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

ACRSR-2241

March 22, 2007

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

SUBJECT: PROPOSED NRC STAFF AND INDUSTRY ACTIVITIES FOR ADDRESSING DISSIMILAR METAL WELD ISSUES RESULTING FROM THE WOLF CREEK PRESSURIZER WELD INSPECTION RESULTS

Dear Mr. Reyes:

During the 540th meeting of the Advisory Committee on Reactor Safeguards, March 8-9, 2007, we discussed the proposed NRC staff and industry activities for addressing the dissimilar metal weld issues resulting from the Wolf Creek pressurizer weld inspection results. Our Subcommittee on Materials, Metallurgy, and Reactor Fuels also reviewed this matter on March 6, 2007. During these meetings, we had the benefit of discussions with representatives of the NRC staff, Nuclear Energy Institute, and FirstEnergy and of the documents referenced.

CONCLUSIONS AND RECOMMENDATIONS

1. We support the agreement reached between the staff and the industry on the resolution of dissimilar metal weld issues on pressurizer nozzles.

2. In the upcoming outages, the staff should encourage the industry to inspect all inspectable dissimilar metal welds on pressurizer nozzles before performing mitigation activities.

BACKGROUND AND DISCUSSION

In October 2006, ultrasonic examination revealed five indications in the welds on three pressurizer nozzles at the Wolf Creek Generating Plant. These indications were interpreted by the nondestructive examination experts as large circumferential cracks in nickel-based dissimilar metal welds joining the ferritic steel nozzles to the austenitic stainless steel coolant piping. No metallurgical samples were taken at Wolf Creek to confirm that the ultrasonic indications were actually stress corrosion cracks rather than weld flaws associated with the original fabrication.

The licensee repaired the nozzles with weld overlays of a nickel alloy with a higher chromium content (Alloy 152) that is much more resistant to primary water stress corrosion cracking (PWSCC). The repairs provide a structural capability equivalent to an original unflawed weld even assuming that the original weld has a through-wall, 360° circumferential crack.

The nickel-based alloys (Alloy 82 and 182) used for these welds are known to be susceptible to PWSCC in the primary coolant environment of pressurized water reactors (PWRs). Because the adjoining base metals are resistant to stress corrosion cracking in the primary coolant environment, axial cracks will be limited in length to a size no greater than the width of the weld.

While they may lead to leakage, such cracks are unlikely to lead to rupture or significant loss of coolant. Circumferential cracks can potentially grow to sizes that could lead to rupture.

Prior to the Wolf Creek finding, the staff and industry had recognized the potential for cracking in these dissimilar metal welds, and the industry had instituted a program to inspect these welds and apply weld overlays similar to those used at Wolf Creek. Most licensees of PWRs with susceptible nozzle welds will complete inspections or apply weld overlays during 2007. However, nine plants plan to perform these activities during outages in the spring of 2008. The plants that have not yet completed inspections or mitigation activities have committed to enhanced leakage detection as a compensatory action until these activities are completed.

Scoping analyses performed by the staff indicate that for the safety valve and relief valve nozzles, the times required for the cracks to grow through-wall and leak are relatively short (1.3 to 2.6 years) and are close to the times required for the cracks to grow large enough to result in gross rupture of the nozzles. Under some assumptions, the relief valve nozzle is predicted to rupture before any leakage occurs. There are substantial uncertainties associated with these analyses.

Only about 15 percent of the dissimilar metal pressurizer nozzle welds in PWRs have been inspected. Consequently, the current state of most welds is unknown. Therefore, the staff has taken the position that mitigation activities should be completed by the end of 2007 rather than the spring of 2008.

The industry has presented arguments that suggest the likelihood that nozzles can rupture without prior warning is sufficiently low, and the increased risk associated with a schedule for completing inspection and mitigation activities in the spring of 2008 is acceptably small. The industry is undertaking a program to develop an advanced finite element analysis capability that can provide a more rigorous basis for its arguments. Licensees have also committed to accelerate the schedule for inspection and mitigation and complete the work by the end of 2007, if this analysis effort is unsuccessful in demonstrating the likelihood of leak-before-break for these nozzles. They have further stated that this schedule could also be accelerated if new information were obtained during upcoming plant inspections that challenges current industry assumptions. In upcoming outages, the staff should encourage the industry to inspect all inspectable dissimilar metal pressurizer nozzle welds before performing mitigation activities.

The work being undertaken by the industry addresses the simplifying approximation usually imposed on fracture mechanics analyses that the crack shape is either elliptical or constant depth. The refined analysis considers crack growth at each point along the crack front and allows the crack to change shape as dictated by the stress distribution and appropriate crack growth correlations. Preliminary results provided by the industry suggest that such analyses may be able to show that crack growth will be such that the leak-before-break principle is preserved. The industry and the staff recognize the need for validation of the analytical models and comparisons of the predictions of the models with experimental data. This work could provide a very significant increase in the capability to realistically model the growth of flaws in

reactor components and would be useful in a variety of applications. We support the agreement reached between the staff and the industry on the resolution of pressurizer nozzle weld issues.

Even with this increased capability to model the growth of cracks, there will still be large uncertainties in important variables that affect the results such as the welding residual stresses, the applied loads on the welds, and the population of cracks that could be present in nozzle welds that have not been inspected. It may eventually be possible to formalize the evaluations of these uncertainties through Monte Carlo simulation, but the present problem will have to be addressed through sensitivity studies. The staff and the industry have not yet settled on how to determine what will constitute an acceptable demonstration that the likelihood of violation of the leak-before-break principle is acceptably low, and this may not be possible until some of the results of the planned analyses are available.

Sincerely,

/RA/

William J. Shack
Chairman

References:

1. Memorandum from Mark A. Cunningham, Director, Division of Fuel, Engineering, and Radiological Research, RES to Frank P. Gillespie, Executive Director, ACRS, dated February 13, 2007, “Transmittal of (Proprietary) Draft Summary Report, ‘Evaluation of Circumferential Indications in Pressurizer Nozzle Dissimilar Metal Welds at the Wolf Creek Power Plant’” (ADAMS ML070460127)

2. Letter from Christine King, Electric Power Research Institute, Materials Reliability Program (MRP), to Tanya Mensah, U.S. Nuclear Regulatory Commission, dated January 22, 2007, transmitting MRP 2007-003, “Implications of Wolf Creek Pressurizer Butt Weld Indications Relative to Safety Assessment and Inspection Requirements” (ADAMS ML070240140)

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