POWER SYSTEMS

NUCLEAR POWER SYSTEMS

COMBUSTION ENGINEERING, INC.
COMPONENTS ENGINEERING
Chattanooga, Tennessee

E-2805

EVALUATION OF PALISADES

AUXILIARY FEEDWATER PIPING

FOR A POSTULATED WATER HAMMER EVENT

SS-801		2966-B
CALCULATION NO.		CONTRACT NO.

PALISADES		STEAM GENERATOR
CUSTOMER		COMPONENT

P. L. Anderson	Principal Engineer	*4-19-84*
PREPARED	TITLE	DATE

J. P. Houstrup	Principal Engineer	*4-19-84*
CHECKED	TITLE	DATE
(Full Review)		

[signature]	Manager	*4-19-84*
REVIEWED	TITLE	DATE

APPROVED	TITLE	DATE

P.l. Anderson, 4-16-84	COMBUSTION ENGINEERING, INC. Chattanooga Nuclear Operations	SHEET _1_ OF _6_
PREPARED DATE		CALC. NO. SS-801
J. Houstrup 4-19-84	COMPONENT ENGINEERING	CONTRACT NO. 2966·B
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TITLE

SUMMARY AND CONCLUSIONS

The Palisades steam generator auxiliary feedwater piping is evaluated for a postulated water hammer event. The analysis addresses the axial stress resulting from a pressure pulse of 4000 psi lasting less than 0.001 sec. The predicted stress at the minimum cross-section is 31 ksi which slightly exceeds the minimum yield stress of 27.5 ksi at $532^{\circ}F$. This stress is significantly below the ultimate tensile stress of 60 ksi at temperature. In view of the ductility of the carbon steel material, the stress of 31 ksi (52% of S_u) is considered to be well below a damaging stress level.

A fatigue evaluation of 25 occurrences of the water hammer event indicates a negligible fatigue usage factor.

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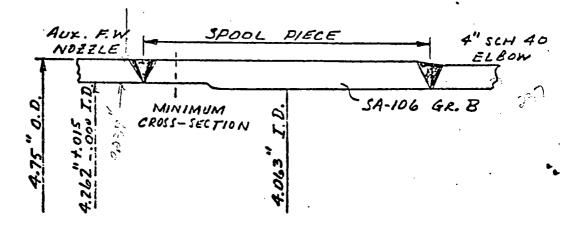| PREPARED | P.L. Anderson 4-19-87 DATE | COMBUSTION ENGINEERING, INC. Chattanooga Nuclear Operations | SHEET 2 OF 6 |
| CHECKED | J. Houstrup 4-19-86 DATE | COMPONENT ENGINEERING | CALC. NO. SS-801 CONTRACT NO. 2966-8 |

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INTRODUCTION

The purpose of this report is to evaluate a section of the
Palisades auxiliary feedwater piping for loads resulting
from a postulated water hammer event. The piping section
of concern consists of the horizontal run extending from
the auxiliary nozzle to the first downturning elbow
external to the generator. A water hammer event is
postulated to produce a pressure pulse of 4000 psi in the
horizontal pipe run. This analysis considers the stresses
resulting from the 4000 psi pressure pulse assuming that
the pipe and welds are in a virgin condition. Duration of
the pulse is 0.00083 sec.

PREPARED	DATE	COMBUSTION ENGINEERING, INC.	SHEET 3 . OF 6
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GEOMETRY AND MATERIAL PROPERTIES

The minimum cross-section of the piping occurs at the piping to nozzle weld.

For the minimum section

$$R_i = 2.139" \text{ (max)}$$

$$t = .236" \text{ (min)}$$

$$A_{min} = 3.35 \text{ in}^2$$

For the SA-106 Gr. B material at $532°F$ the ASME Code (Ref. 1) allowables are
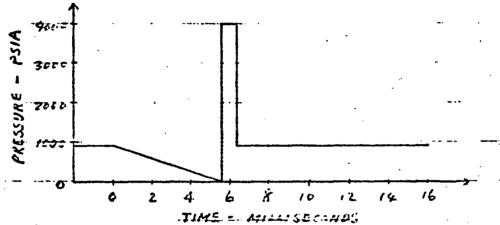
$$S_y = 27.5 \text{ ksi}$$? $S_y = 35.0 \text{ ksi}$

$$\sqrt{} S_u = 60 \text{ ksi}$$ Allowable stress $T \leq 650°F$
= 15.0 ksi

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CHECKED DATE		

TITLE

EVALUATION OF WATER HAMMER LOAD

Reference 2 describes the postulated water hammer event and presents the resulting pressure pulse.

The short duration pulse results in an axial load

$$F = PA \qquad AREA = \frac{\pi}{4}(4.262 + 0.015)^2 = 14.37 \text{ in}^2$$

Minimum cross-section

P = Peak Pressure = 4000 psi

A = Area of Pipe = πR^2 = 12.97 in^2

Considering the load to be suddenly applied and applying a dynamic amplification factor of 2 results in an equivalent static load

$$14.37 = 115 \text{ kips}$$

$$F_s = 2F = 2(4000)(12.97) = 104 \text{ kips}$$

The axial membrane stress at the minimum cross-section is

$$115/3.25 = 35 \text{ KSI}$$

$$S = F_s/A_{min} = 104/3.25 = 31 \text{ ksi}$$

This stress slightly exceeds the yield stress of 27.5 ksi, but is significantly below the ultimate stress of 60 ksi at temperature. In view of the ductility of the carbon steel material, the stress level of 31 ksi (52% of S_u) is considered to be well below a damaging stress level. ASME code rules for a faulted event, for example, permit a membrane stress of 70% of S_u with an adequate margin of safety.

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PREPARED P.L. Anderson 4.19.51 DATE

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SHEET 5 OF 6

CALC. NO. 55-801

CONTRACT NO. 2966-8

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FATIGUE EVALUATION

A conservative stress concentration factor of 4 applied to ~~70 ksi~~
the 31 ksi stress results in an alternating stress of 62 ksi.
Using the fatigue curves of Reference 1, the corresponding
allowable number of cycles is approximately 2000. For a few
cycles, for example 25 occurrecnes, the cumulative usage
factor

$$u = .0125$$

is negligible and fatigue damage is of no concern.

*How do we show
That the system has only experienced
a few cycles?
Can we anneal/stress relieve to return
to the "0" time condition?
Can we replace*

TITLE

REFERENCES

1. ASME B&PV Code, Section III for Nuclear Vessels and Addenda through Summer 1983.

2. CE Report 2966-PSAE-001, "Evaluation of Water Hammer within Steam Generator Feed Pipe", A. J. Sowers.