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INTERIM REPORT - PT-IP-674
INVESTIGATION OF TERMINAL CORROSION RATES
IN ALUMINUM PROCESS TUBES

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INTERIM REPORT - PT-IP-674
INVESTIGATION OF TERMINAL CORROSION RATES
IN ALUMINUM PROCESS TUBES

by

C. G. Hough

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INTERIM REPORT - PT-IP-674
INVESTIGATION OF TERMINAL CORROSION RATES
IN ALUMINUM PROCESS TUBES

INTRODUCTION

Twenty-five aluminum process tubes installed during late 1961 and early 1962 at B and D reactors were selected as monitor tubes for this test. The parent test¹ authorized continued operation of the tubes until they reached a minimum remaining wall thickness of 28-30 mils as indicated by measurements following each metal cycle with the WTG or SAG. At D reactor, 20 of the desired 25 monitor tubes were replaced during April, 1964. Twenty additional tubes were selected so the test could be continued. This report summarizes the WTG results obtained to date and recommends continuation of the test.

SUMMARY AND RECOMMENDATIONS

Each of the 25 monitor tubes at B and D reactors have been gauged four to six times since they were installed in late 1961 or early 1962. Since October, 1962, the WTG data indicates the average corrosion rate is 0.25 to 0.30 mils per month. The corrosion rate of the thinnest tube is about the same as the average tube. As expected, the corrosion rate is low and believed to be a measure of top-wall corrosion. It is estimated that it will take approximately one more year (at 6.6 pH) before the bottom walls will have the same average minimum wall thickness as the top walls. During this period, the main problem will be to determine whether the top walls will continue corroding at rates between 0.25 to 0.30 mils per month. It is recommended the 25 tubes at B and D reactors be gauged with the WTG every metal cycle during the coming year. The Process Engineer will continue to analyze the WTG data as it accumulates and recommend further monitoring or replacement, subject to the details authorized in the parent test.

DISCUSSION

Results

Tables 1, 3, and 5 give the tube numbers, installation dates, and the most recent wall thickness data for the three monitor groups at B and D reactors. The first group of D reactor tubes (Table 1) is no longer monitored because 20 of the tubes were removed during April, 1964. A second group of D reactor tubes (Table 3) was selected to replace the original group so the test could be continued at D reactor. The original 25 tubes at B reactor (Table 5) are still operating.

A final summary of average WTG data is shown in Table 2 and Figure 1 for the original 25 tubes from D reactor. The table gives the average WTG result, corrosion index*, and months-in-reactor for each probolog date. These average results are

¹HW-81543, PT-IP-674-I, Investigation of Terminal Corrosion Rates In Aluminum Process Tubes, C. G. Hough, March 30, 1964, (Secret).

* Corrosion Index = $k(\text{MIR})(\text{TOE})e^{0.057T}$, where MIR is months in reactor, TOE is time operated efficiency, T is tube outlet temperature, and k is a constant. Basically, it is an "index" or "severity" measure of the combined effects of time and temperature.

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plotted in Figure 1. Also shown is the wall thickness of the thinnest tube for each probolog date. The individual WTG results for each probolog date can be obtained from Process Analysis Unit, if desired.

Similar average WTG results are shown in Table 4 and Figure 2 for the current group of 25 tubes from D reactor. The tubes in this group were divided into two subgroups; ten tubes installed between June and November, 1961, and 15 tubes installed during February, 1962. No attempt was made to account for the slight difference in average wall thickness for the two subgroups. There is essentially no difference in the average corrosion rates of the two subgroups. This group of 25 D reactor tubes should continue to be monitored with the WTG until they approach 28-30 mils of remaining wall thickness as authorized in the parent test.

Average WTG results for the 25 tubes from B reactor are shown in Table 6 and Figure 3. These tubes should also continue to be monitored until they approach 28-30 mils of remaining wall thickness.

Conclusions

Each process tube in the three monitor groups has been gauged from four to six times since October, 1962, about one year after they were installed. Since October, 1962, the average corrosion rate has been about 0.40 to 0.45 mils per unit corrosion index, and the average corrosion index generation rate has been about 0.58 to 0.67 index units per month. The thinnest probolog wall thickness was 42 to 46 mils at the end of 1962 and was 37 to 41 mils at the last WTG date. This indicates the thinnest tubes corrode at about the same rate as the average tube.

As expected, the corrosion rates are low and believed to be a measure of top wall corrosion. Recent examination of tubes removed from B and D reactors^{2,3} indicate the bottom wall is much thicker than the top wall for tubes installed during 1961 and 1962. It is expected that it will take approximately one more year (at 6.6 pH) before the bottom walls will have the same average wall thickness as the top walls. During this period, the main problem will be to determine whether the top walls will continue corroding at rates between 0.25 to 0.30 mils per month. Thus, it is recommended the 25 tubes at B and D reactors be gauged with the WTG every metal cycle during the coming year.

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²Strege, D.E., Ex-Reactor Tube Wall Thickness Measurements, D Reactor, RL-REA-181, November 11, 1964, Confidential, Undocumented.

³Strege, D.E., Ex-Reactor Tube Wall Thickness Measurements, B Reactor, RL-REA-278, December 1, 1964, Confidential, Undocumented.

TABLE 1
ORIGINAL D REACTOR MONITOR TUBES, PT-674

<u>Tube No.</u>	<u>Date Installed</u>	<u>Recent WTG Data</u>			
		<u>WTG Date</u>	<u>Wall Thickness</u>	<u>Corrosion Index</u>	<u>Months In Reactor</u>
1389	1/60	1/64	36	17.7	48.7
2383*	6/61	4/64	45	18.2	33.2
2577	8/61	4/64	40	19.9	31.1
2578	8/61	4/64	39	18.8	31.1
3278	8/61	4/64	39	18.4	31.1
3877*	8/61	4/64	45	18.2	31.1
3983	8/61	4/64	42	16.8	31.9
1186	9/61	4/64	40	22.3	30.1
1477*	9/61	4/64	45	18.6	30.6
2382	9/61	4/64	40	18.1	30.4
2878	9/61	4/64	42	18.6	30.2
3280	9/61	4/64	45	18.0	30.1
3582	9/61	4/64	42	16.7	30.1
3976	9/61	4/64	43	18.3	30.4
1479	10/61	4/64	43	17.1	29.3
2086	11/61	4/64	41	18.4	28.9
2776*	11/61	4/64	45	18.4	28.2
2685	12/61	4/64	37	18.7	27.5
2788	12/61	4/64	37	15.9	27.5
3277	12/61	4/64	39	18.0	27.5
3386	12/61	4/64	38	18.3	27.5
2681	2/62	4/64	38	18.3	25.3
3181	2/62	4/64	41	17.2	25.3
3977*	2/62	4/64	45	17.1	25.3
4081	2/62	4/64	38	14.9	25.3

* All tubes except those marked with an asterisk were replaced during April, 1964. The five surviving tubes were included in an alternate group (Table 3) so the test could be continued.

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TABLE 2

PT 674, AVERAGE WTG RESULTS
ORIGINAL 25 TUBES FROM D REACTOR

<u>WTG Date</u>	<u>Average Months In Reactor</u>	<u>Number Gauged</u>	<u>Average WTG Result (Mils)</u>	<u>Average Corrosion Index</u>	<u>Thinnest WTG Result (Mils)</u>
12/62-3/63	14.8	16	45.4	8.6	44
6/63	19.5	24	45.2	10.4	42
10/63	23.9	22	43.0	14.0	40
4/64	29.1	24	41.2	18.0	37

NOTE: Tube 1389 was not included in the averages because the installation date was significantly different from the other 24 tubes. These tubes are no longer monitored as a group since 20 of them were replaced during April, 1964.

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FIGURE 1

AVERAGE PROBLOG WALL THICKNESS OF 25
PROCESS TUBES INSTALLED AT D REACTOR BETWEEN
APRIL 1961 AND FEBRUARY 1962. TWENTY TUBES WERE
SUBSEQUENTLY REPLACED DURING APRIL 1962

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TABLE 3

CURRENT D REACTOR MONITOR TUBES, PT-674

<u>Tube No.</u>	<u>Date Installed</u>	<u>Recent WTG Data</u>			
		<u>WTG Date</u>	<u>Wall Thickness</u>	<u>Corrosion Index</u>	<u>Months In Reactor</u>
0880	8/61	1/64	45	15.3	28.9
1477	9/61	9/64	45	22.5	35.8
1783	8/61	1/64	46	14.3	28.2
2272	11/61	9/64	43	19.5	33.4
2383	6/61	9/64	45	20.9	38.4
2459	8/61	9/64	45	19.0	36.7
2776	11/61	9/64	43	21.8	33.4
2866	11/61	9/64	41	19.4	33.6
2986	11/61	9/64	43	18.6	33.6
3877	8/61	9/64	45	21.5	36.3
0974	2/62	9/64	40	20.1	30.5
1568	2/62	9/64	44	19.3	30.5
1884	2/62	9/64	42	19.3	30.5
2477	2/62	9/64	42	19.4	30.5
2676	2/62	9/64	41	19.4	30.5
2872	2/62	9/64	43	17.8	30.5
3279	2/62	9/64	45	19.6	30.5
3380	2/62	9/64	46	19.9	30.5
3468	2/62	4/64	44	15.6	25.3
3570	2/62	9/64	42	18.7	30.5
3575	2/62	9/64	46	19.3	30.5
3686	2/62	9/64	46	19.0	30.5
3862	2/62	4/64	45	14.9	25.3
3974	2/62	9/64	43	18.0	30.5
3977	2/62	4/64	45	17.1	25.3

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TABLE 4

PT-674, AVERAGE WTG RESULTS
CURRENT 25 TUBES FROM D REACTOR

<u>WTG</u> <u>Date</u>	<u>Average</u> <u>Months</u> <u>In Reactor</u>	<u>Number</u> <u>Gauged</u>	<u>Average</u> <u>WTG</u> <u>Result (Mils)</u>	<u>Average</u> <u>Corrosion</u> <u>Index</u>	<u>Thinnest</u> <u>WTG</u> <u>Result (Mils)</u>
<u>Ten Tubes Installed Between 6/61 and 11/61</u>					
12/62-2/63	16.3	5	48.0	8.6	46
6/63-8/63	20.7	5	46.0	10.5	45
9/63-11/63	23.9	6	44.8	12.9	43
12/63-2/64	27.7	5	44.2	14.6	41
4/64	29.7	6	44.0	17.3	41
9/64	35.1	8	43.7	20.4	41
<u>Fifteen Tubes Installed During 2/62</u>					
6/63-8/63	15.7	7	47.4	9.3	46
9/63-11/63	20.0	9	43.6	11.7	41
12/63-2/64	22.5	4	42.7	13.4	41
4/64	25.3	5	43.4	15.9	41
9/64	30.5	12	43.3	19.1	40

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FIGURE 2

AVERAGE PREDICTED WALL THICKNESS OF 25
FIFTEEN 1962 TUBES INSTALLED AT D REACTOR
BETWEEN JUNE 1961 AND FEBRUARY 1962

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TABLE 5

CURRENT B REACTOR MONITOR TUBES - PT 674

<u>Tube No.</u>	<u>Date Installed</u>	<u>Recent WTG Data</u>			
		<u>WTG Date</u>	<u>Wall Thickness</u>	<u>Corrosion Index</u>	<u>Months In Reactor</u>
2479	7/61	11/64	43	20.9	39.7
3273	6/61	6/64	41	16.6	36.0
3363	4/61	6/64	43	18.0	37.8
3767	7/61	7/64	42	20.6	36.0
3972	6/61	11/64	44	23.5	41.0
1063	1/62	10/64	45	20.1	33.0
1079	1/62	10/64	42	18.3	33.0
1185	1/64	10/64	40	18.2	33.0
1487	1/62	9/64	42	18.4	31.1
2088	1/62	9/64	42	14.6	31.8
2377	12/61	11/64	41	21.2	35.1
3671	11/61	11/64	42	17.5	35.6
3769	1/62	9/64	42	16.8	31.1
3977	1/62	7/64	42	14.7	29.9
1258	4/62	7/64	42	15.6	27.4
1286	4/62	10/64	37	18.4	30.0
1665	4/62	9/64	43	15.1	28.6
1687	4/62	9/64	42	18.2	28.6
1764	4/62	9/64	42	13.7	28.6
2262	4/62	6/64	42	15.2	26.1
2277	4/62	7/64	40	16.8	27.4
2768	4/62	11/64	42	17.5	31.1
2866	4/62	11/64	42	17.9	31.1
3762	4/62	7/64	42	17.6	27.4
3987	4/62	10/64	37	16.6	30.0

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TABLE 6

PT-674, AVERAGE WTG RESULTS
CURRENT 25 TUBES FROM B REACTOR

<u>WTG</u> <u>Date</u>	<u>Average</u> <u>Months</u> <u>In Reactor</u>	<u>Number</u> <u>Gauged</u>	<u>Average</u> <u>WTG</u> <u>Result (Mils)</u>	<u>Average</u> <u>Corrosion</u> <u>Index</u>	<u>Thinnest</u> <u>WTG</u> <u>Result (Mils)</u>
1/63-3/63	12.7	23	46.2	5.9	42
4/63-5/63	16.4	17	44.9	7.8	43
7/63-10/63	18.8	25	44.5	8.8	43
1/64 2/64	24.4	22	42.2	12.7	37
5/64-7/64	29.4	30	41.5	16.0	37
9/64-11/64	32.5	17	41.6	18.0	37

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FIGURE 3

**AVERAGE PROBLOG WALL THICKNESS OF 26
PROCESS TUBES INSTALLED AT B REACTOR
BETWEEN APRIL 1961 AND APRIL 1962**

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