An Alternative Approach for Licensing Spent Fuel Dry Storage Systems (DSS): Shielding Method of Evaluation (MOE)

Introduction

As part of ongoing interactions with industry, the staff is considering the possibility of accepting a method of evaluation (MOE) to demonstrate that a spent fuel dry storage system shielding design meets 10 CFR 72.236(a) and (d) in lieu of having detailed contents specifications in technical specifications. A specific MOE that has been reviewed and approved by the NRC may be able to address the need for specifying certain parameters listed in 10 CFR 72.236(a). Following the risk-informed regulatory guidance provided by the Commission, the NRC staff is looking into if and how an MOE could be specified so that there is a balance between adequate design control and flexibility for the certificate holder and general licensee to make changes following the rules of 10 CFR 72.48. Information provided in this document is solely for the purpose of further exploring the feasibility of an MOE approach.

Regulatory Bases

Certification of a spent fuel dry storage system is governed by Subpart L of 10 CFR Part 72. Section 72.234, "Conditions of approval" states in paragraph (a) "The certificate holder and applicant for a CoC shall ensure that the design, fabrication, testing, and maintenance of a spent fuel storage cask comply with the requirements in § 72.236."

Section 72.236(a) contains requirements for the content specifications. It states:

> "Specifications must be provided for the spent fuel to be stored in the spent fuel storage cask, such as, but not limited to, type of spent fuel (i.e., BWR, PWR, both), maximum allowable enrichment of the fuel prior to any irradiation, burn-up (i.e., megawatt-days/MTU), minimum acceptable cooling time of the spent fuel prior to storage in the spent fuel storage cask, maximum heat designed to be dissipated, maximum spent fuel loading limit, condition of the spent fuel (i.e., intact assembly or consolidated fuel rods), the inerting atmosphere requirements."

Section 72.238 states: "A Certificate of Compliance for a cask model will be issued by NRC for a term not to exceed 40 years on a finding that the requirements in § 72.236(a) through (i) are met."

Importantly, for radiation protection, Section 72.236(d) states: "Radiation shielding and confinement features must be provided sufficient to meet the requirements in §§ 72.104 and 72.106."

The objective of the NRC's regulations for spent fuel dry storage system design is to assure that the system meets certain performance criteria. For shielding design, the performance requirements are the dose limits prescribed in 10 CFR 72.104 and 72.106.

Specifically, 10 CFR 72.104 “Criteria for radioactive materials in effluents and direct radiation from an ISFSI or MRS” requires that:

(a) During normal operations and anticipated occurrences, the annual dose equivalent to any real individual who is located beyond the controlled area must not exceed 0.25 mSv (25 mrem) to the whole body, 0.75 mSv (75 mrem) to the thyroid and 0.25 mSv (25 mrem) to any other critical organ as a result of exposure to:
    (1) Planned discharges of radioactive materials, radon and its decay products excepted, to the general environment,
    (2) Direct radiation from ISFSI or MRS operations, and
    (3) Any other radiation from uranium fuel cycle operations within the region.
(b) Operational restrictions must be established to meet as low as is reasonably achievable objectives for radioactive materials in effluents and direct radiation levels associated with ISFSI or MRS operations.
(c) Operational limits must be established for radioactive materials in effluents and direct radiation levels associated with ISFSI or MRS operations to meet the limits given in paragraph (a) of this section.

Further, 10 CFR 72.106, “Controlled area of an ISFSI or MRS” states that:

(a) For each ISFSI or MRS site, a controlled area must be established.
(b) Any individual located on or beyond the nearest boundary of the controlled area may not receive from any design basis accident the more limiting of a total effective dose equivalent of 0.05 Sv (5 rem), or the sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue (other than the lens of the eye) of 0.5 Sv (50 rem). The lens dose equivalent may not exceed 0.15 Sv (15 rem) and the shallow dose equivalent to skin or any extremity may not exceed 0.5 Sv (50 rem). The minimum distance from the spent fuel, high-level radioactive waste, or reactor-related GTCC waste handling and storage facilities to the nearest boundary of the controlled area must be at least 100 meters.

To date, Certificate of Compliance applicants have demonstrated compliance with these regulations by performing calculations for all the allowable contents or a single bounding content for a given shielding design. As the cask content specifications have become increasingly complicated in order to accommodate a wide range of fuel assembly designs and irradiation parameters, this has created complications in the design analyses and review. Often this involves a review of hundreds of pages of the definitions for allowable spent fuel contents in the form of tables, also known as fuel qualification tables (FQTs), to meet the requirements of 10 CFR 72.236(a) for content specifications. A different approach may be able to simplify the shielding analyses and review, while affording the same protection of public health and safety.

Method of Evaluation Approach:

The staff is considering accepting an MOE to demonstrate that a DSS design meets 10 CFR 72.236(a) and (d). The foundation of the MOE approach is that the focus is on the performance of the system. The applicant could develop an MOE and use it to determine the allowable

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contents required by 10 CFR 72.236(a) and demonstrate that the cask design meets the regulations in 10 CFR 72.236(d) for shielding design. The MOE would be incorporated by reference as part of the TS for the Certificate of Compliance.

The MOE would need to be developed in accordance with the performance requirements of 10 CFR 72.104 and 72.106 which are referenced by 10 CR 72.236(d) for the shielding design of the DSS to be certified. The applicant would include applicable ranges of the input parameters to the MOE to provide reasonable assurance that the performance of the DSS designs meet the regulatory requirements instead of relying on detailed specifications for the contents such as in the form of FQTs in the technical specifications (TS). This approach would provide the same level of assurance for safety because the shielding performance criteria (i.e., the dose limits in 10 CFR 72.104 and 72.106) would continue to apply and the cask contents would be controlled by the MOE and parameter values.

This approach would be an extension to the outcome of the pilot program for the Graded Approach because the review would further focus on the performance of the shielding design and a well-defined MOE. The MOE approach would significantly reduce the detailed specifications for allowable contents, such as elimination of the FQTs, in the TS.

MOE Approach Concepts:

1. This approach would include performance criteria that relate the design to the regulatory limits (i.e., the limits in 10 CFR 72.104(a) (and 10 CFR 72.106(b)). This performance criteria would be items or parameters that are inspectable and could also serve as operational controls or limits for the purposes of 10 CFR 72.104(b) or (c) or design bases or criteria (for 10 CFR 72.236(b)) and may include radiation level limits on or at some specified distance from the cask surfaces.

2. The applicant's MOE would define the content specifications such as maximum burnup and minimum cooling time, as required by 10 CFR 72.236(a), such that the content as propagated through the system shielding meets the performance criteria, e.g. cask radiation levels.

   Other depletion parameters important for determining the source term could be defined in a conservative way, or justified as being appropriate such as fuel class (BWR 10x10, PWR 17x17), heavy metal load per assembly, specific power, minimum enrichment, etc.

3. The MOE together with the area of applicability used in design analyses would be incorporated in the TS for the cask design Certificate of Compliance.

4. The applicant would demonstrate, per 10 CFR 72.236(d), that the shielding is sufficient to meet the requirements in 10 CFR 72.104 and 106 when using the MOE.

   This could be done via a calculation using a representative source (for which a description would be provided) that meets the performance criterion and also meets the regulation (e.g., please see Example 1 below), or by demonstrating that the MOE performance criterion itself meets the regulation.

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Example #1: Using a Surface Source as Performance Criteria

A potential candidate for implementation of the MOE is to use a cask surface source as an intermediate control parameter. Because the cask surface source can be translated into measurable values, they can be used to define the cask design while leaving the details of specifications of the contents to the general licensees (GLs) for site specific ISFSI designs. Conceptually, this would consist of the following steps:

1. Define target cask surface source (spectrum and total for both gamma and neutron) that can be used as intermediate parameters to calculate the dose rate around the cask and the annual dose beyond the controlled area boundary.
2. Build a relationship between the allowable contents based on target surface radiation levels. The GL would be able to use the MOE to determine the loading parameters (e.g. minimum cooling time and maximum allowable burnup).
3. Use the design basis surface source for a single cask and a hypothetical array of casks at various distances to calculate the controlled area boundary annual dose to demonstrate that the cask design meets the requirements of 10 CFR 72.236(d).
4. Establish design criteria for the surface source of the transfer cask as well. This could be translated into a dose rate around the transfer cask for radiation protection to demonstrate compliance with 10 CFR 72.104(b) and (c) and provide information for radiation protection and necessary precaution for the GLs.

Example #2: Using Dose Rates at Specific Locations as Performance Criteria

Conceptually, this would consist of the following:

1. Develop a method that calculates dose rates for important locations around the storage and transfer casks.

2. Select a few specific locations (e.g. top over the annulus, halfway up the side, surface or 1 meter, etc.) and establish a dose rate limit at these locations to serve as performance criteria. The locations should generally represent highest contribution to occupational dose or controlled area boundary dose rates, as appropriate, also considering any potential 72.48 changes to the system shielding.

3. Develop a method to be used by the GL to determine allowable contents for a cask using the specified dose rates as a limit (i.e. any contents that do not meet these dose rate limits for the storage and transfer casks after being propagated through the system shielding will not be allowed).

4. Demonstrate that the cask and an array of casks meets the regulation in 10 CFR 72.104 (or 10 CFR 72.106 as necessary) by performing a simulation that calculates dose rates at the location of the dose rate criteria and locations beyond the controlled area boundary to demonstrate that contents that meet the performance criteria also meet the dose limit in 10 CFR 72.104 beyond the controlled area boundary. The representative

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source should be chosen to have characteristics (i.e. gamma/neutron contribution) to be relatively bounding in terms of controlled area boundary dose.

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