B. D. Liaw

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON, D.C. 20545

File

December 6, 1974

12/23/74

DOCKET NOS. 50-282
50-306

LICENSEE: Northern States Power Company

FACILITY: Prairie Island Nuclear Generating Plant

SUMMARY OF NOVEMBER 25, 1974 MEETING

The purpose of the meeting was to discuss current information concerning steam generator tube corrosion. A list of attendees is attached as Enclosure 1. A meeting agenda is attached as Enclosure 2. A copy of slides presented is attached as Enclosure 3.

A summary was presented of the results of burst tests, collapse tests, and hydraulic leakage tests performed on 7/8-inch OD, Inconel-600 tubes having defects simulating those found in Westinghouse steam generators. Tube sizes in Westinghouse steam generators are either 7/8-inch (OD) for Series 44 and Series 51 (as in Prairie Island) or 3/4-inch OD for Model B.

Significant data and conclusions were presented on slides, copies of which are in Enclosure 3. Additional information presented during the meeting is summarized below.

1. The tube defects were of three types: flat surfaces machined from the tube outer surface to reduce the wall thickness simulating general corrosion over a large area; part-through-wall axial cracks, 3/8-inch wide, formed by electrostatic discharge machining (EDM), and; through-wall narrow cracks having dimensions shown on slides 13 and 14.

2. The maximum size inservice defects observed by Westinghouse were part-through-wall defects 1-1/2 inches long and through wall cracks 0.3 inches long.

3. Westinghouse calculated that a 7/8-inch OD tube uniformly thinned to 0.021 inches (~40% of the nominal 0.50 inches) would not fail under the combined loading of LOCA and the safe shutdown earthquake (SSE). Using minimum mechanical properties of inconel, a uniformly thinned wall of 0.028" (56% of nominal) is required for this loading. The maximum stress for this loading

E-1

would occur at the U-bend section of the tube. The stress at the tube sheet would be sufficiently lower that a tube uniformly thinned to 25% of its nominal thickness would not fail under loads of combined LOCA and SSE. Westinghouse estimates that the dish-shaped geometry of the defects would provide a 1.33 reinforcing faction at the U-bend so that the minimum wall thickness at a defect near the U-bend section should be equal to or greater than 30% of the original wall thickness.

4. For a steam line break, Westinghouse calculates that a tube uniformly thinned to 25% of its nominal wall thickness would not fail under the resulting differential pressure loading for this accident. A tube with a through wall crack 0.6 inches long would not burst under the maximum potential pressure differential following this accident (2500 psi) but leakage would increase above that for the normal operating pressure differential as indicated in Slide 13. For 1500 psid, the measured leakage rate in a simulated crack was 1.5 gallons per minute (gpm).

5. Operating experience over the past several years indicates that a typical Westinghouse reactor will have leakage between the primary system and secondary system due to intergranular corrosion in the range of 60 to 100 gallons per day (gpd): (0.1 gpm = 144 gpd). The minimum detectable leakage is about 10 gpd.

6. Mr. Doug Fletcher (Westinghouse) said that eddy current readings indicating wall penetrations greater than 5% of the original thickness can be observed above background noise. However, inspectors cannot reliably interpret indications less than 20%. In the Prairie Island Unit 1 inspection, no indications above background (~5%) were detected. Tight intergrannular cracks cannot usually be detected. Intergrannular corrosion penetrating over a broad area, similar to the area found for general corrosion, can be detected.

7. Westinghouse has run laboratory tests for corrosion rate in boric acid, sodium hydroxide, and pure water and found a corrosion rate of about 2 mils per 40 years. Under no-fault secondary system conditions and using all volatile water treatment, Westinghouse expects a general corrosion rate of 2-4 mils/40 years. Under fault conditions (e.g., excessive inleakage from the main condenser), cracking due to caustic conditions is expected, but insignificant general corrosion. Beznau experience indicates that with caustic secondary coolant, through wall cracks can develop in 2-3 months.

8. For operation with all volatile treatment, Westinghouse recommends that main condenser tube leaks be repaired very soon after caustic is detected in the secondary coolant to prevent caustic cracking. In addition, primary to secondary leak rate should be monitored to detect through wall cracks if they should develop. Leaks greater than 1 gpm should be a criteria for reactor shutdown and the inspection and plugging of steam generator tubes. Westinghouse does not recommend full flow feedwater demineralizers because of the potential contamination of the secondary coolant with caustic when the resin becomes saturated.

9. Westinghouse said it may require several months of operation after changing to all volatile water treatment to clean phosphate out of system.

10. Westinghouse recommends that defective tubes found by eddy current inspections be plugged if less than 50% of the wall thickness remains and that all leaking tubes found by leakage tests be plugged.

L L Kintner

Lester L. Kintner, Senior Project Manager
Light Water Reactors Branch 2-2
Directorate of Licensing

Enclosures:
As stated

ENCLOSURE 1

AEC NSP MEETING - NOVEMBER 25, 1974

L. L. Kintner, AEC-L
R. M. Gustafson, AEC-L
Stephan Pawlicki, AEC-L
Karl Kniel, AEC-L
John Weeks, BNL
J. P. Knight, AEC-L-MEB
F. M. Almeter, AEC-L-MTEB
B. D. Liaw, AEC-L-MEB
J. M. Kovacks, AEC-L-MEB
D. N. Bridges, AEC-L-OPR
R. S. Bosnak, AEC-L-MEB
L. Frank, AEC-RO
P. E. Bobe, AEC- Reg-OOE
W. R. Rutherford, AEC-MEB
R. W. Reid, AEC-L
H. E. Chakoff, AEC-L-RP
H. M. Fontecilla, AEC-L-AAB
H. L. Brammer, AEC-L-MEB
J. Rajon, AEC-L-MEB
NCChoules, AEC-RO III
J. A. Dyer, AEC-RO
Karl V. Seyfrit, AEC-RO
Bart Buckley, AEC-L
Bernard Turorlin, AEC-L
Gerald Charnoff, Shaw, Pittman
Jay Silberg, Shaw, Pittman
Roland J. Jensen, NSP
Dale M. Vincent, NSP
Stanley N. Ehrenpreis, W, PWRSD
H. J. vonHollen, W - PWRSD
D. C. Marburger, W-PWRSD
J. L. Samios, W-PWRSD
G. L. Lidler, W-PWRSD
E. S. Katz, W-PWR
W. D. Fletcher, W, PWRSD
Martin M. Shrut, W
Ray Maccary, AEC-L
J. Gallo, AEC-OGC
O. G. Lewis, AEC-OGC

ENCLOSURE 2

AEC MEETING - 11/25 P.M.

AGENDA

I. Material Mechanical Properties and Code Acceptability

A. Mechanical Strength of Tubes (HVH).

1. Test Results of Intentionally-Defected Tubes (Bursting and Collapse)
2. Cracking vs. Thinning
3. Thru Wall Defect vs. Leak Rate Testing

B. Minimum Acceptable Wall Concept (DCM)

1. WCAP 7832 (LOCA Analysis)
2. Faulted Condition (30% of Wall Remaining) Related to ASME Code Allowable

C. Eddy Current Inspection (WDF)

1. Rationale for Reporting of Defects
2. Precision of Result
3. Accuracy of Result

D. Corrosion Rates (WDF)

1. Corrosion with AVT Chemistry
2. Why Phosphate Corrosion Rates are not Anticipated with AVT
3. Maintenance of the AVT Specifications

E. Plugging Criteria - HVH

1. 50% EC Indication for Thinning and Intergranular Corrosion
2. Leak Rate Experience with Intergranular Cracking

SUMMARY OF MECHANICAL TESTING PROGRAM

7/8" DIA. x .050" WALL INCONEL 600 TUBING

1. BURST TESTS - MACHINED FLATS — 3/4" ÷ 7/8" ϕ —
   LENGTH - 1/2" TO 9" LONG
   REF: H. B. ROBINSON LETTER - JULY 10, 1974

2. BURST TESTS - PART THRU WALL SLOTS 3/4" ÷ 7/8" ϕ + BOSS —
   LENGTH 1/2" TO 2" LONG
   REF: H. B. ROBINSON LETTER - OCTOBER 27, 1972

3. COLLAPSE TESTS -
   THRU WALL SLOTS - SINGLE & MULTIPLE
   PART THRU WALL SLOTS
   MACHINED FLATS
   LENGTH .8" TO 2" LONG

4. BULGE PRESSURE TESTS -
   THRU WALL CRACKS
   LENGTH .5" TO 2" LONG
   REF: H. B. ROBINSON LETTER - OCTOBER 27, 1972

5. LEAK RATE TESTS - THRU WALL SLOTS
   LENGTH .6" &.7" LONG
   REF: H. B. ROBINSON LETTER - OCTOBER 27, 1972

Up to 2,000 - 4,100

ENCLOSURE 3 (1)

SUMMARY OF RESULTS

1. Burst Tests - Machined Flats

Burst Pressure PSI @ Room Temp.	Length
3700	~~2"~~
4200	1"
6000	~~1"~~ 1/2"

Min. Properties @ 600°F

2500	2"

2. Part Thru Wall Slots

Results Same As Machined Flats

Conclusions: For Maximum Corroded Length in Plant (~ 1-1/2" Length) Tubes have strength substantially in excess of RCS Safety Valve Pressures ~ 2500 PSI

(2)

SUMMARY OF RESULTS

1. BURST TESTS - MACHINED FLATS

BURST PRESSURE PSI @ ROOM TEMP.	LENGTH
3700	~~2"~~
4200	1"
6000	~~1"~~ 1/2"
MIN. PROPERTIES @ 600°F	
2500	2"

2. PART THRU WALL SLOTS

RESULTS SAME AS MACHINED FLATS

CONCLUSIONS: FOR MAXIMUM CORRODED LENGTH IN PLANT (~ 1-1/2" LENGTH) TUBES HAVE STRENGTH SUBSTANTIALLY IN EXCESS OF RCS SAFETY VALVE PRESSURES ~ 2500 PSI

(2)

COLLAPSE TESTS

1. THRU WALL & PART THRU WALL CRACKS -

   COLLAPSE PRESSURE IN EXCESS OF 6500 PSI

2. MULTIPLE THRU WALL CRACKS

   TUBE PRESSURIZED EXTERNALLY TO 5000 PSI - NO COLLAPSE

3. MACHINED FLATS -

   2" LONG - 25% WALL REMAINING

   COLLAPSE PRESSURE > 2200 PSI

CONCLUSION: TUBES HAVE SUBSTANTIAL STRENGTH TO RESIST COLLAPSE IN EXCESS OF STEAM SIDE SAFETY VALVES - SET PRESSURE ~ 1200 PSI

MINIMUM ACCEPTABLE TUBE WALL THICKNESS

STEAM BREAK	-	25% REMAINING
LOCA + SSE	-	25-30% REMAINING

THESE VALUES APPLY FOR BOTH GENERAL CORROSION (FLAT DATA) OR FOR CRACKING (SLOT DATA)

BULGE TEST RESULTS & CONCLUSIONS

1. Crack Length at Normal Operating Pressure Differential (1500 psi)

   .9" Long (Minimum Properties)

2. Crack Length at Elevated Pressures

		Pressure	Length
Minimum Properties	-	2400 psi	.6"
Nominal Properties	-	3000 psi	.6"

3. Leak Rate at .6" & 1500 psi Differential Pressure

   1.5 GPM

TUBE PLUGGING CRITERIA

7/8" DIA. X .050" WALL INCONEL TUBING

1. ALL LEAKING TUBES ARE PLUGGED

2. MINUMUM ACCEPTABLE WALL THICKNESS FOR BOTH GENERAL CORROSION & CRACKING BASED ON FAULTED CONDITION ACCIDENTS

   LOCA & STEAM BREAK - 25% REMAINING

3. PLUGGING CRITERIA BASED ON EDDY CURRENT INDICATION OF 50% OR GREATER. (50% MINIMUM WALL REMAINING)

   ADDITIONAL MARGIN PROVIDED

4. CORROSION RATES ESTIMATED FOR PHOSPHATE CHEMISTRY NOT APPLICABLE FOR INTERGRANULAR CRACKING

5. LEAK RATES FOR CRACKS WHICH CAN SUPPORT FAULTED CONDITION ACCIDENTS (.6") ARE IN EXCESS OF RATES AT WHICH LEAKS WOULD BE REPAIRED.

(5)

SUMMARY OF CONSERVATISMS INCLUDED IN ANALYSIS

1. Tubing Has Consistently Been Produced With Nominal Rather Than Minimum Mechanical Properties.

2. General Corrosion Maximum Length is Approximately 1-1/2" However, Corrosion is Tapered & Point of Maximum Penetration is Over a Shorter Length.

3. E-C Inspection has Generally Overpredicted The Maximum Penetration.

4. Experience In-Plant P/S Leakage - Intergranular Corrosion

   A. Readily Detected & can be measured to as low as 10 GPD

   B. Process is orderly & remained at values of 60 - 100 GPD

   C. When leakage did increase - readily detected & normal operating procedures used to cool down plant.

   D. Examination of tubes indicated that cracks are thru wall when length is approx. .25" long.

   E. Leak rates for .6" crack - well in excess of rates at which leaks would be repaired.

(7)

TABLE IV-1

INCONEL 600
Tube Collapse Tests

0.87 inch OD by 0.048 inch wall

Specimen No.	Defect Type	Collapse Pressure (psi)	Maximum Pressure (psi)
3742-9-2-3	Unflawed	No collapse	10,000
3745-5-1	1.50 inch partial through wall flaw	6500	--
3742-12-1	1.50 inch partial through wall flaw	6900	--
3742-8-1	1.25 inch partial through wall flaw	8500	--
3742-5-3	1.50 inch through wall flaws	6900	--
3742-5-3	1.25 inch through wall flaw	7000	--
3742-12-5	0.80 inch through wall flaw	8650	--
3742-12-4	0.8 inch	7200	--
3742-9-2-4	Preflattened tube 0.560 inch across flats	1750	2200
3742-5-4	1.5 inch through wall flaw	No collapse	5000
3742-M	Ten 1.5 inch through wall flaws	No collapse	5000
4554-IAN-1	2.0 inch long flat 25% remaining wall	2400	2875
4554-IAN-2	2.0 inch long flat 25% remaining wall	2250	--
4554-IAN-3	two adjacent 2.0 flats 25% remaining wall	2275	--
4554-IAN-4	two adjacent 2.0 flat 25% remaining wall	2200	2400

Table III-1

BURST TESTS OF TUBES WITH THROUGH WALL SLITS
0.875" OD by 0.050" Wall

Specimen	Hydraulic	Pneumatic	Burst Pressure (psi)	Slit Length (inches)	Legend Fig. III-1
10-1.0-1	✓		1910	1.00	✓
10-1.5-1	✓		1230	1.50	✓
10-2.0-1	✓		870	2.00	✓
10-1.0-2		✓	1800	1.00	✓
10-1.5-2		✓	1200	1.50	✓
10-2.0-2		✓	770	2.00	✓
5-1.0-1	✓		1930	1.00	✓
5-1.5-1	✓		1230	1.50	✓
5-2.0-1	✓		895	2.00	✓
5-2.0-2	✓		800	2.00	✓
NOK e 274	✓	Oversize slot width	1230	1.50	✓
NOK b 274	✓		1380	1.06	✓
NOK f 191-254		✓	1350	1.50	✓
Virgin unflawed-1	✓		10,500		
Virgin unflawed-2		✓	10,500		
NOK unflawed g		✓	12,800		
NOK g 43-144		✓	Leaked at 4300	1/16 & 1/8 natural flaws	
.5-1	✓		4100	0.50	✓
.5-2	✓		3900	0.50	✓
.5-3	✓		4050	0.50	✓
.75-1	✓		2700	0.75	✓
.75-2	✓		2750	0.75	✓
.75-3	✓		2650	0.75	✓
20-1.5-1	✓		1060	1.50	✓
8-1.0-1A	✓		1000	1.00	

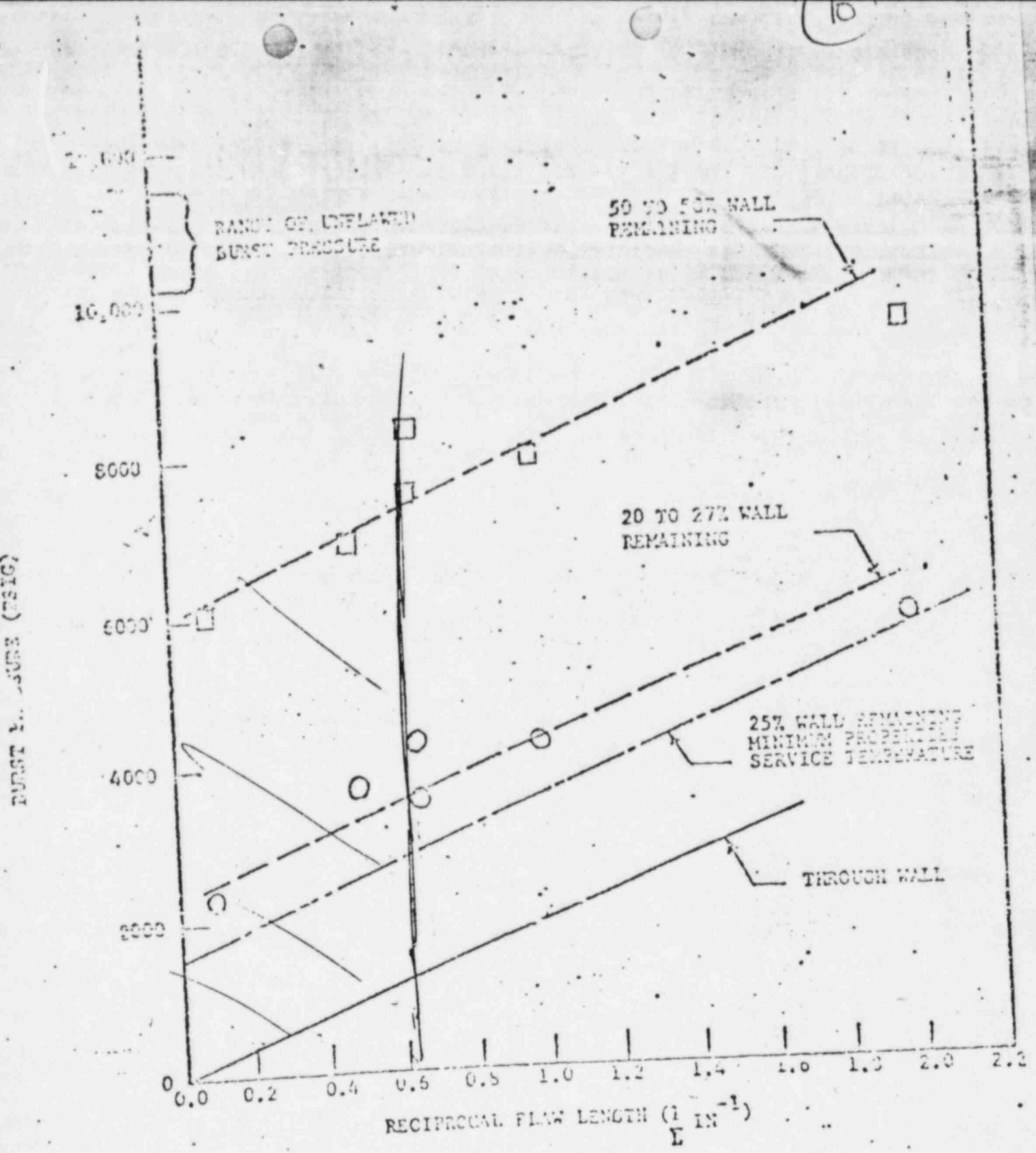
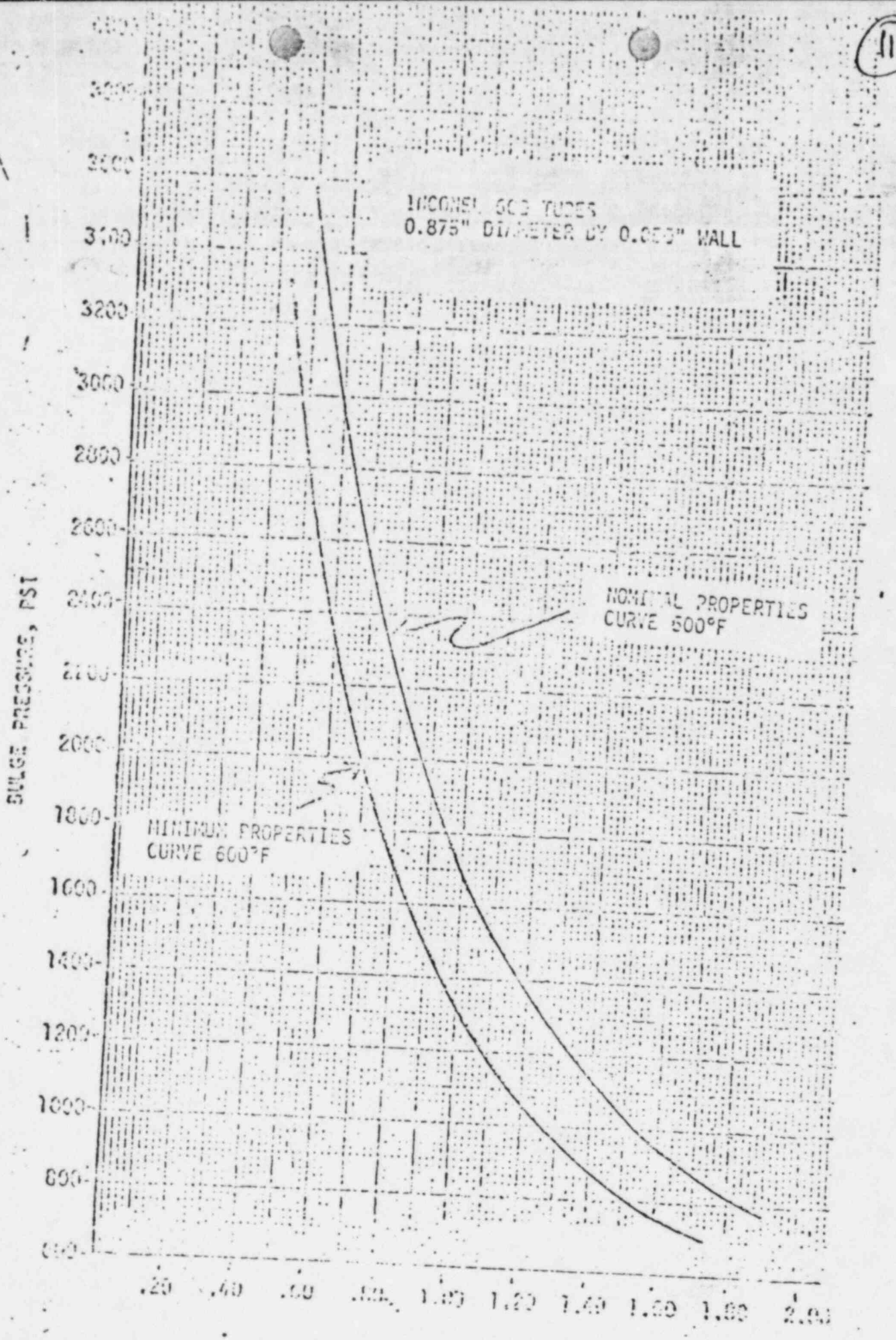
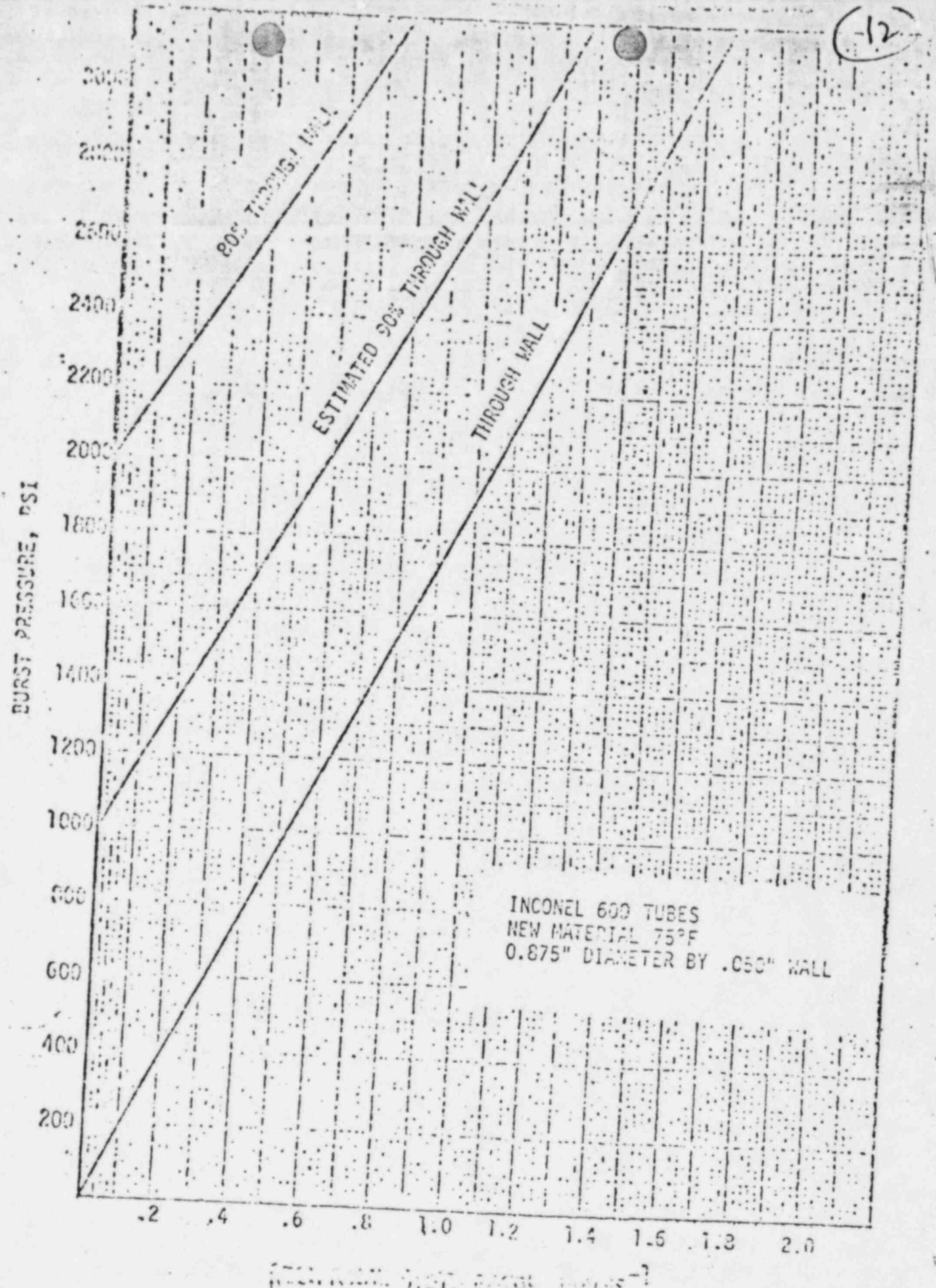
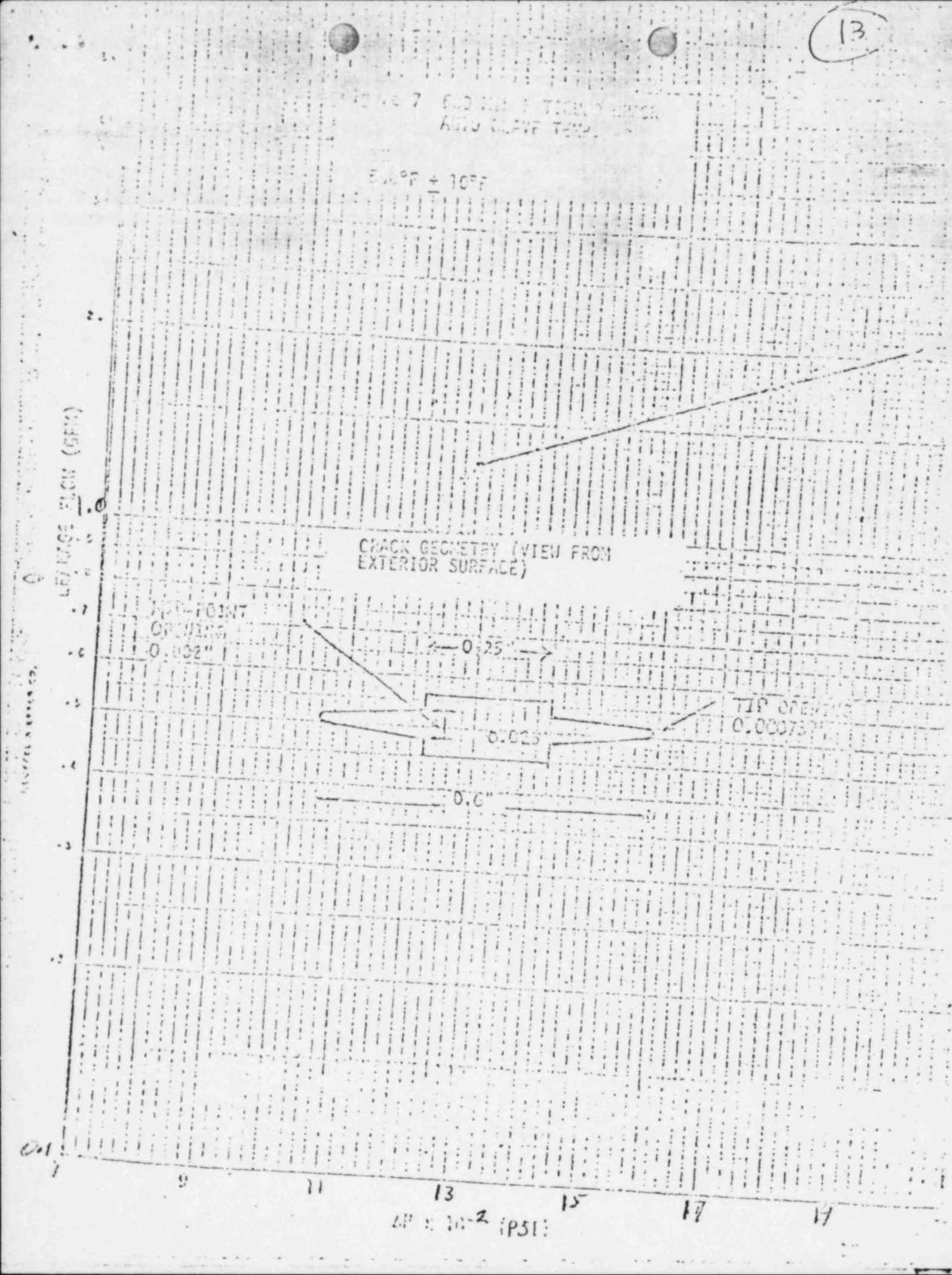
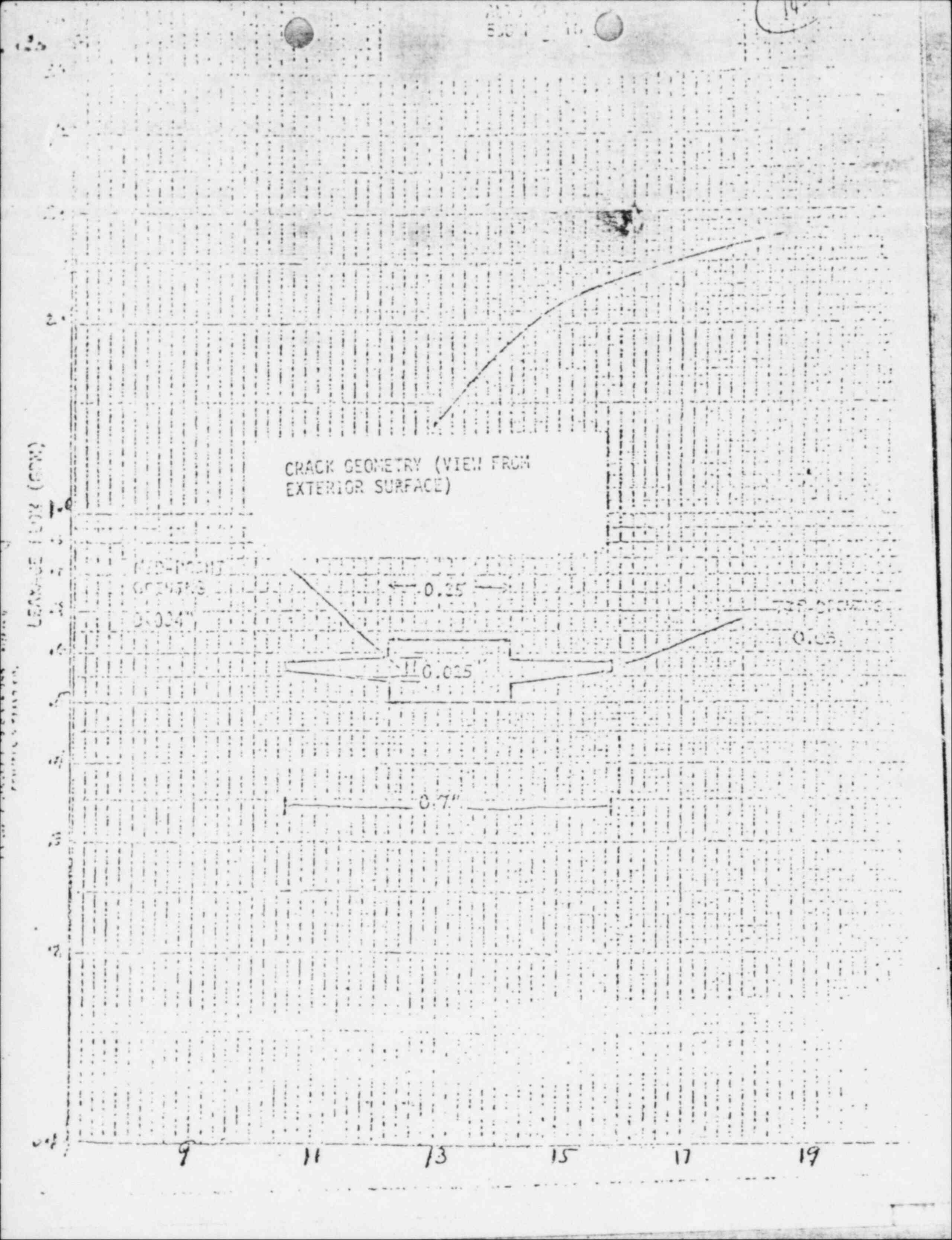


Figure 1. Room Temperature Burst Pressure of 7/8" Tubes with Machined Flaws


INCONEL 600 TUBES
0.875" DIAMETER BY 0.065" WALL
NOMINAL PROPERTIES
CURVE 600°F
MINIMUM PROPERTIES
CURVE 600°F
COLLAPSE PRESSURE, PSI
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
.20
.40
.60
1.00
1.20
1.40
1.60
1.80
2.00
SLOT LENGTH, INCHES


80% THROUGH WALL
ESTIMATED 90% THROUGH WALL
THROUGH WALL
INCONEL 600 TUBES
NEW MATERIAL 75°F
0.875" DIAMETER BY .050" WALL
BURST PRESSURE, PSI
2500
2400
2200
2000
1800
1400
1200
1000
600
400
200
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0


LEAKAGE FLOW (GPM)
1.0
.7
.6
.4
.2
.1
.01
1
9
11
13
15
17
19
ΔP = 10^-2 (PSI)
CRACK GEOMETRY (VIEW FROM EXTERIOR SURFACE)
0.55
0.025
0.0"


CRACK GEOMETRY (VIEW FROM EXTERIOR SURFACE)
0.25
0.025"
0.7"
9
11
13
15
17
19

LAW OFFICES OF

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July 13, 1982

DIRECT DIAL NUMBER
212-530-7534

FREEDOM OF INFORMATION ACT REQUEST
FOIA-82-309
Rec'd 7-15-82

Director, Office of Administration
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Gentlemen:

This is a request under the Freedom of Information Act, as amended, 5 U.S.C. § 552 and the Freedom of Information Act Regulations of the United States Nuclear Regulatory Commission. 10 CFR Part 9.

. . . The undersigned hereby requests:

A. All records (as that term is defined in 10 CFR § 9.3a) provided to NRC by Westinghouse Electric Corporation ("WEC") which refer or relate to the Indian Point Power Plant, Unit Number 2, ("IP2").

B. All records provided to NRC by WEC which refer or relate to tube degradation, denting, corrosion, cracking and/or related phenomena in any steam generator sold or manufactured by WEC for any nuclear power plant other than IP2 including, without limitation, WEC analyses of the causes of tube degradation and suggested or proposed remedial action.

C. All records provided to NRC by any person other than WEC which refer or relate to tube degradation, denting, corrosion, cracking and/or related phenomena in any steam generator sold or manufactured by WEC for any nuclear power plant.

D. All records authored, sponsored or commissioned by NRC and/or its employees which refer or relate to tube

degradation, denting, corrosion, cracking and/or related phenomena in any steam generator sold or manufactured by WEC for any nuclear power plant including, without limitation, analyses of the causes of said tube degradation and suggested or proposed remedial action.

E. All records authored, sponsored or commissioned by NRC and/or its employees which refer or relate to tube degradation, denting, corrosion, cracking and/or related phenomena in any steam generator sold or manufactured for any domestic nuclear power plant including, without limitation, analyses of the causes of said tube degradation and suggested or proposed remedial action.

F. All records provided to NRC by WEC which refer or relate to cracks in rotating components known as discs of steam turbines sold or manufactured by WEC for a nuclear power plant other than IP2 including without limitation, WEC analyses of the causes of such cracking and suggested or proposed remedial action.

G. All records provided to NRC by any person other than WEC which refer or relate to cracks in steam turbine discs sold or manufactured by WEC for a nuclear power plant.

H. All records authored, sponsored or commissioned by NRC and/or its employees which refer or relate to cracks in steam turbine discs sold or manufactured by WEC for any nuclear power plant including, without limitation, analyses of the causes of such cracking and suggested or proposed remedial action.

I note that it is the policy of NRC to disclose records which NRC might consider exempt from disclosure if such disclosure is not contrary to the public interest and will not adversely affect the rights of any person. 10 CFR § 9.9. Accordingly, for any record for which NRC claims an exemption would you specify not only your basis for claiming the exemption but also the reasons why this policy is not applicable.

As provided in the amended Act and 10 CFR

§§ 9.8 and 9.9, I will expect to receive a reply to this request within ten working days of your receipt of this letter. Costs not to exceed $500.00 are acceptable and will be paid. Should estimated costs of production exceed that sum, please advise me prior to commencing production.

Yours truly,

David J. Long

David J. Long