CYGNA
ENERGY SERVICES
101 California Street, Suite 1000, San Francisco, CA 94111-5894
415/397-5600

March 9, 1984
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50-445/446

Mrs. Juanita Ellis, President
Citizens Association for Sound Energy
1426 South Polk
Dallas, Texas 75224

Subject: Comanche Peak Steam Electric Station Independent Assessment Program - Response to CASE Questions

Reference: (1) Brief Summary of Generic Problems from CASE Witness Jack Doyle, 2/22/84.

(2) Brief Summary of Cross-examination Questions from CASE Witness Mark Walsh, 2/22/84.

Dear Mrs. Ellis:

Enclosed please find our responses to reference (1) items 5, 6, 9, 14 and 18; and reference (2) item 1.

Further responses will be forthcoming.

Very truly yours,

N. H. Williams

Nancy H. Williams
Project Manager

NHW:eam
Enclosures: Attachment A, Partial Responses to CASE Questions

cc: See attachment

B001
1/1

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Mrs. J. Ellis
Response to CASE Questions

March 9, 1984
Attachment

Nicholas S. Reynolds, Esq.
Bishop, Liberman, Cook, Purcell & Reynolds
1200 Seventeenth Street, N.W.
Washington, D.C. 20036

Robert Wooldridge, Esq.
Worsham, Forsythe & Sampels
2001 Bryan Tower
Dallas, Texas 75201

Mr. Homer C. Schmidt
Manager - Nuclear Services
Texas Utilities Generating Company
2001 Bryan Tower
Dallas, Texas 75201

Mr. H. R. Rock
Gibbs & Hill, Inc.
393 Seventh Avenue
New York, New York 10001

Mr. A. T. Parker
Westinghouse Electric Corporation
P.O. Box 355
Pittsburgh, Pennsylvania 15230

Renea Hicks
Assistant Attorney General
Environmental Protection Division
P.O. Box 12548, Capitol Station
Austin, Texas 78711

Mr. James E. Cummins
Resident Inspector/Comanche Peak Nuclear Power Station
c/o U.S. Nuclear Regulatory Commission
P.O. Box 38
Glen Rose, Texas 76043

Mrs. S. Burwell
Licensing Project Manager
U.S. Nuclear Regulatory Commission
7920 Norfolk Avenue
Bethesda, Maryland 20014

Mr. H. Schmidt
c/o Westinghouse
4901 Fairmont Avenue
Bethesda, Maryland 20814

Mr. John T. Collins
U.S. NRC, Region IV
611 Ryan Plaza Drive
Suite 1000
Arlington, Texas 76011

Mr. Lanny Alan Sinkin
114 W. 7th, Suite 220
Austin, Texas 78701

B. R. Clements
Vice President Nuclear
Texas Utilities Generating Company
Skyway Tower
400 North Olive Street
L.B. 81
Dallas, Texas 75201

Peter B. Bloch, Esq.
Chairman, Atomic Safety and Licensing Board
U.S. Nuclear Regulatory Commission
4350 East/West Highway, 4th Floor
Washington, D.C. 20814

Dr. Walter H. Jordan
881 W. Outer Drive
Oak Ridge, Tennessee 37830

Dr. Kenneth A. McCollom
Dean, Division of Engineering Architecture and Technology
Oklahoma State University
Stillwater, Oklahoma 74074

Stuart A. Treby, Esq.
Office of the Executive Legal Director
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Mr. J. B. George
Texas Utilities Generating Company
Comanche Peak Steam Electric Station
Highway FM 201
Glen Rose, Texas 76043

Mr. David H. Wade
Texas Utilities Generating Company
2001 Bryan Tower
Dallas, Texas 75201

Mr. David R. Pigott
Orrick, Herrington, & Sutcliffe
600 Montgomery Street
San Francisco, California 94111

Comanche Peak ASLB Hearings
Response to CASE Questions
Question No.: Walsh #1
Exhibit No.: None

1.0 CASE Question

Appendix E of Cygna Report. Section DC-2.2.4. What was the yield point used for A500, Grade B tube steel?

2.0 Cygna Interpretation

N/A.

3.0 Response

Comanche Peak typically used a yield strength equal to 42 ksi. This may have been taken from p. 5-214 of the AISC Code, 7th Edition, which specifies F_y = 42 ksi for round tubes made of A500, Grade B, material.

The correct value for yield strength is 36 ksi, per ASME Code Case N-71-10. Cygna checked the applicable calculations to verify that the tube steel satisfied the lower allowable. In each case, the existing design was satisfactory.

Comanche Peak ASLB Hearings
Response to CASE Questions
Question No.: Doyle #5
Exhibit No.: 891, 894, 897

1.0 CASE Question

Inaccurate conclusions as related to KL/R for pinned columns:

- If a column fixed at its base and free at the top has an effective K of 2.0, cutting at some point up from the base and adding a pin does not address the problem.

2.0 Cygna Interpretation

For CASE Exhibits 891, 894 and 897, are the proper slenderness ratios used in calculating the column capacities?

3.0 Response

The correct value for each component of the slenderness formula was used in the evaluation of the columns shown in CASE Exhibits 891, 894 and 897. This is shown in the following tables:

Exhibit 891

	Used	Actual
K	2.1	2.1
L, in.	21.75	19.75
R, in.	2.99	2.99
KL/R	16	14
f_a/F_a	5%	5%

where K = effective length factor
L = length
R = radius of gyration
f_a = allowable axial stress
F_a = actual axial stress

Exhibit 894

	Used	Actual
K	2.00	2.10
L, in.	71.75	71.75
R, in.	1.44	1.44
KL/R	100.00	105.00
f_a/F_a	5%	6%

The difference in KL/R corresponds to a slight change in the allowable axial stress, but the actual stress remains well below the allowable.

Exhibit 897

This support configuration transfer loads to the baseplate primarily through moments. Therefore, the effect of axial column loads is insignificant.

Comanche Peak ASLB Hearings
Response to CASE Questions
Question No.: Doyle #6
Exhibit No.: 891

1.0 CASE Question

16-inch pipe with about 20 kips load along 3-1/2 inches of length induces high bearing stresses which require pads. This is not addressed.

- ASME Code against flattening.

2.0 Cygna Interpretation

How did Cygna evaluate the stresses induced into the piping by the following, as related to the ASME Code caution against inducing excessive flattening into the pipe wall:

a. U-bolt?

b. 5" x 5" x 1/2" tube steel frame?

3.0 Response

In Section III, the ASME B&PV Code provides the following caution:

Subsection NB-3645 (Class 1 Components)

"Lugs, brackets, stiffeners, and other attachments may be welded, bolted, or studded to the outside or inside of piping. The effects of attachments in producing thermal stresses, stress concentrations, and restraints on pressure retaining members shall be taken into account in checking for compliance with stress criteria."

Subsections NC-3645 (Class 2) and ND-3645 (Class 3)

"External and internal attachments to piping shall be designed so as not to cause flattening of the pipe, excessive localized bending stresses, or harmful thermal gradients in the pipe wall. It is important that such attachments be designed to minimize stress concentrations in applications where the number of stress cycles, due either to pressure or thermal effect, is relatively large for the expected life of the equipment."

The Code statement for Class I components is key, wherein it is specified that local effects due to flattening shall be taken into account during the stress check. It is also important to note that the Code does not quantify the term "flattening" for Class 2 and 3 piping. A reasonable conclusion therefore is that the designer of Class 2 and 3 piping should consider the significance of any additional stresses induced in the pipe wall due to flattening, including fatigue effects.

Asymmetric concentrated loads, capable of introducing varying degrees of flattening, are common in piping systems. These loads can be produced by standard items such as clamps, frames, U-bolts and penetration sleeves.

Therefore, in reviewing the adequacy of loads introduced into the pipe wall by support SI-1-002-S32R (CASE Exhibit 891), Cygna considered the following:

a. U-bolt. Cygna judged that the loads introduced into the piping due to design loads would not prevent the piping from performing its intended function. U-bolts are frequently used in the industry for similar applications. To verify the correctness of this engineering judgment, Cygna subsequently performed an analysis of the pipe wall stresses. The results are provided in our response to Doyle Question #1, part d. Basically, these results show that the induced stresses are low and localized.

b. 5" x 5" x 1/2" Tube. The drawing details specify a 0" gap at the four attachment points. Only an extraordinary construction effort could hope to accomplish this task. For example, the tube frame would have to be heated in order to shrink-fit it onto the pipe. Cygna reviewers concluded that such an effort would not occur, and therefore significant stresses would not develop in the pipe. It should be noted that radial thermal growth would be 1/50", about the width of a mechanical pencil lead.

Comanche Peak ASLB Hearings
Response to CASE Questions
Question No.: Doyle #9
Exhibit No.: 892

1.0 CASE Question

The reduction of weld capacity in the calculation is based on 135 degrees. Actual tangential angle is 150.3 degrees. Therefore, an error exists. Did Cygna take note of this?

- More stress in weld than stated.
- Wide/thin ratio induces cracking as well as the 1.4:1 ratio of width to depth.

2.0 Cygna Interpretation

What was the basis for concluding that the stanchion-to-pipe weld shown in CASE Exhibit 892 is adequate?

3.0 Response

ITT Grinnell design procedure, SA 3912, (attached) states that credit shall only be taken for the portion of the weld up to 135 degrees. Cygna concurred with this procedure and confirmed that it was properly employed on the subject support.

WELD PROPERTIES FOR PIPE/STANCHION AND ELBOW/STANCHION CONNECTIONS

FOR

COMANCHE PEAK PROJECT

PROCEDURE SA 3912

FOR INFORMATION ONLY

Prepared By Anwar [illegible] 2.8.83

Checked By Francis D. [illegible] 2/8/83

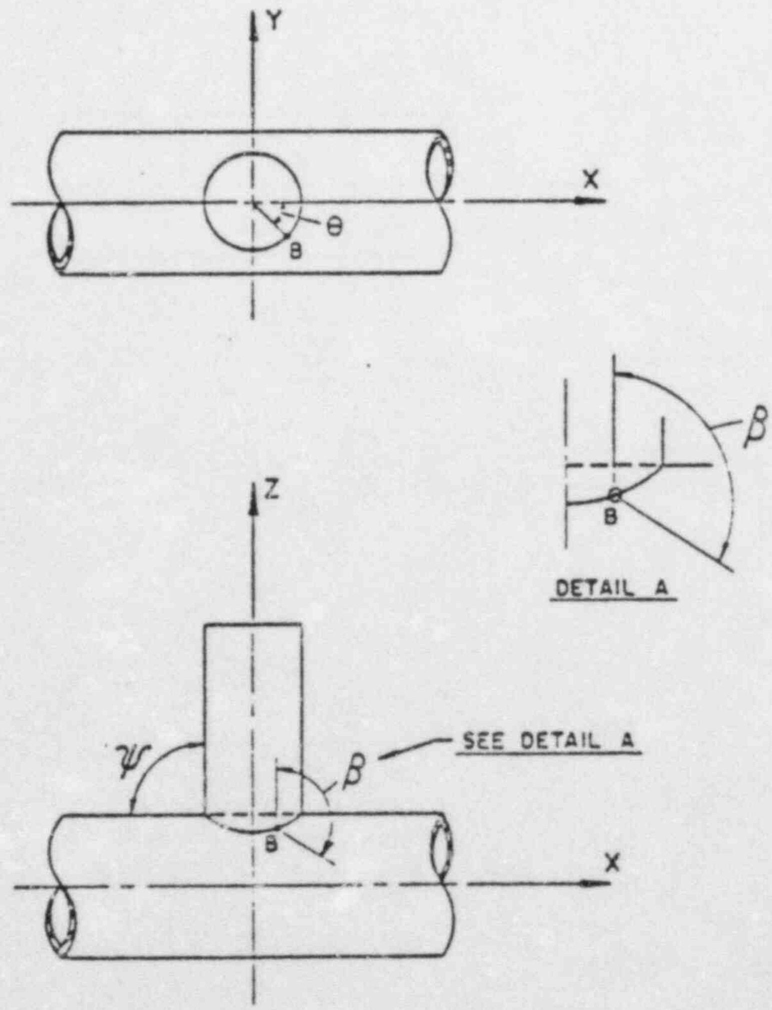
Approved By [illegible] Kumar 2/8/83

Revision A 02/08/83

CMP-6 Rev. 1

CC# ______

WELD ANGLES FOR STRAIGHT PIPES WITH STANCHION ATTACHMENTS



THE β-VALUES OBTAINED FOR θ VARYING FROM 0° TO 90° ARE REPEATED EVERY 90° FOR STRAIGHT PIPE ATTACHMENTS

FIG. 1

4.1 TABLE 1

WELD PROPERTIES OF STRAIGHT PIPES WITH STANCHION ATTACHMENTS (Ref. Fig. 1 & 4)

LIMITING WELD ANGLE = 135°

NOM. PIPE SIZE	NOM STANCH. SIZE	OVERALL WELDED LENGTH	WELD PROPERTIES				
			L_w	S_Y	S_x	J_w	L_s
2 1/2	1	4.24	4.24	1.36	1.36	1.79	4.24
	1 1/2	6.24	6.24	2.84	2.84	5.39	6.24
	2	8.04	5.36	4.17	1.74	7.01	5.36
	2 1/2	11.08	6.16	5.64	1.57	10.37	6.16
3	1 1/2	6.16	6.16	2.84	2.84	5.39	6.16
	2	7.82	7.82	4.43	4.43	10.52	7.82
	2 1/2	9.72	6.48	6.12	2.54	12.44	6.48
	3	13.49	7.50	8.36	2.32	18.71	7.50
4	2	7.69	7.69	4.43	4.43	10.52	7.69
	2 1/2	9.42	9.42	6.49	6.49	18.66	9.42
	3	11.72	8.46	9.29	4.60	24.32	8.46
	4	17.35	9.64	13.82	3.85	39.76	9.64
6	3	11.34	11.34	9.62	9.62	33.67	11.34
	4	14.82	14.82	15.90	15.90	71.57	14.82
	6	25.54	14.19	29.96	8.34	126.87	14.19

4.1 TABLE 1

WELD PROPERTIES OF STRAIGHT PIPES WITH STANCHION ATTACHMENTS (Ref. Fig. 1 & 4)

LIMITING WELD ANGLE = 135°

NOM. PIPE SIZE	NOM. STANCH. SIZE	OVERALL WELDED LENGTH	WELD PROPERTIES				
			L_W	S_Y	S_X	J_W	L_S
8	4	14.57	14.57	15.90	15.90	71.57	14.57
	6	22.14	17.22	33.86	19.76	177.62	17.22
	8	33.25	18.47	50.77	14.14	279.96	18.47
10	4	14.46	14.46	15.90	15.90	71.57	14.46
	6	21.65	21.65	34.47	34.47	228.37	21.65
	8	29.05	20.97	56.44	27.95	363.95	20.97
	10	41.44	23.02	78.88	21.97	542.05	23.02
12	4	14.41	14.41	15.90	15.90	71.57	14.41
	6	21.45	21.45	34.47	34.47	228.37	21.45
	8	28.40	28.40	58.43	58.43	503.93	28.40
	10	36.56	24.37	85.53	35.49	650.46	24.37
	12	49.15	27.31	110.95	30.91	904.37	27.31
14	6	21.37	21.37	34.47	34.47	228.37	21.37
	8	28.18	28.18	58.43	58.43	503.93	28.18
	10	35.93	27 84	89.16	52.02	755.87	27.84

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Comanche Peak ASLB Hearings
Response to CASE Questions
Question No.: Doyle #14
Exhibit No.: 891, 893, 894, 895, 896, 897, 898, 899, 900

1.0 CASE Question

In Note !, the same source, did Cygna consider the additive effects of self-weight excitation if the stiffness is considered from node point to hard point as opposed to the stiffness of the frame independent of hardware, local effects, base plate and anchor bolts?

- Spring rate of base plate/anchor bolts (particularly bearing-type joints) can be considerable (observation of base plate II finite analysis).

2.0 Cygna Interpretation

Did Cygna consider the following:

a. The effect of support stiffness on the evaluation of self-weight excitation?

b. The flexibility of each element in the support load path?

3.0 Response

a. In order to evalute the influence of self-weight excitation on support design, one must apply the appropriate dynamic loads and then calculate the induced stresses and deformations. The applied load, in this case, is the support self-weight. Support stiffness is effectively considered twice in this process. First, it is included in calculating the applied dynamic load. This can be illustrated by the following elementary formulas:

1. Load = function (freq)

2. freq = (1/6.28) · SQRT (Kg/F)

where freq = support fundamental frequency
K = support stiffness
F = self-weight
g = gravity

Secondly, the determination of support stresses and deflections involves a structural evaluation which considers the support stiffness.

For a further description of Cygna's review process relative to support self-weight excitation, see the Cygna response to Doyle Question #11.

b. As stated in the response to Doyle question #13, Cygna recorded that support stiffness calculations on Comanche Peak were potentially deficient. When it was learned that the NRC Staff had evaluated this issue, Cygna deferred to the Staff evaluation rather than performing a redundant review.

Regarding the effects of component flexibilities on the overall support stiffness, standard practice is to consider components like anchor bolts and baseplates to be rigid, unless particularly flexible design details are used. This standard practice is both adequate and appropriate for the following reasons:

- Anchor bolts and baseplates are normally stiff relative to the overall support.

- It is standard practice to assume anchor bolt/baseplate connections as "fixed" in both the analysis and design. This results in a connection that is designed to accommodate the higher forces attracted by such a fixed condition.

- In a standard baseplate connection, the axial stiffness for a compressive load would be greater than for a tensile load. This difference normally will have no significant effect on the overall piping analysis. Standard industry piping programs recognize this and have no provisions for including such refinements.

- Baseplate connections are used throughout the piping system to provide anchorage. Therefore, any refinements to the standard stiffness calculations would have a uniform effect on the system response. CASE Exhibit 884 shows that a large, uniform change in support stiffness has negligible effect on the fundamental system response.

The significance of individual component flexibilities located between the load point and the baseplate connection need to be evaluated on an individual basis.

Comanche Peak ASLB Hearings
Response to CASE Questions
Question No.: Doyle #18
Exhibit No.: 898, 899

1.0 CASE Question

The base plate analysis was performed without including stiffeners alters the stiffness matrix of the base plate and consequently the distribution of moments and tension to the bolts. Beyond this point, stiffeners remain unqualified. Has Cygna addressed this?

2.0 Cygna Interpretation

Did Cygna consider the bolt loading for the baseplate in the stiffened condition? Also, did Cygna qualify the stiffeners?

3.0 Response

It is a conservative approach to ignore the effects of stiffeners on plate or bolt design.

Stiffeners make a flexible baseplate behave more like a rigid plate. By making the plate more rigid, the internal moment arm created in the plate by the compressive force in the concrete and the tensile force in the bolts becomes maximum. Therefore, to resist a given applied external moment, the maximum bolt tension will be smaller in a rigid (stiffened) plate than in a flexible (unstiffened) plate. Consequently, neglecting stiffeners maximizes bolt loads.

Well proportioned stiffeners (relatively thick and deep with length to depth ratio < 3) are generally not a problem in baseplate design. Simple and conservative stiffener analysis shows stresses well below allowables.

Detailed baseplate calculations for SI-1-037-005-S32A and RH-1-024-011-S22A for the stiffened and unstiffened cases support the above observations in a general way. From the attached table it can be observed that for bolts with a larger provision ratio, the bolt loading for the unstiffened condition is greater. Bolt provision ratio is defined as follows:

$$\text{BP ratio} = \frac{T}{T_A} + \frac{V}{V_A}$$

where

T = actual tension
T_A = allowable tension
V = actual shear
V_A = allowable shear

It is expected that the correlation will improve with increasing bolt provision ratios.

Enclosure D18-1

Table 1 - Support SI-1-037-005-S32A

Bolt #	W/O Stiff	W Stiff	Provision Ratio	
			W/O	W
1	1,900	1,700	0.27	0.25
2	0	240	0.13	0.15
3	60	460	0.11	0.14
4	2,260	2,000	0.27	0.25

Table 2 - Support RH-1-024-011-S22A

Bolt #	Case 1		Case 2		Case 3	
	W/O Stiff	W/ Stiff	W/O Stiff	W/ Stiff	W/O Stiff	W/ Stiff
1	1,170	1,580	0	0	0.40	0.43
2	1,260	800	560	610	0.35	0.31
3	0	0	1,610	1,670	0.45	0.46
4	240	770	3,140	2,930	0.41	0.45
5	3,660	2,100	3,050	2,070	0.35	0.23
6	2,510	2,710	250	870	0.40	0.42