

November 6, 2001

U.S. Nuclear Regulatory Commission
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DOCKET 50-255 - LICENSE DPR-20 - PALISADES PLANT

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION REGARDING REPAIR OF CONTROL ROD DRIVE MECHANISM UPPER HOUSING ASSEMBLIES (TAC NO. MB3001)

By letter dated October 16, 2001, the NRC Staff issued the subject request for additional information to the Palisades Plant. The response to the requested information contained in the enclosure to this letter is attached. In addition, the October 16, 2001 letter states that the Staff continues to await our submittal reports detailing the destructive testing and root cause results for CRDM-21. These reports are now complete. The summary root cause remains as stated in the public meeting held between NRC and Palisades on August 1, 2001. It is concluded that the root cause of the through-wall crack at Weld No. 3 of the CRDM-21 location upper housing and the crack indications in the Weld No. 3 locations in other upper housings is attributed to transgranular stress corrosion cracking. The cracking occurred as a result of a susceptible material existing in an enabling chemical environment under adverse stress conditions. These reports will be made available to the NRC Region-III Special Inspection Team actively investigating the upper housing cracking issues at Palisades, as well as to the industry through the Nuclear Energy Institute (NEI).

SUMMARY OF COMMITMENTS

This letter contains no new commitments and one revision to an existing commitment.

The existing commitment, as described in our September 17, 2001 letter, states the following:

In each future refueling outage, until such time as repaired CRDM upper housings are replaced, at least 10% [percent] of those housings for which weld overlay has been applied, but no fewer than 3 CRDM housings, will be inspected. The inspection shall consist of radiographic and ultrasonic testing, at a minimum, to ensure the integrity of the overlay and detect any unexpected crack propagation.

As described in the attached response to item (3) of the request for additional information, we accept the Staff's proposed revision to this commitment. The revised commitment is as follows:

All of the repaired CRDM housings not replaced after one operating cycle will be inspected during the first refueling outage that follows repair. The inspection shall consist of radiographic and ultrasonic testing, as a minimum, to ensure the integrity of the overlay and detect any unexpected crack propagation. A report describing the inspection results and providing an engineering evaluation of those results shall be submitted to the NRC Staff within 60 days after the inspections have been performed. At least 6 months before the start of the next scheduled refueling outage, NMC shall submit, for the NRC's review and approval, a performance-based inspection plan for repaired CRDM housings not replaced.



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Attachment

ATTACHMENT

**NUCLEAR MANAGEMENT COMPANY
PALISADES PLANT
DOCKET 50-255**

November 6, 2001

**Response to Request for Additional Information Regarding Weld Overlay Repair
of Control Rod Drive Mechanism Upper Housings**

7 Pages

REQUEST FOR ADDITIONAL INFORMATION
BY THE OFFICE OF NUCLEAR REACTOR REGULATION REGARDING
WELD OVERLAY REPAIR OF CONTROL ROD DRIVE MECHANISM UPPER
HOUSINGS FOR THE PALISADES PLANT

Requested Item 1.

The NRC staff is concerned for the quality and scope of non-destructive examinations (NDE) completed to date on CRDM housing Weld No. 1 (the first weld above the reactor head). Specifically, the NRC staff is concerned that the ultrasonic testing (UT) examinations completed to date do not provide reasonable assurance that significant cracks, if they exist in this weld, would have been detected. For Weld No. 1 (flange to pipe dissimilar metal weld – 316 stainless steel flange and Inconel pipe), you have conducted UT inspections of [24] accessible housings near the periphery of the vessel head. Because of the curved surface on the flange side of the weld, you were only able to scan from the pipe side during UT examinations. The NRC staff concluded, in Inspection Report 50-255/01-11, that this examination would not likely detect circumferentially oriented cracks in the weld material or flange side base material. This inspection report also documented that UT examinations of Weld No. 3 were not successful in identifying axial or circumferential indications that did not have substantial through-wall extent. Finally, you have not produced a technical basis to exclude Weld No. 1 from being susceptible to the cracking seen at Weld No. 3. Therefore, an adequate basis for the quality and scope of NDE examinations for Weld No. 1 has not been established.

In view of the above NRC staff concern, please indicate and justify your position regarding the quality and scope of NDE completed on Weld No. 1 to date. This discussion should include your basis for not performing an internal visual examination on a sample of CRDM housings at the Weld No. 1 location prior to restart of the plant. Also, provide your basis for the conclusion that you have satisfied the additional examination requirements of ASME Code, Section XI, paragraph IWB-2430(b).

Response

The quality and scope of non-destructive examinations, to ensure a thorough extent of condition is determined and adequate corrective actions are taken, are assured through our corrective action program in accordance with 10CFR50 Appendix B. Although the examinations of Weld No. 1 have no direct relevance to our relief request to use code case N-504-1 to perform a weld overlay repair process for flaw indications on Weld No. 3, we understand the concern expressed by the NRC Staff regarding Weld No. 1 and have provided the additional information below.

QUALITY AND SCOPE OF NDE COMPLETED ON WELD NO. 1 TO DATE

In total, 5 of the Weld No. 1 locations were examined by dye penetrant from the OD surface and 24 were examined by manual UT from the OD, resulting in no flaw indications.

The welds were examined with both surface and volumetric examination techniques. The volumetric exam was a manual ultrasonic (UT) examination-using IGSCC qualified personnel. It was recognized that the UT exams would be limited and that not all of the Code required volume could be obtained due to the geometries involved with each weld. To supplement this examination a surface examination (dye penetrant) of five of the welds was also performed. The surface examination served two purposes, it allowed all of the required weld volume to be examined to satisfy the examination volume requirement and it provided a means to detect any flaws that might be generated from the outside diameter surface.

BASIS FOR NOT PERFORMING AN INTERNAL VISUAL EXAMINATION ON A SAMPLE OF CRDM HOUSINGS AT THE WELD NO. 1 LOCATION PRIOR TO RESTART OF THE PLANT

The basis for not performing an internal visual exam at the Weld No. 1 location prior to startup is based on its low susceptibility to Transgranular Stress Corrosion Cracking – the mechanism determined to be present in the Weld No. 3 cracks. Considering this low susceptibility, the additional radiation exposure and costs that would be incurred are not justified at this time. The low susceptibility is based on the following:

Requirements for Transgranular Stress Corrosion Cracking (TGSCC)

Stress corrosion cracking is a phenomenon that occurs when three concurrent requirements are met: there is a susceptible material such as austenitic stainless steels, there is sufficient tensile stress, and they exist in a suitable environment. There are two typical modes of SCC, transgranular and intergranular. As the names suggest, TGSCC is a cracking mode that goes across the grain, and IGSCC is a cracking mode that tends to favor progression via the grain boundaries. It is important to note that the two modes are not mutually exclusive within a specific failure. TGSCC tends to be caused by impurities such as chlorides in the presence of oxygenated water. As discussed below, the requirements for TGSCC that concurrently existed at Weld No. 3, are not present to nearly the same extent in the Weld No. 1 locations, and therefore, provide the requested basis for not performing additional examinations on CRDM nozzle Weld No. 1 prior to restart of the plant.

Determination of Individual Weld Susceptibility

Material Susceptibility

The CRDM Upper Housing Assemblies are constructed of type 347 stainless steel, and the Weld No. 1 is a bi-metallic weld consisting of the nozzle (alloy 600) welded to a stainless steel (type 316) flange. The weld material is I-82 and I-182. Stainless steel type 316 is slightly more resistant to TGSCC than 347 SS. However, 316 SS is more susceptible to IGSCC than 347 SS. Alloy 600 is more resistant to both TGSCC and IGSCC than either of the stainless steels. With these concessions, 316 SS is considered to be neither better nor worse than 347 SS with respect to susceptibility to SCC.

Tensile Stresses

The stresses in the stainless steel side of Weld No. 1 at the inner surface are, at worst, only slightly tensile, whereas, the other weld stresses are significantly more tensile. There are two major reasons for the substantially lower stresses at Weld No. 1. First the residual stresses are much lower due to the original fabrication process, and second, differential thermal expansion between the stainless steel and Alloy 600 causes compressive forces on the stainless steel. Both axial and hoop stresses were calculated for all of the welds. The determination of operating stresses was a definite calculation, whereas the determination of residual stresses was based on industry data for butt welds, adjusted for the specific manufacturing process used. The inside and outside portions of the CRD nozzle/flange assembly were machined to remove about 50% (~18% of material removed from the ID) of the walls after welding which removed much of the residual tensile stress from the welding process that reside near the surfaces. The residual stresses in both the axial and hoop orientations were both determined to be on the order of 6 ksi tensile. The operating stresses for the axial and hoop orientations were calculated to be approximately 4 ksi compressive and 7 ksi compressive, respectively. The sum of the operating and the residual stresses in the vicinity of Weld No. 1 were 2 ksi tensile for the axial stress and 1 ksi compressive for the hoop stress. The resultant stresses at Weld No. 1 are more than 30 ksi lower than those calculated for Weld No. 3.

Surface condition from the manufacturing process also plays an important role. Although the specified surface finish for all machined surfaces within the upper housing was 125 RMS, this surface finish requirement was specifically waived for locally ground/blended weld areas (such as Welds No. 3). Since Weld No. 3 is located between an eccentric reducer and a long pipe section, this weld would have been the most difficult to post-weld blend due to the design geometry. Visual examinations found the ID of Weld No. 3 heavily ground in a non-uniform manner. This grinding was most likely conducted from the narrow opening of the eccentric reducer (~4 inch diameter), which is about six linear inches from the grinding location. This would have resulted in significantly limited access and visibility for grinding. In contrast, Weld No. 1 was simply machined on both the ID and the OD, with no waiver to allow grinding as was done on Weld No. 3. The

final machining on the ID surface would result in only a thin cold worked layer in the material at Weld No. 1. This contrasts with the abusive grinding process used at Weld No. 3, which resulted in considerably higher surface stresses from the cold work, which extend to a greater depth in the material. The smoother surface finish at Weld No. 1 also indicates an absence of the local stress risers and surface crevices that served as crack initiation sites at Weld No. 3.

Enabling Environment

The most significant variables for an enabling environment for TGSCC are the oxygen and chloride concentrations, with higher levels resulting in greater likelihood of TGSCC occurrence. The environmental conditions are assumed to be similar with respect to O₂ and Cl⁻ concentrations for all welds with the exception of Weld No. 1. The environmental conditions at Weld No. 1 are expected to be more representative of PCS bulk water chemistry than the other welds in the CRD upper housings.

Although one might consider the annulus between the thermal sleeve and the CRD nozzle to be a geometric crevice, conditions exist which should reduce the amount of residual dissolved oxygen that might be present. With the presence of sufficient flow, geometrical crevices are effectively precluded from becoming galvanic crevices and therefore do not exacerbate the SCC process.

Three ¼ inch diameter flow holes exist within each CRDM nozzle tube assembly. They are located about 13 inches from the inside of the reactor head. Due to the presence of the upper guide structure between the fuel and the nozzle tube ends, a portion of the reactor coolant flow proceeds upward into the nozzle tube assemblies and out of the three ¼ inch diameter flow holes. In addition to this, a temperature gradient exists between the inside of the thick vessel head and Weld No. 1. This temperature gradient should promote some convective flow within the annulus surrounding the thermal sleeve as would occur in any environment where a temperature gradient exists.

Although the flow between the two scenarios is limited, it is reasonable to conclude that fluid exchange occurs at some rate within the annulus, causing residual oxygen (from vessel fill) to be lessened within the annulus. This conclusion is supported by the occurrence of Primary Water Stress Corrosion Cracking (PWSCC) observed in other pressurized water reactors in this same general area ("J" weld area) as discussed in Generic Letter 97-01. This operating experience supports the notion that the environment in this area may be devoid of oxygen content because PWSCC occurs in oxygen-depleted environments.

The reason for considering the environment at Weld No. 1 different than the environments at the other welds is because there is no viable mechanism to exchange the water contained within the upper housing with PCS bulk water.

The above mechanism facilitates some flushing of the annulus with water that has the chemistry characteristics of the bulk PCS water.

Weld No. 1 is considered the least susceptible weld because:

- The combined stresses are at worst, only slightly tensile due to the fact that the higher residual stress material near the surface was removed after welding as part of the manufacturing process and due to the different thermal expansion properties between the stainless and the Inconel.
- The material surface is smooth and was exposed to much less cold work since the part was machined.
- The environment is not as stagnate as the other weld locations, and there exists a mechanism to dilute the oxygen concentration.

BASIS FOR THE CONCLUSION THAT THE ADDITIONAL EXAMINATION REQUIREMENTS OF ASME CODE, SECTION XI, PARAGRAPH IWB-2430(b) HAVE BEEN SATISFIED.

Subparagraph IWB-2430(b) reads, "If the additional examinations required by (a) above reveal indications exceeding the acceptance standards of Table IWB-3410-1, the examination shall be further extended to include additional examinations at this outage. The additional examinations shall include all the welds, areas, or parts of similar design, size, and function."

Based on this requirement, it was determined that the scope of the additional examinations would be limited to Weld No. 3. This is because failures have been limited to Weld No. 3, with its specific vulnerabilities as described previously, and Weld No. 1 is not of a similar design and size, and contains different stress profiles.

Requested Item 2.

Describe the qualified NDE inspections, using UT and radiographic test (RT) as a minimum, that will be performed to establish a baseline for future inspections of the flaws in the repaired welds after completion of the weld overlay repairs and prior to the restart of the plant.

Response

The weld overlaid at weld number three will receive:

- a. A dye penetrant, surface examination. Acceptance criteria provided by IWB-3514-2.
- b. A radiograph that satisfies the requirements of ASME Section V, Article 2. The results of the radiography will be compared to radiography results that were obtained prior to welding to verify that the cracking has not increased.
- c. Ultrasonic examination of the outer 25% of the CRDM housing underlying pipe

wall and the entire weld overlay. Examination personnel will be qualified to ASME Section XI, Appendix VIII, Supplement 11 – Qualification Requirements For Full Structural Overlaid Wrought Austenitic Piping Welds. Acceptance criteria shall be in accordance with Table IWB-3514-2.

Requested Item 3.

The NRC staff has requested a revision to the commitment made in our September 17, 2001 letter.

Response

We accept the propose revision to the commitment as stated by the Staff. The existing and revised commitment is provided in the “Summary of Commitments” section contained in this transmittal letter.

Requested Item 4.

The NRC staff is concerned that cracks may occur in welds in repaired CRDM upper housings other than at the Weld No. 3 site during future operation. The existing inspection requirements of the ASME Code, Section XI, for vessel components may not provide for timely detection of the onset of cracking such as has recently been experienced at Palisades Weld No. 3 and earlier at Ft. Calhoun in the weld buildup area (Weld No. 5). Please describe your future inspection plans for all welds and the weld buildup area in the repaired Palisades CRDM upper housings.

Response

The following examinations will be performed on welds on repaired housings other than weld number 3 during future examinations to confirm that new cracking has not occurred as a result of the weld overlay or from additional time in service:

Weld number(s) 1 (Pipe to Flange), 2 (Flange to Reducer), 4 (Pipe to Flange) and 5 (Weld Build-Up) will receive an Ultrasonic Examination and a Bare Metal Visual Examination.

Weld number 2 will also receive a Radiographic Examination.

Evaluation for acceptability will be based on the requirements of ASME Section XI, Paragraph IWB-3523.