Spent Fuel Project Office
Interim Staff Guidance - 8

Issue: **Limited Burnup Credit in the Criticality Safety Analyses of PWR Spent Fuel in Transport and Storage Casks**

Discussion:

When fuel is irradiated in a reactor, the reactivity of the fuel decreases. This reduction of reactivity with burnup is caused by the change in fissile content of the fuel (i.e., burnup of U-235 and production of Pu-239 and other fissile actinides), the production of actinide neutron absorbers, and the production of fission-product neutron absorbers. Until now, criticality safety analyses for spent fuel casks, including storage, transport, and dual-purpose casks, were performed under the assumption that the fuel was unirradiated. This "fresh fuel" assumption was used as a bounding condition because of unresolved issues over the technical basis and methods for including credit for fuel burnup in the criticality analysis of spent-fuel casks.

The U.S. Department of Energy (DOE) has been working on the development of a topical report that proposes a method for taking burnup credit in casks for transporting and storing spent fuel from pressurized water reactors (PWRs). DOE's proposal has been submitted to the U.S. Nuclear Regulatory Commission (NRC) and has gone through two cycles of revisions based on NRC's review and comment. Based on the technical information provided in DOE's topical report, with its supporting technical reports, and information available from other sources, both foreign and domestic, the staff has now found sufficient basis to approve a limited level and scope of burnup credit while it pursues the development of a more complete basis for more comprehensive burnup credit.

As justified through the review of additional supporting data and analysis, the staff will issue revised interim guidance to reflect the evolution of approved methods for greater levels of burnup credit. Future revisions of the Standard Review Plans (NUREG-1617, NUREG-1536, and NUREG-1537) will incorporate or reference the current guidance, as appropriate.

Background:

Existing NRC Uses of Burnup Credit in Spent Fuel Storage

The Office of Nuclear Reactor Regulation (NRR) has long allowed the use of burnup credit in the borated spent fuel storage pools at PWR plants. This is based in part on the established ability of licensees to predict the core burnup behavior over hundreds of reactor years of operation. Additional safety assurance is based on application of the double contingency principle as defined in ANSI/ANS-8.1-1983, and in Title 10, Code of Federal Regulations (10 CFR), Section 72.124(a), which requires two unlikely, independent, concurrent events to produce a criticality accident. For example, if soluble boron is normally present in the spent fuel pool water, the loss of soluble boron is considered as one accident condition and a second concurrent accident need not be assumed. Alternatively, credit for the presence of soluble boron in PWR pools may be assumed in evaluating other accident conditions such as the misloading of fresh fuel assemblies into racks restricted to irradiated fuel. Typically, there is sufficient soluble boron in PWR pools to maintain at least a 5% subcriticality margin even if an entire burnup-dependent storage rack were misloaded with fresh fuel assemblies.

As noted by DOE and others, burnup credit calculations can also be found in the applicants' safety analysis reports (SARs) for two approved single-purpose dry storage casks for PWR spent fuel (i.e., NUHOMS-24P and VSC-24). There, the applicants performed burnup credit calculations in evaluating hypothetical underboration events during wet loading or unloading of the dry storage casks. However, the staff's safety evaluation reports for those cases used the "fresh fuel" analysis assumption in combination with credit for boron in the water. Boron credit was made possible by creating in the license or certificate a Technical Specification requiring two independent verification controls on soluble boron concentration during wet loading and unloading operations. This satisfied the double-contingency criterion of 10 CFR 72.124(a) while obviating consideration of loss-of-boron events in the review under 10 CFR Part 72.

Although triple contingencies are not directly considered in the staff's evaluations for 10 CFR Part 72 reviews, applicants have chosen to retain the burnup credit calculations in their SARs in order to help address plant-specific requirements under 10 CFR 50.59 for use of the casks at reactor spent-fuel pools. Those burnup credit calculations are acknowledged by NRC's Office of Nuclear Material Ssafety and Safeguards as illustrating an additional safety margin, of uncertain magnitude, that goes beyond the regulatory requirements of 10 CFR Part 72. Therefore, the burnup credit analyses for wet loading and unloading of dry storage casks can be viewed as technically consistent with NRR's applications of burnup credit at PWR spent-fuel storage pools in that both are used, on a risk-informed basis, only in addressing the criticality safety margins for extreme hypothetical events that are considered extremely unlikely or incredible.

The need for considering burnup credit after drying and closure of casks has generally been avoided in 10 CFR Part 72 storage applications by showing that fresh-water ingress into sealed dry storage casks is not credible. Specifically, the double-contingency criterion is satisfied by showing that water ingress into a storage cask would require both a flooding event and an accident that would cause seal failure. On the other hand, transportation regulations under 10 CFR Part 71 include explicit requirements for assuming fresh-water inleakage in the criticality analysis of transport packages for fissile materials. Sections 6.5.4 and 6.5.5 in NUREG-1617, "Standard Review Plan for Transportation Packages for Spent Nuclear Fuel," further discuss the water-inleakage considerations for spent-fuel evaluations under 10 CFR Part 71.

Burnup Credit in Other Countries

Several regulatory bodies outside the U.S. have allowed various uses of burnup credit in wet storage and handling operations, and also in reprocessing. However, transportation uses of burnup credit have been granted to-date only in France. The French reprocessing program has developed an extensive set of proprietary validation data to support the limited credit needed for shipping modern PWR fuels with higher initial enrichments in the existing fleet of casks. Safety authorities in the United Kingdom and Japan are now working toward similar uses of burnup credit in transport packages. As noted above, validation benchmarks provided from French and other foreign or proprietary sources may be considered as part of the expanded technical basis needed for future NRC approval of greater levels of burnup credit.

Recommendation:

When performing criticality safety analyses for spent-fuel casks, limited partial credit for the reactivity effects of fuel burnup may be taken as follows:

Method:

- Use the method described in DOE's report entitled, "Topical Report on Actinide-Only Burnup Credit for PWR Spent Nuclear Fuel Packages," DOE/RW-0472, Rev. 2, except as otherwise specified below.
- Assume fuel burnup is 50% of the verified and adjusted burnup level from plant records.

Scope:

- Applies to intact commercial PWR fuel only.
- Includes actinide effects only (change in fissile content and actinide neutron absorbers).

Range of Application:

- Covers UO_2 fuel with nominal initial enrichments up to 4.0 weight percent U-235.
- Covers assembly-average burnup levels up to 45 GWD/MTU.

Establishing the Burnup Value:

- Use the reactor-record assembly burnup, as adjusted, when confirmed by a direct assembly measurement, performed in the storage pool or loading facility, that is calibrated to the reactor records for a representative set of measured assemblies. Measurement confirmation must be within a 95% confidence interval based on the measurement uncertainty. Adjust the burnup-record value by reducing the record value by the combined uncertainties in the records and the measurement. Burnup measurement may be based on gamma emissions of the Cs-137 isotope. The requirement for burnup verification measurements is consistent with Regulatory Guide 3.71 and is justified in part by numerous licensee-reported events involving failure of administrative controls on plant spent-fuel records and the selection, handling, and placement of spent fuel in the storage pools at reactors.

Approved E. William Brach 5/13/99
E. William Brach Date