TU ELECTRIC

Log # TXX-88550
File # 903.1 clo
903.6
Ref .# 10CFR50.4(a)

July 8, 1988

William G. Counsil
Executive Vice President

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D. C. 20555

SUBJECT: COMANCHE PEAK STEAM ELECTRIC STATION (CPSES)
DOCKET NO. 50-445
APPLICATION OF LEAK-BEFORE-BREAK
METHODOLOGY TO BRANCH LINES

Gentlemen:

On April 15, 1988, TU Electric submitted to you by our letter logged TXX-88382 ten (10) copies of the Leak-Before-Break (LBB) "CPSES-1 WHIPJET Program Report" for your review. As a result of your review, a telephone conference call was held on June 22, 1988, among representatives of the NRC staff, TU Electric Licensing and Engineering, and Robert L. Cloud Associates (RLCA), Inc. to discuss the results presented in the CPSES-1 WHIPJET Report. The NRC Staff representatives requested that TU Electric perform the following six action items to enable the Staff to complete its review.

1. The 14-inch pressurizer surge line high stress location occurs at the loop nozzle safe end weld when torsion is included with the bending moments. When torsion is excluded, the high stress location occurs at the opposite end of the surge line, i.e., the pressurizer nozzle safe end weld. The CPSES-1 WHIPJET report provides LBB analysis results for the loop nozzle safe end weld, but the NRC staff requested the pressurizer nozzle safe end weld LBB analysis results. Attachment 1 provides the requested information. As shown in Attachment 1, the required LBB margins are satisfactory at this location.

2. The 12-inch Residual Heat Removal lines have high stress locations in the Class 2 portion of the lines. The Class 1 high stress location was analyzed and reported in the CPSES-1 WHIPJET report because the RHR Class 2 portion of the system experiences a lower pressure and temperature, and is isolatable. As mentioned in the CPSES-1 WHIPJET report, the Class 2 highest stress location was also analyzed and found to have acceptable margins. The NRC staff requested the results for the high-stress location in the Class 2 portion of the RHR system. Attachment 2 provides the requested information on the Class 2 portion of the RHR system.

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3. The 10 gpm crack length reported for the 14-inch pressurizer surge line in the CPSES-1 WHIPJET report, was 5.94 inches. The NRC staff requested the 10 gpm crack length calculated for the "no torsion" case at the reported location. RLCA reanalyzed this location (the loop nozzle safe end weld) for the case with no torsion and determined the 10 gpm crack length to be 8.02 inches. Attachment 3 provides further details of the pressurizer surge line loop nozzle safe end weld.

4. The NRC staff identified a recommendation in Appendix B of the CPSES-1 WHIPJET report for using a 1% strain fit to tensile test data that was mistakenly referenced. The correct reference is Reference 8 and not Reference 12. Attachment 4 provides further details.

5. The NRC staff inquired about the material composition of the SIS accumulator nozzles based on the description of the CPSES-1 WHIPJET program scope presented by the CPSES-1 WHIPJET report. The four accumulator nozzles are made of cast austenitic stainless steel. The conservative approach taken by the CPSES-1 WHIPJET program in analyzing lower bound material properties bounds the LBB behavior of cast stainless steel. The review determined that thermally aged cast stainless steel with an end-of-life condition, has toughness values in excess of the lower bound submerged arc weld metal analyzed by the CPSES-1 WHIPJET program. In addition, Westinghouse considered and analyzed cast material and welds in the CPSES main loop LBB program. Attachment 5 and its Enclosure provide further details and references for the properties of cast material.

6. The NRC staff asked whether the CPSES-1 WHIPJET program considers the RHR containment penetration as an anchor and analyzed systems on an anchor-to-anchor basis. As stated on page 2-2 of the CPSES-1 WHIPJET report, systems were analyzed on an anchor-to-anchor basis. For the Staff's convenience, a copy of that page is provided as Attachment 6. As discussed in the conference call, one anchor of the RHR system is at the containment penetration.

The above discussion, six (6) attachments and two (2) enclosures completes the actions requested by the NRC Staff of TU Electric in the June 22, 1988 conference call concerning the "CPSES-1 WHIPJET Program Report."

We remain available to meet with the Staff to resolve any questions which may arise and to provide any additional information to complete its review of this report. The FSAR will be amended to reflect the revised design bases as a result of implementing LBB methodology upon NRC acceptance.

Very truly yours,

W. G. Counsil

By: Roger D. Walker
R. D. Walker
Manager, Nuclear Licensing

HAM/mlh
Attachments and Enclosures

c - Mr. R. D, Martin, Region IV
Resident Inspectors, CPSES (3)

DATA INPUT AND RESULTS FOR PRESSURIZER NOZZLE SAFE END WELD LOCATION ("No Torsion" High Stress Location)

For node 800 (pressurizer nozzle), the 10 gpm crack length is 4.475 inches. The resulting margins are:

	Load margin (≥ 1.0 required)	Flaw Margin (≥ 2.0 required)
Base Metal	2.72	3.45
Submerged Arc Weld	2.25	3.08
Shielded Metal Arc Weld	2.50	3.29

The LBB input for the pressurizer nozzle location is as follows:

Line	Loading Conditions	Forces (lbs) Fx	Moments (in-lbs) My	Mz
RCS 14-inch.	Deadweight	5170	-2230	5940
Pzr. nozzle	Thermal	-7130	-100990	-2826530
	SSE	7530	39850	110020

<u>PICEP Input</u>

Outside Diameter = 14.0 inches
Pipe Thickness = 1.406 inches
Circumferential crack orientation
Diamond Shaped Crack
E = 25.5D+06 psi
Yield stress = 24.5D+03 psi
Yield strain = 0. (Default value)
Alpha = 3.75
FACN = 4.82
Flow stress = 46.2D+03 psi
Pressure = 2249.7 psi
Temperature = 653 F
Absolute external pressure = 14.7 psi

DATA INPUT AND RESULTS FOR RESIDUAL HEAT REMOVAL (CLASS 2) HIGH STRESS LOCATION

For node 2680 (High stress Class 2 node), the 10 gpm crack length is 5.763 inches. The resulting margins are:

	Load margin (≥ 1.0 required)	Flaw Margin (≥ 2.0 required)
Base Metal	3.11	3.49
Submerged Arc Weld	2.99	3.40
Shielded Metal Arc Weld	3.12	3.50

The LBB input for node 2680 is as follows:

Line	Loading Conditions	Forces (lbs) Fx	Moments (in-lbs) My	Mz
RHR 12-inch.	Deadweight	30	1060	-44650
	Thermal	-9880	-214360	-306870
	SSE	6700	312660	468300
	SAM	1090	113940	-100
	SAM	1130	39550	150

<u>PICEP Input</u>

Outside Diameter = 12.75 inches
Pipe Thickness = 0.375 inches
Circumferential crack orientation
Diamond Shaped Crack
E = 25.5D+06 psi
Yield stress = 24.5D+03 psi
Yield strain = 0. (Default value)
Alpha = 3.75
FACN = 4.82
Flow stress = 46.2D+03 psi
Pressure = 414.7 psi
Temperature = 350 F
Absolute external pressure = 14.7 psi

LEAK RATE DATA INPUT AND RESULTS FOR SURGE LINE LOOP NOZZLE SAFE END WELD LOCATION

For node 1010 (pressurizer surge line nozzle at the main loop), the 10 gpm crack length is 8.019 inches when torsion is not included. Note that this node is not the high stress location when torsion is excluded (see Attachment 1).

The LBB input for the loop nozzle location is as follows:

Line	Loading Conditions	Forces (lbs) Fx	Moments (in-lbs) My	Mz
RCS 14-inch.	Deadweight	2370	49640	105310
	Thermal	-4470	-896720	706880
	SSE	5490	1272360	480810

PICEP Input

Outside Diameter = 14.0 inches
Pipe Thickness = 1.406 inches
Circumferential crack orientation
Diamond Shaped Crack
E = 25.5D+06 psi
Yield stress = 24.5D+03 psi
Yield strain = 0. (Default value)
Alpha = 3.75
FACN = 4.82
Flow stress = 46.2D+03 psi
Pressure = 2249.7 psi
Temperature = 653 F
Absolute external pressure = 14.7 psi

STRAIN RANGE FOR STRESS-STRAIN FIT

With respect to the selection of the Ramberg-Osgood work hardening constants for the EPRI estimation scheme, a low strain-range fit is desirable. Fitting the stress-strain data over a small strain range is consistent with the procedure used in EPRI report NP-4690-SR, Evaluation of Flaws in Austenitic Steel Piping. The discussion in Appendix B of the final CPSES-1 WHIPJET report concerning this approach (p. B-5) should have referred to Reference 8 vice Reference 12. To clarify this issue, the content of the attachment material contained in Reference 8 is summarized by a June 23, 1988 letter from D. M. Norris to D. Quinones and provided as an enclosure to this letter. This same 1% strain fit approach was used for WHIPJET work accepted by the NRC on another docket.

The use of a strain range to 1% is a subset of the approach recommended in the EPRI PICEP manual (NP-3596-SR), e.g., "fitting up to strain of about 5%." For these reasons, fitting the stress-strain data to a plastic strain of 1% is generally conservative.

Attachment 5
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CAST MATERIAL IN CPSES-1 ACCUMULATOR INJECTION LATERALS

The four 10-inch accumulator injection 45-degree laterals, at the 29-inch reactor coolant loop, are constructed from SA 351 Grade CF8A cast steel with E 308-16 manual welds. The CPSES-1 surge line and Residual Heat Removal lines have no cast components. Table B-1-1 in the CPSES-1 WHIPJET final report should be modified with an additional row showing material SA 351 Grade CF8A for 45-degree laterals. A copy of the revised Table B-1-1 is contained as an enclosure to this Attachment. LBB studies on the reactor coolant cast pipes and associated welds previously have been performed by Westinghouse.

The delta ferrite ranges from 20 to 21 percent for the four CPSES-1 accumulator laterals, which is typical for the type of nozzle. The fracture toughness of cast stainless steel manual welds for the thermally aged, end-of-life condition is no worse than the toughness of the worst-case submerged arc or shielded metal arc welds. Furthermore, the nozzle section is thicker than the adjacent pipe section. For these reasons the cast stainless steel laterals have been conservatively bounded by the LBB analysis.

Selected CPSES-1 system lines were screened for abnormal crack growth mechanisms (such as corrosion or gross global fatigue) and other potential failure mechanisms (e.g., water hammer). Additional screening considerations included unexpected flow stratification conditions, erosion/corrosion, and other adverse industry experience.

Applicable stress calculation analyses were examined anchor to anchor on a system line basis to determine which locations (not limited to normal postulated pipe break locations) were most critical in terms of highest stress. These locations were then coupled with all possible material properties (base metal and welds) in a deterministic evaluation that demonstrated sufficient margin against failure. The pertinent system locations were analyzed to determine the stability of postulated through-wall flaws. In flux welds, the loading conditions in the pipe (termed normal + SSE), were the combination of:

$$\left[\text{deadweight} + \text{thermal} + \text{pressure} + \begin{matrix}\text{Safe}\\ \text{Shutdown}\\ \text{Earthquake}\end{matrix} + \begin{matrix}\text{Seismic}\\ \text{Anchor}\\ \text{Motion}\end{matrix} \right]$$

or:

(DW + TH + P + SSE + SAM).

For the consideration of base metal and non-flux welds, thermal loading (expansion) was not included in the normal plus SSE. Leak rate versus crack size was determined considering normal operating loads (DW + TH + P) and fluid conditions [2]. A limiting leak rate based upon a conservative detectable leakage limit of 1.0 gpm multiplied by a margin of 10 was used to determine the crack length corresponding to 10 gpm. This leakage size crack length was analyzed for two margins against failure: first, that a margin of 2 on crack size exists when compared to the (normal + SSE) loading condition critical crack

WHIPJET

EPRI

Electric Power
Research Institute

June 23, 1988

Mr. David Quinones
RLCA
125 University Avenue
Berkeley, CA 94710

Dear Mr. Quinones:

In response to your recent inquiry, this letter gives the recommended procedure for determining the Ramberg-Osgood constants for austenitic steels using the EPRI estimation scheme given in Reports NP-1931 and NP-3607.

Based on the attached work of Dr. Sumio Yukawa, the low strain range (typically to 1% plastic strain), should be used to fit experimental stress-strain curves. The low strain-range fits produced the best match between the EPRI estimation scheme and experimental J_R curve data.

Sincerely,

Douglas M. Norris

Douglas M. Norris
Manager
Structural Mechanics Program

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TABLE B-1-1

TYPICAL PIPE FITTING STEELS IN CPSES-1
SIS, RCS AND RHR LINES

FITTINGS	MATERIALS
Elbow	SA403 WP316 SA182 GRF316 or F304 SA240 Type 316 SA376 Type 304
Sockolet	SA182-F304
Reducer	Type 304 Type 316
Reducing Tee	SA376 Type 316
Weldolet	SA182-F304 SA182-F316
Special Ends	SA403 WP304
Check Valve	SA182 F316
Nozzles	SA376 Type 316 SA312 Type 304 SA182 F16N
Nozzle Safe Ends	SA182 Type 316 or 316L SA376 Type 316 or 316L
Coupling	SA182 Type F304 or F316
45° Reducer	SA351 Grade CF8A