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TEXAS UTILITIES GENERATING COMPANY

SKYWAY TOWER • 400 NORTH OLIVE STREET, L.B. 81 • DALLAS, TEXAS 75201

August 22, 1984

Mr. B. J. Youngblood, Chief
Licensing Branch No. 1
Division of Licensing
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

SUBJECT: COMANCHE PEAK STEAM ELECTRIC STATION
DOCKET NUMBERS 50-445 AND 50-446
RESPONSE TO QUESTIONS CONCERNING REACTOR VESSEL HEAT-UP AND COOLDOWN TECHNICAL SPECIFICATIONS

Dear Mr. Youngblood:

Attached are six copies of our responses prepared by Westinghouse to questions posed by your letter dated June 13, 1984. Based on this and the information we submitted by letter dated May 16, 1984, it is our request that the Comanche Peak Technical Specification Figures 3.4-2 and 3.4-3 should be the curves from Figure 6 and 7 of our May 16 submittal.

If you have any questions about this matter, please call Richard Werner at (214) 979-8227.

Sincerely,

H C Schmidt

H. C. Schmidt
Manager, Nuclear Services

HCS:kp

Attachment

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ATTACHMENT A - WESTINGHOUSE RESPONSE TO NRC COMMENTS ON COMANCHE PEAK UNITS 1 AND 2

Reference A-1 contained NRC comments on the Westinghouse analysis on Comanche Peak Units 1 and 2 given in Reference A-2. These comments and the associated Westinghouse responses are listed in the following sections:

NRC Comment No. 1

In Reference A-2, the calculated total stresses are reported to be 13.42 ksi and 34.90 ksi during vessel cooldown and heatup, respectively.

Westinghouse Response No. 1

Reference A-2 reported total stresses of 13.41 ksi and 24.90 ksi during cooldown and heatup, respectively.

NRC Comment No. 2

In Table 5.2-14 of the Salem FSAR, the total stress intensity at the vessel flange is reported to be 58.20 ksi.

Westinghouse Response No. 2

The stress intensity of 58.20 ksi has no relevance to the bolt preload problem because it is the maximum Stress Intensity Range ($S_{range\ max}$) defined as follows:

$$S_{range\ max} = S_{max} - S_{min} = 58.22 \text{ ksi}$$

where $S_{range\ max}$ = Maximum Stress Intensity Range

S_{max} = Maximum Stress Intensity = 16.36 ksi (occurs at the end of heatup from page A-80 of Reference A-3)

S_{min} = Minimum Stress Intensity = -41.86 ksi (occurs at end of cooldown after the inservice hydrostatic test from page A-81 of Reference A-3)

This subtraction of stresses (or stress intensity range) can give no information at all about the magnitude of the bolt preload stresses.

NRC Comment No. 3

Mr. J. Houstrup obtained a bolt-up peak stress of 30.14 ksi at a typical reactor vessel flange-to-shell junction (a stress concentration factor of 1.29 was used to account for the fillet; i.e., the unconcentrated bolt-up stress was 23.50 ksi). At the vessel head-to-flange junction, the corresponding stresses were reported to be 49.40 ksi (peak) and 31.90 ksi (unconcentrated). These stresses are significantly higher than those calculated in Reference A-2.

Westinghouse Response No. 3

Table 1 shows that Mr. Houstrup's stresses are in good agreement with the Combustion Engineering stress reports for Comanche Peak Unit 2 and Public Service Unit 1. For Comanche Peak Unit 2 and Public Service Unit 1, the stresses are based on the cold hydrotest preload of 145.881 kips/in. Since Mr. Houstrup's values are in good agreement with these stresses, it is judged that his stresses of 30.14 ksi (peak) and 23.50 ksi (unconcentrated) are also based on the cold hydrotest preload of 145.881 kips/in. During the plant heatup and cooldown transients, a lower bolt-up preload of 116.705 kips/in. exists; therefore, bolt-up stresses based on the higher cold hydro-test preload are more conservative than necessary. Comparison of the Comanche Peak Unit 2 and Public Service Unit 1 stresses in Tables 1 and 2 shows the benefit of using the correct bolt-up preload of 116.705 kips/in.

Only the unconcentrated stresses should be used in the analyses in accordance with Appendix G of the ASME Code, Section III and Appendix G to 10CFR Part 50 (References A-4 and A-5). Table 2 compares the unconcentrated stresses in the Comanche Peak and Public Service stress reports with stresses computed by Westinghouse. Two independent Westinghouse stress results are given. One set of stresses is based on the 2D Finite Element model discussed in Reference A-2, and the other stresses are based on a hand calculation using shell theory from Reference A-6. The hand calculation determines the bending stress at distance x along a cylinder when a given radial moment M_0 is applied to the end of the cylinder (see Attachment B). Comparison of the unconcentrated stresses in Table 2 shows that the hand calculation is in good agreement with the Finite Element model. The hand calculation method used is based on fundamental principles of shell theory which have been universally accepted and documented in the well-known book by R. J. Roark (Reference A-6). Therefore, the fact that the hand calculation is in good agreement with the Finite Element model is a verification of the Finite Element model. In addition, Table 2 shows that the Comanche Peak and Public Service stress reports yield results which are approximately 40 percent higher than the realistic stresses obtained with the Westinghouse Finite Element model.

The bolt-up stresses in the Comanche Peak and the Public Service stress reports are 40% higher than those calculated by Westinghouse because of the deliberately conservative analytical model these reports use to satisfy Section III Code Requirements. The model in these reports is an "interaction analysis" model, and it is shown in Figure B-2. As indicated on Figure B-2, bodies 3 and 4 of the model are analyzed as "rings", while bodies 1, 2, and 5 are analyzed as "shells". A shell will exhibit the exponential reduction (attenuation) of the bending stress as shown by Equation B-1 of Attachment B. A ring is a less general model, and it will not include this exponential stress reduction, even when attached to the end of a shell. As a result, the stresses where the ring models are used are more conservative than necessary, and these conservative stresses appear in the Comanche Peak and Public Service stress reports. The Westinghouse hand calculation results shown in Table 2 include the bending stress attenuation, because bodies 4 and 5 were combined into one shell in doing the hand calculation.

Body 3 of the closure head is likewise modeled as a ring in the Comanche Peak and Public Service stress reports, and the reported stress for the vessel head-to-flange junction (31.9 ksi unconcentrated) will also be conservatively high, because the attenuation is not taken into account when body 3 is modeled as a ring. Therefore, the Westinghouse Finite Element stresses are the appropriate values to use at the vessel head-to-flange junction.

The Comanche Peak and Public Service stress reports are excellent reports for their purpose, which is only to demonstrate that Section III Code requirements are satisfied. From this standpoint, the interaction model used is ideal - owing to its conservatism.

Use of the realistic stresses obtained by the Westinghouse Finite Element analysis rather than the more conservative stresses is justified especially since they are applied to the Appendix G analysis method given in References A-4 and A-5. Reference A-7 indicated that many conservatisms already exist in the Appendix G analysis techniques and they include a safety factor of 2.0 on the pressure stress intensity factor and the use of the crack arrest toughness instead of the crack initiation toughness, which is a more realistic value. In addition, the primary and secondary (thermal) stress intensity factors (K_I) which are negative are considered to be zero in Reference A-2.

ATTACHMENT

TABLE 1

COMPARISON OF COLD HYDROTEST PRELOAD STRESSES AT VESSEL FLANGE TO SHELL JUNCTURE

Data Source	Preload (kips/in)	Bolt Circle Radius (in)	Preload Eccentricity (in)	Moment due to Preload ($\frac{in\text{-}kips}{in}$)	Longitudinal Preload Unconcentrated Stress		Longitudinal Preload Peak Stress	
					Inside (ksi)	Outside (ksi)	Inside (ksi)	Outside (ksi)
CENC 1419 for Comanche Peak Unit 2	145.881	95.938	4.969	724.9	-25.43[a]	+25.43	-31.88[c]	+31.88
CENC 1148 for Public Service Unit 1	145.881	95.938	4.907	715.8	-26.00[b]	+26.00	-32.24[d]	+32.24
J. Houstrup	----	----	----	----	----	+23.50	----	+30.14

[a] Page A-130 of CENC-1419 (Reference A-8).

[b] Page A-81 of CENC-1148 (Reference A-3).

[c] Page A-143 of CENC-1419 (Reference A-8).

[d] Page A-95 of CENC-1148 (Reference A-3).

TABLE 2

COMPARISON OF BOLT-UP PRELOAD STRESSES AT VESSEL FLANGE TO SHELL JUNCTURE

Data Source	Preload (kips/in)	Bolt Circle Radius (in)	Preload Eccentricity (in)	Moment due to Preload $(\frac{\text{in-kips}}{\text{in}})$	Longitudinal Preload Unconcentrated Stress		Longitudinal Preload Peak Stress
					Inside (ksi)	Outside (ksi)	Inside (ksi)
CENC 1419 for Comanche Peak Unit 2	116.705	95.938	4.969	579.9	-20.74[a]	+20.74	-26.00[e]
CENC 1148 for Public Service Unit 1	116.705	95.938	4.907	572.7	-21.27[b]	+21.27	-26.38[f]
Hand Calculation Using Shell Theory[c]	116.705	95.938	4.617	538.8	-13.05	+13.05	----
2D Finite Element Model[d]	116.705	95.938	4.617	538.8	-14.24	+15.61	----

[a] Page A-130 of CENC-1419 (Reference A-8).

[b] Page A-80 of CENC-1148 (Reference A-3).

[c] Roark, Case 15, Page 302 4th Edition (Reference A-6).

[d] Cross Section 3 of MT-SME-3362 (Reference A-2).

[e] Page A-143 of CENC-1419 (Reference A-8).

[f] Page A-94 of CENC-1148 (Reference A-3).

ATTACHMENT A REFERENCES

A-1. Youngblood, B. J., "Reactor Vessel Heatup and Cooldown Technical Specification Pressure-Temperature Limits for Comanche Peak Steam Electric Station (Units 1 and 2)", U.S. Nuclear Regulatory Commission, Docket No. 50-445 and 50-446, June 13, 1984.

A-2. Kaiser, W. T., Adamonis, D. C., and Prager, D. E., "Fracture and NDE Evaluations for the Closure Flange Regions of Comanche Peak Units 1 and 2", MT-SME 3362, April 1984.

A-3. Cockrell, C. R., and Lowry, J. C., "Analytical Report for Public Service Reactor Vessel - Unit No. 1", Combustion Engineering Report No. 1148, September 1970.

A-4. ASME Boiler and Pressure Vessel Code, Section III, Division 1 - Appendices, "Rules for Construction of Nuclear Vessels", Appendix G, "Protection Against Nonductile Failure", pp. 559-569, 1983 Edition, American Society of Mechanical Engineers, New York, 1983.

A-5. Code of Federal Regulations, 10 CFR Part 50, Appendix G, "Fracture Toughness Requirements", U.S. Nuclear Regulatory Commission, amended May 17, 1983 (48 Federal Register 24010).

A-6. Roark, R. J., "Formulas for Stress and Strain", 4th Edition, McGraw-Hill Book Company, New York, N.Y., p. 302, 1965.

A-7. Chirigos, J. N. and Meyer, T. A., "Influence of Materia Property Variations on the Assessment of Structural Integrity of Nuclear Components", Journal of Testing and Evaluation, September 1978.

A-8. Silver, J. D., "Addendum 1 to Analytical Report for Texas Utilties Services Corporation Comanche Peak Station Unit No. 2 Reactor Vessel", Combustion Engineering Report No. 1419, May 1980.

ATTACHMENT B - SHELL THEORY USED TO DETERMINE STRESS AT VESSEL FLANGE TO SHELL JUNCTURE

This appendix contains the methods contained in Roark, Case 15, page 302 4th Edition.[B-1] This analysis determines the effect of a uniform radial moment at the end of a long cylinder. Consider the cylinder shown by Figure B-1 imposed with a radial moment M_o of -538.8 in-kips/in. from Table 1. Determine the effect of this moment at distance x from M_o along the cylinder. The bending stress at distance x (σ_x) is given by the following equation:

$$\sigma_x = \pm \frac{6M_o}{t^2} e^{-\lambda x} (\cos \lambda x + \sin \lambda x) = \pm 13.05 \text{ ksi} \qquad \text{(B-1)}$$

where σ_x = bending stress at distance x

M_o = applied radial moment = -538.8 in-kips/in.

$\lambda = \sqrt[4]{\frac{3(1-\nu^2)}{R_2^2 t^2}} = 0.0411/\text{in.}$

γ = Poisson's ratio = 0.3

R_2 = mean radius = $R + \frac{t}{2}$ = 90.975 in.

R = inner radius = 85.60 in.

t = critical cross section thickness shown in Figure B-2 = 10.75 in.

x = distance from M_o to the vessel flange to shell juncture shown in Figure B-2 = 26.00 in.

FIGURE B-1 Uniform Bending Moment M_0 Applied to a Long Cylinder (Positive Direction as Shown)

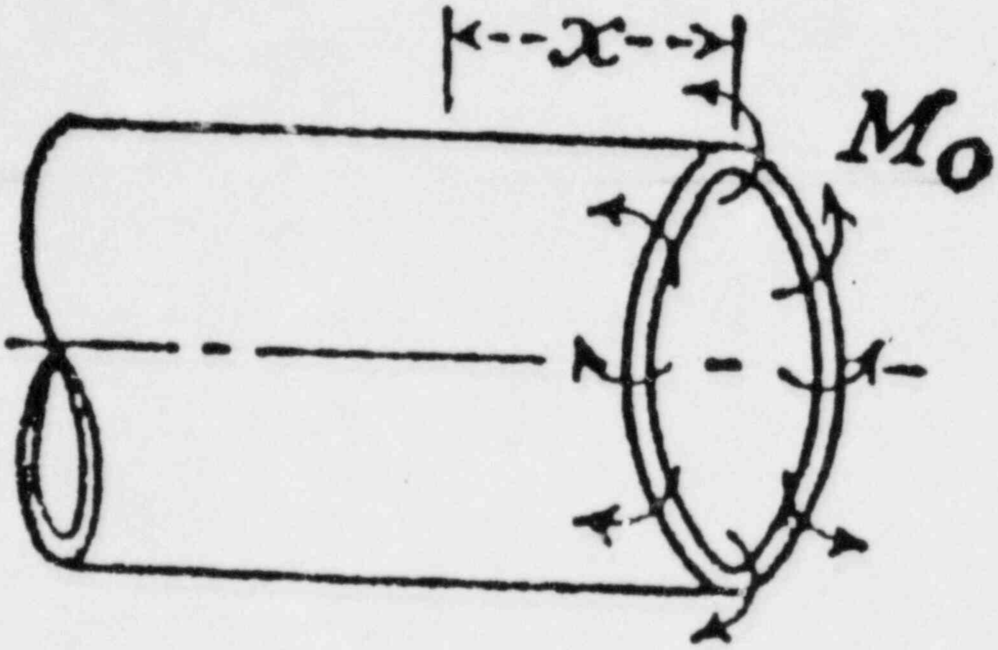

FIGURE B-2

INTERACTION ANALYSIS MODEL