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Subject: Toledo Edison's Response to NRC's Request For Additional Information Concerning Bulletin Number 88-11: Pressurizer Surge Line Thermal Stratification (TAC Number 72128)

Gentlemen:

Toledo Edison's (TE) November 6, 1989 submittal (Serial Number 1729) formally docketed Babcock and Wilcox Owner's Group (B&WOG) responses to NRC questions developed during the review of B&WOG Report BAW-2085. TE's June 2, 1989, submittal (Serial Number 1671), transmitted the response to paragraph 1.b of the subject Bulletin. The response to paragraph 1.b included B&WOG's Report BAW-2085. As preliminary analyses indicated that the surge lines may not meet the applicable design codes for the licensed life of the plant, TE also submitted (Serial Number 1671) a Justification for Continued Operation (JCO) through January 2, 1991. TE's initial response, dated March 3, 1989 (Serial Number 1633) provided the results of a visual inspection as requested in paragraph 1.a of the subject Bulletin. NRC's letter dated February 14, 1990 (Log Number 3168) requested additional information concerning Toledo Edison's June 2, 1989 submittal on pressurizer surge line (PSL) thermal stratification, JCO. The purpose of this letter is to provide Toledo Edison's responses to the request for additional information.

Toledo Edison initiated the Phase I program for Surge Line Thermal Stratification to determine the condition of the Davis-Besse pressurizer surge line, the additional effects of deflections and radial gradient stresses caused by thermal stratification events, and to estimate the remaining fatigue life. Toledo Edison's June 2, 1989 submittal provided the report for this effort to the NRC.

As described in the Toledo Edison report, the process employed in the evaluation was as follows:

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1. Based upon reviews of Davis-Besse operation, the adjusted stratification temperature ranges were defined from Muelheim-Kaerlich data for the various points in the heatup and cooldown at which significant stratification transients might be expected.

2. A sensitivity study was performed. Based upon a range of assumed stratification conditions, the resulting deflection, moments and stresses for each identified condition were evaluated.

3. Considering information identified in the sensitivity study, some surge line whip restraint gaps were modified as a precautionary measure to ensure free movement of the surge line.

4. Specific thermal stratification load cases were selected from the sensitivity analysis as being a realistic and conservative basis for evaluation of fatigue effects.

5. The surge line was instrumented with lanyard potentiometers, and deflection data were acquired during the heatup for the 6th Fuel Cycle to validate the load cases. The deflections measured were substantially less than the calculated deflection for the load cases used in the fatigue analysis, which provided confidence that the model used to calculate the deflections for fatigue analysis in the Phase I Program was conservative.

In preparing for the 7th Fuel Cycle, Toledo Edison is instrumenting the surge line with both thermocouples and displacement monitors. Data will be acquired throughout the heatup in order to characterize both the thermal stratification conditions and the resulting deflection of the surge line. The scope of the instrumentation includes approximately 50 thermocouples and 14 displacement monitors. Thus, both thermal and deflection transients will be quantified, providing the necessary information for a thorough evaluation and for revision of the ASME Code Stress Report in compliance with Part 1-d of the NRC Bulletin 88-11, as committed in Toledo Edison's June 2, 1989 submittal.

Toledo Edison's individual responses were prepared based on the process described above for the Phase I Program and are provided in the attachment.

If you have any questions concerning this matter, please contact Mr. R. W. Schrauder, Manager - Nuclear Licensing, at (419) 249-2366.

Very truly yours,

DC Shelton

RTH/ssg

cc: P. M. Byron, DB-1 NRC Resident Inspector
A. B. Davis, Regional Administrator, NRC Region III
T. V. Wambach, DB-1 NRC Project Manager

RESPONSE TO NRC BULLETIN 88-11

PRESSURIZER SURGE LINE THERMAL STRATIFICATION

FOR

DAVIS-BESSE NUCLEAR POWER STATION

UNIT NUMBER 1

This letter is submitted in conformance with Atomic Energy Act of 1954 Section 182a, in response to NRC Bulletin 88-11 Pressurizer Surge Line Stratification.

For: D. C. Shelton
Vice President Nuclear

By: [signature]
T. J. Myers, Technical Services Director

Sworn and subcribed before me this 20th day of April, 1990

[signature]
Notary Public, State of Ohio

JUDITH HIRSCH
Notary Public State Of Ohio
My Commission Expires June 30, 1992

ATTACHMENT

RESPONSES TO INDIVIDUAL QUESTIONS

PRESSURIZER SURGE LINE (PSL) THERMAL STRATIFICATION JCO

Section III-A, NRC Question 1

"A visual examination of the PSL during cold condition indicated that a deflection shape characterized as concave downward was noted when the pipe was sighted axially. Where is this attributed since no stratification is present during cold condition?"

TE Response

Toledo Edison concluded the observed deflection in the surge line during cold shutdown during the 5th refueling outage to be the result of a possible permanent deformation that occurred early in the plant life as there was no thermal stratification present at the time of the visual examination.

Section III-D, NRC Question 1

"Was any operability study performed with the snubber PSU-R1 removed from the analysis? What are the results at critical locations when compared to the original analysis?"

TE Response

Toledo Edison performed an operability analysis which was conducted in December, 1985. In the analysis, the broken snubber, one of two utilized in parallel on PSU-R1, was considered to be removed. The operability analysis was done at the most highly stressed point of the surge line, which was very close to the failed snubber. The resulting stress was found to be within Davis-Besse's interim design allowables as referenced in the Davis-Besse Design Criteria Manual and used for NRC Bulletin 79-14.

Section III-D, NRC Question 2

"Page 8 indicates that "errors of the same order of magnitude as the observed measurement changes are both possible and likely." How can this review be conclusive that no permanent deformation of the surge line occurred?"

TE Response

The discussion on page 8 of the Phase I report refers to a level of uncertainty of approximately 1/4 inch in the measurements taken in the past. Toledo Edison has studied the changes in the gap measurements, and concluded that the measurements since 1982 did not indicate a process of continuing deformation. The amount of clearance on both sides of the surge line (restraint gap plus pipe-to-wall clearance) is adequate to accommodate

the stratification deflections. Additionally the lanyard potentiometer measurements found no indication of interferences due to stratification transients which occurred during heatup for the 6th Fuel Cycle.

Section III-E, NRC Question 1

"It appears that the M-K plots for temperature and pressure were adjusted from the operational point of view only. What other adjustments if any were made to account for the surge line differences (i.e. pipe wall thickness, thermocouples are measuring outside and not inside temperatures)."

TE Response

The approach taken was to bound the range of possible top-to-bottom temperature differences by adjusting the maximum top-to-bottom stratification transients found by Muelheim-Kaerlich (M-K) to the conditions possible at Davis-Besse considering defined operating limits. In this manner the experience of M-K formed the basis for the sensitivity study of stress and deflection due to stratification. The surge lines at both M-K and Davis-Besse are heavily insulated. Top and bottom temperatures taken from outside the piping in a quasi-steady state condition such as the slow thermal stratification transients would not differ significantly from the respective pipe inside wall temperatures. No adjustment to the M-K data were considered necessary to accommodate inside/outside temperature differences. Geometric differences from M-K such as line configuration and wall thickness were considered in the range of calculated deflections.

Section III-F, NRC Question 1

"What are the results of percent measured versus calculated values at critical locations?"

TE Response

Table 9 in the Toledo Edison Phase 1 report provides the values for the measured and calculated deflections at various points along the surge line. This permits comparison of the measured deflections against the calculated values for the two largest stratification transients measured.

Percentage comparisons between calculated and measured deflection are not direct equivalents of the relative stress levels but do provide some indication of the available margin. Lacking measurements of surge line temperature distribution during the transients, the plots of deflections shown in Figures 15 through 19 effectively illustrate margins between measured and calculated conditions. Figures 15 and 16 in the report show the measured and calculated values respectively for the largest stratification transient occurring early in the heatup. Figures 18 and 19 show results for the largest transient occurring later in the heatup.

The acquisition of detailed temperature and deflection data from the fully instrumented surge line during the heatup for the 7th Fuel Cycle will offer more accurate means for evaluation. This data will be included in the surge lines stress and fatigue analyses as committed in Toledo Edison's June 2, 1989 submittal.

Section III-F, NRC Question 2

"Why were cases 20 through 28 only used for comparison of the analytical results vs measured displacements and not cases 1 through 19 ?"

TE Response

The more important cases for comparison between measured displacements and analytical results have been selected from Load Cases 1 through 19. As discussed in the response to Section III-G, NRC Question 1, Load Cases 11, 13B and 14 were selected as basis for the fatigue analysis from the sensitivity study comprising Load Cases 1 through 19. Comparison of the deflections predicted from these load cases with the measured deflections is the most direct means of estimating conservatism in the fatigue analysis.

Load Cases 20 through 28 were defined after deflection measurements in the heatup were obtained in an effort to reproduce the observed deflections through analysis using an estimated temperature distribution corresponding to the observed thermal transients. Lacking accurate temperature measurements on the surge line during the stratification transients, these calculations produced only rough approximations of the deflections.

Table 9 in the Phase I report presents comparative deflection data derived from measured stratification transients and corresponding analytical results. Analytical results from Load Cases 11, 13B and 14 are shown as well as for Load Case 22.

Section III-F, NRC Question 3

"How was the effect of the broken piston of snubber PSU-R1 evaluated?"

TE Response

See Section III-D, NRC Question 1 response.

Section III-G, NRC Question 1

"What is the justification for Cases 11, 13B, and 14 to be the most conservative cases to be used in the fatigue evaluation?"

TE Response

As discussed in the Phase I report (Section III-E, page 11), a temperature matrix of 19 load cases was constructed for a sensitivity study of surge line thermal stratification. Load Cases 11, 13B and 14 from Group 2, were based

upon the observed data from M-K. Upper bounds of the temperature transients were developed from the M-K data considering Davis-Besse procedural limits.

The fatigue analysis was undertaken based upon Load Cases 11, 13B and 14 on the basis that these cases provide a conservative, and most realistic basis for the evaluation. Deflection measurements of the surge line were taken during the plant heatup, from the 5th Refueling Outage (6th Fuel Cycle). The evaluation of the measurements indicated that the deflections remained well within the predicted ranges, substantiating the conservatism in the selected load cases.

The other sets of stratification conditions (Group 1 and Group 3) considered in the Matrix were considered less realistic.

As described in the Phase I report, Group 1 consists of conditions based upon an assumption that the top-to-bottom temperature difference would be bounded by the hot leg and pressurizer temperatures. While this is of interest in that it provides some information on smaller temperature differentials, these stratification conditions differ significantly from conditions expected at Davis-Besse and were considered unrealistic for application in the fatigue evaluation.

Group 3 was established to determine effects of potentially larger temperature differentials. The assumed larger temperature differential were evaluated to be excessive when compared against actual temperature differentials observed during the heatup from the 5th Refueling Outage.

Section III-G, NRC Question 2

"How was it determined that some plastic deformation of the surge line occurred by two separate occasions early in the plant life?"

TE Response

Toledo Edison took measurements of restraint gaps in 1980, 1982, and the fifth refueling outage. An out-of-tolerance conditions found during whip restraint gap measurements taken in 1980 is an indication that a single case of plastic deformation may have occurred. There is no clear evidence that another instance of plastic deformation occurred, however, two instances were assumed in the fatigue evaluation for conservatism (Note there was a single adjustment in some of the whip restraint gap settings in 1982). There has been no indication of significant change in these gaps thereafter, leading to the conclusion that the change caused no interaction between the surge line and the restraints. The measurements of deflections taken during the heatup following the 5th Refueling Outage gave no indication of any interference with restraints due to the stratification transients.

Section III-H, NRC Question 1

"How will the final temperature profile (axial, circumferential) be developed for the final analysis?"

TE Response

Toledo Edison is participating with the other members of the B&W Owner's Group in a program evaluating the processes occurring in the pressurizer surge line during thermal stratification transients. The surge line of Davis-Besse Unit 1 is being instrumented during the 6th Refueling Outage with both thermocouples and deflection monitors. The information gained during the heatup for the 7th Fuel Cycle will permit plant specific measurement of stratification temperature profiles on the outside surface of the piping. Correlations developed as part of the Owner's Group program will be used for the conservative definition of temperature profiles affecting the interior of the surge line.

Section III-H, NRC Question 2

"How was the temperature profile (axial, circumferential) developed for this JCO report? It appears that only one thermocouple was used. How was the temperature profile determined at other locations?"

TE Response

As stated in the last paragraph of Section III-H, Page 17 of the Phase I report, the surge line temperature indicator is very valuable for identifying trends and stratification events, however, it was not considered reliable for accurate measurement of surface temperature due to lack of instrument calibration.

The temperature profiles were defined using the adjusted M-K data. It was assumed that the lower horizontal run of piping was subjected to the full top-to-bottom temperature stratification transients. The upper horizontal run was assumed to be unstratified at the hot leg temperature. No stratification was assumed for the vertical run.

Table 2, NRC Question 1

"What is the justification for exceeding Code interaction ratio of 1.0 (~1.09) even when the Sm value is adjusted upwards to consider actual CMTR properties?"

TE Response

As stated in the enclosure to the Toledo Edison letter dated June 2, 1989 (Serial Number 1671), Load Cases 11, 13B and 14 are conservative cases derived from M-K data. The data was used to evaluate the fatigue effects from stratification. The three load cases showed interaction ratios of 0.62, 0.81 and 0.71 respectively. The other load cases were included in the table for reference purposes only.

Code qualification of the surge line remains to be completed, and as committed in the Toledo Edison letter dated June 2, 1989, Toledo Edison will update the surge line stress and fatigue analyses to ensure compliance with applicable codes and regulatory commitments in conformance with request 1.d of NRC Bulletin 88-11.

Table 3, NRC Question 1

"SL5 and SL6 show a progressive decrease in gaps. Where is this attributed?"

TE Response

Toledo Edison took measurements of restraint gaps in 1980, 1982, and the 5th Refueling Outage. No definitive cause was determined for the anomalous motion in the direction indicated by these measurements apart from a possible error in an initial measurement taken in 1980. Careful review of the clearance with the wall at the positions opposite the motion implied by the recorded restraint gap change indicated that sufficient margins for deflections exist and that interferences would not occur. Similarly, deflection measurements made during the heatup following the 5th Refueling Outage showed no interference.

Table 5, NRC Question 1

"How were the additional four heatup/cooldown values calculated? Does the total value include striping effects? If not, what is the impact?"

TE Response

Table 5 of Toledo Edison's June 2, 1989 submittal summarizes the results of the fatigue evaluation for several significant locations along the surge line. In this table, the column entitled "TO END CYCLE 5" contains the cumulative usage factors from the stress reports (covering the total lifetime 240 Heatup/Cooldown (HU/CD) cycles without any thermal stratification) as well as the thermal stratification effects from the first 36 cycles of plant life as noted in Table 7.

Column entitled, "ADD FOUR HTUP/CLDNS" contains the thermal stratification effects from the next 4 heatup and cooldown cycles including the Operating Basis Earthquake (OBE) stresses. The thermal stratification effects for each one of these four HU/CD cycles consider the same number of stratification cycles per HU/CD as noted in Table 7. These cycles were added in order to provide margin to cover the heatup and cooldown events which might conceivably occur between the time of this analysis and the beginning of Fuel Cycle 7.

The most critical locations are the hot-leg/surge-line nozzle and the pressurizer nozzle. Thermal striping does not occur at these two locations. The fatigue results in Table 5 include conservative thermal radial gradient stresses which were intended to envelope the striping effects. These conservative stresses envelope the actual striping values when comparing the Oconee bounding fatigue and the Oconee actual fatigue considering the temperature measurements.

Table 7, NRC Question 1

"How were the plastic deformation effects incorporated into the PSL evaluation?"

TE Response

The plastic deformation effects are incorporated in the surge line fatigue evaluation by considering (for two fuel cycles) the stress range due to thermal stratification as two times the actual yield stress.

Table 8, NRC Question 1

"How are these stresses related to table 2?"

TE Response

Both the values in Table 2 and Table 8 are consistent outputs of the same analysis. The stress values listed in Table 2 represent the elastic-plastic discontinuity effects (USAS B31.7, Section I-705, Equation 12) to provide a determination of stresses in the line without fatigue consideration. Stress values in Table 8 represent the principal stress intensities.

The stress values given in both Table 2 and Table 8 are not considered in the surge line fatigue evaluations performed by Babcox & Wilcox. The fatigue values are derived from the moments listed in Table 8.

Table 8, NRC Question 2

"Why were the O.D. and wall thickness of the pressurizer nozzle and hot leg nozzle assumed? What are the actual values?"

TE Response

The exact outside diameter (O.D.) and wall thickness of the nozzles were not available to Impell Corporation who performed the analysis at the time of the stratification moment, stress and deflection evaluations.

The actual dimensions for the pressurizer and hot leg nozzles are 10.875 inch O.D. with 1.275 inch minimum wall thickness, and 12 inch O.D. with 1.44 inch wall thickness, respectively. These nozzles were modeled as rigid elements compared to the surge line, therefore, these dimensions do not diminish the conservatism of the results obtained. The fatigue analysis later performed by Toledo Edison conservatively used the moments from Impell's analysis and considered the actual nozzle configuration.