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**EVALUATION OF FUEL ELEMENTS HAVING
SEALED ANODIZED COATINGS.**

FINAL REPORT, PT-105-621-A-67 MT

R. L. DILLON

OCTOBER 15, 1958

HANFORD LABORATORIES

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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HW-57782

C-67, Technology - Hanford Processes -
Reactor Technology
(M-3679, 22nd Ed.)

This document consists
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SEALED ANODIZED COATINGS.
FINAL REPORT, PT-105-621-A-67 MT

By

R. L. Dillon

Materials Development
Reactor and Fuels Research and Development Operation

October 15, 1958

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

Work performed under Contract No. W-31-109-Eng-52 between
the Atomic Energy Commission and General Electric Company

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EVALUATION OF FUEL ELEMENTS HAVING
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INTRODUCTION

Prior to the installation of improved charging machines and charging techniques serious gouging of the soft aluminum fuel element jackets was not infrequent. ^(1, 2, 3) A certain amount of mechanical abrasion also occurs as the element is pushed over the tube ribs in the course of the loading operation. To eliminate or at least minimize mechanical damage there has been some experimentation with hard anodic coatings applied to the aluminum fuel element jackets.

The first test of anodized fuel elements in-reactor included several types of anodic film, none of which were sealed. ⁽⁴⁾ While the abrasion resistance of these pieces was satisfactory, the corrosion resistance was noticeably inferior to standard autoclaved control pieces.

Subsequent irradiations of anodized fuel elements have been designed to evaluate a sealing process for anodic films developed by the Corrosion and Coatings Operation. As a result of the seal the corrosion resistance of the anodized jacket is made comparable to aluminum with the standard autoclave coat. ^(5, 6) While there is a slight reduction in abrasion resistance of the anodic film as a result of sealing, it is not serious.

For maximum abrasion resistance a coating of 1-1/2 - 2 mils has been employed. A post-irradiation visual inspection of anodized fuel elements indicated that under some exposure conditions heavy anodic coatings are subject to longitudinal cracks which extend through the oxide to the metal surface. ⁽⁶⁾

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OBJECTIVE

This report is an evaluation of thinner anodic coatings which should develop lower mechanical stresses within the oxide and should be less subject to cracking. ⁽⁷⁾

SUMMARY AND CONCLUSIONS

Corrosion data from PT 67 MT has been correlated with corrosion temperature. From the dependence of corrosion rate on corrosion temperature it can be shown:

- (1) In-reactor corrosion rates for sealed anodized fuel element jackets are indistinguishable from autoclaved control pieces.
- (2) Graphical representations of log corrosion rate as a function of reciprocal corrosion temperature are in good agreement with data obtained from PT 68 MT. Most of the data from PT 67 MT lie within the 95 per cent confidence limits established from PT 68 MT.

Reduction of anodic film thickness from 2 to 1 mil has eliminated almost all film cracking.

Improved fuel element charging equipment and procedures have reduced the need for hard abrasion resistant coatings on fuel elements.

DISCUSSION

Description of Test

Normal production pieces were obtained from the canning line prior to the autoclave cycle. These pieces were then anodized in a five per cent oxalic acid electrolyte for 45 minutes with a current density of 15 amps/ft². ⁽⁸⁾ The 40 hour, 170 C, 100 psi autoclaving cycle was employed to produce a corrosion resistant seal of the anodic film. The only feature distinguishing the sealing process from the standard autoclave integrity test is the use of liquid (deionized) water rather than steam.

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Ten charges of alternated anodized and control pieces were prepared from metal lot Z125. All pieces were identified by a stamped number. Sixteen pieces from each charge were weighed before exposure. Anodized pieces were weighed after anodizing and sealing.

The ten loadings were charged into central zone tubes of D-reactor. The weighed pieces were located in the downstream half of the tube so that they were exposed to the higher water temperatures. The exposure conditions for the irradiation are summarized in Table I.

Results

Seven of the ten charges produced usable corrosion data. Of the remaining three, weasel* data reported from tubes 2671 and 3778 were too scattered to analyse; for the third tube (3778) no post exposure weights were obtained.

The experimental weight data for corrosion evaluation of the anodized pieces consist of fuel element weights before exposure uncleaned and after exposure cleaned. The weight losses attributable to corrosion recorded before and after cleaning are listed in columns 2 and 3 of Tables II through VIII. Weasel data and fuel element power are listed in columns 4 and 5. Average tube inlet and outlet temperatures were developed from the daily records. Local water temperatures, column 6, were calculated from the inlet and outlet temperatures and the weasel data.

Before comparisons of corrosion data can be made, further development of the corrosion data is required. For the in-reactor test of X-8001 clad fuel elements a correlation of corrosion rate with corrosion temperature was found effective.^(9, 10) Corrosion temperature is not a directly measurable quantity, but is readily deducible from fuel element power, local water temperature and a plot of corrosion versus fuel element position.

* Weasel (Hanford jargon), a relative measurement of the gamma activity of the irradiated pieces within a charge, useful for estimating individual fuel element power.

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It was found possible to express corrosion temperature as a linear function of local water temperature and fuel element power:

$$T_c = T_w + KP$$

T_c = corrosion temperature in ° C

T_w = local water temperature in ° C

K = 1.7 = power/piece in KW

Experimental weight loss data plotted against fuel element position for PT 67 MT proved to be too scattered for an independent determination of K . The scatter is attributable in part to the relatively small weight losses involved. Corrosion temperatures were, therefore, calculated on the basis of the value of $K = 1.7$ previously established. Column 7 of Tables II - VIII is the temperature increment associated with fuel element power and column 8, the corrosion temperature. Columns 9 and 10 are reciprocal corrosion temperature in degrees Kelvin and the corrosion rate in mils per 30 operating days.

The PT 67 MT corrosion data are plotted as a function of corrosion temperature in Figure 1. For reference the 95 per cent confidence limits for the X-8001 corrosion data are shown. The bulk of the data of this report lie within those 95 per cent confidence limits. The outlying data represent almost entirely those corrosion rates obtained with low weight losses and consequently relatively low precision.

Having established the basis for a temperature scale a comparison of corrosion rates for anodized and control pieces can be made. By a counting process a slope of medians has been determined for anodized and control pieces separately. The lines are almost identical as may be seen in Figures 2 and 3. There is no significant difference between the corrosion behavior of control pieces and pieces having the tested combination of anodic film and seal.

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FIGURE 1

Corrosion Rate as a Function of Reciprocal Corrosion Temperature

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FIGURE 2

Slope of Medians for Anodized Pieces

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FIGURE 3

Slope of Medians for Control Pieces

One point concerning the determination of corrosion losses for anodized pieces should be made clear in concluding the discussion of quantitative aspects of the corrosion problem. Weight changes for anodized pieces refer to the as anodized and sealed piece. Since a weight gain of about 0.5 g results from the surface treatment, reference to the preanodized weight of the fuel elements would put these pieces in a very slightly more favorable light. The correction factor would have no practical significance and has been ignored.

The cracking of the anodic film previously noted for somewhat thicker coatings after irradiation did not appear to be a serious problem with the one mil coatings. Records of the visual inspection of 144 irradiated anodized pieces show that in only two cases was the oxide cracked.

The in-reactor corrosion tests of sealed anodic films have been essentially limited to one sealing procedure. The sealing procedure was deliberately tailored to the current autoclave integrity test for fuel elements. Laboratory experiments make it clear the Hanford autoclave cycle does not produce optimum corrosion protection. Considerably shorter cycle times and higher sealing temperatures might be expected to improve the seal.

Recommendations

The initial goal of the anodizing program was the formation of an abrasion resistant coating less subject to the charging damage which at one time was of serious concern as a source of fuel element failures. Recent improvement in charging machines and charging practice have largely eliminated fuel element failures likely to be related to charging damage. Further testing of coatings intended for protection against abrasion in normal charging is not warranted.

There is a possibility that laboratory experiments will produce a seal significantly more corrosion resistant than those thus far tested. Such a development might warrant a further test of anodized coating for corrosion protection.

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ACKNOWLEDGEMENTS

The writer gratefully acknowledges preparation of the anodized pieces and assembling of the charges by J. N. Casale, weighing and visual examination of the irradiated pieces by members of the Components Testing Operation Irradiation Processing Department.

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TABLE I

SUMMARY OF THE OPERATING CONDITIONS
FOR PRODUCTION TEST 67 MT

<u>Tube</u>	<u>Avg. Tube Inlet ° C</u>	<u>Avg. Tube Outlet ° C</u>	<u>Operating Days</u>	<u>MWD/T</u>	<u>KW/Tube</u>
2785	16.4	92.6	140	700	635
3179	16.6	92.4	130	635	621
3278	16.6	93.1	130	655	640
3367	16.6	93.7	130	665	650
3469	16.4	95.1	140	720	653
3770	16.4	91.5	140	700	635
3775	16.4	91.2	140	680	617

TABLE II
TUBE 3179-D

Inlet Temp. 16.6 C, Outlet Temp. 92.4, Tube Power 621 KW

1	2	3	4	5	6	7	8	9	10
No.	G. Total Wt. Loss (Cleaned)	G. Wt. Loss on Cleaning	Weasel	KW/Piece	T ° C Bulk	ΔT 1.7 x KW	T ° C Corr	1000/T ° K Corr	Corr. Rate Mils/30 Oper. Days
1	3.33	1.34	0.95	9.00	92.4	15.3	107.7	2.625	0.39
2	3.51	1.42	1.15	10.89	91.3	18.5	109.8	2.611	0.41
3	3.83	1.74	1.35	12.78	90.0	21.7	111.7	2.598	0.45
4	3.48	1.49	1.60	15.15	88.4	25.8	114.2	2.581	0.41
5	5.04	1.57	1.75	16.57	86.6	28.2	114.8	2.577	0.59
6	4.20	1.86	1.90	17.99	84.5	30.6	115.1	2.575	0.49
7	4.45	1.84	2.10	19.89	82.3	33.8	116.1	2.569	0.52
8	4.68	1.35	2.25	21.31	79.9	36.2	116.1	2.569	0.55
9	4.22	2.86	2.40	22.73	77.3	38.6	115.9	2.570	0.50
10	3.98	1.18	2.50	23.68	74.5	40.3	114.8	2.577	0.47
11	4.76	1.77	2.65	25.10	71.6	42.7	114.3	2.581	0.56
12	5.32	1.54	2.75	26.04	68.6	44.3	112.9	2.590	0.62
13	3.60	1.78	2.75	26.04	65.4	44.3	109.7	2.612	0.42
14	1.88	1.26	2.80	26.52	62.2	45.1	107.3	2.628	0.22
15	2.53	1.60	2.90	27.46	59.0	46.7	105.7	2.639	0.30
16	1.31	1.08	2.95	27.94	55.6	47.5	103.1	2.657	0.15
17			2.90	27.46	52.2				
18			2.90	27.46	48.9				
19			2.85	26.99	45.5				
20			2.70	25.57	42.2				
21			2.65	25.10	39.1				
22			2.50	23.68	36.0				
23			2.40	22.73	33.1				
24			2.30	21.78	30.4				
25			1.90	17.99	27.7				
26			1.90	17.99	25.5				
27			1.55	14.68	23.3				
28			1.30	12.31	21.5				
29			1.10	10.42	20.0				
30			0.80	7.58	18.7				
31			0.65	6.16	17.8				
32			0.40	3.79	17.1				

$$\frac{621}{65.55} = 9.47 \text{ KW/weasel unit}$$

$$\frac{\Delta T}{\text{Tube Power}} = \frac{75.8}{621} = .1221 \text{ C water temp. rise / KW}$$

65.55

TABLE III
TUBE 2785-D

Inlet Temp. 16.4 C, Outlet Temp. 92.6, Tube Power 635 KW

1	2	3	4	5	6	7	8	9	10
No.	G. Total Wt. Loss (Cleaned)	G. Wt. Loss on Cleaning	Weasel	KW/Piece	T °C Bulk	ΔT 1.7 x KW	T °C Corr	1000/T °K Corr	Corr. Rate Mils/30 Oper. Days
1	2.15	1.37	0.45	4.97	92.7	8.5	101.2	2.671	0.24
2	3.35	0.85	0.60	6.65	92.1	11.3	103.4	2.655	0.37
3	4.78	0.78	0.80	10.05	91.3	17.1	108.4	2.621	0.52
4	4.20	0.90	1.00	11.08	90.1	18.8	108.9	2.617	0.46
5	5.62	1.36	1.20	13.29	88.8	22.6	111.4	2.600	0.62
6	5.84	1.06	1.25	13.85	87.2	23.5	110.7	2.605	0.64
7	7.23	1.17	1.50	16.62	85.6	28.3	113.9	2.583	0.79
8	8.03	1.29	1.65	18.28	83.6	31.1	114.7	2.577	0.88
9	8.19	1.28	1.75	19.39	81.4	33.0	114.4	2.579	0.90
10	4.25	1.12	1.85	20.50	79.0	34.9	113.9	2.583	0.47
11	5.48	1.49	2.00	22.16	76.6	37.7	114.3	2.581	0.60
12			2.15	23.82	73.9	40.5	114.4	2.580	
13	5.57	1.60	2.30	25.48	71.1	43.3	114.4	2.579	0.61
14	4.79	1.16	2.40	26.59	68.0	45.2	113.2	2.588	0.52
15	4.55	1.64	2.45	27.15	64.8	46.2	111.0	2.603	0.50
16	2.18	1.17	2.50	27.70	61.5	47.1	108.6	2.619	0.24
17			2.50	27.70	58.2				
18			2.55	28.25	54.9				
19			2.60	28.81	51.5				
20			2.60	28.81	48.1				
21			2.50	27.70	44.6				
22			2.50	27.70	41.3				
23			2.45	27.15	38.0				
24			2.15	23.82	34.7				
25			2.10	23.27	31.8				
26			2.00	22.16	29.0				
27			1.80	19.94	26.4				
28			1.70	18.84	24.0				
29			1.35	14.96	21.7				
30			1.15	12.74	19.9				
31			0.90	9.97	18.4				
32			0.60	6.65	17.2				

$$\frac{635}{57.30} = 11.08 \text{ KW/weasel unit}$$

$$\frac{76.2}{635} = 0.1200 \text{ C water temp. rise/KW}$$

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TABLE IV
TUBE 3278-D

Inlet Temp. 16.6 C, Outlet Temp. 93.1, Tube Power 640 KW

1	2	3	4	5	6	7	8	9	10
No.	G. Total Wt. Loss (Cleaned)	G. Wt. Loss on Cleaning	Weasel	KW/Piece	T °C Bulk	ΔT 1.7 x KW	T °C Corr	1000/T °K Corr	Corr. Rate Mils/30 Oper. Days
1	1.64	1.30	0.55	5.02	93.1	8.5	101.6	2.668	0.19
2	3.39	1.09	0.75	6.85	92.5	11.6	104.1	2.650	0.39
3	5.72	1.39	1.00	9.13	91.7	15.5	107.2	2.629	0.66
4	6.26	1.14	1.20	10.96	90.6	18.6	109.2	2.615	0.72
5	6.27	1.29	1.45	13.24	89.3	22.5	111.8	2.597	0.72
6	5.68	1.37	1.65	15.06	87.7	25.6	113.3	2.587	0.57
7	6.65	1.54	1.85	16.89	85.9	28.7	114.6	2.579	0.77
8	6.47	1.56	2.00	18.26	83.9	31.0	114.9	2.577	0.75
9	8.22	1.71	2.20	20.09	81.7	34.2	115.9	2.570	0.95
10	6.38	1.28	2.35	21.46	79.3	36.5	115.8	2.571	0.74
11	8.38	1.67	2.55	23.28	76.7	39.6	116.3	2.567	0.97
12	6.24	1.70	2.70	24.65	74.0	41.9	115.9	2.570	0.72
13	4.99	1.93	2.80	25.56	71.0	43.5	114.5	2.579	0.58
14	3.54	0.47	2.90	26.48	68.0	45.0	113.0	2.582	0.41
15	3.61	1.65	2.90	26.48	64.8	45.0	109.8	2.611	0.42
16	2.22	1.22	2.95	26.93	61.6	45.8	107.4	2.627	0.26
17			3.05	27.85	58.4				
18			2.95	26.93	55.1				
19			3.00	27.39	51.9				
20			3.00	27.39	48.6				
21			3.10	28.30	45.3				
22			3.10	28.30	42.0				
23			2.95	26.93	38.6				
24			2.80	25.56	35.3				
25			2.65	24.19	32.3				
26			2.45	22.37	29.4				
27			2.20	20.09	26.7				
28			2.05	18.72	24.3				
29			1.70	15.52	22.1				
30			1.40	12.78	20.2				
31			1.10	10.04	18.7				
32			0.80	7.30	17.5				

70.10

$$\frac{640}{70.10} = 9.13 \text{ KW/weasel unit}$$

$$\frac{76.5}{640.00} = .1195 \text{ C water temp. rise/KW}$$

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TABLE V
TUBE 3367-D

Inlet Temp. 16.6 C, Outlet Temp. 93.7, Tube Power 650 KW

1	2	3	4	5	6	7	8	9	10
No.	G. Total Wt. Loss (Cleaned)	G. Wt. Loss on Cleaning	Weasel	KW/Piece	T °C Bulk	ΔT 1.7 x KW	T °C Corr	1000/T °K Corr	Corr. Rate Mils/30 Oper. Days
1	2.63	1.60	0.40	4.96	93.7	8.4	102.1	2.665	0.30
2	2.10	0.86	0.60	7.44	93.2	12.6	105.8	2.639	0.24
3	2.91	1.56	0.75	9.30	92.3	15.8	108.1	2.623	0.33
4	3.78	1.60	0.90	11.16	91.2	19.0	110.2	2.608	0.44
5	4.12	1.62	1.00	12.40	89.9	21.1	111.0	2.603	0.47
6	3.70	1.10	1.15	14.26	88.4	24.2	112.6	2.592	0.43
7	5.24	1.71	1.30	16.12	86.7	27.4	114.1	2.582	0.60
8	4.97	1.43	1.45	17.98	84.8	30.6	115.4	2.573	0.57
9	5.12	1.62	1.55	19.22	82.7	32.7	115.4	2.573	0.59
10	4.46	1.53	1.80	22.32	80.4	37.9	118.3	2.554	0.51
11	5.82	2.16	1.75	21.70	77.8	36.9	114.7	2.578	0.67
12	4.62	1.73	1.65	20.46	75.2	34.8	110.0	2.610	0.53
13	6.74	4.30	2.15	26.66	72.8	45.3	118.1	2.556	0.77
14	2.51		2.25	27.90	69.6	47.4	117.0	2.563	
15	6.92	1.44	2.30	28.52	66.3	48.5	114.8	2.577	0.82
16	3.28	1.32	2.30	28.52	62.9	48.5	111.4	2.600	0.38
17			2.30	28.52	59.5	48.5	109.9		
18			2.30	28.52	56.2	48.5	106.4		
19			2.30	28.52	52.9	48.5	102.9		
20			2.40	29.76	49.4	50.6	101.5		
21			2.30	28.52	45.9	48.5	95.8		
22			2.20	27.28	42.5	46.4	90.1		
23			2.15	26.66	39.3	45.3	85.7	650	= 12.40 KW/weasel unit
24			2.00	24.80	36.1	42.2	79.3	52.40	
25			2.00	24.80	33.2	42.2	76.3		
26			2.00	24.80	30.2	42.2	73.2	77.1	= .1186 C water temp. rise/KW
27			1.70	21.08	27.3	35.8	63.8	650.00	
28			1.65	20.46	24.8	34.8	60.1		
29			1.40	17.36	22.3	29.5	52.3		
30			1.15	14.26	20.3	24.2	44.8		
31			0.85	10.54	18.6	17.9	36.8		
32			0.50	6.20	17.3	10.5	28.1		
			52.40						

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TABLE VI
TUBE 3469-D

Inlet Temp. 16.4 C, Outlet Temp. 95.1, Tube Power 653 KW

1	2	3	4	5	6	7	8	9	10
No.	G. Total Wt. Loss (Cleaned)	G. Wt. Loss on Cleaning	Weasel	KW/Piece	T °C Bulk	ΔT 1.7 x KW	T °C Corr	1000/T °K Corr	Corr. Rate Mils/30 Oper. Days
1	2.25	1.48	0.40	4.34	95.1	7.4	102.5	2.662	0.24
2	2.47	0.73	0.60	6.51	94.6	11.1	105.7	2.639	0.26
3	3.29	1.37	0.75	8.14	93.8	13.8	107.6	2.626	0.35
4	4.38	1.30	0.95	10.31	92.8	17.6	110.4	2.607	0.47
5	5.44	1.36	1.15	12.48	91.6	21.2	112.8	2.591	0.58
6	4.54	1.22	1.40	15.12	90.1	25.7	115.8	2.571	0.49
7	5.45	1.55	1.50	16.28	88.3	27.7	116.0	2.569	0.58
8	5.59	1.54	1.70	18.44	86.3	31.3	117.6	2.558	0.60
9	5.84	1.79	1.90	20.62	84.1	35.1	119.2	2.548	0.62
10	5.01	1.77	2.00	21.70	81.6	36.9	118.5	2.553	0.54
11	5.95	1.73	2.15	23.33	79.0	39.7	118.7	2.552	0.64
12	4.04	1.73	2.30	24.96	76.2	42.4	118.6	2.552	0.43
13	4.40	1.55	2.40	26.04	73.2	44.3	117.5	2.560	0.47
14	3.32	1.47	2.45	26.58	70.0	45.2	115.2	2.575	0.36
15	3.68	1.82	2.55	27.67	66.9	47.0	113.9	2.583	0.39
16	2.97	1.39	2.60	28.21	63.5	48.0	111.5	2.599	0.32
17			2.65	28.75	60.1				
18			2.65	28.75	56.7				
19			2.65	28.75	53.2				
20			2.75	29.84	49.7				
21			2.65	28.75	46.1				
22			2.65	28.75	42.7				
23			2.55	27.67	39.2				
24			2.45	26.58	36.0				
25			2.35	25.50	32.7				
26			2.20	23.87	29.6				
27			1.95	21.16	26.7				
28			1.75	18.99	24.2				
29			1.45	15.73	21.9				
30			1.10	11.94	20.0				
31			0.95	10.31	18.6				
32			0.70	7.60	17.3				

$$\frac{653}{60.25} = 10.84 \text{ KW/weasel unit}$$

$$\frac{78.7}{653} = .1205 \text{ C water temp. rise/KW}$$

60.25

TABLE VII
TUBE 3770-D

Inlet Temp. 16.4 C, Outlet Temp. 91.5, Tube Power 635 KW

1	2	3	4	5	6	7	8	9	10
No.	G. Total Wt. Loss (Cleaned)	G. Wt. Loss on Cleaning	Weasel	KW/Piece	T °C Bulk	ΔT 1.7 x KW	T °C Corr	1000/T °K Corr	Corr. Rate Mils/30 Oper. Days
1	1.06	0.55	0.40	4.46	91.5	7.6	99.1	2.686	0.11
2		0.76	0.60	6.68	91.0	11.4	102.4	2.662	
3	3.34	1.22	0.75	8.36	90.2	14.2	104.4	2.648	0.35
4	5.55	1.17	0.95	10.58	89.2	18.0	107.2	2.629	0.59
5	6.11	1.19	1.10	12.25	88.0	20.8	108.8	2.618	0.65
6	6.23	1.18	1.30	14.48	86.5	24.6	111.1	2.602	0.66
7	6.88	0.33	1.50	16.71	85.0	28.4	113.4	2.587	0.73
8	6.32	1.18	1.70	18.94	82.8	32.2	115.0	2.576	0.67
9	7.89	1.42	1.80	20.05	80.6	34.1	114.7	2.578	0.84
10	8.31	1.40	1.95	21.72	78.2	36.9	115.1	2.575	0.88
11	7.87	1.62	2.10	23.39	75.6	39.8	115.4	2.573	0.84
12	5.21	1.91	2.20	24.51	72.9	41.7	114.6	2.579	0.55
13	4.93	1.46	2.25	25.07	70.0	42.6	112.6	2.592	0.52
14	3.54	1.44	2.40	26.74	67.0	45.5	112.5	2.593	0.38
15	3.56	1.70	2.50	27.85	63.8	47.3	111.1	2.602	0.38
16	2.52	1.30	2.55	28.41	60.5	48.3	108.8	2.618	0.27
17			2.60	28.96	57.2				
18			2.60	28.96	53.8				
19			2.65	29.52	50.3				
20			2.50	27.85	46.8				
21			2.50	27.85	43.5				
22			2.40	26.74	40.3				
23			2.35	26.18	37.1				
24			2.25	25.07	34.0				
25			2.05	22.84	31.0				
26			1.95	21.72	28.3				
27			1.75	19.50	25.8				
28			1.55	17.27	23.4				
29			1.30	14.48	21.4				
30			1.05	11.70	19.7				
31			.85	9.47	18.3				
32			0.60	6.68	17.2				
			57.00						

$$\frac{635}{57.00} = 11.14 \text{ KW/weasel unit}$$

$$\frac{75.1}{635} = .1183 \text{ C water temp. rise/KW}$$

TABLE VIII
TUBE 3775-D

Inlet Temp. 16.4 C, Outlet Temp. 91.2, Tube Power 617 KW

1	2	3	4	5	6	7	8	9	10
No.	G. Total Wt. Loss (Cleaned)	G. Wt. Loss on Cleaning	Weasel	KW/Piece	T °C Bulk	ΔT 1.7 x KW	T °C Corr	1000/T °K Corr	Corr. Rate Mils/30 Oper. Days
1	1.98	1.58	0.50	4.17	91.2	7.1	98.3	2.691	0.21
2	1.91	1.06	0.75	6.25	90.7	10.6	101.3	2.670	0.21
3	1.64	0.69	1.00	8.33	90.0	14.2	104.2	2.650	0.18
4	3.46	1.19	1.20	10.00	89.0	17.0	106.0	2.637	0.37
5	5.43	1.54	1.50	12.50	87.8	21.3	109.1	2.616	0.59
6	5.29	1.35	1.75	14.58	86.3	24.8	111.1	2.602	0.57
7	5.10	1.73	1.95	16.24	84.6	27.6	112.2	2.595	0.55
8	4.53	1.60	2.20	18.30	82.7	31.1	113.8	2.584	0.49
9	8.68	2.11	2.40	19.99	80.5	34.0	114.5	2.579	0.94
10	6.29	1.88	2.60	21.66	78.2	36.8	115.0	2.576	0.68
11	4.38	1.98	2.75	22.91	75.6	38.9	114.5	2.579	0.47
12	3.84	1.63	2.90	24.16	72.9	41.1	114.0	2.583	0.41
13	5.56	2.05	3.10	25.82	70.1	43.9	114.0	2.583	0.60
14	3.28	1.69	3.25	27.07	67.0	46.0	113.0	2.589	0.35
15	3.66	2.10	3.35	27.91	63.8	47.4	111.2	2.601	0.40
16	2.67	1.57	3.40	28.32	60.5	48.1	108.6	2.619	0.29
17			3.45	28.74	57.2				
18			3.45	28.74	53.8				
19			3.50	29.16	50.4				
20			3.45	28.74	47.0				
21			3.30	27.49	43.6				
22			3.30	27.49	40.4				
23			3.25	27.07	37.1				
24			3.00	24.99	33.9				
25			2.90	24.16	31.0				
26			2.60	21.66	28.1				
27			2.35	19.58	25.6				
28			2.10	17.49	23.3				
29			1.70	14.16	21.2				
30			1.40	11.66	19.5				
31			1.05	8.75	18.2				
32			0.80	6.66	17.2				

76.20

$$\frac{635}{76.20} = 8.33 \text{ KW/weasel unit}$$

$$\frac{74.8}{635} = .1178 \text{ C water temp. rise/KW}$$

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