Regulatory Analysis for the Supplemental Proposed Rule to Amend Alternate Fracture Toughness Requirements for Protection against Pressurized Thermal Shock Events (10 CFR 50.61a)

This document presents a draft regulatory analysis for the proposed revisions to the Pressurized Thermal Shock (PTS) Rule as set forth by the U.S. Nuclear Regulatory Commission (NRC) in Title 10, Section 50.61, of the *Code of Federal Regulations* (10 CFR 50.61). The proposed rule was undertaken as the result of a June 30, 2006, Staff Requirements Memorandum (SRM). In this SRM, the Commission directed the staff to pursue the rulemaking as described in Option 2 of the May 26, 2006, Commission paper, SECY-06-0124, containing the "Rulemaking Plan to Amend Fracture Toughness Requirements for Protection Against Pressurized Thermal Shock Events (10 CFR 50.61)." The NRC published the proposed rulemaking on the alternate fracture toughness requirements for protection against PTS for public comments in the *Federal Register* on October 3, 2007 (72 FR 56275). During the development of the PTS final rule, the NRC determined that several significant changes to the proposed rule language would be needed to adequately address the stakeholders' comments and their associated implementation concerns. Two of the modifications are significant changes to the proposed rule language on which external stakeholders did not have an opportunity to comment. The NRC concludes that obtaining stakeholder feedback on these provisions through the use of a supplemental proposed rule is appropriate. These two modifications subject to comments from the public do not have a measurable impact in this regulatory analysis. However, in the supplemental proposed rule, the NRC is considering limiting the applicability and the use of 10 CFR 50.61a to currently-operating plants only. Therefore, this regulatory analysis is being modified to reflect this change.

1.0 Statement of the Problem and Reasons for the Rulemaking:

The Pressurized Thermal Shock (PTS) rule, 10 CFR 50.61, adopted on July 23, 1985 (50 FR 29937), establishes screening criteria to evaluate when a reactor vessel may be susceptible to failure due to a PTS event. The screening criteria define a limiting level of embrittlement beyond which operation cannot continue without further plant-specific evaluation. Any pressurized water reactor (PWR) vessel with materials predicted to exceed the screening criteria in 10 CFR 50.61 may not continue operation without implementation of compensatory actions or plant-specific analyses unless the licensee receives an exemption from the requirements of the rule. No currently operating PWR is projected to exceed the 10 CFR 50.61 screening criteria before the expiration of its 40 year operating license. However, several plants are approaching the screening criteria, while others are likely to exceed the screening criteria during their first license renewal periods.

The NRC staff has completed a research program to update the PTS regulations. The results of this research program conclude that the risk of through-wall cracking due to a PTS event is much lower than previously estimated. This finding indicates that the screening criteria in 10 CFR 50.61 are unnecessarily conservative and may impose an unnecessary burden on some licensees. Therefore, the NRC is proposing a new rule, 10 CFR 50.61a. The objective of the proposed rule is to provide alternative screening criteria and corresponding embrittlement correlations for licensees seeking regulatory relief from the overly conservative requirements of the current PTS regulation, 10 CFR 50.61.

Further, the NRC has determined that the backfit rule, 10 CFR 50.109, does not apply to this proposed rule because compliance with the requirements of the proposed rule (10 CFR 50.61a) would be an alternative to compliance with the requirements of the current PTS rule

(10 CFR 50.61). Due to the voluntary implementation of this amendment, this proposed rule does not constitute backfitting as defined in 10 CFR 50.109(a)(1), and a backfit analysis is not required.

2.0 Identification of Alternatives

Following the Commission's direction contained in the June 30, 2006, SRM, the staff considered several alternatives to amend the regulation.

Alternative 1: Take no action.

Under Alternative 1, the "no action" alternative, the NRC would not amend the current regulations regarding PTS events. The current requirements of 10 CFR 50.61 would remain in effect and would continue to apply to all current and future PWR licensees.

The "no action" alternative serves as the baseline against which the costs and benefits of the other alternatives are measured. Under the current rule, licensees with reactor pressure vessels (RPVs) that do not meet the current screening limits may implement several compensatory measures, such as flux reduction, submission of plant-specific analyses, and vessel annealing, each of which impose a cost burden on the licensee. Alternatively, licensees may request exemptions from 10 CFR 50.61 to use, for example, plant-specific toughness analyses different from those required by the current rule. Absent the compensatory measures, licensees who exceed the screening limits would be required to cease operation.

Alternative 2: Require all PWRs to implement the requirements in 10 CFR 50.61a.

Under Alternative 2, the NRC would promulgate a new PTS rule which would require all PWR licensees to apply the updated PTS screening criteria and embrittlement correlations. The requirements in this proposed rule would replace the requirements in the current 10 CFR 50.61. All PWR licensees would be required to meet the requirements of the new rule. As a result, current licensees would be required to perform analyses to evaluate their plant(s) using the new embrittlement correlations to assess compliance with the new screening criteria, thereby demonstrating their compliance with the new regulation. Future licensees referencing a certified design would be required to perform similar re-analyses under the new rule. Future licensees not referencing a certified design would be required to comply with the new rule.

All current PWR licensees and future licensees referencing certified designs would be required to comply with the new rule and would incur additional regulatory burden. This additional burden would be caused by the requirement to re-analyze the plant PTS reference temperature ($RT_{MAX\text{-}X}$) values under the new rule, where the design has previously been licensed or certified under the analysis methods and screening criteria defined in the current rule. This would constitute a backfit under 10 CFR 50.109 for those licensees. Future licensees not referencing a certified design would only perform the analyses required in the new rule. However, in this case, it would not constitute a backfit because the licensee had not previously been granted approval of the plant design based on the current rule.

Alternative 3: Permit voluntary compliance with a new PTS rule for existing PWR licensees and require mandatory compliance with the new rule for new PWR licensees.

Under Alternative 3, the NRC would promulgate 10 CFR 50.61a which would be (1) an alternative to requirements of 10 CFR 50.61 for any current PWR reactor with an operating license or combined license in place before the effective date of the proposed rule or new PWR reactor referencing a design certified before the effective date of the proposed rule, and (2) mandatory for any new PWR reactor with an operating license or combined license in place after the effective date of the new rule. All PWR licensees would be required to meet the requirements of 10 CFR 50.61 or 10 CFR 50.61a, depending on the date of their license or design certification and whether they choose to implement the new rule.

Licensees under (1) described above would incur no additional regulatory burden, since the proposed rule would be voluntarily implemented. Licensees under (2) described above would be required to comply with 10 CFR 50.61a, but this would not be a backfit because the licensee had not previously been granted approval of the plant design based on the current rule.

Alternative 4: Permit all PWR licensees to implement either the current 10 CFR 50.61 or the proposed 10 CFR 50.61a.

Under Alternative 4, the NRC would promulgate 10 CFR 50.61a as an alternative to the requirements of 10 CFR 50.61. All PWR licensees would be required to meet the conditions of 10 CFR 50.61, or as an alternative, would be required to comply with 10 CFR 50.61a. This alternative would not constitute a backfit for any licensee because 10 CFR 50.61a would be voluntarily implemented by any PWR licensee who found it advantageous to do so. PWR licensees who are projected to exceed the 10 CFR 50.61 screening criteria during the lifetime of their plant license would likely comply with 10 CFR 50.61a rather than implement the more expensive compensatory actions specified in 10 CFR 50.61. PWR licensees who are not projected to exceed the 10 CFR 50.61 screening criteria would not likely comply with 10 CFR 50.61a due to the unnecessary cost of implementation.

3.0 Estimation and Evaluation of Values and Impacts

This section describes the analysis conducted to identify and evaluate the benefits (values) and costs (impacts) of this proposed rule. Section 3.1 identifies the attributes that the proposed rule is expected to affect. Section 3.2 describes the methodology used to analyze the benefits and costs associated with changes to the affected attributes. The results of the analysis are presented in Section 4.

3.1 Identification of Affected Attributes

This section identifies the factors that the proposed rulemaking is expected to affect. These factors are classified as “attributes” using the list of potential attributes provided in Chapter 5 of the NRC’s “Regulatory Analysis Technical Evaluation Handbook.”[1] Affected attributes from the handbook include the following:

[1] NUREG/BR-0184, “Regulatory Analysis Technical Evaluation Handbook: Final Report,” U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, January 1997.

- Industry Implementation

  Implementation of the new rule would require a licensee to submit a license amendment to the NRC for review and approval, requesting that the licensee comply with the proposed rule. This license amendment request would include analyses of the licensee's vessel under the embrittlement correlations and screening criteria in the proposed rule through the plant's end of life (40 or 60 years, as applicable). This analysis is required to demonstrate the licensee's compliance with the new regulation. The licensee would be required to perform analyses of the volumetric examination of the vessel to ensure that the proposed screening criteria and calculation methodology are applicable. Additionally, the licensee would be required to report the manganese and phosphorus content of the reactor vessel beltline materials.

- Industry Operation

  If implemented, the amended rule would differ from 10 CFR 50.61 only in that, during plant operation, a licensee would be required to perform analyses of the volumetric examination of the vessel to ensure that the proposed screening criteria and calculation methodology are applicable.

- NRC Implementation

  The first component of the NRC implementation cost is the cost for NRC to complete the final rule. The NRC would be affected by this proposed rule because of the level of effort required to review and approve license amendment requests to comply with 10 CFR 50.61a.

- NRC Operation

  The NRC would be required to review and approve the licensee's amendment requests, including the submittal of the analysis of the volumetric examination inspection results of the vessel under the amendment, to comply with 10 CFR 50.61a.

- Improvements in Knowledge

  The NRC and the nuclear industry would acquire additional data concerning vessel weld flaws due to the additional analyses of the volumetric examination inspection results under 10 CFR 50.61a. Each plant implementing the proposed rule would contribute to improvements in NRC's and industry's knowledge of how well the new PTS rule fracture toughness requirements apply to current reactor vessels. The additional insights gained from these inspections could be used in future research projects, with the potential for further revisions to the PTS rule.

- Regulatory Efficiency

  The NRC staff is of the opinion that proposing the amendment as an alternative rule is the most efficient approach. This is accomplished by allowing the licensees to select the option that best serves their situation without any effect on the public health and safety

and common defense and security.

The proposed rule is *not* expected to affect the following attributes:

- public health (accident and routine)
- occupational health (accident and routine)
- property (onsite and offsite)
- other government
- general public
- antitrust considerations
- safeguards and security considerations; and
- environmental considerations.

3.2 Estimation of Values and Impacts

- Industry Implementation

  The projected cost of a licensee implementing the proposed PTS rule is estimated at 0.6 full-time equivalent (FTE)[2], or approximately $90,000. This implementation consists of performing the required analyses, preparing the associated license amendment request, and submitting it for review and approval by the NRC.

- Industry Operation

  The projected additional cost to a licensee performing the analysis of the volumetric examination inspection results is estimated at 0.3 FTE, or approximately $46,000, per analysis. This includes performing the analysis and submitting it for review and approval by the NRC. It would be performed with the vessel inspection frequency (currently every 10 years). This regulatory analysis assumes that the rule will take effect in 2009. The timeframe for which costs are estimated is based on the remaining operating lives of the relevant facilities. For this analysis, costs are estimated over an assumed period of 48 years, with costs discounted at a 7-percent and 3-percent discount rate every 10 years, as specified in NUREG/BR-0184, "Regulatory Analysis Technical Evaluation Handbook." The analysis makes a simplifying assumption that an average plant's next vessel inspection will occur 5 years from the rule's implementation date and every 10 years thereafter through the assumed lifetime of the plant, including license renewal.

  Assuming the 3-percent discount rate results in a discounted flow of funds of approximately $116,200, while the 7-percent rate gives an estimated value of around $60,200. Therefore, operating under 10 CFR 50.61a, those licensees would incur costs projected to exceed those for operating under 10 CFR 50.61. For licensees not projected to exceed the current PTS screening criteria within their plant lifetime, the NRC staff does not expect that any licensees would benefit from implementing and operating under 10 CFR 50.61a due to the cost of implementation and the inspection results

[2] All cost estimates in this analysis are based on the NRC staff's most recent estimate of labor rates to be used in regulatory analyses of $105 per hour or an annual rate of $152,000 assuming 1446 hours worked in a year.

analyses required as described earlier, and would not change the licensee's cost.

- NRC Implementation

  The NRC estimates that it will require approximately 1.2 FTE to complete the final rule portion of this action. Using the same assumptions for labor rates expressed above, this result in a cost of approximately $182,000. The NRC implementation costs are estimated at 0.5 FTE or $76,000 in labor costs to review each license amendment request. However, this cost must be compared with the NRC's costs of having licensees operate under the existing rule. Each licensee projected to exceed the current PTS screening criteria within their plant lifetime would be expected to take compensatory actions in 10 CFR 50.61. The extent of NRC resources would depend on the compensatory actions taken. The NRC staff estimates that the resources required (per licensee) could range from 0.1 to 2.0 FTE or from $15,000 to $300,000. Therefore, for this attribute, the impact could range from a small savings to an increase in costs to the NRC when a licensee would opt for the using the existing 10 CFR 50.61 instead of the amended option.

- NRC Operation

  The projected additional cost to the NRC for reviewing the analysis required by the amended rule is estimated at 0.1 FTE or $15,000 and would be performed with the vessel inspection frequency (currently once every 10 years). Assuming the same timeframe as used in the derivation of the industry operation costs, the discounted flow of funds for NRC implementation per licensee is estimated at $38,000 using a 3-percent discount rate and estimated at $20,000 using the 7-percent rate. There are no alternatives to operating under the new rule after it has been implemented. For licensees not projected to exceed the current PTS screening criteria within their plant lifetime, the NRC staff does not expect that any current or future licensees would benefit from implementing and operating under the amended rule, due to the additional implementation and inspection results analyses required as described earlier, and would not change the NRC's cost.

- Regulatory Efficiency

  Regulatory efficiency is attained by permitting PWR licensees to select the option that is most suitable for their situation without affecting public health and safety or common defense and security. Further, the impact on the NRC is minimal.

4.0 Presentation of Results

This section presents the estimates of the benefits and costs in Section 4.1 and the disaggregation analysis in Section 4.2

4.1 Benefits and Costs

The analyses performed in the technical basis for this rulemaking indicate that the degree of PTS challenge for anticipated lifetimes and operating conditions for current operating PWRs is low. Further, the U.S. domestic commercial operating fleet of 69 PWRs has a low probability of exceeding either the limit on the maximum estimated mean through-wall crack frequency of $5x10^{-6}$ per year expressed by current PTS regulations or the proposed new value of $1x10^{-6}$ per year, consistent with the Commission's direction in their SRM for SECY-06-0124, on the PTS Rulemaking Plan. As a result, the risk of PTS events is much lower than previously estimated. Therefore, the screening criteria in 10 CFR 50.61 are considered unnecessarily conservative and may impose unnecessary burden on licensees. These results provide the basis to support a relaxation of the current PTS regulations while continuing to provide adequate protection to public health and safety.

This proposed action, which would be adopted as an alternative to the current requirements, would result in a burden reduction for some of those licensees with no increase in risk to the public's health and safety.

The current PTS rule, 10 CFR 50.61, requires licensees to take compensatory actions when the value of RT_{PTS} for any material in the beltline is projected to exceed the PTS screening criterion using the plant's projected end of license (EOL) fluence. First, the licensee shall implement those flux reduction programs that are reasonably practical to avoid exceeding the PTS screening criteria. If a licensee has no reasonably practical flux reduction program that will prevent RT_{PTS} from exceeding the PTS screening criteria using the EOL fluence, the licensee is required to submit a safety analysis to determine what, if any, modifications to equipment, systems, and operation are necessary to prevent potential failure of the reactor vessel as a result of the postulated PTS events if continued operation beyond the screening criteria is allowed. Reactor vessel annealing may also be implemented by a licensee to prevent exceeding the screening criteria.

Under the proposed 10 CFR 50.61a, licensees that are projected to exceed the existing requirements in 10 CFR 50.61 before the expiration of their licenses would not be required to comply with the compensatory action requirements described in the preceding paragraph.

However, the alternatives to implementing the new rule for licensees that are projected to exceed the PTS screening criteria within their plant lifetime are to either perform the compensatory actions or to cease operation under 10 CFR 50.61. The cost of compensatory actions in 10 CFR 50.61, including performing flux reduction, vessel annealing, and other analyses, are estimated at $50 million, well exceeding the cost of implementing the proposed rule. Further, the cost of ceasing operation and purchasing replacement power would exceed the cost of implementing the proposed rule, because the replacement energy cost is estimated at $1 million per day. Therefore, implementing the new PTS rule, 10 CFR 50.61a, would provide savings to licensees projected to exceed the PTS screening criteria during their plant lifetimes. For licensees not projected to exceed the PTS screening criteria within their plant lifetime, the NRC staff does not expect that any licensees would benefit from implementing 10 CFR 50.61a, due to the additional costs associated with the required implementation analyses as described earlier.

4.2 Disaggregation

In order to comply with the guidance provided in Section 4.3.2 ("Criteria for the Treatment of Individual Requirements") of the Regulatory Analysis Guidelines[3], the NRC conducted a screening review to ensure that the aggregate analysis does not mask the inclusion of individual rule provisions that are not cost beneficial when considered individually and not necessary to meet the goals of the rulemaking. The NRC has determined that this proposed rule does not contain any individual rule provisions which are not necessary to meet the goals of the rule and, therefore, complies with the NRC's criteria for the treatment of individual requirements.

5.0 Decision Rationale for Selection of the Proposed Action

The NRC staff did not recommend Alternative 1, the no action option. The Commission, in the SRM for SECY-06-0124, approved the rulemaking plan which directed the staff to proceed with preparing a proposed rule. Further, licensees whose plants are projected to exceed the PTS screening limits in the current rule would be required to implement the costly, mandatory compensatory actions with no other alternative available. This option neither satisfies the Commission's SRM direction nor provides regulatory relief for some PWR licensees.

The NRC staff did not recommend Alternative 2. Under this alternative, all current PWR licensees would incur additional regulatory burden from the requirement to re-analyze the plant RT_{PTS} values under the new rule. These designs have previously been licensed or certified under the analysis methods and screening criteria defined in 10 CFR 50.61. As described previously, Alternative 2 would constitute a backfit under 10 CFR 50.109 for these licensees. Further, the NRC determined that the characteristics of advanced PWR designs were not considered in the analysis of this proposed rule. The NRC cannot be assured that reactors that commence commercial power operation after the effective date of this rule will have operating characteristics and materials of fabrication similar to those evaluated as part of the technical basis for the proposed rule. The NRC believes that applicants referencing certified designs should not be allowed to use the alternatives provided by 10 CFR 50.61a. Therefore, the NRC determined that it would be prudent to limit the applicability and use of 10 CFR 50.61a to currently-operating plants only.

The NRC staff did not recommend Alternative 3. For the majority of PWR licensees, this alternative would impose no additional regulatory burden to comply with 10 CFR 50.61a because implementation of 10 CFR 50.61a would be voluntary. Although the Commission directed the NRC staff to consider requiring that new reactors be required to comply with the new rule, the NRC staff determined there was no benefit in requiring mandatory implementation for applicants (i.e., non-licensed, non-design certified). This determination was based on the fact that 10 CFR 50.61 is considered conservative and sufficient. As a result, the NRC staff saw no benefit in requiring implementation of 10 CFR 50.61a for any licensee. Further, as stated previously, the NRC determined that the characteristics of PWR reactors that commence commercial power operation after the effective date of this rule designs were not considered in the analysis of this proposed rule. Therefore, NRC concluded that the use of 10 CFR 50.61a should be limited to currently operating plants only.

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[3] NUREG/BR-0058, Revision 4, "Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission," U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, September 2004.

The NRC staff recommends Alternative 4. This alternative complies with the Commission's SRM that approved the rulemaking plan to prepare a proposed rule. Also, this alternative retains the requirements of the current rule for all PWR licensees, while providing alternative requirements for PWR licensees choosing to implement these requirements. Further, this alternative provides the necessary regulatory flexibility that some current PWR licensees will need to continue to operate throughout their extended lifetimes. Although PWR applicants will not be allowed to use the alternatives provided in the proposed rule, the current 10 CFR 50.61 is conservative but sufficient, and its requirements do not change as a result of this rulemaking. The proposed 10 CFR 50.61a is more realistic yet sufficiently safe, and can be implemented by any current PWR licensee. Therefore, the NRC staff recommends Alternative 4.

6.0 Implementation

This action is being published as a supplemental proposed rule for public comment in the *Federal Register*. After addressing public comments, the final rule would take effect upon Commission approval and publication of the final rule in the *Federal Register*.