



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

June 15, 2007

MEMORANDUM TO: ACRS Members

FROM: Charles G. Hammer, Senior Staff Engineer */RA/*
Technical Support Branch, ACRS

SUBJECT: TRANSMITTAL OF STATUS REPORT, PROPOSED SCHEDULE, AND
REVIEW MATERIALS REGARDING THE DISSIMILAR METAL WELD ISSUE

The full Committee will review the subject dissimilar metal weld issue during the 544th ACRS Meeting on July 11, 2007.

To prepare for these meetings, the following documents are attached:

- 1 Status Report
- 2 Proposed Schedule for July 11, 2007 full Committee meeting

In addition, the following review materials are being transmitted on an enclosed CD:

1. Letter from W.J. Shack, Chairman ACRS, to L.A. Reyes, EDO, "Proposed NRC Staff and Industry Activities for Addressing Dissimilar Metal Weld Issues Resulting from the Wolf Creek Pressurizer Weld Inspection Results", dated March 22, 2007.
2. Letter from L.A. Reyes, EDO, to W.J. Shack, Chairman ACRS, "Response to ACRS Letter, dated March 22, 2007, Concerning Proposed NRC Staff and Industry Activities for Addressing Dissimilar Metal Weld Issues Resulting from the Wolf Creek Pressurizer Weld Inspection Results", dated April 23, 2007
3. Dominion Engineering, Inc., Phase I Pressurizer Nozzle Dissimilar Metal Weld Crack Growth Calculations Using Advanced FEA, Calculation C-5559-00-01 Revision Draft B, (ADAMS ML070940229)
4. Memorandum from M. Gutierrez, RES to J. Uhle, RES, "Summary of the May 31 – June 01, 2007, Category 2 Public Meeting Between the NRC Staff and the Expert Panel for the Wolf Creek Advanced FEA" (with enclosures), dated June 12, 2007

If you have any questions, please contact me at (301) 415-7363 or cgh@nrc.gov.

cc wo/Attachments: F. Gillespie
S. Duraiswamy
C. Santos

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
DISSIMILAR METAL WELD ISSUE
July 11, 2007
ROCKVILLE, MD

- STATUS REPORT -

PURPOSE

The purpose of this meeting is for the industry and the NRC staff to provide the Committee with the results of analyses and evaluations used as a basis for ensuring the structural integrity of pressurizer nozzle dissimilar metal welds at nine plants. The licensees for these nine plants have requested deferring flaw inspection and mitigation activities until early 2008. The recent staff and industry analysis and evaluation activities stem from the pressurizer nozzle weld inspection results at Wolf Creek where large flaws were discovered.

BACKGROUND

In October 2006, large circumferential cracking was found at Wolf Creek on three pressurizer nozzles. Wolf Creek is a Westinghouse-design four-loop PWR having austenitic stainless steel primary coolant piping and transition nickel-based alloy (dissimilar metal) welds at nozzles. Past observation of cracking in these types of welds at various plants has been characterized as primary water stress corrosion cracking (PWSCC) and were mostly axial cracks, all relatively short in length. Unlike previous inspection results, the Wolf Creek pressurizer nozzle weld flaws were long, deep, circumferential cracks. The size and location of the cracks is provided below:

| Location | Crack length | | Crack depth |
|---------------------|--------------|--------------------------|----------------------|
| | inches | % of total circumference | % of total thickness |
| Surge line nozzle | 4" | 11% | 31% |
| " | 2.2" | 6% | 25% |
| " | 0.8" | 2% | - |
| Relief valve nozzle | 7.7" | 47% | 26% |
| Safety valve nozzle | 2.5" | 15% | 23% |

The Wolf Creek inspections were performed in accordance with Materials Reliability Program (MRP) -139 guidance, issued in 2005. The guidance allows application of weld overlays before inspections are performed. However, the Wolf Creek licensee did inspect these welds before applying weld overlays. The last volumetric examinations of these welds were performed in 1993 (surge line nozzle) and 2000 (relief and safety valve nozzles), but the inspections were not nearly as reliable as the current MRP-139 inspections.

Late in 2006, the staff and its contractor performed several evaluations to assess the significance of the Wolf Creek flaws. A key result of these evaluations was whether or not there is significant time required between when the cracks are predicted to leak (i.e., when cracks are predicted to propagate through the wall) and when the piping joint completely fails (i.e, gross rupture). The staff and contractor evaluations indicated that for at least the relief valve and safety valve nozzle configurations, there could be no additional time required to failure. The surge line analyses indicated some time between leakage and rupture; however, most analyses indicated that the time to failure can be less than two operating cycles. The staff also found that significant uncertainties in the analyses may dominate any potential sources of conservatism.

Most of the U.S. PWRs which have dissimilar metal welds on pressurizer nozzles are completing inspections or installing weld overlays sometime in 2007. However, there are nine plants which are currently planning to perform these activities during outages in 2008. These plants are: Braidwood 2, Comanche Peak 2, Diablo Canyon 2, Vogtle 1, Palo Verde 2, South Texas 1, Seabrook, Summer, and Waterford 3. For these plants, the staff has determined that the performance of these activities at dates this far into the future is unacceptable without an additional basis for justifying that leak-before-break will occur for large flaws similar to those at Wolf Creek. To address the staff's concerns and provide such a basis, the industry is undertaking an advanced finite element analysis of flaws wherein the crack shape is not constrained to remain semi-elliptical throughout its growth. This has involved development of a computer model wherein the crack growth varies with the local stress intensity along the crack front. The intent in developing this model is to allow the crack to grow through the pipe wall in a small region while providing a sufficiently large remaining ligament to prevent gross rupture of the weld. The licensees have committed that, if the results of these analyses do not provide an acceptable basis for leak-before-break, they will proceed to inspect the welds before 2008.

On March 6, 2007, the Subcommittee on Materials, Metallurgy, and Reactor Fuels heard presentations by and held discussions with representatives of NRR, RES, the RES contractors, the Nuclear Energy Institute (NEI), and the Electric Power Research Institute (EPRI). On March 8, 2007, the full Committee heard presentations and held discussions on this subject. The Committee issued a letter on March 22, 2007. In its March 22, 2007 letter (Reference 1), the ACRS supported the agreement reached between the staff and the industry on the resolution of dissimilar metal weld issues on pressurizer nozzles. The ACRS letter also stated that in the upcoming outages, the staff should encourage the industry to inspect all inspectable dissimilar metal welds on pressurizer nozzles before performing mitigation activities.

The EDO provided a response to the ACRS in a letter dated April 23, 2007 (Reference 2), which stated that the advanced finite element analysis efforts being performed by both the industry and staff are ongoing. The letter also stated that the staff anticipates reaching conclusions by August 2007 on whether these efforts would provide reasonable assurance of detectable leakage well before rupture. The staff further committed to keep the Committee informed of this issue as these analyses proceed.

The industry has provided the staff with a Phase I calculation which uses the industry's advanced FEA model to calculate crack growth for the cases which the NRC had evaluated in late 2006. This is provided as Reference 3. The industry is currently working on Phase II calculations which are much more extensive and will evaluate key parameter variations, such as states of residual stress due to initial fabrication and weld repairs. The intent of the Phase II

effort is to evaluate these parameters based on plant-specific information. The staff and industry project that the results of the Phase II calculations will be available for discussion at the July 11, 2007 full Committee meeting. However, the staff will not have completely evaluated the calculations by the time of the meeting. The industry plans to submit a final report to the NRC with conclusions based on the Phase II calculations by the end of July 2007.

Since the March 8, 2007 meeting with the full Committee, the staff has held several meetings with the industry to discuss preliminary calculation results. One such recent meeting was held on May 31 and June 1, 2007, and the meeting summary and presentation slides are provided as Reference 4. The meeting specifically covered several key technical issues such as: weld residual stress (WRS) modeling, elastic-plastic fracture mechanics (EPFM) vs. limit load analysis, the role of secondary stresses, K-solution verification, finite element modeling convergence, and the industry proposed sensitivity matrix, acceptance criteria, and necessary safety factors. To support the analysis effort, the industry has gathered information regarding all of the nine plants at issue and has determined the ranges of geometries, fabrications, repairs, residual stresses, and mechanical loadings which need to be analyzed. One interesting more recent finding is that for some of the pressurizer nozzle welds, the last welding pass was made to the nozzle inside diameter, which increases the tendency for cracking and crack growth.

The staff and their contractor have developed a calculational model similar to the industry model and plans to perform confirmatory calculations to verify the industry results. The staff is also making estimates of leakage from through-wall cracks predicted by the analysis to verify leakage estimates being made by the industry to demonstrate that detectable leakage would occur prior to pipe rupture. Following the completion of the staff's calculations and review of the industry report, the staff plans to make a finding relative to the industry conclusions by the end of August 2007 to determine if it is acceptable for the nine plants at issue to defer performing inspection and mitigation activities until early 2008.

EXPECTED COMMITTEE ACTION

After reviewing this matter, the Committee may consider providing a report on this matter.

References

1. Letter from W.J. Shack, Chairman ACRS, to L.A. Reyes, EDO, "Proposed NRC Staff and Industry Activities for Addressing Dissimilar Metal Weld Issues Resulting from the Wolf Creek Pressurizer Weld Inspection Results", dated March 22, 2007.
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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
DISSIMILAR METAL WELD ISSUE
July 11, 2007
ROCKVILLE, MD

-PROPOSED SCHEDULE-

Cognizant Staff Engineer: Charles G. Hammer, cgh@nrc.gov (301) 415-7363

| Topics | Presenters | Time |
|---|---|------------------|
| Opening Remarks | W. Shack, ACRS | 10:30 - 10:35 am |
| Background and Status of dissimilar metal weld issue | E. Sullivan, NRR A. Csontos, RES | 10:35 - 10:50 am |
| Industry analysis of dissimilar metal weld flaws | M. Melton, NEI G. White, et al, DEI T. Gilman, et al, SIA C. Martin, et al, Westinghouse | 10:50 - 11:40 am |
| NRC staff evaluation of industry analysis of dissimilar metal weld flaws | E. Sullivan, NRR A. Csontos, RES D. Rudland, EMCC | 11:40 - 12:00 pm |
| Committee Discussion | W. Shack, ACRS | 12:00 - 12:15 pm |

Note

- Presentation time should not exceed 50 percent of the total time allocated for specific items. The remaining 50 percent of the time is reserved for discussion.
- 35 copies of the presentation materials to be provided to the Committee.