program during the past year was the decision by the U.S. Department of Energy to request the U.S. Congress to significantly increase future RERTR program funding. This decision was prompted, at least in part, by the terrible events of September 11, 2001, and by a recommendation at the highest levels of government calling for an immediate acceleration of RERTR program activities, with the goal of converting all the world's research reactors to low-enriched fuel at the earliest possible time, and including both Soviet-designed and United States-designed research reactors.

The U.S. Congress is expected to approve this request in the very immediate future, and the RERTR program has prepared itself well for the intense activities that the "Accelerated RERTR Program" will require.

- Promising results have been obtained in the effort to develop a fabrication process for monolithic LEU U-Mo fuel. Most existing and future research reactors could be converted to LEU with this fuel, which has a uranium density between 15.4 and 16.4 g/cm^3 and yielded promising irradiation results in 2002. The most promising method hinges on producing the monolithic meat by cold-rolling a thin ingot produced by casting. The aluminum clad and the meat are bonded by friction stir welding and the cladding surface is finished by a light cold roll. This method can be applied to the production of miniplates and appears to be extendable to the production of full-size plates with the possible inclusion of intermediate anneals. Other methods planned for investigation include high temperature bonding and hot isostatic pressing.

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REFERENCES

[1] A. Travelli, "Status and Progress of the RERTR Program in the Year 2002," Proceedings of the XXIV International Meeting on Reduced Enrichment for Research and Test Reactors, San Carlos de Bariloche, Argentina, 3 -8 November 2002.

[2] U.S. Nuclear Regulatory Commission: "Safety Evaluation Report Related to the Evaluation of Low-Enriched Uranium Silicide-Aluminum Dispersion Fuel for Use in Non-Power Reactors," US. Nuclear Regulatory Commission Report NUREG-1313 (July 1988).

[3] U.S. Department of Energy, Assistant Secretary for Environmental Management, "Record of Decision on a Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel," May 13, 1996.

[4] P. Lemoine, J.M. Hamy, M. Boyard, J.L. Emin, Se. de Perthuis, "The French U-Mo Group Development Program: Status as of October 2003," these proceedings.

[5] The full text of the joint statement can be found at http://www.energy.gov/HQPress/releases02/seppr/jointstatement.htm

[6] C.R. Clark, G.C. Knighton, M.K. Meyer, G.L. Hofman, "Monolithic Fuel Plate Development at Argonne National Laboratory," these proceedings.

[7] M. López, A. Gonzalez, E. Pasqualini, “Characteristics of HMD U-Mo Powder Production,” these proceedings

[8] G.L. Hofman, Y.S. Kim, M.R. Finlay, J.L. Snelgrove, S.L. Hayes, M.K. Meyer, C.R. Clark Recent Observations at the Postirradiation Examination of Low-Enriched U-Mo Miniplates Irradiated to High Burnup”, these proceedings.

[9] S.L. Hayes, M.K. Meyer, G.L. Hofman, J.L. Snelgrove, “Modeling RERTR Experimental Fuel Plates using the PLATE Code,” these proceedings.

[10] H. Taboada, J. Rest (USA), R. Saliba, M.V. Moscarda, “DART-TM: A Thermomechanical Version of DART Code for LEU VHD Dispersed and Monolithic Fuel Analysis,” these proceedings.

[11] V. Bezzubtsev, N. Arkhangelsky, V. Aden, V. Chernyshov, A. Vatulin “The Current Status and Future Plans of the Russian RERTR Program,” these proceedings.

[12] A. Vatulin, A. Morozov, Y. Stetskiy, I. Dobrikova, V. Suprun, Y. Trifonov, V. Mishunin, V. Sorokin, “Major Results on the Development of High Density U-Mo Fuel and Pin-Type Fuel Elements Executed Under Russian RERTR Program and in Cooperation with ANL (USA),” these proceedings.

[13] I. Izhutov, N.G. Gataulin, V.V. Pimenov, M.N. Svyatkin, V.A. Starkov, “Conditions and Preliminary Results of Low Enrichment U-Mo Pin Type Fuel Testing in the MIR Reactor,” these proceedings.

[14] K. Konoplev, R.G. Pikulik, D.V. Tchmshkyan, L.V. Tedoradze, A.S. Zakharov, “Pin-type Fuel Test at WWR-M Reactor,” these proceedings.

[15] J.E. Matos, Accelerating the Design and Testing of LEU Fuel Assemblies for Conversion of Russian-Designed Research Reactors Outside of Russia”, these proceedings.

[16] N.A. Hanan, M.M. Bretscher, A.P. Olson, and J.E. Matos, “Feasibility Studies for LEU Conversion of the WWR-SM Reactor in Uzbekistan Using Pin-Type and Tubular Fuels,” these proceedings.

[17] L. Alvarez, N. Boero, E. Pasqualini, P. Echenique, G. Ruggirello, “Status of RERTR Activities in Argentina,” these proceedings.

[18] G. Malkoske, “Status of the LEU Target Development and Conversion Program for the MAPLE Reactors and New Processing Facility,” these proceedings.

[19] A. Bakel, G.F. Vandegrift, K. Quiqley, J. Falkenberg, J.L. Snelgrove, A. Travelli, “ANL Progress in Minimizing Effects of LEU Conversion on Calcination of Fission-Product 99Mo Acid Waste Solution,” these proceedings.

[20] F.J. Wijtsma, P.J.M. Thijssen, R. May, A. Gevers, “Status Report on the HFR Conversion and Relicensing Project,” these proceedings.