

RULEMAKING ISSUE NOTATION VOTE

May 26, 2006

SECY-06-0124

FOR: The Commissioners

FROM: Luis A. Reyes
Executive Director for Operations

SUBJECT: RULEMAKING PLAN TO AMEND FRACTURE TOUGHNESS
REQUIREMENTS FOR PROTECTION AGAINST PRESSURIZED
THERMAL SHOCK EVENTS (10 CFR 50.61)

PURPOSE:

To request Commission approval of a rulemaking plan to amend fracture toughness requirements for protection against pressurized thermal shock events for pressurized water reactors (PWRs).

BACKGROUND:

The Pressurized Thermal Shock (PTS) Rule (Title 10 of the Code of Federal Regulations, Section 50.61) protects against brittle fracture of reactor vessels during severe cooldown events. The screening limits in the existing rule were based on a conservative probabilistic fracture mechanics analysis. Several licensees will exceed the screening limits in the existing rule before the expiration of their renewed licenses.

The Nuclear Regulatory Commission staff is engaged in a research program to update the technical basis for 10 CFR 50.61. The results to date suggest that the risk of through-wall cracking due to PTS is much lower than was previously calculated; therefore, the screening limits in the existing version of 10 CFR 50.61 may impose unnecessary burden on the licensees. The staff proposes to revise the screening limits to reflect the updated technical basis if the final results support the conclusion that the current limits are unnecessarily conservative. Some issues with the risk quantification remain to be resolved before it will be known how much generic conservatism may be safely eliminated from a revised rule.

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The staff's approach to reevaluate the screening limits in 10 CFR 50.61 for reactor pressure vessel (RPV) material characteristics is described in SECY-00-0140, "Reevaluation of the Pressurized Thermal Shock Rule (10 CFR 50.61) Screening Criterion," dated June 23, 2000, and the subsequent periodic status reports SECY-01-0045, SECY-01-0185, and SECY-02-0092, dated March 16, 2001, October 5, 2001, and May 30, 2002, respectively.

CURRENT RULE REQUIREMENTS:

Section 50.61 requires PWR licensees to estimate an embrittlement metric for their RPV materials. Any vessel with materials predicted to exceed the screening limits in 10 CFR 50.61 may not continue to be operated without implementation of compensatory actions unless the licensee receives an exemption from the requirements of the rule. Acceptable compensatory actions are neutron flux reduction, plant-specific analyses, and RPV annealing. These actions are addressed in 10 CFR 50.61(b)(3), 10 CFR 50.61(b)(4), and 10 CFR 50.61(b)(7), respectively.

No currently operating PWR will exceed the 10 CFR 50.61 screening limits before the expiration of its license, but several plants are close to the limit and a few plants will probably exceed the limit during the first license renewal period.

The primary method to avoid exceeding the limits is to reduce the fast neutron flux. Because many plants operated with higher flux cores early in life and because the embrittlement metric is a function of the flux accumulated over plant life, relatively aggressive flux reduction is necessary to ensure the level of embrittlement remains below the 10 CFR 50.61 screening limits for the most seriously affected plants. Flux can be managed using burnable poisons, dummy fuel pins, or absorber rods. These features tend to result in power density distributions that have less margin than higher leakage designs. In some cases aggressive fuel management results in asymmetrical cores and cores with such high peaking factors in the center that axial offset anomalies become more prevalent. Regardless of the fuel management practices, some neutrons continue to escape and irradiate the vessel wall. In reactors with materials that are most susceptible to embrittlement, after some number of years of operation, the accumulated neutron irradiation causes the vessel materials to exceed the screening limits. For a few plants, it is not necessarily advisable to implement flux reduction practices that are aggressive enough to avoid reaching the screening limits during license extensions.

An alternative compensatory action is to perform a safety analysis to show that operation with a reference temperature higher than the screening limits is safe, i.e., would continue to ensure an adequately low probability of through-wall cracking. Regulatory Guide (RG) 1.154, "Format and Content of Plant-Specific Pressurized Thermal Shock Safety Analysis Reports for Pressurized Water Reactors," describes a method for doing this type of analysis. The staff and industry have limited experience with this alternative. In COMSECY-91-008, the Commission requested the staff to clarify the guidance provided in RG 1.154. In response, in SECY-91-333, the staff proposed to revise the basis for RG 1.154 in conjunction with a revision to the technical basis for the PTS Rule. COMSECY-91-008 provided the impetus to undertake the revision to the technical basis that is the subject of the proposed revision to 10 CFR 50.61.

Another potential compensatory action available to licensees with vessels expected to exceed the screening limits is to anneal the reactor vessel. The current regulatory process for approval of annealing is described in 10 CFR 50.66. No domestic commercial nuclear power plant has yet annealed its reactor vessel. The staff and industry have very little experience with this alternative. The process is complicated and expensive and is not guaranteed to result in a condition that supports continued operation of the plant. Substantial NRC and licensee resources would be required to prepare and review the thermal annealing report. Many licensees; therefore, do not consider annealing a viable alternative. Some foreign plants have annealed their vessels, but their experience is not particularly applicable to domestic reactor vessels primarily because of differences in vessel designs.

An alternative is to request an exemption from 10 CFR 50.61. For example, to justify continued operation, licensees could provide plant-specific toughness measurements that reduce some of the uncertainties associated with determining RPV embrittlement. The disadvantage of this approach is that several plants will prepare a variety of submittals or exemption requests to justify continued operation. These submittals may vary widely in quality and topical content, which can lead to an inefficient use of staff and licensee resources during the preparation and review of the submittals.

UPDATED TECHNICAL BASIS:

The current version of 10 CFR 50.61 is based on a probabilistic fracture mechanics (PFM) analysis done during the 1980s using conservative estimates of material embrittlement and RPV flaw parameters, simplified neutron fluence assumptions, and coarse binning of operational events. The analysis, using the limited computer resources of the time, provided limits that were believed to be very conservative. The Office of Nuclear Regulatory Research (RES) used the same general approach to update the technical basis but applied more recent knowledge of fracture mechanics, the response of materials to irradiation, thermal-hydraulics analysis, and frequencies of (and plant and operator responses to) overcooling transients. The RES reevaluation employed updated approaches to uncertainty analysis and was executed on contemporary hardware and software platforms.

The updated technical basis is described in NUREG-1806, "Technical Basis for Revision of the Pressurized Thermal Shock (PTS) Screening Limit in the PTS Rule (10 CFR 50.61): Summary Report," which summarizes and references several additional NUREG reports on the same topic. These draft reports are scheduled for release in May 2006 for public comment.

The updated technical basis indicates that after 60 years of operation, the risk of reactor vessel failure due to PTS is much lower than the risk value estimated from the technical basis for the existing rule. An external peer review panel, the Advisory Committee on Reactor Safeguards (ACRS), the Electric Power Research Institute (EPRI), and the Office of Nuclear Reactor Regulation (NRR) staff have reviewed the technical basis and found it to be comprehensive and well-executed. The NRR staff review found that some risk quantification issues needed clarification to better quantify the plant-to-plant variations and determine a sufficient generic margin for the revised rule. The staff is currently performing additional analyses to quantify the plant-to-plant variation and confirm the margins for the revised screening criteria. The staff expects that the results of those analyses will support the relaxation of the screening limits in 10 CFR 50.61 and, on that basis, recommends that the NRC commence rulemaking while these analyses are completed in parallel.

The updated technical basis uses many different models and parameters to estimate the yearly probability that a PWR will develop a through-wall crack as a consequence of PTS loading. One of these many models is a revised embrittlement correlation that uses information on the chemical composition and neutron exposure of steels in the vessel's beltline region to estimate the resistance to fracture of these materials. The revised embrittlement correlation differs substantially from the correlation in the existing 10 CFR 50.61. The correlation has been updated to more accurately represent the substantial amount of reactor vessel surveillance data that has accumulated since the embrittlement correlation was last revised during the 1980s. The updated embrittlement correlation will be published in Revision 3 to RG 1.99, "Effect of Residual Elements on Predicted Irradiation Damage to Reactor Vessel Materials." The technical basis for the revision to 10 CFR 50.61 will use the updated correlation. It is possible that during the revision process, the correlation in RG 1.99, Revision 3, may be changed as a result of public comments, or as the result of comments received during ACRS review of the correlation. Ideally, the embrittlement correlation that will be published in RG 1.99, Revision 3, and that will be codified in this revision to 10 CFR 50.61, will be identical. There were instances in the past where the correlations were different. For regulatory consistency, the staff will make every effort to ensure that they are identical. Therefore, the staff is currently coordinating the schedules for the revised 10 CFR 50.61 and RG 1.99 to support this consistency. The staff notes that if the effort on the proposed revision to 10 CFR 50.61 and the revision to RG 1.99 is unable to be completed at the same time, then the staff will inform the Commission and provide a proposal for subsequent staff actions.

OPTIONS FOR RULEMAKING:

The staff has considered the following options:

- Option 1: Retain the current rule. Licensees with RPVs that do not meet the current screening limits may produce and submit plant-specific analyses to demonstrate that an adequately low risk of through-wall cracking is ensured during continued operation. Alternatively, licensees may request exemptions from 10 CFR 50.61 to use, for example, plant-specific toughness measurements that are not permitted by the current rule. Absent RPV annealing or approval of an exemption or plant-specific RPV analysis, plants that exceed the screening limits would be required to cease operation.
- Option 2: Amend the existing regulation to allow licensees to voluntarily implement the less restrictive screening limits based on the updated technical basis. The requirements of the current version of the PTS Rule would apply to licensees that choose not to implement the less restrictive screening limits.
- Option 3: Amend the existing regulation to allow licensees to voluntarily implement the less restrictive screening limits based on the updated technical basis and to require the use of the updated embrittlement correlation by all licensees.
- Option 4: Amend the existing regulation to require all licensees to implement the less restrictive screening limits based on the updated technical basis and use the updated embrittlement correlation.

RECOMMENDATION:

The staff recommends revising 10 CFR 50.61 in accordance with Option 3. This option is expected to permit several plants to continue operating through at least one license extension period, maintains safety, and maintains regulatory consistency within 10 CFR 50.61 with respect to the updated embrittlement correlation. In addition, there is broad industry support for and interest in proceeding with the rulemaking in accordance with the discussions at previous public meetings.

A rule revision in accordance with Option 3 is expected to provide financial benefits to licensees and efficiency benefits to the NRC staff. All licensees would expend resources to revise their analyses consistent with the updated embrittlement correlation. Licensees would not be required to submit the analyses unless their RPV materials are projected to exceed the revised screening limits. Some licensees would expend resources to implement the voluntary component associated with the updated technical basis. This expenditure would be offset by the elimination of the need for alternatives such as aggressive neutron flux reduction, plant-specific analyses, or submission of exemption requests. The NRC staff would benefit by the reduction in the number and variety of exemption requests that would otherwise be submitted by licensees absent a rule change. The disadvantage of this approach is that every PWR would be required to recalculate its material embrittlement metric using the updated embrittlement correlation, which would be a backfit. A documented evaluation would need to be prepared in accordance with 10 CFR 50.109(a)(4) to justify an exemption from the requirements to perform a backfit analysis.

RESOURCES:

For NRR, approximately 2.9 FTE and \$50K are needed for this rulemaking during the FY 2006 - FY 2008 time frame. Of this amount, 1.1 FTE is budgeted for FY 2006 and 1.1 FTE and \$25K is budgeted for FY 2007. The remaining resources of 0.7 FTE and \$25K for FY 2008 will be addressed during the FY 2008 PBPM process. For RES, 2 FTE and \$310K is needed during the FY 2006 - FY 2008 time frame. Of this amount, 0.5 FTE and \$200K is budgeted for FY 2006, 1.0 FTE and \$75K is budgeted for FY 2007, and 0.5 FTE and \$35K will be addressed during the FY 2008 PBPM process. For ADM, 0.1 FTE is budgeted each year for FY 2006 - FY 2008.

SCHEDULE:

The staff plans to provide a proposed rule to the Commission in March 2007. This schedule is contingent on RES resolution of the remaining technical issues and NRR review and acceptance of the final technical basis in November 2006. The staff expects to forward the final rule to the Commission in January 2008.

COORDINATION:

The Office of the General Counsel has reviewed this Commission paper and has no legal objection.

The Commissioners

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The Office of the Chief Financial Officer has reviewed this Commission paper for resource implications and has no objection.

/RA Martin J. Virgilio Acting for/

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Enclosure: Rulemaking Plan

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The Office of the Chief Financial Officer has reviewed this Commission paper for resource implications and has no objection.

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Enclosure: Rulemaking Plan

Package Accession Number: ML060530626
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Commission Paper Accession Number: ML060530624
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