OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE, LLC
POST OFFICE BOX 2008, OAK RIDGE, TENNESSEE 37831

ORNL

FOREIGN TRIP REPORT

226719

Date: July 13, 2005

Subject: Report of Foreign Travel to Russia — Team Report for M. Jonathan Haire, TA 226719, Charles W. Forsberg, TA 226742, Les R. Dole, TA 226743, and Ray G. Wymer, TA 226744

To: James M. (Mike) Kuperberg, Division Director, Environmental Remediation Sciences Division, DOE Office of Science

From: M. Jonathan Haire, Charles W. Forsberg, Les R. Dole, and Ray G. Wymer

Purpose: The primary objective of this foreign travel was to review the technical progress of International Science and Technology Center (ISTC) Projects 2691, 2693, and 2694 in Moscow, Russia. Other objectives were to review the status of proposals to design and fabricate prototype spent nuclear fuel transport and storage casks and to discuss future work.

Travel Dates: June 17–25, 2005

Summary: Experimental results were presented for International Science and Technology center (ISTC) project numbers 2691, 2693, and 2694. All results show that the use of depleted uranium dioxide (DUO_2) has significant advantages when compared to conventional technologies. The projects are on schedule and within budgets.

The progress of these projects continues to meet or exceed our expectations. (1) Preliminary experimental results show that Np(V), Np(IV) and Tc(IV) are sorbed on uranium dioxide (ISTC Project #2694). This result should significantly lower calculated site boundary radiation dose at the U.S. Yucca Mountain (YM) spent nuclear fuel (SNF) repository. Therefore, these results could support the licensing basis of YM, and may ultimately simplify repository design and operation by avoiding the need for various expensive engineered barriers such as the drip shield. Based on these highly encouraging results, we shall seek a two year extension for ISTC Project #2694. (2) We saw samples and metallographs of high density depleted uranium–steel cermets (ISTC Project 2693). (3) The Russians have developed their own depleted uranium aggregate (DUAGG) recipe (ISTC Project # 2691). Compression tests have been conducted. Depleted uranium concrete (DUCRETE) logs have been fabricated and tensile tests are ready to begin. New DU-steel cermets and

DUCRETE composite materials will enable superior, next generation SNF and high-level waste casks to be designed, licensed, and deployed.

Our Russian colleagues have fabricated 50 kg of DUAGG and will fabricate 30 kg of DU-steel cermets for shipment to the U.S. A decision must be made by September 30, 2005, as to whether the U.S. will receive these samples and conduct testing on them in the U.S.

Two technical tours were conducted. In Moscow samples of DUAGG, DUCRETE, and DU-steel cermets were shown. In Sarov, laboratory facilities were toured where investigations of DUCRETE physical properties and sorption of radionuclides onto UO_2 are conducted.

Background

ISTC Projects 2691 (DUCRETE), 2693 (cermet), and 2694 (sorption) have the common goal to develop beneficial uses of surplus depleted uranium (DU). This work is funded through the International Science and Technology Center (ISTC) by the U.S. Department of State. The ISTC paid travel expenses for this trip. This work supports the U.S. Department of Energy (DOE) Depleted Uranium Uses Research and Development Project funded by DOE-Environmental Management (EM)-21 Cleanup Technologies. Labor costs for this travel was paid by DOE-EM.

Review of ISTC Projects

ISTC Project #2691, "*Production and Testing of Heavy Concretes Including Depleted Uranium Dioxide Concerning Their Use as Shielding Materials in Construction of Casks for Spent Nuclear Fuel*." There was significant progress in Project #2691 towards achieving this program's goals. This project has augmented the U.S. DU aggregate (DUAGG) process and has improved the understanding of the associated materials science. Russian colleagues have improved and simplified the DUAGG formulation and production processes. Experiments have been conducted to measure DUAGG density, uranium to oxygen ratio, compressive strength, porosity, chemical stability via leaching testing, and structural analysis. DU concrete with high compressive strength (~670 kg force/cm^2) and high density (~6.4 gm/cm^3) has been produced. The possibility of applying for a patent for the improved performance and production technology for DU concrete is being investigated by our Russian colleagues. Potential U.S. involvement in the patent is being pursued. This heavy concrete conforms to the specifications used in manufacturing of IAEA concrete-steel cask for spent fuel transport and storage.

ISTC Project #2693: "*Production and Testing of Cast Cermet on the Base of Stainless Steel and Depleted Uranium Dioxide as Applied to Its Use as Shielding Materials in Construction of Casks for Spent Nuclear Fuel and Radioactive Wastes*." Samples of DU oxide/steel cermets have been produced and examined. The initial preparation process failed to produce high quality cermet. However, our Russian colleagues have developed a successful process with large (~1 mm diam.) UO_2 particulates of high density mixed with stainless steel (density of plus 7.8 g/cm^3) in about a 50% volume ratio and determined that they can produce cermets with a density of about 9 g/cm^3. Cermets of at least 9.2 g/cm^3 density are possible. Micro analysis of the UO_2-steel interface needs to be made to determine the composition of the interface. It was

agreed to reduce the quantity of cermet to be shipped to the U.S. from 50 kg to 30 kg to allow for additional characterization in Russia of cermet properties.

ISTC Project #2694: "*Investigation of Sorption Capture of Long-Lived Radionuclides from Underground Waters by Depleted Uranium Oxides and Hydroxides*." Samples of DUO_2 prepared at 650, 700, and 800EC have been studied. The solubility of these samples in water representative of Yucca Mountain geological repository was measured: Low-fired UO_{2+x} samples were the most soluble. Experimental results show that Np(V) and Np(IV) are sorbed on all three UO_{2+x} samples. Tc(IV) sorbs on UO_{2+x} and sorption increases as pH increases. These results could have a major impact on the YM SNF geologic repository licensing. The predicted long-term radiation dose from release of radionuclides from YM is controlled by neptunium. The sorption of neptunium onto uranium oxides potentially suggests that there will be a lower release of neptunium from the repository and that repository performance is better than current models predict. This project, as currently funded, ends in December 2005. Because of the very encouraging and significant results of the first two years, it is proposed to extend this work to further explore and understand the potential benefits for the repository. A work scope for a proposed extension of the project was discussed.

A project, "*The Production of Granulated Depleted Uranium (DUO_2) Particles by Melting in Induction Cold Crucible Melter for Use in Radiation Shielding Concrete Materials, Cermets, and Other Materials as Applied in Construction of Storage Sites and casks for Spent Nuclear Fuel and Radioactive Wastes,*" was approved by DOE-EM in September 2004. The Russian Department of Science approved the project in April 2005. This Civilian Research and Development Foundation (CRDF) project number RUC2-20203-MO-05 will officially begin July 2005. This project is budgeted at $420K over four years.

Proposals to Build 1/4 Scale DU Composite Material Prototype Casks

The ISTC funded bench-scale experiments are successful and indicate the need for large (1/4) scale tests for licensing purposes. It appears that DUCRETE and DU-steel cermets are equally good radiation shielding materials. It is unlikely that any single organization will support building two casks. Therefore, ROSATOM/RAS has submitted a proposal to ISTC to build a cermet cask. This proposal will be reviewed at the October 2005 meeting of the ISTC Governing Board. ORNL has submitted an International Proliferation Prevention (IPP) proposal to DOE to fabricate and test a DUCRETE cask. Everything was in place for official notification that this $1M project would be funded when Holtec International withdrew as the U.S. private company partner. It is expected that Holtec will be replaced by either General Atomic Company, or NAC International Company as a Cooperative Research and Development Agreement (CRADA) partner for this project.

Tours

On Monday, June 20, 2005, a tour was made of a VNIINM laboratory where samples of DU-steel cermets, DAUGG and DUCRETE test specimens were viewed. The cermet samples produced using the first process method with fine, relatively low-density UO_2 powder showed segregation of UO_2 and steel. The sample produced by the second method showed significantly improved properties. The DUAGG samples were irregular and showed sharp edges: this is good. Tensile tests of DUCRETE "logs" have not yet begun.

On Wednesday, tours were made of VNIIEF laboratories where mechanical tests will be conducted on DUAGG and DUCRETE samples. Conventional compression and tensile test equipment was viewed. VNIIEF is in the process of purchasing a $150,000 mass spectrometer that will be available for use in September 2005. This equipment will make possible the measurement of gaseous species evolved during the treatment of samples and thus help to establish optimum process conditions.

Travel Schedule:

June 17–18, 2005	Air travel from Oak Ridge, TN, to Moscow, Russia
June 19, 2005	Team meeting in hotel, preparation
June 20, 2005	VNIINM, morning, overview of DU collaboration. Review ISTC Project #2691. Afternoon, technical tour of VNIINM laboratory where DUAGG, DUCRETE, and cermet samples were viewed. Evening, dinner hosted by VNIIEF and VNIINM
June 21, 2005	ISTC, morning, reviewed ISTC project #2693. Afternoon, discussed prototype cask proposals. Evening, overnight train from Moscow to Sarov
June 22, 2005	VNIIEF, morning, review of ISTC Project #2694. Afternoon, technical tour of DUAGG, DUCRETE, and cermet testing laboratories. Evening, dinner hosted by Oak Ridge National Laboratory
June 23, 2005	VNIIEF, day, discuss CRADA candidates for IPP prototype cask projects. Developed and signed record of meeting. Overnight train to Moscow
June 24, 2005	VNIIKhT, morning, discuss status of CRDF Project #20203, ICCM project. Visit to Nuclear Assurance Corporation to discuss cask fabrication. Afternoon, M.J. Haire visit Mark Whitney at U.S. Embassy
June 25, 2005.	Travel from Moscow, Russia, to Oak Ridge, TN

Major Persons Contacted

Lev Tocheny	ISTC Project Manager
Vyacheslav I. Shapovalov	VNIIEF, PhD, Deputy Head of Scientific Engineering Dept., Coordinator of Russian Program on Depleted Uranium Use in Cask, and Project Manager for ISTC Project #2694
Sergey G. Ermichev	VNIIEF, Head of Laboratory, Project Manager of ISTC Project #2691
Viatly Z. Matveyev	VNIIEF, PhD, Head of Laboratory, Project Manager of ISTC Project #2691
Aleksei M. Visik	VNIINM (Bochvar), Deputy Chief of Department, theorist on cold wall melter technology

Tatiana Kazakovskaya	VNIIEF, Senior Scientific Worker, translator
Elena V. Zakharova	IPC, Head of Laboratory, an experimentalist in ISTC Project #2694
Anna Galkino	VNIIEF translator
Vladimir I. Sorokin	VNIINM, Head of Department
Victor A. Seredenko	VNIIKhT, Division Director, Institute of Chemical Technology, RAS
Stepan N. Kalmykov	Associate Professor, Moscow University, PhD, works for Ac. Boris Myasoedov
Nikolay V. Sviridov	VNIIEF, Distinguished Member of Technical Staff
Nina V. Kushnir	VNIIEF, senior scientific worker
Vitaly T. Gotovchikov	VNIIKhT, Head of Laboratory [PI for DOE induction cold crucible melter (ICCM) project]
Vladimir K. Saranchin	VNIIKhT, Senior Scientific worker (translator for ICCM)
Alexander A. Maslov	VNIINM, Principle Process Engineer
Victor M. Sergeev	VNIINM, Head of Department
Alexander V. Ivanov	VNIINM, Head of Laboratory
Oleg V. Yuferov	VNIINM, Deputy Head of Department

Distribution:

1. Gerald Boyd, U.S. Department of Energy, MS-M-1, P.O. Box 2001, Oak Ridge, TN 37831 [boydg@oro.doe.gov]

2. J. M. Kuperberg, Office of Science, U.S. Department of Energy, SC-75, Germantown HQ, Rm. J116, 1000 Independence Ave. SW, Washington, DC 20585 [michael.kuperberg@science.doe.gov]

3. Charles L. Nalezny, Office of Cleanup Technologies, EM-21, U.S. Department of Energy, Office of Environmental Management, 1000 Independence Ave., SW, Washington, DC 20585 [charles.nalezny@em.doe.gov]

4. Mark Sheland, Office of Proliferation Threat Reduction, U.S. Department of State, Rm. 3327, Truman Building, 2201 C Street, NW, Washington, DC 20520 [shelandmd@state.gov]

5. L. Sparks, U.S. Department of Energy, P.O. Box 2001, MS-OS203, Oak Ridge, TN 37831 [sparkslm@oro.doe.gov]

6. Debbie Tijani, Office of Intelligence, U.S. Department of Energy, IN-1, 1000 Independence Ave. SW, Washington, DC 20585 [Debbie.Tijani@hq.doe.gov]

7. R. L. Beatty, 5700, MS-6165 [beattyrl1@ornl.gov]

8. L. R. Dole, 5700, MS-6166 [dolelr@ornl.gov]

9. C. W. Forsberg, 5700, MS-6165 [forsbergcw@ornl.gov]

10. M. J. Haire, 5700, MS-6166 [hairemj@ornl.gov]

11. D. J. Hill, 4500N, MS-6248 [hilldj@ornl.gov]

12. B. E Lewis, Jr., 4500N, MS-6243 [lewisbejr@ornl.gov]

13. C. V. Parks, 5700, MS-6170 [parkscv@ornl.gov]

14. J. E. Rushton, 5700, MS-6152 [rushtonje@ornl.gov]

15. F. M. Wallace [wallacefm@y12.doe.gov]

16. R. M. Wham, 5700, MS-6154 [whamrm@ornl.gov]

17. R. G. Wymer, 5700, MS-6166 [rgwymer@prodigy.net]

18. Office of Counterintelligence, 4007, MS-6076 [lowryj@ornl.gov]

19. ORNL Foreign Travel Office—RC, 5002, MS-6389 [efs@ornl.gov]