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March 22, 1976

Regulatory Docket File

Director of Nuclear Reactor Regulation
Att: Mr Robert A. Purple, Chief
Operating Reactor Branch No 1
US Nuclear Regulatory Commission
Washington, DC 20555

DOCKET 50-255, LICENSE DPR-20 -
PALISADES PLANT - CORRECTIONS TO ALLOWABLE
TUBE WALL DEGRADATION ANALYSIS

Our letter of February 12, 1976 transmitted a request titled "Analysis To Determine Allowable Tube Wall Degradation for Palisades Steam Generators." Following submission of this report, a number of errors have been observed.

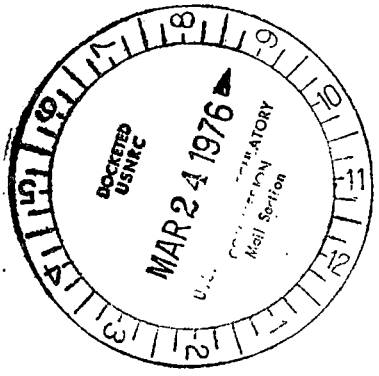
The following pages have been revised correcting these errors:

Title Page
Sheet 5
Sheet 6
Figure A.5
Figure A.6
Figure A.20
Figure B.4
Figure B.5

The border has been marked where changes were made and the corrected pages are attached.

David A. Bixel
Assistant Nuclear Licensing Administrator

CC: JGKeppler, USNRC



2957

POWER SYSTEMS

NUCLEAR POWER SYSTEMS

COMBUSTION ENGINEERING, INC.
COMPONENTS ENGINEERING
Chattanooga, Tennessee

E-2805

ANALYSIS TO DETERMINE ALLOWABLE TUBE WALL DEGRADATION FOR PALISADES STEAM GENERATORS

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January 29, 1976

Revision 1, March 5, 1976

4. DEVELOPMENT OF LOADS ON TUBES FOR LOCA AND SSE (Cont'd)

Here f is the friction factor (0.011 from the Moody diagram[14] for a Reynolds' Number of $.964 \times 10^6$, W the mass flow rate per tube (lbm/sec) and v the specific volume (ft^3/lbm) in flowpath 42, and D the tube diameter. Multiplication by the horizontal length between the ascending and descending tube legs yields the total friction force or drag on that section of the tube.

The magnitude of the horizontal component of the centrifugal force is given by

$$Fc(t) = \frac{1.273 \cdot W^2 v}{D^2 g}$$

This force was computed for each 90° bend and the algebraic sum applied to the tube. These computations are summarized in Figure B.4.

A parametric study was performed in order to identify a "worst case" in terms of the horizontal loading on the bend region of a critical tube row. Possible break locations and areas, and break opening times were chosen according to company standards.[15] Except where otherwise noted, all results shown are for tube row 114.

Results for different break types are summarized in Figure B.5, where it is seen that the most severe loading occurs for a double ended guillotine break in the cold leg, downstream of the generator. A comparison of the effect of such parameters as tube row (horizontal span length), number of tubes, and break opening time upon results for the cold leg guillotine break are shown in Figure B.6. Here ΔP_{max} is seen to increase with tube row and decrease with both the number of functioning tubes and the break opening time.

From this parametric study, the base case for detailed structural analysis was taken to be as follows:

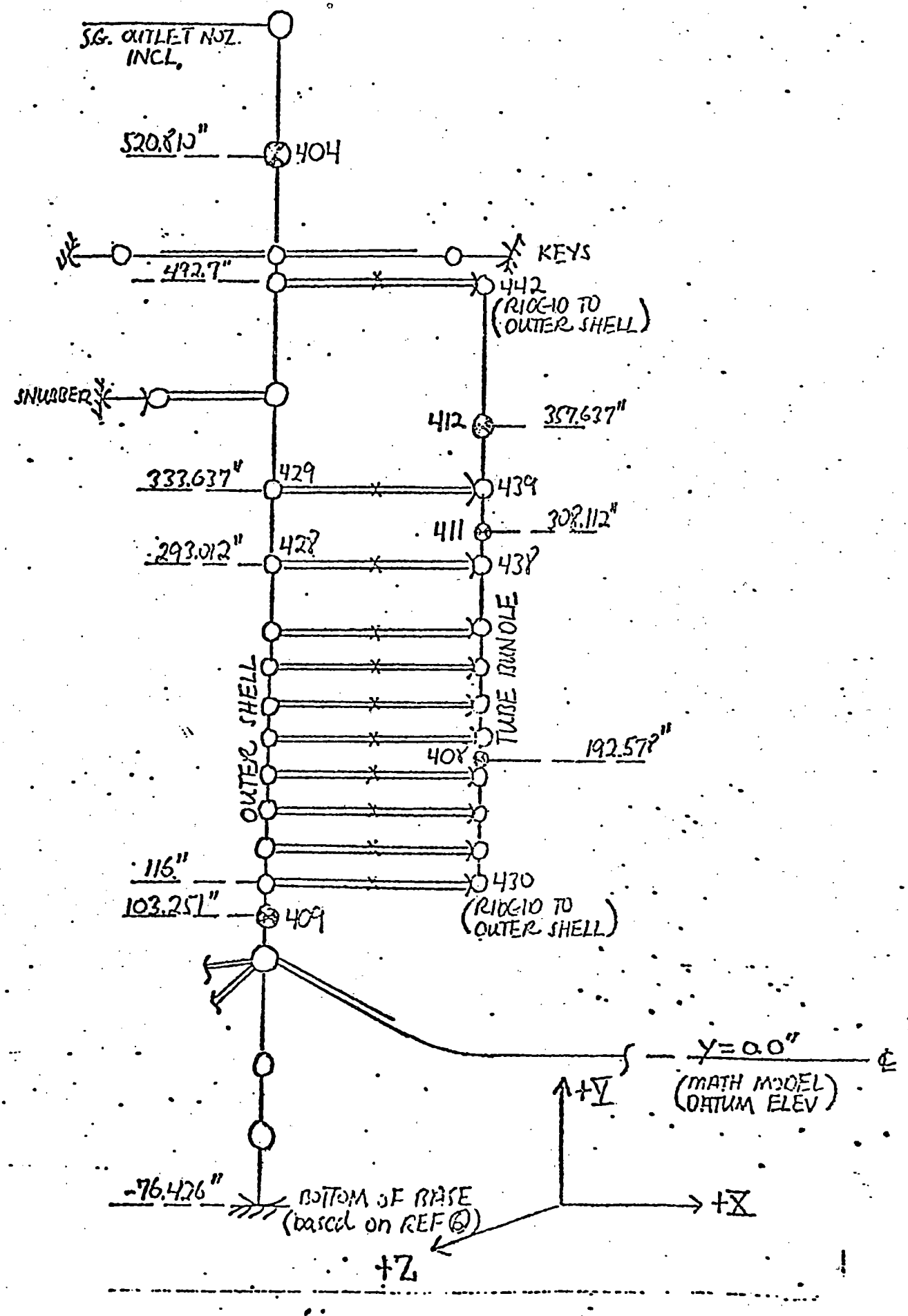
cold leg guillotine break

4. DEVELOPMENT OF LOADS ON TUBES FOR LOCA AND SSE (Cont'd)

tube row 114
6742 tubes
break opening time 0.010 secs.

The absolute pressue history during the transient for Nodes 37 and 42, the nodes in the two 90° bends of tube row 114, are shown in Figure B.7 and the relative pressure differente acting between them is shown in Figure B.8. The maximum difference is 185 psi. The corresponding pressure force, the fluid friction and centrifugal force histories are shown in Figure B.9. The algebraic summation of these component forces to produce the net LOCA induced hydraulic loading on the horizontal portion of the tube is also presented in Figure B.9. The maximum resultant loading is 56.0 lb.

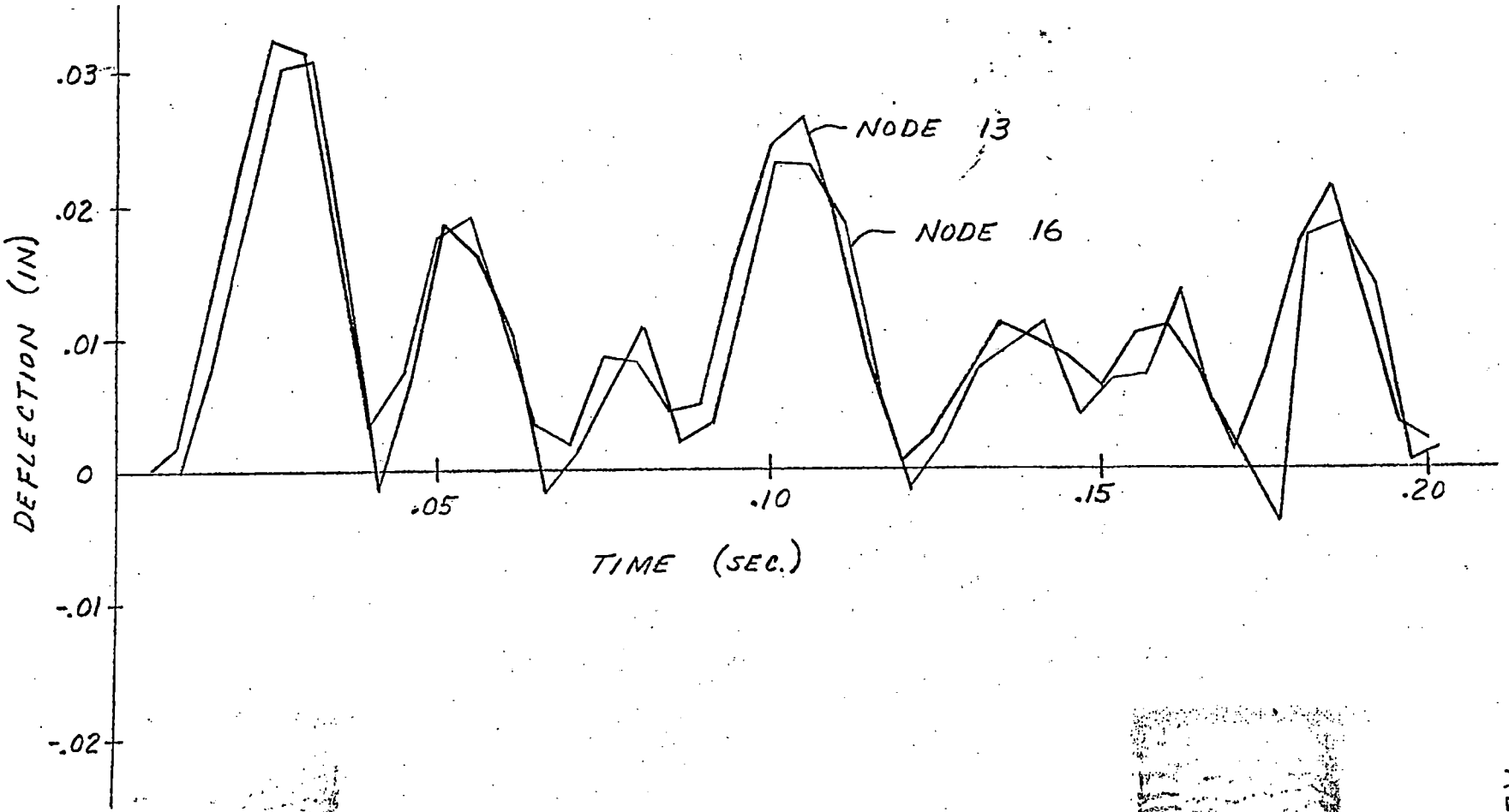
STEAM GENERATOR STRUCTURAL JOINTS AND MASS POINTS



LOCA SHAKING

DISPLACEMENT HISTORY

X DIRECTION

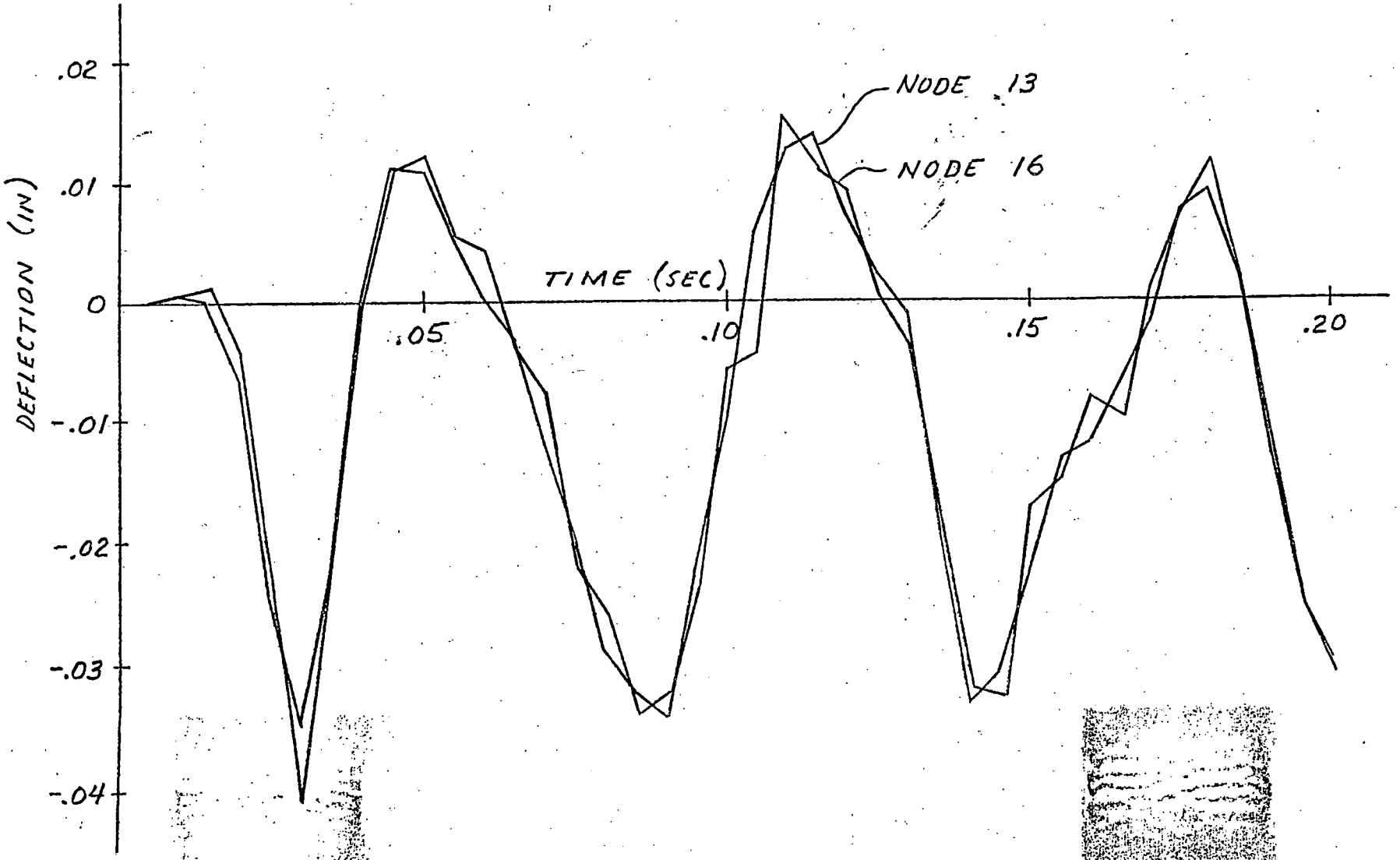


A.5
REV. 1

LOCA SHAKING

DISPLACEMENT HISTORY

Z DIRECTION



A.6
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ALLOWABLE STRESS FOR TUBE MATERIAL

MILL TEST REPORT

	NUMBER OF SAMPLES	ULTIMATE TENSILE (RT) NO. BELOW 90 KSI	% BELOW 90 KSI	MINIMUM VALUE
A-UNIT SAWHILL TUBULAR PRODUCTS	278	1	0.4	88.0
B-UNIT PACIFIC TUBE COMPANY	603	7	1.1	87.5
TOTAL	881	8	0.9	87.5

BASED ON CURVES FROM:

NUCLEAR SYSTEMS MATERIALS HANDBOOK

FOR OPERATING TEMPERATURE OF 600°F

S_u = 80.0 KSI

FROM SECTION III ASME CODE:

S_m = 23.3 KSI AND S_y = 27.9 KSI, 600°F

FROM APPENDIX F TO SECTION III FOR FAULTED CONDITIONS:

ALLOWABLE $S_{MEMB} = .7\ S_u = 2.4\ S_m = 56$ KSI

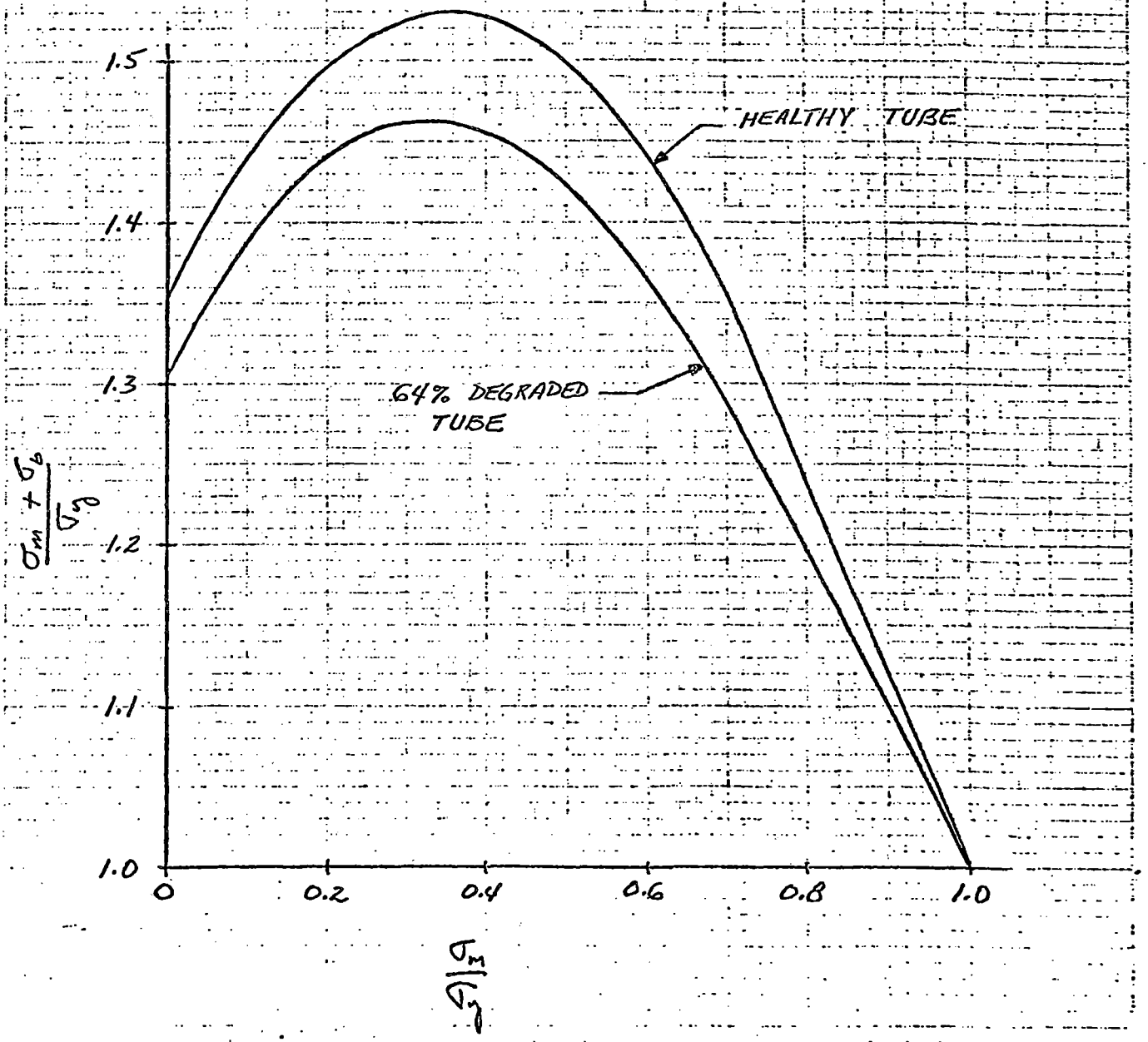
ALLOWABLE $S_{MEMB + BEND} = f_s\ (S_{MEMB}) = 1.44(56) = 80.6$ KSI

WHERE f_s IS THE SHAPE FACTOR FROM FIG. A.21

EVALUATION PER NRC STAFF (KNIGHT'S) CRITERIA

	1. NORMAL OPERATION	2. NORMAL OPERATION	3. STEAMLINE BREAK
	$\sigma < S_y = 27.9$ ksi, 600°F	$3\sigma < S_u = 80.0$ ksi, 600°F	$\sigma < .7S_u = 56.0$ ksi, 600°F
	$t_r = \frac{\Delta P\ R_i}{S_y - 0.5(P_1+P_2)}$	$t_r = \frac{3\ \Delta P\ R_i}{S_u - 0.5(P_1+P_2)}$	$t_r = \frac{\Delta P\ R_i}{.7S_u - 0.5(P_1+P_2)}$
SPECIFICATION OPERATING CONDITIONS P_1 = 2150 PSI P_2 = 770 PSI ΔP = 1380 PSI	$t_r = \frac{1.38\ (.327)}{27.9 - 0.5(2.92)}$ $t_r = 0.017$ % Allow. Degradation $\% = \frac{.048 - .017}{.048}$ % = 64	$t_r = \frac{3(1.38)(.327)}{80.0 - 0.5(2.92)}$ $t_r = 0.017$ % Allow. Degradation $\% = \frac{.048 - .017}{.048}$ % = 64	$t_r = \frac{2.15\ (.327)}{56.0 - 0.5(2.15)}$ $t_r = 0.013$ % Allow. Degradation $\% = \frac{.048 - .013}{.048}$ % = 73
TODAY'S OPERATING CONDITIONS P_1 = 1850 PSI P_2 = 600 PSI ΔP = 1250 PSI	$t_r = \frac{1.25\ (.327)}{27.9 - 0.5(2.45)}$ $t_r = 0.015$ % Allow. Degradation $\% = \frac{.048 - .015}{.048}$ % = 68	$t_r = \frac{3(1.25)(.327)}{80.0 - 0.5(2.45)}$ $t_r = 0.016$ % Allow. Degradation $\% = \frac{.048 - .016}{.048}$ % = 66	$t_r = \frac{1.85\ (.327)}{56.0 - 0.5(1.85)}$ $t_r = 0.011$ % Allow. Degradation $\% = \frac{.048 - .011}{.048}$ % = 77

MEMBRANE AND BENDING INTERACTION



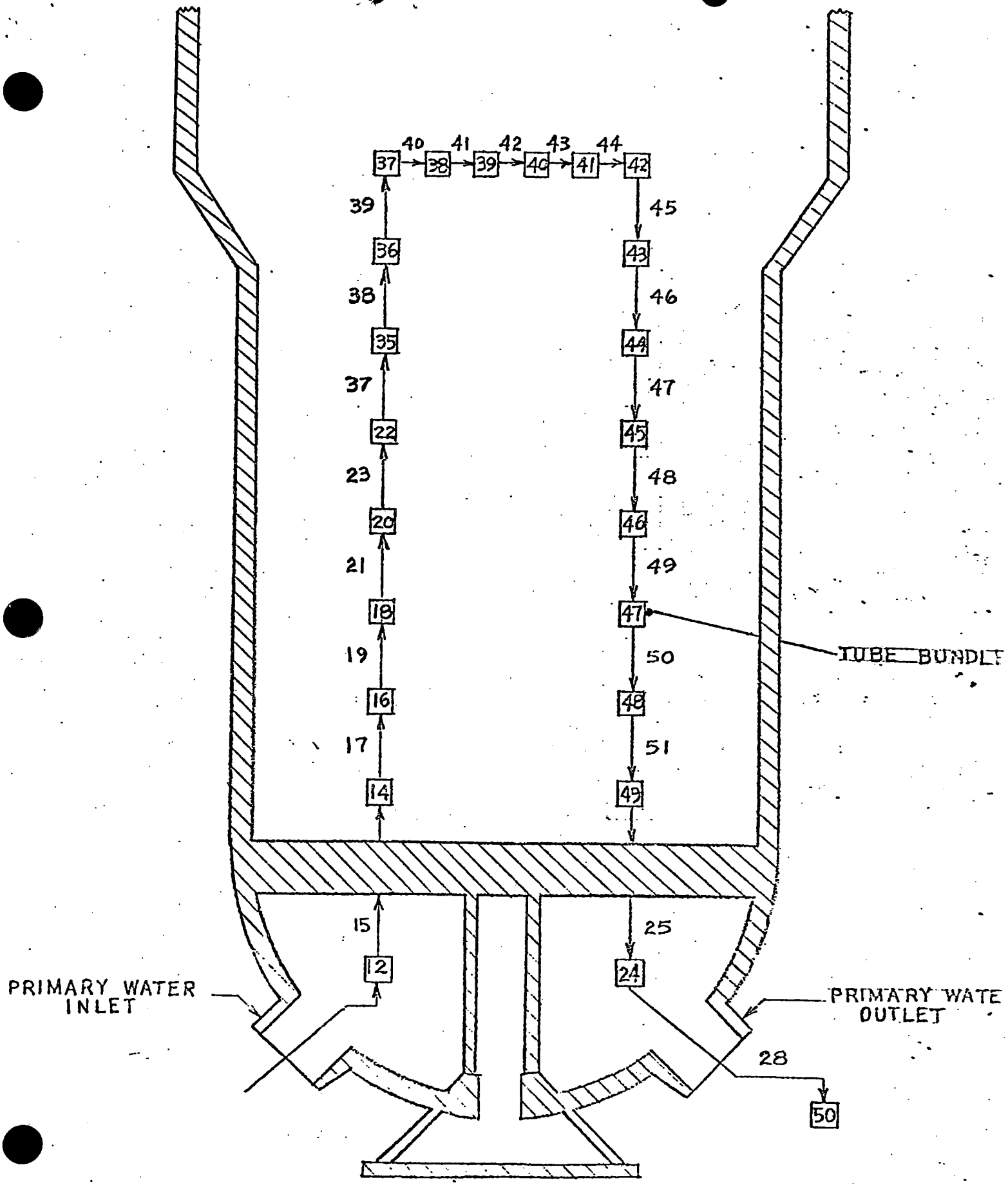


FIGURE B.3: FLASH STEAM GENERATOR DETAIL

$$F_{NET} = F_P - F_F - (F_{C_{X1}} - F_{C_{X2}})$$

$$F_{NET} = 60.8 - 3.5 - 1.2 = 56.1 \text{ LBF.}$$

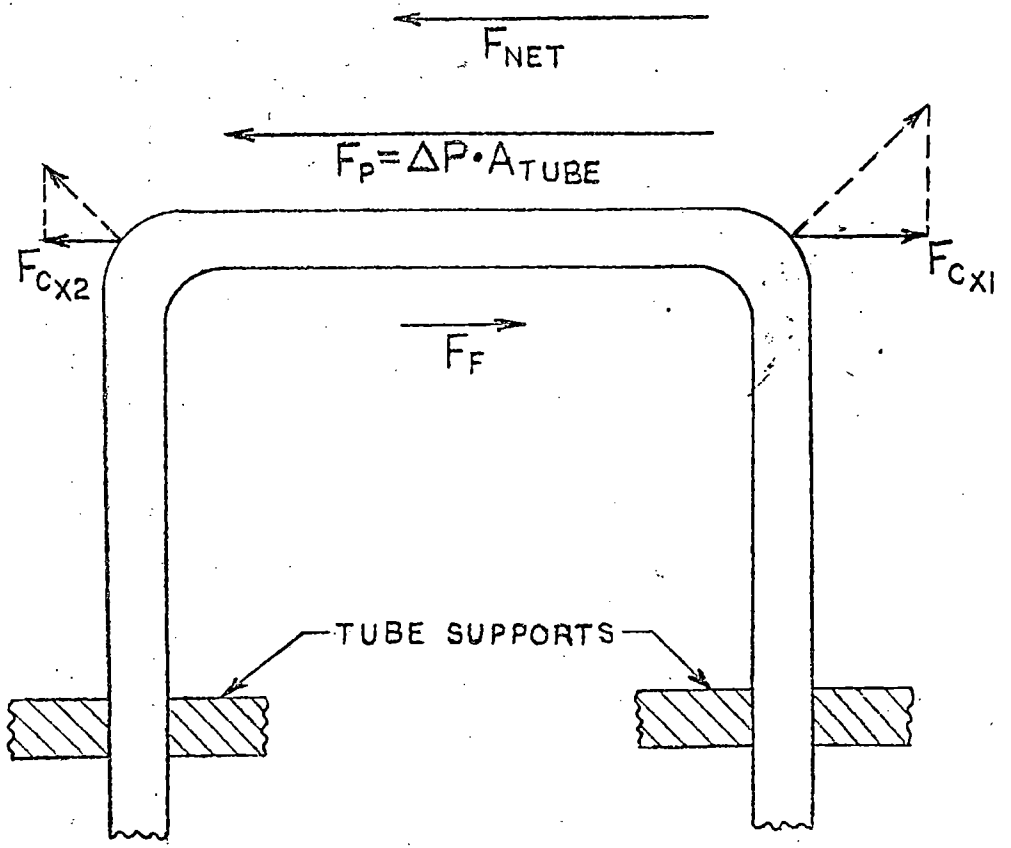


FIGURE B.4: FLUID FORCES ACTING ON TUBE

REV. 1

FIGURE B.5

PALISADES STEAM GENERATOR
COMPARISON OF POSTULATED LOCA BREAKS

TYPE OF BREAK	AREA IN^2	B.O.T. SEC X 10^3	ΔP_{max} psi	DURATION OF Δ PULSE (SEC)	AREA OF Δ PULSE (LB-SEC)
COLD LEG					
A) GUILLOTINE	707	10	185	0.0296	0.9189
B) SLOT	530	5.1	103	0.0420	0.7270
HOT LEG					
A) GUILLOTINE	425	15	-153	0.0258	-0.6630
B) SLOT	812	7.5	-130	0.0256	-0.5588

FIGURE B.6

PARAMETRIC STUDY OF LOCA LOADING

PARAMETER	IDEN.	ΔP_{max} (psi)	DURATION OF Δ PULSE (SEC)	AREA OF Δ PULSE (LB-SEC)
TUBE ROW	23: (27")	72.8	0.0319	0.3897
	114: (118")	184.6	0.0296	0.9189
	140: (144")	213.3	0.0294	1.0527
NUMBER OF TUBES	6742	184.6	0.0296	0.9189
	7380	173.7	0.0301	0.8791
BREAK OPENING TIME (SEC)	0.01	184.6	0.0296	0.9189
	0.005	187.0	0.0309	0.9697