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UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATIONS
OFFICE OF NUCLEAR MATERIAL SAFETY AND SAFEGUARDS
WASHINGTON, DC 20555-0001

December 29, 2011

NRC REGULATORY ISSUE SUMMARY 2011-14 METAL FATIGUE ANALYSIS PERFORMED BY COMPUTER SOFTWARE

ADDRESSEES

All holders of, and applicants for, a power reactor operating license or construction permit under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," except those that have permanently ceased operations and have certified that fuel has been permanently removed from the reactor vessel.

All holders of, and applicants for, a power reactor early site permit, combined license, standard design approval, or manufacturing license, and all applicants for a standard design certification, under 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants."

INTENT

The U.S. Nuclear Regulatory Commission (NRC) is issuing this regulatory issue summary (RIS) to remind addressees of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (ASME Code) requirements in accordance with 10 CFR 50.55a, "Codes and Standards," and of the quality assurance (QA) requirements for design control in accordance with Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50. Specifically, this RIS informs addressees of concerns with using computer software packages to demonstrate compliance with Section III, "Rules for Construction of Nuclear Facility Components," of the ASME Code. This RIS also informs addressees of the NRC's findings from license renewal and new reactor audits on applicants' analyses and methodologies that used the WESTEMS™ computer software to demonstrate compliance with Section III of the ASME Code. The NRC expects addressees to review this RIS for applicability to their facilities and to consider actions as appropriate. This RIS requires no action or written response from addressees.

BACKGROUND INFORMATION

Section 54.21 of 10 CFR, "Contents of Application-Technical Information," requires applicants for license renewal to perform an evaluation of time-limited aging analyses relevant to structures, systems, and components within the scope of license renewal. In most cases, fatigue analyses of the reactor coolant pressure boundary components involve time-limited assumptions. In addition, the staff has provided guidance in NUREG-1800, "Standard Review

Plan for Review of License Renewal Applications for Nuclear Power Plants," Revision 2, issued December 2010, which recommends that the effects of the reactor water environment on fatigue life be evaluated for a sample of components to provide assurance that cracking due to fatigue will not occur during the period of extended operation. Because the reactor water environment has a significant impact on the fatigue life of components, many license renewal applicants have performed supplemental detailed analyses to demonstrate acceptable fatigue life for these components.

Regulatory Guide 1.28, "Quality Assurance Program Criteria (Design and Construction)," describes methods that the NRC considers acceptable for complying with the requirements in Appendix B to 10 CFR Part 50 for establishing and implementing a QA program for the design and construction of nuclear power plants and fuel reprocessing plants.

The regulations at 10 CFR 50.55a specify the ASME Code requirements. In particular, 10 CFR 50.55a(c) requires, in part, that components of the reactor coolant pressure boundary must meet the requirements for Class 1 components in Section III of the ASME Code, with limited exceptions specified in 10 CFR 50.55a(c)(2) thru 10 CFR 50.55a(c)(4). Some operating facilities may have performed a supplemental detailed fatigue analysis of components because of new operating conditions identified after the plant began operation.

SUMMARY OF ISSUE

The staff has identified concerns regarding the implementation of computer software packages used to demonstrate the ability of nuclear power plant components to withstand the cyclic loads associated with plant transient operations. In particular, the concerns were associated with the computer software package, WESTEMS™, which involves the use of a computer code developed to calculate fatigue usage during plant transient operations such as startups and shutdowns, as discussed in ASME Code, Section III, Subsection NB, Subarticles NB-3200, "Design By Analysis," and NB-3600, "Piping Design."

The staff identified these concerns with the WESTEMS™ computer software package during the review of the AP1000® design certification application, and they are described in the staff's safety evaluation report (Agencywide Documents Access and Management System (ADAMS) Accession No. ML103430502) and its related "Onsite and Offsite Review Summary Report" (ADAMS Accession No. ML110250634). One such concern was that the methodology used by this computer software package to determine the peak and valley times in the total stress intensity time history used in fatigue calculations may involve the algebraic summation of three orthogonal moment vectors. This algebraic summation methodology is not consistent with ASME Code, Section III, Subsection NB, Subarticle NB-3650, "Analysis of Piping Products," which states that resultant moments from different load sets shall not be used in calculating the moment range (i.e., this algebraic summation methodology is not an accurate representation of the moment range). Therefore, the use of this practice could provide results that are not accurate. The staff also identified a concern in which, under certain circumstances, the use of this computer software package allows the user to manually modify stress peak and valley times in the total stress intensity time history used to calculate the cumulative usage factor during intermediate calculations. Although this method of analyst intervention could provide acceptable results in some cases, reliance on the user's engineering judgment and ability to modify stress peak and valley times in the total stress intensity time history, without control and documentation, could produce results that are not predictable, repeatable, or conservative. By letter dated September 29, 2010, in response to an NRC request for additional information, the applicant for the AP1000® design certification elected to remove the use of this computer software package from its design control document amendment, as documented in ADAMS Accession No. ML102770329.

License renewal applicants have proposed the use of various computer software packages in License Renewal Applications to demonstrate acceptable fatigue calculations for plant operation during the period of extended operation. As a result of the concerns described above, the staff asked a license renewal applicant in its request for additional information dated November 22, 2010, to demonstrate that the package provides acceptable results and to assess the impact of these identified concerns on the license renewal applicant's fatigue calculations (ADAMS Accession No. ML102810194). The staff conducted an audit to (1) review this evaluation, (2) address the user's ability to manually modify peak and valley times/stresses, and (3) address the aforementioned concern with the algebraic summation of three orthogonal moment vectors.

At the conclusion of the audit, the staff determined, as described in its audit report (ADAMS Accession No. ML110871243), that the license renewal applicant's use of this computer software package demonstrated (1) that it produced calculations of stresses and cumulative usage factors that are consistent with the methodology in ASME Code, Section III, Subsection NB, Subarticle NB-3200, (2) that the analyst's judgment in manually modifying peak and valley times/stresses in these calculations was reasonable and can be appropriately justified and documented, though justification of any user intervention should be documented, (3) that this applicant did not use this software to perform fatigue calculations as described in ASME Code, Section III, Subsection NB, Subarticle NB-3600, and (4) future use of this software should be accompanied by an acceptable demonstration that it performs fatigue calculations in accordance with ASME Code, Section III, Subsection NB, Subarticle NB-3600.

This license renewal applicant performed evaluations on two of its components: a pressurized-water reactor (PWR) pressurizer surge nozzle and a PWR safety injection boron injection tank nozzle. When considering the effects of the reactor water environment on fatigue life, these evaluations indicated a cumulative usage factor that was less than the ASME Code design limit of 1.0, provided that there was sufficient and clear records of justification for analyst intervention.

The staff acknowledges that addressees may have used, or will make use of, other computer software packages in performing ASME Code fatigue calculations. Thus, the NRC encourages addressees to review the documents discussed above and to consider actions, as appropriate, to ensure compliance with the requirements for ASME Code fatigue calculations and QA programs, as described in 10 CFR 50.55a and Appendix B to 10 CFR Part 50, respectively.

BACKFIT DISCUSSION

This RIS informs addressees of potential concerns with the use of computer software packages to perform ASME Code fatigue calculations and reminds them that they should perform these calculations in accordance with ASME Code requirements. The regulations at 10 CFR 50.55a specify the ASME Code requirements. Regulatory Guide 1.28 describes methods for establishing and implementing a QA program for the design and construction of nuclear power plants. For license renewal, metal fatigue is evaluated as a time-limited aging analysis in accordance with 10 CFR 54.21(c). Section 4.3, "Metal Fatigue," of NUREG-1800 provides the associated staff review guidance. This RIS does not impose a new or different regulatory staff position. It requires no action or written response and, therefore, is not a backfit under 10 CFR 50.109, "Backfitting." Consequently, the NRC staff did not perform a backfit analysis.

FEDERAL REGISTER NOTIFICATION

The NRC published a notice of opportunity for public comment on this RIS in the *Federal Register* (76 FR 60939) on September 30, 2011. The agency received comments from two commenters (ADAMS Accession Numbers ML11301A104 and ML11307A391). The staff considered all comments, and its evaluation of these comments is publicly available under ADAMS Accession No. ML11320A023.

CONGRESSIONAL REVIEW ACT

The NRC has determined that this RIS is not a rule as designated by the Congressional Review Act (5 U.S.C. §§ 801–808) and, therefore, is not subject to the Act.

PAPERWORK REDUCTION ACT STATEMENT

This RIS does not contain any information collections and, therefore, is not subject to the requirements of the Paperwork Reduction Act of 1995 (44 U.S.C. 3501 et seq.). Existing collection requirements under 10 CFR Part 54 were approved by the Office of Management and Budget, control number 3150-0155.

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Please direct any questions about this matter to the technical contact listed below.

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