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The following summaries are provided as fulfillment of milestone M4FT-16SN080305022 and represent international collaboration activities in disposal research funded by the US DOE Used Fuel Disposition (UFD) Campaign during Fiscal Year 2016.

***UFD funded international interactions with the Germany***

## **WEIMOS**

The project name in German is: Weiterentwicklung und Qualifizierung der gebirgsmechanischen Modellierung für die HAW-Endlagerung im Steinsalz (WEIMOS), which translates as: Further Development and Qualification of the Rock Mechanical Modeling for the Final HLW Disposal in Rock Salt. WEIMOS recently received approved from the German Ministry and continues a previous collaboration called the Joint Project, which concerned benchmarking and improvement of constitutive models in geomechanics simulations of field experiments conducted in bedded and domal salt, comprising WIPP/bedded formation in the US and Asse/dome formation in Germany.

The WEIMOS project reflects the current stage of our respective repository programs, which includes consideration of bedded or domal salt as candidate host media. In recent years, extensive laboratory testing of intact WIPP samples, petrological studies, and consolidation of mine-run granular WIPP salt by German colleagues have extended the already substantial database. The theoretical work described in the WEIMOS project plan derives from a research agenda compiled by several collaborators (Popp et al. 2016). One measure of our collective ability to model salt deformation is matching observed room closure, which is a process that can lead to a release of radionuclides from the repository. Within the scope of the long-term safety analysis, rock mechanical predictions covering periods up to 1 million years have to be made. The research agenda expounded upon by Popp et al. (2016) identified key testing regimes to enhance parameterization of constitutive model features:

* Shearing of inhomogeneities (e.g., clay seams)
* Tensile and extensile salt properties
* Damage and healing behavior
* Creep of salt at low deviatoric stress

## **KOSINA**

The KOSINA project focuses on the analysis of integrity of the geological barrier for generic locations in bedded salt and salt pillows by means of geomechanical model calculations. There is no laboratory testing associated with the KOSINA project as there is in the WEIMOS project, which is further developing constitutive models and simulation procedures.

Partners in KOSINA include

* BGR – Bundesanstalt für Geowissenschaften und Rohstoffe (Federal Institute for Geosciences and Natural Resources)
* DBE TEC – Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe GmbH (The [German](https://en.wikipedia.org/wiki/Germany" \o "Germany) Society for the construction and operation of waste repositories)
* GRS – Gesellschaft für Anlagen- und Reaktorsicherheit GmbH (Society for Plant and Reactor Safety)
* IfG – Institut fur Gebirgsmechanik GmbH (Institute for Geomechanics)
* SNL – Sandia National Laboratories (Associate Partner)

In the past, bedded salt formations in Germany were not considered for HLW disposal even though bedded salt has been and still is used to host underground hazardous waste disposal facilities. Therefore, the KOSINA project was addressed in BMWi’s new research concept as an important issue to improve knowledge and perform investigations that clarify conceptual questions and to contribute to the technical-scientific basis for the safety-oriented evaluation of potential repository systems in host rocks available in Germany.  The topics of concern for KOSINA show good collaboration potential with the Design Concepts and Safety Analysis work packages in the DOE-Managed SNF and HLW (a/k/a D-rep) research portfolio.

Representatives from SNL visited BGR in March 2016 to conduct meetings associated with WEIMOS, KOSINA, and other topics of general interest for US/German collaboration in Salt R&D.  These discussions will continue at the 7th US/German Workshop on Salt Repository Research, Design, and Operation, to be held from September 7-9 in Washington, DC.

**References**

Popp T. W. Minkley, S. Fahland, J. Hammer, A. Hampel, K.-H. Lux, N. Müller-Hoeppe, J. Stahlmann, C. Missal, K. Wieczorek, and F. Hansen. 2016. *Salt Repository Research Agenda*. (US/German Workshop website: <http://energy.sandia.gov/energy/nuclear-energy/ne-workshops/usgerman-workshop-on-salt-repository-research-design-and-operation/>.

**Safety Case for Heat-Generating Waste Disposal in Salt**

Specific collaborations in FY16 included:

* Subject matter experts from the US and Germany are in the process of compiling a comprehensive Features, Events, and Processes (FEPs) catalogue for disposal of heat-generating waste in salt (Sevougian et al. 2015).  This collaborative effort is the primary topic of a bimonthly videocon between researchers from SNL and GRS (Gesellschaft für Anlagen- und Reaktorsicherheit).  A face-to-face three-day workshop was held in February in Washington, DC between SNL and GRS researchers to further this effort.  An associated electronic FEPs database is being created by the GRS researchers.  This collaborative effort is also a key topic during periodic (generally, semi-annual) meetings of the NEA Salt Club, e.g., at the September 6, 2016 meeting to be held in conjunction with the 7th US/German Workshop on Salt Repository Research, Design, and Operation, to be held from September 7-9 in Washington, DC.

The overriding premise for these US/German collaborations is to advance the scientific bases for salt repositories.

***UFD funded international interactions with the Republic of Korea***

**Korea Atomic Energy Research Underground Research Tunnel (KURT)**

Deliverable M[4FT-16SN080303091: International collaboration on the development of site and material characterization techniques](https://www.picsne.com/)” (Y. Wang) will contain the discussion of interactions with KURT

**Fuel Cycle Alternative Working Group (FCAWG) under the Joint Fuel Cycle (JFCS) US-ROK Bi-lateral agreement**

The Fuel Cycle Alternative Working Group under the Joint Fuel Cycle Studies bilateral between the Republic of Korea (ROK) and the United States (US) Department of Energy (DOE) held meetings in Gyeongiu, ROK beginning on Monday, November 16 through Tuesday, November 17, then a technical coordination committee meeting and a steering committee meeting was held in Seoul on November 18 and 19 respectively. The status of activities and plans within the FCAWG were summarized by Dr. Boyle from the United States with material provided by Mr. Bang, Mr. Park, Mr. Lee and Dr. Ko from the ROK. The three subgroups of the FCAWG are shown below with summaries of areas of mutual interest for continued bi-lateral collaborations.

Each of the subgroups within the FCAWG met together, then separately. The three subgroups are shown below with summaries of bi-lateral collaborations.

The areas of mutual consideration for collaboration will continue to be conducted as information exchanges since no explicit funding for the FCAWG is provided from either the United States or the Republic of Korea. For all three subgroups, deliverables were identified by the United States and the Republic of Korea for all collaboration areas.

**FCAWG Used Fuel Disposition Subgroup**

* Evaluation tools for repository decisions
* Borehole Research – Collaboration on planned deep borehole disposal research
* Engineered and Natural barrier systems databases and Robust Materials for Disposal System for Spent Fuel
* Natural System Evaluation – Joint field testing and modeling to support the study of high level waste disposal in crystalline geologic media
* Spent fuel degradation, long term durability over geological time

**FCAWG Storage and Transportation Subgroup**

* Canister corrosion/SCC
* Cladding Investigation:
  + - Low burnup (KAERI) & High burnup (DOE)
* Storage thermal and structural analysis
* Centralized storage siting and planning
* Transportability
* Aging Management
* Monitoring/Inspection Technologies

**FCAWG Systems Evaluation Subgroup**

The Systems Evaluation Subgroup will be moved to the Safeguards and Security Working Group (SSWG) of the JFCS for all future interactions.

**High Level Bilateral Commission (HLBC):**

Future collaborations between the ROK and US on the topics from the JFCS FCAWG will be conducted within working groups chartered under the High Level Bilateral Commission (HLBC).The purpose of the working groups is to facilitate between the ROK and the United States peaceful nuclear and strategic cooperation and an ongoing dialogue regarding the areas of mutual interest in civil nuclear energy. Specifically, collaborations from FCAWG will be addressed under the Spent Fuel Management Working Group (SFMWG) of the HLBC, as well as newly identified collaborations. The scope of the SFMWG is:

1. Research, development, demonstration and technical cooperation on storage, transportation, and disposal of spent fuel;
2. Joint efforts to diversify options on spent fuel management in each country;
3. Development of advanced technology to minimize the impact of spent fuel management on the environment, public health and safety;
4. Cooperation on the effective implementation of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, and other relevant international cooperation mechanism
5. Exchange of technical expertise and cooperation in the decommissioning of nuclear power plants; and
6. Other areas of cooperation as determined by the Commission.

A meeting of the HLBC is scheduled for the end of August, 2016 in Washington, DC. Details of future working group meetings as well as identification of future areas of collaboration under the SFMWG will be determined.

***UFD funded international interactions with Taiwan***

TECRO-AIT Joint Standing Committee Meeting on Civil Nuclear Cooperation, Taipei, Taiwan (ROC). December -11, 2015

SNL researcher attended this meeting on behalf of both SNL and DOE. William Boyle (DOE NE 53) was unable to attend. The SNL researcher participated in information exchanges and identification of mutual areas of interest within multiple working groups, all having to do with the back end of the commercial nuclear fuel cycle. Specific areas of mutual interest included ROC interest in sharing experiences and exchange of information with the US DOE on:

* Public participation in siting of nuclear facilities,
* Geological repository sciences,
* Technology transfer for radioactive waste disposal,
* Nuclear fuel extended storage and transportation projects and
* The UFD campaign progress in general.

SNL researcher provided DOE UFD Milestone repots on the following topics:

* Public Preferences Related to Radioactive Waste Management, Nuclear Energy, and Environment
* Evaluation of Used Fuel Disposition in Clay-Bearing.
* Used Fuel Disposal in Crystalline Rocks
* Application of Generic Disposal System Models
* Deep Borehole Field Test Specifications
* Test Proposal Document for Phased Field Thermal Testing in Salt
* Test Plan for Sister Rod Characterization and Testing
* The High Burnup Confirmation Data Project (4 separate reports)
* Characterization of Weld Residual Stresses on a Full-Diameter SNF Interim Storage Canister Mockup
* Preliminary Evaluation of Removing Used Nuclear Fuel from Nine Shutdown Sites
* Surrogate Assembly Test Simulating Normal Conditions of Rail Transport

The next annual meeting is scheduled for early December, 2016 and will be held in the US at Sandia National Laboratories.

*UFD funded international interactions with the United Kingdom*

1. Researchers at SNL and the Univ. of Sheffield/UK are collaborating on R&D for deep borehole disposal (DBD) sealing. Specific FY16 activities included: (i) Univ. of Sheffield participation in the U.S Nuclear Waste Technical Review Board (NWTRB) International Technical Workshop on Deep Borehole Disposal of Radioactive Waste held October 20-21, 2015 in Washington, D.C., (ii) SNL participation in the International Meeting on Deep Borehole Disposal of High-Level Radioactive Waste held June 13-15, 2016 in Sheffield, U.K., and (iii) Univ. of Sheffield preparation of an outline for DBD sealing R&D activities to support SNL documentation and research for the Deep Borehole Field Test (DBFT) project.
2. SNL participated in a joint peer review with RWM/NDA in the UK whereby SNL reviewed 2 of their major reports (thermal and MPC related), and they reviewed SNL’s latest report on DPC direct disposal and supporting documents.

***OECD-NEA Repository Metadata (RepMet) project***

SNL researcher has been participating in the OECD-NEA sponsored project entitled RepMet for the last few years, and was elected Vice Chair of the project (the chair is from the NDA in the UK).  The project involves over 10 different countries and the objective is to create a metadata registry that can be used by national programs to manage their repository data and records in a way that is harmonized internationally and is suitable for long-term management.

Over these few years, we have created conceptual data models for waste-package, HLW/SNF repository (currently in development) and geoscience (also currently in development).  The real benefit of the project is to eventually supply those countries without RWM programs the metadata registry as a starting point.  Beneficiaries will not likely be countries like the US, UK, Sweden, Finland or France…but all of these countries are participating and contributing their experience and expertise.

The benefit to the US (and DOE) is that our expertise is sought and utilized in the development of these models.  The SNL representative is the only one from the US. Although the SNL researcher has traveled in the past on SNL overhead funding, it is clear to the participants that SNL is a DOE lab, and implicit that DOE is being represented. in some manner

When this project was started, OECD-NEA waived the registration fee in consideration of the fact that meetings (normally 2 per year) required more travel expenditures for US participants than those primarily from Europe.  Additionally, the project greatly desired the input and participation from the US. Consequently, there have not been, nor will there be registration fees due for the US.

Beginning with the next project meeting in November, 2016, expenses will be covered by UFD through the SNL international collaborations funding. Future reports will outline in more detail the outcomes and products from the RepMet project.