FOREIGN TRIP REPORT

SUBJECT

Staff Visit to Germany to Exchange Views on the Behavior of Spent Nuclear Fuel (SNF) under Repository Conditions

DATES OF TRAVEL AND COUNTRIES/ORGANIZATIONS VISITED

May 30, 2005; two nuclear institutes in Karlsruhe, Germany: the Institut für Nukleare Entsorgung (INE), a German laboratory, and the Institute for Transuranic Elements (ITU), a European Union laboratory.

AUTHOR, TITLE, AND AGENCY AFFILIATION

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BACKGROUND/PURPOSE

The behavior of actinides under repository conditions is important to the long-term performance assessment of the potential Yucca Mountain (YM) repository. The possible condition of SNF upon receipt at the potential YM repository is also important to the assessment of the safety associated with the potential repository construction/operation. European experience on these subjects is supplementary to the corresponding U.S. experience in some detailed aspects.

The staff visited two nuclear institutes conducting high-level waste research in Karlsruhe, Germany: the Institut für Nukleare Entsorgung (INE), a German laboratory; and the Institute for Transuranic Elements (ITU), a European Union laboratory. A staff member of Framatome Aircraft Nuclear Propulsion (ANP) GmbH, a nuclear fuel company, was also present during the visit. The two institutes are active in research of the behavior of radionuclides under repository conditions. Framatome ANP GmbH has extensive experience in the handling of SNF and nuclear fuel fabrication. The visit provided an opportunity to exchange current information on the behavior of actinides under repository conditions and the possible condition of SNF upon receipt at a potential repository. NRC staff also gave a presentation titled, “Long-Term Materials Behavior at the Potential YM Repository” at INE.

ABSTRACT

The discussions with the engineers and scientists of INE, ITU and Framatome ANP GmbH focused on: (1) the release of dissolved Np-237 and Pu-(239 + 240) colloids in a repository environment; (2) SNF conditions such as high burnup effects and hydride embrittlement; and

(3) the detection of mechanical and other cladding failures. Several new insights were gained on mechanisms that may enhance or decrease the release of actinides in a potential repository environment. The staff member of Framatome ANP GmbH indicated that the mechanical properties of high burnup fuel do not seem to give rise to any safety issue in a potential repository. He also believes that the current approaches for detecting hairline cracks and pinholes on the cladding are sufficiently sensitive, based on more than two decades of experience.

The visit provided an excellent opportunity to gain insights from engineers and scientists in the European community on the behavior of actinides and the possible condition of SNF upon receipt in the potential YM repository. These insights should be valuable during a review of a potential License Application for a geological repository at YM, Nevada. The visit also allowed a U.S. Nuclear Regulatory Commission (NRC) staff member to present the current NRC understanding of potential materials behavior to international counterparts. It is recommended that these types of interactions continue with foreign and domestic institutes in various topics related to the performance and the design of the potential repository. This trip was coordinated with another trip to Générale de Sûreté Nucléaire et de la Radioprotention (DGSNR), a French nuclear authority, and COEMA's La Hague SNF reprocessing facility in France.

DISCUSSION

(1) Np-237 Transport in the Repository

Np-237 is a major dose contributor in later repository times after other dose contributors such as Tc-99, I-129 and Pu-239 are depleted by dissolution or decay away. INE shared the following insights from its research:

- Np-237 can be sorbed in humic acid as colloids or associated with other groundwater colloids. Contrary to the expectation, Np-237 carrying colloids are not always facilitated in the transport compared with dissolved Np-237. Colloids can interact with geometrically heterogeneous host rock surfaces and be strangled (or strained with limited water volume). This will effectively retain Np-237 in the repository. Additionally the groundwater redox (especially influenced by radiolysis) changes the Np-237 sorption behavior.

- Np-237 retention in the secondary minerals has been studied to determine the realistic values of its solubility limits. Both kinetic and thermodynamic effects were discussed on determining solubility controlling solid phases.

- The Np-237 sorption in iron-bearing compounds, such as hematite, seems to depend on Pe and pH.

(2) Pu- (239+240) Colloids

Dissolved Pu-(239+240) are generally considered to be strongly retarded at host rocks, whereas association with colloids will facilitate their transport. Pu-239 colloids are important dose contributors in later repository times, before Np-237 contributes significantly. INE

discussed with new research results, including:

- Pu-(239+240) and Am-241 forms colloids with humic acids. They also transport readily.

- Colloids generated during the glass leaching showed electrostatic attraction and subsequent sedimentation.

- Irreversible colloids may not be possible to form in far field where the radionucilide concentrations are below solubility limits.

- The valence state of Pu is very important in sorption and transport. For +5, Pu will be desorbed from host rocks, whereas +4 will be sorbed on host rocks and colloids simultaneously. The net effect will be significant Pu transport in either case. This alternate situation would happen during the groundwater transport with local variations of Pe and pH.

(3) SNF Conditions Arriving at the Repository Site

The condition of SNF received at the repository may be important to the repository performance assessment. Framatome ANP GmbH and ITU discussed field and research experience on SNF behavior and high burnup SNF, including:

- Cladding performance of high burnp SNF is generally acceptable during transportation, based on limited experience. Properties of creep, fracture toughness and strength are not substantially changed with high burnup.

- The test for detecting breached SNF (e.g., sipping tests) are generally sensitive (i.e., pressure drop) enough to determine the presence of the hairline cracks or pinholes. The French noted that SNF, with burnups up to 60 Gwd/MTHM, shipped to the reprocessing site did not show any additional cladding breach during transportation. German engineers support the French observation.

- The oxidation of fine-grained rim structure of high burnup SNF may be slower or inhibited compared with the interior matrix. UO_2 doped with 20% Zr was not oxidized easily. The rim appears to be mixed with Zr.

- Generally the rim structure is more pristine compared with the interior structure because the new crystallization occurs. This seems to be leading to slower dissolution of the rim. However, fission products may be accumulated in numerous micro-pores present and this will in turn increase the instant release of radionuclides.

- FeO may form Np compounds in reducing environments when iron is corroded.

The purpose of the trip was achieved. The European experience provides a broader data base on Np solubility and Pu colloids. It also provides insights on the safety of handling bare SNF, especially high burnup SNF.

PENDING ACTIONS/PLANNED NEXT STEPS FOR NRC

None

POINTS FOR COMMISSION CONSIDERATION/ITEMS OF INTEREST

None

ATTACHMENTS
None

"ON THE MARGINS"

None