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NUCLEAR FUEL ASSESSMENT PROJECT SUMMARY
SANDIA NATIONAL LABORATORIES' MIXED WASTE LANDFILL

New Mexico Environment Department

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EXECUTIVE SUMARY

Copies of memoranda concerning Sandia National Laboratories' (Sandia's) Mixed Waste Landfill were obtained from the U. S. Department of Energy (DOE) by Citizen Action, a citizen advocacy group, through the Freedom of Information Act. These memoranda discuss neutron-activated canisters that formerly contained oxide nuclear fuels that were subjected to experiments in the Annular Core Research Reactor located at Sandia. The New Mexico Environment Department (NMED) was asked by Citizen Action to determine whether high-level (nuclear fuel) waste was buried with the canisters in the landfill. Based on extensive investigation, the NMED concludes that the canisters did not contain oxide nuclear fuels when the canisters were disposed of in the Mixed Waste Landfill.

BACKGROUND

Memoranda written in early 1997 by Jerry Peace and Warren Cox of Sandia's Environmental Restoration Project identified stainless steel canisters that were placed in the Mixed Waste Landfill. The memoranda describe how the canisters had been used to contain oxide nuclear fuels subjected to experiments in the Annular Core Research Reactor located in Sandia's Technical Area V. The memoranda also state that the fuels were removed from the canisters prior to the canisters' disposal in the landfill; however, the canisters had become activated during the tests due to neutron capture. The activated canisters were placed into open pits in the classified portion of the Mixed Waste Landfill after the experiments were completed.

A survey conducted during the RCRA Facility Investigation of the Mixed Waste Landfill later revealed gamma radiation at ground surface at activity levels appreciably higher than the local background level. The main objective of the subject memoranda was thus to convey information to Sandia management so that a decision could be made to correct this problem. Eventually, the decision was made to backfill the pits with clean soil to act as shielding; this work has been completed. Gamma radiation at ground surface is now within background levels.

Citizen Action, a citizen advocacy group, obtained the memoranda through a Freedom of Information Act request. Citizen Action provided the memoranda to the Environment Department, and requested the NMED to determine if high-level waste was buried in the landfill. High-level waste is defined by the Nuclear Regulatory Commission as: 1) spent nuclear fuel; and 2) wastes from the reprocessing of spent nuclear fuel. Follow up interviews with Sandia personnel familiar with the fuel experiments, and with the memoranda's authors indicated that no fuel from the experiments went into the landfill. Based on the review of the information provided and subsequent clarification, the NMED concluded that high-level waste was not buried with the canisters.

In response to a subsequent inquiry from Maurice Weisberg to NMED Cabinet Secretary Pete Maggiore dated June 25, 2002, the NMED initiated research to more fully understand the tests and to examine documentation that would show the fate of the tested fuels. To determine if high-level waste was buried with the canisters in the landfill, the NMED concentrated on spent nuclear fuel received by Sandia, and

subjected to experiments in the Annular Core Research Reactor. Experiments using fresh fuel material (not necessarily rods or pellets) were also conducted in the reactor. The duration of these experiments did not cause the fuel to become spent, and therefore were not the focus of the NMED's effort. The research is summarized below:

- Discussed our information needs, received a detailed briefing[1] from the primary experimenter describing the sources of fuels, types of fuels, how the experiments were conducted, and how the fuels and canisters were managed at the end of the experiments.

- Reviewed an Unclassified Controlled Nuclear Information report describing some of the experiments, especially the Fuel Disruption (FD) and Effective Equation of State (EEOS), and the characterization and storage location of some of the tested fuels.

- Reviewed a technical report[3] regarding the FD High Ramp Rate (HRR) experiments.

- Reviewed a technical report[4] regarding the Sandia Transient Axial Relocation (STAR) experiments.

- Reviewed two technical reports[5,6] and an unpublished experiment plan[7] describing the experimental design and results of the Source Term (ST) experiments.

- Reviewed a report[8] describing the characteristics of fuel rods irradiated in the BR3 Reactor in Mol, Belgium.

- Examined records from a classified database that tracks Special Nuclear Material. The database provided verification of the number of experiments, and identified storage locations of test items.

- Queried and received clarification from Sandia personnel about the experiments, management and storage of the test packages.

- Personally observed items in storage. Also viewed photos from 2000-2002 time frame showing items temporarily removed from storage. Personal viewing of these particular items was not possible due to difficulties with physical access requiring special equipment and security reasons.

SUMMARY OF FINDINGS

- Spent nuclear fuel was sent to Sandia primarily from two sources, the EBR-II reactor at INEEL and the BR3 reactor in Mol, Belgium. A section of a single fuel pin was obtained from the KNK-II reactor (Kernforschungzentrum Karlsruhe) in Karlsruhe, Germany.

- A portion of this spent nuclear fuel was used in four experimental series (FD, EEOS, STAR, and ST). A total of 34 tests using spent nuclear fuel were identified. The unused remainder of the fuel is in storage at Sandia.

- Four canisters from two experiments (the last experiment series, ST) were put in the landfill.

- The fuels from the ST experiments were stabilized in epoxy then removed from the canisters.
- Post-experiment examination of the ST fuel packages occurred after the MWL stopped accepting waste.
- Discussing specific quantities and locations of fuels would make this summary Unclassified Controlled Nuclear Information, and therefore not suitable for unlimited release. Therefore, information about the quantities and locations of nuclear fuel material is not provided.
- All fuels, whether tested or not, are considered Special Nuclear Material.
- Special Nuclear Material is required to be inventoried to the nearest gram; any amount greater than 0.5 gm is tracked.
- All Special Nuclear Material must be accounted for within 3 hours of notification from DOE.
- The spent fuels were exposed to thermal stress during the experiments resulting in varying amounts of damage to cladding and fuel. However the fuel remained within the primary containment.
- The uranium or plutonium composition of the fuel was unchanged. In other words, the short duration of the irradiation in the ACRR did not change the U/Pu inventory in either spent or fresh fuels. Another aspect of the short duration of the tests is that fresh fuels used in tests did not become spent.
- The NMED has verified that all experimental packages containing spent fuel are accounted for in storage at Sandia.

FUEL SOURCES

Spent nuclear fuels that were tested in the ACRR came primarily from two reactors. These spent fuels are referred to as PNL from a reactor in Idaho, and BR3 from a Belgian reactor. Portions of a single fuel pin designated KfK from a German reactor were used in one experiment.

PNL Fuel Pins

ORIGIN: PNL stands for Pacific Northwest Laboratory in Richland, Washington. The fuel pins were manufactured at PNL and then irradiated in the Experimental Breeder Reactor II (EBR-II) at the Idaho National Environmental Engineering Laboratory.

FUEL TYPE: mixed oxide, that is, uranium oxide (UO_2) and plutonium oxide (PuO_2). Fuel pellets were clad in stainless steel.

The fuel pins were sent to Sandia in multiple shipments.[1]

Thirty-one NRC supported tests were performed on PNL fuel materials between 1974-1982.[1]

Two to seven inches were cut from original pins for use in three series of experiments (FD, EEOS, and STAR). Remnants were returned to storage.

EXPERIMENT SERIES USING PNL FUEL:

-Effective Equation of State (EEOS)

- EEOS-1 through EEOS-9 used only fresh fuel material (confirmed by classified database)
- EEOS-1 through EEOS-3 around 1977
- EEOS-4 through EEOS-9 around 1984
- EEOS-10 through EEOS-13 between 1986 and 1990
- Only EEOS-10 through EEOS-13 used spent nuclear fuel. (confirmed by classified database)
- Canisters were approximately 23 inches long by 5 inches in diameter, and provided double containment for the experiments.
- Three containment canisters were constructed and reused during the series.
- The fuel was sealed in a combination pressure cell and calorimeter, about 5 inches high combined. The arrangement effectively provided a third layer of containment. This combination was removed from the canisters and put in corporate storage. The outer canisters could be reused in EEOS because the pressure cell and calorimeter used to contain the fuel never leaked.
- The Bureau visually verified the location of pressure cell and calorimeter combos from EEOS-10 and EEOS-11 experimental packages in storage (classified database verified location).
- Photos taken in January 2002 show two canisters in storage location not available for personal viewing. These contain EEOS-12 and EEOS-13 experiments unopened.
- The third canister was visually verified in storage, and location verified through the classified database.

-Fuel Disruption (FD)

- FD 1.1 thru FD 1.12 prior to 1979: 12 experiments, 2 used fresh fuel, 10 used sections of PNL (spent fuel). FD 1.2 was a repeat of FD 1.1 using the same fuel and canister.
- High Ramp Rate sub series (HRR) 1 through 6 during 1980. HRR 1 (also known as FD 2.1) and 6 were fresh fuel.[3]
- FD 2.4, 2.6 thru 2.8 during 1981 and 1982: 4 experiments using PNL fuel.
- FD 4.0 thru 4.5 during 1981 and 1982: 6 experiments. FD-4.0 was also known as FD-2.5, and used fresh fuel material. FD-4.5 used KfK fuel.
- Canisters used in the FD 1 series were about 17 inches long and 9 inches in diameter.
- The FD 2, 4, and HRR series canisters were about 23 inches long and 9 inches in diameter.
- Early tests used 1 fuel pellet each. Later experiments used about 5 fuel pellets each.
- Quartz windows and high-speed cameras allowed for visual inspection of experimental effects.
- Inner and outer canisters were made of aluminum, and provided double containment for the experiment. Primary containment was never breached. Canisters containing the fuel

packages are in corporate storage. The spent fuel experiments are stored in drums shielded with lead.

- NMED personnel accounted for all FD and HRR test packages, and visually verified the storage location of 24 items.
- The NMED was provided photos taken in December 2000 of 3 canisters showing HRR-1/FD-2.1, FD-4.0 (aka FD-2.5), and HRR-6 temporarily removed from storage. It was not feasible to remove these from storage for our personal inspection due to difficulties with physical access and security reasons.

-Sandia Transient Axial Relocation (STAR)[4,9]

- Continuation of the FD tests using longer fuel pins.
- There were 7 experiments all together, STAR-1 and 2 used fresh fuel material, STAR-3 through 7 used PNL spent mixed oxide fuel.
- Canisters approx 120 inches long, and were never opened following experiment.
- Length required unique storage location.
- Fuel pins were 26 inches long, except for STAR-7, which were 32 inches long.
- Quartz windows and high-speed cameras allowed for visual inspection of experimental effects.
- All canisters with fuel are in storage. NMED staff saw photos taken in December 2000 of STAR-4 temporarily removed from storage, and of STAR-4 and two other STAR canisters in their storage hole. It was explained that three other canisters are stored beneath the three in the photo. Cables attached to the lower three can be seen in the photo. It was not feasible to remove these from storage for personal inspection due to difficulties with physical access and security reasons.
- Another photo showing STAR-7 removed from storage was shown to staff.

KfK Fuel Pin

ORIGIN: A single pin (small section of a rod) irradiated in the KNK-II reactor from Kernforschungzentrum Karlsruhe (KfK) in Karlsruhe, Germany was received in 1982.[12]

FUEL TYPE: mixed oxide, that is, uranium oxide (UO_2) and plutonium oxide (PuO_2). The pin was 1.16 inches long and clad in stainless steel.

EXPERIMENT SERIES USING KfK FUEL:

-Fuel Disruption (FD-4.5)

- The pin was cut into four pieces, and only two were used in a single experiment.
- The Bureau visually verified this container in storage.

BR3 Fuel Rods

ORIGIN: The BR3 rods were irradiated in the BR3 reactor in Mol, Belgium.

FUEL TYPE: uranium oxide (UO_2). Fuel pellets were clad in zircaloy-4. Rods were 113.6 cm long.[5]

16 rods sent to Sandia in one shipment in the mid 1980s.[1]

EXPERIMENT SERIES USING BR3 FUEL:

-Source Term (ST)[5,6,7,13]

- ST-1 and ST-2 occurred in 1986 and 1987, and had the same design.
- Canisters were about 7 inches in diameter, and 16 feet long to accommodate sensors and filters.
- Two canisters provided double containment.
- Actual fuel test package was about 20 inches long.
- Fuel rod sections used were about 6 inches long.
- 4 spent fuel rod sections were placed above 4 fresh fuel rod sections.
- Filter samplers above the fuel sections collected fission product vapors and aerosols.
- The filters were leached with water, then nitric acid for analysis of the fission products (e.g., Cs, I, Ba, Sr, Eu, Te).
- Fuel section was encased in epoxy before opening the canisters.
- Canisters were disassembled and the fuels removed in the Hot Cell facility with remote controlled arms and hands.
- The post-test examination of the epoxied fuels was done in 1989, after the closure of the MWL.
- The epoxied fuel section of ST-1 was cut into 18 sections.[5] ST-2 was cut into 20 sections.[13]
- Two sections of ST-1 were sent to Argonne National Laboratory for study.[16]
- Fresh fuel pellets remained intact.
- Spent fuel pellets near the center of the package swelled and fractured, but didn't flow.
- Zirconium clad melted and relocated near bottom of fueled section. The fueled section did not come in contact with the inner canister. Photomicrographs of the cut fuel sections verified the post-test condition of the fuel.
- NMED staff tracked the sections through the classified database, and verified the location in storage. Examined the shipping record for the two sections of ST-1 sent to Argonne National Lab.

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