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CONDENSER TUBE-TO-SUPPORT PLATE SEAL LEAKAGE TESTS FOR FOSTER WHEELER CORPORATION

J. A. Smith

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Final Report

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SUMMARY

Leakage tests were conducted by the Oak Ridge National Laboratory for the Office of Saline Water on the condenser tube-to-support plate seal proposed by the Foster Wheeler Corporation for use in the West Coast MSF Test Module. Test seals made of teflon, nylon, and two grades of Nordel were tested for leakage in air and steam test environments in an eight-tube, two-stage test condenser with intermediate support plate hole sizes of .8005 in. and .8105 in. The leakage rates with the teflon and nylon seals were satisfactory, whereas the leakage rates for both grades of Nordel seals were excessive.

INTRODUCTION

The ASTM B-111 specification for 3/4-in. copper-nickel tubing allows an outside diameter variation of +.0035 in. and -.003 in., whereas the TEMA specification for 3/4-in. support plate holes allows a variation of +.010 in. and +.006 in. for standard fit holes (average +.008 in.) and +.008 in. and +.006 in. for special close fit holes (average +.007 in.). Thus, the annular (radial) clearance between a tube and the support plate hole for 3/4-in. tubes can vary from .00125 in. to .0065 in. with an average clearance of .004 in. for standard size holes and from .00125 in. to .0055 in. with an average clearance of .0035 in. for special close fit holes.

An earlier study[1] indicates that, for plants with annular clearances of .001 in. or less, sealing devices are not needed. For plants with

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[1] B. E. Mitchell and J. A. Smith, "Interstage Vapor Leakage in MSF Plants," ORNL-TM-1770 (April, 1967).

annular clearances of .002 in. or larger, sealing devices are needed for some high-temperature stages.

Tests were conducted by the Oak Ridge National Laboratory for the Office of Saline Water on the seals proposed by the Foster Wheeler Corporation for use in the West Coast Test Module.

TEST RESULTS

Details of the Foster Wheeler seal are shown in Figure 1. Test seals made of teflon, nylon, and two grades of Nordel were tested for air and steam leakage in an eight-tube, two-stage test condenser. Foster Wheeler supplied two intermediate support plates. One plate was .780 in. thick with .800 + .002-in. and -.000-in. holes, and one plate was .740 in. thick with .812 + .000-in. and -.002-in. holes. However, the supporting bolt circles were drilled on a 14.250-in. diameter rather than on a 14.750-in. diameter, and these plates could not be used. Accordingly, two new plates were fabricated in the ORGDP shop to the original specifications with the hole sizes averaging .8005 in. for the first plate and .8105 in. for the second plate.

Sixteen seals of each type material were required for tests on both intermediate support plates. The nylon seals used in the .8005-in. holes were received with four V-notched holes cut in the tapered end of each seal, presumably to make tube insertion easier. The nylon seals used in the .8105-in. holes did not have these notches cut in the tapered end of the seal. As expected, the leakage was greater when the teflon seals were used in the .8105-in. holes than when they were used in the .8005-in. holes. However, when the nylon seals were used, the leakage was greater with .8005-in. holes than with .8105-in. holes. Because of

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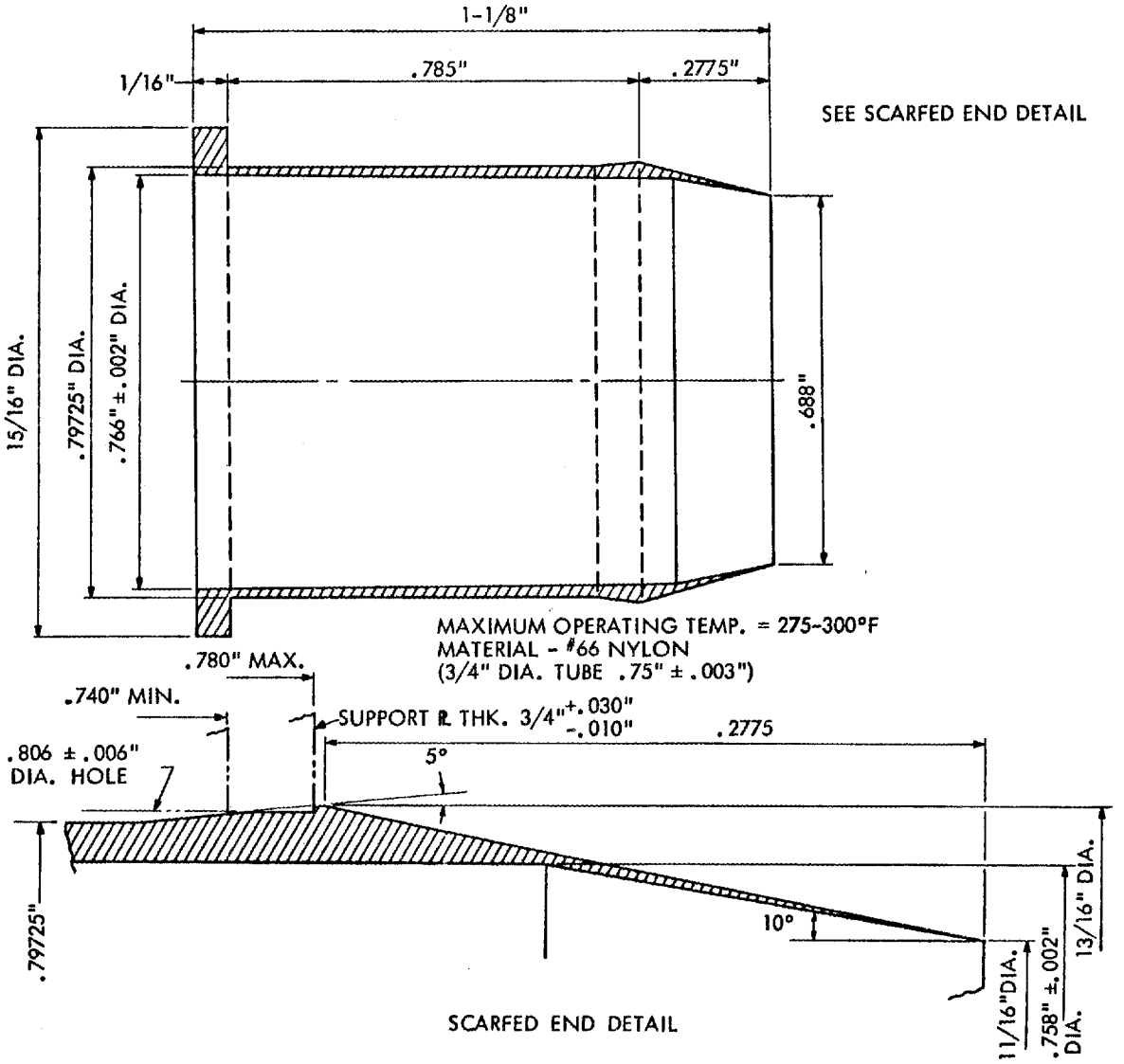

Figure 1

INTERSTAGE SEAL BUSHING FOR 3/4" TUBES
3/4" THICK SUPPORT PLATES

the discrepancy, it may be assumed that some leakage occurred through the V-notches cut in the nylon seals.

With this type of seal design, it can be expected that stiff materials will produce a more satisfactory seal than soft materials. In these tests the teflon and nylon material produced a satisfactory seal, whereas the Nordel material did not.

Table I shows the leakage experienced on the air leakage tests. Table II shows the leakage experienced on the steam leakage tests.

Figure 2 shows a plot of differential stage pressure versus air leakage. Figure 3 shows a plot of differential stage pressure versus steam leakage.

TABLE I

AIR LEAKAGE DATA ON 8-TUBE TEST VESSEL WITH FOSTER-WHEELER TUBE-TO-SUPPORT PLATE SEALS

				Normal (High to Low)[a]			Reverse (Low to High)[b]		
Date	Seal Material	Tube Sheet Hole Size, inches	Tube Size O.D., inches	Diff. Press. Across Seals, psi	Air Leakage for 8 Seals, scfm	Air Leakage per Seal, scfm	Diff. Press. Across Seals, psi	Air Leakage for 8 Seals, scfm	Air Leakage per Seal, scfm
.8005" Support Plate Holes									
6-14-67	Teflon	.8005	.7490	1.0	Too low to measure	-	1.0	Too low to measure	Too low to measure
				2.0	Too low to measure	-	2.0	Too low to measure	Too low to measure
				3.22	.0267	.0033	3.07	.0165	.00206
				4.36	.0454	.00567	4.18	.0210	.00262
				5.40	.0604	.00755	5.40	.0254	.00317
				7.32	.0973	.0121	7.32	.0316	.00395
6-30-67	Soft Nordel	.8005	.7490	1.06	.053	.00663	.98	1.43	.179
				2.00	.2995	.0375	2.04	2.64	.330
				2.91	.562	.0703	3.00	3.32	.415
				3.97	1.041	.130	4.04	4.13	.516
				4.89	1.332	.1665	5.03	4.79	.600
				5.91	1.609	.201	5.92	5.37	.672
				6.88	1.934	.242	6.85	6.07	.759
8-15-67	Nylon	.8005	.7506	1.0	.0880	.0110	1.0	.0830	.0104
				2.0	.1664	.0208	2.0	.1546	.0193
				3.0	.2298	.0287	3.0	.2149	.0268
				4.0	.2810	.0351	4.0	.2786	.0348
				5.0	.3141	.0392	5.0	.3377	.0422
				6.0	.3398	.0424	6.0	.3938	.0492
				7.0	.3550	.0443	7.0	.4593	.0574

[a]Flow from tapered to flanged end.

[b]Flow from flanged to tapered end.

TABLE I (CONTINUED)

AIR LEAKAGE DATA ON 8-TUBE TEST VESSEL WITH FOSTER-WHEELER TUBE-TO-SUPPORT PLATE SEALS

Date	Seal Material	Tube Sheet Hole Size, inches	Tube Size O.D., inches	Normal (High to Low)[a] Diff. Press. Across Seals, psi	Normal (High to Low)[a] Air Leakage for 8 Seals, scfm	Normal (High to Low)[a] Air Leakage per Seal, scfm	Reverse (Low to High)[b] Diff. Press. Across Seals, psi	Reverse (Low to High)[b] Air Leakage for 8 Seals, scfm	Reverse (Low to High)[b] Air Leakage per Seal, scfm
8-18-67	Hard Nordel	.8005	.7506	1.00	Too low to measure	-	1.00	Too low to measure	-
				2.06	.1463	.0182	1.98	.1122	.01402
				2.94	.4266	.0533	2.98	.7493	.0936
				3.88	1.0704	.1338	4.00	2.4509	.3063
				4.94	1.9756	.2469			
				5.93	3.0378	.3797	5.99	5.6487	.7060
				6.86	3.8726	.48407	6.90	7.0315	.8797
.8105" Support Plate Holes									
6-9-67	Teflon	.8105	.7490	1.0	1.06	.1325	1.0	1.39	.1737
				2.0	1.51	.1887	2.0	2.11	.2637
				3.0	2.06	.2575	3.0	2.57	.3212
				4.0	2.45	.3062	4.0	3.07	.3837
				5.0	2.82	.3525	5.0	3.36	.4200
				7.0	3.56	.4450	7.0	3.70	.4625
8-30-67	Nylon	.8105	.7506	1.0	Too low to measure	-	1.08	.0250	.00313
				2.04	.0233	.0029	1.95	.0440	.0055
				3.01	.0302	.0038	2.99	.0649	.0081
				4.05	.0381	.0047	4.00	.0868	.0108
				4.94	.0462	.0057	4.97	.1116	.0139
				5.98	.0538	.0067	5.99	.1388	.0174
				6.91	.0595	.0074	6.99	.1726	.0216

[a]Flow from tapered to flanged end.

[b]Flow from flanged to tapered end.

TABLE II

STEAM LEAKAGE DATA ON 8-TUBE TEST VESSEL WITH
FOSTER WHEELER TUBE-TO-SUPPORT PLATE SEALS

Date	Material	Tube Sheet Hole Size, inches	Tube Size O.D., inches	Ave. High Side Steam Pressure, psig	Average Diff. Press. Across Seals, psi	Leakage, lb/hr	
						8 Seals	1 Seal
.8005" Support Plate Holes							
6-14-67	Teflon	.8005	.7490	2.3	2.2	.0625	.00782
				6.4	5.5	.0625	.00782
8-16-67	Nylon	.8005	.7506	2.1	1.47	.344	.043
				6.1	5.0	.625	.0782
8-21-67	Hard Nordel	.8005	.7506	2.1	1.57	2.71	.339
				6.0	5.0	5.38	.674
.8105" Support Plate Holes							
6-9-67	Teflon	.8105	.7490	2.0	1.3	0.50	.0625
				12.0	6.0	1.50	.1875
8-31-67	Nylon	.8105	.7506	2.1	1.84	.25	.032
				6.0	5.0	.625	.078

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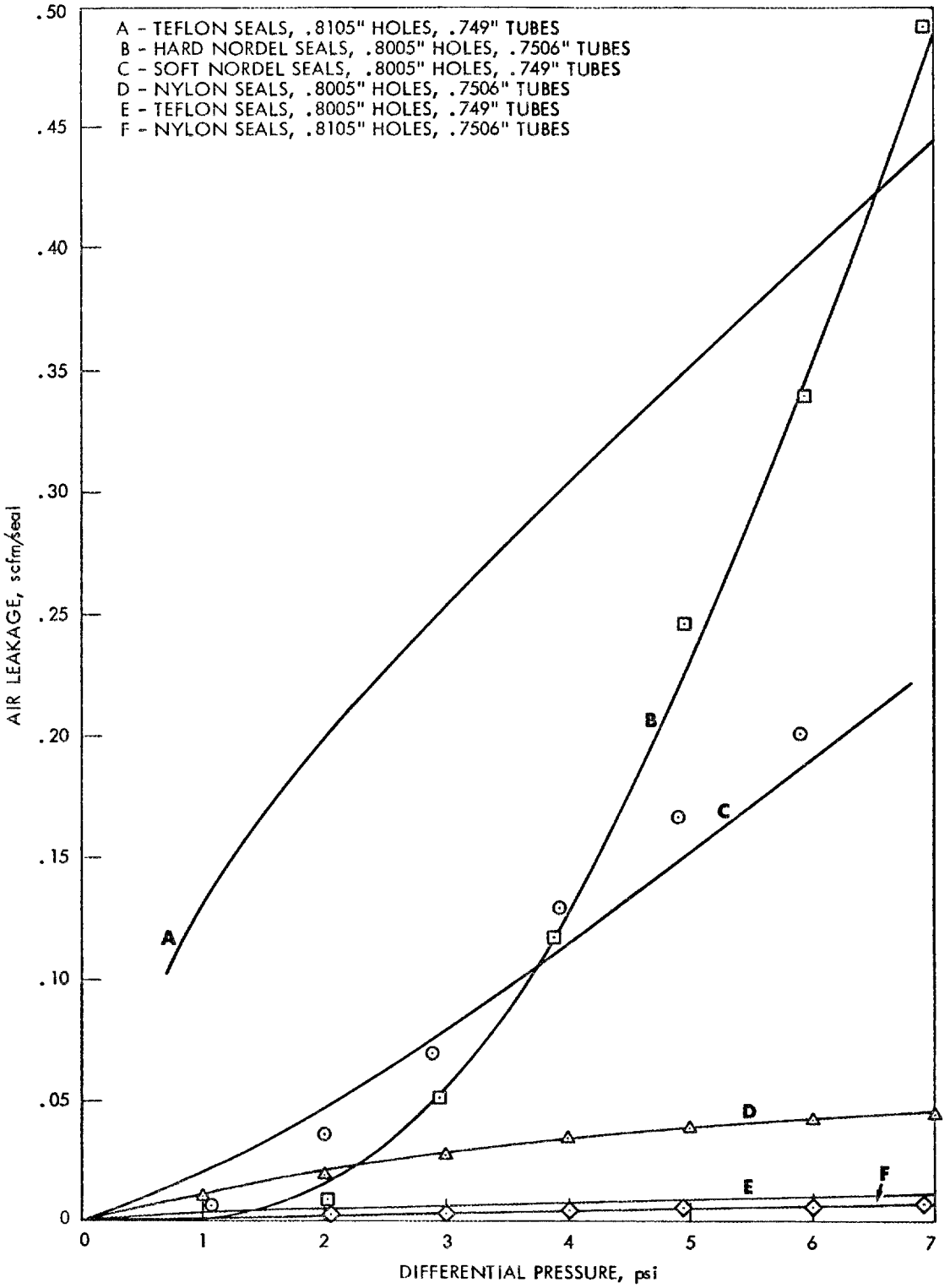

Figure 2

AIR FLOW TEST RESULTS FOR FOSTER-WHEELER SEALS

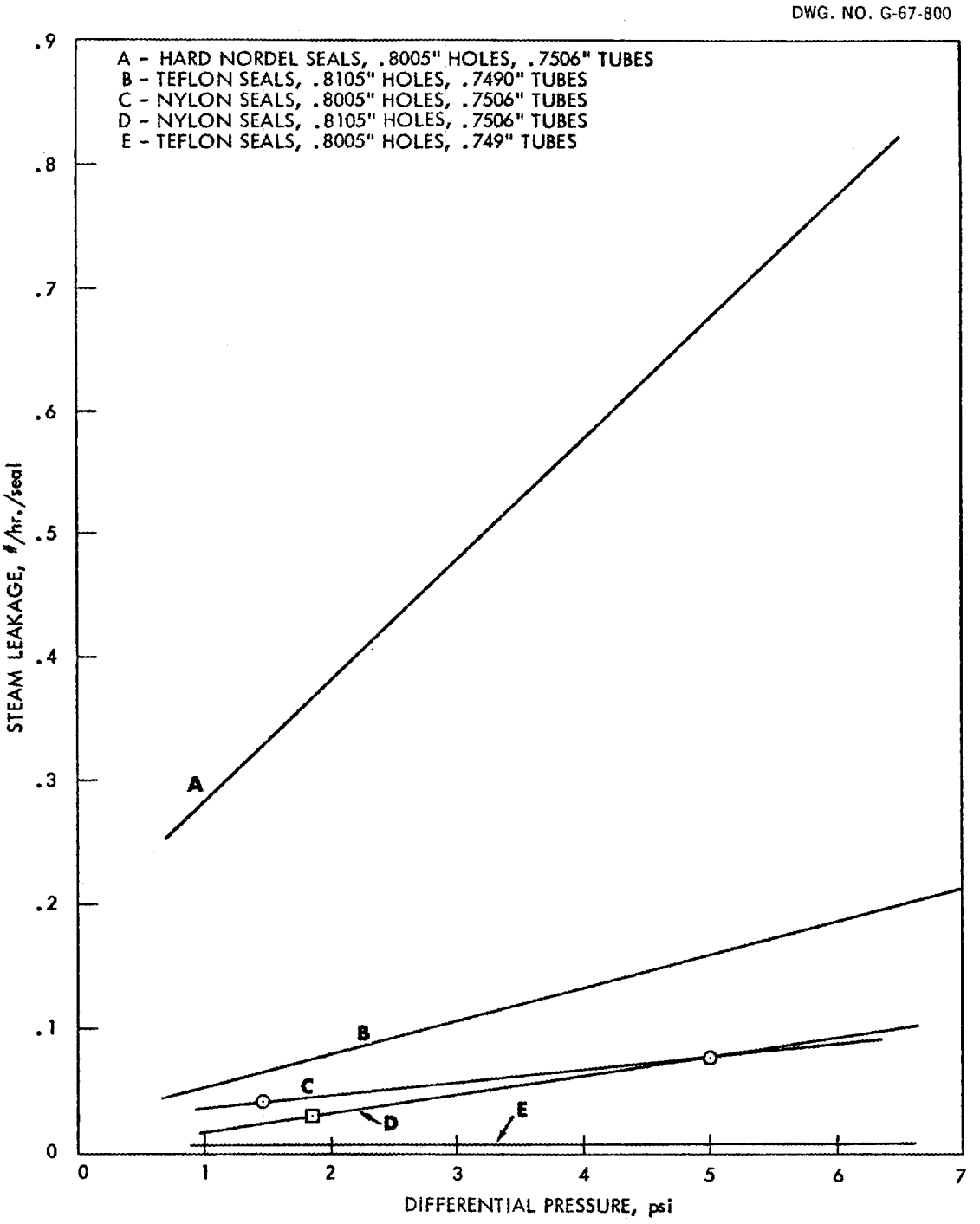

Figure 3

STEAM LEAKAGE TEST RESULTS FOR FOSTER-WHEELER SEALS

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