TENNESSEE VALLEY AUTHORITY

CHATTANOOGA, TENNESSEE 37401

400 Chestnut Street Tower II

NRC REGION II ATLANTA, GEORGIA

December 16, 1982

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BLRD-50-438/81-77
BLRD-50-439/81-76

U.S. Nuclear Regulatory Commission
Region II
Attn: Mr. James P. O'Reilly, Regional Administrator
101 Marietta Street, Suite 3100
Atlanta, Georgia 30303

Dear Mr. O'Reilly:

BELLEFONTE NUCLEAR PLANT UNITS 1 AND 2 - ALLOWABLE STRESSES FOR PIPE SUPPORT DESIGN - BLRD-50-438/81-77, BLRD-50-439/81-76 - FINAL REPORT

The subject deficiency was initially reported to NRC-OIE Inspector R. V. Crlenjak on December 7, 1981 in accordance with 10 CFR 50.55(e) as NCR BLN CEB 8110. This was followed by our interim reports dated December 30, 1981 and May 11 and September 20, 1982. Enclosed is our final report. TVA does not now consider the subject nonconforming condition adverse to the safe operation of the plant. Therefore, TVA will amend our records to delete the subject nonconformance as a 10 CFR 50.55(e) item.

If you have any questions concerning this matter, please get in touch with R. H. Shell at FTS 858-2688.

Very truly yours,

TENNESSEE VALLEY AUTHORITY

L. M. Mills

L. M. Mills, Manager
Nuclear Licensing

Enclosure
cc: Mr. Richard C. DeYoung, Director (Enclosure)
Office of Inspection and Enforcement
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

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ENCLOSURE

BELLEFONTE NUCLEAR PLANT UNITS 1 AND 2
ALLOWABLE STRESSES FOR PIPE SUPPORT DESIGN
NCR BLN CEB 8110
BLRD-50-438/81-77, BLRD-50-439/81-76
10 CFR 50.55(e)
FINAL REPORT

Description of Deficiency

For the upset condition for primary load sources, the Bellefonte FSAR indicates that allowable stresses for support design is 1.0 times the normal condition AISC allowable stresses. The procedures governing Bellefonte piping analysis (TVA's Civil Engineering Branch Engineering Procedure CEB-EP 21.12, Analysis Handbook, etc.) indicate that a factor of 1.33 can be used.

TVA design criteria N4-50-D717 indicates that the allowable stress for the upset condition for primary plus secondary load sources is 1.5 times the normal condition AISC allowable. Design Criteria N4-50-D717 also indicates an allowable stress for the faulted condition of 1.6 times the normal condition AISC allowable. However, ITT Grinnell Corporation load ratings for component standard supports are based on a comparable load factor for the upset condition of 1.0 per ASME, Section III, Division 1, subsection NF, and a faulted load factor which ranges lower than 1.6 as per Appendix F, ASME, Section III, Division 1, code.

Safety Implications

Based on the following discussion, TVA does not consider this nonconformance to document a condition adverse to safe plant operation and therefore no longer considers this item reportable under 10 CFR 50.55(e).

I. Introduction

The ASME code of record for design of pipe supports for TVA's Bellefonte Nuclear Plant (BLN) is the 1974 subsection NF summer 1976 addenda. The NF code treats support loads resulting from constraint of free end displacements as a secondary stress in the support. The allowable stress for mechanical plus constraint of free end displacement is three times the stress limits of Appendix XVII-2000 for the design, normal, and upset operating condition. In the emergency and faulted condition, constraint of free end displacement loads on the support are not evaluated.

Regulatory Guide 1.124 (issued November 1976) endorses the NF code limits but defines the increase to three times Appendix XVII-2000 as a stress range. This regulatory guide further requires supports whose normal function is required during an emergency or faulted plant condition to be designed to upset limits.

TVA does not agree that the constraint of free end displacement of the piping system can be treated as a secondary stress in the support. Further, as indicated by Regulatory Guide 1.124, the emergency and faulted condition code limits do not ensure functionality. Consequently, TVA developed a support design concept which is in general much more conservative than the code.

Table 1 is a comparison of design of linear type supports by analysis from different codes, NRC documents, and the Bellefonte design.

II. <u>BLN CEB 8110 Part (1)</u>

For the upset condition for primary load sources, the BLN FSAR indicates that allowable support design is 1.0 times the normal condition AISC allowable stresses. The procedures governing BLN piping analysis (CEB-EP 21.12, analysis handbook, etc.) indicate that a factor of 1.33 can be used.

A. Background:

The ASME code, subsection NF, defines piping system loads on supports resulting from constraint of free end displacements as secondary. The upset allowable stress for mechanical plus constraint of free end displacement is 3.0 times Appendix XVII (copied from AISC) allowable. The NF code does not require consideration of constraint of free end displacement loads in the emergency and faulted condition. Further, the jurisdictional boundary of NF is not well defined. Before 1974 all structural steel used to support pipe was called "supplemental steel" and designed to AISC.

Classification of system restraint loads caused by constraint of free end displacements is very controversial. For example, the code permits design of supports by analysis and by load rating. Design by load rating treats all loads on the support as mechanical (or primary) loads, and no primary plus secondary allowable is provided.

B. TVA Position:

The BLN support design criteria considers all system loads on the support as primary. Constraint of free end displacement loads in the emergency and faulted condition are combined with mechanical loads, and resulting allowable stress is less than yield. Further, compression members are limited to less than 2/3 critical buckling for all operating conditions for the total applied load.

Table 1 provides a comparison of allowable stresses in linear type supports designed by analysis.

As indicated by table 1, the faulted allowable for BLN is only 1/2 the NF allowable and additional conservatism results from considering constraint of free end displacement loads as primary. The BLN upset primary plus secondary allowable is treated as a stress range and is maintained well below code allowable.

In summary, the BLN support design criteria is in general much more conservative than the NF code. The allowable upset primary (dead load plus Operational Basis Earthquake (OBE inertial) loads are 1.33 (versus 1.0 in the NF code). The AISC code has for many years permitted a 1/3 increase for wind and seismic loads. The BLN design criteria for pipe supports is conservative and reflects good design practice. The FSAR will be revised by February 28, 1983 to reflect allowable stresses used in support design. The discrepancy was caused by the EP and handbook being issued with the 1.33 factor in anticipation that the ASME Code would adopt the 1.33 factor. The ASME Code adopted a factor of 1.0 instead of 1.33.

III. BLN CEB 8110 Part (2)

TVA design criteria N4-50-D717 indicates that the allowable stress for the upset condition for primary plus secondary load sources is 1.5 times the normal condition AISC allowable. Design Criteria N4-50-D717 also indicates an allowable stress for the faulted condition of 1.6 times the normal condition AISC allowable. However, ITT Grinnell Corporation load ratings for component standard supports are based on a comparable load factor for the upset condition of 1.0 per ASME, Section III, Division 1, subsection NF, and a faulted load factor which ranges lower than 1.6 as per Appendix F, ASME, Section III, Division 1, code.

A. Spring Hangers:

A separate load table for each analysis problem is generated for selecting spring hangers. Dead load on the support is determined by a rigorous flexibility analysis of the system. Design travel is determined by enveloping the movement from the specified thermal operating modes analyses. If the design travel exceeds a specified limit (usually 1 inch), a constant support hanger is specified. Maximum travel at the spring hanger is specified to ensure the spring does not bottom out during design transients and seismic events. Spring hanger design meets all code requirements and is in accordance with good design practice.

B. Snubbers:

A separate load table for each analysis problem is generated for selecting snubbers. OBE, Safe Shutdown Earthquake (SSE), and other applicable dynamic loads are provided. Design travel is determined by enveloping pipe movements at the snubber support point from the specified operating modes analyses. The support designer selects a snubber from snubber capacity which meets or exceeds the specified loads and travel requirements. Snubber selection meets all code requirements and is in accordance with good design practice.

C. Struts:

A separate load table for each analysis problem is generated for design of rigid type supports. A strut or a built-up structural steel support is considered a rigid support. To meet the 2/3 of critical buckling stress, the design load is multiplied by the following factors. (Refer to Attachment 1 for derivation of factors.)

Slenderness Ratio	Multiply Design Load By	Resulting Multiple Stress Allowable
1 to 60	1.43	1.11
61 to 120	1.31	1.22
>120	1.25	1.28

As indicated by the resulting multiple stress allowable for any load combination including faulted condition mechanical plus restraint of free end displacement loads, the maximum allowable stress in a strut is only 1.28 times the normal load rating.

A review of ITT Grinnell's standard support data for struts indicates that all struts have a faulted condition load rating greater than 1.28 times the normal load rating. The 1/3 increase in allowable stress for the upset load condition as discussed in part 1 of this NCR is in effect negated for struts. If the upset mechanical load combination governs and a strut with a very high slenderness ratio ($l/r > 120$) is specified, the allowable stress is 1.33/1.25 or 1.064 times Appendix XVII. The 6.4-percent margin is well within the accuracy of our calculations. The primary upset stress allowable for a reasonable length strut is less than 1.0.

Therefore, all strut designs meet code allowable stress and are within the support contractor's load rating.

Table 1
Comparison of Design of Linear Type Supports By Analysis

Condition/ System Load	ASME - NF 1974 through Summer 1982	ASME - NF Design Work Group Proposed 10/17/79	NRC Reg Guide 1.124 Nov. 1976	AISC Proposed Nuclear Code	NRC Standard Review Plan Section 3.8.3, July 1981	TVA Bellefonte Nuclear Plant
Normal						
Mechanical	1.0(1)	Not considered	1.0(1)	1.0	1.0	1.0
Mechanical plus constraint of free end displacement	3.0(1)	1.0(1)	3.0(1,2)	1.5	1.5	1.5(1)
Upset						
Mechanical	1.0(1)	Not considered	1.0(1)	1.0	1.0	1.33(1)
Mechanical plus constraint of free end displacement	3.0(1)	1.33(1)	3.0(1,2)	1.5	1.5	1.5(1)
Emergency						
Mechanical	1.33(1)	Not considered	1.33(1,2,3)	not provided	not provided	Not considered
Mechanical plus constraint of free end displacement	Not considered	1.5(1)	Not considered			1.5(1)
Faulted						
Mechanical mechanical	$1.2\ S_y/F_t$ (1) $\leq 0.7 S_u/F_t$	Not considered	$1.2\ S_y/F_t$ (1,2,3) $\leq 0.7 S_u/F_t$	1.6(4,5) or 1.7	1.6(4,5) or 1.7	Not considered
Mechanical plus constraint of free end displacement	Not considered	$1.2\ S_y/F_t$ $\leq 0.7 S_u/F_t$	Not considered	Not considered	Not considered	1.6(1)

(1) Not to exceed 2/3 critical buckling.

(2) This allowable is a stress range.

(3) Component supports whose normal function is required during an emergency or faulted plant condition should be designed to normal and upset <u>or other justifiable</u> design limits.

(4) Coefficient in shear shall not exceed 1.4.

(5) LOCA loads may be combined with seismic loads; the SRSS may be used and a coefficient of 1.7.

Attachment 1

The multiplication factor to meet 2/3 critical buckling is based on the highest allowable stress multiple of 1.6 for the faulted load. They were derived by the following equation.

Beginning with the AISC equation for <u>normal</u> allowable compression stress (F_a)

$$F_a = \left[1 - (kl/r)^2/2C_c\right]F_y / \left[5/3 + 3(kl/r)/8C_c - (kl/r)^3/(8C_c^3)\right]$$

AISC Eq. 1.5-1

The components of AISC Eq. (1.5-1) are as follows:

1. Euler's equation = $\left[1 - (kl/r)^2/2C_c\right]F_y$

2. Variable factor of safety (FS) = $5/3 + 3(kl/r)/(8C_c) - (kl/r)^3/(8C_c^3)$

As kl/r approaches 0 the FS becomes:

FS = 5/3 or 1.67

As kl/r approaches 126.1 (the upper limit of AISC Eq. 1.5-1) the FS becomes:

FS = 1.92

Including the 1.6 faulted factor of safety in our support design load (P_s):

$$P_s = 1.6\ P_A \qquad \text{Eq. (1)}$$

The support design load is also limited to 2/3 CB:

$$P_s \leq 2/3\ CB \qquad \text{Eq. (2)}$$

Using figure 1, the CB may be equated to F_a:

$$2/3\ CB = 2/3\ (FS)(F_a) \qquad \text{Eq. (3)}$$

Combining equations (1), (2), and (3):

$$1.6\ P_A \leq 2/3(FS)(F_a) \text{ or}$$

$$F_a \geq 3(1.6)P_A/2(FS) \geq 2.4\ P_A/(FS) \qquad \text{Eq. (4)}$$

Therefore, by multiplying the computer generated analysis support load by a predetermined constant [3(1.6)/2(FS)] the resulting design load can be used to calculate a stress that may be compared to the normal AISC allowable compression stress (F_a).

For convenience, the constants were tabulated for a range of kl/r values (using the more conservative value).

Nomenclature:

CB = Critical buckling stress
C_c = Column slenderness ratio
F_a = AISC allowable axial c[illegible]pression stress
FS = Factor of safety
F_y = Yield stress
k = Effective length factor
l = Distance between braced cross sections
P_A = Piping analysis, computer generated, support load
P_s = Support design load
r = Radius of gyration

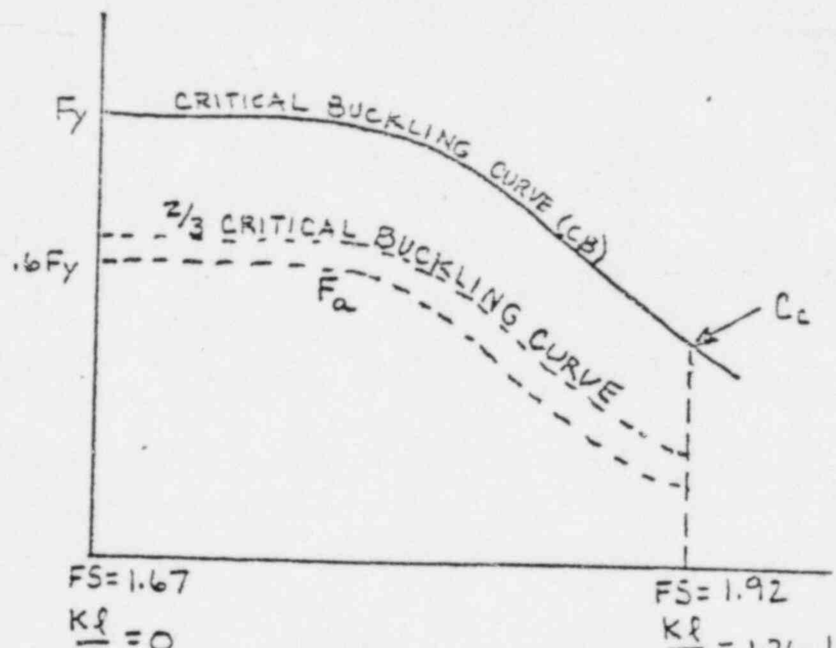

FIGURE 1