April 12, 2002

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SUBJECT STAFF COMMENTS ON GE-NE PLEDGE MODEL

By letter dated June 7, 1996, General Electric Nuclear Energy (GE-NE) provided to the staff for information purposes the GE-NE proprietary report NEDC-32613P, "Prediction of Environmentally Assisted Cracking in Boiling Water Reactors, Part I: Unirradiated Stainless Steel Components," dated June 1996. This report describes a life prediction mechanistically-based methodology for stainless steel structures in unirradiated regions of boiling water reactors (BWRs) that are susceptible to environmentally-assisted cracking (e.g., stress corrosion cracking, strain-induced cracking, corrosion-fatigue) and the examples of the application of the resulting PLEDGE (Plant Life Extension Diagnosis by General Electric) code to reactor components to determine cracking susceptibility and determining inspection periodicities.

The staff, and its contractor Argonne National Laboratory (ANL), has met with your staff on three occasions (July 7, 1997, public meeting at the NRC's Headquarters in Rockville, MD, for a demonstration of the PLEDGE computer code; September 14, 1998, public meeting at GE Corporate Research and Development Center (GE-CRD) in Schenectady, NY, to discuss technical questions; and, March 21, 2001, public meeting at ANL in Chicago, IL, to discuss additional technical questions) to discuss staff questions related to PLEDGE. Based on these discussions and the staff and ANL's review of the subject report, we have several comments on the subject report (see attached). These comments should also be considered for Part II of this report, concerning irradiated stainless steel components, which you have stated you will submit to the staff for information purposes in the near future.

The basic physical description of stress corrosion cracking that underlies the PLEDGE model is consistent with the basic anodic dissolution model of SCC developed by Parkins and his colleagues for several decades. Although the detailed mathematical description of the model and the experimental data used to develop the correlations used in PLEDGE are proprietary, the acceptability of PLEDGE for modeling stress corrosion cracking behavior can be established by comparison with the extensive data on SCC in BWR environments available in the literature. Based on this comparison with the available experimental data, it appears that PLEDGE provides conservative predictions of crack growth rates in unirradiated sensitized materials provided that an appropriate value is chosen for the parameter used to characterize the grain boundary sensitization, denoted by EPR. For applications to unirradiated weldments a value of EPR = 15 C/cm^2 would appear appropriate and yields a moderate degree of conservatism. With this value for EPR, PLEDGE should give somewhat conservative predictions for IGSCC under constant and cyclic loads and provide a conservative estimate for environmentally assisted fatigue (i.e., transgranular crack growth, under cyclic loading). This

EPR choice should also provide sufficient conservatism in application to weldments that the predictions can also be applied to irradiated components with fluence < 5 x 10^{20} n/cm^2.

For environmentally assisted fatigue in unsensitized materials, the choice of EPR = 0 C/cm^2 may not give sufficiently conservative estimates in the low conductivity water chemistries characteristic of current BWR operation; therefore, some additional margin appears to be appropriate. This could be provided by assuming EPR = 15 C/cm^2, but other approaches (e.g., an appropriate multiplier) could be used, but would have to be justified by comparison with appropriate data.

The choice of an appropriate degree of conservatism in the development of a disposition curve is to some extent not a technical question. However, we believe that the use of a 95-percent confidence limit on the predictions is overly conservative. There is inevitable scatter in SCC measurements, and the focus should be on the main trends not the scatter in the tails. The James and Jones approach of adopting a 95-percent confidence limit on the mean has been adopted here as an appropriate method to compare the model predictions with the experimental data.

PLEDGE appears to overestimate the deleterious effect of impurity additions and its predictions become more conservative for conductivities > 0.2 µS/cm. It also appears to overestimate the deleterious effect of sensitization as characterized by EPR, at least for EPR values > 20 C/cm^2. Because current BWRs generally operate with conductivities much lower than 0.2 µS/cm^2 and most weldments will have sensitization levels < 15 C/cm^2, these shortcomings of the model are of limited importance. However, it is important to recognize that comparing PLEDGE predictions with data for high conductivities or high EPR could give a misleading picture of the degree of conservatism in PLEDGE predictions.

Please contact C. E. (Gene) Carpenter, Jr., of my staff at (301) 415-2169 if you have any further questions regarding this subject.

Sincerely

/ra/

William H. Bateman, Chief
Materials and Chemical Engineering Branch
Division of Engineering
Office of Nuclear Reactor Regulation

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