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Operating Reactor Branch No 5
Nuclear Reactor Regulation
US Nuclear Regulatory Commission
Washington, DC 20555

DOCKET 50-255 - LICENSE DPR-20 -
PALISADES PLANT - RESPONSES TO NRC PALISADES STEAM GENERATOR CONCERNS

In response to the NRC request at the April 10, 1984 Palisades Steam Generator Tube Plugging Meeting to provide additional written response to identified concerns, Consumers Power Company is providing the following information.

COMMENT A-1

Burst pressure data for uniformly thinned tubes obtained by Battelle - Pacific Northwest Laboratory and Combustion Engineering indicates that variation in burst pressures can be from 1200 psi to 6000 psi for tubes thinned to a 15-20 percent remaining wall thickness. The data presented by Westinghouse does not seem to include all data points. A 95/95 lower tolerance limit established after inclusion of all data points would predict lower burst pressures for steamline break (SLB) and would impact the proposed plugging limit. Provide a clarification of this apparent discrepancy.

RESPONSE TO COMMENT A-1

A discussion was held on April 13, 1984 with a member of the NRC Branch to clarify the data quoted in the NRC comment. It was concluded that the data cited by the NRC was burst data for axially slotted tubes reported in NUREG/CR-0718. As discussed, the data is not applicable for comparison to the plugging limit curves presented for the Palisades steam generators. It was noted, based on information presented in the referenced document, that the data exhibited considerable scatter. This was attributed to potential variations in the slot configurations and in the slot depths possibly not being as reported. Based on this discussion the comment is considered to be resolved.

COMMENT A-2

The bending stresses due to the rotation of the tubesheet, flow induced vibration, and thermal growth mismatch between tube and shell have not been addressed for normal operation and accident conditions. The failure analysis

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of defects with limited circumferential and axial extent should take these stresses into account.

RESPONSE TO COMMENT A-2

As stated in Section 4.0 of the Palisades Steam Generator Evaluation and Report Report, stresses in degraded tubes are considered secondary. This is due to either: 1) bending moments at the degradation locations are not necessary to satisfy equilibrium equations, or 2) deformation of degraded tubes is limited by the tube bundle. The report further notes that the ultimate limit moment carrying capability for the axially limited degraded tube is higher than the ultimate limit moment capability of a tube uniformly thinned to 64%. Since the axial strength of the limited degraded tube has been demonstrated to be the same as the 64% uniformly degraded tube, and the ultimate limit moment is higher, then the primary membrane plus primary bending capability of the limited degraded tube is higher than that for the uniformly thinned tube. Since this strength exceeds the strength of a tube with uniform degradation depth at the plugging limit, further analysis is considered unnecessary.

COMMENT A-3

Verify that the loads on steam generator tubes during a LOCA are the same as presented earlier on February 2, 1984 and contained in CE Report NP-2652 - November 1982.

RESPONSE TO COMMENT A-3

The loads used for the LOCA analysis are the same as presented at the February 2, 1984 meeting. The EPRI Report, NP-2652 - November 1982, was used to verify the CEFLASH computer code, and as a basis for the latest LOCA analysis.

COMMENT A-4

It is not clear what stress concentration factor has been used for circumferential cracks and limited axial extent defects in the fatigue evaluation.

RESPONSE TO COMMENT A-4

As stated in Section 4 of the Palisades Steam Generator Repair Report, a stress concentration factor of 5.9 can be tolerated prior to the fatigue usage factor exceeding 1, based on a 40 year design life of the Palisades plant. For the limited axial extent defects, the maximum stress concentration factor required for evaluation by the ASME Code is 5.0.

Since this is less than the tolerable factor, a detailed fatigue analysis is not necessary. Considering the defects as crack like, the plugging margin report demonstrates that leak before break will occur and that expected fatigue crack growth is small.

COMMENT A-5

The methodology used to modify the relations to account for limited axial and azimuthal extent defects is not rigorous and it is not clear how it would be applicable to circumferential cracks.

RESPONSE TO COMMENT A-5

Section 4 of the Palisades Steam Generator Repair Report provides a rigorous explanation of the methodology used to modify the relations to account for the limited axial and azimuthal extent of the defects. Based on the possibility of uncertainties in the characterization of the morphology of the defects, the plugging limit evaluation was performed for both defects of limited axial and circumferential extent, and for cracks. For defects of limited but finite axial extent the plugging limit curve presented is applicable to 360° thinning. The evaluation demonstrates that for a through wall crack the criteria is limited to an azimuthal extent of 145° to meet a safety factor of 3 on burst at normal operating pressure, and 187° for burst at a postulated SLB differential pressure of 2150 psi.

COMMENT A-6

The end conditions and plastic instability model indicated on the plot of normalized burst pressure versus normalized half crack length needs explanation.

RESPONSE TO COMMENT A-6

For the plastic instability calculations, the end conditions of the tube are assumed to be free, i.e., no bending restraint. The end conditions referenced on the plot of normalized burst pressure versus normalized half crack length apply to the conditions under which circumferentially cracked tubes were burst tested. This is discussed in detail in Section 4 of the Palisades Return to Power report.

COMMENT B-1

Provide a tabulated summary of all the primary to secondary leakage history to date (including those leak rates below the Technical Specification Limit) going back to before the 1984 tube leak.

RESPONSE TO COMMENT B-1

Attached is a graph of the primary to secondary steam generator tube leakage since 1975. Data for 1974 (two months in operation) is not readily available. The data indicates the existance of a low level leakage in the steam generators ever since 1974.

COMMENT B-2

Provide a tabulation of the total population of eddy current indication deleted during the current outage giving the depth magnitude in steps of 10% of wall thickness and the tube location and elevation of indication along the tube.

RESPONSE TO COMMENT B-2

A table of the total population of eddy current indications is included in Section 3.2.9 of the Palisades Steam Generator Repair Report. It should be emphasized that this is a composite of all types of indications (i.e., wastage as well as IGA.)

COMMENT B-3

Provide a steam generator tube map for this inspection, for all indications detected, noting removed, and previously plugged tubes.

RESPONSE TO COMMENT B-3

Steam generators maps of every support plate for each S/G leg are attached. These maps include all indications greater than or equal to 30%, cracks and also a specific symbol for tube intersections which were metallurgically examined. (Note this would not identify intersections removed but not sectioned).

COMMENT B-4

Provide a discussion of the differences in the September 1983 "In Generator" and the "Out of Generator" ECT Measurements on B&W Tubes Nos 16, 18, 63, 65, 85, and 97. (Reference to Table in "Failure Analysis" hand out.)

RESPONSE TO COMMENT B-4

Each tube support intersection which was removed and subsequently metallurgically sectioned has three eddy current results. The first call is that which resulted from the data collected in the fall of 1983. This data was also interpreted in the fall of 1983 without the aid of an interpretation standard or a qualified interpretation curve. This was considered to be preliminary data.

Prior to metallurgical sectioning, two additional calls were recorded. One call was a reevaluation of the in-generator collected data (same data evaluated above) and was now interpreted based on a modified calibration curve and standard which reflected the results of the inspections performed on the fabricated IGA samples. The other call was from data collected on the intersection after removal from the steam generators. This interpretation was performed also using the same modified calibration curve and standard as mentioned above. The latter two ET results were both obtained just prior to starting the metallurgical evaluation of the intersections. The table containing these results (see Steam Generator Repair Report - Table 2.4) has been changed to reflect the different readings.

COMMENT B-5

With respect to non-leaking tubes reported to have 100 percent through wall penetration such as B&W Nos. 72 and 63, explain how these findings are consistent with leak before break and how high a leakage rate one would expect under postulated accident conditions.

RESPONSE TO COMMENT B-5

All throughwall defects are believed to have been leaking during operation (see response to Comment B-1). One of the throughwall defects, B&W No 63, was selected for detailed microchemistry analysis. The defect was mechanically opened and the exposed IGA face was examined by Secondary Ion Mass Spectroscopy (SIMS) using Oxygen Ion Sputtering. The SIMS analysis indicated the presence of Sulfur Dioxide, Phosphorus, Sodium, Boron and Lithium along the fracture surface. The Lithium and Boron deposits are the result of chemical additivies to the primary plant, whose presence indicates the existance of primary to secondary system leakage.

The leak before break covers cracks through the wall such that leakage at operating conditions would exceed the technical specification leak rate prior to the crack being of such size that burst would result during steam line break (SLB). As such leak rate testing is usually not performed to quantify leakage rates at SLB pressures and an accurate estimate of the leak rate for the referenced Paliades tubes under SLB conditions are not available. The physical dimensions of the flaws as determined metallographically were such that burst at SLB should not occur.

The metallographic examination revealed the size of the through wall portion of the defect was very small (see Table 2.5 in 1983/1984 Steam Generator Evaluation and Repair Report). Thus, additional growth, if necessary to achieve a leak rate on the order of the technical specification limit, could be tolerated without achieving a size which would result in burst during a postulated SLB.

COMMENT B-6

Provide the fabrication history of the steam generator tubes with respect to the 90° bends in the U-bend region.

RESPONSE TO COMMENT B-6

Consumers Power Company has attempted (in 1974 and in 1984) to obtain the fabrication history of the tubes (both pre-and post-fabrication) without success. We have contacted the original tubing vendors, the steam generator vendor (Combustion Engineering) and reviewed our company files without success. This information (desirable to Consumers Power Company) is not available. We do not, however, believe that this information is crucial to a decision on how to repair the steam generators. We know the strength, hardness and micro structure of the tubing. We do not know the exact nature of possible residual stresses, however, based upon 10 years predictable operation and currently postulated mechanisms we do not think this lack of knowledge seriously affects our conclusions.

COMMENT C-1

Thermalmechanical history of the steam generator tubes before and after fabrication of the steam generators.

RESPONSE TO COMMENT C-1

See Response to Comment B-6.

COMMENT C-2

Location and distribution of the degraded steam generator tubes.

RESPONSE TO COMMENT C-2

Attachment N of the Palisades Steam Generator Repair Report contains tube support plate elevation maps detailing XX, and quantifiable XS indications above 50% through wall.

COMMENT C-3

Determination of causative agent(s) and the damage scenario.

RESPONSE TO COMMENT C-3

Section 2.4 of the Palisades Steam Generator Repair Report discusses the causative agents and the damage scenario.

COMMENT C-4

Laboratory tests which substantiate the proposed damage scenario and corrosion mechanism(s).

RESPONSE TO COMMENT C-4

Tests performed to produce ET laboratory standards produced corrosion similar to that observed on the removed tube examination. This process is discussed in section 3.4 of the Palisades Steam Generator Repair Report.

COMMENT C-5

Metallurgical examination results and the steam generator tube thermal-mechanical history which demonstrate the cracking at the 90-degree bends was IGA and not IGSCC.

RESPONSE TO COMMENT C-5

No 90-degree bend samples with 4C4F XX indications were removed from the steam generator. Use of the 4C4F ET probe results in the designation of these defects signals as cracks. Given the observed morphology of the cracklike defects which were removed from other areas in the steam generators and the similarity of the defect signals we have no reason to believe that the cracks in the 90° bend are any different from the ones removed from the generator. However, all such defects will be plugged.

COMMENT C-6

Inspection results or other information which show that the remainder of the secondary system does not suffer the same type of degradation observed on the steam generator tubes.

RESPONSE TO COMMENT C-6

No other portions of the Palisades secondary system (safety related or otherwise) contain inconel 600 tubing. In addition, we have observed no (sulfur related) corrosion failures of secondary components since the switch to all volatile chemistry control in 1975.

COMMENT C-7

Test results or analysis which provide reasonable assurance that the steam generator tube degradation have been stopped, the cracks were arrested, the contaminant(s) were removed.

RESPONSE TO COMMENT C-7

Section 3.3 of the Palisades Steam Generator Repair Report discusses corrosion rate. The contaminant (sulfur) has not been removed (similarly it was not removed from TMI-1 or ANO-1). The sulfur is rendered innocuous through rigorous application of the plant chemistry program.

COMMENT C-8

Procedures and administrative controls which will be implemented to prevent reintroduction of contaminant(s).

RESPONSE TO COMMENT C-8

The use of sodium sulfite for oxygen scavenging in the steam generator was discontinued in 1973. The current secondary chemistry control program is provided in Attachment M of the Palisades Steam Generator Repair Report. No procedural changes are anticipated.

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Attachments