

POLICY ISSUE NOTATION VOTE

October 22, 2007

SECY-07-0185

FOR: The Commissioners

FROM: Luis A. Reyes
Executive Director for Operations

SUBJECT: MODERATOR EXCLUSION IN TRANSPORTATION PACKAGES

PURPOSE:

To request that the Commission approve Option 3 of staff recommendations on its approach for considering the use of moderator exclusion for spent fuel transportation packages.

SUMMARY:

Fissile-material transportation packages are required, by regulation, to be subcritical with fresh (i.e., unborated) water inside the containment system. Packages based on "moderator exclusion" would not meet this requirement, because the criticality safety of the package relies on fresh water not getting into the containment system. Moderator exclusion is allowed only as an exception to the regulations, and has not previously been used as a basis for approval of a spent fuel transportation package design. Applicants have indicated that they wish to submit applications for spent fuel transportation package designs based on moderator exclusion. This paper describes: (1) the issues surrounding the use of moderator exclusion as a basis for design approval for spent fuel transportation packages, including a discussion of the current staff practice; (2) three regulatory options for addressing moderator exclusion; and (3) a recommendation regarding these options, that includes rulemaking to incorporate regulatory provisions addressing moderator exclusion. Because a change in staff practice would represent a departure with safety significance, the staff is requesting Commission direction on the moderator-exclusion issue.

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BACKGROUND:

The Nuclear Regulatory Commission (NRC) approves designs for transportation packages for large (Type B) quantities of radioactive material and fissile material. NRC transportation regulations, including performance standards for these packages, are in 10 CFR 71, "Packaging and Transportation of Radioactive Material." Regulations that specify criticality safety requirements for fissile-material packages are 10 CFR 71.55, "General Requirements for Fissile Material Packages," and 10 CFR 71.59, "Standards for Arrays of Fissile Material Packages." In certain instances, these provisions specifically address the presence and degree of water moderation that must be assumed when showing subcriticality of the fissile contents under normal conditions of transport and hypothetical-accident conditions. For a single package, 10 CFR 71.55(b) requires that a package must be designed and the contents limited such that a single package "would be subcritical if water were to leak into the containment system." Paragraph 71.55(c) allows the Commission to approve exceptions to this requirement, such as the approval of a package that relies on moderator exclusion. The regulations in 10 CFR 71.55 and 71.59 are consistent with, but not identical to, regulations promulgated by the International Atomic Energy Agency (IAEA). Enclosure 1 provides the applicable NRC and IAEA regulatory references.

DISCUSSION:

Transportation packages are required to be designed and the fissile contents limited, so that the package is subcritical, with fresh water in the containment system. This requirement (codified in 10 CFR 71.55(b)) provides a significant margin of safety and a defense-in-depth against accidental criticality in transport, such that a criticality accident is considered impossible. In fact, environmental impact statements and risk assessments for transportation are based on this premise. Such a robust defense-in-depth is consistent with NRC's strategic outcome of prevention of inadvertent criticality events. This is particularly important for transportation, because effects of an inadvertent criticality could adversely impact the public and not be limited to a nuclear facility site. Because most industry interest in moderator exclusion centers on spent fuel transport, this paper emphasizes this type of fissile material.

Staff Practice to Date

To date, NRC has not approved any spent fuel transportation package design that could be critical with fresh water in the containment system (i.e., no spent fuel transportation package design has been approved based on moderator exclusion). Practical design methods and features have been used to ensure subcriticality of transportation casks for all types of commercial- and research-reactor spent fuel. Such design features include geometry control and neutron-absorber plates incorporated into the basket structure that supports the fuel elements.

The requirement that water be assumed within the containment system is not explicitly tied to the ability of the package to limit water in-leakage under the regulatory tests and conditions that simulate normal conditions of transport and accident conditions. Instead, it is a general design requirement that is intended to ensure that no criticality accident could occur in transportation,

considering analytical uncertainties and uncertainties in the transportation environment. For example, although transportation risk studies to date show that the regulatory accident tests bound the conditions in most credible accidents, uncertainties still exist, particularly with respect to future transportation systems and practices. For spent fuel casks, this requirement also ensures safety during underwater loading and unloading operations.

The provisions of 10 CFR 71.55(c) allow the Commission to approve an exception to the requirement that the package must be subcritical with water in the containment system. The staff's long-term practice has been to consider this exception to be appropriate only for limited shipments and not for general approval of a design. Approval of a moderator exclusion exception under 10 CFR 71.55(c) should include risk information appropriate for the conditions of the particular shipments, including consideration of transportation operations, mode, route, and number of shipments. Using the moderator-exclusion provision of 10 CFR 71.55(c) for the general approval of a spent fuel cask design has not been considered appropriate in the past, because it would lead to the routine use of an exception that has important safety implications. In this regard, a Part 71 general design approval would allow an unlimited number of casks to be fabricated to that design, with essentially no restriction on transportation mode, route, or number of shipments.

Limited Use of Moderator Exclusion and the Transport of Commercial High-burnup Spent Fuel

Staff has issued guidance, regarding criticality assessments for transportation package designs for commercial spent fuel, that considers the ability of the cask to prevent water in-leakage under the regulatory hypothetical-accident conditions (10 CFR 71.55(e)). The guidance was issued as Interim Staff Guidance No. 19 (ISG-19). The guidance allows applicants to take credit for moderator exclusion under 10 CFR 71.55(e), provided that physical testing demonstrates the performance of the water-tight boundary under the regulatory-accident tests. The guidance was developed to address the possibility of fuel reconfiguration to a more reactive geometry under accident conditions, particularly in the case of high-burnup fuel that has unknown cladding strength and ductility.

Practical Implications of Moderator Exclusion

Applicants have claimed that using moderator exclusion as a basis for package-design approval could result in fewer future spent fuel shipments, because the number of fuel assemblies within a cask could be increased. The staff believes that there are reasonable and practical alternatives, that do not rely upon the moderator exclusion exception, and that these alternatives allow casks to retain defense-in-depth against accidental criticality in transport. It is primarily casks designed for an exceptionally large capacity (e.g., 32 pressurized water reactor (PWR) fuel assemblies) or without neutron-absorber plates, that may need to rely upon the moderator exclusion exception of 10 CFR 71.55(c). In contrast, the U.S. Department of Energy's (DOE) transport, aging, and disposal canister being developed for Yucca Mountain has a limited payload of commercial spent fuel (e.g., 21 PWR fuel assemblies) and is being designed so that it is critically safe with fresh water within the canister. Although NRC does not, in general, regulate DOE transportation activities, the Nuclear Waste Policy Act requires that shipments to the repository be made in NRC-certified packages.

Besides limiting the fuel payload, using burnup credit in criticality evaluations is an alternative method that can be used to achieve the same high capacity as would be possible with moderator exclusion. Burnup credit involves quantifying the decrease in nuclear reactivity of the fuel, due to fissile material depletion and the buildup of actinide and fission-product poisons during irradiation. The primary difference would be that designs using burnup credit would still incorporate neutron absorbers in the fuel basket. The use of burnup credit, with neutron absorbers, retains a margin of safety and defense-in-depth that ensures subcriticality in the unlikely event of fresh water entering into the containment system. NRC has recently approved a large-capacity spent fuel transport cask that takes limited credit for fuel burnup, to ensure criticality safety with fresh water in the containment system. Staff continues to interface with industry on the use of burnup credit in criticality safety evaluations for spent fuel transportation casks.

Possibility of Requests for Design Approval Using Moderator Exclusion

Some cask designers have stated that they intend to submit applications for spent fuel cask-design approvals based on moderator exclusion. For example, staff has held public meetings, with Holtec International, on its new design for a dual-purpose (storage and transport) cask that may rely on moderator exclusion. Other vendors for large-capacity, dual-purpose casks (e.g., Transnuclear and NAC International) have also said that they intend to submit designs that would need approval under 10 CFR 71.55(c). In addition, the staff has received a written query, from DOE, about the acceptability of using moderator exclusion as part of the design basis for a standardized canister being developed, by Idaho National Laboratory (INL), for shipments of non-commercial spent fuel from research and weapons-production reactors. DOE has indicated that it has near-term plans to submit a topical report for the INL canister design for NRC staff review.

Regulatory Options for Moderator Exclusion for Spent Fuel Casks

Prevention of an accidental criticality is a fundamental safety principle in the transport of fissile material. The regulatory approach currently in place, including regulations and staff practice, assures that there will be no inadvertent criticality events in spent fuel transportation activities. However, addressing moderator exclusion provisions in rulemaking may be an effective way of retaining appropriate margins of safety while recognizing the robust nature of spent fuel casks and the very small likelihood of fresh water inadvertently getting into the containment system during actual transport. A rulemaking process will also provide an opportunity for stakeholder comment and engagement with the staff in discussing views on moderator exclusion.

On February 15 and March 20, 2007, Spent Fuel Storage and Transportation staff made presentations to the Advisory Committee on Nuclear Waste and Materials (ACNW&M) on moderator exclusion in spent fuel transportation packages. In a letter to Chairman Klein (ADAMS Accession Number ML071150483), dated April 23, 2007, the ACNW&M recommended deferring the rulemaking decision and gaining experience through processing of applicants' requests for moderator exclusion. Staff stated, in its response dated June 1, 2007 (ADAMS Accession Number ML071380463), that it is actively engaged with potential applicants to gain this experience, although ACNW&M noted in its summary report dated July 27, 2007 (ADAMS

Accession Number ML072110537), that this experience would address moderator exclusion only under accident conditions, and was not consistent with its recommendation. The staff believes that rulemaking ultimately provides the best approach to assure adequate stakeholder input in this matter.

Approval of spent fuel package designs based on moderator exclusion would represent a major departure from current practice, and may preclude NRC from making categorical statements about the impossibility of criticality accidents during transportation. Because of the likelihood that applicants may, in the future, submit spent fuel package applications, requesting approval under 10 CFR 71.55(c), and because of the safety implications, staff is proposing three options to address the moderator exclusion issue. The options, including the pros and cons and resource estimates for each, are described in Enclosure 2. The three options are: (1) consider moderator exclusion only on a limited-shipment basis, as a 10 CFR 71.55(c) exception to the subcriticality requirement of 10 CFR 71.55(b); (2) consider moderator exclusion in spent fuel cask-design approvals under the provisions of 10 CFR 71.55(c), with additional risk information; and (3) initiate rulemaking to codify the acceptable uses of moderator exclusion for spent fuel transportation packages (recommended option). Enclosure 3 provides a discussion of security-related issues associated with moderator exclusion.

RECOMMENDATION:

The staff recommends that the Commission approve Option 3, to codify the acceptable uses of moderator exclusion for spent fuel transportation packages, using the rulemaking process, which assures appropriate stakeholder participation. The activities associated with this option are described in Enclosure 2. As the initial steps, the staff would: (1) evaluate existing environmental, risk, and security assessments; (2) develop the risk information needed for a technical basis for the rulemaking; and (3) develop a proposed rule and guidance. It is estimated that these initial steps would take approximately 2 years.

RESOURCES:

Because resources for Fiscal Year (FY) 2008 are already budgeted, any needed resources for moderator exclusion would have to be reprogrammed from existing budgeted efforts. For FY 2008 activities, if resources are reprogrammed to support moderator exclusion tasks, Office of Nuclear Material Safety and Safeguards (NMSS) work that may be deferred, delayed, or canceled includes the Division of Spent Fuel Storage and Transportation's (SFST's) efforts on risk-informing guidance, multi-lateral cooperation and assistance, inspection, and lower-priority licensing casework. The budgeting process for FY 2009 would be handled in a similar manner, although staff may have somewhat more latitude in reallocating workload resources in FY 2009, given the additional time for planning.

Resource estimates for the three regulatory options are described in Enclosure 2. For the recommended option (Option 3), the Fiscal Year (FY) 2008 resources are estimated as 2.0 full-time equivalents (FTEs) and \$300,000 contract cost for technical assistance. Resources needed for FY 2009 and FY 2010 are estimated as 2.7 FTEs and 1.0 FTE, respectively. Enclosure 3 addresses security-related resources.

The Commissioners

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The Office of the General Counsel has reviewed this package and has no legal objection. The Office of the Chief Financial Officer has reviewed this package for resource implications and concurs.

/RA/

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Enclosures:

1. Regulatory References
2. Regulatory Options
3. Security-Related Issues

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