DD-84-9

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS
John G. Davis, Director

In the Matter of	)	
	)	
SHIPMENTS OF HIGH LEVEL NUCLEAR POWER PLANT WASTE	)	(10 CFR §2.206)
	)	

DIRECTOR'S DECISION UNDER 10 CFR §2.206

By letter to Charles E. MacDonald, Chief, Transportation Certification Branch of the Nuclear Regulatory Commission (NRC) dated November 7, 1983, Marvin Resnikoff, on behalf of the Sierra Club, requested the NRC to halt all dry cask shipments of spent fuel in Model Nos. NLI-1/2, NFS-4 (NAC-1) and IF-300 casks, including shipments from West Valley, New York and the Cooper Nuclear Station in Nebraska, until appropriate analyses are performed of an incident involving possible oxidation of spent fuel in a shipping cask received at Battelle Columbus Laboratories (BCL) in Ohio. In support of its request, the Sierra Club stated "If nuclear fuel is shipped dry and an accident involving impact and fire occurs, then uranium could oxidize rapidly, producing a radioactive dust. As far as we are aware, this type of accident has not been analyzed by the NRC." The Sierra Club also requested that NRC:

1. Require General Electric (GE) and Nuclear Assurance Corporation (NAC) to update their Safety Analysis Reports (SAR) for the IF-300, NLI-1/2, and NFS-4 (NAC-1) casks to consider oxidized fuel; and

2. Reanalyze accident scenarios in NUREG-0170, NUREG/CR-0743, and NUREG/CR-2472 to consider the oxidation phenomena.

Notice of receipt of the request and the NRC's intent to treat the request as a petition under 10 CFR §2.206 of the Commission's regulations was published in the Federal Register on December 5, 1983 (48 FR 54550).

For the reasons set forth below, I have determined that: (1) fuel shipments need not be halted, (2) GE and NAC need not update their Safety Analysis Reports, and (3) the NRC accident scenarios to evaluate potential impacts of transportation need not be reanalyzed.

BACKGROUND

The NRC establishes safety and design standards for packages, known as Type B packaging, used to transport potentially hazardous radioactive materials, including spent reactor fuel. These standards require Type B packages to withstand conditions incident to normal transport (see 10 CFR §§71.51(a) and 71.71) and certain hypothetical accident conditions,

including impact and fire, without serious loss of containment and limited loss of shielding capability (see 10 CFR §§71.51(a) and 71.73). The NRC reviews and specifically approves each Type B package design (10 CFR §71.31) to assure that the design meets applicable requirements. The approvals are issued in the form of a Certificate of Compliance for each package design. The NRC rules (10 CFR Part 71) also require various procedural, administrative and technical requirements to be followed for use of Type B packages. The NRC regulations also specify Quality Assurance standards under which packages must be designed, fabricated, and used and require an NRC approved Quality Assurance Program (10 CFR §71.101).

The NRC has conducted several studies of the environmental impacts of the transportation of radioactive materials, including spent fuel (WASH-1238, "Environmental Survey of Transportation of Radioactive Materials To and From Nuclear Power Plants," December 1972; and NUREG-0170, "Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes," December 1977). In each case, the risk of radiological effects from the transport of spent fuel under both normal and accident conditions was found to be small.

INCIDENT

Details of the incident at BCL form the basis of Sierra Club's request and are documented in "Airborne Contamination Released During Underwater Unloading of a Failed PWR Spent Fuel Assembly," R. W. Klingensmith,

PATRAM Proceedings - Berlin 1980, pages 646-653 and "Investigation of Stainless Steel Clad Fuel Rod Failures and Fuel Performance in the Connecticut Yankee Reactor," V. Pasupathi and K. W. Klingensmith, EPRI-2119, November 1981. Basically, in May 1980, an irradiated fuel assembly with known severe cladding failure (stainless steel) was shipped to BCL for examination. The fuel was shipped dry in a Model No. NFS-4 cask. Rod failure included 4-5 foot long cracks approximately 1/8-inch wide. During shipment, the fuel may have reached a temperature of 285°C in an air environment. Upon removal of the cask head following flooding of the cask cavity and with the cask submerged in the pool, a dark cloud of material emanated from the cask. This resulted in contamination of the pool water and airborne contamination within the cask handling area.

No significant radiation doses were received by any employees during the incident and there was no release of radioactive material from the building.

The circumstances associated with the incident were reviewed in a routine NRC inspection at the BCL facility. The results were reported in Region III Inspection Report No. 70-008/80-02; 30-5728/80-02; 50-6/80-01 (November 25, 1980). A Notice of Violation was issued to BCL on December 8, 1980, for an overexposure to an employee's hand during preparation of the cask for reuse and for radioactivity in the fuel storage pool exceeding license conditions.

Subsequent to the incident, BCL reviewed and revised their receipt and handling procedures to consider receipt of failed fuel. Also, the Commission amended the Certificate of Compliance for the Model No. NFS-4 cask to preclude shipment of failed fuel assemblies (pellets) which are oxidized and to authorize other failed fuel to be shipped only in a dry non-oxidizing atmosphere. (Certificate of Compliance No. 6698, Rev. No. 15, to Nuclear Assurance Corporation and all users dated January 25, 1982.)

There are other Certificates of Compliance issued for Model Nos. IF-300, NLI-1/2, TN-8, TN-8L, TN-9, and NLI-10/24 casks which authorize the dry shipment of spent fuel. Certificates of Compliance for Model Nos. NLI-1/2 and NLI-10/24 casks require inerting of the cask cavity. The Certificates of Compliance for the Model Nos. NFS-4, IF-300, TN-8, TN-8L, and TN-9 casks permit an air environment.

DISCUSSION

In its petition, the Sierra Club does not ask that shipments of spent fuel be halted because of non-compliance with regulatory requirements. Rather, it asserts that the BCL incident is a type of incident that has not been previously considered by the NRC and that approvals issued by the NRC do not consider the oxidation phenomenon.

Following the receipt of the petition, the UO_2 fuel oxidation phenomenon and its potential impact on the transportation of irradiated power reactor fuel assemblies were further assessed in NRC Research Information Letter (RIL) No. 139, "Potential Oxidation of UO_2 in Irradiated Fuel and Its Regulatory Implications," March 5, 1984 (RIL-139), a copy of which is appended to this decision. Its conclusions are briefly summarized below.

Under certain conditions UO_2 can react with available oxygen to form higher oxidation states. One of these higher oxidation states is U_3O_8. Production of U_3O_8 is accompanied by a decrease in density from that of UO_2 (i.e., volumetric expansion). The U_3O_8 expands and breaks off to form a powder as it is produced from the oxidation of the original UO_2. This process is known as spalling.

The conditions necessary for UO_2 to achieve higher oxidation states are the presence of oxygen and sufficient heat. Conversely, the absence of either oxygen or sufficient heat will preclude UO_2 oxidation. In most cases spent fuel which is shipped is undamaged (i.e., >97% of rods are expected to have undamaged cladding). Because the fuel rods are filled with helium, one of the necessary conditions for oxidation is not present (i.e., oxygen) when cladding is not damaged. So, in the case of undamaged rods, even with high levels of heating, oxidation of UO_2 to higher oxidation states is precluded.

For damaged fuel rods, the internal helium gas would be lost. Such fuel would be exposed to its immediate ambient environment. In the case of spent fuel in transport, the immediate environment would be the cask cavity gas. If the cavity gas contains oxygen, one of the necessary conditions for oxidation is met. If sufficient heat is also present, then oxidation could take place. Experimental data indicate that temperatures exceeding 150°C (302°F) may be sufficient for UO_2 oxidation. Thermal analyses on NRC approved spent fuel casks indicate that peak fuel temperatures, even with relatively low internal heat loads, may exceed 150°C under the normal and hypothetical accident conditions considered under the requirements of 10 CFR Part 71.

Oxidation of UO_2 in failed fuel rods causes spalling of the fuel matrix. As the fuel spalls dispersible radioactive material is produced. The spall product releases additional gaseous fission products and contaminated particles. Although the start of spalling (i.e., reaction initiation) is not immediate once the conditions necessary for oxidation are present, it can occur in a matter of minutes to hours at temperatures of 250°C or more, in a matter of days at about 200°C, and over a matter of years at about 150°C. It is evident that lower temperatures delay the initiation of the potential for UO_2 oxidation, but lower temperatures do not necessarily preclude it.

The spall product increases the available dispersible radioactive material but does not significantly add to the driving force needed to release material from a cask. The shipping casks have been designed to preclude the release of radioactive material under normal and hypothetical accident conditions of 10 CFR Part 71. Because oxidation does not create or add to the driving force for release evaluated in the Part 71 analyses, these air filled casks will preclude release even for conditions where oxidation occurs.

The potential for UO_2 oxidation does not reduce packaging effectiveness for normal or hypothetical accident conditions of 10 CFR Part 71. The overall risk to public health and safety for conditions beyond the hypothetical accident conditions of 10 CFR Part 71 and for sabotage events has been considered. Evaluations were done in the past (NUREG-0170; WASH-1238; NUREG/CR-0743, "Transportation of Radionuclides in Urban Environs: Draft Environmental Assessment," July 1980; and NUREG/CR-2472, "Final Report on Shipping Cask Sabotage Source Term Investigation," October 1982), but the possibility of UO_2 spalling was not specifically considered in these reports. Evaluations were performed recently by the NRC's Office of Research to determine if there was any increase in risk over previous studies from potential oxidation in the five air filled cask designs and two helium filled cask designs (see RIL-139, pp. 13-15, 19-23.) In both cases it was estimated that consequences are not increased by more than a factor of 4.0 and that impact on risk is

minor (<15% increase). This upper bound of increased risk is not considered significant. For example, based on 2,182 spent fuel shipments/year (70% by truck and 30% by train), there is a likelihood of one latent cancer fatality in 2,060 years from an extremely severe transportation accident in which oxidation occurs.

The other situation to be considered for air filled casks is the receipt and handling of these packages. While fuel oxidation does not significantly alter the risks of transport, it could increase the risks of personnel exposure during receiving and handling operations. This is especially true if the occurrence of oxidation is unsuspected; or if oxidation is suspected, but the extent of oxidation is unknown.

In view of the foregoing, and because there is no practical means of identifying all failed fuel assemblies, particularly if the cladding defects are small, I have concluded that the public health and safety requires that all dry spent fuel shipping casks should be inerted for shipment in order to avoid handling problems at facilities receiving spent fuel. In addition, fuel assemblies (rods) known or suspected to be failed should be canned for shipment. Accordingly, the applicable

NRC Certificates of Compliance have been revised to require inerting for shipment. In addition, the certificates, except Certificate of Compliance No. 9010, prohibit shipment of failed fuel assemblies and fuel with cladding defects greater than pin holes and hairline cracks. Certificate No. 9010 permits such shipment only if the fuel is canned appropriately for shipment. Revisions may be made to the other certificates in the future to permit shipments of canned failed fuel. Copies of the revised certificates are attached to this decision.

CONCLUSION

The Sierra Club's request to halt all dry cask shipments of spent fuel including shipments from West Valley, New York and the Cooper Nuclear Station in Nebraska is based on its belief that appropriate analyses of fuel oxidation have not been performed. As outlined above, and in RIL-139, the issue of fuel oxidation has been addressed. Based on the information available to the NRC, the regulations governing the transportation of spent fuel and the requirements for inerting dry spent fuel casks and canning grossly failed spent fuel are adequate to protect public health and safety. Consequently, the Sierra Club's first request to halt shipments is denied. Because of the action taken to require inerting of all dry cask shipments of spent fuel, the Sierra Club's second request

to require General Electric and Nuclear Assurance Corporation to update their Safety Analysis Reports to consider oxidized fuel is also denied. Based on the analysis of fuel oxidation as described in RIL-139 and the finding therein that the oxidation phenomena is not a significant contribution to overall transport risk, the Sierra Club's third request to reanalyze accident scenarios in NUREG-0170, NUREG/CR-0743, and NUREG/CR-2472 is also denied.

A copy of this decision will be filed with the Secretary for the Commission's review in accordance with 10 CFR §2.206(c) of the Commission's regulations. As provided in 10 CFR §2.206(c), the decision will constitute the final action of the Commission 25 days after the date of issuance, unless the Commission on its own motion institutes review of this decision within that time.

John G. Davis, Director
Office of Nuclear Material
Safety and Safeguards

Enclosure: As stated

Dated at Silver Spring, Maryland
this 13 day of April, 1984.