UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, DC 20555 - 0001

ACRSR-2230

December 18, 2006

Mr. Luis A. Reyes
Executive Director for Operations
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: DRAFT FINAL REGULATORY GUIDE 1.207 (DG-1144), "GUIDELINES FOR EVALUATING FATIGUE ANALYSES INCORPORATING THE LIFE REDUCTION OF METAL COMPONENTS DUE TO THE EFFECTS OF THE LIGHT-WATER REACTOR ENVIRONMENT FOR NEW REACTORS"

Dear Mr. Reyes:

During the 538th meeting of the Advisory Committee on Reactor Safeguards, December 7-8, 2006, we met with representatives of the NRC staff, American Society of Mechanical Engineers (ASME), and AREVA to discuss the draft final Regulatory Guide (RG) 1.207, "Guidelines for Evaluating Fatigue Analyses Incorporating the Life Reduction of Metal Components Due to the Effects of the Light-Water Reactor Environment for New Reactors." Our Subcommittee on Materials, Metallurgy, and Reactor Fuels reviewed this matter on December 6, 2006. We had the benefit of the documents referenced.

RECOMMENDATION

Regulatory Guide 1.207 should be issued as final.

BACKGROUND AND DISCUSSION

The ASME Boiler and Pressure Vessel Code Section III fatigue design curves, developed in the late 1960s and early 1970s, are based on tests conducted in laboratory air environments at ambient temperatures. In the Code, adjustments are made to strain and cyclic life to account for variations in material properties, surface finish, data scatter, and unknown effects. The Code does not explicitly account for potential degradation in the fatigue properties attributable to exposure to light water reactor (LWR) coolant environments. Recent fatigue test data and analyses have demonstrated conclusively that LWR environments have a significant impact on the fatigue life of reactor structural materials. Although the ASME Code Committee has recognized this issue for many years, it has been unable to reach consensus on how to resolve the matter. The staff has therefore taken the initiative to develop this Regulatory Guide.

Given that the fatigue life of ASME Class 1 components in LWR coolant environments is a function of several parameters, the NRC staff has selected an environmental correction factor, F_{en}, to account for LWR environments. By definition, F_{en} is the ratio of fatigue life of the material in a room temperature air environment to its fatigue life in a LWR coolant environment at operating temperature. To incorporate environmental effects into the fatigue evaluation, the fatigue usage is calculated using ASME Section III Code procedures, and the fatigue usage is multiplied by the correction factor. In license renewal applications, applicants have used this methodology to evaluate the fatigue usage of materials in Class 1 components.

The F_{en} methodology that the staff considers acceptable is described in RG 1.207. NUREG/CR-6909, "Effect of LWR Coolant Environments on the Fatigue Life of Reactor Materials," provides the technical basis for this methodology. In developing the underlying models, Argonne National Laboratory (ANL) researchers analyzed existing data to predict fatigue life as a function of temperature, strain rate, dissolved oxygen level in water, and sulfur content of the steel. They identified a strain threshold below which environmental effects on fatigue life do not occur. Using this guidance, only the types of stress cycles or load set pairs that exceed strain threshold criteria for carbon steels, low-alloy steels, austenitic stainless steels, and Ni-Cr-Fe alloys need to be considered for F_{en} calculations. The evaluation options depend on the complexity of the analyzed transient condition and the level of detail in the analysis. Detailed analyses may be used to reduce the conservatism in the calculated F_{en} values while simplified calculations will yield more conservative results. The calculated F_{en} values are then used to adjust ASME fatigue usage to account for environmental effects.

Another issue addressed by the staff in RG 1.207 is the non-conservatism of the current ASME stainless steel air design curve. Recent evaluations of stainless steel and nickel alloy fatigue test data demonstrate that the ASME air design curve is non-conservative in the mid-to-high cycle fatigue range. RG 1.207 provides a new stainless steel air design curve and a comprehensive technical basis for the new curve. RG 1.207 states that the F_{en} values defined for stainless steel in NUREG/CR-6909 should be used in conjunction with the new stainless steel air design curve when evaluating the fatigue usage of ASME Class 1 components.

In addition, the staff and ANL evaluated the incorporation of the F_{en} approach methodology in fatigue analyses for Ni-Cr-Fe alloys (e.g., Alloy 600 and 690) and welds. The staff concluded that the new fatigue design curve proposed for stainless steels also adequately represented the fatigue behavior of these alloys.

NUREG/CR-6909 contains evaluations of the margins of the ASME design curves. In conducting these evaluations, ANL researchers reviewed the literature to assess the factors (excluding environment) necessary to account for the effects of various uncertainties and differences between actual components and laboratory test specimens. The researchers also performed statistical analyses using Monte Carlo simulations to develop fatigue design curves. The staff has concluded that this approach is acceptable because the fatigue design curves are based on crack initiation, rather than component failure, and thus provide adequate margin. We concur with the staff's conclusion.

Key comments on RG 1.207 received from industry and the ASME were that the existing ASME design curves and methodology are adequate, that there is no need for a new regulatory guide, that the new guide will require more detailed and costly analyses in the design of new plants, and that the use of the new guide will also result in the need for an excessive number of snubbers and pipe whip restraints. These comments and the associated staff's responses were discussed with representatives of the ASME, AREVA, and the NRC staff during our Subcommittee and full Committee meetings. We are satisfied that these comments have been properly addressed by the staff. Therefore, RG 1.207 should be issued as final.

ASME representatives expressed their intent to continue their efforts to prepare a Code Case that would treat the reactor coolant environmental effects on fatigue and meet the objectives of RG 1.207. If a Code Case is developed that is acceptable to the staff, it would also provide an acceptable alternative to RG 1.207 for addressing the environmental effects on fatigue. The staff should interact with ASME in the development of this Code Case, as appropriate.

Dr. William Shack did not participate in the Committee's deliberations regarding this matter.

Additional comments by ACRS Member Otto L. Maynard are provided below.

Sincerely,

/RA/

Graham B. Wallis
Chairman

Additional comments by ACRS Member Otto L. Maynard

I agree with my colleagues that the draft final Regulatory Guide (RG) 1.207 represents a significant improvement in the understanding and quantification of the influence of reactor coolant environments on the fatigue properties of certain materials. However, comments from the public and affected stakeholders have not been properly addressed. Stakeholders have argued that the implementation of RG 1.207 will require increased expenditures with questionable safety benefit. The ASME and other stakeholders have further argued that the existing codes and standards provide sufficient conservatism to account for fatigue-related issues. The NRC staff has not identified events or significant fatigue-related issues that would have been prevented by the implementation of the provisions of RG 1.207.

RG 1.207 should not be issued until the staff has demonstrated that the improvement in safety from implementation of the new requirement is sufficient to justify the increased cost to licensees of new reactors.

References:

1. Memorandum from Farouk Eltawila, Director, Division of Risk Assessment and Special Projects, Office of Nuclear Regulatory Research, to John T. Larkins, Executive Director, Advisory Committee on Reactor Safeguards/Advisory Committee on Nuclear Waste, "Transmittal of Final Regulatory Guide 1.207, 'Guidelines for Evaluating Fatigue Analyses Incorporating the Life Reduction of Metal Components Due to the Effects of of the Light-Water Reactor Environment for New Reactors,'" dated November 29, 2006
2. Draft final Regulatory Guide 1.207 (DG-1144), "Guidelines for Evaluating Fatigue Analyses Incorporating the Life Reduction of Metal Components Due to the Effects of the Light-Water Reactor Environment for New Reactors"
3. Draft final NUREG/CR-6909, Rev. 1, "Effect of LWR Coolant Environments on the Fatigue Life of Reactor Materials"
4. Draft Staff Response to Public Comments on DG-1144 and draft NUREG/CR-6909
5. Redline-strikeout comparison between DG-1144 and draft final Regulatory Guide 1.207