SUMMARY OF U.S. NUCLEAR REGULATORY COMMISSION (NRC) AND
U.S. DEPARTMENT OF ENERGY (DOE) TECHNICAL EXCHANGE ON
WASTE FORM: SPENT REACTOR FUEL
February 25-26, 1992
Pasco, Washington

On February 25-26, 1992, staff from the NRC, DOE, State of Nevada, and affected units of local government participated in a technical exchange on DOE's current and projected work in the area of nuclear reactor spent fuel characterization. The purpose of the technical exchange was to present an overview of DOE's ongoing spent fuel characterization program and discuss, in more detail, the results of current work, and plans for future activities. The agenda is enclosed as Attachment 1. Attachment 2 is a list of attendees.

Michael Cloninger, Yucca Mountain Project Office technical lead, opened the first day of the meeting with an introduction of the four release modes from spent fuel during postclosure. These included: 1) rapid release of gaseous radionuclides, 2) gap/grain boundary inventory of radionuclides, 3) grain boundary dissolution, and 4) grain dissolution. An overview of the spent fuel research pointed out that the objective of this research was to perform tests, obtain data, and develop/validate models. The product of this research will go into the Waste Form Characteristics Report and its subsequent update.

Oxidation research status and plans were discussed in more detail. Areas for future work include: high and low burnup spent fuel tests; Gadolinium containing spent fuel tests; long-term stability of UO2.4; oxidation kinetics beyond UO2.4; and leaching dependence of oxidation state. A discussion was held on dissolution research status and plans including the identification of data needs, including LLNL's test matrix for both unirradiated UO2, and spent fuel and work to determine the rate of dissolution of solubility limiting phases for both UO2.4 and U3O8. The role of the Materials Characterization Center (MCC) was also discussed, including new criteria to be used by MCC in selecting spent fuel assemblies for Approved Testing Materials (ATMs). Other discussions focused on the current status of at-reactor storage and, the effects of an oxidizing environment on long-term spent fuel storage.

DOE concluded the first day with an open period for discussion by all attendees on any of the topics covered during the course of the meeting. NRC believed that the exchange promoted a better understanding of the direction that DOE is pursuing with respect to spent fuel characterization. Representatives from the State of Nevada and affected units of local government had no comments during this period.

Enclosure 1

A tour of DOE Hanford facilities, currently used by Pacific Nothwest Laboratories for ongoing spent fuel characterization, and a drive-by tour of Hanford's high-level liquid waste underground storage tanks, and a view of the site for the Hanford waste vitrification facility took place on the second day.

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NRC STAFF SUMMARY OF THE TECHNICAL EXCHANGE
ON WASTE FORM: SPENT REACTOR FUEL

February 25-26, 1992
Pasco, Washington

On February 25-26, 1992, staff from the U.S. Nuclear Regulatory Commission, the U.S. Department of Energy (DOE), the State of Nevada, and affected units of local government participated in a technical exchange for the purpose of discussing DOE's current and projected work in the area of waste form-spent reactor fuel. The second day of the technical exchange was devoted to a tour of Pacific Northwest Laboratories (PNL) at Hanford, WA to observe the spent fuel research and other facilities.

The first presentation was an overview of the current spent fuel research conducted by DOE. This encompassed: initial fuel characterization (eg., BWR vs. PWR, and burn-up state); summarizing the results of DOE's preliminary "Waste Form Characterization Report;" reviewing the test range of environmental variables; discussing characteristics and effects of oxidation and dissolution; and reviewing cladding failure, C-14 and fission gas.

Following the overview, a presentation was given on spent fuel performance modeling. The topics that were covered in this subject area were gaseous release, cladding failure rate, oxidation response, and dissolution response. DOE indicated that their initial modeling work in each of the aforementioned topic areas was incomplete, and would require more data and testing. DOE's approach to spent fuel modeling is to: represent only what is observable in tests; attain an understanding of mechanisms in the response to address the worst case scenario, and then refine the process; and interface the testing and modeling programs to insure a system of checks and balances is in place.

The third presentation discussed work in the area of oxidation research. The purpose of this presentation was the identification of various stoichiometric processes of oxide formation in an air environment. Preliminary research has shown: spent fuel has a different oxidation behavior than non-irradiated UO-2; fuel variability affects oxidation rates in a transitory manner; after the transitory period, all tested fuels had a similar oxidation behavior; atmospheric moisture and burn-up state of spent fuel have relatively no effect on oxidation rate; as the oxygen ratio to uranium increases at high temperatures (Temperature greater than 250C), the volume expansion associated with oxidation causes a significant fracture of fuel; and lower temperatures form oxides of lower oxygen to uranium ratios, resulting in contraction that causes inter-granular cracking in the fuel. DOE indicated that little future effort is planned to expand the oxidation research program beyond its current level.

Enclosure 2

The fourth presentation covered work in the area of dissolution research. The objective of this program is to provide experimental source-term data and models that can be used to predict the potential for release of radionuclides from a repository in the event that spent fuel is contacted by groundwater. Current testing in the area of dissolution has shown: solubility constraints are likely to limit release of actinides (over 98% of total activity) to far less than one part in 100,000 per year; development of accurate methods for measuring grain-boundary inventories; development of methods for accurately measuring the dissolution rate of UO-2 matrix in spent fuel; oxidation and burn-up rate have little effect on dissolution rate under the conditions tested; dissolution rates in flow-through tests are not considered to be substantially different from those observed in semi-static (more repository relevant) tests; and the presence of Si or Ca in test solutions has an important influence on dissolution rates. DOE indicated that future work in this area would consist of a systematic test program to determine the effects of various paramenters on the dissolution rate of the UO-2 matrix of the spent fuel.

The fifth presentation examined the status of cladding research. The focus of this discussion was on oxide film degradation, hydride reorientation, and temperature-gradient effects. In studying the effects of C-14 on cladding degradation, initial test results indicated C-14 release rates and levels were temperature and atmospheric dependent. Fuoride-induced corrosion was also identified to be a potentially important failure mode. The issue of hydride reorientation is considered unimportant in the absence of preexisting cracks or stress concentrators. Additionally, the effect of temperature gradient appears to be a trivial problem because the cladding is very thin.

The sixth presentation discussed the status of spent fuel initial characterization. This activity is conducted at DOE's Materials Characterization Center (MCC). The mission of the MCC is to provide high-quality characterization and qualification of waste materials and develop test methods for DOE's high-level waste programs.

The seventh presentation covered the effects of long term interim storage. Based on cladding tests, the following conclusions were made: oxidation of cladding is insignificant; cladding crack extension can be avoided if maximum temperatures are maintained no higher than 170 C with a two year lag in storage, or no higher than approximately 130 C with a 40 year lag in storage; if temperature constraints are exceeded, crack extension may lead to rod fracture upon further handling; cladding dilation due to oxidation may cause problems during rod consolidation; and creep is the principle failure mechanism of cladding.

The final presentation discussed DOE's current agreement with the Atomic Energy of Canada, Limited (AECL). Presently, DOE has an agreement with AECL for technical exchanges concerning spent fuel.

DOE concluded the technical exchange with an open period for discussion by all attendees on any of the topics covered during the course of the meeting. Representatives from the State of Nevada and affected units of local government had no comments during this period.

# FINAL AGENDA
# DOE/NRC TECHNICAL EXCHANGE
# WASTE FORM: SPENT REACTOR FUEL
# FEBRUARY 25-26, 1992

**February 25, 1992**

| | | |
|---|---|---|
| 8:15-8:30 | Coffee | |
| 8:30-8:45 | Introduction | Steve Marschman (PNL)<br>Mike Cloninger (YMPO) |
| 8:45-9:30 | Overview of Spent Fuel Research:<br>• Initial Characterization (example: BWR or PWR, and burnup state)<br>• Waste Form Characterization Report<br>• Test Range of Environment Variables<br>• Oxidation and Dissolution<br>• Cladding Failure/C-14 and Fission Gas | Ray Stout (LLNL) |
| 9:30-10:15 | Spent Fuel Performance Modeling | Ray Stout (LLNL) |
| 10:15-10:30 | Break | |
| 10:30-11:15 | Oxidation Research Status/Plans | Bob Einziger (PNL) |
| 11:15-12:15 | Dissolution Research Status/Plans | Herman Leider (LLNL)<br>Walt Gray (PNL) |
| 12:15-1:30 | Lunch | |
| 1:30-2:00 | Cladding Research Status/Plans | Ray Stout (LLNL) |
| 2:00-2:45 | Spent Fuel Initial Characterization Status/Plans | Steve Marschman (PNL) |
| 2:45-3:00 | Break | |
| 3:00-3:45 | Effects of Long Term Interim Storage | Bob Einziger (PNL) |
| 3:45-4:00 | DOE/AECL Agreement | Ray Stout (LLNL) |
| 4:00-5:30 | Overall Discussion/Questions<br>• High Burnup/Future Fuels<br>• NRC Current Licensing Perspective on Spent Fuel | DOE/NRC |

Attachment #1

# FINAL AGENDA
# DOE/NRC TECHNICAL EXCHANGE
# WASTE FORM: SPENT REACTOR FUEL
# FEBRUARY 25-26, 1992
# (continued)

**February 26, 1992**

| | | |
|---|---|---|
| 8:00-8:30 | Badging/Security Briefing<br>(All participants on tour must be identified to DOE/YMPO by 2/7 with name, company affiliation, place and date of birth, and SS#) | Steve Marschman (PNL) |
| 8:30-9:00 | Overview of PNL/OCRWM Support Activities | Max Kreiter (PNL) |
| 9:00-11:30 | Tour of Spent Fuel Facilities | PNL Staff |
| 1:00-4:00 | Tour of Other HLW Facilities | PNL Staff |

# DOE/NRC TECHNICAL EXCHANGE MEETING

## February 25, 1992

| Name/Title | Affiliation | Address | Phone # |
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| Ray B Stout | LLNL | PO Box 808 Livermore CA 94550 | 510 422-3965 |
| Diane Harrison-Griesen | DOE/YMPO | 101 Convention LAS VEGAS | (702)-794-7275 |
| THOMAS W. BUERSTEDT | DOE/YMPO | 101 CONVENTION LAS VEGAS | 702-794-7570 |
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| HUGH BENTON | M&O/BWFC | " | 702/794/1891 |
| HAL CLEARY | WESTON | 955 L'ENFANT PLAZA, DC. | 202-646-6728 |
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Attachment #2

| | Name /Title | Affiliation | Address | Phone # |
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| | CARL DI BELLA | NWTRB | 1100 Wilson Blvd Suite 900 Arlington VA | 703 235 4473 |
| | MAX KREITER | PNL | RICHLAND | (509) 376-9589 |
| | JACK PARROT | NWTRB | Wash. D.C. | 703 235 4473 |
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| 28 | Steve Marschman | PNL | P.O. Box 999 P7-18 Richland WA 99337 | (509) 376- FTS 444 3569 |
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