NATIONAL TRANSPORTATION SAFETY BOARD

Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594

August 15, 1997

METALLURGIST'S FACTUAL REPORT — Report No. 97-136

A. ACCIDENT

Place	: Pensacola, Florida
Date	: July 6, 1996
Vehicle	: MD-88, N927DA
NTSB No.	: DCA96-M-A068
Investigator	: Thomas Conroy, AS-10

B. COMPONENTS EXAMINED

Metallographic specimen through the fracture origin.

C. DETAILS OF THE EXAMINATION

On July 21, a metallographic section through the fracture origin of the hub was sent to Pratt & Whitney for an Electron Probe Microanalysis (EPMA) of oxygen, nitrogen, carbon, and iron in the altered microstructure area. Aluminum silicon, and vanadium were also analyzed and reported. The EPMA spectra (concentration profiles) were collected from the hole wall inward at three separate radial positions indicated by arrows "c", "d", and "e" in figure 1. Concentration profiles at the positions denoted by arrows "c" and "d" in this figure were across the layer of altered microstructure. The third profile, at the position denoted by arrow "e", was through the area that contained no evidence of altered microstructure.

Table 1 summarizes the number of data points collected during the analysis, the distance between each data point (spacing), and the total distance from the surface of the hole to the last data point (depth of the profile) for each concentration profile. Tables 2, 3, and 4 show reported concentrations of analyzed elements at each of the data point. Pratt & Whitney reported that no evidence of nitrogen was found in the area of altered microstructure. Figures 2 through 7 display composite plots of variations of carbon, oxygen, iron, and silicon concentrations versus distances from the wall at all three radial positions presented by Pratt & Whitney. The analysis indicated as much as 3 to 7 percent oxygen and as much as about 3.5 percent iron were in the first 50- to 60-micron layer of altered microstructure adjacent to the wall of the hole.

[redacted]

Jean Bernstein
Metallurgist

Table 1

PROFILE	NO. OF POINTS	SPACING (MICRONS)	DEPTH (MICRONS)
C	100	4.727	468
D	100	3.515	348
E	75	2.945	218

MA-97400: PWA 1215 HUB, FRONT COMPRESSOR										
	EPMA of Bolt Hole Rupture Section				R32971					
FILE	LOCATION	D, microns	C Ka	O Ka	Al Ka	Si Ka	V Ka	Fe Ka	N*	
97400a	Ti std.									
97400b	Base Metal		0.33	1.30	3.63	0.86	4.38	0.22	0.00	
		Distance	C KA	O KA	Al Ka	Si Ka	V Ka	FE KA		
97400c_1	Bolt Hole	0.000	0.36	2.36	2.01	0.94	3.92	0.39	0.10	
2	Abnormal	4.727	0.39	3.58	2.48	1.71	3.81	2.78	0.00	
3	Surface	9.454	0.44	2.84	2.96	1.82	3.83	3.55	0.00	
4	Layer	14.181	0.21	2.74	3.50	0.42	3.75	1.94	0.00	
5		18.908	0.20	2.64	3.33	1.41	4.37	3.18	0.00	
6		23.635	0.20	2.46	3.64	1.33	4.24	1.82	0.00	
7		28.362	0.17	2.66	3.45	1.55	3.64	1.37	0.00	
8		33.089	0.18	2.08	3.53	1.29	3.83	2.78	0.00	
9		37.816	0.17	2.00	3.54	0.64	4.07	1.54	0.00	
10		42.543	0.18	1.70	3.58	1.10	3.92	1.26	0.00	
11		47.270	0.19	1.65	3.48	0.87	4.13	0.48	0.00	
12		51.997	0.13	1.42	3.57	0.45	4.17	0.17	0.00	
13		56.724	0.15	1.43	3.45	1.66	4.18	0.17	0.00	
14		61.451	0.13	1.30	3.71	0.76	3.58	0.19	0.00	
15		66.178	0.17	1.44	3.46	1.28	4.38	0.21	0.00	
16		70.905	0.18	1.35	3.49	1.13	4.58	0.17	0.00	
17		75.632	0.18	1.26	3.47	0.45	4.17	0.19	0.00	
18		80.359	0.12	1.27	3.62	0.45	3.80	0.18	0.00	
19		85.086	0.14	1.33	3.16	0.30	6.06	0.32	0.00	
20		89.813	0.15	1.22	3.66	0.11	3.77	0.18	0.00	
21		94.540	0.20	1.42	3.26	1.28	5.04	0.16	0.00	
22		99.267	0.21	1.29	3.27	0.15	4.63	0.26	0.00	
23		103.994	0.14	1.32	3.11	1.40	4.75	0.22	0.00	
24		108.721	0.13	1.37	3.22	0.75	5.39	0.28	0.00	
25		113.448	0.16	1.20	3.68	0.34	2.85	0.08	0.00	
26		118.175	0.14	1.23	4.11	0.38	2.27	0.06	0.00	
27		122.902	0.15	1.27	3.59	0.68	3.98	0.20	0.00	
28		127.629	0.13	1.11	3.69	0.04	3.09	0.14	0.00	
29		132.356	0.13	1.17	3.23	0.87	4.77	0.21	0.00	
30		137.083	0.12	1.04	3.89	0.38	2.53	0.10	0.00	
31		141.810	0.16	1.01	3.93	1.47	2.10	0.02	0.00	
32		146.537	0.14	1.19	4.18	0.68	2.08	0.05	0.00	
33		151.264	0.13	1.18	3.34	0.53	4.56	0.18	0.00	
34		155.991	0.11	1.07	4.22	0.00	1.87	0.01	0.00	
35		160.718	0.12	1.06	3.95	1.59	2.05	0.01	0.00	
36		165.445	0.12	1.20	3.23	0.00	4.92	0.18	0.00	
37		170.172	0.11	1.18	3.32	0.94	4.01	0.17	0.00	
38		174.899	0.13	1.13	3.39	0.98	4.13	0.23	0.00	
39		179.626	0.11	0.87	3.93	0.30	1.85	0.00	0.00	
40		184.353	0.11	0.83	4.19	0.26	1.89	0.00	0.00	
41		189.080	0.15	0.96	4.16	0.98	1.94	0.01	0.00	
42		193.807	0.09	1.01	3.26	0.79	5.28	0.29	0.00	
43		198.534	0.12	1.12	3.11	0.45	5.78	0.22	0.00	
44		203.261	0.06	0.98	3.09	0.23	5.64	0.25	0.00	
45		207.988	0.09	1.10	3.19	1.28	4.30	0.25	0.00	
46		212.715	0.11	0.88	3.74	0.60	1.87	0.05	0.00	
47		217.442	0.12	1.01	2.58	0.45	6.89	0.32	0.00	
48		222.169	0.07	0.83	2.99	0.60	4.88	0.23	0.00	
49		226.896	0.14	1.02	3.01	0.68	4.36	0.17	0.00	
50		231.623	0.09	0.87	3.13	0.72	4.30	0.18	0.00	
51		236.350	0.14	0.90	2.99	0.94	5.14	0.25	0.00	
52		241.077	0.06	0.81	2.82	0.45	5.00	0.22	0.00	
53		245.804	0.08	0.86	2.44	0.07	6.69	0.35	0.00	
54		250.531	0.07	0.92	2.49	0.53	7.86	0.37	0.00	
55		255.258	0.13	0.81	2.48	1.95	7.19	0.38	0.00	

56		259.985	0.09	0.85	2.55	0.68	7.39	0.44	0.00	
57		264.712	0.09	0.87	3.66	0.34	1.94	0.05	0.00	
58		269.439	0.06	0.67	3.89	0.53	2.27	0.05	0.00	
59		274.166	0.10	0.83	3.12	0.83	4.61	0.19	0.00	
60		278.893	0.08	0.71	2.65	0.34	5.99	0.33	0.00	
61		283.620	0.10	0.70	2.92	0.83	3.36	0.10	0.00	
62		288.347	0.05	0.61	3.87	0.60	1.93	0.05	0.00	
63		293.074	0.11	0.67	3.77	0.83	1.90	0.01	0.00	
64		297.801	0.08	0.67	3.63	0.49	2.25	0.01	0.00	
65		302.528	0.10	0.70	3.66	1.36	1.94	0.03	0.00	
66		307.255	0.08	0.58	3.78	1.02	1.85	0.05	0.00	
67		311.982	0.08	0.63	3.71	1.09	1.88	0.02	0.00	
68		316.709	0.05	0.63	3.09	0.22	4.10	0.21	0.00	
69		321.436	0.09	0.59	3.54	0.90	1.95	0.03	0.00	
70		326.163	0.05	0.47	4.03	0.15	1.90	0.00	0.00	
71		330.890	0.12	0.64	3.09	0.53	4.41	0.14	0.00	
72		335.617	0.08	0.63	2.73	0.71	4.48	0.12	0.00	
73		340.344	0.11	0.57	2.61	0.79	5.50	0.28	0.00	
74		345.071	0.06	0.47	3.97	0.60	2.09	0.02	0.00	
75		349.798	0.07	0.54	3.94	1.13	1.92	0.04	0.00	
76		354.525	0.05	0.53	2.86	0.60	5.31	0.29	0.00	
77		359.252	0.08	0.53	2.81	0.11	5.68	0.28	0.00	
78		363.979	0.08	0.56	3.36	0.75	4.07	0.13	0.00	
79		368.706	0.08	0.43	3.18	1.13	4.36	0.16	0.00	
80		373.433	0.05	0.43	3.94	0.60	2.46	0.05	0.00	
81		378.160	0.08	0.54	3.27	1.51	4.77	0.26	0.00	
82		382.887	0.05	0.45	4.06	0.07	1.80	0.01	0.00	
83		387.614	0.07	0.51	3.92	0.76	2.04	0.01	0.00	
84		392.341	0.07	0.46	4.02	0.79	1.87	0.04	0.00	
85		397.068	0.08	0.56	4.06	0.23	2.00	0.04	0.00	
86		401.795	0.03	0.38	4.07	0.49	1.93	0.01	0.00	
87		406.522	0.06	0.48	3.96	1.25	2.08	0.00	0.00	
88		411.249	0.04	0.36	4.17	0.11	1.80	0.01	0.00	
89		415.976	0.07	0.42	4.17	1.10	1.78	0.01	0.00	
90		420.703	0.03	0.21	3.79	0.38	2.10	0.00	0.00	
91		425.430	0.08	0.39	2.72	1.24	6.28	0.36	0.00	
92		430.157	0.04	0.35	3.02	0.75	5.38	0.26	0.00	
93		434.884	0.09	0.37	2.71	1.35	6.04	0.39	0.00	
94		439.611	0.06	0.37	3.48	0.15	3.41	0.08	0.00	
95		444.338	0.06	0.36	2.79	1.20	5.60	0.35	0.00	
96		449.065	0.06	0.49	3.22	0.34	4.66	0.17	0.00	
97		453.792	0.04	0.43	3.17	0.45	4.91	0.21	0.00	
98		458.519	0.04	0.30	3.26	0.60	4.70	0.19	0.00	
99		463.246	0.08	0.30	3.00	0.64	5.46	0.33	0.00	
100		467.973	0.06	0.40	3.26	0.49	5.34	0.31	0.00	

MA-97400: PWA 1215 HUB, FRONT COMPRESSOR										
	EPMA of Bolt Hole Rupture Section				R32971					
FILE	LOCATION	D, microns	C Ka	O Ka	Al Ka	Si Ka	V Ka	Fe Ka	N *	
97400d_1	Bolt Hole	0	8.76	7.97	0.56	3.76	3.38	0.59	2.40	
2	Abnormal	3.515	4.29	9.05	0.00	0.62	3.84	0.53	1.24	
3	Surface	7.030	0.68	4.54	5.11	1.51	4.48	0.43	0.67	
4		10.545	1.16	5.69	5.19	2.15	4.91	2.96	0.58	
5		14.060	3.08	7.14	5.19	4.84	4.54	2.84	1.04	
6		17.575	2.12	7.20	4.51	2.89	3.26	1.16	0.75	
7		21.090	2.11	4.78	4.49	2.80	4.00	3.12	0.49	
8		24.605	0.52	5.40	4.72	1.46	4.04	3.12	0.46	
9		28.120	2.03	5.40	4.58	4.97	4.57	2.00	0.43	
10		31.635	0.47	4.66	4.59	1.34	3.63	2.21	0.06	
11		35.150	1.35	4.14	4.48	2.32	4.42	1.65	0.59	
12		38.665	0.39	3.79	4.49	0.87	4.25	1.21	0.00	
13		42.180	0.95	3.92	4.27	1.86	3.98	1.47	0.27	
14		45.695	0.39	3.67	4.55	0.67	3.90	0.91	0.18	
15		49.210	1.41	3.10	4.38	1.94	4.08	0.29	0.51	
16		52.725	0.41	2.73	4.58	1.04	4.11	0.16	0.11	
17		56.240	0.95	2.96	4.33	0.62	4.09	0.18	0.00	
18		59.755	0.39	2.85	4.21	0.74	4.20	0.17	0.17	
19		63.270	1.11	2.65	4.13	1.80	3.72	0.16	0.28	
20		66.785	0.40	2.65	4.19	0.41	3.37	0.14	0.02	
21		70.300	1.19	3.22	3.55	1.20	5.57	0.26	0.23	
22		73.815	0.42	2.79	4.09	0.93	4.23	0.19	0.10	
23		77.330	0.85	2.69	4.17	1.35	3.25	0.14	0.25	
24		80.845	0.40	2.84	3.59	1.02	5.08	0.22	0.09	
25		84.360	1.03	2.84	3.68	1.02	4.75	0.19	0.29	
26		87.875	0.40	2.75	3.84	0.67	4.07	0.18	0.00	
27		91.390	1.01	3.27	3.35	1.90	5.30	0.20	0.38	
28		94.905	0.40	2.67	4.19	0.76	2.73	0.10	0.01	
29		98.420	1.11	2.68	4.00	1.91	2.78	0.12	0.43	
30		101.935	0.37	2.84	3.24	1.12	5.11	0.24	0.11	
31		105.450	0.96	2.78	3.34	1.83	3.78	0.14	0.41	
32		108.965	0.42	2.77	3.37	0.92	4.88	0.17	0.05	
33		112.480	0.98	2.91	3.03	1.43	5.03	0.26	0.17	
34		115.995	0.41	2.42	3.57	0.89	4.02	0.16	0.01	
35		119.510	0.79	2.48	3.58	0.73	3.62	0.08	0.22	
36		123.025	0.44	2.68	3.62	0.00	3.03	0.08	0.00	
37		126.540	0.87	2.52	3.76	1.23	2.38	0.03	0.26	
38		130.055	0.47	2.08	3.80	0.34	1.96	0.02	0.18	
39		133.570	0.81	2.38	3.61	0.92	1.98	0.00	0.05	
40		137.085	0.41	2.39	3.41	0.52	3.61	0.18	0.05	
41		140.600	0.89	2.89	2.93	0.52	5.34	0.27	0.10	
42		144.115	0.41	2.82	2.87	0.98	5.66	0.27	0.07	
43		147.630	0.89	2.93	3.03	2.21	3.46	0.17	0.36	
44		151.145	0.43	2.51	3.47	0.52	2.41	0.08	0.00	
45		154.660	0.85	2.47	3.43	0.77	2.02	0.02	0.13	
46		158.175	0.69	2.06	3.94	0.00	1.97	0.01	0.00	
47		161.690	0.76	2.43	3.88	1.45	2.01	0.00	0.31	
48		165.205	0.36	2.34	3.82	0.34	1.95	0.01	0.00	
49		168.720	0.83	2.85	2.63	0.92	6.35	0.27	0.17	
50		172.235	0.50	2.58	2.88	0.15	5.31	0.28	0.00	
51		175.750	0.85	2.76	2.53	0.37	6.34	0.34	0.24	
52		179.265	0.45	2.48	3.66	0.53	2.34	0.06	0.21	
53		182.780	0.76	2.28	3.59	0.59	2.05	0.00	0.29	
54		186.295	0.45	2.22	2.87	1.51	2.00	0.01	0.21	
55		189.810	0.91	2.73	2.22	0.83	3.47	0.16	0.35	
56		193.325	0.67	2.82	2.15	0.49	8.48	0.49	0.00	
57		196.840	0.79	2.38	3.42	0.71	1.98	0.01	0.11	
58		200.355	0.40	2.40	3.66	0.56	1.98	0.02	0.16	
59		203.870	0.96	2.50	3.55	0.86	2.12	0.00	0.44	

60		207.385	0.43	2.10	3.20	0.03	2.03	0.00	0.01	
61		210.900	0.81	2.37	2.96	0.40	1.96	0.02	0.24	
62		214.415	0.44	2.71	2.10	1.08	8.59	0.40	0.20	
63		217.930	0.77	2.42	3.51	0.28	2.00	0.02	0.09	
64		221.445	0.46	2.20	3.25	0.40	2.06	0.00	0.00	
65		224.960	0.76	2.54	3.00	1.45	1.93	0.01	0.22	
66		228.475	0.56	2.46	3.52	0.40	2.39	0.05	0.13	
67		231.990	0.86	2.66	2.50	1.05	5.76	0.28	0.53	
68		235.505	0.41	1.97	2.56	0.71	3.22	0.08	0.16	
69		239.020	0.79	2.31	2.85	0.40	1.97	0.03	0.13	
70		242.535	0.41	2.18	3.04	0.03	2.96	0.06	0.02	
71		246.050	0.91	2.47	2.43	1.26	4.47	0.16	0.27	
72		249.565	0.43	2.41	2.76	0.87	4.49	0.19	0.22	
73		253.080	1.07	2.51	2.67	1.70	5.12	0.19	0.37	
74		256.595	0.41	2.33	2.85	0.15	4.76	0.18	0.19	
75		260.110	0.97	2.33	2.54	1.11	5.23	0.21	0.37	
76		263.625	0.47	2.18	2.64	1.05	5.38	0.26	0.16	
77		267.140	0.99	2.44	2.41	1.48	5.73	0.25	0.21	
78		270.655	0.43	2.73	1.95	0.00	7.95	0.45	0.00	
79		274.170	1.04	2.40	1.99	1.04	6.97	0.38	0.35	
80		277.685	0.39	1.98	2.71	0.71	2.38	0.04	0.11	
81		281.200	0.90	2.24	2.76	1.14	1.90	0.01	0.25	
82		284.715	0.42	2.08	3.14	0.87	2.09	0.03	0.17	
83		288.230	1.03	2.31	2.96	1.88	2.11	0.01	0.36	
84		291.745	0.41	1.96	2.70	0.86	1.99	0.00	0.16	
85		295.260	1.05	2.33	2.55	2.12	2.05	0.03	0.37	
86		298.775	0.55	2.27	2.01	1.17	6.97	0.43	0.27	
87		302.290	0.88	2.33	2.84	0.46	2.25	0.00	0.22	
88		305.805	0.36	1.92	3.45	0.49	1.98	0.02	0.23	
89		309.320	0.83	2.26	3.30	0.68	1.89	0.02	0.35	
90		312.835	0.40	2.34	2.48	0.68	5.68	0.31	0.21	
91		316.350	1.03	2.50	2.39	1.05	5.62	0.28	0.35	
92		319.865	0.42	2.13	2.05	0.58	5.02	0.25	0.13	
93		323.380	0.91	2.23	1.71	1.78	6.47	0.32	0.41	
94		326.895	0.41	1.98	3.21	0.86	2.48	0.04	0.14	
95		330.410	0.97	2.09	2.75	0.86	3.91	0.13	0.29	
96		333.925	0.59	2.37	2.68	0.95	5.35	0.30	0.27	
97		337.440	0.88	2.35	2.63	1.11	4.22	0.16	0.35	
98		340.955	0.68	2.19	2.31	0.21	5.60	0.28	0.13	
99		344.470	0.86	2.26	2.27	0.09	5.78	0.24	0.13	
100		347.985	0.38	2.02	2.44	0.89	5.24	0.23	0.24	

MA-97400: PWA 1215 HUB, FRONT COMPRESSOR										
	EPMA of Bolt Hole Rupture Section				R32971					
FILE	LOCATION	D, Microns	C Ka	O Ka	Al Ka	Si Ka	V Ka	Fe Ka	N *	
97400e_1	Bolt Hole	0	1.81	2.34	4.44	9.69	1.65	0.07	0.00	
2	Normal	2.945	2.64	4.08	4.15	2.24	1.64	0.03	0.00	
3	Surface	5.890	22.08	8.45	3.35	5.84	2.09	0.15	0.03	
4		8.835	2.49	4.70	3.79	1.15	2.17	0.04	0.00	
5		11.780	1.85	2.89	3.96	1.85	1.86	0.04	0.00	
6		14.725	7.19	7.69	3.99	5.31	1.86	0.10	0.00	
7		17.670	4.47	20.46	3.40	3.92	1.84	0.00	3.13	
8		20.615	1.76	2.08	3.76	0.92	2.36	0.01	0.00	
9		23.560	0.58	1.48	2.68	0.88	6.76	0.42	0.00	
10		26.505	0.75	1.52	3.12	0.16	4.29	0.18	0.00	
11		29.450	0.69	1.93	3.00	1.12	5.91	0.29	0.00	
12		32.395	1.25	1.48	3.11	1.25	5.28	0.27	0.00	
13		35.340	0.53	1.42	3.08	1.69	4.76	0.26	0.00	
14		38.285	0.75	1.54	3.31	0.71	5.67	0.35	0.00	
15		41.230	0.49	1.44	4.23	0.92	2.00	0.00	0.00	
16		44.175	0.84	1.37	4.10	0.45	2.01	0.01	0.00	
17		47.120	0.46	1.55	3.94	0.76	1.95	0.01	0.00	
18		50.065	0.73	1.50	4.14	0.10	2.01	0.00	0.00	
19		53.010	0.52	1.47	4.02	0.76	1.90	0.01	0.00	
20		55.955	0.69	1.39	4.12	0.63	1.84	0.02	0.00	
21		58.900	0.59	1.35	3.06	0.81	4.35	0.21	0.00	
22		61.845	0.82	1.90	2.55	1.40	8.44	0.63	0.00	
23		64.790	0.61	1.77	2.40	1.15	8.41	0.59	0.00	
24		67.735	0.64	1.47	2.69	0.46	8.35	0.54	0.00	
25		70.680	0.54	1.46	3.08	0.84	5.05	0.23	0.00	
26		73.625	0.95	1.38	4.37	0.50	2.44	0.05	0.00	
27		76.570	0.57	1.50	4.61	0.57	2.04	0.03	0.00	
28		79.515	0.67	1.36	4.17	0.39	1.95	0.03	0.00	
29		82.460	0.89	1.71	4.08	0.85	1.95	0.01	0.00	
30		85.405	0.79	1.19	4.49	0.82	1.96	0.00	0.00	
31		88.350	0.58	1.59	3.28	0.43	5.58	0.33	0.00	
32		91.295	0.97	1.85	3.29	0.07	5.33	0.25	0.00	
33		94.240	0.53	1.82	3.23	0.43	5.14	0.21	0.00	
34		97.185	0.67	1.73	2.79	0.86	8.31	0.54	0.00	
35		100.130	0.61	1.64	4.17	1.15	2.00	0.01	0.00	
36		103.075	0.93	1.35	4.17	0.90	1.99	0.01	0.00	
37		106.020	0.54	1.37	4.16	1.19	1.98	0.03	0.00	
38		108.965	0.62	1.54	4.25	0.00	1.91	0.03	0.00	
39		111.910	0.56	1.60	3.51	0.97	3.58	0.14	0.00	
40		114.855	0.62	1.41	3.07	0.18	7.60	0.51	0.00	
41		117.800	0.60	1.59	3.13	1.26	5.77	0.28	0.00	
42		120.745	0.63	1.63	3.47	0.39	5.37	0.25	0.00	
43		123.690	0.68	1.53	3.73	0.57	3.79	0.14	0.00	
44		126.635	0.67	1.47	3.39	0.97	5.41	0.31	0.00	
45		129.580	0.59	1.75	3.34	0.97	5.56	0.27	0.00	
46		132.525	0.90	1.60	3.43	0.50	4.98	0.23	0.00	
47		135.470	0.48	1.69	3.23	0.75	4.53	0.16	0.00	
48		138.415	0.73	1.42	3.05	0.65	5.98	0.41	0.00	
49		141.360	1.10	1.87	2.75	0.61	7.29	0.41	0.00	
50		144.305	0.65	1.64	2.86	1.08	7.26	0.50	0.00	
51		147.250	0.67	1.48	4.11	0.69	1.99	0.01	0.00	
52		150.195	0.66	1.25	4.02	1.19	2.02	0.01	0.00	
53		153.140	0.58	1.60	3.78	0.90	2.08	0.02	0.00	
54		156.085	0.63	1.33	4.25	1.08	1.90	0.03	0.00	
55		159.030	0.52	1.21	3.97	0.40	1.87	0.03	0.00	
56		161.975	0.78	1.58	3.30	0.50	4.84	0.33	0.00	
57		164.920	0.88	1.88	3.11	1.01	5.72	0.30	0.00	
58		167.865	0.80	1.51	3.39	0.76	5.25	0.29	0.00	
59		170.810	0.69	1.38	3.35	0.58	4.80	0.20	0.00	

60		173.755	0.57	1.60	3.12	0.61	5.60	0.32	0.00	
61		176.700	0.72	1.73	3.43	1.48	3.31	0.07	0.00	
62		179.645	0.61	1.66	3.20	0.61	4.87	0.22	0.00	
63		182.590	0.77	1.56	2.99	0.54	4.68	0.18	0.00	
64		185.535	0.62	1.64	3.62	0.47	2.84	0.04	0.00	
65		188.480	0.68	1.55	3.99	0.47	1.95	0.00	0.00	
66		191.425	0.80	1.55	4.16	0.91	2.02	0.00	0.00	
67		194.370	1.44	1.46	4.05	1.30	1.95	0.01	0.00	
68		197.315	0.76	1.47	4.20	0.87	1.95	0.01	0.00	
69		200.260	0.73	1.44	3.94	0.11	1.93	0.02	0.00	
70		203.205	0.59	1.30	3.23	0.72	5.41	0.26	0.00	
71		206.150	0.74	1.57	3.54	0.76	2.72	0.02	0.00	
72		209.095	1.08	1.86	3.45	0.36	2.80	0.00	0.00	
73		212.040	0.76	1.71	3.25	1.23	3.09	0.06	0.00	
74		214.985	0.76	1.69	3.16	0.32	5.07	0.16	0.00	
75		217.930	0.74	1.99	2.30	0.43	9.01	0.64	0.00	

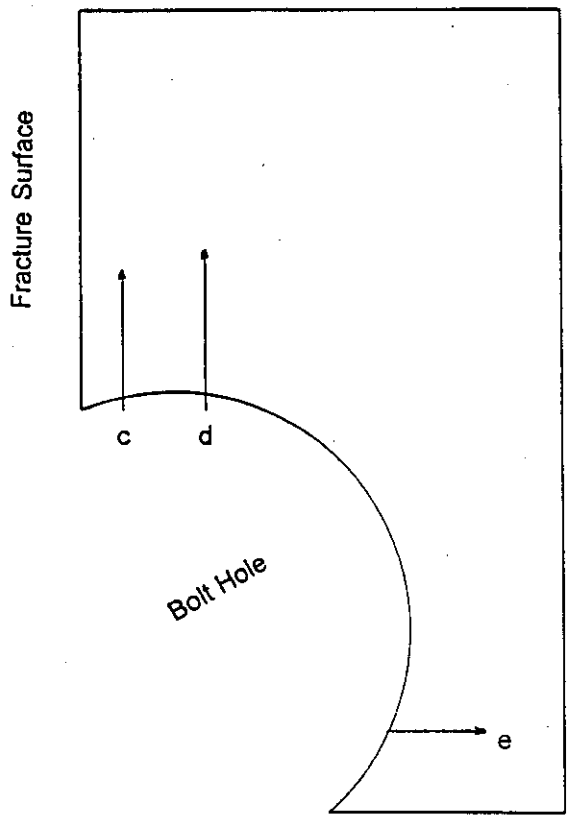
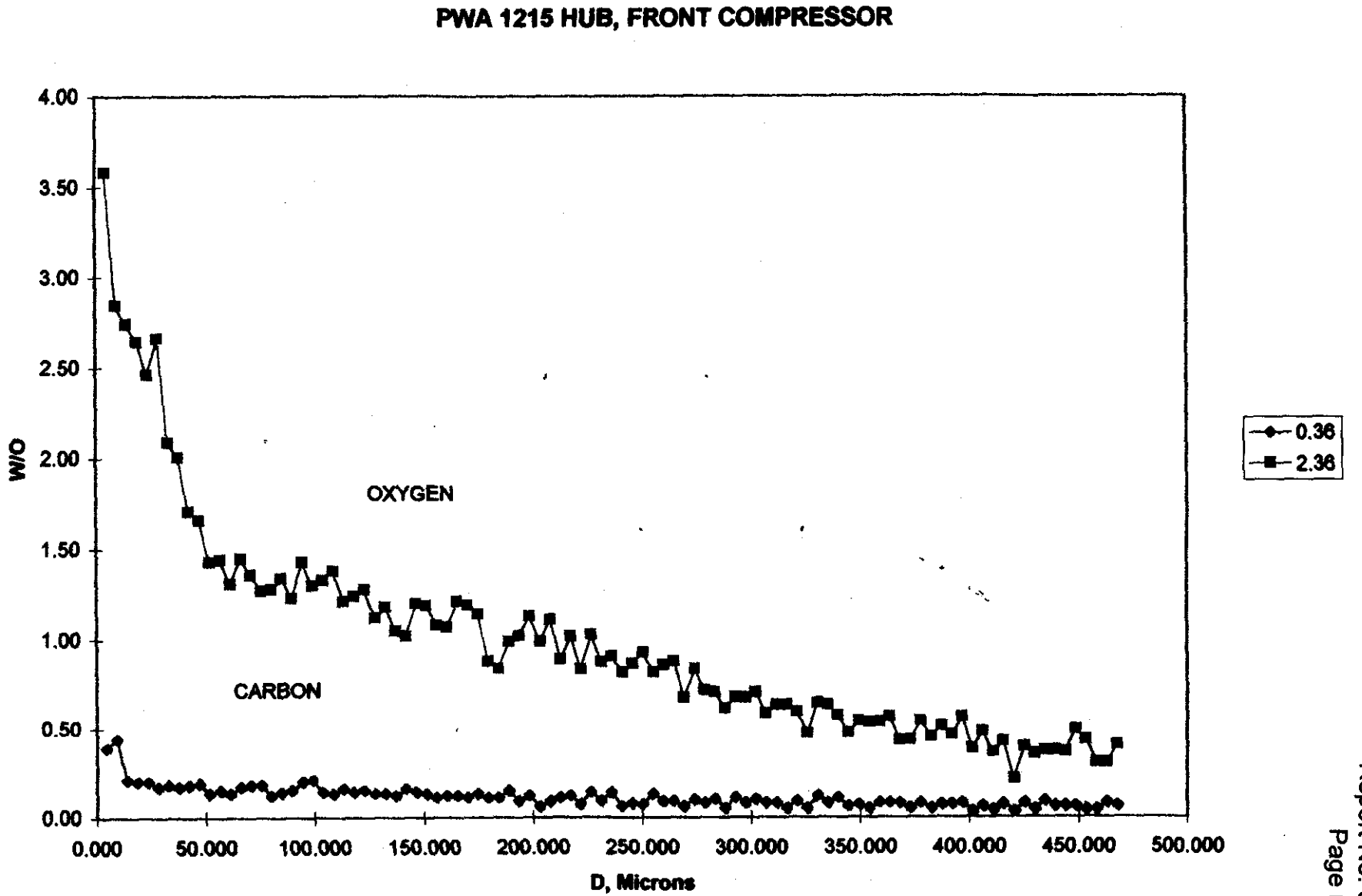


Figure 1. Locations of EPMA concentration profiles performed by Pratt & Whitney.



MA-97400

Figure 2. Concentrations of oxygen and carbon radially inward from the hole wall at the position indicated by arrow "c" in figure 1.

Chart2

BOLT
HOLE

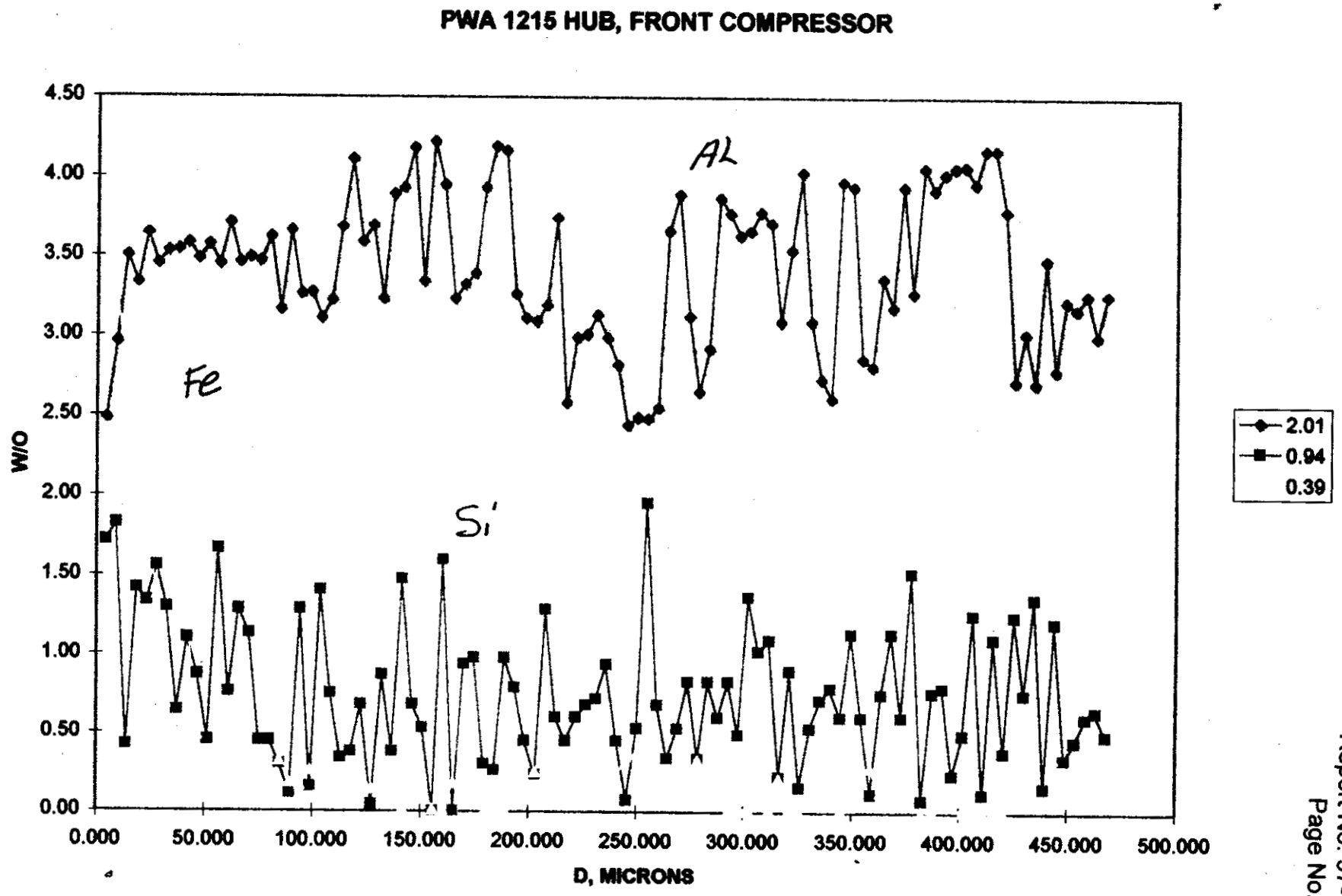


Figure 3. Concentrations of iron, silicon and aluminum radially inward from the hole wall at the position indicated by arrow "c" in figure 1.

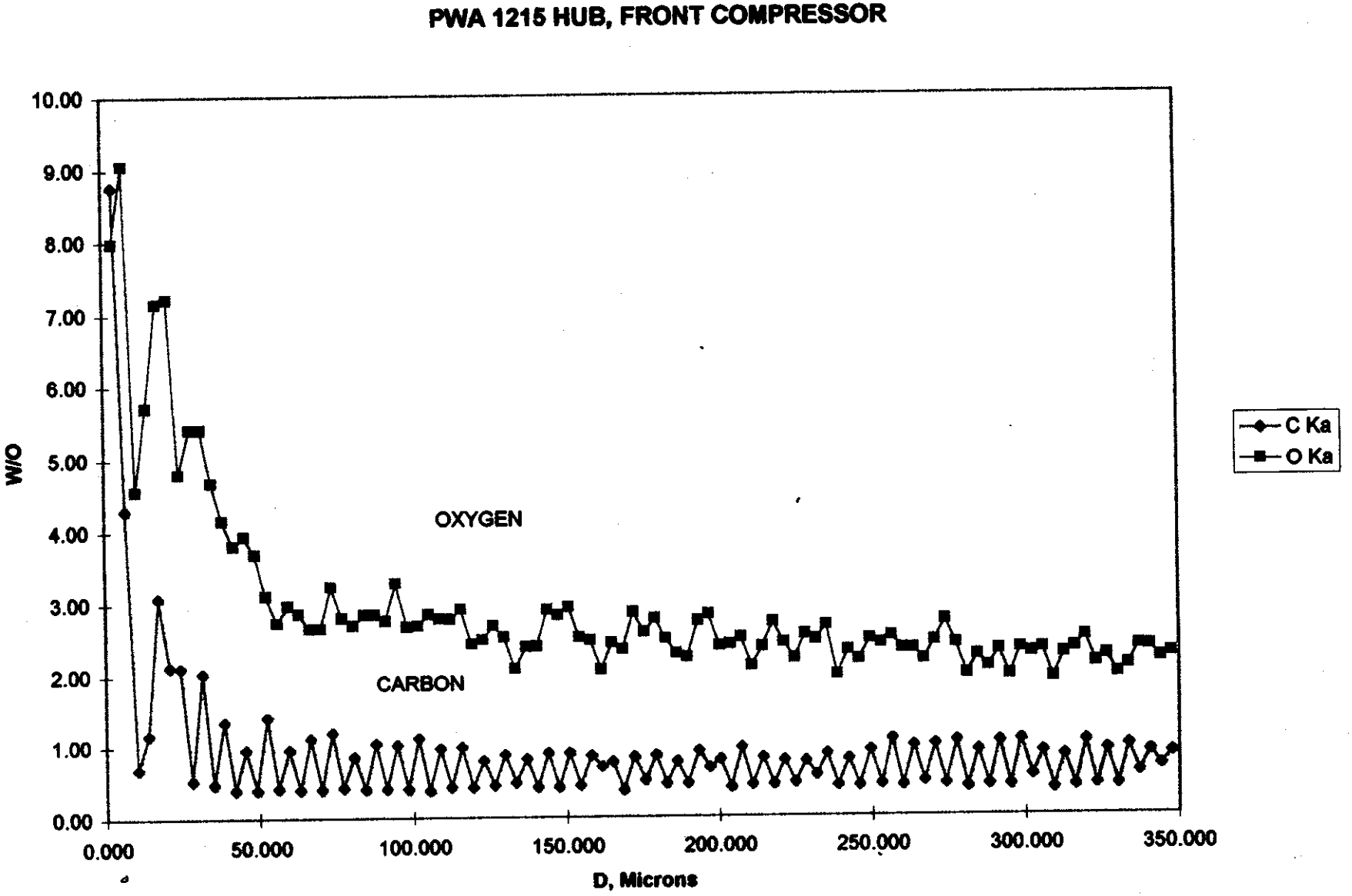


Figure 4. Concentrations of oxygen and carbon radially inward from the hole wall at the position indicated by arrow "d" in figure 1.

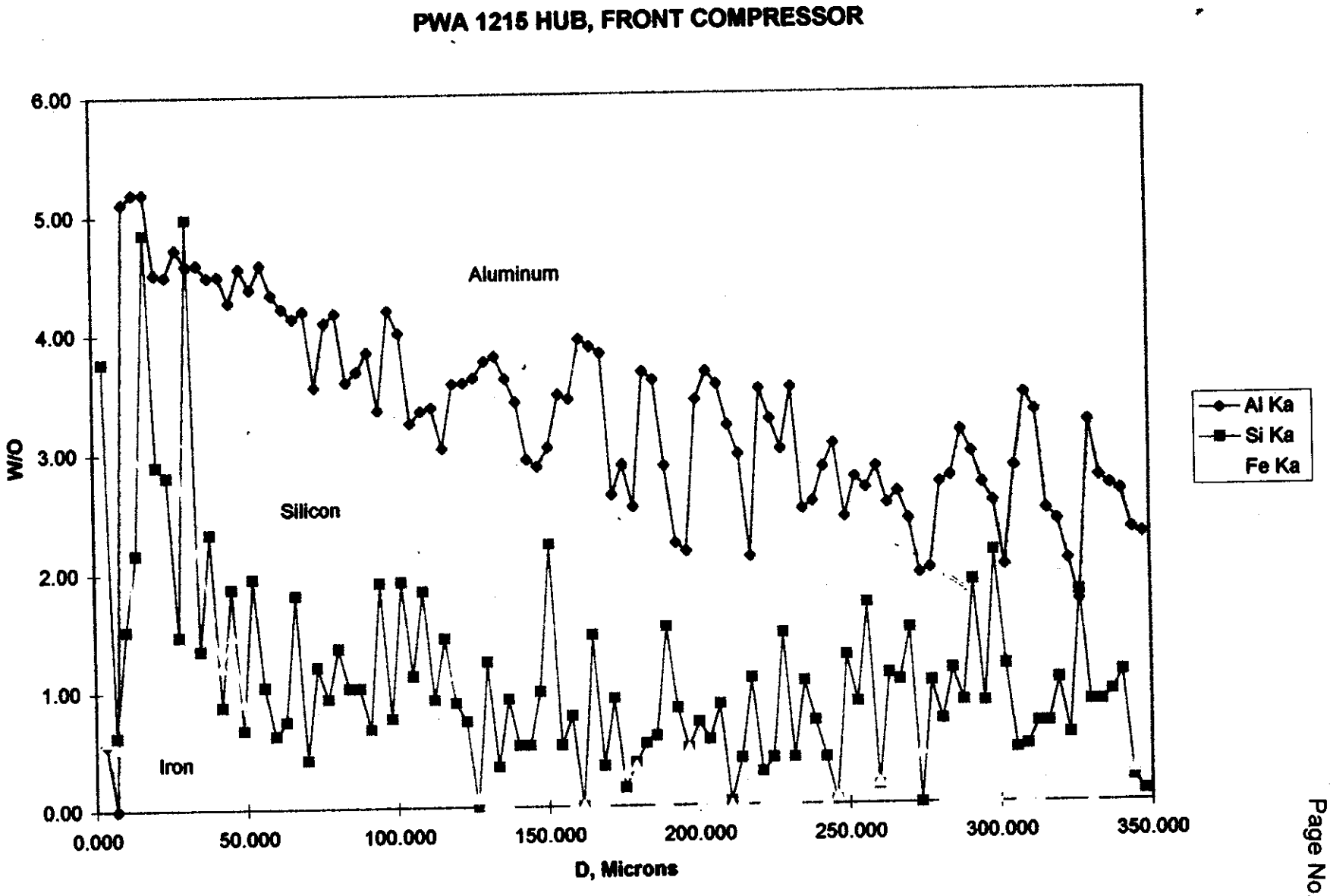
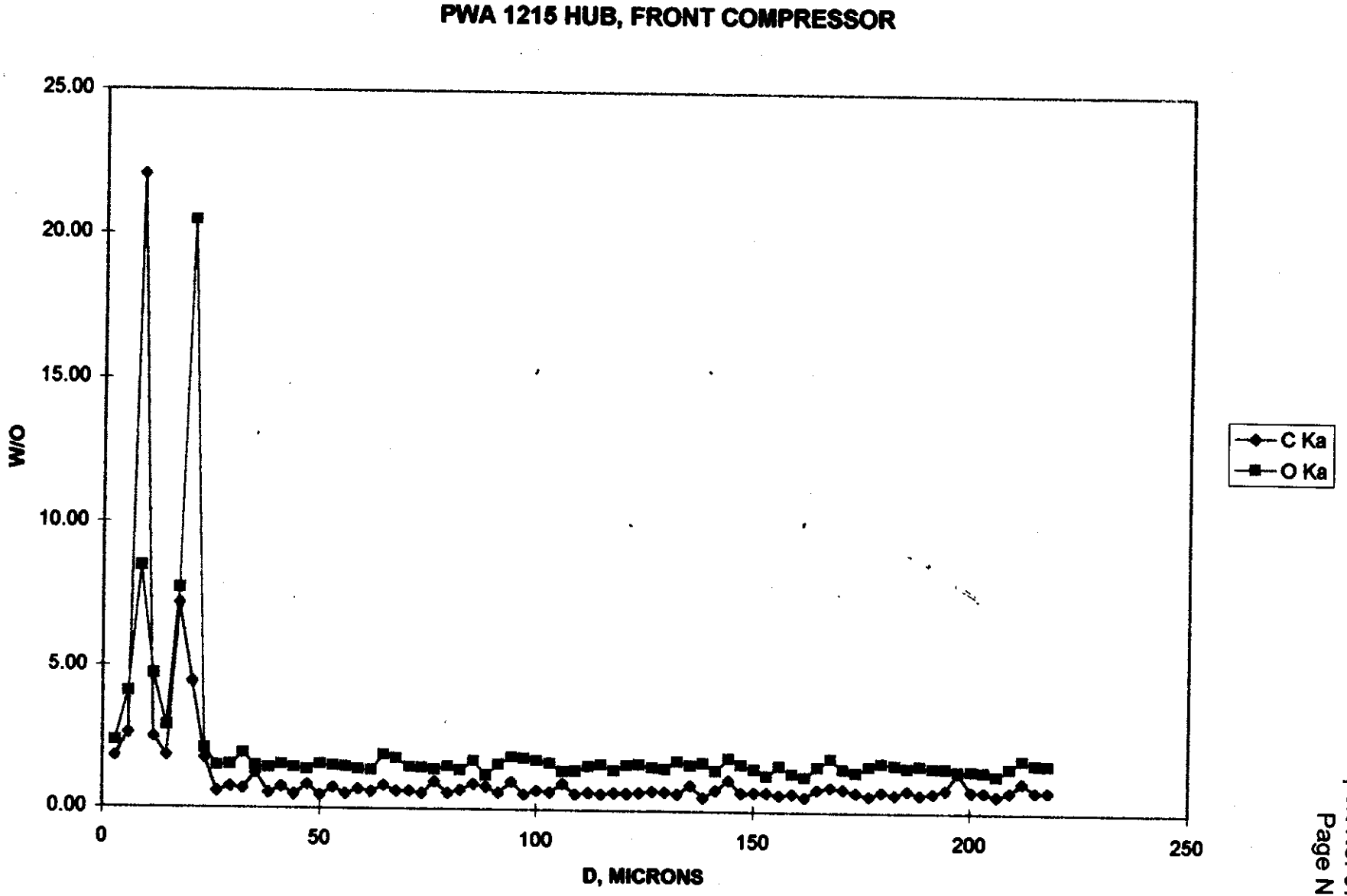


Figure 5. Concentrations of iron, silicon and aluminum radially inward from the hole wall at the position indicated by arrow "d" in figure 1.



MA-97400

Figure 6. Concentrations of oxygen and carbon radially inward from the hole wall at the position indicated by arrow "e" in figure 1

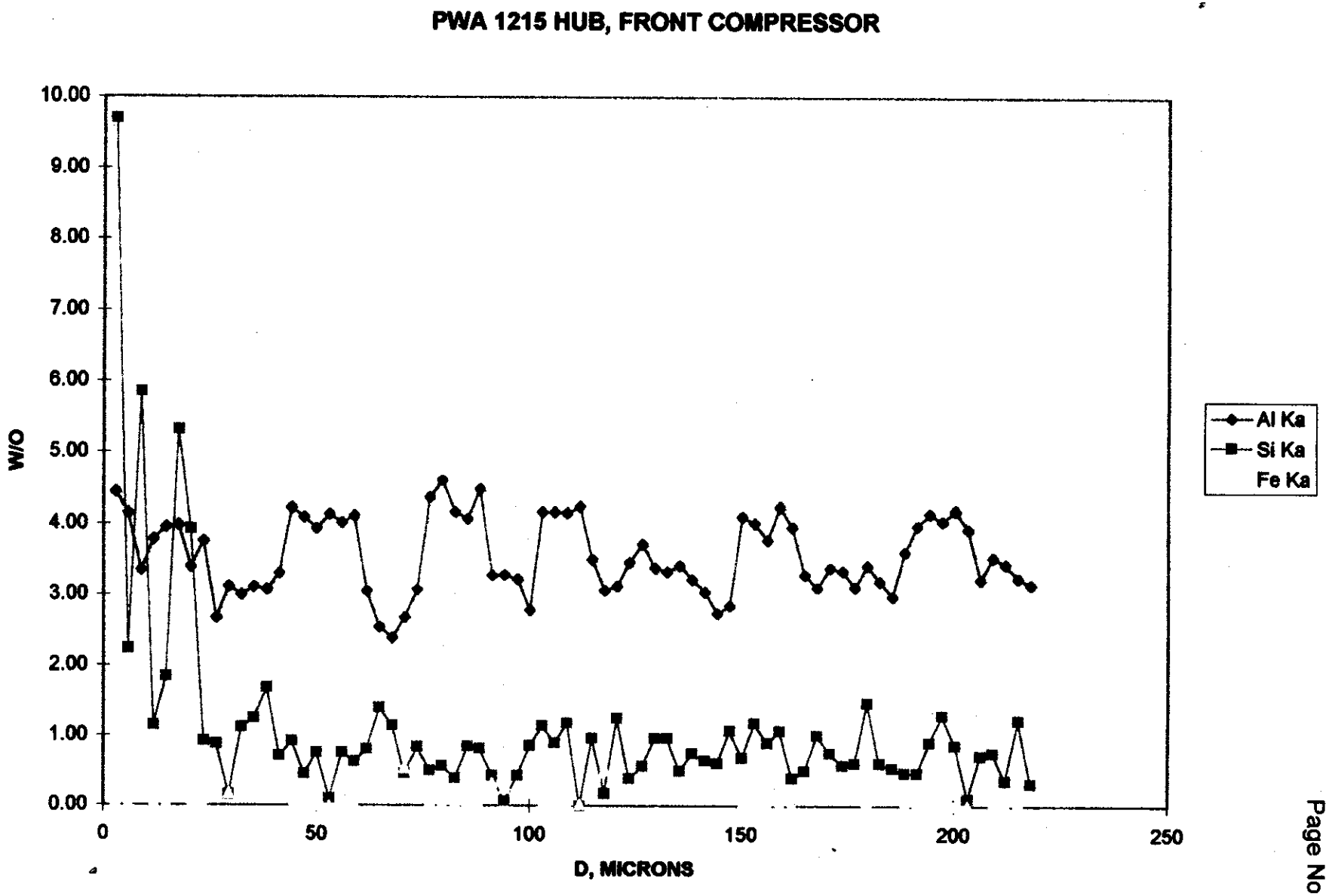


Figure 7. Concentrations of iron, silicon and aluminum radially inward from the hole wall at the position indicated by arrow "e" in figure 1.