

FINAL REPORT
FOR CRADA NO. C-98-15
BETWEEN
BROOKHAVEN SCIENCE ASSOCIATES
AND
THORIUM POWER, INC.

Project Entitled: Radkowsky Thorium Fuel Project

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Memo

date: *December 23, 2009*

to: *M. Furey*

from: *M. Todosow, Head, Nuclear Science and Technology Division*

subject: *CRADA No. BNL-C-98-15 Between BNL and Radkowsky Thorium Power Corp./Thorium Power, Inc.*

In the early/mid 1990's Prof. Alvin Radkowsky, former chief scientist of the U.S. Naval Reactors program, proposed an alternate fuel concept employing thorium-based fuel for use in existing/next generation pressurized water reactors (PWRs). The concept was based on the use of a "seed-blanket-unit" (SBU) that was a one-for-one replacement for a standard PWR assembly with a uranium-based central "driver" zone, surrounded by a "blanket" zone containing uranium and thorium. Therefore, the SBU could be retrofit without significant modifications into existing/next generation PWRs. The objective was to improve the proliferation and waste characteristics of the current once-through fuel cycle.

The objective of a series of projects funded by the Initiatives for Proliferation Prevention program of the U.S. Department of Energy (DOE-IPP) - BNL-T2-0074,a,b-RU "Radkowsky Thorium Fuel (RTF) Concept" – was to explore the characteristics and potential of this concept. The work was performed under several BNL CRADAs (BNL-C-96-02 and BNL-C-98-15) with the Radkowsky Thorium Power Corp./Thorium Power Inc. and utilized the technical and experimental capabilities in the Former Soviet Union (FSU) to explore the potential of this concept for implementation in Russian pressurized water reactors (VVERs), and where possible, also generate data that could be used for design and licensing of the concept for Western PWRs. The Project in Russia was managed by the Russian Research Center-"Kurchatov Institute"(RRC-KI), and included several institutes (e.g., PJSC "Electrostal", NPO "LUCH" (Podolsk), RIINM (Bochvar Institute), GAN RF (Gosatomnadzor), Kalininskaja NPP (VVER-1000)), and consisted of the following phases:

- Phase-1 (\$550K/\$275K to Russia): The objective was to perform an initial review of all aspects of the concept (design, performance, safety, implementation issues, cost, etc.) to confirm feasibility/viability and identify any "show-stoppers".
- Phase-2 (\$600K/\$300K to Russia): Continued the activities initiated under Phase-1 with a focus on expanded design and safety analyses, and to address fuel fabrication and testing issues.

- Phase-3 (\$300K/\$290K to Russia): Focus on thermal-hydraulic testing at Kurchatov for both VVER and PWR lattices.

The final invoice under the IPP-funded project was paid in December 2005. Significant funding was also provided by Radkowsky Thorium Power Corp (RTPC)/Thorium Power (TP) during this period. Their funding was primarily directed at fuel fabrication and irradiation testing.

Key accomplishments include:

- No “showstoppers” were identified as a result of design studies or independent reviews
- Performance with respect to achieving nonproliferation, retrofittability, and Environment, Safety and Health (ES&H) goals has been confirmed by independent analyses in Russia, Israel, and the U.S.
- Initial design and safety analyses were performed for the VVERT (thorium fuel variant of VVER) demonstrating characteristics comparable to those of a conventional uranium-fuelled VVER.
- Interactions with GAN (Russian Nuclear Regulator) were an integral part of the program for initial licensing of design methods and tests/experiments.
- Thermal-hydraulic (T-H) experiments have been performed at the Kurchatov Institute and OKBM on single rods and multi-rod arrays at facilities that had also been used for T-H testing of conventional VVER fuel thereby allowing a direct comparison between the two concepts.
- Prototype fuel fabrication for seed and blanket rods has been performed at MZ Electrostal. Initial irradiation of prototype samples of both fuels was performed at the IR-8 reactor at the Kurchatov Institute which has a thermal and nuclear environment representative of operating light water reactors.

In the course of the project on the order of one-hundred reports were generated, some in English, and some in Russian. The Final Report from RRC-KI is attached. Technical presentations/papers were made at American Nuclear Society meetings, and most recently at the Advances in Nuclear Fuel Management –IV conference.

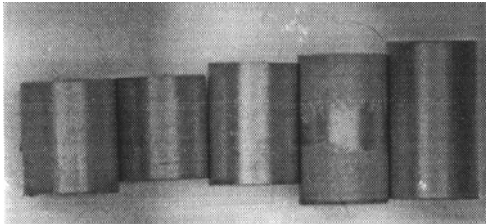
In addition to the work in Russia, during the period of the CRADAs (~1995 – 2005) studies were performed on the concept suitable for implementation in Western PWRs by BNL, the Massachusetts Institute of Technology (MIT), and Ben Gurion University utilizing funding from DOE-IPP, RTPC, and under a Nuclear Energy Research Initiative (NERI) project 2001-2004.



Sample “Seed” Rods for T-H Testing



T-H Test Facility @ Kurchatov



Thorium-Uranium Fuel Samples & Irradiation Testing at Kurchatov IR-8 Reactor

