Ideas for New Cooperation I: Office of Environmental Management

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U.S. Department of Energy—Russian Academy of Sciences Joint Coordinating Committee on Science and Technology
Moscow, Russia, March 31, 2003

Background

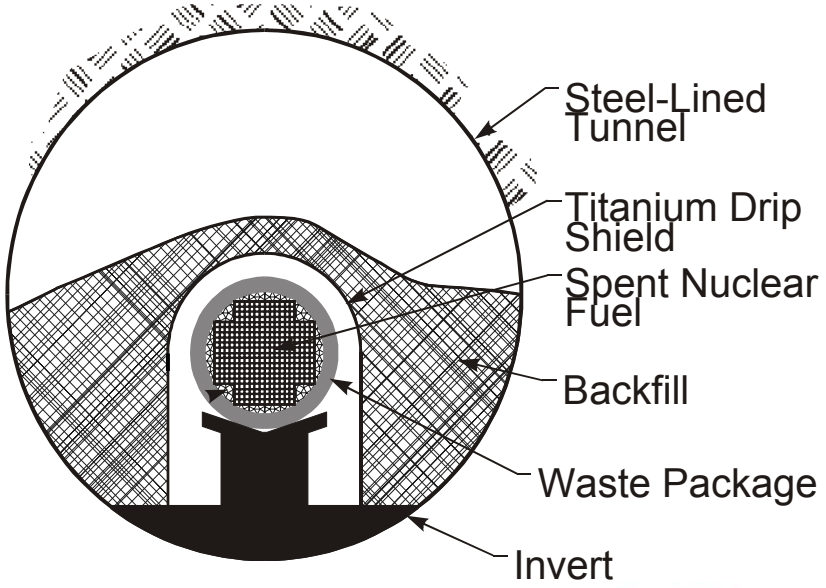
- A Russian–American workshop on Management of Depleted Uranium (DU) was held December 9–10, 2002, in Moscow, Russia
- Approximately 20 potential research activities were discussed
- Three full proposals were developed and submitted to the International Science and Technology Center (ISTC)
- Four topics were chosen to be developed into preproposals for this JCCST meeting
- We need from the JCCST an indication as to whether it is worthwhile to develop full proposals on these topics

Depleted Uranium Proposals to this JCCST

1. "Geochemistry"

"Geochemistry Behavior of a DU Dioxide–Steel Cermet Waste Package"

- **Performers:** Lead Institution: Russian Academy of Sciences (RAS) Institute of Physical Chemistry (IPC)– Prof. V. Gromov and Elena V. Zakharova; other participating institutes VNIIEF–V. Shapovalov
- **Description:** Use DU dioxide to maintain reducing conditions and to reduce the solubility of the spent fuel to potentially yield beneficial geochemical effects that reduce repository cost. Determine ability of the DUO_2-steel cermets to maintain reducing and uranium-saturated conditions
- **Benefits:** Success would contribute to elimination of costly [Yucca Mountain (YM)] geologic repository baseline components such as C-22 alloy clad on the waste package (WP) and/or titanium drip shields
- **Relationship:** This project complements ISTC Projects 2693 and 2694
- **Cost:** $450K over 4 years



"Geochemistry": Proposed Tasks

Study the oxidation of DUO_2 and steel WP components during their long-term contact with groundwater

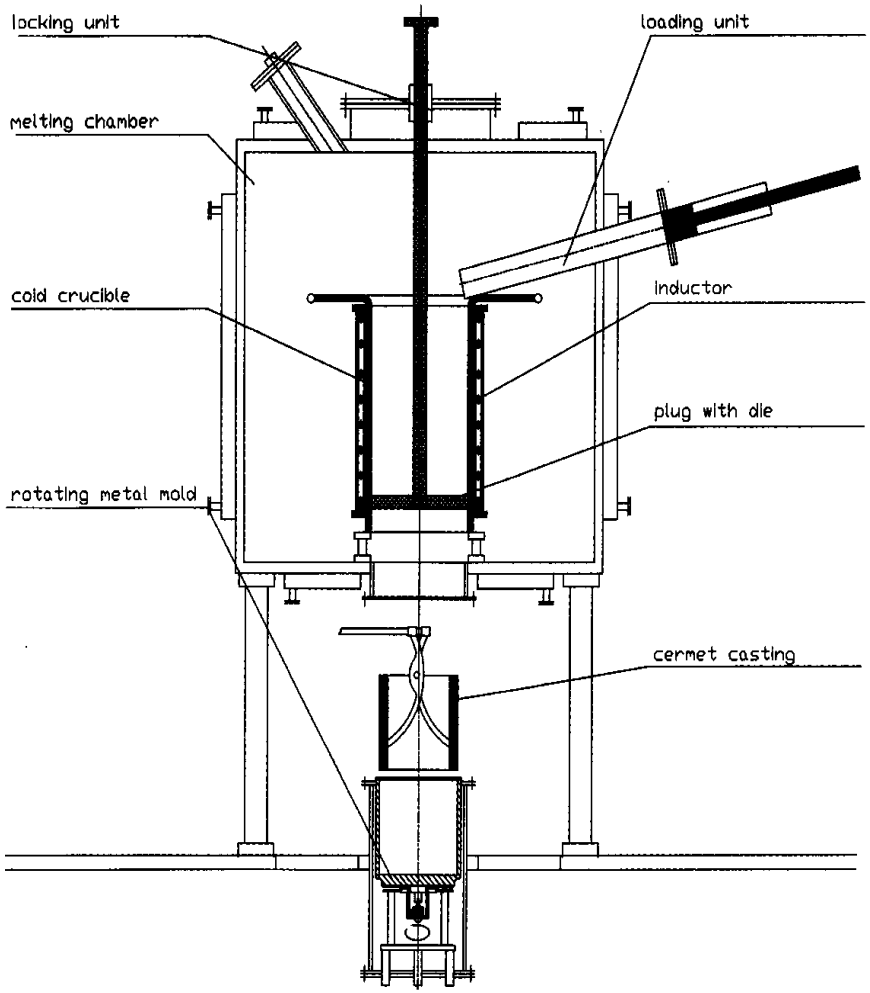
1. **Diffusion transport of DUO_2-steel WP in groundwater**
2. **Composition of degradation products under oxidizing and reducing conditions, mobility, interaction mechanisms**
3. **Influence of temperature and radiation**
4. **DUO_2 oxidation**
5. **Time dependence of cermet degradation process**

2. "Cold Wall Melter"

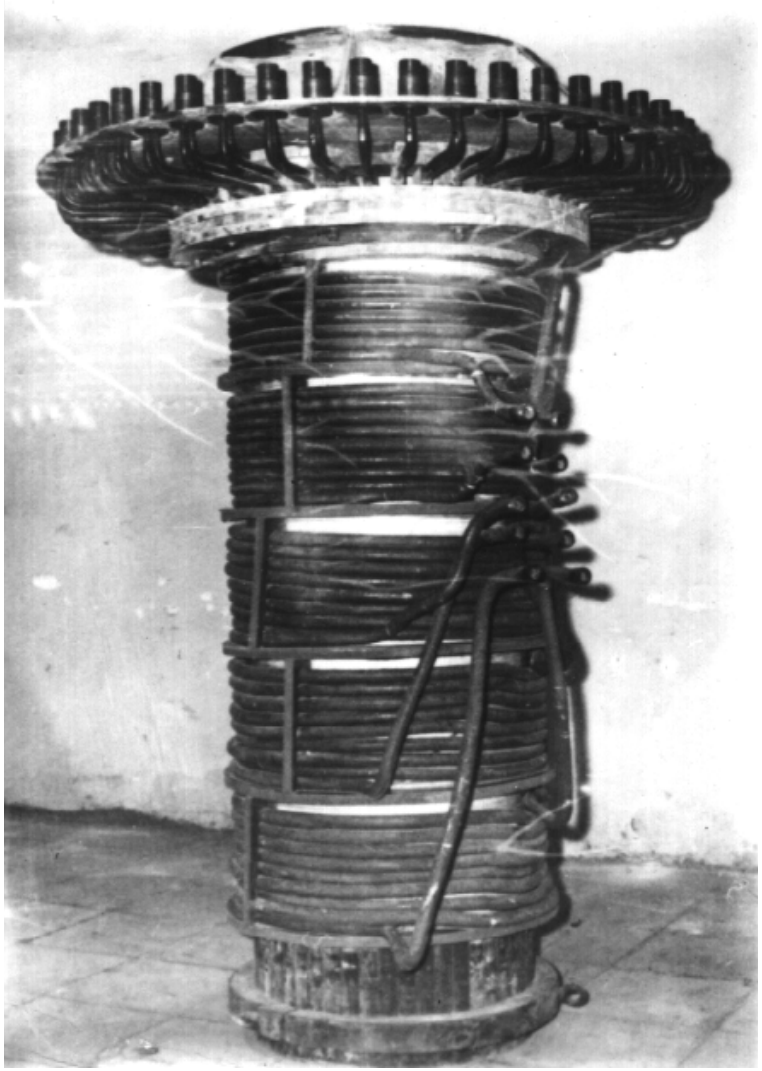
"Use of a Cold Wall Melter for the Production of UO_2 Particulates for Cermets and Direct Formation of DUCRETE"

- **Performers:** VNIIKhT–Seredenko, Gotovchikov
- **Description:** Eliminate dusty, costly process of forming DU oxide particulates for DUCRETE and DU-steel cermets through use of a cold wall melter
- **Benefits:** This work will dramatically lower the costs of producing DU dioxide particles for use in DUCRETE and cermet fuel cycle and repository components
- **Relationship:** Successful outcome would greatly benefit ISTC Projects 2691 and 2693. It will eliminate several steps in the baseline process for production of DU dioxide particles, which are used to make DUAGG/DUCRETE and DU-steel cermet spent nuclear fuel (SNF) casks
- **Cost:** Phase 1, $420K over 3 years; Phase 2 (design of a DUO_2 cold wall melter with a capacity of 5000 to 20,000 t/year), $1270K

Laboratory-Scale All Russian Institute of Chemical Technology (RRICT) Induction Cold Crucible Melter



RRICT Industrial Cold Crucible with Inductor Coil [Inner Diameter of Crucible: 65 cm (~26 in.)]



"Cold Wall Melter": Proposed Tasks

Develop the technology to produce cheap, clean DUO_2 particulates for DUCRETE and DU-steel cermets for SNF casks

1. **Design and build a laboratory-scale induction cold crucible melter**
2. **Investigate the technology of melting, draining, and granulation**
3. **Test the device by fabricating ~200 kg of DUO_2 particulates**

3. "Micro-reinforcement"

"Micro-reinforcement of Concrete in SNF Cask Shielding"

- **Performers:** Lead Institution: Russian Federal Nuclear Center – All Russia Science and Research Institute of Experimental Physics (RFNC-VNIIEF), Project Manager: S. Ermichev, Shapovalov. Other participating institutes: VNIIKhT–Seredenko; RAS ICP–Gromov; VNIINM–Orlov, Sergeev; the RAS IHT–Mineev

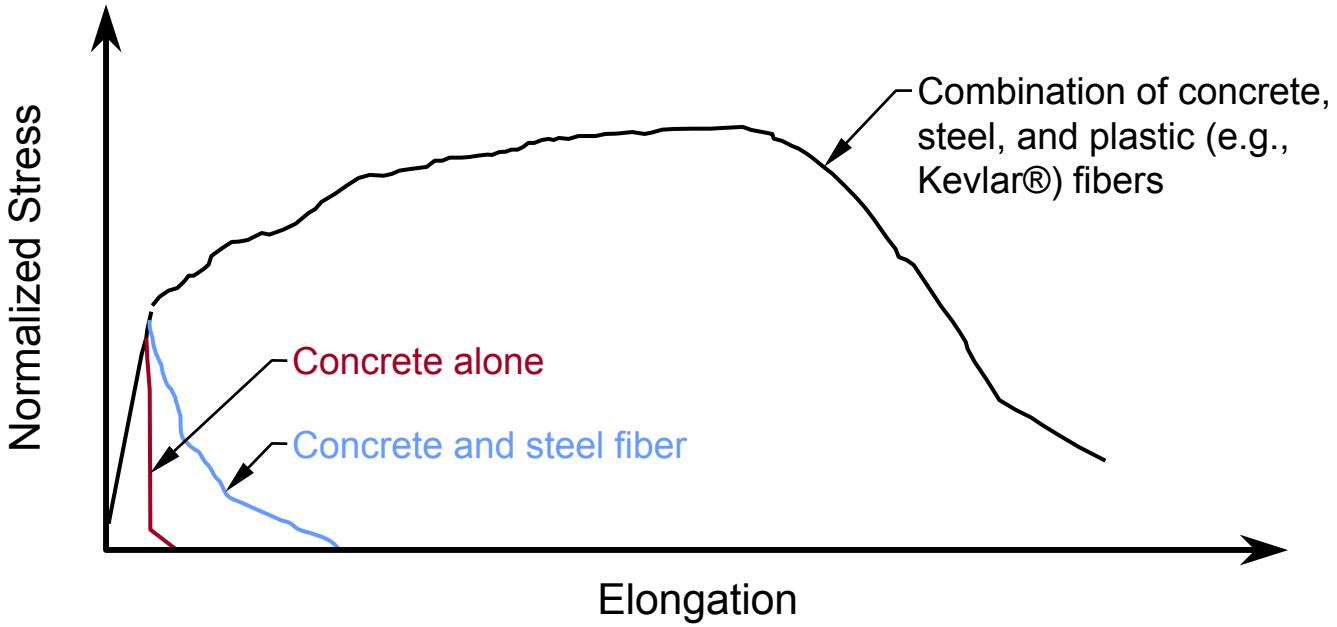
- **Description:** The addition of micro-reinforcement to concrete structures increases their fracture toughness and therefore the ability of the concrete to absorb energy (e.g., rocket from a terrorist attack or airplane crash). This enhances the durability and reliability of an SNF cask under high-impulse stresses and provides for more effective physical protection of the cask contents. It is proposed that the tensile strength of concrete be increased by adding metal and/or polymeric fibers

- **Benefits:** The use of micro-reinforcement may eliminate the need for rebar in construction of concrete structures, specifically concrete SNF storage casks

- **Relationship:** This project complements ISTC Project 2691. Also, it will be coordinated with DOE proposal, "Depleted Uranium Production Using a Cold Wall Melter"

- **Cost:** $800K over 3 years

Energy Absorption by Concrete



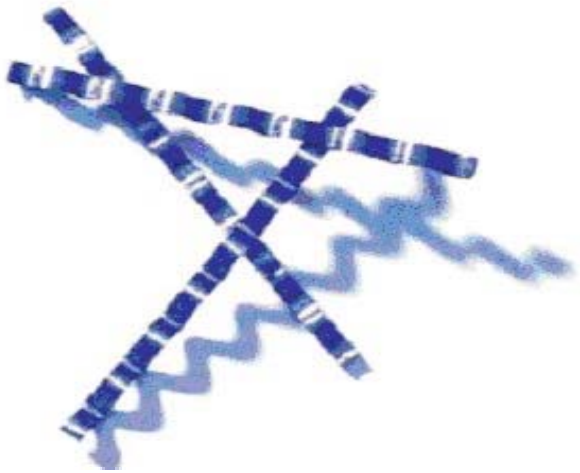
Metal and fiber reinforcement of concrete greatly increases fracture toughness (i.e., area under the curve)

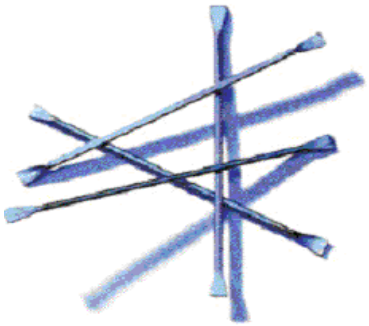
(Ref. www.civil.columbia.edu/meyer/fiberreein.html)

“Micro-reinforcement”: Proposed Tasks

Increase the fracture toughness of SNF casks through development of micro-reinforcement technology

1. **Prepare and test laboratory specimens to establish an experimental base**
2. **Production of DUAGG and DUO_2 steel cermets containing micro-reinforcement**
3. **Model-scale studies to evaluate efficiency of concrete fracture toughness and ability to absorb energy**
4. **Final testing and evaluation of micro-reinforcement concrete properties**

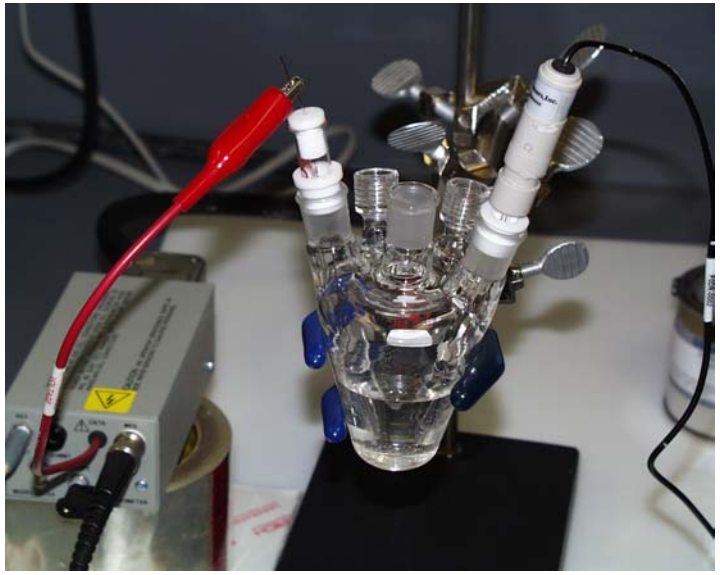




4. "Battery"

"Long-Life Uranium Dioxide Power Source"

- **Performers:** Lead Institution: RAS IPC–Prof. V. Gromov. Other Participating Institute VNIIEF–Shapovalov
- **Description:** This project will develop a battery-like device powered by DU to provide continuous, noninvasive, remote monitoring of WP conditions (temperature, pressure, etc.) over many hundreds of thousands of years
- **Benefits:** This proposal will enhance nonproliferation of nuclear materials and nonintrusively monitor the SNF WP for radionuclide migration in geologic repositories. Success would reduce uncertainty in repository performance, thereby enhancing the acceptability of the YM repository during licensing
- **Relationship:** This is the first proposed research in this general topic
- **Cost:** $650K over 4 years

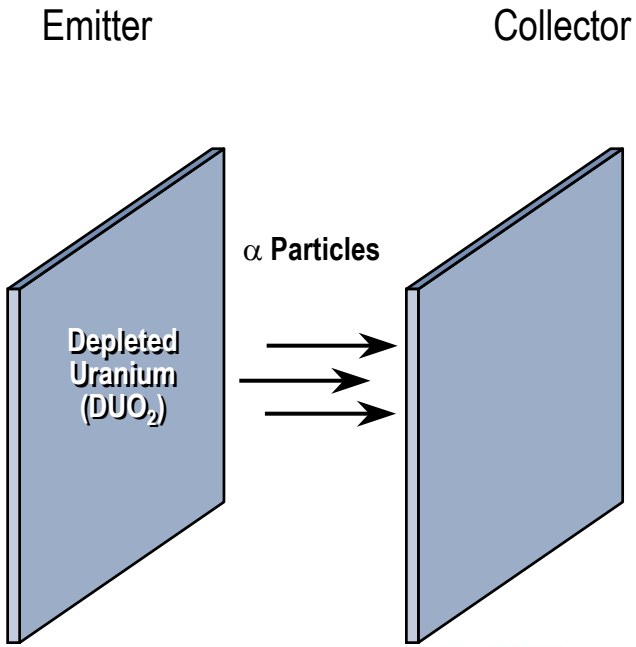


DUO_2 battery test at the University of Kentucky

"Battery": Proposed Tasks

Develop a long-lived (centuries) DUO_2 battery to provide a power source for long-term monitoring of SNF casks, environmental conditions at a geologic repository after full closure, and deep-sea conditions

1. **Develop an elementary-cell structure of a nuclear battery that provides maximum current collection**
2. **Investigate long-term factors affecting performance (e.g., humidity, temperature, ionizing radiation)**
3. **Select insulating material**
4. **Determine radiation resistance to insulating material and sealing compounds**
5. **Fabricate and test the prototype**



5. "Silicates in Concrete"

"Formation and Investigation of UO_2-SiO_2 System for Use in High-Strength Concrete"

- **Performers:** RRICT–Prof. Seredenko and A. Ivanov
- **Status:** DOE received this proposal in March and is in the process of reviewing it for application to DOE needs

Three Full Proposals Have Been Submitted to the ISTC

1. ISTC #2691, "Production and Testing of Heavy Concretes Including DU Dioxide Concerning Their Use as Shielding Materials in Construction of Casks for SNF"

2. ISTC #2693, "Production and Testing of Cast Cermet on the Base of Stainless Steel and DU Dioxide as Applied to Its Use in Construction of Casks for SNF and Radioactive Wastes"

3. ISTC #2694, "Investigation of Sorption Capture of Long-Lived Radionuclides from Underground Waters by DU Oxides and Hydroxides"

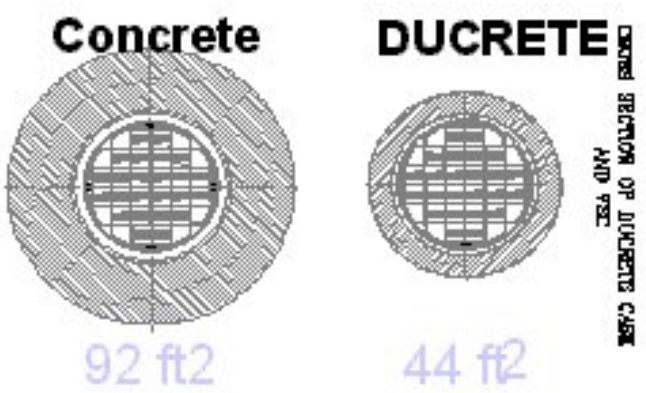
Backup Viewgraphs

DU Proposals to the ISTC Expected to be Approved at the March 31, 2003, Governing Board Meeting

ISTC Proposal No. 2691, "DUCRETE"

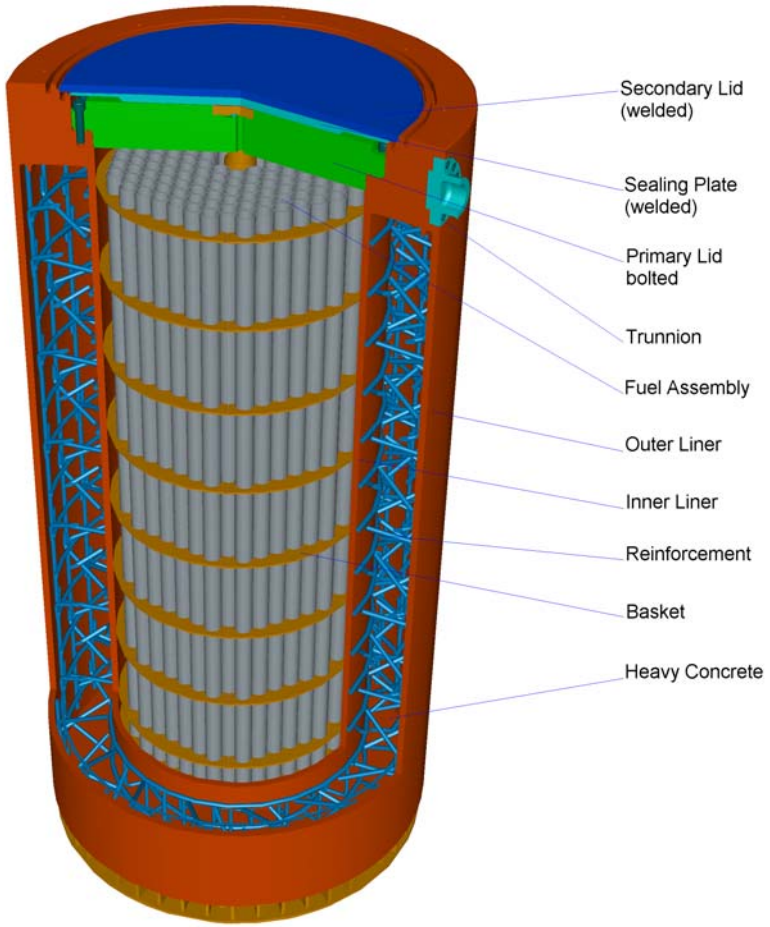
"Production and Testing of Heavy Concretes Including DU Dioxide Concerning Their Use as Shielding Materials in Construction of Casks for SNF"

- **Performers:** Lead Institution: RFNC-VNIIEF–Shapovalov, Ermichev; VNIIKhT–Seredenko; VNIINM–Orlov, Sergeev
- **Description:** This project will produce test quantities of DUAGG and DUCRETE and ship ~1.2 t of samples to the U.S. Potential commercial partner
- **Benefits:** Promotes development of second-generation SNF/HLW casks. Much less costly source of DUAGG samples for testing in Russia and the U.S.
- **Costs:** $300K over 3 years



Cross Section of SNF Casks

General Nuclear Services, Inc. (GNSI), Multipurpose CONSTOR® Storage, Transport, and Disposal Cask



Approach: Replace existing heavy concrete with DUCRETE in CONSTOR® cask

ISTC Proposal No. 2693, "Cermets"

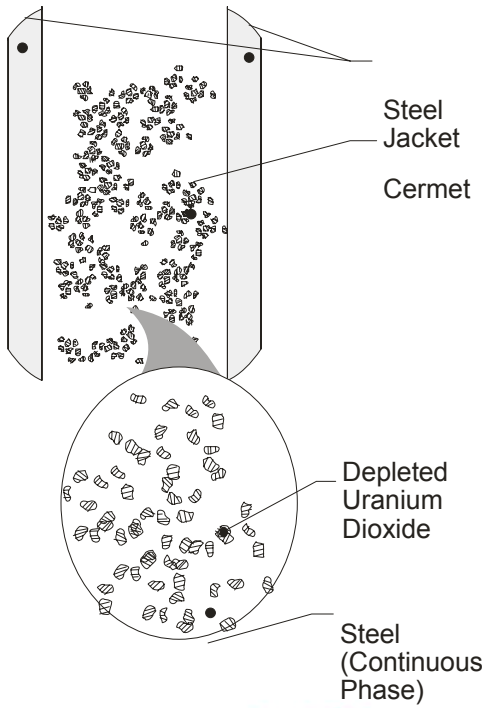
"Production and Testing of Cast Cermet on the Base of Stainless Steel and DU Dioxide as Applied to Its Use in Construction of Casks for SNF and Radioactive Wastes"

- **Performers:** Lead Institution: RFNC-VNIIEF–Matveev, Shapovalov; VNIIKhT–Seredenko; VNIINH–Orlov, Sergeev

- **Description:** This project will (a) produce test quantities of a DU dioxide in a steel matrix (a cermet) clad with a clean layer of steel using conventional fabrication techniques that could be used to construct spent fuel storage, transport, and disposal casks; (b) ship test specimens to the U.S.; and (c) test the properties of the cermets. Potential commercial partner

- **Benefits:** Promotes development of second-generation SNF/HLW casks. Potentially lowers cost of geologic repository (e.g., YM). Much less costly source of DU-steel samples for testing in Russia and the U.S.

- **Relationship:** Core project for DU-steel cermet research

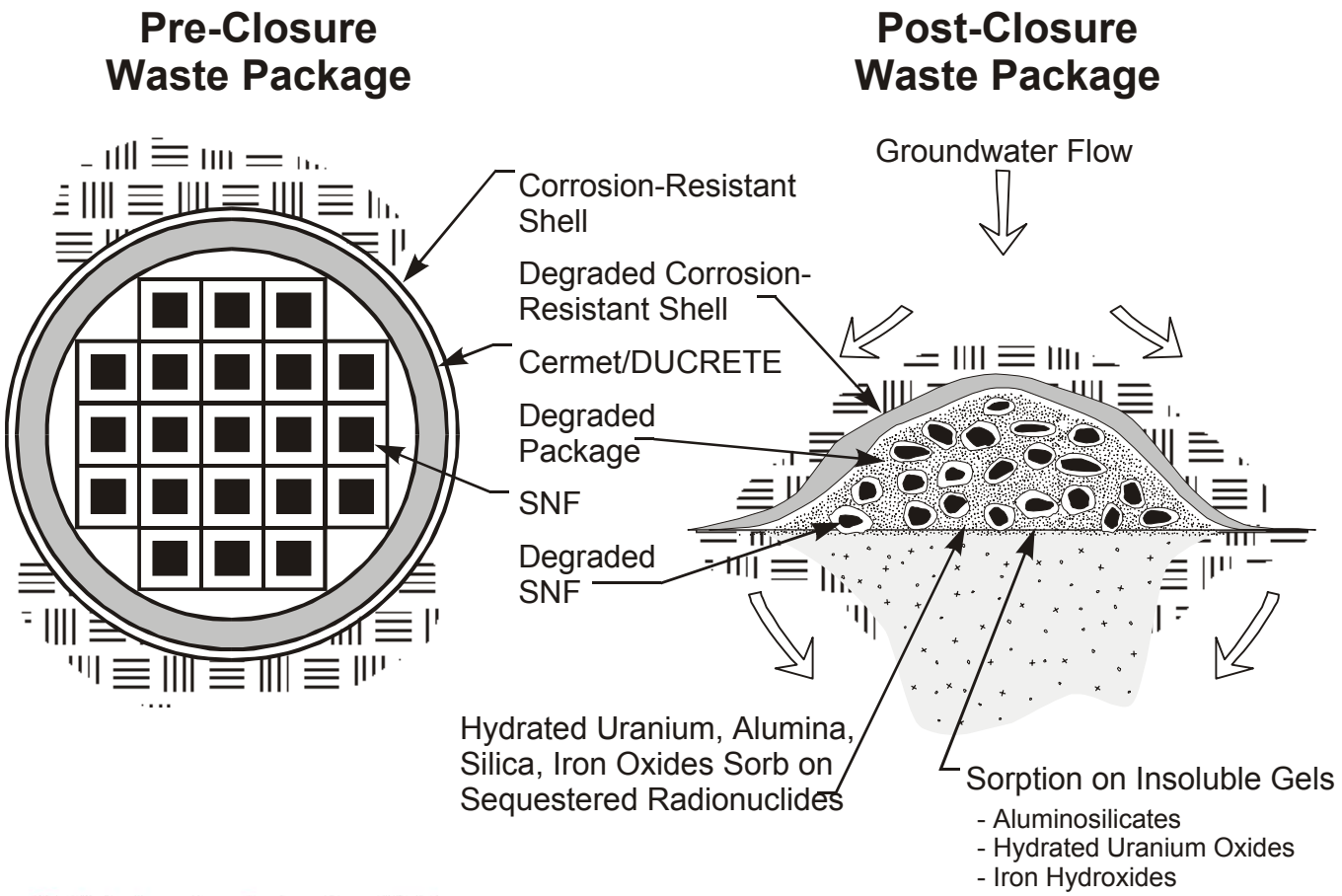


ISTC Proposal No. 2694, "Sorption"

"Investigation of Sorption Capture of Long-Lived Radionuclides from Underground Waters by DU Oxides and Hydroxides"

- **Performers:** RFNC-VNIIEF–Shapovalov, Matveev; RAS IPC–Gromov, Zakharova
- **Description:** Evaluate the potential for DU dioxide to reduce radionuclide migration by sorption, thereby reducing the need for costly repository components such as C-22 alloy WP cladding and the titanium drip shield at YM
- **Benefits:** Success would contribute to elimination of costly baseline components such as C-22 alloy clad on geologic repository WP or titanium drip shield
- **Relationship:** A key project for geologic repository DU geochemistry
- **Costs:** $200K over 2 years

Degraded Depleted Uranium Shielding (Hydrated Uranium, Silica, Alumina, and Iron Oxides) Limits Groundwater Transport and Radionuclide Release



The speakers were originally scheduled to give this paper today:

A Collaboration to Develop the Next-Generation Spent Nuclear Fuel (SNF)/High Level Waste (HLW) Cask

M. Jonathan Haire and Leslie R. Dole
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Oak Ridge, TN USA 37831-6179

H. W. Arrowsmith and Mark S. Denton
General Nuclear Services, Inc.
Oak Ridge, TN USA 37830-6927

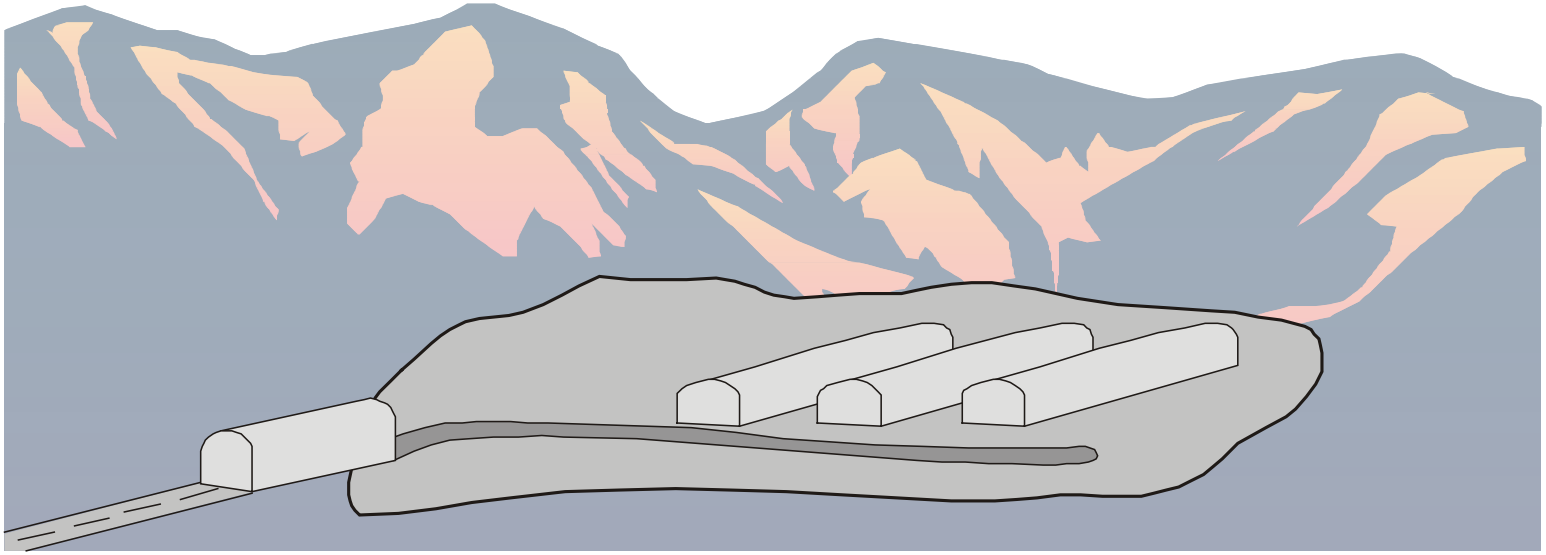
V. I. Shapovalov and V. Z. Matveev
VNIIEF
Sarov, Nizhni Novgorod, Russia

Presented at the
2003 IHLRWM Conference
Las Vegas, Nevada, USA
March 31, 2003

The Objective of U.S./Russia/Private Industry SNF Cask Development

- To design, license, and deploy next-generation casks that
  - Have smaller dimensions
  - Weigh less
  - Are capable of higher heat loads from shorter-cooled SNF
  - Are more resistant to terrorist attack
  - Are more proliferation resistant

It is believed that placing surplus DU in and around SNF will substantially improve geologic repository performance



U.S. YM Geologic SNF Repository

Depleted Uranium Research Institute (DURI)

DURI is proposed for management, technical oversight, and communication of the DOE-RAS research on DU

- **Approximately seven DOE and ISTC proposed DU research projects totaling >$2M**
- **Will report to JCCST (a subcommittee)**
- **Will meet twice each year to review technical progress of the research**

DU Uses R&D Project Strategy

- The project emphasizes two main scenarios for use of DU
  - Large-volume, low-value uses (e.g., shielding, cermets, SNF package fill)
    - Could use entire inventory
    - Value of DU to repository (in terms of improved performance) difficult to establish
  - Low–volume, high–value uses
    - Examples: catalysts, semiconductors, hydrogen production, fuel cells, batteries, and high-value fluorine products
    - Could create market and potential revenue to effectively offset the cost of conversion utilizing smaller markets