Report No. [illegible]

PALISADES STEAM GENERATOR TUBE

EXAMINATION AND REPAIR

This [illegible] conclusions [illegible] corrosion at the Palisades plant of Consumers Power Company. The report is divided into five sections:

- Appendix I Examination of removed Palisades steam generator tubing
- Appendix II Effects of wall degradation on burst and collapse strength of steam generator tubing.
- Appendix III Tube Plugging Criterion
- Appendix IV Effect of Vibration on degraded tubing
- Appendix V Effects of tube plugging on power generation.

Appendix I details the results of inspection of corroded tubes removed from the Palisades steam generators. Comparison of these results with laboratory experiments indicates that further corrosion at Palisades can be curtailed or arrested by using volatile chemistry control of the steam generator secondary water.

Appendix II describes the mechanical strength test program for both artificially defected tubes and those removed from the Palisades steam generator. The data is utilized in Appendix III, which demonstrates that the actual criterion used for plugging tubes, degradation greater than or equal to 60% wall thickness, is conservative.

Appendix IV confirms that the chosen tube plugging criterion is satisfactory with respect to metal fatigue of the tubing.

Appendix V calculates the effect on steam generator performance of plugging tubes to the above criterion. No reduction below rated capacity exists.

54-255

COMBUSTION ENGINEERING, INC.

REPORT [illegible]

(Non-proprietary version of CEN-2(P))

<u>PALISADES STEAM GENERATOR</u>

<u>TUBE EXAMINATION AND REPAIR</u>

JANUARY, 1974

COMBUSTION ENGINEERING, INC.
NUCLEAR POWER SYSTEMS
WINDSOR, CONN.

APPENDIX I

EXAMINATION OF REMOVED

PALISADES STEAM GENERATOR TUBING

I. PALISADES STEAM GENERATOR TUBE EXAMINATION

Four Tubes were removed from the hot leg side of "B" and one each from the hot and [illegible] of "A" steam generator.

[illegible] tube-to-support plate [illegible]. [illegible] tube removal, detailed visual and eddy current examination revealed no evidence of tube wall cracking. It should be recognized that if cracks were present, their circumferential components would have been torn open during the pulling operation.

The wastage corrosion is identical to that reproduced in laboratory experiments. Metallographic cross sections showed no intergranular cracks or even incipient crevices. Photomicrographs revealed that the tubing was representative of that in accord with Combustion Engineering nuclear tubing specification.

Corrosion products were removed from the generators following tube removal. Sample locations and analyses are summarized in Table I and II.

II. EDDY CURRENT CORRELATION

In-generator eddy current measurements were correlated with physical measurements of wall degradation on sections of 4 tubes removed from the "B" steam generator. It was seen that in every instance the eddy current measurement over-predicted the extent of actual tube degradation. Thus, in-generator eddy current measurements provide conservatism in subsequent assessments of tube integrity.

III. CORROSION REVIEW

Localized wastage corrosion of Inconel 600 identified in Palisades was reproduced in laboratory experiments. Briefly, concentration of sodium phosphates and sodium hydroxide and subsequent formation of thermal by-products at pseudo-stagnant steam/water interfaces induced local attack of Inconel 600. The more stable this steam/water interface was, the greater the localized corrosion rate.

This localized Inconel 600 corrosion can be stifled or arrested. An experiment determined that even tube attack initiated at a stable steam/water interface (a particularly onerous concentrating mechanism), subsequently did not propagate in volatile control. Accumulations of injected pre-[illegible] corrosion products and salts from Lake Michigan water were purposely left on surfaces during this test, fouling support plates and [illegible] the concentrating devices. Thermal hydraulic conditions which previously induced wastage were identical to those for the volatile exposures wherein no evidence of additional attack could be identified.

It was concluded that Inconel 600 tube degradation initiated by concentration of sodium phosphate and sodium hydroxide and subsequent formation of thermal byproducts in steam blanketed regions had been terminated on switching to volatile chemistry control. Thermal hydraulic parameters were constant in both chemistry environments.

GAMMA SPECTROMETRIC ANALYSIS OF PALISADES SECONDARY CRUD SAMPLED DECEMBER 1973

SAMPLE LOCATION	ISOTOPES AND AMOUNTS (DPM/mg)	
	Co^{58}	Co^{60}*
1. Tube sheet, "B" generator	113	18
2. Support plate #1 (top) "B" generator	799	145
3. Support plate #2 (top) "B" generator	347	63
4. Support plate #3 (top) "B" generator	402	67
5. Composite	392	69

*May include some Fe^{59}

X-RAY FLUORESCENCE ELEMENTAL ANALYSIS
OF PALISADES SECONDARY CRUD
SAMPLED DECEMBER 1973

SAMPLE LOCATION*

ELEMENT	TUBE SHEET	PLATE #1	PLATE #2	PLATE #3	COMPOSITE
Aluminum	0.24	0.28	0.54	0.062	0.59
Silicon	0.31	0.30	0.34	0.041	0.31
Phosphorus	2.8	2.4	2.4	2.4	2.3
Sulfur	0.057	0.051	0.076	0.062	0.054
Chlorine	0.012	0.020	0.019	0.019	0.017
Potassium	0.007	0.009	0.008	0.009	0.007
Calcium	6.7	6.2	5.1	5.6	5.4
Titanium	0.072	0.072	0.062	0.083	0.072
Manganese	0.70	0.65	0.58	0.74	0.72
Iron	Major	Major	Major	Major	Major
Cobalt	0.11	0.097	0.11	0.12	0.053
Nickel	2.9	2.9	3.7	2.9	3.2
Copper	14.2	15.8	16.1	17.1	14.4
Zinc	3.3	3.1	2.9	2.6	3.2
Cadmium	0.019	0.029	0.019	0.029	0.029
Tin	0.087	0.12	0.076	0.065	0.098
Lead	0.035	0.035	0.035	0.029	0.035

*All values reported in percentages.

AND COLLAPSE PRESSURE OF INCONEL 600T STEAM GENERATOR TUBING

RODUCTION

allowable limit for wall reduction in Inconel 600T tubing prototypic the Palisades steam generators has been established through an experimental gram. Degraded tubing was tested under biaxial tensile loads to simulate response to a main steam line break (MSLB) and under biaxial compressive ds to simulate the response to a Loss of Coolant Accident (LOCA). In ition, the effects of tube ovality and the transient loading expected during B or a LOCA have been determined. Both artificially defected tubes and tions of tubes removed from the Palisades "B" steam generator were tested. completeness a wide variety of artificially defected tubes were tested. expected and subsequently observed type of corrosion defect was of a eral wastage nature. Three separate general wastage geometries were pro- ed for testing:

An elliptical, spark discharge machined defect with a major axis of 1-1/2 inches and a minor axis of 3/4 inch.

A 1/2 inch, 360° milled defect.

A 1-1/2 inch, 360° milled defect that was included as a possible worst case.

n testing of the actual Palisades tubing, it was found that the results best related with those from the [ ] defects, as expected.

test outset tube cracking could not be completely ruled out prior to visual ination of tubes removed from the Palisades steam generators, therefore onel 600 tubes were intergranularly cracked and tested. (No intergranular other crack forms were detected by visual or metallographic examination tubes subsequently removed from Palisades steam generators). The cracking accomplished by exposing pressurized furnace sensitized tubes to [ ] acid.

tests were performed on 0.750" OD, 0.048" nominal wall Inconel 600T steam erator tubing produced either by [ ] or by [ ].

S ON ARTIFICIALLY DEFECTED TUBING

Transient Studies

The 360° degraded tubes were subjected to stress transients calculated to be typical of a MSLB or a LOCA. The test procedure for the MSLB is as follows:

Primary (water) and secondary (gas) pressures are raised simultaneously to [illegible] psig. Primary pressure is then raised to [illegible] psig.

Gas pressure is bled off.

After secondary (gas) pressure has gone to zero, primary (water) pressure is held.

n simulation of the LOCA transient, the following procedure is followed:

<u>Collapse (LOCA) Test</u>

Primary (gas) and secondary (water) pressures are raised simultaneously to 1000 psig.

Gas pressure is bled off

After primary (gas) pressure has gone to zero, secondary (water) pressure is held.

ter subjecting the defected tubing to these transients, the tube specimens re removed and examined. The results are presented in Table I and indicate at only the [ ] defected tube showed any deformation. Sample C, under a B simulation, plastically deformed about [ ]. The insensitivity of Inconel) to the mild stress transient is not surprising when it is recognized that is material is routinely explosively formed.

<u>MSLB Simulation</u>

Standard burst tests on the tubes were performed in air at both room temperature (RT) and 600°F to determine the allowable wall degradation lim The pressurizing medium was water or inert gas at RT and inert gas at 600° The burst test results for Lot A and Lot B non-degraded tubing are shown in Table II. The minimum burst pressures observed for Lot A tubing were [ ] psi at RT and [ ] psi at 600°F. Minimums for Lot B were [ ] ps at RT and [ ] psi at 600°F. Previous work done by CE indicated that conservative minimum burst pressures for any Inconel 600T tube of this size made to CE's specification would be [ ] psi at RT and [ ] psi at 600°

The results of the elliptical defect burst tests are summarized in Table III. Similar information for the 360° defects is shown in Table IV. All this data is plotted in Figures 1-3. The description of the various lines are as follows:

1. Average burst pressure for this lot

2. Minimum burst pressure for this lot

3. Estimated minimum burst pressure for any lot

B. MSLB Simulation (continued)

This estimate was derived on the basis of the maximum burst pressure deviation observed from lot to lot in full wall tubing.

In addition, the measured burst pressures at room temperature for the cracked tubing are presented in Table V and Figure 4. The scatter is greater in this case due to uncertainties in measuring the initial crack length. All crack lengths were measured to ensure conservatism so that the presented results represent a conservative estimate of the relationship between burst pressure and wall degradation. Nevertheless, these results are similar to those obtained for the [ ] defect, as represented by the dashed lines on Figure 4. This behavior is consistent with the well-documented resistance of Inconel 600 to notch sensitivity.

Figures 1-5 allow an estimate of the allowable wall degradation for the different defect geometries as a function of imposed stress. The horizontal line on the graph represents the current primary system maximum pressure of 2150 psi.

C. LOCA Simulation

Collapse tests were conducted to determine the allowable wall thickness in the event of a LOCA. These tests were performed at RT. The results were extrapolated to 600°F by means of ratioing code calculations at RT and at 600°F. The expected collapse pressure at 600°F is [ ] of that at RT. The collapse results are presented for the 360° and elliptical defects in Tables VI, VII and VIII. The results are presented graphically in Figures 5 and 6. The full wall tube results are taken from a previous CE study.

The horizontal lines are drawn at 900 and 770 psi and indicate wall wastage in excess of [ ] may be safely sustained. Upon collapse of the [ ] defected tubes, ruptures only occurred in tubes with [ ] or greater wall reduction.

A further consideration is the effect of ovality on collapse pressures. This is of particular importance in U-bend regions where the fabrication process induces a small initial ovality. Tests performed previously indicate that in the U-bend region, geometric stiffening offsets the ovality caused by forming so that collapse pressures are identical with those of straight tubes. In general, this testing indicates that the collapse pressure of a perfectly round tube, P could be related to that of an oval tube P_o by:

$$\frac{P_o}{P} = [\quad\quad\quad]$$

where X is the percent ovality.

III. [illegible]

As described in an earlier section, four tubes were removed from the Palisades "B" steam generator. From these, 10-14 inch long tube burst specimens were sectioned so as to position the most highly defected regions in the center of the specimen. The samples were descaled using the cleaning solution and burst tested at 600°F. A photograph of the defected samples after bursting is presented in Figure 7. Defect regions [ ] were included. The measured burst pressures and eddy current indications of the maximum wall reduction are presented in Table IX. Before use, correction for the strain hardening that occurred during the tube pulling operation must be made. As shown in Figure 8, a sample was sectioned longitudinally and a hardness traverse made. This traverse include a region which had suffered a [ ] wall reduction. These hardness measurements then were used to predict the local increase in tensile strength caused by the local strain hardening. The maximum hardness variation observed was f a Rockwell B (R_B) of [ ] in the undisturbed region increasing to a R_B of [in the most heavily wasted area. As presented in Figure 8, this represents a tensile strength variation of from [ ] to [ ] ksi or of [ ]. Based on this result, all measured rupture strengths on defected tubing were reduced by [ ], as shown in Table IX. The corrected data is plotted in Figures 9 and 10 in comparison with the 1-1/2, 360° defect data and with the combined elliptica and 1/2", 360° defect results. Agreement is seen to be better with the [ ] defect results. This direct correlation of tube burst properties from actual degraded tubing with those from the artificially defected tubing establishes that the laboratory results are directly applicable for determini the allowable amount of wall reduction. Figures [ ] and [ ] will be used for determining allowable wall reduction under burst or collapse conditions.

IV. CONCLUSIONS

The allowable wall thinning for a variety of reactor conditions are presented in Table X. These results are based on the experimental results which inclu tests on both artificially defected tubes and actual tubes removed from the Palisades "B" steam generator. These results indicate that wall reduction of [ ] could withstand either a MSLB or a LOCA.

TABLE I

Inconel 600 Tubing - Heat [illegible]
3/4" x 0.04[illegible]" Wall Nominal
0.745" x 0.051" Wall Actual Tubing Tested

Sample #	± .001 X, Init., in.	Wall, Reduced, in.	% Wall Deg.	X", Final in
1	0.730	0.043	15.7	
2	0.730	0.043	15.7	
3	0.710	0.033	35.3	
4	0.710	0.033	35.3	
5	0.690	0.023	54.9	
6	0.690	0.023	54.9	
7	0.674	0.015	70.6	
8	0.674	0.015	70.6	

Odd numbered samples - Collapse Test

Even numbered samples - Burst Test

[illegible]

BURST TESTS

NONDEGRADED TUBING

0.750" OD, 0.043" to 0.051" WALL

ROOM TEMPERATURE

BURST PRESSURES, psi

Lot A	Lot B

600°F

BURST PRESSURES, psi

Lot A	Lot B

BURST TESTS

ELLIPTICAL DEFECTS

ROOM TEMPERATURE

SAMPLE NO.	% WALL DEGRADATION	BURST PRESSURE, psi
21	66	
29	66	
30	68	
7	76	
9	78	
16	86	
20	86	

600°F

SAMPLE NO.	%WALL DEGRADATION	BURST PRESSURE, psi
23	70	
24	68	
25	70	
28	68	
1	78	
2	80	
4	80	
12	84	
5	86	
15	88	
18	90	
19	88	

BURST TEST

CIRCULAR DEFECTS

ROOM TEMPERATURE

1-1/2" AXIAL LENGTH DEFECT

SAMPLE NO.	%WALL DEGRADATION	BURST PRESSURE, psi
50	70	
51	70	
52	70	
53	70	
60	80	
61	80	
62	80	
63	80	
70	90	
71	88	
72	90	
73	90	

600°F

SAMPLE NO.	%WALL DEGRADATION	BURST PRESSURE, psi
54	72	
57	72	
58	72	
59	70	
64	80	
65	80	
66	80	
67	80	
75	90	

TABLE [illegible] (CONT.)

1/2" AXIAL LENGTH DEFECT

600°F

SAMPLE NO.	% WALL DEGRADATION	BURST PRESSURE, PSI
115	70	
116	70	
117	70	
118	70	
119	70	
124	80	
125	80	
126	80	
127	80	
128	80	
134	90	
135	90	
137	90	
138	90	
139	94	

TABLE V

BURST TESTS

INTERGRANULARLY CRACKED SAMPLES

ROOM TEMPERATURE

% WALL DEGRADATION	BURST PRESSURE, PSI
85	
75	
75	
73	
73	
71	
69	
55	

COLLAPSE TESTS

ELLIPTICAL DEFECTS - 70% WALL DEGRADATION

ROOM TEMPERATURE

SAMPLE NO.	COLLAPSE PRESSURE, psi
81	
82	
83	
84	
85	
86	
87	
88	
89	

1-1/2" CIRCULAR DEFECTS - 70% WALL DEGRADATION

ROOM TEMPERATURE

SAMPLE NO.	COLLAPSE PRESSURE, psi
55	
56	

1/2" CIRCULAR DEFECTS - 70% WALL DEGRADATION

ROOM TEMPERATURE

SAMPLE NO.	COLLAPSE PRESSURE, psi
110	
111	
112	
113	
114	

[illegible]

COLLAPSE TEST

ELLIPTICAL DEFECTS - 80% WALL DEGRADATION

ROOM TEMPERATURE

SAMPLE NO.	COLLAPSE PRESSURE, PSI
90	
91	
92	
93	
94	
95	
96	
97	
98	
99	

1/2" CIRCULAR DEFECTS - 80% WALL DEGRADATION

ROOM TEMPERATURE

SAMPLE NO.	COLLAPSE PRESSURE, PSI
120	
121	
122	
123	

COLLAPSE TEST

ELLIPTICAL DEFECTS - 90% WALL DEGRADATION

ROOM TEMPERATURE

SAMPLE NO.	COLLAPSE PRESSURE, PSI
100	
101	
102	
103	
104	
105	
106	
108	
109	

1/2" CIRCULAR DEFECTS - 90% WALL DEGRADATION

ROOM TEMPERATURE

SAMPLE NO.	COLLAPSE PRESSURE, PSI
130	
131	
132	
133	

TABLE X

ALLOWABLE WALL DEGRADATION BASED ON

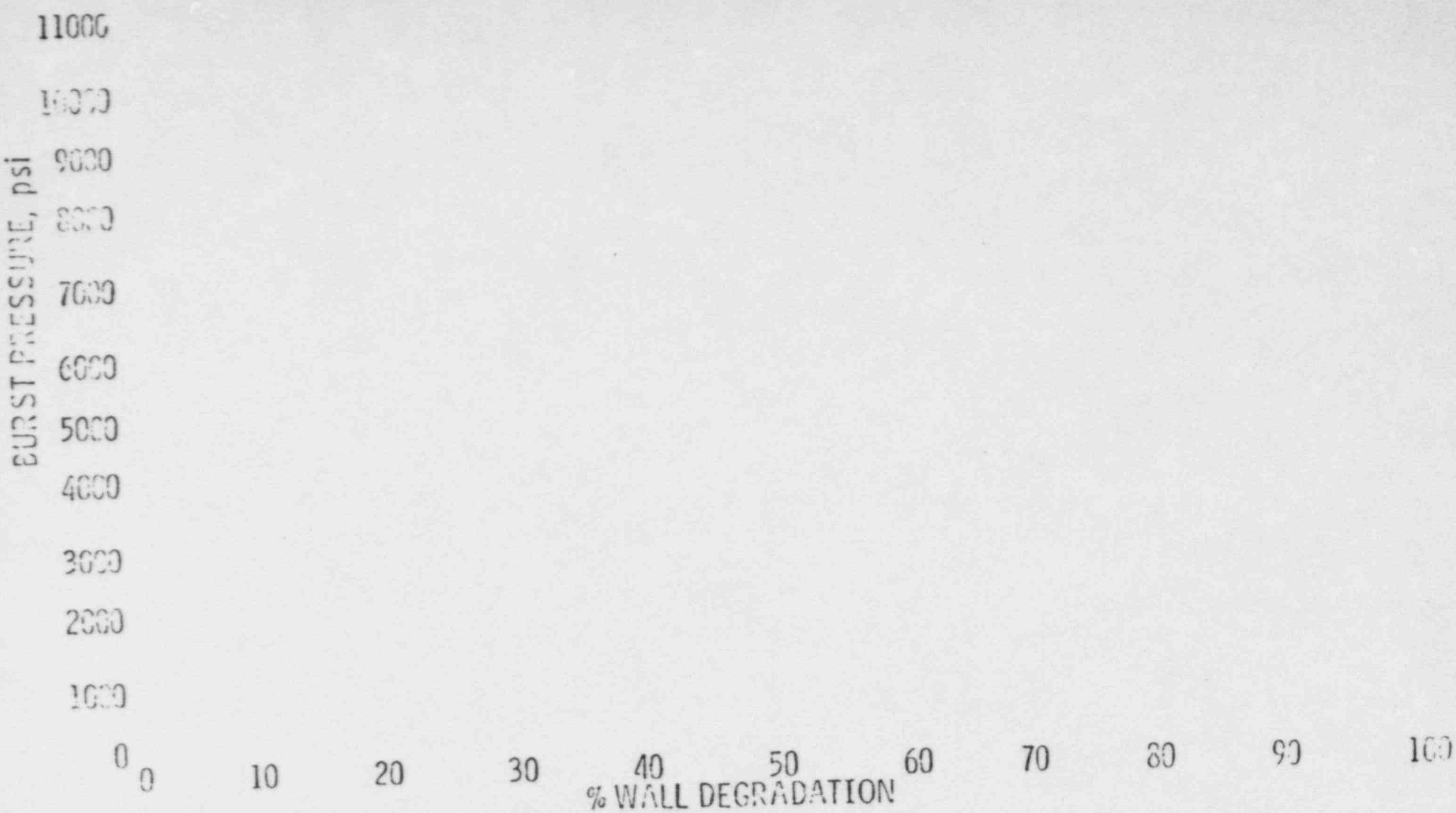
EXPERIMENTAL TUBE BURST AND COLLAPSE DATA

POSTULATED ACCIDENT	PRIMARY PRESSURE (PSI)	SECONDARY PRESSURE (PSI)	ALLOWABLE WALL DEGRADATION (%)
MSLB	1850	0	
MSLB	2150	0	
MSLB	2300	0	
LOCA	0	770	
LOCA	0	900	

[illegible]

ELLIPTIC[illegible]L DEFECT

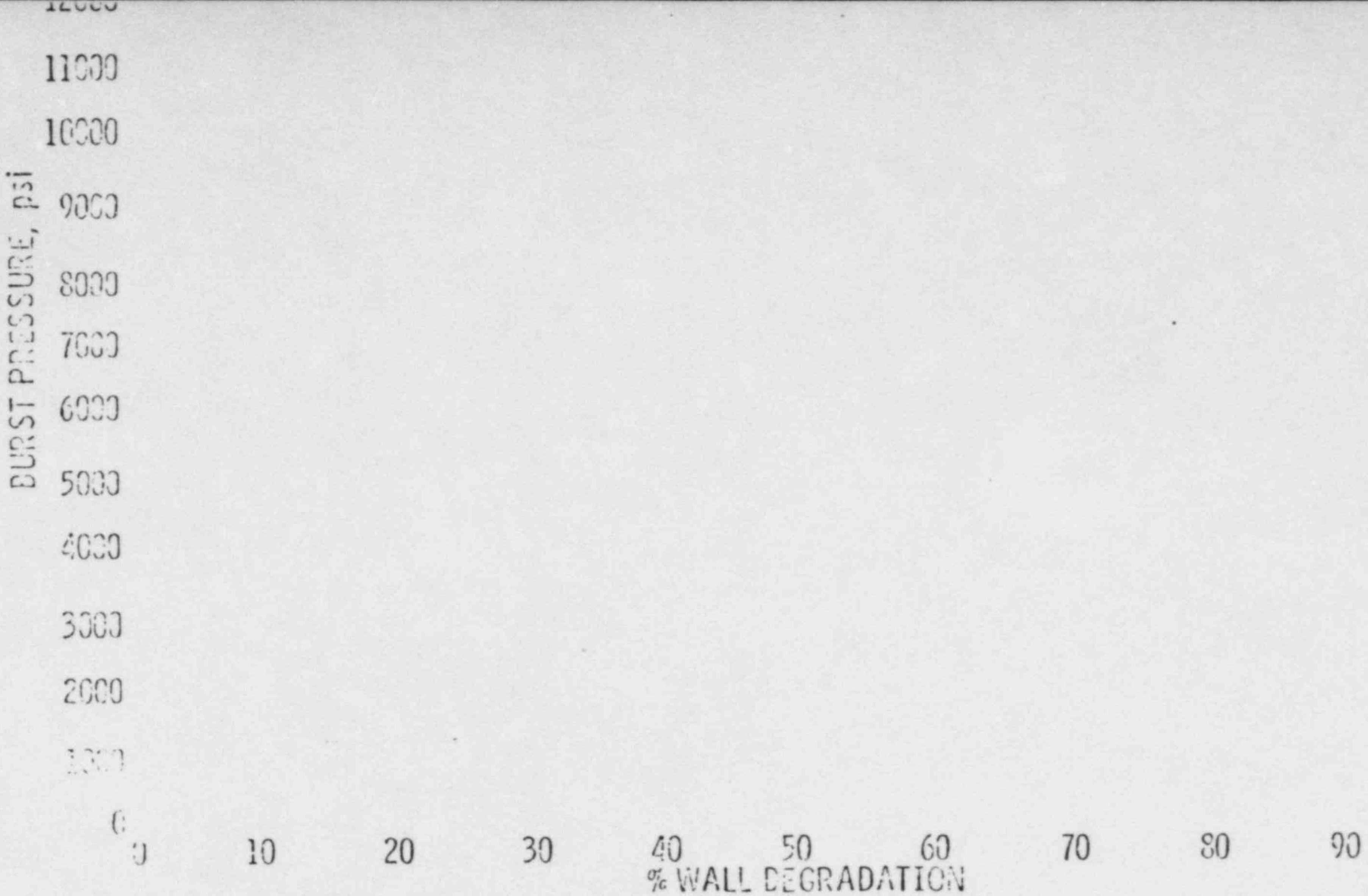
RT


BURST PRESSURE, psi
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
100
% WALL DEGRADATION

BURST PRESSURE .. % WALL DEGRADATION
ELLIPTICAL DEFECT
600 ^{o}F


BURST PRESSURE, psi
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
% WALL DEGRADATION

BURST PRESSURE vs % WALL DEGRADATION
1/2" LONG CIRCULAR DEFECT
600 °F


BURST PRESSURE, psi
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
0
10
20
30
40
50
60
70
80
90
% WALL DEGRADATION

1 1/2" CIRCULAR DEFECT
ROOM TEMPERATURE

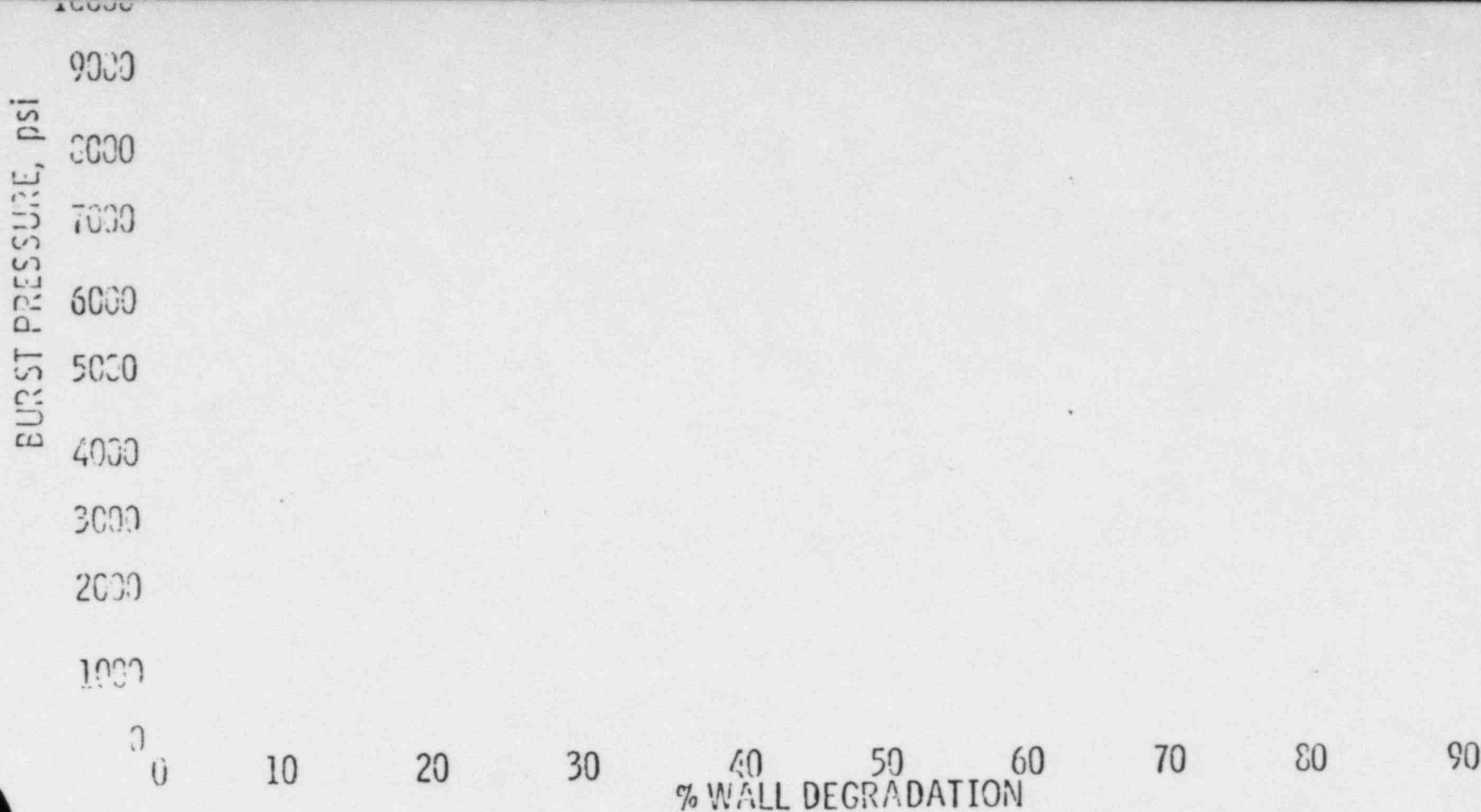
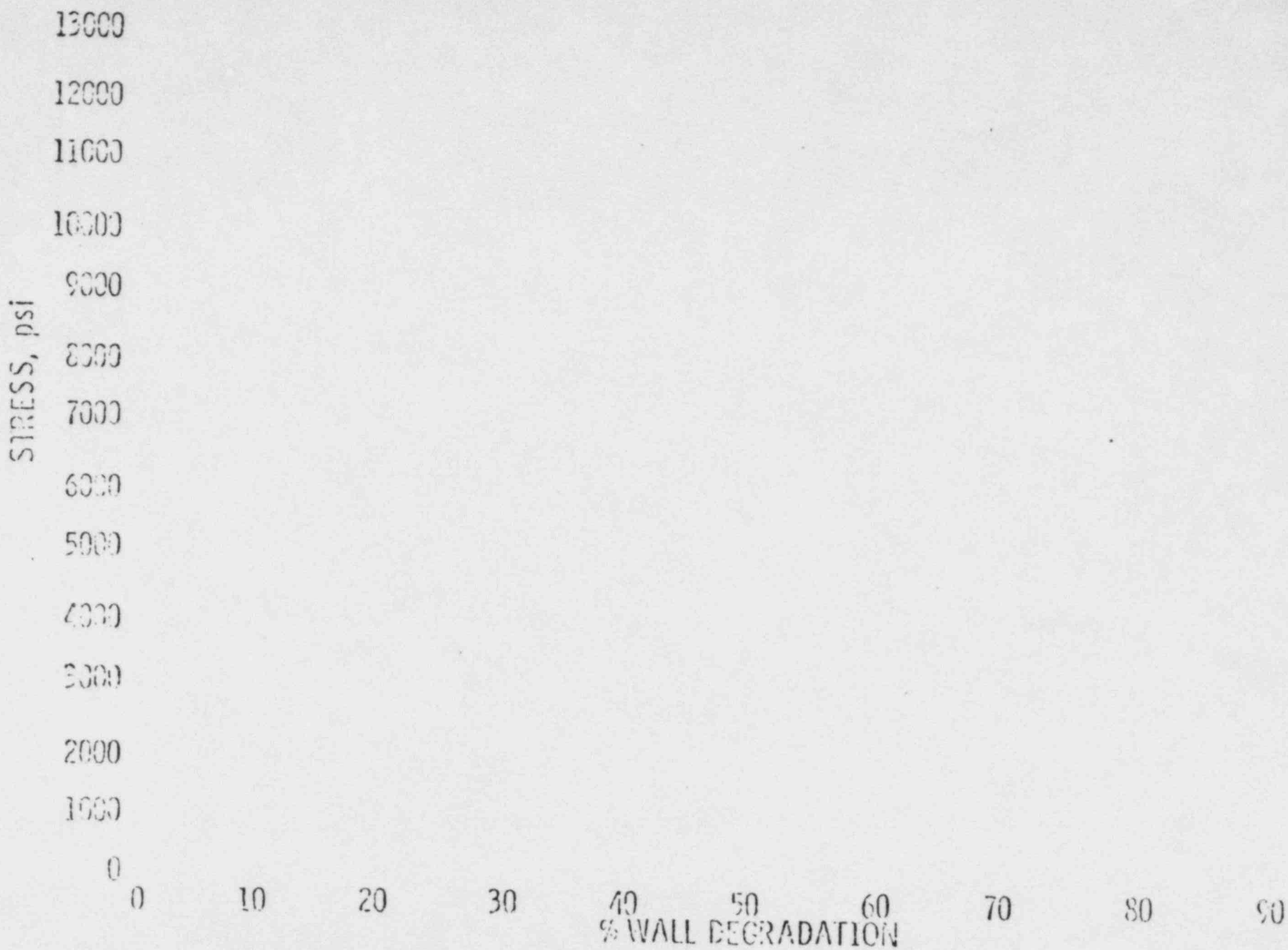

BURST PRESSURE, psi
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
% WALL DEGRADATION

Fig. 3A

600 °F

BURST PRESSURE, psi
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
100
% WALL DEGRADATION


13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
STRESS, psi
0
10
20
30
40
50
60
70
80
90
% WALL DEGRADATION

ELLIPTICAL DEFECT
ROOM TEMPERATURE

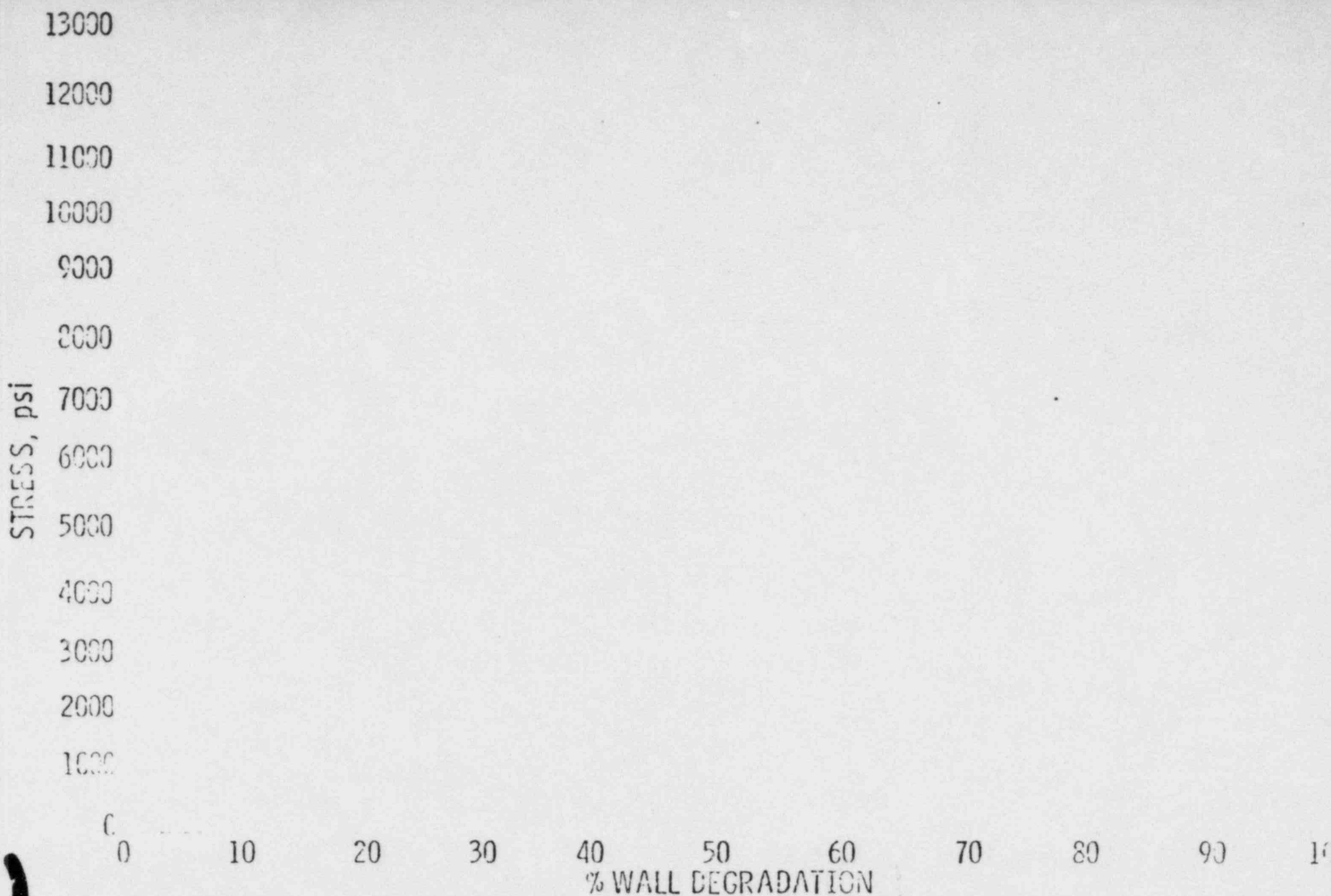

STRESS, psi
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
% WALL DEGRADATION

Fig. 5

COLLAPSE PRESSURE vs % WALL DEGRADATION

1/2" 360° DEFECT

RT

13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000

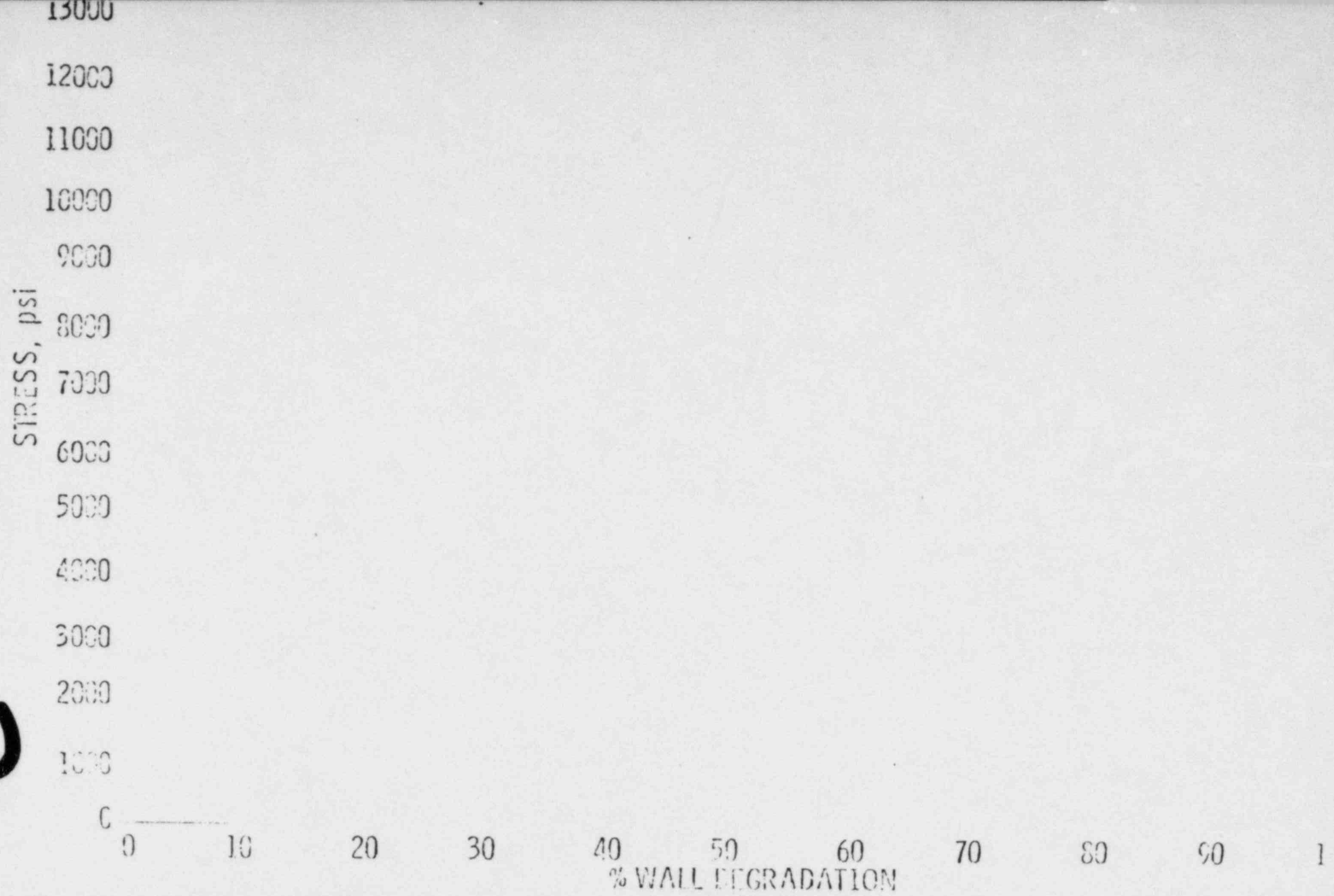
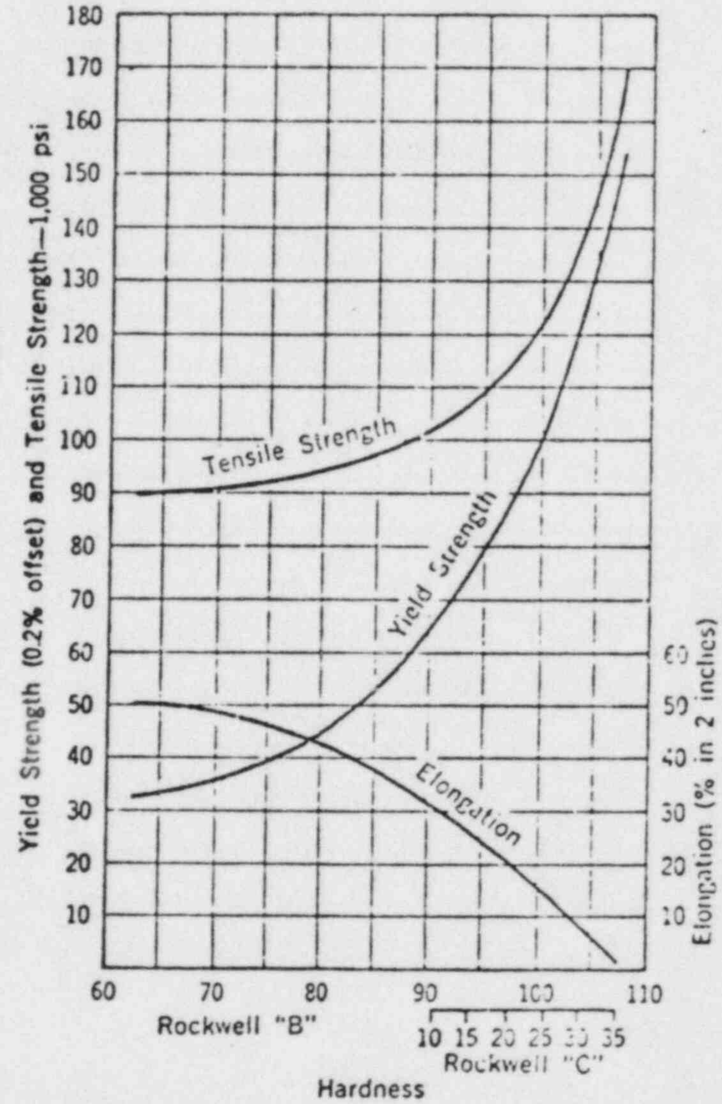

13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
STRESS, psi
0
10
20
30
40
50
60
70
80
90
1
% WALL DEGRADATION

Figure 7

TUBE BURST SAMPLES FROM ACTUAL PALISADES TUBING

Tube section
hardness, R_B



Average tensile properties of INCONEL alloy 600 sheet and strip.

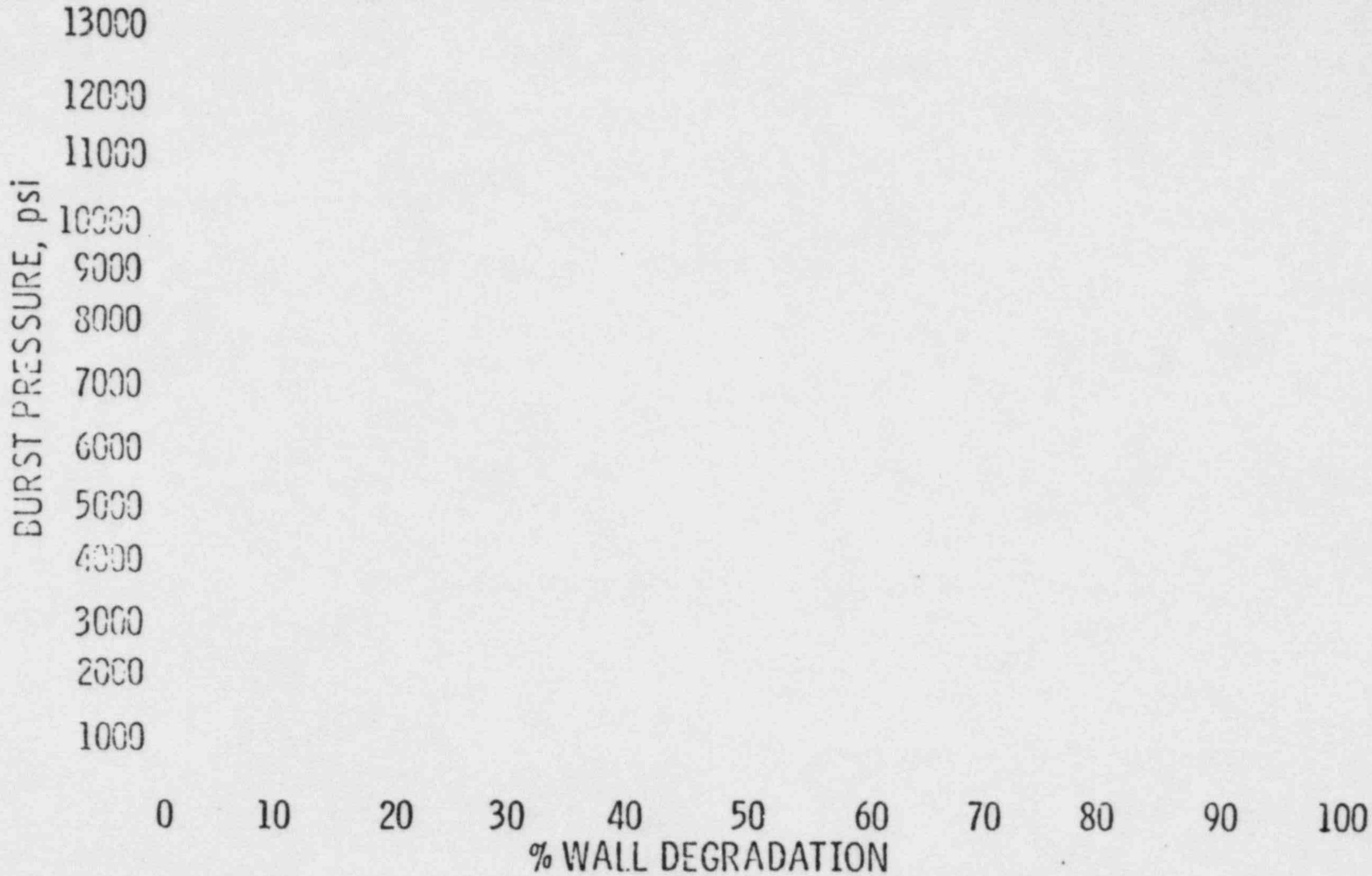
Figure 8

Hardness Profile of Removed Tube

BURST PRESSL E vs % WALL DEGRADATICN

CIRCULAR DEFECT

600 °F



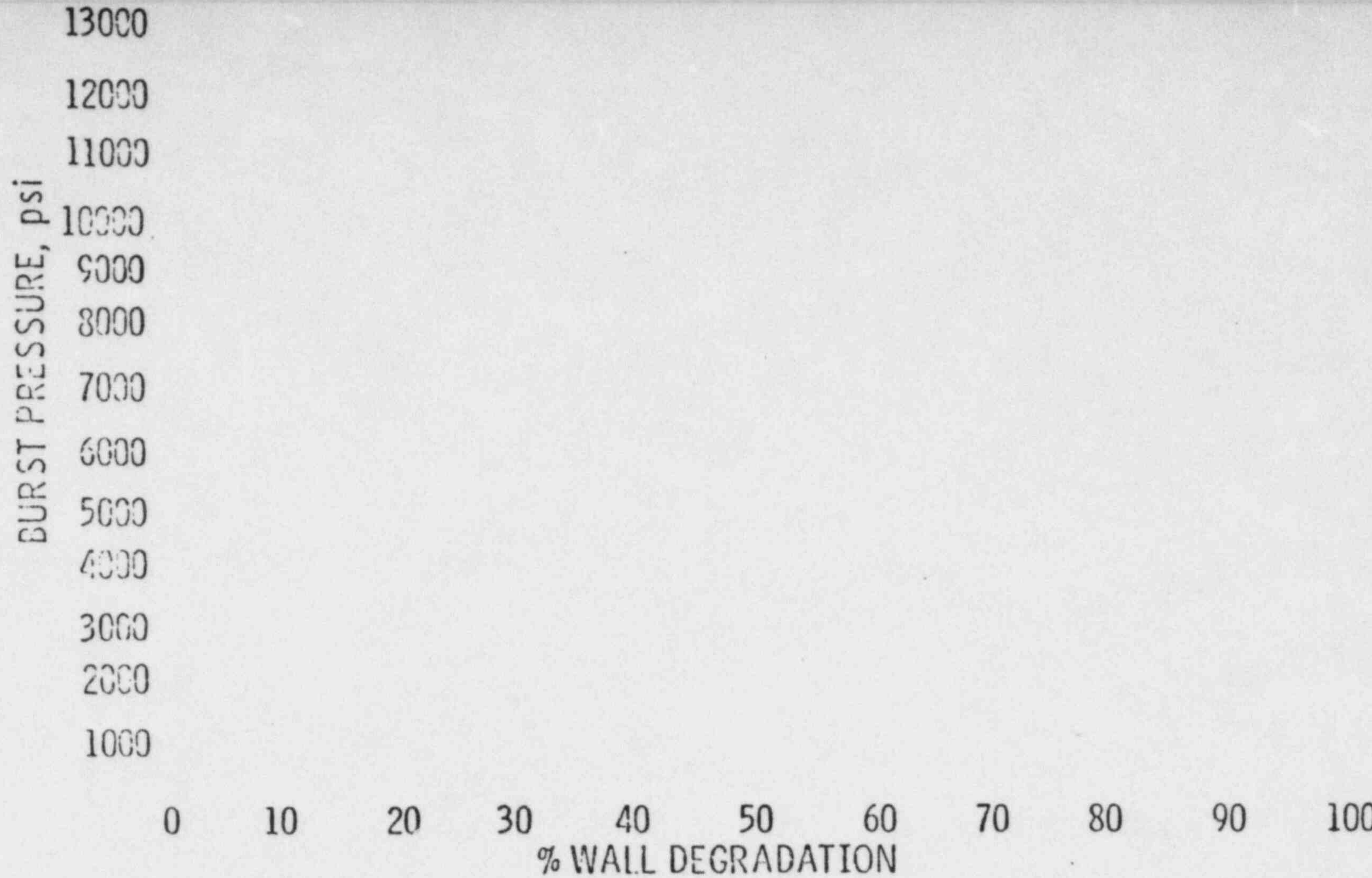

BURST PRESSURE, psi
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
10
20
30
40
50
60
70
80
90
100
% WALL DEGRADATION

Fig. 9

ELLIPTICAL DEFECT

600 °F


BURST PRESSURE, psi
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
10
20
30
40
50
60
70
80
90
% WALL DEGRADATION

P_1 = internal pressure

R = inner tube radius = 0.327 inch

P_2 = external pressure

Use of this equation leads to the results presented in Table I for different operational conditions. It should be noted that a primary system pressure of 1850 psi is intended for the near future. The 2150 psi maximum primary pressure is included for future application. The 2300 psi is included as a reference calculation.

3. Stresses imposed during a main steam line break (MSLB) or a loss of coolant accident (LOCA) shall not exceed 70% of those required for either collapse or rupture. The 70% value was selected on the basis of the margin of safety provided by the ASME pressure vessel code under faulted conditions.

   Application of this condition leads to the results presented in Table II. The MSLB results were taken from Figure[ ]and the LOCA numbers from Figure[ ]. The minimum numbers derived from the normal operation and accident analysis for the two pertinent reactor conditions are presented in Table III. For near term operation, the allowable wall degradation is found to be 75% The plugging of all tubes with 60% or greater degradation therefore yields a high degree of conservatism, since the available wall thickness is 60% greater than required above.

TABLE I

ALLOWABLE WALL DEGRADATION BASED ON TUBE PLUGGING CRITERION FOR STEADY STATE CONDITION

PRIMARY PRESSURE (PSI)	SECONDARY PRESSURE (PSI)	DIFFERENTIAL PRESSURE (PSI)	ALLOWABLE WALL REDUCTION (%)
2300	770	1530	
2150	770	1380	
1850	770	1080	

TABLE II

ALLOWABLE WALL DEGRADATION BASED ON TUBE PLUGGING CRITERION FOR ACCIDENT CONDITION

POSTULATED ACCIDENT	PRIMARY PRESSURE (PSI)	SECONDARY PRESSURE (PSI)	ALLOWABLE WALL REDUCTION
MSLB	1850	0	
MSLB	2150	0	
MSLB	2300	0	
LOCA	0	770	
	0	900	

TABLE III

TUBE PLUGGING CRITERION FOR NEAR-TERM OPERATION WHERE:

PRIMARY PRESSURE	2150 PSI	1850 PSI
SECONDARY PRESSURE	770 PSI	770 PSI
ALLOWABLE WALL REDUCTION		

APPENDIX IV

EFFECTS OF VIBRATION IN DEGRADED TUBING OF PALISADES STEAM GENERATORS

The approach of the C-E vibration analysis of the Palisades steam generator is to demonstrate that either the natural frequencies of tube spans are removed from the exciting frequency by a significant separation factor or that the stresses on tubes resulting from vibratory excitation are small with respect to the endurance limit of Inconel. This approach is still valid when considering the tubes in a degraded condition. In this report stresses are evaluated with consideration given to the decrease in strength due to 60% tube degradation. The results of this study indicate that no vibratory damage will occur to tubes of 60% or less degradation.

Plugging of all tubes with 60% and greater eddy current test indications will remove an additional [ ] tubes from heat transfer service in the A steam generator,[ ] tubes in the B steam generator. In combination with the tubes previously plugged (Rows 1 - 11) the active heat transfer surface has been reduced to approximately [ ] ft^2 in the A steam generator and [ ] ft^2 in the B steam generator.

The Palisades steam generators, as originally installed, had considerable excess heat transfer surface. Considering the operating parameters specified in the original equipment specification, a large margin of excess heat transfer surface still remains, more than [ ] tubes in each steam generator. The original operating parameters are:

$Q = 4.181 \times 10^9$ Btu/hr

$W_p = 62.25 \times 10^6$ lb/hr

$T_{hot} = 598.5^oF$

$T_{cold} = 547^oF$

Primary Pressure = 2100 psia

Secondary Pressure = 770

The operating limitations currently imposed on the Palisades Plant result in operating parameters as listed below:

$Q = 3.775 \times 10^9$ Btu/hr (2200 MWt)

W_p = [ ] $\times 10^6$ lb/hr*

$T_{cold} = 530^oF$ maximum

Primary Pressure = 1800 psia

* The primary flow rate listed is a conservative estimate. Measured primary flow prior to shutdown was [ ] x 10^6 lb/hr.

With all tubes containing 60% and greater ECT indications plugged, CE estimates steam pressures under the above conditions to be [ ] psia for the A steam generator and [ ] psia for the B steam generator.

END

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