August 11, 2003

Dr. Mario V. Bonaca, Chairman
Advisory Committee on Reactor Safeguards
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

SUBJECT: VESSEL HEAD PENETRATION CRACKING AND REACTOR PRESSURE VESSEL DEGRADATION

Dear Dr. Bonaca:

In your letter dated May 16, 2003, you provided the Committee's conclusions and recommendations regarding the action plans developed by the Office of Nuclear Reactor Regulation (NRR) and the Office of Nuclear Regulatory Research (RES) to address the recommendations of the Davis-Besse Lessons Learned Task Force on the above subject. The staff's comments on the conclusions and recommendations in your letter are provided below.

(1) The action plans, developed to address the recommendations of the Lessons Learned Task Force (LLTF), define the work needed to provide a sound technical basis for assessing industry's development of a proactive life management methodology for materials degradation in PWR [pressurized water reactor] vessel head penetrations.

Staff comment: The staff appreciates the Committee's recognition of its efforts to develop effective action plans.

(2) The LLTF action plans need to be augmented in some areas:

(a) Cracking prediction algorithms that address pressure vessel penetrations other than those in the vessel head
(b) Flaw Evaluation Guidelines for vessel head penetrations
(c) Qualification criteria for vessel head penetration inspection techniques
(d) Other degradation modes for high-chromium nickel-base alloys.

Staff comment: The focus of the action plans is to address the LLTF recommendations to develop and issue improved requirements for inspection of vessel head penetration (VHP) nozzles, and to ensure that licensees have implemented effective boric acid corrosion control programs. The revised requirements will be based on the best available information, analytical methods, and inspection technologies. The staff agrees with the ACRS that there are limitations in the capability of these tools. There are research activities underway to improve these capabilities, but management of these research activities is beyond the scope of the action plans.

The ACRS points out that the Effective Degradation Years (EDY) metric used for prioritizing VHP inspections is incomplete because it does not take into account stress and material parameters, but concludes it is adequate for the near future for this application. The staff recognizes that the susceptibility model does not include many parameters known to affect the potential for and the rate of cracking, and agrees that, while not perfect, it is a useful tool for

ranking the importance of the issue for various plants. The only plants which have been found to have leaking nozzles or J-welds are in the high-susceptibility category. Some moderate-susceptibility plants have been found to have cracks (which were repaired) but no leaks. Bare metal visual examinations of plants in the low-susceptibility category have not identified any leaks. At this point in time, only one low-susceptibility plant has performed a non-visual (i.e., volumetric) examination, and found no cracks.

The ACRS states that different prioritization algorithms are needed for other penetrations with different residual stress profiles, and given the cracking event in the bottom head at South Texas Project (STP), Unit 1, these other algorithms should be developed now. The leakage found at STP focused additional attention on an existing staff concern regarding potential degradation of lower head penetrations. We generally agree with the ACRS that a variation on the susceptibility model, which is most appropriate for Alloy 600 used for the upper head penetrations, may be warranted. When the root cause of the STP cracking is known, we will move forward with a new ranking model. The staff is actively engaged on this issue and will develop new models, if warranted. Independent of the STP evaluation, the staff reviewed the responses to Bulletin 2002-01 in accordance with the action plans and determined that current inspection requirements for early reactor coolant system pressure boundary leak detection should be improved. The action plans will be used to manage development and issuance of revised regulatory requirements for inspections of the lower head and other components.

The ACRS states that a specific objective of the LLTF action plans should be to develop a predictive capability for boric acid corrosion under the specific system conditions relevant to the VHP geometry and operating conditions. Based on the number of leaking events and only one major corrosion event, it seems reasonable to conclude that a leaking penetration is a necessary but not sufficient condition. It appears that a major boric acid deposit on the head coupled with a local leak is needed to create the conditions observed at Davis-Besse. RES has initiated corrosion studies on low-alloy steels exposed to boric acid solutions. From this work, it will be possible to develop models to predict the behavior observed at Davis-Besse and to assess the potential for degradation in other situations. Order EA-03-009 contains requirements for inspection of reactor pressure vessel heads. In addition, the action plans address the development of revised inspection requirements and inspection monitoring guidelines. These actions should provide for more timely leak detection and prevention of large boric acid accumulations.

The ACRS states that the recently revised flaw evaluation guidelines issued by the U.S. Nuclear Regulatory Commission (NRC) are acceptable, but there are gaps (i.e., there is no guidance on the residual stress profile needed in calculation of stress intensity, and there is no justification for the choice of the 75/50 curve fit for crack propagation rate vs. stress intensity rather than the 95/50 curve used in the earlier guideline, and the impact this has on uncertainty in predicted crack depths at the end of an inspection period). The staff generally agrees and is continuing its review of the industry report on growth by primary water stress corrosion cracking (PWSCC) and continues to work with the American Society of Mechanical Engineers code to develop inspection requirements. In addition, RES is developing an integrated analysis method that can support evaluations of inspection techniques and intervals for long-term management of VHP degradation and incorporation in risk assessments. The integrated analysis includes guidance on how to treat probability of detection, flaw sizing, residual stresses, crack initiation processes, and growth rate.

The ACRS expressed concerns regarding the capability of current inspection techniques to identify and quantify cracking. The staff agrees that the current technologies have limitations; however, they can be used for specific applications as long as appropriate qualification and demonstration programs are developed. For many years, the RES nondestructive examination (NDE) program has sought to identify strengths and weaknesses of modern NDE technologies, primarily ultrasonic and eddy current. In addition, RES has work underway to address the capability and reliability of VHP inspection and this will be part of the integrated model mentioned previously. The staff will continue to work with industry to seek improvements in technology. Also, the revised inspection guidelines discussed in the action plans refer to inspection procedures for NRC inspectors to use in evaluating licensee compliance with revised NRC requirements, once they have been promulgated.

The ACRS recommends that the action plans should address other degradation modes for high-chromium nickel-based alloys. It should be noted that studies of various types of degradation of nickel-based alloys in penetrations other than the reactor pressure vessel head have been underway for several years. RES is starting a program to explore other types of degradation and other sites that could be susceptible to PWSCC in Alloy 600. We agree that the work should be done, but these studies are part of a longer term program and are outside the scope of the action plans, which were developed to address the specific recommendations of the LLTF. RES will consider developing a broad-based research plan, coupled with the work NRR is doing, to capture the whole issue, and we will continue to review the work of the nuclear navy and industry in this area.

(3) Although we support cooperation with other organizations in collecting the required data, the staff must analyze the data independently.

Staff comment: We are fully aware of the concern ACRS raises, and agree. The staff policy and practice is to accept industry assessments in our joint programs only after independent evaluations of the data and, on occasion, confirmatory tests.

Sincerely,

/RA/

William D. Travers
Executive Director
for Operations

cc: Chairman Diaz
Commissioner McGaffigan
Commissioner Merrifield
SECY

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