MASTER

GEAP-3726(Vol. 3)

SODIUM MASS TRANSFER: II
SCREENING TEST DATA AND ANALYSIS
3. CORROSION SAMPLE DATA

Issued by:
R. W. Lockhart

May 1962

Atomic Power Equipment Department
General Electric Company
San Jose, California

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights, or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

This report has been reproduced directly from the best available copy.

Printed in USA. Price \$3.00. Available from the Office of Technical Services, Department of Commerce, Washington 25, D. C.

SODIUM MASS TRANSFER: II.
SCREENING TEST DATA AND ANALYSIS.
3. CORROSION SAMPLE DATA

Issued by R. W. Lockhart

Volume 1 - Mass Transfer Results
Volume 2 - Metallurgy
Volume 3 - Corrosion Sample Data

Prepared for the
SODIUM COMPONENTS DEVELOPMENT PROGRAM
of the
UNITED STATES ATOMIC ENERGY COMMISSION
UNDER CONTRACT AT(04-3)-189
PROJECT AGREEMENT #15

May, 1962

ATOMIC POWER EQUIPMENT DEPARTMENT

GENERAL ELECTRIC

SAN JOSE, CALIFORNIA

SODIUM MASS TRANSFER: II
SCREENING TEST DATA AND ANALYSIS
- CORROSION SAMPLE DATA

Corrosion data were obtained from analysis of the results of exposing metallic samples to flowing sodium within six sodium mass transfer test loops. This volume contains a compilation of the test data for about 570 samples that were exposed prior to December 31, 1961. Details of the test loop design, sample preparation and pre and post examinations are described in the preceeding two volumes of this report.

After 700 hours of exposure and after 1400 hours of exposure during the course of a normal 2800 hour test run, six of twenty-six samples are removed from the test loop sample holders and replaced by new ones. At the end of the run (2800 hours) all twenty-six samples in the sample holders plus approximately six pipe samples are removed and examined. Thus, the exposure of a complete set of new corrosion samples (approximately 44) to flowing sodium under varying test conditions is defined as a test run.

In order to transmit corrosion data to the project personnel and the customer expeditiously, an Analysis Report system was established. For each test loop an "AR" is issued for every scheduled sample removal period. The individual reports contained in this volume were issued as attachments to Monthly Progress Letters sent to the Commission. This volume contains a collection of the AR's for all the test runs that were completed prior to December 31, 1961.

The AR's are identified with a three-digit number system: the first digit refers to the test loop, the second digit refers to the run number and the third digit the numerical sequence number. For example, AR 4-1-2 refers to the samples that are removed from loop #4, run 1 at the 1400 hour (second) sampling period. Each report contains loop operating conditions, sample period information and data describing the individual corrosion samples. These data include the hardness and

weight before and after exposure, appearance upon removal from the test loop and observations from the metallographic examination. Gamma count data are reported for those test runs utilizing the radio tracer technique. All corrosion samples exposed with an irradiated foil in the loop are counted to determine the activity at sample locations.

The AR's issued prior to October, 1961, contain nominal values for sample temperatures, flow rates, and plugging temperatures (oxygen level). Averaged test values of these conditions for the exposure period have been reported in more recent reports. A table summarizing these averaged conditions for test runs included in this volume is presented below.

Time Averaged Values for
Sample Temperature, Plugging Temperature and Flow

Run No.	Test Hours	Temperature, deg. F								Flow gpm
		H1	H2	H3	H3R	C1	C2	C3	Ts	
1-P	394	1099	1198	1295	1276	1198	1097	796	455	0.58
1-1	2989	1099	1200	1297	1298	1175	1084	793	428	0.40
1-2	2165	1002	1104	1199	1204	1094	997	704	321	0.56
2-1	2782	983	1082	1181	1178	1082	983	690	309	0.70
2-2	714	985	1082	1179	1174	1082	985	698	327	0.60
2-3	712	997	1102	1200	1196	1090	1007	704	317	0.26
2-4	2800	995	1097	1196	1203	1092	1001	700	301	0.24
3-1	2729	997	1100	1198	1189	1099	1001	693	432	0.53
3-2	704	994	1083	1198	1182	1101	1008	707	296	0.52
3-3	700	1005	1120	1199	1172	1081	983	706	323	0.29
3-4	712	1004	1104	1202	1186	1100	1008	702	328	0.69
3-5	716	1008	1102	1202	1190	1090	993	699	311	0.90
3-6	1527	1004	1102	1202	1190	1096	1001	706	310	0.72
4-1	2802	999	1100	1192	1181	1087	990	703	418	0.41
4-2	2803	1001	1099	1097	1184	1087	999	699	319	0.35
4-3	700	1199	1195	1192	1189	805	696	701	296	0.39
5-1	2697	997	1096	1187	1184	1079	987	695	435	0.35
5-2	3002	1000	1098	1197	1196	1097	1000	701	320	0.55
6-1	2792	993	1093	1179	1169	1086	983	696	424	0.49
6-2	2805	1003	1101	1197	1184	1091	1004	705	316	0.40

The pipe samples, exposed within loop pipe sections located at the minimum and maximum temperature regions, were usually exposed for longer periods of time and to a wider range of flow and plugging temperature conditions than the standard corrosion samples located in sample holders. For example, pipe samples inserted in loop #2 at the end of run 2-1 were exposed to the following conditions prior to removal at the end of run 2-4:

Run	Exposure Hours	Flow gpm	Plugging Temperature deg. F
2-2P *	624	0.80	450 (50 ppm O ₂)
2-2	651	0.60	327 (15)
2-3	741	0.26	317 (13)
2-4	2800	0.24	301 (11)

Pipe sample data, including the time averaged values for temperature, flow, and plugging temperature, are included with the "end of the run" AR's listed below:

1-1-3	2-1-3	3-1-3	4-1-3	5-1-3	6-1-3
1-2-3	2-4-1	3-6-1	4-2-3	5-2-3	-

The data presented in the following Analysis Reports are analyzed and discussed in the first two volumes of this report. In this volume, the Analysis Reports are collated for each loop in the chronological order of the test run and, within the run, by the sampling period sequence. Colored divider pages separate the reports for each test loop.

* Run 2P was used for cleaning the system of the original sodium charge. The high plugging temperature is based upon circulation of hot sodium through the cold trap prior to removal of the original sodium charge and the flush charge of reactor grade sodium.

LOOP NO. 1

Hot Leg

316 Stainless Steel

Cold Leg

316 Stainless Steel

SODIUM MASS TRANSFER
ANALYSIS REPORT

ISSUED BY G. Billuris DATE 10/28/60
LOOP NO. 1 RUN NO. P (pre-irradiated specimen)
SAMPLE REMOVAL DATE 10/7/60 ACCUMULATED TEST TIME 394 HRS.
 T_{max} 1300 F ΔT 500 F
SODIUM FLOW 0.6 gpm OXIDE LEVEL 50 ppm O_2

CORROSION SAMPLES

SAMPLE NO.	1100	1101	1102	1175	
SAMPLE LOCATION	H1	H1	H1	H1	
AVERAGE VELOCITY, fps	6	6	6	18	
TEMPERATURE, °F	1100	1100	1100	1100	
INITIAL WEIGHT, g	4.35228	4.33107	4.27167	4.31357	
FINAL WEIGHT, g	4.35127	4.33039	4.27143	4.31296	
WEIGHT CHANGE, mg	-1.01	-0.68	-0.24	-0.61	
CORROSION RATE, mg/dm ² -mo	-20.4	-13.7	-4.8	-12.3	

APPEARANCE AFTER TEST:

H1 sample had thin gray film apparent under sodium residue.
Plier marks evident at top of samples.

METALLOGRAPHIC EXAMINATION:

All specimens from this run were prepared from 316 SS with elongated grain (not heat treated) and showed following characteristics after test:

1. Elongated grains. Grain size indeterminate due to transformed structure.
2. Good surface.
3. Sensitized condition.

All specimens had metallic surface layers and surface carbides except the following samples (primarily in the cold leg) which had only surface carbides: 1101, 1701, 1900, 1901, 1902, 1903, 1904 and 1905.

CORROSION SAMPLES

SAMPLE NO.	1200	1201	1202	1275	
LOCATION	H2	H2	H2	H2	
TEMPERATURE, °F	1200	1200	1200	1200	
VELOCITY, fps	6	6	6	18	
INITIAL WEIGHT, g	4.33923	4.29721	4.29276	4.30561	
FINAL WEIGHT, g	4.33511	4.29280	4.28860	4.29656	
WEIGHT CHANGE, mg	-4.12	-4.31	-4.16	-9.04	
CORROSION RATE, mg/dm ² -mo	-83.	-89.	-84.	-182.	

APPEARANCE AFTER TEST:

Plier marks evident on all samples. Thin dark film evident on specimens.

SAMPLE NO.	1400	1401	1500	1502	1503
LOCATION IN LOOP	H3	H3	H3R	H3R	H3R
TEMPERATURE, °F	1300	1300	1300	1300	1300
VELOCITY, fps	18	18	6	6	6
INITIAL WEIGHT, g	4.29694	4.30294	4.31728	4.29389	4.38340
FINAL WEIGHT, g	4.21341	4.25176	4.31156	4.28821	4.37932
WEIGHT CHANGE, mg	-83.53	-51.18	-5.72	-5.68	-4.08
CORROSION RATE, mg/dm ² -mo	-1680.	-1020.	-106.	-105.	-83.

APPEARANCE AFTER TEST:

Plier marks on all samples.

METALLOGRAPHIC EXAMINATION:

Results reported on p.1.

CORROSION SAMPLES

SAMPLE NO.	1600	1601	1602	1700	1701	1702
LOCATION	C1	C1	C1	C2	C2	C2
TEMPERATURE, °F	1200	1200	1200	1100	1100	1100
VELOCITY, fps	6	6	6	6	6	6
INITIAL WEIGHT, g	4.30337	4.40641	4.37378	4.31368	4.35073	4.26741
FINAL WEIGHT, g	4.32614	4.43326	4.39954	4.34561	4.38840	4.30972
WEIGHT CHANGE, mg	+22.77	+26.85	+25.76	+31.93	+37.67	+42.31
CORROSION RATE, mg/dm ² -mo	+460.	+542.	+520.	+644.	+732.	+855.

APPEARANCE AFTER TEST:

Plier marks noted on cell samples except 1601 and 1602.
Irregular dark gray deposits on sample surface.

SAMPLE NO.	1900	1901	1902	1903	1904	1905
LOCATION	C3	C3	C3	C3	C3	C3
TEMPERATURE, °F	800	800	800	800	800	800
VELOCITY, fps	6	6	6	6	6	6
INITIAL WEIGHT, g	4.36981	4.30828	4.27123	4.34550	4.31359	4.33553
FINAL WEIGHT, g	4.38732	4.34497*	4.30167*	4.36539	4.34870*	4.35568
WEIGHT CHANGE, mg	+17.51	+36.69	+30.44	+19.89	+35.11	+20.15
CORROSION RATE, mg/dm ² -mo	+356.	+742.	+615.	+401.	+709.	+407.

APPEARANCE AFTER TEST:

Plier marks at upper end of all samples. Dark gray deposit on sample surface.

METALLOGRAPHIC EXAMINATION:

Results reported on p. 1.

* Includes 1.8 - 1.9 mg of loose scale weighed separately.

SODIUM ANALYSIS

SAMPLE NO.	S6a					
TEST TIME, HRS.	100					
COMPOSITION, ppm	CHEM.	SPEC.	CHEM.	SPEC.	CHEM.	SPEC.
Ca	67	120				
Cr	2	4				
Co	-	8				
Fe	16.5	8				
Li	383	-				
Mn	-	1				
Mo	-	2				
Ni	10	16				
K	246	-				
Si	-	20				
Ti	-	4				

PLUG. INDICATOR DATA

Test Time, hrs 10

Plug Temp., °F 450

Oxide Conc. *, ppm O₂ 50

REMARKS:

SODIUM MASS TRANSFER
ANALYSIS REPORT

ISSUED BY J. Damon DATE 12/22/60
 LOOP NO. 1 RUN NO. 1
 SAMPLE REMOVAL DATE 12/13/60 ACCUMULATED TEST TIME 779 HRS.
 T_{max} 1300 F ΔT 500 F
 SODIUM FLOW 0.45 gpm OXIDE LEVEL 24-48 ppm O_2

CORROSION SAMPLES

SAMPLE NO.	1104	1475	1575	1603	1910	1911
LOCATION & MATERIAL	H1-316	H3-316	H3R-316	C1-316	C3-316	C3-316
TEMPERATURE, °F	1100	1300	1300	1200	800	800
VELOCITY, fps	4.5	13.5	13.5	4.5	4.5	4.5
HARDNESS, R_B	63	69	-	68	57	60
INITIAL WEIGHT, g	4.51902	4.38550	0.55761	4.40889	4.44677	4.49940
FINAL WEIGHT, g	4.41270	4.29743	0.55516	4.43313	4.45568	4.50344
WEIGHT CHANGE, mg	-6.32	-88.07	-2.45	+24.24	+8.91	+4.04
CORROSION RATE, mg/dm^2-mo	-65.0	-905.	-27.6	+249.	+91.7	+41.6

*Foil sample removed at 715 hrs; replaced with radioactive sample. Sample No. 1504 was lost in transit to laboratory due to a broken test tube.

APPEARANCE AFTER TEST:

H1 & H3 samples were clean. The H3R foil was partially covered with a black deposit and showed plier marks. The C1 & C3 samples were covered with a gray film and scattered black deposits.

METALLOGRAPHIC EXAMINATION:

Sample 1104) ASTM grain size 1 with areas of grain size 4. Few carbides noted.
 1603) Incipient surface layer. Surface good.
 1475) ASTM grain size 1 with areas of grain size 4. Sensitized. Incipient surface layer. Surface good.
 Foil No data available yet.
 1910) ASTM grain size 2. Structure approaching that of normal 316 SS.
 1911) Surface layer with depth of 0.70 mils. Good surface.

AR No. 1-1-1Page 2 of 2SODIUM ANALYSIS

SAMPLE NO.	S14a		S22a		
TEST TIME, HRS.	0		779		
COMPOSITION, ppm	CHEM.	SPEC.	CHEM.	SPEC.	
Ca	50	< 3			
Cr	0.83	< 15			
Co		< 9			
Fe	178	< 6			
Li	56	-			
Mn		< 3			
Mo		< 6			
Ni	1.11	60			
K	304	-			
Si		210			
Ti		< 15			

AVERAGE FLOW AND PLUGGING INDICATOR DATA

TEST TIME, HRS.	0	96	120	480	624
PLUG TEMP., °F	410	370	445**	435	430
OXIDE CONC. *, ppm O ₂	36	24	48	44	42

** 5½ grams of Na₂O were added to dump tank and the sodium dumped to pick up additional oxygen.

REMARKS:

* Based upon KAPL data, TID 5277, p.7

SODIUM MASS TRANSFER
ANALYSIS REPORT

ISSUED BY G. Billuris DATE 4/3/61LOOP NO. 1 RUN NO. 1SAMPLE REMOVAL DATE 2/23/61 ACCUMULATED TEST TIME 1470 HRS. $T_{\max}$ 1300 °F ΔT 500 °FSODIUM FLOW 0.4 gpm OXIDE LEVEL 45 ppm O₂

CORROSION SAMPLES

SAMPLE NO.	1103	1476	1604	1906	1913*	
LOCATION & MATERIAL	H1-316	H3-316	C1-316	C3-316	C3-316	
TEMPERATURE, °F	1100	1300	1200	800	800	
VELOCITY, fps	4	12	4	4	4	
HARDNESS, R _B Before After	← 64	62	62 ~ 58	66	67 →	
INITIAL WEIGHT, g	4.35588	4.43120	4.41395	4.42614	4.26148	
FINAL WEIGHT, g	4.34378	4.33271	4.51330	4.43466	4.28597	
WEIGHT CHANGE, mg	-12.10	-98.49	+99.35	+ 8.52	+24.49	
CORROSION RATE, mg/dm ² -mo	-65.8	-536.	+540.	+ 46.3	+283	

* Loaded @ 878 hours.

APPEARANCE AFTER TEST:

- 1103 - Relatively clean with slight grayish discoloration.
 1476 - Scattered black globules. Observed pits at top of sample.
 1604 - Dark gray deposit over surface.
 1906, 1913 - Dark gray with scattered black deposits on surface.

METALLOGRAPHIC EXAMINATION:

- 1604 - Large grained with some duplexing. Numerous carbides in prior grain sites. Heavy surface carbides. Incipient ferritic layer.
 1103 - Duplex grain size. Numerous carbides in prior grain sites. Light surface carbides.
 1913)
 1906) No change in microstructure.
 1476 - Large grained with twins. Very heavily distributed carbides. Surface layer 0.788 mils. deep. Incipient ferritic layer - Widmanstätten structure.

AR No. 1-1-2Page 2 of 3Date of Analysis 3/10/61RADIOCHEMICAL ANALYSISCORROSION AND SODIUM SAMPLES

Decay Correction Date:

SAMPLE NO.	1103	1476	1604	1906	1909
LOCATION & MATERIAL	H1-316	H3-316	C1-316	C3-316	C3-316
TEMPERATURE, °F	1100	1300	1200	800	800
VELOCITY, fps	4	12	4	4	4
SAMPLE ACTIVITY, μ c					
Cr 51	1.16×10^{-2}	-	3.75×10^{-1}	2.02×10^{-2}	7.16×10^{-2}
Mn 54	1.36×10^{-3}	1.17×10^{-3}	3.22×10^{-2}	7.12×10^{-3}	2.28×10^{-2}
Fe 59	2.98×10^{-4}	6.53×10^{-4}	1.65×10^{-1}	3.57×10^{-3}	2.46×10^{-2}
Co 60					
WASH ACTIVITY, μ c					
Cr 51	1.83×10^{-4}	1.34×10^{-4}	3.68×10^{-3}	1.22×10^{-2}	8.80×10^{-3}
Mn 54	6.75×10^{-5}	6.22×10^{-5}	1.48×10^{-3}	3.59×10^{-2}	1.19×10^{-2}
Fe 59	-	6.62×10^{-5}	4.22×10^{-2}	7.95×10^{-3}	3.79×10^{-3}
Co 60	5.49×10^{-5}	1.23×10^{-5}	2.76×10^{-3}	5.40×10^{-3}	7.52×10^{-3}
TOTAL ACTIVITY μ c	1.36×10^{-2}	1.84×10^{-2}	5.48×10^{-1}	8.13×10^{-2}	1.51×10^{-1}

IRRADIATED FOIL DATA:

Weight, mg - 555.16

Activity, c

Cr 51 - 3.24×10^3 Mn 54 - 1.03×10^2 Fe 59 - 4.08×10^2 Co 60 - 5.40×10^3 Total - 9.15×10^3

* These data are based upon a previous radiochemical analysis of the same lot of 316 stainless steel foil which was reported in the April, 1960 Progress Letter. The data are corrected to March 10, 1961.

SODIUM ANALYSIS

SAMPLE NO.	S 14		S 22		1-1-7	
TEST TIME, HRS.	694		779		1470	
COMPOSITION, ppm	CHEM.	SPEC.	CHEM.	SPEC.	CHEM.	SPEC.
Ca	50	< 3	21.8	3.5		
Cr	0.83	< 15	0.25	< 2		
Co		< 9		< 5		
Fe	177	< 6	2.0	< 2		
Li	56		93			
Mn		< 3	2.4	< 2		
Mo		< 2	1.6	< 2		
Ni	1.11	< 8	2.5	< 2		
K	154		316			
Si				2.5		
Ti		< 15		< 5		

PLUG. INDICATOR DATA

Test Time, hrs	803	925	1972**	1183**	1333
Plug Temp., °F	420°	435	430°	430	427
Oxide Conc.*, ppm O ₂	39	44	42	42	41

REMARKS:

** After cold trapping 30 minutes at 430°F - 450°F.

SODIUM MASS TRANSFER
ANALYSIS REPORT

ISSUED BY J. Damon DATE 6/2/61

LOOP NO. 1 RUN NO. 1

SAMPLE REMOVAL DATE 5/16/61 ACCUMULATED TEST TIME 2989 HRS.

T_{max} 1300° F Δ T 500° F

SODIUM FLOW 0.4 gpm OXIDE LEVEL 50 ppm O₂

CORROSION SAMPLES

SAMPLE NO.	1105	1106*	1107**	1176		
LOCATION & MATERIAL	H1-316	H1-316	H1-316	H1-316		
TEMPERATURE, °F	1100	1100	1100	1100		
VELOCITY, fps	4	4	4	12		
HARDNESS, R _B	Before	62	62	62		
	After	68	64	65		
INITIAL WEIGHT, g	4.45816	4.35472	4.36463	4.50229		
FINAL WEIGHT, g	4.44076	4.34343	4.35760	4.46237		
WEIGHT CHANGE, mg	-17.40	-11.29	-7.03	-39.93		
CORROSION RATE, mg/dm ² -mo	-46.6	-41.0	-37.1	-107.		

* Loaded at 779 hrs; ** Loaded at 1470 hrs.
APPEARANCE AFTER TEST:

All samples are relatively clean with only minute amounts of black scale - Medium to dark gray color.

METALLOGRAPHIC EXAMINATION:

- 1105 } Duplexed grain structure. Carbides heavily distributed preferentially in
1106 } - the small grains. Thin intergrannular carbide network. Carbides pre-
1176 } - cipitated at the slip planes, dislocation clusters, & the free surface.
Ferrite incipient on the surface and occasionally intergrannularly.
- 1107 - Uniformly small grained structure - (This specimen had not been subjected to the improper heat-treatment) Intergrannular carbide network more dominate in comparison to specimens above. Surface conditions similar to above

CORROSION SAMPLES

SAMPLE NO.	1203	1204	1205	1276	1477*	1478**
LOCATION & MATERIAL	H2-316	H2-316	H2-316	H2-316	H3-316	H3-316
TEMPERATURE, °F	1200	1200	1200	1200	1300	1300
VELOCITY, fps	4	4	4	12	12	12
HARDNESS, R _B	Before	62	62	62	62	62
	After	71	63	70	63	72
INITIAL WEIGHT, g	4.53423	4.38931	4.47900	4.34800	4.26347	4.32733
FINAL WEIGHT, g	4.47678	4.32328	4.41247	4.23543	4.10949	4.22371
WEIGHT CHANGE, mg	-57.45	-66.03	-66.53	-112.57	-153.98	-103.62
CORROSION RATE, mg/dm ² -mo	-154	-177	-178	-301	-560	-546

*Loaded at 779 hrs; **Loaded at 1470 hrs.

APPEARANCE AFTER TEST:

H2 - Slight evidence of black scale. Light to medium gray in color.

H3 - Sodium oxide layer over surface as a result of undrained sample holder.

METALLOGRAPHIC EXAMINATION:

1203 - Uniformly large grained structure, heavily sensitized. Numerous carbide clusters. Heavy surface carbides and incipient ferritic layer on free surface and inter-grannularly.

1204 - Similar to 1203 except duplexed.

1205 } Same as 1204 except 6 mils of ferrite on sheared edge.
1276 }

1477 - Same as 1203 except light surface carbides.

1478 - Same as 1107 with exception to lighter surface carbides, and incipient ferrite to 14 mils at sheared edge.

CORROSION SAMPLES

SAMPLE NO.	1503	1505	1506*	Foil* (1576)		
LOCATION & MATERIAL	H3R-316	H3R-316	H3R-316	H3R-316		
TEMPERATURE, °F	1300	1300	1300	1300		
VELOCITY, fps	4	4	4	12		
HARDNESS, R _B Before	← 62 →					
HARDNESS, R _B After	63	68	65			
INITIAL WEIGHT, g	4.42600	4.10882	4.18649	0.5168		
FINAL WEIGHT, g	4.19667	4.09916	4.18436	0.5694		
WEIGHT CHANGE, mg	-229.33	-9.66	-2.13	+52.6		
CORROSION RATE, mg/dm ² -mo	-614	-25.5	-7.74	+190.3		

*Installed at 779 hrs.

APPEARANCE AFTER TEST:

Sodium oxide film covered sample surface from undrained sample holder.

METALLOGRAPHIC EXAMINATION:

1503 - Duplexed structure. Light surface carbides but usual heavy intergrannula and clustered carbides. Ferrite incipient, 14 mils on sheared edges.

1505 - Same as 1503 except heavier surface carbides.

1506 - Same as 1505 - 1/2 mil solid ferritic layer.

CORROSION SAMPLES

SAMPLE NO.	1605	1606*	1607**	1703	1704	1706†
LOCATION & MATERIAL	C1-316	C1-316	C1-316	C2-316	C2-316	C2-316
TEMPERATURE, °F	1200	1200	1200	1100	1100	1100
VELOCITY, fps	4	4	4	4	4	4
HARDNESS, R _B	Before	62	62	62	62	62
	After	64	62	62	61	68
INITIAL WEIGHT, g	4.42644	4.29280	4.31341	4.36159	4.44745	4.27815
FINAL WEIGHT, g	4.51758	4.44840	4.41198	4.43590	4.51372	4.32963
WEIGHT CHANGE, mg	+91.14	+155.60	+98.57	+74.31	+66.27	+51.48
CORROSION RATE, mg/dm ² -mo	+244.	+565.	+520.	+199.	+178.	+195.

*Loaded at 779 hrs; ** loaded at 1470 hrs., † loaded at 878 hrs.

APPEARANCE AFTER TEST:

Sodium oxide film over all specimens from undrained holders.
Some black scale at top of C1 samples.

METALLOGRAPHIC EXAMINATION:

1605 } Same as 1505.
1606 }
1607 - Same as 1107.

1703 }
1704 } Same as 1105
1706 }

CORROSION SAMPLES

SAMPLE NO.	1907	1909	1912*	1914 A ‡	1914 B **	1915 **
LOCATION & MATERIAL	C3-316	C3-316	C3-316	C3-316	C3-316	C3-316
TEMPERATURE, °F	800	800	800	800	800	800
VELOCITY, fps	4	4	4	4	4	4
HARDNESS, R _B	Before	62	62	62	62	62
	After	59	60	58	62	61
INITIAL WEIGHT, g	4.50014	4.41924	4.26728	4.13787	4.30937	4.28445
FINAL WEIGHT, g	4.51652	4.45222	4.28714	4.17185	4.33626	4.31259
WEIGHT CHANGE, mg	+16.38	+32.98	+19.86	+33.98	+26.89	+28.14
CORROSION RATE, mg/dm ² -mo	+43.8	+87.5	+72.2	+129	+142	+148

*Loaded at 779 hrs. **Loaded at 1470 hrs. ‡ Loaded at 878 hrs.

APPEARANCE AFTER TEST:

Samples relatively free of sodium and discoloration.
Scattered black deposits evident over sample surface.

METALLOGRAPHIC EXAMINATION:

1907 } No change -
 1909 } Same as standard heat-treated
 1912 } Specimen AlOM.
 1914 A } No change -
 1914 B } Same as standard non-heat-treated
 1915 } Specimen Al4M.

SODIUM ANALYSIS

SAMPLE NO.	1-1-7		1-1-12			
TEST TIME, HRS.	1470		2989			
COMPOSITION, ppm	CHEM.	SPEC.	CHEM.	SPEC.	CHEM.	SPEC.
Ca	< 7.9		< 8.6			
Cr	1.1		1.4			
Co						
Fe	3.5		1.5			
Li	< 14.1		< 13.2			
Mn	< 1.7		< 1.9			
Mo	0.3		0.2			
Ni	2.8		1.4			
K	229		203			
Si						
Ti						

PLUG. INDICATOR DATA

Test Time, hrs	1495	1845	2110**	2134	2345	2925
Plug Temp., °F	435	430	385	430	440	410
Oxide Conc. *, ppm O ₂	44	42	29	42	46	36

REMARKS:

**Increased plugging temperature by cold trapping at 450°F.

RADIOCHEMICAL ANALYSIS

CORROSION AND SODIUM SAMPLES*

Decay Correction Date: 6-1-61

SAMPLE NO.	1103	1476	1604	1906	1913
LOCATION & MATERIAL	H1-316	H3-316	C1-316	C3-316	C3-316
TEMPERATURE, °F	1100	1300	1200	800	800
VELOCITY, fps	4	12	4	4	4
HRS. IN LOOP**	691	691	691	691	691
TIMES WASHED	1	1	1	1	1
SAMPLE ACTIVITY, μ c					
Cr 51	1.38×10^{-3}	-	4.45×10^{-2}	2.40×10^{-3}	8.50×10^{-3}
Mn 54	1.12×10^{-3}	0.97×10^{-3}	2.66×10^{-2}	5.87×10^{-3}	1.88×10^{-2}
Fe 59	-	-	2.16×10^{-1}	7.38×10^{-3}	1.59×10^{-2}
Co 60	2.89×10^{-4}	6.34×10^{-4}	7.2×10^{-2}	3.99×10^{-4}	-
WASH ACTIVITY, μ c					
Cr 51	2.17×10^{-5}	1.59×10^{-5}	4.37×10^{-4}	1.45×10^{-3}	1.04×10^{-3}
Mn 54	5.57×10^{-5}	5.14×10^{-5}	1.22×10^{-3}	2.96×10^{-2}	0.98×10^{-2}
Fe 59	-	1.85×10^{-5}	1.18×10^{-2}	2.22×10^{-3}	1.06×10^{-3}
Co 60	5.33×10^{-5}	1.19×10^{-5}	2.68×10^{-3}	5.24×10^{-3}	7.3×10^{-3}
TOTAL ACTIVITY, μ c	2.92×10^{-3}	1.70×10^{-3}	3.75×10^{-1}	5.55×10^{-2}	6.24×10^{-2}

* These data are identical to those published in Progress Letter No. 20 except for decay correction.

** Irradiated foil was added after 779 hrs. test operation for Run 1-1. Tabulated hours in loop refers to test time after irradiated foil was added.

RADIOCHEMICAL ANALYSIS
CORROSION AND SODIUM SAMPLES

Decay Correction Date: 6-1-61

SAMPLE NO.	1105	1106	1107	1176	1203
LOCATION & MATERIAL	H1-316	H1-316	H1-316	H1-316	H2-316
TEMPERATURE, °F	1100	1100	1100	1100	1200
VELOCITY, fps	4	4	4	12	4
HRS. IN LOOP	2210	2210	1519	2210	2210
TIMES WASHED	1	1	1	1	1
SAMPLE ACTIVITY, μC					
Cr 51	2.17×10^{-3}	1.54×10^{-2}	-	2.06×10^{-3}	-
Mn 54	2.96×10^{-3}	3.4×10^{-3}	3.49×10^{-3}	3.08×10^{-3}	1.78×10^{-3}
Fe 59	-	5.53×10^{-3}	-	-	4.1×10^{-5}
Co 60	2.34×10^{-4}	3.39×10^{-4}	2.35×10^{-4}	3.25×10^{-4}	5.7×10^{-4}
WASH ACTIVITY, μC					
Cr 51	7.88×10^{-4}	-	1.47×10^{-3}	-	5.68×10^{-4}
Mn 54	6.26×10^{-4}	5.72×10^{-4}	2.57×10^{-4}	1.02×10^{-3}	5.15×10^{-4}
Fe 59	4.73×10^{-4}	1.31×10^{-4}	3.29×10^{-4}	1.03×10^{-3}	1.58×10^{-3}
Co 60	4.68×10^{-4}	1.89×10^{-4}	2.61×10^{-4}	1.58×10^{-4}	3.20×10^{-4}
TOTAL ACTIVITY, μC	7.72×10^{-3}	2.56×10^{-2}	6.04×10^{-3}	7.67×10^{-3}	5.37×10^{-3}

RADIOCHEMICAL ANALYSIS

CORROSION AND SODIUM SAMPLES

Decay Correction Date: 6-1-61

SAMPLE NO.	1204	1205	1276	1477	1478
LOCATION & MATERIAL	H2-316	H2-316	H2-316	H3-316	H3-316
TEMPERATURE, °F	1200	1200	1200	1300	1300
VELOCITY, fps	4	4	12	12	12
HRS. IN LOOP	2210	2210	2210	2210	1519
TIMES WASHED	1	1	1	1	1
SAMPLE ACTIVITY, μ c					
Cr 51	-	-	2.48×10^{-4}	2.01×10^{-4}	-
Mn 54	1.19×10^{-3}	1.64×10^{-3}	8.83×10^{-4}	1.27×10^{-2}	2.51×10^{-3}
Fe 59	-	-	-	-	1.07×10^{-3}
Co 60	4.22×10^{-4}	4.73×10^{-4}	2.74×10^{-4}	5.9×10^{-4}	5.77×10^{-4}
WASH ACTIVITY, μ c					
Cr 51	-	1.955×10^{-3}	1.62×10^{-3}	1.85×10^{-3}	4.88×10^{-3}
Mn 54	2.35×10^{-4}	4.65×10^{-4}	1.195×10^{-3}	1.99×10^{-4}	8.08×10^{-4}
Fe 59	5.18×10^{-4}	2.66×10^{-4}	9.03×10^{-4}	4.37×10^{-4}	2.26×10^{-3}
Co 60	3.97×10^{-4}	2.08×10^{-4}	3.39×10^{-4}	4.47×10^{-4}	4.47×10^{-4}
TOTAL δ ACTIVITY, μ c	2.76×10^{-3}	5.01×10^{-3}	5.46×10^{-3}	1.64×10^{-2}	1.26×10^{-2}

AR No. 1-1-3APage 4 of 7

RADIOCHEMICAL ANALYSIS

CORROSION AND SODIUM SAMPLES

Decay Correction Date: 6-1-61

SAMPLE NO.	1503	1505	1506	FoillMT-2A*	
LOCATION & MATERIAL	H3R-316	H3R-316	H3R-316	H3R-316	
TEMPERATURE, °F	1300	1300	1300	1300	
VELOCITY, fps	4	4	4	12	
HRS. IN LOOP	2210	2210	2210	2210	
TIMES WASHED	1	1	1	1	
SAMPLE ACTIVITY, μc					
Cr 51	8.47×10^{-2}	-	-	1485	
Mn 54	3.72×10^{-3}	3.37×10^{-3}	4.17×10^{-3}	359	
Fe 59	-	-	-	1710	
Co 60	7.47×10^{-4}	4.00×10^{-4}	4.77×10^{-4}		
WASH ACTIVITY, μc					
Cr 51	2.31×10^{-3}	9.16×10^{-4}	2.40×10^{-3}		
Mn 54	4.28×10^{-3}	4.40×10^{-4}	5.60×10^{-4}		
Fe 59	4.92×10^{-4}	4.61×10^{-4}	3.79×10^{-4}		
Co 60	8.15×10^{-3}	2.80×10^{-4}	4.78×10^{-3}		
TOTAL ACTIVITY, μc	1.044×10^{-1}	6.37×10^{-3}	1.277×10^{-2}		

* Weight of foil after test: 0.5694 g.

RADIOCHEMICAL ANALYSIS
CORROSION AND SODIUM SAMPLES

Decay Correction Date: 6-1-61

SAMPLE NO.	1605	1606	1607	1703	1704
LOCATION & MATERIAL	C1-316	C1-316	C1-316	C2-316	C2-316
TEMPERATURE, °F	1200	1200	1200	1100	1100
VELOCITY, fps	4	4	4	4	4
HRS. IN LOOP WITH FOIL	2210	2210	1519	2210	2210
TIMES WASHED *	2	2	2	2	2
SAMPLE ACTIVITY, μc					
Cr 51	4.10×10^{-3}	1.12×10^{-1}	5.81×10^{-2}	3.53×10^{-2}	3.01×10^{-4}
Mn 54	2.70×10^{-2}	7.78×10^{-2}	3.13×10^{-2}	1.43×10^{-3}	2.71×10^{-2}
Fe 59	-	-	-	6.72×10^{-2}	-
Co 60	6.75×10^{-2}	2.95×10^{-1}	8.37×10^{-2}	4.62×10^{-2}	5.31×10^{-2}
WASH ACTIVITY, μc					
Cr 51	5.06×10^{-3}	6.77×10^{-3}	3.07×10^{-4}	2.33×10^{-4}	1.39×10^{-4}
Mn 54	9.60×10^{-4}	9.66×10^{-4}	4.64×10^{-4}	8.95×10^{-4}	5.35×10^{-4}
Fe 59	1.19×10^{-3}	4.07×10^{-4}	9.5×10^{-5}	2.82×10^{-4}	1.41×10^{-4}
Co 60	7.5×10^{-3}	5.21×10^{-3}	2.04×10^{-3}	1.46×10^{-3}	6.74×10^{-4}
TOTAL ACTIVITY, μc	1.133×10^{-1}	4.96×10^{-1}	1.76×10^{-1}	1.93×10^{-1}	8.20×10^{-2}

* Wash activity of samples washed more than once is activity of first wash only.

RADIOCHEMICAL ANALYSIS
CORROSION AND SODIUM SAMPLES

Decay Correction Date: 6-1-61

SAMPLE NO.	1706	1907	1909	1912	1914a
LOCATION & MATERIAL	C2-316	C3-316	C3-316	C3-316	C3-316
TEMPERATURE, °F	1100	800	800	800	800
VELOCITY, fps	4	4	4	4	4
HRS. IN LOOP	2210	2210	2210	2210	2210
TIMES WASHED	2	2	2	2	2
SAMPLE ACTIVITY, μ c					
Cr 51	3.17×10^{-2}	3.93×10^{-3}	7.84×10^{-5}	6.76×10^{-5}	5.36×10^{-3}
Mn 54	3.60×10^{-2}	2.67×10^{-2}	5.23×10^{-2}	3.41×10^{-2}	2.58×10^{-2}
Fe 59	-	3.82×10^{-4}	-	-	5.57×10^{-4}
Co 60	3.68×10^{-2}	2.21×10^{-3}	6.39×10^{-3}	4.82×10^{-3}	3.66×10^{-3}
WASH ACTIVITY, μ c					
Cr 51	8.70×10^{-3}	7.6×10^{-5}	8.18×10^{-5}	7.47×10^{-5}	2.39×10^{-4}
Mn 54	6.54×10^{-4}	5.41×10^{-3}	9.92×10^{-4}	3.97×10^{-4}	1.41×10^{-3}
Fe 59	3.29×10^{-4}	6.15×10^{-3}	1.19×10^{-4}	8.86×10^{-5}	2.08×10^{-4}
Co 60	1.59×10^{-3}	2.43×10^{-4}	2.63×10^{-4}	1.56×10^{-4}	2.76×10^{-4}
TOTAL ACTIVITY, μ c	1.15×10^{-1}	4.51×10^{-2}	6.02×10^{-2}	3.97×10^{-2}	3.78×10^{-2}

RADIOCHEMICAL ANALYSIS
CORROSION AND SODIUM SAMPLES

Decay Correction Date: 6-1-61

SAMPLE NO.	1914b	1915	1-1-7*	1-1-12*	
LOCATION & MATERIAL	C3-316	C3-316	DT-Na	DT-Na	
TEMPERATURE, °F	800	800	500	500	
VELOCITY	4	4	-	-	
HRS. IN LOOP	1519	1519	691	2210	
TIMES WASHED	2	2	-	-	
SAMPLE ACTIVITY, μc					
Cr 51	1.28×10^{-2}	6.12×10^{-5}	2.58×10^{-4}	2.66×10^{-4}	
Mn 54	4.15×10^{-2}	4.13×10^{-2}	2.58×10^{-5}	3.61×10^{-5}	
Fe 59	-	1.66×10^{-4}	5.72×10^{-5}	4.72×10^{-5}	
Co 60	8.01×10^{-2}	2.68×10^{-3}	1.14×10^{-5}	1.28×10^{-5}	
WASH ACTIVITY, μc					
Cr 51	3.20×10^{-4}	1.67×10^{-4}			
Mn 54	2.80×10^{-3}	2.15×10^{-4}			
Fe 59	2.91×10^{-4}	2.88×10^{-3}			
Co 60	4.60×10^{-4}	5.85×10^{-5}			
TOTAL μ ACTIVITY, μc	1.38×10^{-1}	4.75×10^{-2}	3.52×10^{-4}	3.62×10^{-4}	

*Sodium samples from dump tank. Activity values are in $\mu\text{c/g}$ sodium.

SODIUM MASS TRANSFERAR No. 1-1-3BANALYSIS REPORTPage 1 of 1

(Supplement to AR 1-1-3)

Run No. 1-1 Issued by Billuris/Hetzler Date August 4, 1961Sample Removal Date 7/8/61 Accumulated Test Hours 4320 ***T_{max} 1300 °F ΔT 500 °F Flow 0.4 gpm Oxygen Level 50 ppmCORROSION SAMPLES

SAMPLE NO.	1300	1301	1302	1800	1801	1802
LOCATION & MATERIAL **	Pipe H3-316	Pipe H3-316	Pipe H3-316	Pipe C3-316	Pipe C3-316	Pipe C3-316
TEMPERATURE, °F	1300	1300	1300	800	800	800
VELOCITY, fps	0.60	0.60	0.60	0.24	0.24	0.24
HARDNESS, R _B	Before	92	-	92	-	-
	After	86	-	98	-	-
INITIAL WEIGHT, g	8.14164	8.16600	8.08477	7.56068	7.58934	7.38615
FINAL WEIGHT, g	7.88854	7.79410	7.86500	7.57806	7.60800	7.40767
WEIGHT CHANGE, mg	-253.10	-371.90	-219.77	+17.38	+18.66	+21.52
CORROSION RATE, mg/dm ² -mo	-286.3	*	-248.2	+19.6	+21.1	+24.3

* Sample cut during removal from pipe. ** Samples located upstream of sample holder.

APPEARANCE AFTER TEST:

1300)
1301) - All samples were light gray. 1301 had a saw cut
1302) from removal technique.
1800, 1801, 1802 - All samples were dark gray with flecks of black scale.

METALLOGRAPHIC EXAMINATION:

1300 - Sensitized cold rolled structure with what appears to be rather large amounts of sigma phase. This specimen has been sent for sigma verification by X-ray diffraction techniques.
1800 - No change in microstructure.
1301)
1302)
1801) - Not examined; returned to loop.
1802)

*** Test runs completed while these samples were in the loop included 1-P, 1-1 and 1-1-F (fouling). The oxygen level was about 80 ppm for 300 hours during run 1-1-F and just prior to removing these samples from the test loop.

SODIUM MASS TRANSFERAR No. 1-2-1ANALYSIS REPORTPage 1 of 3Run No. 2 Issued by J. Damon/ Date 9/21/61F. HetzlerSample Removal Date 9/18/61 Accumulated Test Hours 737T_{max} 1200 °F ΔT 500 °F Flow 0.65 gpm Oxygen Level 12 ppmCORROSION SAMPLES

SAMPLE NO.	1110	1481	1608	1916	1919	
LOCATION & MATERIAL	H1 - 316	H3 - 316	C1 - 316	Inlet C3 - 316	Outlet C3 - 316	
TEMPERATURE, °F	1002	1199	1096	704	704	
VELOCITY, fps	7.19	21.6	7.19	7.19	7.19	
HARDNESS, R _B	Before	74	74	77	75	
	After	74	77	78	77	
INITIAL WEIGHT, g	4.26955	4.18713	4.31847	4.37514	4.26300	
FINAL WEIGHT, g	4.27046	4.16680	4.32826	4.38190	4.26458	
WEIGHT CHANGE, mg	+ 0.91	-20.33	+ 9.79	+ 6.76	+ 1.58	
CORROSION RATE, mg/dm ² -mo	+ 9.70	-216.1	+104.2	+ 72.0	+ 16.81	

APPEARANCE AFTER TEST:

- 1110 - The observable surface is dark gray to black.
- 1481 - Still shiny - Two small areas of black film on sample holder
- 1608 - Dark gray
- 1916 - Medium gray - One black globule on side of sample
- 1919 - Light to medium gray - Two small areas of black film

METALLOGRAPHIC EXAMINATION:

- 1110 - Lightly sensitized. Ferrite to 0.5 mil of sheared edge with Widmanstaetten structure.
- 1481 - Heavily sensitized. Even, solid layer of ferrite 0.3 mils. Widmanstaetten structure at sheared edge with no increase in ferrite thickness.
- 1608 - Moderately sensitized. Even, solid layer of ferrite 0.1 mils.
- 1916 - } No change in microstructure. 0.3 mils banding anomaly at free
- 1919 - } surface.

RADIOCHEMICAL ANALYSIS
CORROSION AND SODIUM SAMPLES

Decay Correction Date: 6-1-61

SAMPLE NO.	1110	1481	1608	1916	1919
LOCATION & MATERIAL	H1 - 316	H3 - 316	C1 - 316	Inlet C3 - 316	Outlet C3 - 316
TEMPERATURE, °F	1002	1199	1096	704	704
VELOCITY, fps	7.19	21.6	7.19	7.19	7.19
HRS. IN LOOP	737	737	737	737	737
TIMES WASHED	1	1	1	1	1
SAMPLE ACTIVITY, μC					
Cr 51	2.53	1.11	48.2	15.6	3.90
Mn 54	1.93×10^{-1}	1.31×10^{-2}	5.13×10^{-2}	5.64×10^{-2}	1.99×10^{-2}
Fe 59	-	-	-	1.35×10^{-3}	8.21×10^{-3}
Co 60	9.1×10^{-4}	3.71×10^{-3}	2.11×10^{-1}	1.54×10^{-2}	3.07×10^{-3}
WASH ACTIVITY, μC					
Cr 51	1.31×10^{-3}	5.85×10^{-3}	5.77×10^{-1}	5.18×10^{-1}	2.31
Mn 54	2.03×10^{-3}	1.20×10^{-3}	2.38×10^{-2}	1.02×10^{-1}	2.49×10^{-2}
Fe 59	1.17×10^{-3}	1.20×10^{-3}	1.02×10^{-1}	3.83×10^{-1}	9.06×10^{-2}
Co 60	2.88×10^{-4}	1.53×10^{-4}	5.99×10^{-2}	7.30×10^{-2}	1.26×10^{-2}
TOTAL ACTIVITY μC	2.72	1.13	49.2	16.8	6.37

AR No. 1-2-1Page 3 of 3SODIUM ANALYSIS

SAMPLE NO.	1-2-1	1-2-2			
TEST TIME, HRS.	0	692			
SAMPLING TEMP., °F	650	660			
SAMPLING LOCATION	Surge	Surge			
COMPOSITION, ppm					
Ca	<9.9	<9.5			
Cr	0.8	0.8			
Fe	3.7	3.5			
K	129	280			
Li	< 9	< 11			
Mn	<1.6	<1.5			
Mo	0.2	0.4			
Ni	2.1	1.9			
C	4	15			

AVERAGE FLOW AND PLUGGING INDICATOR DATA

TEST TIME, HRS.	0-700				
AVERAGE FLOW, gpm	0.654				
AVERAGE PLUGGING TEMP., °F	310				
OXIDE CONC. *, ppm O ₂	12				

REMARKS:

* Based upon KAPL data, TID 5277, p.7

SODIUM MASS TRANSFERAR No. 1-2-2ANALYSIS REPORTPage 1 of 2Run No. 1-2 Issued by J. Damon/
F. Hetzler Date 10/25/61Sample Removal Date 10/19/61 Accumulated Test Hours 1400T_{max} 1200 °F ΔT 500 °F Flow 0.597 gpm Oxygen Level 11 ppmCORROSION SAMPLES

SAMPLE NO.	1109	1482	1609	1917	1920	
LOCATION & MATERIAL	H1-316	H3-316	C1-316	inlet C3-316	outlet C3-316	
TEMPERATURE, °F	1002	1199	1096	704	704	
VELOCITY, fps	6.57	19.7	6.57	6.57	6.57	
HARDNESS, R _B	Before	75	75	77	77	
	After	75	74	78	78	
INITIAL WEIGHT, g	4.25210	4.28292	4.32119	4.20163	4.34545	
FINAL WEIGHT, g	4.25320	4.26281	4.34264	4.20342	4.35005	
WEIGHT CHANGE, mg	+1.10	-20.11	+21.45	+1.79	+4.60	
CORROSION RATE, mg/dm ² -mo	+6.17	-112.8	+120.5	+10.01	+25.8	

APPEARANCE AFTER TEST:

- 1109 - Medium gray
- 1482 - Light to medium gray
- 1609 - Medium to dark gray
- 1917 - Dark gray, one spot of black film
- 1920 - Medium gray

METALLOGRAPHIC EXAMINATION:

- 1109 - Lightly sensitized. Surface anomaly not apparent. Incipient ferrite and light Widmanstaetten at sheared edge.
- 1482 - Moderately sensitized. Ferrite developed in Widmanstaetten structure at sheared edge to 10.5 mil. Solid 3.0 mil ferritic layer developed at other surfaces. Intergranular ferrite not observed.
- 1609 - Moderately sensitized. Very small amounts of ferrite at sheared edge.
- 1917 - No apparent change in microstructure.
- 1920 - 0.5 mil surface anomaly.

AR No. 1-2-2Page 2 of 2RADIOCHEMICAL ANALYSISCORROSION AND SODIUM SAMPLES

Decay Correction Date: 6-1-61

SAMPLE NO.	1109	1482	1609	1917	1920
LOCATION & MATERIAL	H1 - 316	H3-316	C1 - 316	inlet C3 -316	outlet C3-316
TEMPERATURE, °F	1002	1199	1096	704	704
VELOCITY, fps	6.57	19.7	6.57	6.57	6.57
HRS. IN LOOP	1400	1400	1400	1400	1400
TIMES WASHED	1	1	1	1	1
SAMPLE ACTIVITY, μC					
Cr 51	2.47	1.00	6.16	2.38	8.51
Mn 54	2.60×10^{-2}	1.67×10^{-2}	0.128	1.56×10^{-2}	4.36×10^{-2}
Fe 59	-	-	-	-	-
Co 60	8.78×10^{-4}	4.17×10^{-3}	0.399	1.93×10^{-3}	9.28×10^{-3}
WASH ACTIVITY, μC					
Cr 51	7.15×10^{-4}	1.08×10^{-3}	0.388	0.251	0.117
Mn 54	4.60×10^{-5}	7.52×10^{-5}	1.43×10^{-3}	1.40×10^{-3}	8.55×10^{-4}
Fe 59	-	-	-	-	-
Co 60	3.00×10^{-4}	5.67×10^{-4}	2.33×10^{-2}	8.06×10^{-3}	4.14×10^{-3}
TOTAL δ ACTIVITY μC	2.50	1.02	62.5	2.65	8.58

SODIUM MASS TRANSFERAR No. 1-2-3Page 1 of 8ANALYSIS REPORTRun No. 1-2 Issued by J. Damon/R. S. Young Date 12/7/61Sample Removal Date 12/6/61 Accumulated Test Hours 2165 $T_{\max}$ 1204 °F T 501 °F Flow 0.56 gpm Oxygen Level 11 ppmCORROSION SAMPLES

TEST HOURS	2165	1428	765	2165		
SAMPLE NO.	1108	1111A	1112	1177		
LOCATION & MATERIAL	H1-316	H1-316	H1-316	H1-316		
TEMPERATURE, °F	1002	1002	1001	1002		
VELOCITY, fps	6.2	5.7	5.4	18.6		
HARDNESS, R_B	Before	75	77	76	75	
	After	77	77	72	77	
INITIAL WEIGHT, g	4.20530	4.40500	4.32165	4.28129		
FINAL WEIGHT, g	4.20629	4.40455	4.32137	4.28137		
WEIGHT CHANGE, mg	+0.99	-0.45	-0.28	+0.08		
CORROSION RATE, mg/dm ² -mo	+3.59	-2.47	-2.87	+0.29		

APPEARANCE AFTER TEST: 1108, 1111A, 1112, 1177 - Gray film with traces of black deposit.

METALLOGRAPHIC EXAMINATION:

- 1108 - Small spheroidized carbides dispersed similar to Std (A24M); grain size similar to Std; carbide precipitation all grain boundaries; sensitization moderate and uniform with corrosion layer (possibly ferritic) approximately 0.3 mils having heavy dark precipitation (carbides?) in narrow band separating it from body of specimen; precipitation of carbides at preferred sites in areas of cold work; surface layer might be fouling material since this specimen registered weight gain.
- 1111A - Moderate sensitization throughout; small spheroidized carbides dispersed similar to 1108; no band or incipient ferrite;
- 1112 - Very moderate sensitization (less in center); few spheroidized carbides in grains; heavier carbide precipitation washed areas; no band or ferrite layer.
- 1177 - Fewer carbides at grain boundaries than 1108; precipitate is discontinuous; sensitization less than 1108; corrosion uniform with appearance of surface similar to 1108 but less in thickness of affected zone; heavy carbide precipitate in worked areas of surface.

CORROSION SAMPLES

TEST HOURS	2165	2165	2165	2165	1428	765
SAMPLE NO.	1206	1207	1208	1277	inlet 1483	outlet 1484
LOCATION & MATERIAL	H2-316	H2-316	H2-316	H2-316	H3-316	H3-316
TEMPERATURE, °F	1104	1104	1104	1104	1199	1200
VELOCITY, fps	6.2	6.2	6.2	18.6	16.7	16.3
HARDNESS, R _B Before	75	75	75	76	77	77
HARDNESS, R _B After	78	81	81	80	78	75
INITIAL WEIGHT, g	4.16211	4.35631	4.32553	4.30943	4.26700	4.37385
FINAL WEIGHT, g	4.16093	4.35556	4.32417	4.30556	4.25070	4.36570
WEIGHT CHANGE, mg	-1.18	-0.75	-1.36	-3.87	-16.30	-8.15
CORROSION RATE, mg/dm ² -mo	-4.28	-2.72	-4.94	-14.0	-89.6	-83.6

APPEARANCE AFTER TEST: 1206, 1207, 1208, 1277 - Gray color with streaks of black deposit.

1483, 1484 - Light gray color with scattered black film.

METALLOGRAPHIC EXAMINATION:

1206 - Heavier precipitate of carbides at grain boundaries than samples exposed at 1000°F; high density of carbide precipitate in grains adjacent to grain boundaries; precipitate on twin planes; ferrite layer on surface approximately 0.3 mils thick; extensive carbide precipitate in areas of cold work near short edges.

1207, 1208 & 1277 appear same as 1206

1483 - Moderate carbide precipitate at grain boundaries - heavier than 765 hr. H-3 outlet sample; discontinuous ferritic layer near sample short edges (in some areas heavy - approximately 0.5 mils thick)

1484 - Less sensitization than 1483; incipient and discontinuous ferritic layer on surface - Maximum depth 0.3 mils.

CORROSION SAMPLES

TEST HOURS	2165	2165	2165	2165		
SAMPLE NO.	1507	1508	1509	MT4-4 1577		
LOCATION & MATERIAL	H3R-316	H3R-316	H3R-316	H3R-316		
TEMPERATURE, °F	1204	1204	1204	1204		
VELOCITY, fps	6.2	6.2	6.2	18.6		
HARDNESS, R _B Before	74	75	76	-		
HARDNESS, R _B After	77	77	77	-		
INITIAL WEIGHT, g	4.37620	4.36704	4.38666	0.5566		
FINAL WEIGHT, g	4.37481	4.36616	4.38505	0.5400		
WEIGHT CHANGE, mg	-1.39	-0.88	-1.61	-16.6		
CORROSION RATE, mg/dm ² -mo	-5.05	-3.19	-5.85	-66.6		

APPEARANCE AFTER TEST: 1507,1508,1509,1577 - Light gray color.

METALLOGRAPHIC EXAMINATION:

1507- Carbide precipitate same as sample 1484; relatively uniform ferrite layer on surface - maximum depth 0.6 mils.

1508- Same general appearance as 1507 except maximum depth of ferrite layer 0.4 mils.

1509- Same appearance as 1507.

CORROSION SAMPLES

TEST HOURS	2165	1428	765	2165	2165	2165
SAMPLE NO.	1610	1611	1612	1707	1708	1709
LOCATION & MATERIAL	C1-316	C1-316	01-316	C2-316	C2-316	C2-316
TEMPERATURE, °F	1094	1093	1090	997	997	997
VELOCITY, fps	6.2	5.7	5.4	6.2	6.2	6.2
HARDNESS, R _B Before	74	75	75	77	75	74
HARDNESS, R _B After	77	75	77	77	74	75
INITIAL WEIGHT, g	4.31300	4.31260	4.37188	4.31000	4.36230	4.31327
FINAL WEIGHT, g	4.34091	4.32052	4.38595	4.32933	4.38312	4.32144
WEIGHT CHANGE, mg	+27.91	+7.92	+14.07	+19.33	+20.82	+8.17
CORROSION RATE, mg/dm ² -mo	+100.	+43.5	+144.	+70.0	+75.6	+29.6

APPEARANCE AFTER TEST: 1610,1611,1612 - Covered with a dark gray film.
1707,1708,1709 Gray color streaked with black film.

METALLOGRAPHIC EXAMINATION:

1610-Moderate sensitization; surface reaction zone approximately 0.2 mils thick
(May be ferritic layer)

1611-Body of sample appears same as 1610; however, band areas under surface show absence of fine particle precipitate within grains and density of precipitate near grain boundaries considerably less than body of sample; very little surface layer reaction zone.

1612-Same appearance as 1611.

1707,1708,1709 - All surfaces are similar; slight sensitization throughout;
Knoop hardness of body on 1708 is 86.07.

CORROSION SAMPLES

TEST HOURS	2165	2165	1428	1428	765	765
SAMPLE NO.	1918	1921	1922	1923	1924	1925
LOCATION & MATERIAL	ⁱⁿ C3-316	^{out} C3-316	ⁱⁿ C3-316	^{out} C3-316	ⁱⁿ C3-316	^{out} C3-316
TEMPERATURE, °F	704	704	702	702	703	703
VELOCITY, fps	6.2	6.2	5.7	5.7	5.4	5.4
HARDNESS, R _B Before	74	75	77	77	77	77
HARDNESS, R _B After	75	80	78	77	80	74
INITIAL WEIGHT, g	4.23064	4.17967	4.26455	4.25650	4.21027	4.25440
FINAL WEIGHT, g	4.23226	4.18248	4.27450	4.24789	4.21183	4.25510
WEIGHT CHANGE, mg	+1.62	+2.81	+9.95	-8.61	+1.56	+0.70
CORROSION RATE, mg/dm ² -mo	+5.89	+10.2	+54.7	-47.4	+16.0	+7.18

APPEARANCE AFTER TEST: 1918, 1921, 1922, 1923, 1924, 1925 - Dark gray film over scattered black scale deposits.

METALLOGRAPHIC EXAMINATION:

1924 & 1925 Same appearance as standard A24M

1922 - Body of sample same as standard A24M; light etching surface layer, Probably ferrite, 0.4 mils thick.

1923 - Same appearance as standard A24M, no ferrite layer.

1918 - Same as 1921

1921 - Structure of body same as standard A24M; surface ferrite layer 0.6 mils thick; Knoop hardness in body of sample 86.9 while surface layer measured 102.3, 88.9, 85.4 and 15.4 Knoop at various locations.

AR No. 1-2-3Page 6 of 8SURGE TANK
CORROSION SAMPLES

TEST HOURS	2165	765				
SAMPLE NO.	1804	1806				
LOCATION & MATERIAL	S.T.-316	S.T.-316				
TEMPERATURE, °F	~ 675	~ 675				
VELOCITY, fps	< 0.1	< 0.1				
HARDNESS, R _B Before	64	78				
HARDNESS, R _B After	71	77				
INITIAL WEIGHT, g	7.03338	8.27035				
FINAL WEIGHT, g	7.02474	8.26934				
WEIGHT CHANGE, mg	-8.64	-1.01				
CORROSION RATE, mg/dm ² -mo	-31.4	-10.4				

APPEARANCE AFTER TEST: 1804, 1806 - Gray film, no scale evident.

METALLOGRAPHIC EXAMINATION:

1804- Body of sample appeared same as standard A24M; a uniform light etching layer appeared on all surfaces (ferrite?) Approximately 0.5 mils thick; hardness of surface layer appears less than body of sample.

1806- Same as 1804.

SODIUM MASS TRANSFER

AR No. 1-2-3ANALYSIS REPORTPage 7 of 8Run No. 1-2 Issued by J. Damon/ Date 12/12/61

R.S. Young

Sample Removal Date 12/7/61 Accumulated Test Hours 2326*T_{max} 1199 °F ΔT 495 °F Flow 0.57 gpm Oxygen Level 14 ppm316SS PIPE
CORROSION SAMPLES

SAMPLE NO.	1301	1302	1303*	1801	1802	1803*
LOCATION & MATERIAL	H3-H3R	H3-H3R	H3-H3R	C3 out	C3 out	C3 out
TEMPERATURE, °F	1199	1199	1199	704	704	704
VELOCITY, fps	0.88	0.88	0.88	0.86	0.86	0.86
HARDNESS, R _B Before	-	-	-	-	-	-
HARDNESS, R _B After	-	-	-	-	-	-
INITIAL WEIGHT, g	7.79410	7.86500	7.11121	7.60800	7.40767	7.20972
FINAL WEIGHT, g	7.78675	7.85730	7.10670	7.60242	7.39920	7.21300
WEIGHT CHANGE, mg	-7.35	-7.70	-4.51	-5.58	-8.47	+3.28
CORROSION RATE, mg/dm ² -mo	-15.5	-16.2	-9.49	-11.8	-17.8	+6.81

*New samples for run 1-2; other samples reloaded after exposure during run 1-1.

APPEARANCE AFTER TEST:

1301, 1302, 1303 - Light gray film, no scale.

1801, 1802, 1803 - Gray film over scattered black deposit.

METALLOGRAPHIC EXAMINATION:

No metallography data - Above samples were reinstalled in loop for run 1-3.

AR No. 1-2-3Page 8 of 8SODIUM ANALYSIS

SAMPLE NO.	1-2-1	1-2-2	1-2-3	1-2-5	
TEST TIME, HRS.	0	692	1400	2165	
SAMPLING TEMP., °F	670	680	675	680	
SAMPLING LOCATION	Surge	Surge	Surge	Surge	
COMPOSITION, ppm					
Ca	< 10	< 10	< 11	< 17	
Cr	0.8	0.8	1.0	0.3	
Fe	3.7	3.5	2.9	2.0	
K	129	280	286	193	
Li	< 9	< 11	-	-	
Mn	< 1.6	< 1.5	-	-	
Mo	0.2	0.4	-	-	
Ni	2.1	1.9	1.5	1.8	
C	4	15	9	9	

AVERAGE FLOW AND PLUGGING INDICATOR DATA

TEST TIME, HRS.	0-737	0-1400	1400-2165	737-2165	0-2165
AVERAGE FLOW, gpm	0.65	0.60	0.49	0.52	0.56
AVERAGE PLUGGING TEMP., °F	310	300	306	298	308
OXIDE CONC. *, ppm O ₂	12	11	12	11	12

REMARKS:

Run was terminated at 2165 hours due to excessive flow fouling.

* Based upon KAPL data, TID 5277, p.7

AR No. 1-2-3 APage 1 of 5RADIOCHEMICAL ANALYSISCORROSION AND SODIUM SAMPLES

Decay Correction Date: 12/18/61

SAMPLE NO.	1108	1111A	1112	1177	1206
LOCATION & MATERIAL	H1-316	H1-316	H1-316	H1-316	H2-316
TEMPERATURE, °F	1002	1002	1001	1002	1104
VELOCITY, fps	6.2	5.7	5.4	18.6	6.2
HRS. IN LOOP	2165	1428	765	2165	2165
TIMES WASHED	1	1	1	1	1
SAMPLE ACTIVITY, A_c					
Cr 51	1.82×10^{-2}	2.05×10^{-3}	1.93×10^{-3}	2.72×10^{-2}	5.80×10^{-3}
Mn 54	1.41×10^{-2}	5.22×10^{-3}	5.52×10^{-3}	1.35×10^{-2}	9.95×10^{-3}
Fe 59	-	-	-	-	-
Co 60	2.47×10^{-5}	2.88×10^{-5}	1.84×10^{-5}	6.70×10^{-5}	1.30×10^{-5}
WASH ACTIVITY, A_c					
Cr 51	-	-	-	-	-
Mn 54	-	-	-	-	-
Fe 59	-	-	-	-	-
Co 60	-	-	-	-	-
TOTAL δ ACTIVITY A_c	3.23×10^{-2}	7.30×10^{-3}	7.47×10^{-3}	4.08×10^{-2}	1.58×10^{-2}

*Wash activity for hot leg samples not analyzed because previous data indicates these activities much lower than measured sample activities.

AR No. 1-2-3 APage 2 of 5RADIOCHEMICAL ANALYSISCORROSION AND SODIUM SAMPLES

Decay Correction Date: 12-18-61

SAMPLE NO.	1207	1208	1277	1483	1484
LOCATION & MATERIAL	H2-316	H2-316	H2-316	H3-316	H3-316
TEMPERATURE, °F	1104	1104	1104	1199	1200
VELOCITY, fps	6.2	6.2	18.6	16.7	16.3
HRS. IN LOOP	2165	2165	2165	1428	765
TIMES WASHED	1	1	1	1	1
SAMPLE ACTIVITY, μC					
Cr 51	6.43×10^{-3}	6.35×10^{-3}	1.06×10^{-2}	3.03×10^{-3}	2.43×10^{-3}
Mn 54	1.04×10^{-2}	1.11×10^{-2}	1.28×10^{-2}	7.11×10^{-3}	5.53×10^{-3}
Fe 59	-	-	-	-	-
Co 60	2.56×10^{-4}	2.60×10^{-5}	5.58×10^{-5}	8.81×10^{-5}	5.22×10^{-5}
WASH ACTIVITY, μC					
Cr 51	-	-	-	-	-
Mn 54	-	-	-	-	-
Fe 59	-	-	-	-	-
Co 60	-	-	-	-	-
TOTAL ACTIVITY μC	1.68×10^{-2}	1.75×10^{-2}	2.34×10^{-2}	1.02×10^{-2}	8.01×10^{-3}

AR No. 1-2-3APage 3 of 5RADIOCHEMICAL ANALYSISCORROSION AND SODIUM SAMPLES

Decay Correction Date: 12-18-61

SAMPLE NO.	1507	1508	1509	1610	1611
LOCATION & MATERIAL	H3R-316	H3R-316	H3R-316	C1-316	C1-316
TEMPERATURE, °F	1204	1204	1204	1094	1093
VELOCITY, fps	6.2	6.2	6.2	6.2	5.7
HRS. IN LOOP	2165	2165	2165	2165	1428
TIMES WASHED	1	1	1	1	1
SAMPLE ACTIVITY, μC					
Cr 51	6.56×10^{-3}	8.00×10^{-3}	7.73×10^{-3}	3.79×10^{-1}	9.35×10^{-2}
Mn 54	1.05×10^{-2}	9.90×10^{-3}	1.01×10^{-2}	2.89×10^{-2}	8.50×10^{-3}
Fe 59	-	-	-	-	-
Co 60	3.46×10^{-5}	4.36×10^{-5}	2.92×10^{-5}	1.01×10^{-2}	2.72×10^{-3}
WASH ACTIVITY, μC					
Cr 51	-	-	-	2.26×10^{-2}	1.29×10^{-2}
Mn 54	-	-	-	2.72×10^{-3}	1.17×10^{-3}
Fe 59	-	-	-	8.41×10^{-3}	4.86×10^{-3}
Co 60	-	-	-	5.85×10^{-2}	1.98×10^{-2}
TOTAL δ ACTIVITY μC	1.71×10^{-2}	1.79×10^{-2}	1.78×10^{-2}	0.511	0.149

RADIOCHEMICAL ANALYSISCORROSION AND SODIUM SAMPLES

Decay Correction Date: 12-18-61

SAMPLE NO.	1612	1707	1708	1709	1918
LOCATION & MATERIAL	C1 - 316	C2 - 316	C2 - 316	C2 - 316	in C3 - 316
TEMPERATURE, °F	1090	997	997	997	704
VELOCITY, fps	5.4	6.2	6.2	6.2	6.2
HRS. IN LOOP	765	2165	2165	2165	2165
TIMES WASHED	1	1	1	1	1
<u>SAMPLE ACTIVITY, μc</u>					
Cr 51	1.37×10^{-1}	3.30×10^{-1}	3.24×10^{-1}	1.42×10^{-1}	1.94×10^{-2}
Mn 54	1.84×10^{-2}	3.03×10^{-2}	3.08×10^{-2}	1.95×10^{-2}	1.03×10^{-2}
Fe 59	-	-	-	-	-
Co 60	4.58×10^{-3}	3.50×10^{-3}	3.01×10^{-3}	1.13×10^{-3}	7.56×10^{-5}
<u>WASH ACTIVITY, μc</u>					
Cr 51	3.38×10^{-3}	4.08×10^{-2}	3.36×10^{-2}	8.68×10^{-3}	6.39×10^{-2}
Mn 54	5.94×10^{-4}	6.07×10^{-3}	(Samples lost in chemical analysis)		7.33×10^{-2}
Fe 59	4.50×10^{-3}	8.90×10^{-3}	6.43×10^{-3}	1.47×10^{-3}	2.98×10^{-2}
Co 60	8.70×10^{-3}	4.14×10^{-2}	3.02×10^{-2}	6.03×10^{-3}	2.53×10^{-2}
TOTAL δ ACTIVITY μ c	0.177	0.461	0.428	0.179	0.155

RADIOCHEMICAL ANALYSIS
CORROSION AND SODIUM SAMPLES

Decay Correction Date:

SAMPLE NO.	1921	1922	1923	1924	1925
LOCATION & MATERIAL	out C3 - 316	in C3 - 316	out C3 - 316	in C3 - 316	out C3 - 316
TEMPERATURE, °F	704	702	702	703	703
VELOCITY, fps	6.2	5.7	5.7	5.4	5.4
HRS. IN LOOP	2165	1428	1428	765	765
TIMES WASHED	1	1	1	1	1
SAMPLE ACTIVITY, μC					
Cr 51	3.13×10^{-2}	1.72×10^{-2}	8.64×10^{-3}	1.02×10^{-2}	3.94×10^{-3}
Mn 54	1.57×10^{-2}	1.41×10^{-2}	1.10×10^{-2}	1.04×10^{-2}	2.47×10^{-5}
Fe 59	-	-	-	-	-
Co 60	1.53×10^{-4}	7.52×10^{-5}	7.87×10^{-5}	1.28×10^{-4}	6.70×10^{-5}
WASH ACTIVITY, μC					
Cr 51	3.55×10^{-2}	2.95×10^{-2}	1.32×10^{-2}	9.81×10^{-3}	7.88×10^{-3}
Mn 54	3.25×10^{-2}	3.45×10^{-2}	6.56×10^{-3}	1.35×10^{-2}	2.10×10^{-3}
Fe 59	5.80×10^{-3}	6.65×10^{-3}	1.96×10^{-3}	1.08×10^{-2}	1.03×10^{-3}
Co 60	1.02×10^{-2}	7.86×10^{-3}	2.14×10^{-3}	6.88×10^{-3}	9.0×10^{-4}
TOTAL δ ACTIVITY μC					
	0.131	0.120	4.34×10^{-2}	6.17×10^{-2}	1.59×10^{-2}

LOOP NO. 2

Hot Leg

316 Stainless Steel

Cold Leg

2-1/4 Chromium - 1 Molybdenum

SODIUM MASS TRANSFER
ANALYSIS REPORT

ISSUED BY J. DamonDATE 11/22/60LOOP NO. 2RUN NO. 1SAMPLE REMOVAL DATE 11/7/60 ACCUMULATED TEST TIME 651 HRS.T_{max} 1200 °FΔT 500 °FSODIUM FLOW 0.7 gpmOXIDE LEVEL 12 ppm O₂

CORROSION SAMPLES

SAMPLE NO.	2100	2475	2500	2600	2902	2905
SAMPLE LOCATION	H1	H3	H3R	C1	C3	C3
AVERAGE VELOCITY, fps	7	21	7	7	7	7
APPEARANCE AFTER TEST:						
TEMPERATURE, °F	1000	1200	1200	1100	700	700
INITIAL WEIGHT, g	4.39752	4.42685	4.38558	4.31074	4.11785	4.27204
FINAL WEIGHT, g	4.39872	4.42101	4.38507	4.31018	4.12360	4.27570
WEIGHT CHANGE, mg	+1.20	-5.84	-0.51	-0.56	+5.75	+3.66
CORROSION RATE, mg/dm ² -mo	+14.75	-72.0	-6.27	-6.9	+70.06	+44.9

METALLOGRAPHIC EXAMINATION:

- Sample No. 2100 - (316 SS) Slight sensitization. Intergranular attack. Prior structure remains. No surface carbides or layer.
- 2475 - (316 SS) Sensitized. Incompletely transformed structure. Surface carbides and layer.
- 2500 - (316 SS) Sensitized. Completely transformed structure. Carbides remain in prior sites. Surface carbides and layer.
- 2600 - (2 $\frac{1}{4}$ Cr) Surface decarburization to depth of 0.16 mm. Carbides spheroidized.
- 2902 - (2 $\frac{1}{4}$ Cr) Surface decarburization to depth of 0.12 mm. Structure resembles full annealed.
- 2905 - (2 $\frac{1}{4}$ Cr) Surface decarburization to depth of 0.15 mm. Structure resembles full annealed.

AR No. 2-1-1Page 2 of 2SODIUM ANALYSIS

SAMPLE NO.	S7a		S18a		
TEST TIME, HRS.	0		651		
COMPOSITION, ppm	CHEM.	SPEC.	CHEM.	SPEC.	
Ca	67.2	25			
Cr	2.7	< 15			
Co		< 9			
Fe	15.0	< 6			
Li	19.0				
Mn		11.1			
Mo		8.4			
Ni	< 10	7.7			
K	< 10				
Si		18			
Ti		< 15			

AVERAGE FLOW AND PLUGGING INDICATOR DATA

TEST TIME, HRS.	0	120	120**	312	655
PLUG TEMP., °F	420°	410°	330°	310	325***
OXIDE CONC. *, ppm O ₂	39	36	16	12	15

** Loop was cold trapped to operating level of ~ 10 ppm Oxygen.
 *** Cold trap temperature after samples removed.

REMARKS:

* Based upon KAPL data, TID 5277, p.7

SODIUM MASS TRANSFER

AR No. 2-1-2

ANALYSIS REPORT

Page 1 of 2Run No. 2-1 Issued by J. Damon Date 12/22/60Sample Removal Date 12/14/60 Accumulated Test Hours 1438T_{max} 1200 °F ΔT 500 °F Flow 0.7 gpm Oxygen Level 10 ppm

CORROSION SAMPLES

SAMPLE NO.	2101	2476	2501	2601	2901	2904
LOCATION & MATERIAL	H1-316	H3-316	H3R-316	C1-2½	C3-2½	C3-2½
TEMPERATURE, °F	1000	1200	1200	1100	700	700
VELOCITY, fps	7	21	7	7	7	7
HARDNESS, R _B	Before	62	62	85	85	85
	After	66	69	64	91	92
INITIAL WEIGHT, g	4.30577	4.33970	4.46126	4.07928	4.21786	4.11778
FINAL WEIGHT, g	4.30697	4.33249	4.45999	4.07921	4.21949	4.11334
WEIGHT CHANGE, mg	+1.20	-7.21	-1.27	-0.07	+1.63	-4.44
CORROSION RATE, mg/dm ² -mo	+6.78	-40.2	-7.06	-0.39	+9.05	-24.7

APPEARANCE AFTER TEST:

Sample 2476 clean - All others had gray film - C3 samples had scattered black particles on surface. Plier marks on 2101 and 2901.

METALLOGRAPHIC EXAMINATION:

Sample 2101 - Grain size 1 & 2 - Carbon in solution. Surface grains sensitized. Good surface.

2476 - Grain size 1 & 3. Incipient surface layer. Good surface.

2501 - Grain size 1 & 3. Heavy surface carbides. Incipient layer. Good surface.

2601 - Carbides small, spherodized, & heavily distributed. Surface attack max. depth 0.50 mils.

2901 - Structure resembling bainite in ferrite matrix. Surface attack 0.50 mils

2904 - Same as 2901 except surface attack depth 0.60 mils.

AR No. 2-1-2Page 2 of 2SODIUM ANALYSIS

SAMPLE NO.	S7a		S18a		S23a	
TEST TIME, HRS.	0		651		1438	
COMPOSITION, ppm	CHEM.	SPEC.	CHEM.	SPEC.	CHEM.	SPEC.
Ca	67.2	25	16.4	4500		
Cr	2.7	<15	0.16	< 15		
Co		<9		< 9		
Fe	15.0	<6	12.84	< 6		
Li	19.0		268	-		
Mn		11		4		
Mo		8		< 6		
Ni	<10	8	2.53	< 8		
K	<10		345	-		
Si		18		15		
Ti		< 15		< 15		

AVERAGE FLOW AND PLUGGING INDICATOR DATA

TEST TIME, HRS.	747**	891	893***	1275	
PLUG TEMP., °F	375	290	290	290	
OXIDE CONC. *, ppm O ₂	25	10	10	10	

** After filling with dump tank at 400°F.

*** Loop was cold trapped for 40 min. @ 320°- 330°F.

REMARKS:

* Based upon KAPL data, TID 5277, p.7

SODIUM MASS TRANSFER
ANALYSIS REPORT

ISSUED BY J. Damon DATE 2/21/61LOOP NO. 2 RUN NO. 1SAMPLE REMOVAL DATE 2/9/61 ACCUMULATED TEST TIME 2782 HRS. $T_{\max}$ 1200 F ΔT 500 FSODIUM FLOW 0.7 gpm OXIDE LEVEL 10 ppm O_2

CORROSION SAMPLES

SAMPLE NO.	2102	2103	2104*	2175		
LOCATION & MATERIAL	H1-316	H1-316	H1-316	H1-316		
TEMPERATURE, °F	1000	1000	1000	1000		
VELOCITY, fps	7	7	7	21		
HARDNESS, R_B	66	67	58	66		
INITIAL WEIGHT, g	4.34319	4.35775	4.34230	4.45319		
FINAL WEIGHT, g	4.34340	4.35825	4.34232	4.45424		
WEIGHT CHANGE, mg	+ 0.21	+ 0.50	+ 0.02	+1.05		
CORROSION RATE, mg/dm^2-mo	+ 0.60	+ 1.43	+ 0.12	+ 3.01		

* Added at 1438 hrs.

APPEARANCE AFTER TEST:

All samples were clean except for a grayish film over surface.

METALLOGRAPHIC EXAMINATION:

2102 } Duplex structure. Twinned. Sensitized with increasing precipitation at
 2103 } boundary grains. Good surface.
 2175 }

2104 Large grained. Twinned. Slight sensitization. Good surface.

CORROSION SAMPLES

SAMPLE NO.	2200	2201	2202	2275		
LOCATION & MATERIAL	H2-316	H2-316	H2-316	H2-316		
TEMPERATURE, °F	1100	1100	1100	1100		
VELOCITY, fps	7	7	7	21		
HARDNESS, R _B	60	70	73	62		
INITIAL WEIGHT, g	4.40357	4.40805	4.46130	4.28833		
FINAL WEIGHT, g	4.40185	4.40659	4.45969	4.28317		
WEIGHT CHANGE, mg	-1.72	-1.46	-1.61	-5.16		
CORROSION RATE, mg/dm ² -mo	-4.93	-4.19	-4.61	-14.8		

APPEARANCE AFTER TEST:

All samples were clean except 2200 which had a slight grayish deposit along its length.

METALLOGRAPHIC EXAMINATION:

2200 } Duplex structure. Heavy carbides in small grain sites.
2201 } Sensitized. Surface carbides.
2202 }

2275 Same as above with exception of duplexing.

CORROSION SAMPLES

SAMPLE NO.	2477**	2478*	2502	2503**	2504*	(FOIL) 2575
LOCATION & MATERIAL	H3-316	H3-316	H3R-316	H3R-316	H3R-316	H3R-316
TEMPERATURE, °F	1200	1200	1200	1200	1200	1200
VELOCITY, fps	21	21	7	7	7	21
HARDNESS, R _B	70	62	65	65	66	--
INITIAL WEIGHT, g	4.29700	4.29217	4.33037	4.04142	4.33818	0.55512
FINAL WEIGHT, g	4.27623	4.28412	4.32860	4.03917	4.33653	0.55190
WEIGHT CHANGE, mg	-20.77	-8.05	-1.77	-2.25	-1.65	-3.22
CORROSION RATE, mg/dm ² -mo	-78.0	-47.9	-5.07	-8.44	-9.82	-9.23

* Added @ 1438 hours

** Added @ 651 hours

APPEARANCE AFTER TEST:

2477 & 2478 - Both samples were clean & free of deposit.

2502, 2503, 2504, 2575 - All samples were clean and free from scale.

All were slightly darker gray than at installation.

METALLOGRAPHIC EXAMINATION:

2477 - Duplex structure. Numerous residual carbides remaining at prior grain boundaries. Large grains indicate twinned structure. Surface carbides & 0.1 mil ferritic layer.

2478 } Same as above with exception to solid ferritic layer. These specimens
2502 } all have an incipient ferritic layer.
2503 }
2504 }

2575 Unexamined.

CORROSION SAMPLES

SAMPLE NO.	2602	2603**	2604*	2700	2701	2702
LOCATION & MATERIAL	C1-2 $\frac{1}{4}$	C1-2 $\frac{1}{4}$	C1-2 $\frac{1}{4}$	C2-2 $\frac{1}{4}$	C2-2 $\frac{1}{4}$	C2-2 $\frac{1}{4}$
TEMPERATURE, °F	1100	1100	1100	1000	1000	1000
VELOCITY, fps	7	7	7	7	7	7
HARDNESS, R _B	56	60	66	79	77	75
INITIAL WEIGHT, g	3.90493	3.86777	4.02045	4.16075	4.11756	4.06695
FINAL WEIGHT, g	3.90667	3.86885	4.02105	4.16350	4.12069	4.06983
WEIGHT CHANGE, mg	+ 1.74	+ 1.08	+ 0.60	+ 2.75	+ 3.13	+ 2.88
CORROSION RATE, mg/dm ² -mo	+ 4.99	+ 4.05	+ 3.57	+ 7.88	+ 8.96	+ 8.25

* Loaded @ 1438 hours

** Loaded @ 651 hours

APPEARANCE AFTER TEST:

2602, 2603, 2604 - All samples were clean. No scale or deposit in evidence.

2700, 2701, 2702 - All samples were clean with small areas of medium to dark gray.

METALLOGRAPHIC EXAMINATION:

2602 } Carbides spherodized and well distributed with respect
 2603 } to cross sectional area.
 2604 } Good surface.

2700 } Carbides spherodized and more numerous in central section than the 1100°F
 2701 } specimens. Decarburized zone 4-5 mils.
 2702 } Good surface.

CORROSION SAMPLES

SAMPLE NO.	2900	2903	2906**	2907**	2908*	2909*
LOCATION & MATERIAL	C3-2½	C3-2½	C3-2½	C3-2½	C3-2½	C3-2½
TEMPERATURE, °F	700	700	700	700	700	700
VELOCITY, fps	7	7	7	7	7	7
HARDNESS, R _B	89	90	87	86	90	87
INITIAL WEIGHT, g	4.21868	4.12639	4.18011	4.11835	4.17183	4.04825
FINAL WEIGHT, g	4.23409	4.13754	4.18897	4.13312	4.18940	4.05611
WEIGHT CHANGE, mg	+15.41	+11.15	+ 8.86	+14.77	+17.57	+ 7.86
CORROSION RATE, mg/dm ² -mo	+44.3	+32.0	+33.2	+ 55.3	+104.3	+46.7

*Loaded @ 1438 hours.

**Loaded @ 651 hours.

APPEARANCE AFTER TEST:

All samples were darker in color than when new.
No evidence of scale.

METALLOGRAPHIC EXAMINATION:

2900	} Pearlitic structure. Decarburized zone 5 mils.
2903	
2906	
2907	
2908	
2909	

CORROSION SAMPLES

SAMPLE NO.	2300	2301	2302	2800	2801	2802
LOCATION & MATERIAL	H3 pipe 316	H3 pipe 316	H3 pipe 316	C3 pipe 2 $\frac{1}{4}$	C3 pipe 2 $\frac{1}{4}$	C3 pipe 2 $\frac{1}{4}$
TEMPERATURE, °F	1200	1200	1200	700	700	700
VELOCITY, fps	1.05	1.05	1.05	0.42	0.42	0.42
HARDNESS, R _B	95	-	-	96	-	-
INITIAL WEIGHT, g	7.62074	7.59340	7.60460	7.32683	7.28440	7.36835
FINAL WEIGHT, g	7.61361	7.58774	7.59687	7.32271	7.27985	7.36351
WEIGHT CHANGE, mg	- 7.13	- 5.66	- 7.73	- 4.12	- 4.55	- 4.84
CORROSION RATE, mg/dm ² -mo	-12.4	- 9.83	-13.4	- 7.16	- 7.90	- 8.40

* Pipe samples

APPEARANCE AFTER TEST:

The hot leg samples were clean with no trace of scale formation. The cold leg samples were very dark gray with some slight evidence of black scale.

METALLOGRAPHIC EXAMINATION:

2300 - Cold worked structure. Sensitized. Surface carbides & ferritic layer.
Layer depth on sides; 0.3 mil, on sheared ends; 4.9 mils.

2800 - Banded, cold worked structure. Carbides spherodized.

2301, 2302, 2801 and 2802 returned to loop.

SODIUM ANALYSIS

SAMPLE NO.	S23a		S2-1-5(surge)		S2-1-6(dump)	
TEST TIME, HRS.	1438		2782		2782	
COMPOSITION, ppm	CHEM.	SPEC.	CHEM.	SPEC.	CHEM.	SPEC.
Ca	<13	3	<14		<10	
Cr	0.5	<2	5.4		4.9	
Co		<5				
Fe	3.6	<2	3.2		3.2	
Li	186		172		176	
Mn		<2				
Mo		<2				
Ni	2.5	<2	3.1		1.5	
K	384		490		504	
Si		2.5				
Ti		<5				

PLUG. INDICATOR DATA

Test Time, hrs	1500	1570	1947	2110	2710
Plug Temp., °F	325**	340***	330	290	290
Oxide Conc.*, ppm O ₂	15	18	16	10	10

REMARKS:

- ** After sampling and refilling from 350° F dump tank.
- *** After using additional heat on cold trap and plugging indicator outlet valves.

* Based upon KAPL data, TID 5277, p. 7.

SODIUM MASS TRANSFER

AR No. 2-2-1

ANALYSIS REPORT

Page 1 of 5Run No. 2-2 Issued by G. Billuris/
F. Hetzler Date 8-11-61Sample Removal Date 7-14-61 Accumulated Test Hours 714T_{max} 1200 °F ΔT 500 °F Flow 0.60 gpm Oxygen Level 15 ppm

CORROSION SAMPLES

SAMPLE NO.	2176	2276	2479	Foil MT4-1		
LOCATION & MATERIAL	H1-316	H2-316	H3-316	H3R-316		
TEMPERATURE, °F	1000	1100	1200	1200*		
VELOCITY, fps	18	18	18	18		
HARDNESS, R _B	Before After	69 83	72 81	75 81		
INITIAL WEIGHT, g	4.24267	4.28954	4.30270	0.5781		
FINAL WEIGHT, g	4.24294	4.28837	4.29851	0.5641		
WEIGHT CHANGE, mg	+0.27	-1.17	-4.19	-14.0		
CORROSION RATE, mg/dm ² -mo	+2.97	-12.9	-46.1	-170.		

*Temperature excursion to 1600°F for several hours - at zero flow and with loop dumped.

APPEARANCE AFTER TEST:

2176)

2276) - Clean, no evidence of scale. Light gray color

2479)

METALLOGRAPHIC EXAMINATION:

2176 - Very light sensitization.

2276 - Heavily sensitized. Widmanstaetten structure at sheared edge.
Incipient ferrite 0.1 mil or less. Heavy surface carbides.2479 - Moderately sensitized. Widmanstaetten structure at sheared edge.
Heavy surface carbides. Ferrite layer 0.1 mil.

Foil MT-4-1 - Not examined

CORROSION SAMPLES

SAMPLE NO.	2675	2775	2975			
LOCATION & MATERIAL	C1-2 $\frac{1}{4}$	C2-2 $\frac{1}{4}$	C3-2 $\frac{1}{4}$			
TEMPERATURE, °F	1100	1000	700			
VELOCITY, fps	18	18	18			
HARDNESS, R _B	Before	70	71			
	After	65	69	77		
INITIAL WEIGHT, g	3.85003	4.00689	3.75284			
FINAL WEIGHT, g	3.85407	4.01093	3.75922			
WEIGHT CHANGE, mg	+4.04	+4.04	+6.38			
CORROSION RATE, mg/dm ² -mo	+44.5	+44.5	+70.4			

APPEARANCE AFTER TEST:

2675)
2775) - Clean with no evidence of scale. Medium gray in color.
2975)

METALLOGRAPHIC EXAMINATION:

2675 - Ferritic grains. No surface irregularities
2775 - Ferritic grains with small pearlitic patches.
2975 - Ferritic grains with small pearlitic patches.

AR No. 2-2-1Page 3 of 5RADIOCHEMICAL ANALYSISCORROSION AND SODIUM SAMPLES

Decay Correction Date: 6-1-61

SAMPLE NO.	2176	2276	2479	MT4-1	
LOCATION & MATERIAL	H1-316	H2-316	H3-316	H3R-316	
TEMPERATURE, °F	1000	1100	1200	1200	
VELOCITY, fps	18	18	18	18	
HRS. IN LOOP	714	714	714	714	
TIMES WASHED	1	1	1	1	
<u>SAMPLE ACTIVITY, μc</u>					
Cr 51	7.16×10^{-1}	1.21	1.64	2.19×10^5	
Mn 54	6.90×10^{-3}	8.2×10^{-3}	1.75×10^{-2}	710	
Fe 59	1.90×10^{-2}	5.31×10^{-2}	9.23×10^{-2}	2,200	
Co 60	6.17×10^{-3}	1.58×10^{-2}	2.34×10^{-2}		
<u>WASH ACTIVITY, μc</u>					
Cr 51	5.0×10^{-3}	3.80×10^{-2}	1.03×10^{-2}		
Mn 54	1.68×10^{-4}	1.68×10^{-4}	3.43×10^{-4}		
Fe 59	1.33×10^{-3}	3.08×10^{-3}	1.11×10^{-3}		
Co 60	1.40×10^{-3}	4.55×10^{-3}	1.63×10^{-3}		
TOTAL δ ACTIVITY μ c	0.75	1.33	1.79		

AR No. 2-2-1Page 4 of 5

RADIOCHEMICAL ANALYSIS
CORROSION AND SODIUM SAMPLES

Decay Correction Date: 6-1-61

SAMPLE NO.	2675	2775	2975		
LOCATION & MATERIAL	C1-2 $\frac{1}{2}$	C2-2 $\frac{1}{2}$	C3-2 $\frac{1}{2}$		
TEMPERATURE, °F	1100	1000	700		
VELOCITY, fps	18	18	18		
HRS. IN LOOP	714	714	714		
TIMES WASHED	1	1	1		
SAMPLE ACTIVITY, μ c					
Cr 51	43.5	28.9	4.13		
Mn 54	6.85×10^{-2}	3.81×10^{-2}	9.67×10^{-3}		
Fe 59	5.27×10^{-1}	3.45×10^{-1}	2.96×10^{-2}		
Co 60	1.07×10^{-1}	6.03×10^{-2}	1.18×10^{-2}		
WASH ACTIVITY, μ c					
Cr 51	9.42×10^{-1}	3.24×10^{-1}	9.81×10^{-2}		
Mn 54	4.60×10^{-3}	2.13×10^{-3}	2.24×10^{-3}		
Fe 59	6.94×10^{-2}	1.47×10^{-2}	3.52×10^{-2}		
Co 60	7.52×10^{-2}	1.13×10^{-2}	1.48×10^{-3}		
TOTAL ACTIVITY μ c	44	30	4.3		

AR No 2-2-1Page 5 of 5SODIUM ANALYSIS

SAMPLE NO.	2-2-5		2-2-6	
TEST TIME, HRS.	75		714	
SAMPLING TEMP., °F	700		680	
SAMPLING LOCATION	Surge		Surge	
COMPOSITION, ppm				
Ca	<19		<14	
Cr	0.9		0.3	
Fe	3.32		1.7	
K	261		151	
Li	<14		<12	
Mn	<3.2		<1.7	
Mo	1.06		<0.2	
Ni	1.39		1.2	
C	68		7.6	

PLUG. INDICATOR DATA

Test Time, hrs.	4	267**	435	691
Plug Temp., °F	315	325	305	315
Oxide Conc.*, ppm O ₂	13	15	11	15

** Cold trapped at 300°F after plugging determination.

REMARKS:

* Based upon KAPL data, TID 5277, p. 7.

SODIUM MASS TRANSFERAR No. 2-3-1Page 1 of 5ANALYSIS REPORTRun No. 3 Issued by J. Damon/F. Hetzler Date 8/29/61Sample Removal Date 8/28/61 Accumulated Test Hours 712 hrs. T_{max} 1200 °F ΔT 500 °F Flow 0.26 gpm Oxygen Level 13 ppmCORROSION SAMPLES

SAMPLE NO.	2105	2203	2400	2605	2703	2910
LOCATION & MATERIAL	H1-316	H2-316	H3-316	C1-2½	C2-2½	C3-2½
TEMPERATURE, °F	997	1102	1200	1090	1007	704
VELOCITY, fps	8.67	8.67	8.67	8.67	8.67	8.67
HARDNESS, R _B	Before	83	84	81	81	88
	After	78	77	78	71	74
INITIAL WEIGHT, g	4.33857	4.38443	4.29373	3.86800	3.89373	3.93177
FINAL WEIGHT, g	4.33850	4.38385	4.29193	3.86829	3.89424	3.93556
WEIGHT CHANGE, mg	-0.07	-0.58	-1.80	+0.29	+0.51	+3.79
CORROSION RATE, mg/dm ² -mo	-0.77	-6.4	-19.8	+3.2	+5.6	+41.8

2910 - Dark gray - No scale.

APPEARANCE AFTER TEST:

2105 - Still shiny-A light scratch appears on the side.

2203 - Light gray with some shiny areas remaining.

2400 - Light gray and slightly shiny-one fleck of black scale noted near the bottom.

2605 - Medium gray-Small leg of "1" is bent upward.

2703 - Medium gray-Slight bend in sample near top.

METALLOGRAPHIC EXAMINATION:

2105 - Light sensitized. Ferritic layer at sheared edge 0.4 mils.

2203 - Heavily sensitized. Ferritic layer 0.2 mils, 0.5 mil at sheared edge.

2400 - Very heavily sensitized. Ferritic layer 1.5 mils at sheared edge, otherwise not observable.

2605)- Ferritic grains with carbides coalesced at grain boundaries.

2703)

2910 - No significant change in microstructure.

Note: All samples in outlet coolant passage.

CORROSION SAMPLES

SAMPLE NO.	2505*					
LOCATION & MATERIAL	H3R-316					
TEMPERATURE, °F	1196					
VELOCITY, fps	8.67					
HARDNESS, R _B	-					
INITIAL WEIGHT, g	0.56790					
FINAL WEIGHT, g	0.56410					
WEIGHT CHANGE, mg	-3.80					
CORROSION RATE, mg/dm ² -mo	-26.2					

*Foil MT 4-3

APPEARANCE AFTER TEST:

MT 4-3 Covered with sodium. Top was bent and deformed. The observable surface was medium gray in color.

METALLOGRAPHIC EXAMINATION:

None

RADIOCHEMICAL ANALYSIS
CORROSION AND SODIUM SAMPLES

Decay Correction Date: 6-1-61

SAMPLE NO.	2105	2203	2400	2505*	
LOCATION & MATERIAL	H1-316	H2-316	H3-316	-	
TEMPERATURE, °F	997	1102	1200	-	
VELOCITY, fps	8.67	8.67	8.67	-	
HRS. IN LOOP	712	712	712	0	
TIMES WASHED	1	1	1	0	
<u>SAMPLE ACTIVITY, μc</u>					
Cr 51	4.08	6.08	6.67	219,000	
Mn 54	1.09×10^{-2}	8.57×10^{-3}	4.02×10^{-3}	710	
Fe 59	-	-	-	2200	
Co 60	6.71×10^{-4}	1.18×10^{-3}	3.75×10^{-3}		
<u>WASH ACTIVITY, μc</u>					
Cr 51	5.95×10^{-3}	2.53×10^{-2}	2.89×10^{-2}		
Mn 54	1.35×10^{-4}	1.67×10^{-4}	2.25×10^{-4}		
Fe 59	5.41×10^{-4}	1.08×10^{-3}	5.23×10^{-3}		
Co 60	1.40×10^{-4}	2.88×10^{-4}	6.44×10^{-4}		
TOTAL μ ACTIVITY μ c	4.10	6.11	6.70	222,000	

* Foil MT4-3 - Pre test data reported

AR No. 2-3-1Page 4 of 5RADIOCHEMICAL ANALYSISCORROSION AND SODIUM SAMPLESDecay Correction Date: 6-1-61

SAMPLE NO.	2605	2703	2910		
LOCATION & MATERIAL	C1-2½	C2-2½	C3-2½		
TEMPERATURE, °F	1009	1007	704		
VELOCITY, fps	8.67	8.67	8.67		
HRS. IN LOOP	712	712	712		
TIMES WASHED	1	1	1		
SAMPLE ACTIVITY, μc					
Cr 51	2.57	10.0	3.65		
Mn 54	1.63×10^{-2}	9.46×10^{-3}	6.94×10^{-2}		
Fe 59	4.10×10^{-2}	4.87×10^{-2}	2.40×10^{-2}		
Co 60	2.59×10^{-2}	6.81×10^{-4}	2.15×10^{-3}		
WASH ACTIVITY, μc					
Cr 51	2.85×10^{-1}	9.06×10^{-2}	6.99×10^{-2}		
Mn 54	1.09×10^{-3}	3.29×10^{-4}	2.00×10^{-2}		
Fe 59	1.44×10^{-2}	6.94×10^{-3}	1.87×10^{-2}		
Co 60	4.01×10^{-3}	1.09×10^{-3}	2.14×10^{-3}		
TOTAL δ ACTIVITY μc	2.96	10.1	3.86		

SODIUM ANALYSIS

SAMPLE NO.	2-3-1	2-3-1			
TEST TIME, HRS.	22	693			
SAMPLING TEMP., °F	680	675			
SAMPLING LOCATION	Surge	Surge			
COMPOSITION, ppm					
Ca	< 14	25.9			
Cr	0.3	0.2			
Fe	1.0	7.9			
K	270	246			
Li	< 10	< 11			
Mn	< 1.5	< 1.6			
Mo	< 0.2	0.6			
Ni	1.8	1.4			
C	22	5			

AVERAGE FLOW AND PLUGGING INDICATOR DATA

TEST TIME, HRS.	0 - 700				
AVERAGE FLOW, gpm	0.263				
AVERAGE PLUGGING TEMP., °F	317				
OXIDE CONC. *, ppm O ₂	13				

REMARKS:

* Based upon KAPL data, TID 5277, p.7

SODIUM MASS TRANSFER

AR No. 2-4-1ANALYSIS REPORTPage 1 of 4Run No. 2-4 Issued by J. Damon/
R.S. Young Date 1-9-62Sample Removal Date 1-2-62 Accumulated Test Hours 2800T_{max} 1203 °F ΔT 503 °F Flow 0.24 gpm Oxygen Level 11 ppmCORROSION SAMPLES

SAMPLE NO.	2106	2204	2401	MT 4-5 2506		
LOCATION & MATERIAL	H1-316	H2-316	H3-316	H3R-316		
TEMPERATURE, °F	995	1097	1196	1203		
VELOCITY, fps	7.8	7.8	7.8	7.8		
HARDNESS, R _B	Before	71	75	74		
	After	80	84	74		
INITIAL WEIGHT, g	4.33358	4.33988	4.32414	0.5636		
FINAL WEIGHT, g	4.33485	4.33865	4.31690	0.5590		
WEIGHT CHANGE, mg	+1.27	-1.23	-7.24	-4.6		
CORROSION RATE, mg/dm ² -mo	+3.56	-3.45	-20.3	-14.3		

APPEARANCE AFTER TEST: 2106, 2401 - Gray with scattered black film
 2204 - Gray
 2506 (Foil MT 4-5) - Lower half covered with black deposit

METALLOGRAPHIC EXAMINATION:

- 2106 - Surface attack is uniform; heavy sensitization to about 10 mil depth; Center lightly sensitized; no evidence of ferrite on surfaces except worked edges; heavy precipitate at worked edges.
- 2204 - Surface attack uniform; heavily sensitized throughout; heavier small carbide precipitate near surface; incipient ferrite on surface approximately 0.2 mils thick; worked edges same as 2106.
- 2401 - Less sensitization than 2204 but heavier incipient ferrite on surface approximately 0.4 mils thick; worked edges same as 2106.
- 2506 - Not examined.

CORROSION SAMPLES

TEST HOURS	2800	2800	2735			
SAMPLE NO.	2606	2704	2912			
LOCATION & MATERIAL	C1-2½	C2-2½	C3-2½			
TEMPERATURE, °F	1092	1001	700			
VELOCITY, fps	7.8	7.8	7.8			
HARDNESS, R _B Before	71	72	75			
HARDNESS, R _B After	67	71	77			
INITIAL WEIGHT, g	3.82857	4.00246	4.00660			
FINAL WEIGHT, g	3.84000	4.01108	4.01451			
WEIGHT CHANGE, mg	+11.43	+8.62	+7.91			
CORROSION RATE, mg/dm ² -mo	+32.0	+24.2	+22.7			

APPEARANCE AFTER TEST: 2606,2912 - Medium to dark gray
 2704 - Dark film over entire surface

METALLOGRAPHIC EXAMINATION:

- 2606 - Sample structure uniform over cross-section: no pearlite present; spherodized carbides.
- 2704 - Same appearance as 2606
- 2912 - Same appearance as 2606 except slight decarburization in evidence at surface.

SODIUM MASS TRANSFER

AR No. 2-4-1ANALYSIS REPORTPage 3 of 4Run No. 2-4 Issued by J. Damon/ Date 2-5-62

R.S. Young

Sample Removal Date 1-19-62 Accumulated Test Hours 4893**T_{max} 1196 °F ΔT 496 °F Flow 0.36 gpm Oxygen Level 18 ppmPIPE
CORROSION SAMPLES

SAMPLE NO.	2301 ‡	2302 ‡	2303	2801 ‡	2802 ‡	2803
LOCATION & MATERIAL	H3-H3R	H3-H3R	H3 H3R	C3-out	C3-out	C3-out
TEMPERATURE, °F	1196	1196	1196	700	700	700
VELOCITY, fps	0.56	0.56	0.56	0.53	0.53	0.53
HARDNESS, R _B	Before	-	-	-	-	-
	After	100	-	98	-	-
INITIAL WEIGHT, g	7.58774	7.59687	7.05734	7.27985	7.36351	7.28157
FINAL WEIGHT, g	7.58420	7.59360	7.05701	7.28215	7.36542	7.28090
WEIGHT CHANGE, mg	-3.54	-3.27	-0.33	+2.30	+1.91	-0.67
CORROSION RATE, mg/dm ² -mo	-3.54	-3.27	-0.33	+2.30	+1.91	-0.67

* H3-H3R pipe samples are 316SS, C3 pipe samples are 2½ Cr.

** Exposure for runs 2-2, 2-3, & 2-4. ‡ Previously exposed in run 2-1.

APPEARANCE AFTER TEST: 2301, 2302, 2303 - Covered with sodium film
 2801, 2802, 2803 - Scattered dark deposits evident under sodium film.

METALLOGRAPHIC EXAMINATION:

2301 - Severely worked structure with elongated grains; uniform ferrite layer 0.4 mils thick with heavy carbide precipitate under layer. Knoop micro hardness of body of specimen 85.4 while surface ferrite measured 45.8, 48.8 and 60.3 Knoop at various locations (last reading was nearer interface of carbide precipitate area)

2801 Severely worked structure with elongated grains; decarburized layer at surface approximately 3.5 mils deep.

AR No. 2-4-1Page 4 of 4SODIUM ANALYSIS

SAMPLE NO.	2-3-2	2-4-1	2-4-2		
TEST TIME, HRS.	0	1430	2799		
SAMPLING TEMP., °F	675	695	690		
SAMPLING LOCATION	Surge	Surge	Surge		
COMPOSITION, ppm					
Ca	26	< 7			
Cr	0.2	0.3	0.8		
Fe	7.9	1.2	5.7		
K	246	228	-		
Li	< 11	< 32	-		
Mn	< 1.6	-	-		
Mo	0.6	-	-		
Ni	1.4	0.4	0.8		
C	5	11	13		

AVERAGE FLOW AND PLUGGING INDICATOR DATA

TEST TIME, HRS.	0-2800				
AVERAGE FLOW, gpm	0.24				
AVERAGE PLUGGING TEMP., °F	302				
OXIDE CONC.* , ppm O ₂	11				

REMARKS:

* Based upon KAPL data, TID 5277, p.7

AR No. 2-4-1APage 1 of 2RADIOCHEMICAL ANALYSISCORROSION AND SODIUM SAMPLES

Decay Correction Date: 12-28-61

SAMPLE NO.	2106	2204	2401		
LOCATION & MATERIAL	H1-316	H2-316	H3-316		
TEMPERATURE, °F	995	1097	1196		
VELOCITY, fps	7.8	7.8	7.8		
HRS. IN LOOP	2800	2800	2800		
TIMES WASHED	1	1	1		
SAMPLE ACTIVITY, A_c					
Cr 51	1.25×10^{-2}	1.13×10^{-2}	1.13×10^{-3}		
Mn 54	6.56×10^{-3}	5.76×10^{-3}	4.68×10^{-3}		
Fe 59	-	-	-		
Co 60	2.10×10^{-3}	1.48×10^{-3}	1.63×10^{-3}		
WASH ACTIVITY, A_c					
Cr 51	3.91×10^{-3}	3.47×10^{-3}	6.65×10^{-3}		
Mn 54	1.44×10^{-3}	5.13×10^{-4}	1.92×10^{-4}		
Fe 59	5.04×10^{-4}	1.24×10^{-4}	1.8×10^{-4}		
Co 60	3.60×10^{-4}	4.05×10^{-5}	4.68×10^{-5}		
TOTAL ACTIVITY A_c	2.72×10^{-2}	2.27×10^{-2}	1.45×10^{-2}		

RADIOCHEMICAL ANALYSIS
CORROSION AND SODIUM SAMPLES

Decay Correction Date:

SAMPLE NO.	2606	2704	2912	2301	2801
LOCATION & MATERIAL	C1-2½	C2-2½	C3-2½	H3 Pipe 316	C3 Pipe 2½
TEMPERATURE, °F	1092	1001	700	1196	700
VELOCITY, fps	7.8	7.8	7.8	0.56	0.53
HRS. IN LOOP	2800	2800	2735	4893	4893
TIMES WASHED	1	1	1	1	1
<u>SAMPLE ACTIVITY, μc</u>					
Cr 51	1.06	0.477	0.120	1.82×10^{-2}	1.60×10^{-2}
Mn 54	3.53×10^{-2}	3.22×10^{-2}	0.206	1.71×10^{-2}	3.59×10^{-2}
Fe 59	-	-	-	-	-
Co 60	0.102	3.51×10^{-2}	7.20×10^{-3}	6.93×10^{-3}	8.50×10^{-3}
<u>WASH ACTIVITY, μc</u>					
Cr 51	0.229	8.10×10^{-2}	3.77×10^{-2}	6.25×10^{-3}	3.48×10^{-2}
Mn 54	3.99×10^{-2}	2.34×10^{-2}	6.75×10^{-2}	8.46×10^{-3}	5.98×10^{-2}
Fe 59	2.05×10^{-2}	1.14×10^{-2}	6.61×10^{-3}	5.45×10^{-3}	4.28×10^{-3}
Co 60	3.87×10^{-2}	1.94×10^{-2}	3.04×10^{-3}	-	1.85×10^{-3}
<u>TOTAL δ ACTIVITY μc</u>					
	1.52	0.677	0.447	6.23×10^{-2}	0.161

LOOP NO. 3

Hot Leg

316 Stainless Steel

Cold Leg

2-1/4 Chromium - 1 Molybdenum

ANALYSIS REPORTRun No. 3-1 Issued by G. Billuris Date 9/30/60Sample Removal Date 9/13/60 Accumulated Test Hours 696T_{max} 1200 °F ΔT 500 °F Flow 0.50 gpm Oxygen Level 38 ppmCORROSION SAMPLES

SAMPLE NO.	5902*	5904*	3500	3476		
LOCATION & MATERIAL	C3-2½	C3-2½	H3R 316	H3 316		
TEMPERATURE, °F	700	700	1200	1200		
VELOCITY, fps	5	5	5	15		
HARDNESS, R _B Before	-	-	-	-		
After	-	-	-	-		
INITIAL WEIGHT, g	4.29683	4.29326	4.17799	4.39046		
FINAL WEIGHT, g	4.30043	4.29473	4.17790	4.38977		
WEIGHT CHANGE, mg	+3.60	+1.47	-0.09	-0.69		
CORROSION RATE, mg/dm ² -mo	+41.3	+16.9	-1.03	-7.93		

*Samples incorrectly numbered

APPEARANCE AFTER TEST:

- 5902 } - Adherent black film on surface
 5904 }
 3500 - Clean Surface
 3476 - Clean surface. Score marks near top end

METALLOGRAPHIC EXAMINATION:

Samples 3476 & 3500 (TP316SS)

1. ASTM austenitic grain size 1 - Abnormal grain growth noted.
2. Carbide precipitation at grain boundaries.
3. Carbide transformation not complete.

Samples 590 & 5904 (2½ Cr)

1. Normal grain appearance - no gross change from pre-test condition.
2. Evidence of decrease in carbide content as outer sample surface is approached.

AR No. 3-1-1Page 2 of 2SODIUM ANALYSIS

SAMPLE NO.	S11				
TEST TIME, HRS.	696				
SAMPLING TEMP., °F	500				
SAMPLING LOCATION	Dump Tk				
COMPOSITION, ppm					
Ca	90				
Cr	0.1				
Fe	1.0				
K	-				
Li	-				
Mn	-				
Mo	-				
Ni	3.4				
C	-				

AVERAGE FLOW AND PLUGGING INDICATOR DATA

TEST TIME, HRS.	0-696				
AVERAGE FLOW, gpm	0.50				
AVERAGE PLUGGING TEMP., °F	417				
OXIDE CONC. *, ppm O ₂	38				

REMARKS:

* Based upon KAPL data, TID 5277, p.7

SODIUM MASS TRANSFER
ANALYSIS REPORT

ISSUED BY J. Damon DATE 10/18/60LOOP NO. 3 RUN NO. 1SAMPLE REMOVAL DATE 10/13/60 ACCUMULATED TEST TIME 1410 HRS. T_{max} 1200 °F ΔT 500 °FSODIUM FLOW 0.50 gpm OXIDE LEVEL 38 ppm O₂

CORROSION SAMPLES

SAMPLE NO.	3478*	3502	* 5903	3906*
SAMPLE LOCATION	H3	H3R	C3	C3
AVERAGE VELOCITY, fps	15	5	5	5
APPEARANCE AFTER TEST:	Clean except for film of sodium	Clean except for sodium film	Adherent black film on surface	Adherent black film on surface
INITIAL WEIGHT, g	4.33818	4.22089	4.21500	4.24400
FINAL WEIGHT, g	4.33187	4.22087	4.21636	4.24554
WEIGHT CHANGE, mg	-6.31	-0.02	+1.36	+1.54
CORROSION RATE, mg/dm ² -mo.	-70.7	-0.113	+7.70	+17.3

* This sample loaded at 696 hrs.

* This sample incorrectly numbered.

METALLOGRAPHIC EXAMINATION:

Samples 3478 and 3502 (TP 316 SS)

1. ASTM austenitic grain size 1. Abnormal grain growth noted.
2. Carbide precipitation at grain boundaries.
3. Carbide transformation not complete.

Sample 3906 (2½)

Equiaxed grains. Good surface condition. Pearlitic structure. Deep carburization. Heavy surface layer.

Sample 5903 (2½)

Equiaxed grains. Good surface condition. Carbides spheroidized. Carbide precipitation moderately heavy. Slight decarburization on one side of specimen.

AR No. 3-1-2Page 2 of 2SODIUM ANALYSIS

SAMPLE NO.	S16				
TEST TIME, HRS.	1410				
SAMPLING TEMP., °F	500				
SAMPLING LOCATION	Dump Tk.				
COMPOSITION, ppm					
Ca	40				
Cr	1.0				
Fe	329				
K	291				
Li	9				
Mn	-				
Mo	-				
Ni	1.1				
C	-				

AVERAGE FLOW AND PLUGGING INDICATOR DATA

TEST TIME, HRS.	0-1410				
AVERAGE FLOW, gpm	5.0				
AVERAGE PLUGGING TEMP., °F	418				
OXIDE CONC. *, ppm O ₂	38				

REMARKS:

* Based upon KAPL data, TID 5277, p.7

SODIUM MASS TRANSFERAR No. 3-1-3Page 1 of 6ANALYSIS REPORTRun No. 1 Issued by J. Damon Date 12/21/60Sample Removal Date 12/9/60 Accumulated Test Hours 2729 $T_{\max}$ 1200 °F ΔT 500 °F Flow 0.55 gpm Oxygen Level 29-65 ppmCORROSION SAMPLES

SAMPLE NO.	3100	3101	3102	3175		
LOCATION & MATERIAL	H1-316	H1-316	H1-316	H1-316		
TEMPERATURE, °F	1000	1000	1000	1000		
VELOCITY, fps	5	5	5	15		
HARDNESS, R_B	69	64	64	65		
INITIAL WEIGHT, g	4.12833	4.40979	4.39210	4.38366		
FINAL WEIGHT, g	4.12989	4.41197	4.39488	4.38478		
WEIGHT CHANGE, mg	+1.56	+2.18	+2.78	+1.12		
CORROSION RATE, $\text{mg}/\text{cm}^2\text{-mo}$	+4.56	+6.39	+8.14	+3.28		

APPEARANCE AFTER TEST:

All samples had black scale.

METALLOGRAPHIC EXAMINATION:

- 3100 } ASTM grain size 1 with areas of grain size 4. Surface grains sensitized.
3101 } Good surface.
3102 } ASTM grain size 1 with areas of grain size 4. Carbon fairly well in solution.
Sensitized. Good surface.
3175 } ASTM grain size 1 with areas of grain size 4. Carbon in solution. Sensitized.
Good surface.

CORROSION SAMPLES

SAMPLE NO.	3200	3201	3202	3276		
LOCATION & MATERIAL	H2-316	H2-316	H2-316	H2-316		
TEMPERATURE, °F	1100	1100	1100	1100		
VELOCITY, fps	5	5	5	5		
HARDNESS,	70	61	63	66		
INITIAL WEIGHT, g	4.42543	4.44513	4.32433	4.36141		
FINAL WEIGHT, g	4.42129	4.44154	4.31982	4.34771		
WEIGHT CHANGE, mg	-4.14	-3.59	-4.51	-13.70		
CORROSION RATE, mg/dm ² -mo	-12.1	-11.5	-13.2	-40.2		

APPEARANCE AFTER TEST:

Gray film deposit with some scattered black particles.

METALLOGRAPHIC EXAMINATION:

- 3200 - ASTM grain size 1 with areas of grain size 3. Heavy surface carbides. Good surface. Sensitized.
- 3201 - ASTM grain size 1 with areas of grain size 3. Surface grains sensitized. Good surface.
- 3202 - ASTM grain size 1 with areas of grain size 2. Heavy carbide deposits. Sensitized. Good surface.
- 3276 - ASTM grain size 1 with areas of grain size 5. Heavy surface carbides. Good surface.

CORROSION SAMPLES

SAMPLE NO.	3475	3479*	3501	3503*	3504*	Foil
LOCATION & MATERIAL	H3-316	H3-316	H3R-316	H3R-316	H3R-316	H3R-316
TEMPERATURE, °F	1200	1200	1200	1200	1200	1200
VELOCITY, fps	15	15	5	5	5	15
HARDNESS, R _B	67	71	69	65	69	--
INITIAL WEIGHT, g	4.44287	4.30441	4.36552	4.37572	4.28447	0.42467
FINAL WEIGHT, g	4.41122	4.26577	4.36346	4.37037	4.28428	0.41614
WEIGHT CHANGE, mg	-31.65	-38.64	-2.06	-5.35	-0.19	-8.53
CORROSION RATE, mg/dm ² -mo	-92.9	-227	-6.04	-21.0	-1.05	-24.9

APPEARANCE AFTER TEST:

H3 samples had relatively clean surface with some scattered black particles.

H3R samples clean except for 3504 which had a streak of black scale on one side

METALLOGRAPHIC EXAMINATION:

- 3475 } ASTM grain size 1 with areas of grain size 3. Sensitized.
 3504 } Surface carbides. Surface good.
 3479 } ASTM grain size 1 with areas of grain size 3. Sensitized.
 Surface layer 0.20 mils. Good surface.
 3501 } ASTM grain size 1 with areas of grain size 3. Incipient surface layer on
 small grains. Surface carbides on large grains.
 3575 } Specimen highly magnetic. Etches as iron. Grains elongated.
 (Sent for X-ray diffraction)
 Foil } Not examined yet.

* Loaded at 1410 hours

** Loaded at 696 hours

CORROSION SAMPLES

SAMPLE NO.	3600	3601	3602	3700	3701	3702
LOCATION & MATERIAL	C1-2½	C1-2½	C1-2½	C2-2½	C2-2½	C2-2½
TEMPERATURE, °F	1100	1100	1100	1000	1000	1000
VELOCITY, fps	5	5	5	5	5	5
HARDNESS, R _B	65	67	67	96	91	91
INITIAL WEIGHT, g	4.25828	4.29314	4.29180	4.20398	4.18523	4.08522
FINAL WEIGHT, g	4.26414	4.29937	4.29868	4.21422	4.19589	4.09604
WEIGHT CHANGE, mg	+ 5.86	+ 6.23	+ 6.88	+ 10.24	+ 10.66	+ 10.82
CORROSION RATE, mg/dm ² -mo	+17.2	+18.3	+20.8	+ 30.0	+ 36.3	+31.2

APPEARANCE AFTER TEST:

Scattered black scale on surfaces with gray film near top of specimens.

METALLOGRAPHIC EXAMINATION:

All specimens have small, spherodized, heavily distributed carbides. All specimens have poor surface with maximum depth of attack:

3600 - 1.0 mils
3601 - 0.5
3602 - 0.5
3700 - 1.0
3701 - 0.7
3702 - 1.5

CORROSION SAMPLES

SAMPLE NO.	3900	3901	3905	3907**	3908*	3909*
LOCATION & MATERIAL	C3-2½	C3-2½	C3-2½	C3-2½	C3-2½	C3-2½
TEMPERATURE, °F	700	700	700	700	700	700
VELOCITY, fps	5	5	5	5	5	5
HARDNESS,	Rc 32	Rc 31	Rc 32	93	90	93
INITIAL WEIGHT, g	4.24400	4.25334	4.29714	4.13765	3.92726	4.01012
FINAL WEIGHT, g	4.24810	4.25681	4.31168	4.13899	3.92945	4.01292
WEIGHT CHANGE, mg	+ 4.10	+ 3.47	+14.54	+ 1.34	+ 2.19	+ 2.80
CORROSION RATE, mg/dm ² -mo	+12.0	+10.2	+42.6	+ 5.10	+12.5	+16.0

APPEARANCE AFTER TEST:

Heavy black scale on all specimens.

METALLOGRAPHIC EXAMINATION:

3900 } Structure resembles martensitic patches in ferrite matrix.
 3901 } Good surface.
 3905 }

 3907 } Structure resembles bainitic patches in ferrite matrix.
 3908 } Good surface.
 3909 }

* Loaded at 1410 hours

** Loaded at 696 hours

SODIUM ANALYSIS

SAMPLE NO.	S-3a		S11a		S16a		S21a	
TEST TIME, HRS.	0		696		1410		2729	
COMPOSITION, ppm	CHEM.	SPEC.	CHEM.	SPEC.	CHEM.	SPEC.	CHEM.	SPEC.
Ca		500	90	< 3	40	< 3		
Cr		< 4	0.14	< 15	0.99	< 15		
Co		< 8		< 9		< 9		
Fe		12	1.04	< 6	329.8	< 6		
Li		< 1	100		128			
Mn				< 3		< 3		
Mo		< 2		< 6		< 6		
Ni			3.42	< 8	1.15	21		
K			100		380			
Si		< 2		< 9		12		
Ti				< 15		< 15		

PLUG. INDICATOR DATA

Test Time, hrs	1504	1888	1936	**1939	2608
Plug Temp., °F	425	400	385	480	430
Oxide Conc.*, ppm O ₂	41	33	29	65	42

** 5½ grams of Na₂O were added to dump tank and the loop was dumped to increase oxygen saturation temperature. Afterwards the loop was cold trapped for 15 minutes at 450-470° to bring saturation temp. down to about 50 °

REMARKS:

* Based upon KAPL data, TID 5277, p. 7.

SODIUM MASS TRANSFERAR No. 3-1-3APage 1 of 1ANALYSIS REPORTRun No. 1 Issued by J. Damon Date 1-16-61Sample Removal Date 12-20-60 Accumulated Test Hours 2729 T_{max} 1200 °F T 500 °F Flow 0.55 gpm Oxygen Level 29-65 ppmCORROSION SAMPLES

SAMPLE NO.	3300	3301	3302	3800	3801	3802
LOCATION & MATERIAL	H3 Pipe 316	H3 Pipe 316	H3 Pipe 316	C3 Pipe 2-1/4	C3 Pipe 2-1/4	C3 Pipe 2-1/4
TEMPERATURE, °F	1200	1200	1200	700	700	700
VELOCITY, fps	0.8	0.8	0.8	0.3	0.3	0.3
HARDNESS, R_B	95	-	-	96	-	-
INITIAL WEIGHT, g	7.59078	7.64910	7.61313	7.31472	7.25400	7.37865
FINAL WEIGHT, g	7.59268	7.65060	7.61433	7.31394	7.25374	7.37858
WEIGHT CHANGE, mg	+1.90	+1.50	+1.20	-0.78	-0.26	-0.07
CORROSION RATE, mg/dm ² -mo	+3.35	+2.64	+2.14	-1.38	-0.46	-0.12

APPEARANCE AFTER TEST:

Clean - Dark gray in color - No evidence of scale.

METALLOGRAPHIC EXAMINATION:

3300 (316) Cold worked structure. Surface carbides. 0.197 mil. ferritic layer. Sensitized. Good surface. One end has been sheared and ferritic layer is 2.462 mils. at this point.

3800 (2-1/4) Longitudinal section: Carbides spherodized. Good surface.

3301, 3302, 3801, 3802 returned to loop.

SODIUM MASS TRANSFERAR No. 3-2-1Page 1 of 5ANALYSIS REPORTRun No. 2 Issued by J. Damon Date 4/15/61Sample Removal Date 4/10/61 Accumulated Test Hours 704 T_{max} 1200 °F ΔT 500 °F Flow 0.55 gpm Oxygen Level 10 ppmCORROSION SAMPLES

SAMPLE NO.	3103	3104	3105	3176		
LOCATION & MATERIAL	H1-316	H1-316	H1-316	H1-316		
TEMPERATURE, °F	1000	1000	1000	1000		
VELOCITY, fps	5.5	5.5	5.5	16.5		
HARDNESS, R_B	Before	74	76	75	71	
	After	73	75	75	75	
INITIAL WEIGHT, g	4.31447	3.92729	4.32656	4.35448		
FINAL WEIGHT, g	4.31516	3.92811	4.32747	4.35480		
WEIGHT CHANGE, mg	+ 0.69	+ 0.82	+ 0.91	+ 0.32		
CORROSION RATE, mg/dm ² -mo	+ 7.84	+ 9.31	+10.3	+ 3.64		

APPEARANCE AFTER TEST: Samples were fairly clean - Medium gray color - #3103 has olight evidence of black scale.

METALLOGRAPHIC EXAMINATION: General Note: All specimens have a uniform grain size of ASTM 3.

- 3103) Continuous carbide network established intergrannularly, with exception of
3105) small central area on transverse specimen. Some carbon traffic to free surface, but no change noted in randomly dispersed spheroidized carbide with reference to the standard specimen. Good surface.

CORROSION SAMPLES

SAMPLE NO.	3203	3204	3205	3277	3480	3481
LOCATION & MATERIAL	H2-316	H2-316	H2-316	H2-316	H3-316	H3-316
TEMPERATURE, °F	1100	1100	1100	1100	1200	1200
VELOCITY, fps	5.5	5.5	5.5	16.5	16.5	16.5
HARDNESS, R _B Before	74	70	70	72	68	75
HARDNESS, R _B After	78	78	79	76	76	79
INITIAL WEIGHT, g	4.27063	4.11393	4.22943	4.25667	4.28377	4.25393
FINAL WEIGHT, g	4.27199	4.11500	4.23068	4.25639	4.27421	4.24766
WEIGHT CHANGE, mg	+1.36	+1.07	+1.25	-0.28	-9.56	-6.27
CORROSION RATE, mg/dm ² -mo	+15.4	+12.2	+14.2	-3.18	-108.7	-71.2

APPEARANCE AFTER TEST: H2 - Dark gray - small amount of black scale.
H3 - Light gray - slight amount of black scale.

METALLOGRAPHIC EXAMINATION: (Cont'd from Page 1)

- 3104 Same as 3103 & 3105 with exception to Widmanstatten structure at sheared edge.
3176 Same as 3103 & 3105 with exception to Widmanstatten structure at deformed section caused by Rockwell test.
- 3203 } Intergrannular carbide network.
3205 } Carbide at free surface, slip & twin boundaries. Widmanstatten structure at deformed surface. Incipient ferritic layer at deformed surface.
- 3204 Same as 3203 & 3205 with exception to fine carbide precipitation along strain lines.
- 3277 Same as 3203 & 3205 with exception to a 2 mil ferritic layer at a sheared edge.
- 3480 } Intergrannular carbide network with carbides at slip & twin boundaries and heavy
3481 } accumulation at free surface. Very fine precipitate covers the specimen with accent on the strain lines. 3480 - Solid ferritic layer 0.2 mils.
3481 - Solid ferritic layer 0.1 mils.

CORROSION SAMPLES

SAMPLE NO.	3505	3506	3507	3576		
LOCATION & MATERIAL	H3R-316	H3R 316	H3R-316	Foil H3R-316		
TEMPERATURE, °F	1200	1200	1200	1200		
VELOCITY, fps	5.5	5.5	5.5	16.5		
HARDNESS, R _B Before	72	75	71	-		
HARDNESS, R _B After	79	79	80	-		
INITIAL WEIGHT, g	4.25121	4.07856	4.23519	0.52665		
FINAL WEIGHT, g	4.25042	4.07777	4.23414	0.52525		
WEIGHT CHANGE, mg	-0.79	-0.79	-1.05	-1.40		
CORROSION RATE, mg/dm ² -mo	-8.97	-8.97	-11.9	-15.9		

APPEARANCE AFTER TEST:

All samples were clean and still shiny. The color was very slightly darker than at installation.

METALLOGRAPHIC EXAMINATION:

3205 } Heavy sensitization on 1/2 of specimen similar to those of holder H-3 and the
 3206 } other 1/2 similar to those from specimen holder H-2 with less sensitization.
 3207 }

3505 Ferritic layer incipient

3506 Ferritic layer 0.1 mils

3507 Ferritic layer 0.1 mils to 0.2 mils

3576 Not analysed.

CORROSION SAMPLES

SAMPLE NO.	3603	3604	3605	3703	3704	3705
LOCATION & MATERIAL	C1	438 alloy C1	C1	C2	438 alloy C2	C2
TEMPERATURE, °F	1100	1100	1100	1000	1000	1000
VELOCITY, fps	5.5	5.5	5.5	5.5	5.5	5.5
HARDNESS, R _B Before	96	96	98	99	98	99
HARDNESS, R _B After	92	95	96	98	99	99
INITIAL WEIGHT, g	4.20089	4.21046	4.18020	4.08620	3.98577	3.78232
FINAL WEIGHT, g	4.20200	4.21158	4.18162	4.08830	3.98879	3.78485
WEIGHT CHANGE, mg	+1.11	+1.12	+1.42	+2.10	+3.02	+2.53
CORROSION RATE, mg/dm ² -mo	+12.6	+12.7	+16.1	+23.8	+34.3	+28.7

APPEARANCE AFTER TEST: C1 - Samples were clean and free of scale. Some darkening in color and loss of shine.

C2- Samples were relatively clean and free of scale. Some darkening in color and loss of shine.

METALLOGRAPHIC EXAMINATION:

3603 }
 3604 }
 3605 } Extremely fine grained structure with an appearance similar to an air-
 3703 } hardened 2½ Croloy specimen
 3704 } More carbides visible than encountered in the standard specimen.
 3705 }

CORROSION SAMPLES

SAMPLE NO.	3910	3911	3912	3913	3914	3915
LOCATION & MATERIAL	← 4S8 Alloy → C3 in.	C3 in.	C3 in.	← 4S4 Alloy → C3 out	C3 out	C3 out
TEMPERATURE, °F	700	700	700	700	700	700
VELOCITY, fps	5.5	5.5	5.5	5.5	5.5	5.5
HARDNESS, R _B	Before	104	105	105	100	101
	After	105	104	102	99	100
INITIAL WEIGHT, g	4.17733	4.15535	4.20020	4.07320	4.09940	4.0847
FINAL WEIGHT, g	4.18261	4.15952	4.20461	4.07487	4.10135	4.08585
WEIGHT CHANGE, mg	+ 5.28	+ 4.17	+ 4.41	+ 1.67	+ 1.95	+ 1.58
CORROSION RATE, mg/dm ² -mo	+ 59.9	+ 47.2	+ 50.1	+ 18.9	+ 22.2	+ 17.9

APPEARANCE AFTER TEST: All samples were relatively clean. Very slight evidence of black scale. All samples still had some shine.

METALLOGRAPHIC EXAMINATION:

3910 }
 3911 } Same as previously noted on page 4.
 3912 }
 3913 }

3914 } Slightly heavier carbide precipitation than noticed on previous specimens.
 3915 }

Note: 3913 fits pattern similar to 4S8 specimen.

SODIUM ANALYSIS

SAMPLE NO.	3-2-3**	3-2-4	3-2-6	3-2-7**
TEST TIME, HRS.	0	0	664	664
SAMPLING TEMP., °F	700	700	700	700
SAMPLING LOCATION	Surge	Surge	Surge	Surge
COMPOSITION, ppm				
Ca	< 15	< 14	< 10	< 10
Cr	2.5	1.3	0.8	1.2
Fe	0.8	0.9	0.7	5.0
K	187	173	175	165
Li	< 9	< 8	< 11	< 5
Mn	< 2.4	< 2.2	< 2.4	< 2.0
Mo	1.5	0.4	0.4	0.4
Ni	1.7	0.4	0.5	1.2

PLUGGING INDICATOR DATA

TEST TIME, HRS.	58	252	539***	659
PLUG TEMP., °F	290	305	325	280
OXIDE CONC. *, ppm O ₂	10	11	15	9

REMARKS:

** Samples 3-2-3 and 3-2-7 were obtained through 65/ sintered stainless steel filters.

*** Cold trapped at 290° F - 300° F after plugging determination.

* Based upon KAPL data, TID 5277, p. 7

SODIUM MASS TRANSFER

AR No. 3-3-1
Page 1 of 2

ANALYSIS REPORT

Run No. 3 Issued by G. Billuris Date 6/5/61
Sample Removal Date 5/28/61 Accumulated Test Hours 700
 T_{max} 1200 °F ΔT 500 °F Flow 0.25 gpm Oxygen Level 10 pp

CORROSION SAMPLES

SAMPLE NO.	3106	3206	3400	(F011) 3508 *	3606	3706	39	
LOCATION & MATERIAL	H1-316	H2-316	H3-316	H3R-316	C1-2½	C2-2½	C3-	
TEMPERATURE, °F	1000	1100	1200	1200	1100	1000	7	
VELOCITY, fps	7.5	7.5	7.5	7.5	7.5	7.5	7	
HARDNESS, R _B	Before	69	66	70	-	68	71	6
	After	77	74	66	-	67	66	6
INITIAL WEIGHT, g	4.33853	4.25422	4.32156	0.51136	3.89594	3.87961	3.84	
FINAL WEIGHT, g	4.33821	4.25153	4.31363	0.51487	3.90279	3.88457	3.84	
WEIGHT CHANGE, mg	-0.32	-2.69	-7.93	+3.51	+6.85	+4.96	+5.	
CORROSION RATE, mg/dm ² -mo	-3.66	-30.8	-90.7	+42.7	+78.5	+56.8	+58.	

3106 - Slight amount of black scale - medium to dark gray
3206 - Medium gray - fairly clean
3400 - Medium gray - fairly clean
APPEARANCE AFTER TEST: 3508 - Dark gray - Lower half inch of sample is black
3606 - Medium gray - Two small black globules on side
3706 - Medium gray - fairly clean
3906 - Dark gray color - No evidence of black scale

METALLOGRAPHIC EXAMINATION:

3106 Bright surface. Uniform grain size. Intergrannular sensitization. Widmanstatten structure at deformed areas. No surface effects. No grain growth.
3206 Bright surface. Uniform grain size. Heavier intergrannular sensitization than 3106. Carbides of slip planes & dislocation clusters. Heavy surface carbides & incipient ferritic layer.

* Rusty appearance after cleaning and before weighing.

CORROSION SAMPLES

TEST HOURS						
SAMPLE NO.						
LOCATION & MATERIAL						
TEMPERATURE, °F						
VELOCITY, fps						
HARDNESS, R _B Before						
HARDNESS, R _B After						
INITIAL WEIGHT, g						
FINAL WEIGHT, g						
WEIGHT CHANGE, mg						
CORROSION RATE, mg/dm ² -mo						

APPEARANCE AFTER TEST:

METALLOGRAPHIC EXAMINATION: (Continued)

3400 Same as 3206 with exception to carbide precipitation along the strain lines.

3606 }
 3706 } Ferritic structure with small well dispersed carbides.
 3906 }

3906 Thin grey oxide with fluffy oxide 2 mils thick covering approximately 40% of the surface area.

3706 Bright surface.

3606 Bright surface with fluffy oxide ~ 2 mils deep covering approximately 25% of surface area.

3508 (foil) Not examined.

AR No. 3-3-1APage 1 of 1SODIUM ANALYSIS

SAMPLE NO.	3-2-8**	3-3-1	3-3-2		
TEST TIME, HRS.	0	98	653		
SAMPLING TEMP., °F	700	700	680		
SAMPLING LOCATION	Surge	Surge	Surge		
COMPOSITION, ppm					
Ca	< 10	< 9	< 16		
Cr	0.7	0.8	0.6		
Fe	0.8	2.6	9.8		
K	217	210	245		
Li	< 8	< 13	< 11		
Mn	< 1.6	< 1.9	< 1.7		
Mo	< 0.2	0.3	0.2		
Ni	0.8	1.3	2.6		
C		58			

AVERAGE FLOW AND PLUGGING INDICATOR DATA

TEST TIME, HRS.	127***	272***	495	671	
PLUG TEMP. °F	322	325	305	290	
OXIDE CONC. *, ppm O ₂	14	15	11	10	

REMARKS:

** This sample taken after adding reactor grade sodium.

*** Cold trapped at 300°F to reduce Na₂O content after plugging determination.

* Based upon KAPL data, TID 5277, p.7

SODIUM MASS TRANSFER

AR No. 3-4-1ANALYSIS REPORTPage 1 of 3Run No. 3-4 Issued by G. Billuris/ Date 8-1-61
F. HetzlerSample Removal Date 7-20-61 Accumulated Test Hours 712 $T_{\max}$ 1200 °F ΔT 500 °F Flow 0.65 gpm Oxygen Level ~10 ppmCORROSION SAMPLES

SAMPLE NO.	3177	3278	3482	(Foil) 3577		
LOCATION & MATERIAL	H1-316	H2-316	H3-316	H3R-316		
TEMPERATURE, °F	1000	1100	1200	1200		
VELOCITY, fps	19.5	19.5	19.5	19.5		
HARDNESS, R _B Before	74	75	74	-		
After	78	80	77	-		
INITIAL WEIGHT, g	4.33880	4.25445	3.93930	0.52652		
FINAL WEIGHT, g	4.33845	4.25180	3.93208	0.52458		-
WEIGHT CHANGE, mg	-0.35	-2.65	-7.22	-1.94		-
CORROSION RATE, mg/dm ² -mo	-3.93	-29.8	-81.1	-23.2		

APPEARANCE AFTER TEST: 3177 - Fairly clean - Small area of black scale on side
 3278 - Slight discoloration at top of sample
 3482 - Covered with sodium from undrained sampleholder
 3577 - Still clean and shiny. One scratch at top caused by pliers at removal.

METALLOGRAPHIC EXAMINATION:

- 3177 - Uniform equiaxed grains - ASTM 5.
 Sensitized to a depth of 16 mils, otherwise no change in microstructure.
- 3278 - Uniform equiaxed grains - ASTM 5.
 Very heavily sensitized.
 Incipient ferritic layer.
- 3482 - Uniform equiaxed grains - ASTM 5.
 Very heavily sensitized to a depth of 16 mils, thereafter the specimens appear sensitized to a lesser degree.
 Incipient ferritic layer.
- 3577 (Foil) Not examined.

CORROSION SAMPLES

SAMPLE NO.	3675	3775	3975			
LOCATION & MATERIAL	C1-2½	C2-2½	C3-2½			
TEMPERATURE, °F	1100	1000	700			
VELOCITY, fps	19.5	19.5	19.5			
HARDNESS, R _B Before	72	75	75			
HARDNESS, R _B After	72	72	77			
INITIAL WEIGHT, g	3.95393	3.75896	3.92472			
FINAL WEIGHT, g	3.97456	3.77704	3.93207			
WEIGHT CHANGE, mg	+ 20.63	+ 18.08	+ 7.35			
CORROSION RATE, mg/dm ² -mo	+ 232.	+ 203.	+ 83.1			

APPEARANCE AFTER TEST: 3675 - Some black scale at the bottom of the sample
3775 - Twist in sample at top. Covered with sodium from undrained sampleholder.
3975 - Black scale along both sides near top.

METALLOGRAPHIC EXAMINATION:

3675 - Ferritic grains with out pearlitic phase.
Carbides appear at grain boundaries and as small spherodized particles.
Grain size ASTM 8 or smaller.
3775 } - Similar to above, however, more carbides are
3975 } situated at the grain boundaries.

SODIUM ANALYSIS

SAMPLE NO.	3-3-2***	3-4-1			
TEST TIME, HRS.	653	694			
SAMPLING TEMP., °F	680	680			
SAMPLING LOCATION	Surge	Surge			
COMPOSITION, ppm					
Ca	<16	<13			
Cr	0.6	0.05			
Fe	9.8	1.0			
K	245	366			
Li	<11	<12			
Mn	<1.7	<1.4			
Mo	0.2	<0.2			
Ni	2.6	1.3			
C	17				

AVERAGE FLOW AND PLUGGING INDICATOR DATA

TEST TIME, HRS.	40	232**	424**	689	
PLUG TEMP., °F	290	350	355	300	
OXIDE CONC.*, ppm O ₂	10	20	21	11	

REMARKS:

** Cold trapped at 300°F after plugging determination.

*** This sample represents initial run 3-4 composition.

* Based upon KAPL data, TID 5277, p.7

SODIUM MASS TRANSFER

AR No. 3-5-1ANALYSIS REPORTPage 1 of 3Run No. 3-5 Issued by Damon/Hetzler Date 9/6/61Sample Removal Date 9/5/61 Accumulated Test Hours 716T_{max} 1200 °F ΔT 500 °F Flow 0.9 gpm Oxygen Level 12 ppmCORROSION SAMPLES

SAMPLE NO.	3178	3279	3483	3578		
LOCATION & MATERIAL	H1-316	H2-316	H3-316	H3R-316 ^{foil}		
TEMPERATURE, °F	1000	1100	1200	1200		
VELOCITY, fps	27	27	27	27		
HARDNESS, R _B Before	72	72	71	-		
HARDNESS, R _B After	78	78	78	-		
INITIAL WEIGHT, g	4.11785	4.04114	3.88025	0.53096		
FINAL WEIGHT, g	4.12015	4.04780	3.87045	0.53130		
WEIGHT CHANGE, mg	+2.30	+6.66	-9.80	+0.34		
CORROSION RATE, mg/dm ² -mo	+27.3	+79.0	-116.	+4.13		

APPEARANCE AFTER TEST:

3178 - Medium gray color - no scale.

3279 - Dark gray color.

3483, 3578 - Light to medium gray.

Foil - Upper 1/4" deformed.

METALLOGRAPHIC EXAMINATION:

3178 - Lightly sensitized. No surface irregularities.

3279 - Heavily sensitized. Widmanstaetten structure at sheared edge.

Incipient ferritic layer to 0.1 mil or less. Heavy carbide formation at the surface boundary.

3483 - Moderately sensitized. Widmanstaetten structure at sheared edge.

Ferritic layer 0.1 mil. Heavy surface carbides.

3578 - Not examined.

CORROSION SAMPLES

SAMPLE NO.	3676	3776	3976			
LOCATION & MATERIAL	C1-2½	C2-2½	C3-2½			
TEMPERATURE, °F	1100	1000	700°			
VELOCITY, fps	27	27	27			
HARDNESS, R _B Before	70	69	70			
HARDNESS, R _B After	68	75	74			
INITIAL WEIGHT, g	3.50355	3.50852	3.57958			
FINAL WEIGHT, g	3.52610	3.52415	3.59920			
WEIGHT CHANGE, mg	+22.55	+15.63	+19.62			
CORROSION RATE, mg/dm ² -mo	+268.	+185.	+233.			

APPEARANCE AFTER TEST:

- 3676 - Medium gray with small area of black film.
- 3776 - Fairly clean - Medium gray.
- 3976 - Fairly clean - Medium gray - Scattered, black scale.

METALLOGRAPHIC EXAMINATION:

- 3676 - Ferritic structure. No pearlitic fields.
- 3776 - Ferritic structure. No pearlite, however, more carbides are present at the grain boundaries than 3676.
- 3976 - Ferritic grains with small areas of pearlite.

AR No. 3-5-1Page 3 of 3SODIUM ANALYSIS

SAMPLE NO.	3-4-1	3-5-1			
TEST TIME, HRS.	0	696			
SAMPLING TEMP., °F	690	690			
SAMPLING LOCATION	Surge	Surge			
COMPOSITION, ppm					
Ca	< 13	17.1			
Cr	0.3	0.5			
Fe	1.0	1.1			
K	366	295			
Li	< 12	< 10			
Mn	< 1.4	< 1.7			
Mo	< 0.2	0.3			
Ni	1.3	1.1			
C	19.6	5.0			

AVERAGE FLOW AND PLUGGING INDICATOR DATA

TEST TIME, HRS.	1	164	401	570	667
PLUG TEMP., °F	310	320	305	285	310
OXIDE CONC.* , ppm O ₂	12	14	11	9	12

REMARKS:

* Based upon KAPL data, TID 5277, p.7

ANALYSIS REPORT

Run No. 3-6 Issued by J. Damon/

Date 12/6/61

F. Hetzler

Sample Removal Date 11/30/61 Accumulated Test Hours 1527

T_{max} 1202 °F ΔT 496 °F Flow 0.715 gpm Oxygen Level 12 ppm

CORROSION SAMPLES

SAMPLE NO.	3179	3280	3480	3579		
LOCATION & MATERIAL	H1-316	H2-316	H3-316	H3R-316		
TEMPERATURE, °F	1004	1102	1202	1190		
VELOCITY, fps	7.15	7.15	7.15	7.15		
HARDNESS, R _B Before	72	74	77	-		
After	75	81	78	-		
INITIAL WEIGHT, g	4.35098	4.32828	4.37925	0.53217		
FINAL WEIGHT, g	4.34990	4.32285	4.36520	0.52820		
WEIGHT CHANGE, mg	-1.08	-5.43	-14.05	-3.97		
CORROSION RATE, mg/dm ² -mo	-5.56	-28.0	-72.3	-22.6		

APPEARANCE AFTER TEST:

3179

3280 - Light gray film

3480

3579

METALLOGRAPHIC EXAMINATION:

3179 - Very lightly & partially sensitized.

Ferritic layer & lightly defined Widmanstaetten structure at sheared edge.

3280 - Moderately sensitized. Incipient ferritic layer increasing to 3 mils at sheared edge. Widmanstaetten structure to 5 mils at sheared edge. Carbide density greater at free surface to one grain in depth. Intergranular ferrite, free surface inward one grain.

3480 - Similar to 3280 except for increased carbide density.

CORROSION SAMPLES

SAMPLE NO.	3677	3777	3977			
LOCATION & MATERIAL	C1-2½	C2-2½	C3-2½			
TEMPERATURE, °F	1096	1001	706			
VELOCITY, fps	7.15	7.15	7.15			
HARDNESS, R _B	Before	74	75	72		
	After	65	69	69		
INITIAL WEIGHT, g	3.96046	4.01212	3.93467			
FINAL WEIGHT, g	3.99707	4.03600	3.96070			
WEIGHT CHANGE, mg	+ 36.61	+ 23.88	+ 26.03			
CORROSION RATE, mg/dm ² -mo	+188.	+123.	+134.			

APPEARANCE AFTER TEST:

- 3677 - Light to medium gray.
 3777 - Medium gray - scattered spots of black film.
 3977 - Medium to dark gray - traces of black scale.

METALLOGRAPHIC EXAMINATION:

- 3677 } - Carbides distributed at grain boundaries.
 3777 }
 3977 - Heavier carbide distribution than 3677 & 3777.

ANALYSIS REPORT

Run No. 3-6[‡] Issued by J. Damon Date 12/6/61

F. Hetzler

Sample Removal Date 12/4/61 Accumulated Test Hours 5244

T_{max} 1201 °F ΔT 498 °F Flow 0.689 gpm Oxygen Level 19 ppm

CORROSION SAMPLES

(pipe)

SAMPLE NO.	3301	3302	3303 [*]	3801	3802	3803 [*]
LOCATION & MATERIAL	316 H3-H3R	316 H3-H3R	316 H3-H3R	2 1/2 C3-out	2 1/2 C3-out	2 1/2 C3-out
TEMPERATURE, °F	1201	1201	1201	703	703	703
VELOCITY, fps	1.07	1.07	1.07	1.03	1.03	1.03
HARDNESS, R _B Before	~92	-	-	~86	-	-
After	93	-	-	88	-	-
INITIAL WEIGHT, g	7.65060	7.61433	6.76472	7.25374	7.37858	7.25403
FINAL WEIGHT, g	7.63939	7.60392	6.75613	7.25655	7.38128	7.24457
WEIGHT CHANGE, mg	-11.21	-10.41	-8.59	+2.81	+2.70	-9.46
CORROSION RATE, mg/dm ² -mo	-10.5	-9.75	-8.03	+2.63	+2.53	-8.85

* New samples installed prior to run 2, other samples exposed during run 1 - then reinstalled after cleaning.

APPEARANCE AFTER TEST: 3301 }
 3302 } Medium gray
 3303 }
 3801 }
 3802 } Dark gray
 3803 }

METALLOGRAPHIC EXAMINATION:

3301 - Cold worked structure with severe grain elongation. Ferritic development at free surface, otherwise no localized effects.

3801 - Cold worked structure with severe grain elongation. No significant change in microstructure or surface condition.

[‡] Samples were installed at completion of run 3-1 and removed at termination of run 3-6.

LOOP NO. 4

Hot Leg

316 Stainless Steel

Cold Leg

**5 Chromium - 1/2 Molybdenum
- 1/2 Titanium**

SODIUM MASS TRANSFERAR No. 4-1-1Page 1 of 2ANALYSIS REPORTRun No. 4-1 Issued by G. Billuris Date 9/30/60Sample Removal Date 9/17/60 Accumulated Test Hours 698 $T_{\max}$ 1200 °F ΔT 500 °F Flow 0.42 gpm Oxygen Level 41 ppmCORROSION SAMPLES

SAMPLE NO.	4901	4904	4500	4476		
LOCATION & MATERIAL	C3-5Cr	C3-5Cr	H3R-316	H3-316		
TEMPERATURE, °F	700	700	1200	1200		
VELOCITY, fps	4.2	4.2	4.2	12.6		
HARDNESS, R_B Before	-	-	-	-		
After	-	-	-	-		
INITIAL WEIGHT, g	3.98647	3.99347	4.41577	4.44785		
FINAL WEIGHT, g	3.98700	3.99480	4.41400	4.43817		
WEIGHT CHANGE, mg	+0.53	+1.33	-1.77	-9.68		
CORROSION RATE, mg/dm ² -mo	+6.08	+15.3	-20.3	-111.0		

APPEARANCE AFTER TEST:

4901, 4904 : Irregular black scale on surface.

4500, 4476: Clean surface.

METALLOGRAPHIC EXAMINATION:

Samples 4476 and 4500 (TP 316 SS)

1. ASTM austenitic grain size 1. Abnormal grain growth noted.
2. Carbide precipitation at grain boundaries.
3. Carbide transformation incomplete.

Samples 4901 and 4904 (5 Cr)

1. Normal grain appearance. No change.

SODIUM ANALYSIS

SAMPLE NO.	S8	S12			
TEST TIME, HRS.	120	698			
SAMPLING TEMP., °F	500	500			
SAMPLING LOCATION	Dump Tk.	Dump Tk.			
<u>COMPOSITION, ppm</u>					
Ca	35	90			
Cr	1.6	0.8			
Fe	15.6	4.9			
K	-	-			
Li	-	-			
Mn	-	-			
Mo	-	-			
Ni	11	2.4			
C	-	-			

AVERAGE FLOW AND PLUGGING INDICATOR DATA

TEST TIME, HRS.	0.698				
AVERAGE FLOW, gpm	0.42				
AVERAGE PLUGGING TEMP., °F	426				
OXIDE CONC. *, ppm O ₂	41				

REMARKS:

* Based upon KAPL data, TID 5277; p.7

SODIUM MASS TRANSFER
ANALYSIS REPORT

ISSUED BY J. Damon DATE 10/22/60
LOOP NO. 4 RUN NO. 1
SAMPLE REMOVAL DATE 10/17/60 ACCUMULATED TEST TIME 1411 HRS.
 $T_{\max}$ 1200 °F ΔT 500 °F
SODIUM FLOW 0.4 gpm OXIDE LEVEL 44-20 ppm O₂

CORROSION SAMPLES

SAMPLE NO.	4475	4501	4900	4905
SAMPLE LOCATION	H3	H3R	C3	C3
AVERAGE VELOCITY, fps	12	4	4	4
APPEARANCE AFTER TEST:	Plier marks - vertical scratch along entire length file marks at bottom	Plier marks	Aluminum foil bits on sample	Very slight plier marking
INITIAL WEIGHT, g	4.45924	4.65338	3.92547	3.98171
FINAL WEIGHT, g	4.28834	4.65284	3.93154	3.99186
WEIGHT CHANGE, mg	-170.90	-0.54	+ 6.07	+ 10.15
CORROSION RATE, mg/dm ² -mo	-880.	-3.05	+ 34.4	+ 57.5
TEMPERATURE, °F	1200	1200	700	700

METALLOGRAPHIC EXAMINATION:

Sample 4475 (316 SS)

1. Sensitized
2. Intergranular attack
3. Surface carbides
4. Completely transformed grain structure
5. Grain size larger than ASTM #1

Sample 4501 (316 SS)

1. Sensitized
2. Intergranular attack
3. Surface carbides
4. Incomplete transformation
5. Grain size: old ASTM #4
new ASTM #1

Samples 4900 and 4905 (5 Cr)

No change from original structure.

SODIUM ANALYSIS

SAMPLE NO.	S17a					
TEST TIME, HRS.	1411					
COMPOSITION, ppm	<u>CHEM.</u>	<u>SPEC.</u>	<u>CHEM.</u>	<u>SPEC.</u>	<u>CHEM.</u>	<u>SPEC.</u>
Ca						
Cr						
Co						
Fe						
Li						
Mn						
Mo						
Ni						
K						
Si						
Ti						

PLUG. INDICATOR DATA

Test Time, hrs	678	836	1124	1126	1390
Plug Temp., °F	410	435	**350	**390	430
Oxide Conc.* , ppm O ₂	36	44	20	30	42

REMARKS:

** These saturation temperatures were difficult to determine because of an erratic flow signal. Installation of new flowmeters has subsequently overcome the problem.

SODIUM MASS TRANSFER
ANALYSIS REPORT

ISSUED BY G. Billuris DATE 12-28-60LOOP NO. 4 RUN NO. 1SAMPLE REMOVAL DATE 12-15-60 ACCUMULATED TEST TIME 2802 HRS. $T_{\max}$ 1200 F ΔT 5000 FSODIUM FLOW 0.4 gpm OXIDE LEVEL 27-55 ppm O_2

CORROSION SAMPLES

SAMPLE NO.	4100	4101	4102	4175		
LOCATION & MATERIAL	H1-316	H1-316	H1-316	H1-316		
TEMPERATURE, °F	1000	1000	1000	1000		
VELOCITY, fps	4	4	4	12		
HARDNESS, R_B	66	61	61	69		
INITIAL WEIGHT, g	4.34327	4.35483	4.47485	4.31342		
FINAL WEIGHT, g	4.34101	4.35309	4.47292	4.30925		
WEIGHT CHANGE, mg	-1.46	-1.74	-1.93	-4.17		
CORROSION RATE, mg/dm^2-mo	-4.17	-4.96	-5.50	-11.9		

APPEARANCE AFTER TEST:

Samples were clean and free of scale deposits. All samples were dark gray in color.

METALLOGRAPHIC EXAMINATION:

4100 - ASTM grain size 1. Carbide ppt. along strain lines. Sensitized.
Good Surface.

4101 - ASTM grain size 1 with areas of ASTM grain size 4. Sensitized. Good surface.

4102 - ASTM grain size 1. Carbon in solution. Sensitized. Good surface.

4175 - ASTM grain size 5. Highly sensitized. Fair surface.

CORROSION SAMPLES

SAMPLE NO.	4200	4201	4202	4275	4477**	4478*
LOCATION & MATERIAL	H2-316	H2-316	H2-316	H2-316	H3-316	H3-316
TEMPERATURE, °F	1100	1100	1100	1100	1200	1200
VELOCITY, fps	4	4	4	12	12	12
HARDNESS, R _B	61	66	65	69	68	63
INITIAL WEIGHT, g	4.34145	4.37359	4.10717	4.17186	4.27080	4.26325
FINAL WEIGHT, g	4.33138	4.36397	4.09684	4.15214	4.20144	4.22282
WEIGHT CHANGE, mg	-10.07	-9.62	-10.33	-19.72	-69.36	-40.43
CORROSION RATE, mg/dm ² -mo	-28.7	-27.5	-29.5	-56.3	-263.	-231.

APPEARANCE AFTER TEST:

Samples clean with small amount of gray film. Plier marks on 4478.

METALLOGRAPHIC EXAMINATION:

4200 - ASTM grain size 1 with normal structure of grain size 4 starting to form. Sensitized. Good surface.

4201 - ASTM grain size 1 with areas of grain size 4. Sensitized. Good surface.

4202 - ASTM grain sized. Carbides lay along strain lines. Incipient surface layer. Good surface.

4275 } ASTM grain size 1 with areas of grain size 4. Sensitized. Good surface.

4477 }

4478 }

* Loaded @ 1411 hours.

** Loaded @ 698 hours.

CORROSION SAMPLES

SAMPLE NO.	4502	4503**	4504*	4575 (FOIL)		
LOCATION & MATERIAL	H3R-316	H3R-316	H3R-316	H3R-316		
TEMPERATURE, °F	1200	1200	1200	1200		
VELOCITY, fps	4	4	4	12		
HARDNESS, R _B	64	58	64	-		
INITIAL WEIGHT, g	4.39296	4.41192	4.26748	0.46519		
FINAL WEIGHT, g	4.38432	4.40403	4.25911	0.45163		
WEIGHT CHANGE, mg	-8.64	-7.89	-8.37	-13.56		
CORROSION RATE, mg/dm ² -mo	-24.6	-30.0	-47.7	-42.1		

APPEARANCE AFTER TEST:

H3R foil was clean (no evidence of scale deposit) and bowed.
 Other specimens relatively clean with slight gray film.
 Evidence of plier marks on 4502 and 4503.

METALLOGRAPHIC EXAMINATION:

4502 } - ASTM grain size 1 with areas of grain size 4. Sensitized.
 4503 } Good surface.
 4504 }

FOIL - Solid surface layer 0.2 mils. Carbide ppt. at surface. Good surface.

* Loaded at 1411 hours.

** Loaded @ 698 hours.

CORROSION SAMPLES

SAMPLE NO.	4600	4601	4602	4700	4701	4702
LOCATION & MATERIAL	C1-5	C1-5	C1-5	C2-5	C2-5	C2-5
TEMPERATURE, °F	1100	1100	1100	1000	1000	1000
VELOCITY, fps	4	4	4	4	4	4
HARDNESS, R _B	66	62	67	67	67	67
INITIAL WEIGHT, g	4.02753	3.93382	3.91399	3.96611	3.93134	3.96762
FINAL WEIGHT, g	4.04266	3.97742	3.95900	4.00311	3.96489	4.00151
WEIGHT CHANGE, mg	+15.13	+43.60	+45.01	+37.00	+33.55	+33.89
CORROSION RATE, mg/dm ² -mo	+43.2	+124.2	+128.2	+105.5	+95.6	+96.6

APPEARANCE AFTER TEST:

Localized areas of black scale particles. Dark gray film over most of surface.

METALLOGRAPHIC EXAMINATION.

All specimens have same structure as the standard 5 Croloy specimen. Inter-triangular attack from surface to maximum depth:

4600 - 0.8 mils
4601 - 1.0
4602 - 1.0
4700 - 0.7
4701 - 0.4
4702 - 0.8

CORROSION SAMPLES

SAMPLE NO.	4902	4903	4906**	4907**	4908*	4909*
LOCATION & MATERIAL	C3-5	C3-5	C3-5	C3-5	C3-5	C3-5
TEMPERATURE, °F	700	700	700	700	700	700
VELOCITY, fps	4	4	4	4	4	4
HARDNESS, R _B	71	67	66	73	69	70
INITIAL WEIGHT, g	3.91082	3.91415	4.02995	3.71612	3.85163	3.76937
FINAL WEIGHT, g	3.91414	3.91872	4.03600	3.72111	3.85419	3.77318
WEIGHT CHANGE, mg	+ 3.32	+4.57	+ 6.05	+4.99	+ 2.56	+ 3.81
CORROSION RATE, mg/dm ² -mo	+ 9.47	+13.0	+23.0	+18.9	+14.6	+21.7

APPEARANCE AFTER TEST:

Dark black scale in varying amounts on all samples.
 Dark gray film apparent over most of sample surface.

METALLOGRAPHIC EXAMINATION:

All specimens have same structure as the standard 5 Croloy specimen.
 Surface condition good.

* Loaded @ 1411 hours.

** Loaded @ 698 hours.

SODIUM ANALYSIS

SAMPLE NO.	S8a		S12a		S17a		S24a		
TEST TIME, HRS.	120		700		1410		2802		
COMPOSITION, ppm			CHEM. SPEC.		CHEM. SPEC.		CHEM. SPEC.		
Ca	34.7	< 3	90		80	< 3			
Cr	1.6	< 15	0.82		1.85	< 15			
Fe		< 9				< 9			
K	15.6	< 6	4.95		3.2	< 6			
Li	28		100		56				
Mn		< 3				< 3			
Mo		< 6				< 6			
Ni	11	11	2.44		0.89	14			
C	<10		100		166				
		< 9				< 27			
		< 15				< 15			

AVERAGE FLOW AND PLUGGING INDICATOR DATA

TEST TIME, HRS.	1430	1742	1743**	2160	2180**	2350	2380**
PLUG TEMP., °F	440	390	435	360	430	390	460
OXIDE CONC. *, ppm O ₂	46	30	44	22	42	30	55

REMARKS:

** After holding sodium in dump tank for 1/2-1 hr. at 500-600°F.

* Based upon KAFL data, TID 5277, p.7.

SODIUM MASS TRANSFER
ANALYSIS REPORT

ISSUED BY J. Damon DATE 1-17-61
LOOP NO. 4 RUN NO. 1
SAMPLE REMOVAL DATE 1-10-61 ACCUMULATED TEST TIME 2802 HRS.
 $T_{\max}$ 1200 F ΔT 500° F
SODIUM FLOW 0.40 gpm OXIDE LEVEL 27-55 ppm O₂

CORROSION SAMPLES

SAMPLE NO.	5300	5301	5302	5800	5801	5802
LOCATION & MATERIAL	H3 Pipe 316	H3 Pipe 316	H3 Pipe 316	C3 Pipe 5 Cr	C3 Pipe 5 Cr	C3 Pipe 5 Cr
TEMPERATURE, °F	1200	1200	1200	700	700	700
VELOCITY, fps	0.60	0.60	0.60	0.24	0.24	0.24
HARDNESS, R _B	96	—	—	—	76	—
INITIAL WEIGHT, g	7.52973	7.54091	7.57657	7.41486	7.41321	7.43327
FINAL WEIGHT, g	7.52615	7.53747	7.57270	7.41595	7.41489	7.43450
WEIGHT CHANGE, mg	-3.58	-3.44	-3.87	+1.09	+1.68	+1.23
CORROSION RATE, mg/dm ² -mo	-6.13	-5.89	-6.63	+1.87	+2.88	+2.13

APPEARANCE AFTER TEST:

Clean - Dark gray in color - No scale.

METALLOGRAPHIC EXAMINATION:

5300 Cold worked structure. Surface carbides, 0.394 mils ferritic layer. Sensitized. Good surface. One end has been sheared and ferritic layer is 4.925 mils max.

5801 No change from standard specimen.

5301, 5302, 5800, 5802 returned to loop.

SODIUM MASS TRANSFERAR No. 4-2-1Page 1 of 3ANALYSIS REPORTRun No. 2 Issued by G. Billuris/F. Hetzler Date 7-7-61Sample Removal Date 6-19-61 Accumulated Test Hours 729T_{max} 1200 °F ΔT 500 °F Flow 0.45 gpm Oxygen Level 10 ppCORROSION SAMPLES

SAMPLE NO.	4103	4479	4603	4910	4913	
LOCATION & MATERIAL	H1-316	H3-316	C1-5Cr	(C3 (in) 5 Cr	C3(out) 5 Cr	
TEMPERATURE, °F	1000	1200	1100	700	700	
VELOCITY, fps	4.5	13.5	4.5	4.5	4.5	
HARDNESS, R _B	Before	73	71	63	64	65
	After	79	79	65	65	69
INITIAL WEIGHT, g	4.32127	4.32907	3.94266	3.90135	3.91278	
FINAL WEIGHT, g	4.32128	4.32244	3.94654	3.90559	3.91473	
WEIGHT CHANGE, mg	+0.01	-6.63	+3.88	+4.24	+1.95	
CORROSION RATE, mg/dm ² -mo	+0.11	-72.6	+42.5	+46.4	+21.4	

APPEARANCE AFTER TEST:

4103, 4479, 4603: Light sodium oxide film but no evidence of scale on surfaces.

4910, 4913: Some scale noted under sodium oxide layer.

METALLOGRAPHIC EXAMINATION:

CORROSION SAMPLES

METALLOGRAPHIC EXAMINATION:

4103 - Uniform grain size ASTM 5
Lightly sensitized.
No ferritic layer.
Widmanstatten structure at narrow dimension
indicating prior, localized, cold work.

4479 - Uniform grain size ASTM 5
Heavily sensitized.
Ferritic layer 0.2 mils that is
not continuous except at the
narrow dimension where prior,
localized, cold work formed a
Widmanstatten structure, with
heavy carbide deposits.

4603 }
4910 } No change from the original structure.
4913 } Carburization to 0.2 mil depth.

SODIUM ANALYSIS

SAMPLE NO.	4-2-3	4-2-4			
TEST TIME, HRS.	79	700			
SAMPLING TEMP., °F	680	660			
SAMPLING LOCATION	Surge	Surge			
COMPOSITION, ppm					
Ca	< 15	< 10			
Cr	0.1	< 0.05			
Fe	3.5	0.8			
K	334	331			
Li	< 11	< 10			
Mn	< 1.6	< 1.1			
Mo	< 0.3	< 0.2			
Ni	1.6	1.5			

AVERAGE FLOW AND PLUGGING INDICATOR DATA

TEST TIME, HRS.	17	98**	294	554	
PLUG TEMP., °F	305	345	315	315	
OXIDE CONC.* , ppm O ₂	11	19	13	13	

REMARKS:

** Cold trapped at 300°F to reduce Na₂O concentration

* Based upon KAPL data, TID 5277, p.7

AR No. 4-2-1APage 1 of 1

RADIOCHEMICAL ANALYSIS
CORROSION AND SODIUM SAMPLES

Decay Correction Date: 6-1-61

SAMPLE NO.	4103	4479	4603	4910	4913
LOCATION & MATERIAL	H1-316	H3-316	C1-5Cr	C3-5Cr	C 3-5Cr
TEMPERATURE, °F	1000	1200	1100	700	700
VELOCITY, fps	4.5	13.5	4.5	4.5	4.5
HRS. IN LOOP	729	729	729	729	729
TIMES WASHED	1	1	1	1	1
<u>SAMPLE ACTIVITY, μc</u>					
Cr 51	7.03×10^{-1}	4.37×10^{-1}	34.7	9.15×10^{-1}	4.59
Mn 54	9.15×10^{-3}	7.17×10^{-3}	8.29×10^{-2}	3.35×10^{-2}	1.74×10^{-2}
Fe 59	4.44×10^{-2}	2.86×10^{-3}	1.13×10^{-1}	1.90×10^{-2}	1.10×10^{-2}
Co 60	1.19×10^{-2}	1.47×10^{-3}	2.46×10^{-2}	3.82×10^{-3}	1.72×10^{-3}
<u>WASH ACTIVITY, μc</u>					
Cr 51	1.70×10^{-3}	9.06×10^{-4}	6.06×10^{-2}	1.02	3.85×10^{-1}
Mn 54	4.73×10^{-5}	7.12×10^{-5}	6.71×10^{-4}	4.14×10^{-3}	1.82×10^{-3}
Fe 59	1.05×10^{-4}	1.17×10^{-4}	3.37×10^{-3}	1.10×10^{-2}	5.62×10^{-3}
Co 60	2.3×10^{-5}	3.65×10^{-5}	2.35×10^{-3}	2.33×10^{-3}	1.16×10^{-3}
TOTAL μ ACTIVITY μ c	0.77	0.45	35.0	2.01	5.01

SODIUM MASS TRANSFERAR No. 4-2-2ANALYSIS REPORTPage 1 of 2Run No. 2 Issued by Billuris/Hetzler Date 8/11/61Sample Removal Date 7/24/61 Accumulated Test Hours 1489T_{max} 1200 °F ΔT 500 °F Flow 0.40 gpm Oxygen Level 13 ppmCORROSION SAMPLES

SAMPLE NO.	4104	4480	4604	Inlet 4911	outlet 4914	
LOCATION & MATERIAL	H1-316	H3-316	C1-5 Cr	C3-5 Cr	C3-5 Cr	
TEMPERATURE, °F	1000	1200	1200	700	700	
VELOCITY, fps	4	12	4	4	4	
HARDNESS, R _B	Before	69	66	62	64	
	After	75	67	71	68	
INITIAL WEIGHT, g	4.35384	4.33751	3.88404	3.92477	3.87759	
FINAL WEIGHT, g	4.35346	4.33019	3.89250	3.93360	3.88005	
WEIGHT CHANGE, mg	-0.38	-7.32	+8.46	+8.83	+2.46	
CORROSION RATE, mg/dm ² -mo	-2.00	-38.6	+44.6	+46.3	+13.0	

APPEARANCE AFTER TEST:

- 4104 - Fairly clean, no scale, light gray.
- 4480 - Fairly clean, no scale, light gray
- 4604 - Fairly clean, medium gray at top of sample.
- 4911 - Fairly clean, medium gray color, slight twist at top.
- 4914 - Fairly clean, medium gray color.

METALLOGRAPHIC EXAMINATION:

- 4104 - Lightly sensitized. Widmanstaetten structure at sheared edge.
- 4480 - Moderately sensitized. Widmanstaetten structure at sheared edge. Ferritic layer 0.3 mil at shear, otherwise incipient.
- 4604 - No change in microstructure. Intergranular oxide or carbide penetration 0.2 mil.
- 4911 - No change in microstructure.
- 4914 - No surface attack.

AR No. 4-2-2Page 2 of 2

RADIOCHEMICAL ANALYSIS
CORROSION AND SODIUM SAMPLES

Decay Correction Date: 6-1-61

SAMPLE NO.	4104	4480	4604	4911	4914
LOCATION & MATERIAL	H1-316	H3-316	C1-5Cr	C3-5Cr	C3-5Cr
TEMPERATURE, °F	1000	1200	1100	700	700
VELOCITY, fps	4	12	4	4	4
HRS. IN LOOP	1489	1489	1489	1489	1489
TIMES WASHED	1	1	1	1	1
SAMPLE ACTIVITY, μc					
Cr 51	6.30×10^{-1}	3.84×10^{-1}	41.3	11.1	4.73
Mn 54	9.60×10^{-3}	6.98×10^{-3}	2.36×10^{-2}	4.73×10^{-2}	2.32×10^{-2}
Fe 59	6.35×10^{-4}	1.61×10^{-3}	3.00×10^{-1}	9.77×10^{-2}	2.45×10^{-2}
Co 60	6.75×10^{-4}	1.84×10^{-3}	5.50×10^{-2}	1.05×10^{-2}	4.69×10^{-3}
WASH ACTIVITY, μc					
Cr 51	5.50×10^{-4}	5.81×10^{-4}	3.56×10^{-1}	8.10×10^{-1}	4.14×10^{-1}
Mn 54	2.66×10^{-5}	2.97×10^{-5}	2.37×10^{-3}	4.25×10^{-3}	3.46×10^{-3}
Fe 59	3.24×10^{-4}	2.67×10^{-4}	3.35×10^{-2}	1.41×10^{-2}	8.47×10^{-3}
Co 60	7.35×10^{-5}	2.16×10^{-5}	1.95×10^{-2}	3.00×10^{-3}	2.28×10^{-3}
TOTAL ACTIVITY μc	0.64	0.40	42.1	12.1	5.21

SODIUM MASS TRANSFERAR No. 4-2-3Page 1 of 13**ANALYSIS REPORT**Run No. 4-2 Issued by J. Damon/F. Hetzler Date 10/3/61Sample Removal Date 9/21/61 Accumulated Test Hours 2803 $T_{\max}$ 1197 °F ΔT 498 °F Flow 0.350 gpm Oxygen Level 14 pp**CORROSION SAMPLES**

TEST HOURS	2803	2074	1314	2803		
SAMPLE NO.	4105	4106	4107	4176		
LOCATION & MATERIAL	H1-316	H1-316	H1-316	H1-316		
TEMPERATURE, °F	1001	1001	1001	1001		
VELOCITY, fps	3.85	3.75	3.65	11.5		
HARDNESS, R_B	Before	77	75	72		
	After	77	77	75		
INITIAL WEIGHT, g	4.31700	4.33686	4.24200	4.35192		
FINAL WEIGHT, g	4.31533	4.33491	4.24103	4.34824		
WEIGHT CHANGE, mg	-1.67	-1.95	-0.97	-3.68		
CORROSION RATE, mg/dm ² -mo	-4.67	-7.38	-5.79	-10.3		

APPEARANCE AFTER TEST: All samples were light to medium gray. #4107 had some small areas of reddish, rust-like deposit.

METALLOGRAPHIC EXAMINATION:

4105 }
4106 } Lightly sensitized. Incipient ferrite developed at sheared edges.
4107 } Surface anomaly not apparent.
4176 }

CORROSION SAMPLES

TEST HOURS	2803	2803	2803	2803	2074	1314
SAMPLE NO.	4203	4204	4205	4276	4481	4482
LOCATION & MATERIAL	H2-316	H2-316	H2-316	H2-316	inlet H3-316	outlet H3-316
TEMPERATURE, °F	1099	1099	1099	1099	1197	1197
VELOCITY, fps	3.85	3.85	3.85	11.5	11.2	11.0
HARDNESS, R _B Before	71	70	73	70	78	73
HARDNESS, R _B After	77	80	80	78	75	80
INITIAL WEIGHT, g	4.35371	4.33247	4.31023	4.32990	4.25691	4.36171
FINAL WEIGHT, g	4.34772	4.32674	4.30484	4.31718	4.21009	4.34530
WEIGHT CHANGE, mg	-5.99	-5.73	-5.39	-12.72	-46.82	-16.41
CORROSION RATE, mg/dm ² -mo	-16.7	-16.1	-15.1	-35.6	-177.0	-98.1

APPEARANCE AFTER TEST: 4203 } Light to medium gray. (4203 - Two flecks of scale).
4204 }
4205 }
4276 }
4481 } Light gray. 4482 had slight bend at top.
4482 }

METALLOGRAPHIC EXAMINATION :

4203 }
4204 } Heavily sensitized. 0.3 mil ferritic layer at sheared edge with
4205 } Widmanstaetten to 3 mils.

4276 Heavily sensitized. Incipient ferritic layer at surface. Ferrite developed at grain boundaries through-out sample which generally has not expanded greater than 0.0012 mil.
4481 } Heavily sensitized. Possible minute amounts of intergranular ferrite.
4482 } 0.4 mils ferrite at sheared edge and Widmanstaetten to 15 mils.

CORROSION SAMPLES

TEST HOURS	2803	2803	2803	2803		
SAMPLE NO.	4505	4506	4507	MT 4-2 4578		
LOCATION & MATERIAL	H3R-316	H3R-316	H3R-316	H3R-316		
TEMPERATURE, °F	1184	1184	1184	1184		
VELOCITY, fps	3.85	3.85	3.85	11.5		
HARDNESS, R _B	Before	66	71	72	-	
	After	77	78	77	-	
INITIAL WEIGHT, g	4.32996	4.35990	4.34943	0.5505		
FINAL WEIGHT, g	4.32487	4.35518	4.34430	0.5472		
WEIGHT CHANGE, mg	-5.09	-4.72	-5.13	- 3.3		
CORROSION RATE, mg/dm ² -mo	-14.2	-13.3	-14.3	-10.3		

APPEARANCE AFTER TEST: All samples were light gray & clean

METALLOGRAPHIC EXAMINATION:

4505 - Heavily sensitized. 0.3 mils ferrite at sheared edge with Widmanstaetten to 11 mils. Ferritic development to intergranular depth of one grain.

4506 - Extremely heavily sensitized, 0.5 mil ferritic layer at sheared edges. Widmanstaetten to 40 mils. Incipient ferrite on other surfaces with intergranular ferrite to approximately 1/2 grain.

4507 - Similar to 4506 with exception that deep Widmanstaetten not present.

4578 - Not examined.

CORROSION SAMPLES

TEST HOURS	2803	2074	1314	2803	2803	2803
SAMPLE NO	4605	4606	4607	4703	4704	4705
LOCATION & MATERIAL	C1-5Cr	C1-5Cr	C1-5Cr	C2-5Cr	C2-5Cr	C2-5Cr
TEMPERATURE, °F	1087	1087	1087	999	999	999
VELOCITY, fps	3.85	3.75	3.65	3.85	3.85	3.85
HARDNESS, R _B	Before	68	72	63	66	62
	After	75	71	72	72	70
INITIAL WEIGHT, g	3.90957	3.87881	3.99227	3.90176	3.83487	3.81905
FINAL WEIGHT, g	3.93667	3.90423	4.00815	3.92185	3.85681	3.93927
WEIGHT CHANGE, mg	+ 27.10	+ 25.42	+ 15.88	+ 20.09	+ 21.94	+120.22*
CORROSION RATE, mg/dm ² -mo	+ 75.8	+ 96.2	+ 94.9	+ 56.2	+ 61.3	+ 341.

* Final wt. to be rechecked after scan.

APPEARANCE AFTER TEST:
4605 }
4606 }
4607 }
4703 }
4704 }
4705 }

Medium to dark gray - Scattered traces of black film.

Medium to dark gray.

METALLOGRAPHIC EXAMINATION:

All samples - No apparent change in microstructure

4605 - Intergranular penetration - 0.9 mil
4606 - " " - 0.4 mil
4607 - " " - 1.0 mil
4703 - " " - 0.6 mil
4704 - " " - 0.3 mil
4705 - " " - 0.2 mil

CORROSION SAMPLES

TEST HOURS	2803	2803	2074	2074	1314	1314
SAMPLE NO.	4912*	4915	4916*	4917	4918*	4919
LOCATION & MATERIAL	inlet C3-5Cr	outlet C3-5Cr	inlet C3-5Cr	outlet C3-5Cr	inlet C3-5Cr	outlet C3-5Cr
TEMPERATURE, °F	699	699	699	699	699	699
VELOCITY, fps	3.85	3.85	3.75	3.75	3.65	3.65
HARDNESS, R _B	Before	65	64	68	68	70
	After	75	72	70	67	77
INITIAL WEIGHT, g	4.06895	3.90451	4.05787	3.87650	3.98839	3.85815
FINAL WEIGHT, g	4.07307	3.90966	4.07362	3.87978	3.99425	3.86055
WEIGHT CHANGE, mg	+ 4.12	+ 5.45	+ 15.75	+ 3.28	+ 5.86	+ 2.40
CORROSION RATE, mg/dm ² -mo	+ 11.5	+ 15.2	+ 59.5	+ 12.4	+ 35.0	+ 14.3

* Samples processed through NH₃ extraction prior to final cleaning and weighing.

APPEARANCE AFTER TEST: All samples dark gray with areas of black film scattered throughout.

METALLOGRAPHIC EXAMINATION:

4912)
4915)
4916)
4917)
4918)
4919)

No apparent change in microstructure.

CORROSION SAMPLES

TEST HOURS	4029	4029	4029			
SAMPLE NO.	5301*	5302*	4303*			
LOCATION & MATERIAL	H3 Pipe 316	H3 Pipe 316	H3 Pipe 316			
TEMPERATURE, °F	1197	1197	1197			
VELOCITY, fps	0.84	0.84	0.84			
HARDNESS, R _B	Before					
	After					
INITIAL WEIGHT, g	7.53747	7.57270	7.35778			
FINAL WEIGHT, g	7.52526	7.56013	7.34515			
WEIGHT CHANGE, mg	-12.21	-12.57	-12.63			
CORROSION RATE, mg/dm ² -mo	-13.9	-14.3	-14.4			

* Above pipe samples were reinstalled in loop after cleaning & weighing.

APPEARANCE AFTER TEST: All samples were light gray in color. No scale.

METALLOGRAPHIC EXAMINATION: Samples were not examined.

RADIOCHEMICAL ANALYSIS
CORROSION AND SODIUM SAMPLES

Decay Correction Date: 6/1/61

SAMPLE NO.	4105	4106	4107	4176	4276
LOCATION & MATERIAL	H1-316	H1-316	H1-316	H1-316	H2-316
TEMPERATURE, °F	1001	1001	1001	1001	1099
VELOCITY, fps	3.85	3.75	3.65	11.5	11.5
HRS. IN LOOP	2803	2074	1314	2803	2803
TIMES WASHED	1	1	1	1	1
SAMPLE ACTIVITY, μC					
Cr 51	1.09	0.743	0.526	1.323	0.652
Mn 54	102×10^{-2}	1.48×10^{-2}	9.81×10^{-3}	1.12×10^{-2}	8.91×10^{-3}
Fe 59	-	-	-	-	-
Co 60	8.51×10^{-4}	7.83×10^{-4}	9.5×10^{-4}	1.52×10^{-3}	1.84×10^{-3}
WASH ACTIVITY, μC					
Cr 51	0.0115	2.34×10^{-3}	5.62×10^{-3}	3.93×10^{-3}	6.12×10^{-3}
Mn 54	1.23×10^{-4}	4.86×10^{-5}	5.54×10^{-5}	1.25×10^{-4}	1.62×10^{-4}
Fe 59	-	-	-	-	-
Co 60	1.08×10^{-4}	9.6×10^{-5}	1.13×10^{-4}	5.67×10^{-5}	4.86×10^{-4}
TOTAL ACTIVITY μC	1.11	0.760	0.543	1.340	0.670

AR No. 4-2-3Page 8 of 13

RADIOCHEMICAL ANALYSIS
CORROSION AND SODIUM SAMPLES

Decay Correction Date: 6/1/61

SAMPLE NO.	4203	4204	4205	4481	4482
LOCATION & MATERIAL	H2-316	H2-316	H2-316	H3-316	H3-316
TEMPERATURE, °F	1099	1099	1099	1197	1197
VELOCITY, fps	3.85	3.85	3.85	11.2	11.0
HRS. IN LOOP	2803	2803	2803	2074	1314
TIMES WASHED	1	1	1	1	1
SAMPLE ACTIVITY, μc					
Cr 51	0.433	0.504	0.576	0.167	1.498
Mn 54	8.46×10^{-3}	8.24×10^{-3}	0.346	5.31×10^{-4}	1.49×10^{-2}
Fe 59	-	-	-	-	-
Co 60	7.42×10^{-4}	8.64×10^{-4}	1.04×10^{-3}	1.15×10^{-3}	9.54×10^{-4}
WASH ACTIVITY, μc					
Cr 51	4.18×10^{-3}	4.32×10^{-4}	1.60×10^{-3}	2.43×10^{-4}	4.59×10^{-4}
Mn 54	3.6×10^{-5}	2.8×10^{-5}	2.43×10^{-5}	5.36×10^{-5}	2.29×10^{-4}
Fe 59	-	-	-	-	-
Co 60	7.11×10^{-5}	4.63×10^{-5}	3.06×10^{-5}	9.2×10^{-5}	1.49×10^{-4}
TOTAL ACTIVITY μc	0.446	0.514	0.925	0.169	1.515

AR NO. 4-2-3Page 9 of 13RADIOCHEMICAL ANALYSISCORROSION AND SODIUM SAMPLESDecay Correction Date: 6/1/61

SAMPLE NO.	4505	4506	4507	4605	4606
LOCATION & MATERIAL	H3R-316	H3R-316	H3R-316	Cl - 5Cr	Cl - 5 Cr
TEMPERATURE, °F	1184	1184	1184	1087	1087
VELOCITY, fps	3.85	3.85	3.85	3.85	3.75
HRS. IN LOOP	2803	2803	2803	2803	2074
TIMES WASHED	1	1	1	1	1
<u>SAMPLE ACTIVITY, μc</u>					
Ce 51	0.205	0.364	0.325	47.2	72.0
Mn 54	6.39×10^{-3}	9.76×10^{-3}	8.46×10^{-3}	7.60×10^{-2}	0.142
Fe 59	-	-	-	-	-
Co 60	6.53×10^{-4}	6.52×10^{-4}	6.08×10^{-4}	0.166	0.401
<u>WASH ACTIVITY, μc</u>					
Cr 51	2.15×10^{-3}	2.12×10^{-3}	4.46×10^{-3}	0.743	0.770
Mn 54	2.3×10^{-5}	3.6×10^{-5}	2.97×10^{-5}	2.84×10^{-3}	2.67×10^{-3}
Fe 59	-	-	-	-	-
Co 60	1.89×10^{-4}	9.45×10^{-5}	9.86×10^{-2}	0.104	0.122
TOTAL Σ ACTIVITY μ c	0.215	0.377	0.437	48.2	78.4

RADIOCHEMICAL ANALYSIS
CORROSION AND SODIUM SAMPLES

Decay Correction Date: 6/1/61

SAMPLE NO.	4607	4703	4704	4705	4915
LOCATION & MATERIAL	C1-5Cr	C2-5Cr	C2-5 Cr	C2-5Cr	outlet C3-5 Cr
TEMPERATURE, °F	1087	999	999	999	699
VELOCITY, fps	3.65	3.85	3.85	3.85	3.85
HRS. IN LOOP	1314	2803	2803	2803	2803
TIMES WASHED	1	1	1	1	1
<u>SAMPLE ACTIVITY, μc</u>					
Cr 51	33.4	0.936	46.4	44.5	7.24
Mn 54	6.93×10^{-2}	5.31×10^{-3}	9.63×10^{-2}	7.96×10^{-2}	3.74×10^{-2}
Fe 59	-	-	-	-	-
Co 60	8.37×10^{-2}	1.22×10^{-4}	0.117	0.117	1.45×10^{-2}
<u>WASH ACTIVITY, μc</u>					
Cr 51	*	0.937	1.48	3.6×10^{-2}	0.495
Mn 54	-	5.00×10^{-3}	7.47×10^{-3}	9.81×10^{-3}	3.25×10^{-3}
Fe 59	-	-	-	-	-
Co 60	-	2.81×10^{-4}	0.100	0.100	4.30×10^{-3}
TOTAL δ ACTIVITY μ c	33.6	1.88	48.2	44.8	7.76

* Wash sample lost.

AR No. 4-2-3Page 11 of 13RADIOCHEMICAL ANALYSISCORROSION AND SODIUM SAMPLES

Decay Correction Date: 6-1-61

SAMPLE NO.	4917	4919	4912	4916	4918
LOCATION & MATERIAL	outlet C3-5Cr	outlet C3-5Cr	inlet C3-5Cr	inlet C3-5Cr	inlet C3-5Cr
TEMPERATURE, °F	699	699	699	699	699
VELOCITY, fps	3.75	3.65	3.85	3.75	3.65
HRS. IN LOOP	2074	1314	2803	2074	1314
TIMES WASHED	1	1	1	1	1
SAMPLE ACTIVITY, μc					
Cr 51	3.28	2.07	-	39.0*	-
Mn 54	2.55×10^{-2}	1.57×10^{-2}	-	0.266	-
Fe 59	-	-	-	0.837	-
Co 60	9.86×10^{-3}	7.38×10^{-3}	-	7.2×10^{-2}	-
WASH ACTIVITY, μc					
Cr 51	0.273	0.149	-	-	-
Mn 54	8.64×10^{-3}	1.16×10^{-3}	-	-	-
Fe 59	--	-	-	-	-
Co 60	3.35×10^{-3}	2.60×10^{-3}	-	-	-
TOTAL $\propto$ ACTIVITY μc	3.60	2.24		40.18	

Total activity before samples were washed with NH_3 and later with alcohol, then water.

RADIOCHEMICAL ANALYSIS
CORROSION AND SODIUM SAMPLES

Decay Correction Date: 6-1-61

SAMPLE NO.		4-2-4	4-2-6	4-2-7	
LOCATION & MATERIAL		←	Surge Tk Sodium	→	
TEMPERATURE, °F		660	685	675	
VELOCITY, fps		-	-	-	
HRS. IN LOOP		700	1922	2759	
TIMES WASHED		-	-	-	
SAMPLE ACTIVITY, μc					
Cr 51		7.51×10^{-5}	5.3×10^{-4}	1.52×10^{-4}	
Mn 54		5.85×10^{-6}	1.22×10^{-5}	1.98×10^{-5}	
Fe 59		1.08×10^{-4}	4.05×10^{-5}	1.40×10^{-5}	
Co 60		1.75×10^{-4}	6.3×10^{-6}	1.80×10^{-6}	
WASH ACTIVITY, μc					
Cr 51		-	-	-	
Mn 54		-	-	-	
Fe 59		-	-	-	
Co 60		-	-	-	
TOTAL ACTIVITY μc^*		3.64×10^{-4}	5.89×10^{-4}	1.86×10^{-4}	

* Activity per gram of sodium

SODIUM ANALYSIS

SAMPLE NO.	4-2-3	4-2-4	4-2-6	4-2-7	
TEST TIME, HRS.	79	700	1922	2759	
SAMPLING TEMP., °F	680	660	685	675	
SAMPLING LOCATION	Surge	Surge	Surge	Surge	
COMPOSITION, ppm					
Ca	< 15	< 10	24.7	10.5	
Cr	0.1	< 0.05	1.0	0.7	
Fe	3.5	0.8	8.5	6.1	
K	334	331	99	270	
Li	< 11	< 10	< 10	< 10	
Mn	< 1.6	< 1.1	< 1.5	< 1.6	
Mo	0.3	< 0.2	< 0.2	0.4	
Ni	1.6	1.5	1.8	1.3	
C	-	23	10	-	

AVERAGE FLOW AND PLUGGING INDICATOR DATA

TEST TIME, HRS.	0-729	0-1480	1489-2800	729-2803	0-2803
AVERAGE FLOW, gpm	0.377	0.368	0.332	0.341	0.350
AVERAGE PLUGGING TEMP., °F	315	319	319	320	319
OXIDE CONC. *, ppm O ₂	13	14	14	14	14

REMARKS:

* Based upon KAPL data, TID 5277, p.7

SODIUM MASS TRANSFERAR No. 4-3-1 (End of run)ANALYSIS REPORTPage 1 of 5Run No. 4-3 Issued by J. Damon Date 11-1-61
F. HetzlerSample Removal Date 10/31/61 Accumulated Test Hours 700T_{max} 1200 °F ΔT 500 °F Flow 0.390 gpm Oxygen Level 10 ppmCORROSION SAMPLES

SAMPLE NO.	4108	4109	4110	4177		
LOCATION & MATERIAL	H1-316	H1-316	H1-316	H1-316		
TEMPERATURE, °F	1199	1199	1199	1199		
VELOCITY, fps	4.3	4.3	4.3	12.9		
HARDNESS, R _B Before *						
After *						
INITIAL WEIGHT, g	4.15789	4.27904	4.17317	4.23246		
FINAL WEIGHT, g	4.15381	4.27487	4.16944	4.22769		
WEIGHT CHANGE, mg	-4.08	-4.17	-3.73	-4.77		
CORROSION RATE, mg/dm ² -mo	-45.7	-46.7	-41.8	-53.5		

APPEARANCE AFTER TEST:

- 4108) -Light gray - Surface partially covered with black film.
4109) -Light gray
4110 - Light gray
4177 - Surface is shiny except when covered with black film. (50%)

METALLOGRAPHIC EXAMINATION:

*All 26 samples: Not performed.

The weight change data does not indicate values that would justify a metallographic examination.

CORROSION SAMPLES

SAMPLE NO.	4206	4207	4208	4277		
LOCATION & MATERIAL	H2-316	H2-316	H2-316	H2-316		
TEMPERATURE, °F	1195	1195	1195	1195		
VELOCITY, fps	4.3	4.3	4.3	12.9		
HARDNESS, R _B						
INITIAL WEIGHT, g	4.27565	4.10283	4.14974	4.17736		
FINAL WEIGHT, g	4.27485	4.10175	4.14883	4.17651		
WEIGHT CHANGE, mg	-0.80	-1.08	-0.91	-0.85		
CORROSION RATE, mg/dm ² -mo	-9.0	-12.1	-10.2	-9.5		

APPEARANCE AFTER TEST:

4206)
4207)
4208) - Light gray - Scattered evidence of black film.
4277)

METALLOGRAPHIC EXAMINATION:

CORROSION SAMPLES

SAMPLE NO.	4483	4484	4508	4509	4510	4576
LOCATION & MATERIAL	inlet H3-316	outlet H3-316	H3R-316	H3R-316	H3R-316	H3R-316
TEMPERATURE, °F	1192	1192	1189	1189	1189	1189
VELOCITY, fps	12.9	12.9	4.3	4.3	4.3	12.9
HARDNESS, R _B						
INITIAL WEIGHT, g	4.12846	4.12690	4.19425	4.19718	4.03935	0.53178
FINAL WEIGHT, g	4.12786	4.12708	4.19465	4.19731	4.03967	0.53174
WEIGHT CHANGE, mg	-0.60	+0.18	+0.40	+0.13	+0.32	-0.04
CORROSION RATE, mg/dm ² -mo	-6.7	+2.02	+4.5	+1.46	+3.6	-0.45

APPEARANCE AFTER TEST: 4483)
4484)
4508) - Light gray surface partially covered with black film.
4509)
4510)
4576) - Top is shiny - bottom half appears scorched.

METALLOGRAPHIC EXAMINATION:

CORROSION SAMPLES

SAMPLE NO.	4608	4609	4610	4706	4707	4708
LOCATION & MATERIAL	C1-5Cr	C1-5Cr	C1-5Cr	C2-5Cr	C2-5Cr	C2-5Cr
TEMPERATURE, °F	805	805	805	696	696	696
VELOCITY, fps	4.3	4.3	4.3	4.3	4.3	4.3
HARDNESS, R _B						
INITIAL WEIGHT, g	3.72700	3.98926	3.89240	3.81402	3.88119	3.99963
FINAL WEIGHT, g	3.73912	3.99564	3.90532	3.82084	3.88898	4.00780
WEIGHT CHANGE, mg	+12.12	+6.38	+12.92	+6.82	+7.79	+8.17
CORROSION RATE, mg/dm ² -mo	+136.0	+71.5*	+145.0	+76.4	+87.3	+91.5

* Non standard size sample holder.

APPEARANCE AFTER TEST: 4608 - Medium gray.
4609)
4610)
4706) - Medium gray with scattered areas of black film.
4707)
4708)
METALLOGRAPHIC EXAMINATION:

CORROSION SAMPLES

SAMPLE NO.	4919A	4920	4921	4922	4923	4924
LOCATION & MATERIAL	C3-5Cr	inlet C3-5Cr	C3-5Cr	C3-5Cr	outlet C3-5Cr	C3-5Cr
TEMPERATURE, °F	701	701	701	701	701	701
VELOCITY, fps	4.3	4.3	4.3	4.3	4.3	4.3
HARDNESS, R _B						
INITIAL WEIGHT, g	3.88697	4.01005	3.94800	3.91641	3.98101	3.89091
FINAL WEIGHT, g	3.88981	4.01187	3.95146	3.91707	3.98165	3.89179
WEIGHT CHANGE, mg	+2.84	+1.82	+3.46	+0.66	+0.64	+0.88
CORROSION RATE, mg/dm ² -mo	+31.8	+20.4	+38.7	+7.40	+7.18	+9.86

APPEARANCE AFTER TEST: 4919A)
4920)
4921) Medium to dark gray with scattered patches of black film.
4922)
4923)
4924)
METALLOGRAPHIC EXAMINATION:

AR No. 4-3-1 APage 1 of 1SODIUM ANALYSIS

SAMPLE NO.	4-3-1				
TEST TIME, HRS.	673				
SAMPLING TEMP., °F	675				
SAMPLING LOCATION	Surge				
COMPOSITION, ppm					
Ca	<10				
Cr	10.7				
Fe	1.3				
K	359				
Li	< 32				
Mn	-				
Mo	-				
Ni	1.9				
C	< 5				

AVERAGE FLOW AND PLUGGING INDICATOR DATA

TEST TIME, HRS.	700				
AVERAGE FLOW, gpm	0.390				
AVERAGE PLUGGING TEMP., °F	296				
OXIDE CONC. *, ppm O ₂	10				

REMARKS:

* Based upon KAPL data, TID 5277, p.7

LOOP NO. 5.

Hot Leg

2-1/4 Chromium - 1 Molybdenum

Cold Leg

2-1/4 Chromium - 1 Molybdenum

SODIUM MASS TRANSFER
ANALYSIS REPORT

ISSUED BY J. Damon DATE 10/15/60

LOOP NO. 5 RUN NO. 1
SAMPLE REMOVAL DATE 10/7/60 ACCUMULATED TEST TIME 626 HRS.
 T_{max} 1200 °F ΔT 500 °F
SODIUM FLOW 0.4 gpm OXIDE LEVEL 74 - 32 ppm O₂

CORROSION SAMPLES

SAMPLE NO.	5501	5475	5902	5903
SAMPLE LOCATION	H3R	H-3	C-3	C-3
AVERAGE VELOCITY, fps	4	12	4	4
APPEARANCE AFTER TEST:	Plier marks	Plier marks	Plier marks	Copper on sample
INITIAL WEIGHT, g	4.11287	4.15108	4.08682	4.15395
FINAL WEIGHT, g	4.10980	4.13857	4.09197	4.15737
WEIGHT CHANGE, mg	-3.07	-12.51	+ 5.15	+3.42
CORROSION RATE, mg/dm ² -mo	-39.4	-160.5	+66.1	+ 43.8

METALLOGRAPHIC EXAMINATION:

Sample 5501 (2 $\frac{1}{4}$)

Equiaxed grains. Surface good. Carbides spheroidized. Slight decarburization.

Sample 5475 (2 $\frac{1}{4}$)

Equiaxed grains. Surface good. Carbides spheroidized. Heavy decarburization.

Samples 5902 and 5903 (2 $\frac{1}{4}$)

Equiaxed grains. Surface condition good. Pearlitic structure. Deep decarburization.

SODIUM ANALYSIS

SAMPLE NO.	S9a					
TEST TIME, HRS.	74					
COMPOSITION, ppm	CHEM.	SPEC.	CHEM.	SPEC.	CHEM.	SPEC.
Ca	47.1					
Cr	0.8					
Co						
Fe	13.2					
Li	28					
Mn						
Mo						
Ni	11					
K	< 10					
Si						
Th						

PLUG. INDICATOR DATA

Test Time, hrs	25	465	467	615
Plug Temp., °F	495**	395**	460	445
Oxide Conc.*, ppm O ₂	74	32	55	48

REMARKS:

Steel samples were removed ahead of schedule (626 hours) due to overtemperature trip caused by reduction of flow.

* Based upon KAPL data, TID 5277, p. 7.
 ** cold trapped at 450°F immediately after plug run.

SODIUM MASS TRANSFER
ANALYSIS REPORT

ISSUED BY J. DamonDATE 11/21/60LOOP NO. 5RUN NO. 1SAMPLE REMOVAL DATE 11/17/60ACCUMULATED TEST TIME 1251 HRS.T_{max} 1200 °FΔT 500 °FSODIUM FLOW 0.4 gpmOXIDE LEVEL 42 ppm O₂

CORROSION SAMPLES

SAMPLE NO.	5101	5476	5502	5600	5901	5905
SAMPLE LOCATION	H1	H3	H3R	C1	C3	C3
AVERAGE VELOCITY, fps	4	12	4	4	4	4
APPEARANCE AFTER TEST:	Some plier marks - slight oxide deposit dark gray	Black globule at top - scat- tered evidence of oxide deposit	Rust and oxidation from fuel & cleaning	Light oxide film	Black scale covered by oxide film.	
INITIAL WEIGHT, g	4.30189	4.14338	4.13515	4.26793	3.94365	4.20865
FINAL WEIGHT, g	4.29940	4.12556	4.13139	4.27337	3.94511	4.21058
WEIGHT CHANGE, mg	-2.49	-17.82	-3.76	+5.44	+1.46	+1.93
CORROSION RATE, mg/dm ² -mo	-15.9	-113.5	-24.02	+34.7	+9.31	+12.39
TEMPERATURE, °F	1000	1200	1200	1100	700	700

METALLOGRAPHIC EXAMINATION: (All samples 2 1/4 Cr)

- 5101 - Carbides pearlitic. Surface decarburization - Surface good.
- 5476 - Carbides spheroidized. No decarburization. Surface good.
- 5502 - Slight surface decarburization. Carbide precipitation moderate to heavy. Carbides spheroidized. Surface good.
- 5600 - Carbides in stage between spheroidal and pearlitic. Surface decarburization. Surface good.
- 5901 - Carbides pearlitic. Surface decarburization. Surface good.
- 5905 - Carbides pearlitic. Surface decarburization. Surface good.

SODIUM MASS TRANSFER
ANALYSIS REPORT

ISSUED BY J. Damon DATE 11/28/60

LOOP NO. 5 RUN NO. 1
SAMPLE REMOVAL DATE 11/17/60 ACCUMULATED TEST TIME 1251 HRS.
T_{max} 1200 °F ΔT 500 °F
SODIUM FLOW .4 gpm OXIDE LEVEL 42 ppm O₂

CORROSION SAMPLES*

SAMPLE NO.	5500	5503**	5575	
SAMPLE LOCATION	H3R	H3R	H3R	
AVERAGE VELOCITY, fps	4	4	12	
APPEARANCE AFTER TEST:	All samples covered with rust and oxidation from the fire and cleaning process.			
INITIAL WEIGHT, g	4.17551	3.94932	0.55858	
FINAL WEIGHT, g	4.17085	3.94632	0.55083	
WEIGHT CHANGE, mg	-4.66	-3.00	-7.75	
CORROSION RATE, mg/dm ² -mo	-29.9	-19.2	-51.3	
TEMPERATURE, °F	1200	1200	1200	

* Special sample removal due to leak and fire damage to sample holder.

** This sample inserted at 626 hours, Net operating time 625 hours.

METALLOGRAPHIC EXAMINATION:

None. Samples returned to new sample holder.

SODIUM ANALYSIS

SAMPLE NO.	S9a		S13a		S20a	
TEST TIME, HRS.	74		626		1251	
COMPOSITION, ppm	CHEM.*	SPEC.	CHEM.	SPEC.**	CHEM.	SPEC.
Ca	47.1			< 3		
Cr	.8			< 15		
Co				< 9		
Fe	13.2			< 6		
Li	28					
Mn				< 3		
Mo				< 6		
Ni	11			60		
K	< 10					
Si				< 9		
Ti				< 15		

** Preliminary results -- analytical methods being reviewed.

PLUG. INDICATOR DATA

Test Time, hrs	698	986	986***	1250
Plug Temp., °F	445°	420	440	430
Oxide Conc.*, ppm O ₂	48	39	46	42

*** Loop was cold trapped to raise oxide concentration.

REMARKS:

Samples were prematurely removed after H3R gasket leak and fire.
Sample holder had to be replaced.

SODIUM MASS TRANSFER
ANALYSIS REPORT

ISSUED BY G. Billuris DATE 3/30/61LOOP NO. 5 RUN NO. 1SAMPLE REMOVAL DATE 3/3/61 ACCUMULATED TEST TIME 2697 HRS. $T_{\max}$ 1200 °F ΔT 500 °FSODIUM FLOW 0.4 gpm OXIDE LEVEL 50 ppm O₂

CORROSION SAMPLES

SAMPLE NO.	5100	5102	5103**	5175		
LOCATION & MATERIAL	H1-2 $\frac{1}{4}$	H1-2 $\frac{1}{4}$	H1-2 $\frac{1}{4}$	H1-2 $\frac{1}{4}$		
TEMPERATURE, °F	1000	1000	1000	1000		
VELOCITY, fps	4	4	4	12		
HARDNESS, R _B	83	78	82	83		
INITIAL WEIGHT, g	4.14112	4.30315	4.22038	4.39021		
FINAL WEIGHT, g	4.17979	4.29017	4.21944	4.37101		
WEIGHT CHANGE, mg	+38.67	-12.98	-0.95	-19.20		
CORROSION RATE, mg/dm ² -mo	+ 114.2	-38.4	-5.25	-56.7		

** Loaded at 1251 hr.

APPEARANCE AFTER TEST:

All samples were relatively clean and free of oxide layer. Color was slightly more gray than at installation.

METALLOGRAPHIC EXAMINATION:

5100 } Pearlitic structure. Decarburized zone resulting from prior heat-treatment.
 5101 } (Plier marks on 5100) Good surface.
 5102 }
 5175 }

5103 Pearlitic structure shifting to spheroidized carbide formation. Decarburized zone resulting from prior heat-treatment. Good surface.

CORROSION SAMPLES

SAMPLE NO.	5200	5201	5202	5275		
LOCATION & MATERIAL	H2-2 $\frac{1}{4}$	H2-2 $\frac{1}{4}$	H2-2 $\frac{1}{4}$	H2-2 $\frac{1}{4}$		
TEMPERATURE, °F.	1100	1100	1100	1100		
VELOCITY, fps	4	4	4	12		
HARDNESS, R _B	71	71	72	72		
INITIAL WEIGHT, g	4.28023	4.23597	4.28569	4.07568		
FINAL WEIGHT, g	4.25606	4.21072	4.25973	4.03392		
WEIGHT CHANGE, mg	-24.17	-25.25	-25.96	-41.76		
CORROSION RATE, mg/dm ² -mo	-71.5	-74.8	-76.9	-123.7		

APPEARANCE AFTER TEST:

All samples were relatively clean. The color was slightly darker gray than at installation.

METALLOGRAPHIC EXAMINATION:

5200 } Spherodized carbide formation. Carbides small and evenly distributed.
5201 } Slight intergranular surface attack noted.
5202 }
5275 }

CORROSION SAMPLES

SAMPLE NO.	5477*	5478**	5500	5503*	5504**	5576***
LOCATION & MATERIAL	H3-2 $\frac{1}{4}$	H3-2 $\frac{1}{4}$	H3R-2 $\frac{1}{4}$	H3R-2 $\frac{1}{4}$	H3R-2 $\frac{1}{4}$	H3R-2 $\frac{1}{4}$
TEMPERATURE, °F	1200	1200	1200	1200	1200	1200
VELOCITY, fps	12	12	4	4	4	12
HARDNESS, R _B	52	57	56	54	60	64
INITIAL WEIGHT, g	4.10541	4.28084	4.17551	3.94932	4.16713	3.99793
FINAL WEIGHT, g	4.02051	4.22572	4.16243	3.93833	4.15860	3.99106
WEIGHT CHANGE, mg	-84.90	-55.12	-13.08	-10.99	-8.53	-6.87
CORROSION RATE, mg/dm ² -mo	-313	-305	-38.6	-40.7	-47.2	-38.1

*Loaded at 626 hr; **Loaded @ 1251 hr; *** regular sample, new sample holder.

APPEARANCE AFTER TEST:

H3 - Both samples were clean and shiny.

H3R- All samples were clean except 5503 which had a small amount of black scale.

METALLOGRAPHIC EXAMINATION:

5477 - Spherodized carbides, sparsely distributed. Good surface.

5478 - Spherodized carbides with heavier distribution than 5477. Good surface.
Plier marks and stripped edge.

5500 } Spherodized carbides tending to congregate at the grain boundarys.
5503 } Slight intergranular surface attack.
5504 }
5576 }

CORROSION SAMPLES

SAMPLE NO.	5601	5602	5603**	5700	5701	5702
LOCATION & MATERIAL	C1-2 $\frac{1}{4}$	C1-2 $\frac{1}{4}$	C1-2 $\frac{1}{4}$	C2-2 $\frac{1}{4}$	C2-2 $\frac{1}{4}$	C2-2 $\frac{1}{4}$
TEMPERATURE, °F	1100	1100	1100	1000	1000	1000
VELOCITY, fps	4	4	4	4	4	4
HARDNESS, R _B	76	76	80	85	86	85
INITIAL WEIGHT, g	4.09982	4.19750	4.09039	4.29652	4.09077	4.03803
FINAL WEIGHT, g	4.11802	4.21782	4.10939	4.31685	4.10976	4.05317
WEIGHT CHANGE, mg	+ 18.20	+ 20.32	+19.00	+20.33	+18.99	+ 15.14
CORROSION RATE, mg/dm ² -mo	+ 53.8	+ 60.0	+ 103	+ 60.1	+ 56.2	+ 44.8

** Loaded at 1251 Hr.

APPEARANCE AFTER TEST:

- C1 - Relatively clean, probably due to recent removal for inspection and cleaning.
 C2 - All samples were dark gray and covered with black scale

METALLOGRAPHIC EXAMINATION:

5601 }
 5602 }
 5603 } Spherodized carbides tending to congregate at the grain boundarys.
 5700 } Slight intergranular surface attack. Slightly decarburized due to
 5701 } prior heat-treatment.
 5702 }

5601 Plier marks.

CORROSION SAMPLES

SAMPLE NO.	5900	5904	5906 *	5907 *	5908 **	5909 **
LOCATION & MATERIAL	C3-2 $\frac{1}{4}$	C3-2 $\frac{1}{4}$	C3-2 $\frac{1}{4}$	C3-2 $\frac{1}{4}$	C3-2 $\frac{1}{4}$	C3-2 $\frac{1}{4}$
TEMPERATURE, °F	700	700	700	700	700	700
VELOCITY, fps	4	4	4	4	4	4
HARDNESS, R _B	89	89	90	90	90	90
INITIAL WEIGHT, g	4.33000	4.20620	3.97563	4.23335	4.06000	4.13742
FINAL WEIGHT, g	4.34396	4.21641	3.98409	4.24328	4.06534	4.14471
WEIGHT CHANGE, mg	+ 10.96	+ 10.21	+ 8.46	+ 9.93	+ 5.34	+ 7.29
CORROSION RATE, mg/dm ² -mo	+ 32.6	+ 30.2	+ 31.2	+ 36.6	+ 29.6	+ 40.3

* Loaded at 626 hr; ** Loaded at 1251 hr.

APPEARANCE AFTER TEST:

All samples were covered with a layer of white flaky material and scattered black globules.

METALLOGRAPHIC EXAMINATION:

5900
 5904
 5906
 5907
 5908
 5909

Pearlitic structure. Decarburized zone due to prior heat-treatment
 Good surface.

CORROSION SAMPLES

SAMPLE NO.	4800	4801	4802	4300*	4301	4302
LOCATION & MATERIAL	C3 Pipe 2 $\frac{1}{4}$	C3 Pipe 2 $\frac{1}{4}$	C3 Pipe 2 $\frac{1}{4}$	H3 Pipe 2 $\frac{1}{4}$	H3 Pipe 2 $\frac{1}{4}$	H3 Pipe 2 $\frac{1}{4}$
TEMPERATURE, °F	700	700	700	1200	1200	1200
VELOCITY, fps	0.60	0.60	0.60	0.24	0.24	0.24
HARDNESS, R _B Before After	← Rc 33	-	-85 -	-	-	→ 66
INITIAL WEIGHT, g	7.46810	7.81525	7.67128	7.79835	7.56218	7.75833
FINAL WEIGHT, g	7.47076	7.81811	7.67315	7.77800	7.54152	Weld Damage
WEIGHT CHANGE, mg	+ 2.66	+2.86	+ 1.87	-20.35	-20.66	-
CORROSION RATE, mg/dm ² -mo	+ 4.86	+ 5.23	+ 3.42	-37.2	-37.8	-

* Sample edge damaged in removal due to contact at pipe weld.

APPEARANCE AFTER TEST:

C3 pipe samples had black film over entire surface.
H3 pipe samples were bright and clean.

METALLOGRAPHIC EXAMINATION:

Examination in progress

SODIUM ANALYSIS

SAMPLE NO.	S 9		S 13		S 20		5-1-7 †	
TEST TIME, HRS.	74		626		1251		2601	
COMPOSITION, ppm	CHEM.	SPEC.	CHEM.	SPEC.	CHEM.	SPEC.	CHEM.	SPEC.
Ca	47.1		80	< 3	1972	250	-	< 10
Cr	0.8		1.2	< 15	0.73	< 15	0.71	< 2
Co				< 9		< 9		
Fe	13.2		5.2	< 6	156	< 6	31.4	< 2
Li	28		134		166		172	
Mn				< 3		< 3	4.9	< 2
Mo				< 6		< 6	0.9	< 2
Ni	11		1.1	60	4.19	< 8	3.02	< 2
K	< 10		304		333		521	
Si				< 9		< 9		< 2
Ti				< 15		< 15		< 2

PLUG. INDICATOR DATA

Test Time, hrs	1310	1479	1724	2072	2243
Plug Temp., °F	475	450	440	445	450°
Oxide Conc.* , ppm O ₂	62	50	46	48	50

REMARKS:

† Surge Tank Sample.

SODIUM MASS TRANSFER

AR No. 5-2-1ANALYSIS REPORTPage 1 of 3Run No. 5-2 Issued by G. Billuris/ Date 8-11-61

F. Hetzler

Sample Removal Date 8/4/61 Accumulated Test Hours 682T_{max} 1200 °F ΔT 500 °F Flow 0.40 gpm. Oxygen Level 10 ppmCORROSION SAMPLES

SAMPLE NO.	5104	5176*	5479	5505		
LOCATION & MATERIAL	H1-2½	H1-2½	H3-2½	H3R-2½		
TEMPERATURE, °F	1000	1000	1200	1200		
VELOCITY, fps	4	12	12	4		
HARDNESS, R _B Before	77	-	77	77		
HARDNESS, R _B After	74	-	65	67		
INITIAL WEIGHT, g	3.81863	4.06599	3.80649	3.89614		
FINAL WEIGHT, g	3.81737	4.06349	3.79153	3.89169		
WEIGHT CHANGE, mg	-1.26	-2.50	-14.96	-4.45		
CORROSION RATE, mg/dm ² -mo	-14.5	-28.8	-172.	-51.2		

* Sample reloaded in loop after cleaning and weighing.

APPEARANCE AFTER TEST: 5104 Fairly clean. Light to medium gray color
5176

5479 -Fairly clean - light gray

5505 -Clean. Light gray

METALLOGRAPHIC EXAMINATION.

5104 } Ferritic grains - no pearlite.
 5479 } Few, well dispersed, fine, spherodized, carbides.
 5505 }

CORROSION SAMPLES

SAMPLE NO.	5604	5910	5913			
LOCATION & MATERIAL	C1-2 $\frac{1}{4}$	inlet C3-2 $\frac{1}{4}$	outlet C3-2 $\frac{1}{4}$			
TEMPERATURE, °F	1100	700	700			
VELOCITY, fps	4	4	4			
HARDNESS, R _B	Before	75	75			
	After	68	72			
INITIAL WEIGHT, g	3.66974	3.97447	3.87285			
FINAL WEIGHT, g	3.70183	3.98437	3.87809			
WEIGHT CHANGE, mg	+2.09	+9.90	+5.24			
CORROSION RATE, mg/dm ² -mo	+24.1	+113.8	+60.3			

APPEARANCE AFTER TEST: 5604 - Clean. Light gray.
 5910 - Dark gray. Very slight evidence of black scale.
 5913 - " " No scale.

METALLOGRAPHIC EXAMINATION:

5604 Ferritic grains - no pearlite.
 5910
 5913 Few, well dispersed, fine, spherodized, carbides.

AR No 5-2-1Page 3 of 3SODIUM ANALYSIS

SAMPLE NO.	5-2-3	5-2-4		
TEST TIME, HRS.	138	664		
SAMPLING TEMP., °F	665	670		
SAMPLING LOCATION	Surge	Surge		
COMPOSITION, ppm				
Ca	< 27			
Cr	0.9			
Fe	4.2			
K	167			
Li	< 12			
Mn	< 1.5			
Mo	< 0.2			
Ni	2.3			

PLUG. INDICATOR DATA

Test Time, hrs.	267	360**	516**	610**
Plug Temp., °F	310	350	335	350
Oxide Conc.%, ppm O ₂	12	20	17	20

REMARKS:

** Cold trapped at 300°F after plugging determination

* Based upon KAPL data, TID 5277, p. 7.

SODIUM MASS TRANSFERAR No. 5-2-2ANALYSIS REPORTPage 1 of 2Run No. 5-2 Issued by J. Damon Date 10/9/61Sample Removal Date 10/2/61 Accumulated Test Hours 1401T_{max} 1200 °F ΔT 500 °F Flow .54 gpm Oxygen Level 12 ppmCORROSION SAMPLES

SAMPLE NO.	5105	5480	5506	5605	5911	5914
LOCATION & MATERIAL	H1-2 $\frac{1}{4}$	Outlet H3-2 $\frac{1}{4}$	H3R-2 $\frac{1}{4}$	C1-2 $\frac{1}{4}$	Inlet C3-2 $\frac{1}{4}$	Outlet C3-2 $\frac{1}{4}$
TEMPERATURE, °F	1000	1200	1200	1100	700	700
VELOCITY, fps	5.4	16.2	5.4	5.4	5.4	5.4
HARDNESS, R _B	Before	77	75	78	75	78
	After	77	64	64	71	77
INITIAL WEIGHT, g	3.91056	4.02011	3.82371	3.81820	4.03156	3.67971
FINAL WEIGHT, g	3.90942	4.00957	3.81956	3.82042	4.04112	3.68692
WEIGHT CHANGE, mg	-1.14	-10.54	-4.15	+2.22	+9.56	+7.21
CORROSION RATE, mg/dm ² -mo	-6.38	-59.0	-23.2	+12.4	+53.5	+40.4

APPEARANCE AFTER TEST: 5105 - clean, light gray color. Two flecks of black scale
5480 - clean and still shiny
5506, 5605 - light to medium gray
5911, 5914 - medium to dark gray - no scale

METALLOGRAPHIC EXAMINATION:

5101 } Ferritic grains - spherodized carbides within grain sties.
5605 } Oxide layer at free surface.

5480 } Ferritic grains - intergranular carbides
5506 }

5911 } Ferritic grains - pearlitic areas.
5914 }

AR No. 5-2-2
Page 2 of 2

SODIUM ANALYSIS

SAMPLE NO.	5-2-3	5-2-4		
TEST TIME, HRE.	130	664		
SAMPLING TEMP., °F	665	670		
SAMPLING LOCATION	Surge	Surge		
<u>COMPOSITION, ppm</u>				
Ca	< 27	22.9		
Cr	0.9	0.4		
Fe	4.2	8.5		
K	167	254		
Li	< 12	< 10		
Mn	< 1.5	< 1.7		
Mo	< 0.2	< 0.2		
Ni	2.3	2.9		
		4		
<u>PLUG. INDICATOR DATA</u>				
Test Time, hrs.	706	1136	1231	1354
Plug Temp., °F	315	300	325	300
Oxide Conc.*, ppm O ₂	13	11	15	11

REMARKS:

* Based upon KAPL data, TID 5277, p. 7.

SODIUM MASS TRANSFER

AR No. 5-2-3

ANALYSIS REPORT

Page 1 of 7Run No. 5-2 Issued by J. Damon/ Date 12/16/61

F. Hetzler

Sample Removal Date 12/12/61 Accumulated Test Hours 3002T_{max} 1197 °F ΔT 496 °F Flow 0.546 gpm Oxygen Level 14 ppm

CORROSION SAMPLES

TEST HOURS	3002	2320	1601	3002		
SAMPLE NO.	5106	5107	5108	5176		
LOCATION & MATERIAL	H1-2½	H1-2½	H1-2½	H1-2½		
TEMPERATURE, °F	1000	1001	1000	1000		
VELOCITY, fps	6.01	5.94	5.94	18.0		
HARDNESS, R _B Before	77	77	75	77		
After	74	77	75	75		
INITIAL WEIGHT, g	3.81589	4.08792	3.92400	4.06599		
FINAL WEIGHT, g	3.80451	4.08818	3.92429	4.06326		
WEIGHT CHANGE, mg	-11.38	+0.26	+0.29	-2.73		
CORROSION RATE, mg/dm ² -mo	-29.7	+0.38	+1.42	-7.13		

APPEARANCE AFTER TEST: Gray film over surfaces. Sample 5106 had some black scale along one side.

METALLOGRAPHIC EXAMINATION:

Spherodized carbides throughout the structure.

5106 } Carbides have migrated preferentially to grain boundaries. These
 5107 } samples appear identical metallographically with no explanation for
 5108 } the variance in corrosion rate.
 5176 }

CORROSION SAMPLES

TEST HOURS	3002	3002	3002	3002	2320	1601
SAMPLE NO.	5203	5204	5205	5276	5481	5482
LOCATION & MATERIAL	H2-2½	H2-2½	H2-2½	H2-2½	In H3 - 2½	Out H3 - 2½
TEMPERATURE, °F	1098	1098	1098	1098	1199	1199
VELOCITY, fps	6.01	6.01	6.01	18.0	17.8	17.8
HARDNESS, R _B	Before	78	75	77	78	77
	After	72	72	75	72	64
INITIAL WEIGHT, g	4.04496	3.92583	3.91544	3.98717	3.93970	3.96450
FINAL WEIGHT, g	4.04080	3.92121	3.91143	3.98136	3.93149	3.95780
WEIGHT CHANGE, mg	-4.16	-4.62	-4.01	-5.81	-8.21	-6.70
CORROSION RATE, mg/dm ² -mo	-10.9	-12.0	-10.5	-15.2	-27.8	-32.8

APPEARANCE AFTER TEST: 5203
5204
5205
5276 } Medium gray film. Black scale over 25% of surface.

METALLOGRAPHIC EXAMINATION: 5481
5482 } Light gray film. Black scale over 10% of surface.

5203
5204
5205
5276 } The microstructures are practically identical with the 1000°F samples.

5481
5482 } A noticeable decrease in carbides was observed.

CORROSION SAMPLES

TEST HOURS	3002	2320	1601	3002		
SAMPLE NO.	5507	5508	5509	5577		
LOCATION & MATERIAL	H3R-2½	H3R-2½	H3R-2½	H3R-2½		
TEMPERATURE, °F	1196	1196	1198	1196		
VELOCITY, fps	6.01	5.94	5.94	18.0		
HARDNESS, R _B	Before	78	77	77		
	After	64	67	65		
INITIAL WEIGHT, g	3.89119	4.03044	3.89367	3.87214		
FINAL WEIGHT, g	3.88579	4.02640	3.88944	3.86862		
WEIGHT CHANGE, mg	-5.40	-4.04	-4.23	-3.52		
CORROSION RATE, mg/dm ² -mo	-14.1	-13.7	-20.7	-9.19		

APPEARANCE AFTER TEST:

Gray film over clear surface.

METALLOGRAPHIC EXAMINATION:

5507
 5508
 5509
 5577

} Identical to 5481 & 5482

CORROSION SAMPLES

TEST HOURS	3002	2320	1601	3002	3002	3002
SAMPLE NO.	5606	5607	5608	5703	5704	5705
LOCATION & MATERIAL	C1-2½	C1-2½	C1-2½	C2-2½	C2-2½	C2-2½
TEMPERATURE, °F	1097	1098	1097	1000	1000	1000
VELOCITY, f _{ps}	6.01	5.94	5.94	6.01	6.01	6.01
HARDNESS, R _B	Before	77	78	75	79	77
		72	75	72	77	75
INITIAL WEIGHT, g	3.76590	3.96786	3.78087	3.95179	3.95299	3.82111
FINAL WEIGHT, g	3.76892	3.96927	3.78162	3.95700	3.95790	3.82555
WEIGHT CHANGE, mg	+ 3.02	+ 1.41	+ 0.75	+ 5.21	+ 4.91	+ 4.44
CORROSION RATE, mg/dm ² -mo	+ 7.87	+ 4.77	+ 3.67	+13.6	+12.8	+11.6

APPEARANCE AFTER TEST:

5606, 5607, 5608 - Clear metallic surface.

5703, 5704, 5705 - Gray film. Black scale over 10% of surface.

METALLOGRAPHIC EXAMINATION:

5606 }
5607 } Carbides are spherodized, numerous. Appear to be preferentially located at
5608 } the grain boundarys

5703 }
5704 } Carbide distribution slightly greater than observed in the previous group.
5705 }

CORROSION SAMPLES

TEST HOURS	3002	3002	2320	2320	1601	1601
SAMPLE NO.	5912	5915	5916	5917	5918	5919
LOCATION & MATERIAL	In C3-2 $\frac{1}{4}$	Out C3-2 $\frac{1}{4}$	In C3-2 $\frac{1}{4}$	Out C3-2 $\frac{1}{4}$	In C3-2 $\frac{1}{4}$	Out C3-2 $\frac{1}{4}$
TEMPERATURE, °F	701	701	702	702	706	706
VELOCITY, fps	6.01	6.01	5.94	5.94	5.94	5.94
HARDNESS, R _B	Before	77	77	78	77	75
	After	75	75	77	77	78
INITIAL WEIGHT, g	3.97812	3.75574	3.80237	3.95382	3.91118	3.93419
FINAL WEIGHT, g	3.98509	3.76045	3.80639	3.95739	3.91828	3.93593
WEIGHT CHANGE, mg	+6.97	+4.71	+4.02	+3.57	+7.10	+1.74
CORROSION RATE, mg/dm ² -mo	+18.2	+12.3	+13.6	+12.1	+34.7	+8.5

APPEARANCE AFTER TEST:

Medium gray with scattered spots of black scale.

METALLOGRAPHIC EXAMINATION:

5912
 5915
 5916
 5917
 5918
 5919

} No apparent change in microstructure.

ANALYSIS REPORT

Run No. 5-2 Issued by J. Damon/
F. Hetzler Date 12/16/61

Sample Removal Date 12/12/61 Accumulated Test Hours 3236

T_{max} 1197 °F ΔT 496 °F Flow 0.612 gpm Oxygen Level 16 ppm

CORROSION SAMPLES

(2½ Cr Pipe)

SAMPLE NO.	4300	4301	5303*	4801	4802	5803*
LOCATION & MATERIAL	H3-H3R	H3-H3R	H3-H3R	C3 out	C3 out	C3 out
TEMPERATURE, °F	1197	1197	1197	701	701	701
VELOCITY, fps	0.948	0.948	0.948	0.918	0.918	0.918
HARDNESS, R _B	Before After	~ 120 68		~ 120 110		
INITIAL WEIGHT, g	7.77800	7.54152	7.04043	7.81811	7.67315	7.34550
FINAL WEIGHT, g	7.77454	7.53881	7.01917	7.81842	7.67407	7.34490
WEIGHT CHANGE, mg	-3.46	-2.71	-21.26	+0.31	+0.92	-0.60
CORROSION RATE, mg/dm ² -mo	-5.23	-4.11	-32.3	+0.47	+1.39	-0.89

* New sample installed for run 2. Others exposed in run 1 then reinstalled
APPEARANCE AFTER TEST: for run 2.

4801, 4802, 5803 - Dark gray. No visible scale.
4300, 4301, 5303 - Medium gray. No visible scale.

METALLOGRAPHIC EXAMINATION:

4300 - Carbides spheroidized, & present in minor proportions. Original structure was severely work hardened & distorted, but appears completely relieved.

4801 - No apparent change in microstructure from original distorted, cold worked form.

Samples 4301, 5303, 4802, 5803 returned to loop

SODIUM ANALYSIS

SAMPLE NO.	5-2-3	5-2-4	5-2-5		
TEST TIME, HRS.	138	664	2766		
SAMPLING TEMP., °F	665	670	675		
SAMPLING LOCATION	Surge	Surge	Surge		
COMPOSITION, ppm					
Ca	< 27	22.9	< 12		
Cr	0.9	0.4	0.4		
Fe	4.2	8.5	2.8		
K	167	254	95		
Li	< 12	< 10	< 22		
Mn	< 1.5	< 1.7	-		
Mo	< 0.2	< 0.2	-		
Ni	2.3	2.9	0.8		
C	29	4	*		

*Analysis not completed

AVERAGE FLOW AND PLUGGING INDICATOR DATA

TEST TIME, HRS.	0-682	0 - 1401	0 - 3002	682 - 3002	1401-3002
AVERAGE FLOW, gpm	0.562	0.552	0.546	0.540	0.540
AVERAGE PLUGGING TEMP., °F	331	326	320	316	314
OXIDE CONC. *, ppm O ₂	16	15	14	13	12

REMARKS:

* Based upon KAPL data, TID 5277, p.7

LOOP NO. 6

Hot Leg

**5 Chromium - 1/2 Molybdenum
- 1/2 Titanium**

Cold Leg

**5 Chromium - 1/2 Molybdenum
- 1/2 Titanium**

SODIUM MASS TRANSFER
ANALYSIS REPORT

ISSUED BY J. DamonDATE 10/22/60LOOP NO. 6RUN NO. 1SAMPLE REMOVAL DATE 10/12/60 ACCUMULATED TEST TIME 696 HRS.T_{max} 1200 °F ΔT 500 °FSODIUM FLOW 0.5 gpm OXIDE LEVEL 46-27 ppm O₂

CORROSION SAMPLES

SAMPLE NO.	6476	6502	6900	6903
SAMPLE LOCATION	H3	H3R	C-3	C-3
AVERAGE VELOCITY, fps	15	5	5	5
APPEARANCE AFTER TEST:	Clean surface light sodium film	Clean surface light sodium film	Whitish film under sodium layer on surface	Whitish film under sodium layer on surface
INITIAL WEIGHT, g	3.91144	3.93371	3.93523	4.04599
FINAL WEIGHT, g	3.90644	3.93500	3.93664	4.04732
WEIGHT CHANGE, mg	-5.00	+1.29	+1.41	+1.33
CORROSION RATE, mg/dm ² -mo	-57.5	+14.8	+16.2	+15.3

METALLOGRAPHIC EXAMINATION:

Samples 6476 and 6502 (5 Cr)

Equiaxed grains. Surface condition good. Pearlitic structure. Deep decarburization.

Samples 6900 and 6903 (5 Cr)

Same as for above samples, except that fewer carbides were noted.

SODIUM ANALYSIS

SAMPLE NO.	S10a					
TEST TIME, HRS.	~ 50					
COMPOSITION, ppm	CHEM.	SPEC.	CHEM.	SPEC.	CHEM.	SPEC.
Ca	40					
Cr	0.2					
Co						
Fe	0.5					
Li	300					
Mn						
Mo						
Ni	0.95					
K	900					
Si						
Ti						

PLUG. INDICATOR DATA

Test Time, hrs	85	565	661
Plug Temp., °F	440	400	380
Oxide Conc. *, ppm O ₂	46	33	27

REMARKS:

* Based upon KAPL data, TID 5277, p. 7.

SODIUM MASS TRANSFER
ANALYSIS REPORT

ISSUED BY J. Damon DATE 11/22/60

LOOP NO. 6 RUN NO. 1

SAMPLE REMOVAL DATE 11/11/60 ACCUMULATED TEST TIME 1397 HRS.

T_{max} 1200 °F ΔT 500 °F

SODIUM FLOW 0.55 gpm OXIDE LEVEL 39-55 ppm O₂

CORROSION SAMPLES

SAMPLE NUMBER	6100	6475	6501	6600	6902	6905
SAMPLE LOCATION	H1	H3	H3R	C1	C3	C3
AVERAGE VELOCITY, fps	5	15	5	5	5	5
APPEARANCE AFTER TEST:	All samples covered with light oxide film.					Black scale under oxide film
INITIAL WEIGHT, g	3.95589	3.90294	4.08788	3.89531	3.97430	3.94999
FINAL WEIGHT, g	3.95484	3.89248	4.08800	3.90051	3.97640	3.95241
WEIGHT CHANGE, gm	-1.05	-10.46	+0.12	+5.20	+2.10	+2.42
CORROSION RATE, mg/dm ² -mo	-6.01	-60.0	+0.685	+29.7	+12.0	+13.9
TEMPERATURE, °F	1000	1200	1200	1100	700	700

METALLOGRAPHIC EXAMINATION: (All Samples 5 Cr)

All specimens show no change from original structure.

700 hour samples, Numbers 6476, 6502, 6900 and 6903 reported in AR #6-1-1 were reviewed. There was an error in reporting "deep decarburization," since there is no change from the original structure in these specimens.

SODIUM ANALYSIS

SAMPLE NO.	S10a		S15a			
TEST TIME, HRS.	50		696			
COMPOSITION, ppm	CHEM**	SPEC.	CHEM.	SPEC.**	CHEM.	SPEC.
Ca	40			< 3		
Cr	0.2			< 15		
Co				< 9		
Fe	0.5			< 6		
Li	300					
Mn				< 3		
Mo				< 6		
Ni	1			< 7.5		
K	900					
Si				51		
Ti				< 15		

** Preliminary Data -- analytical methods being reviewed.

PLUG. INDICATOR DATA

Test Time, hrs	744	936	1176	1200***
Plug. Temp., °F	460°	435°	420°	435°
Oxide Conc.*, ppm O ₂	55	44	39	44

*** After cold trapping operation.

* Based upon KAPL data, TID 5277, p. 7

SODIUM MASS TRANSFER
ANALYSIS REPORT

ISSUED BY G. Billuris DATE 1-31-61
LOOP NO. 6 RUN NO. 1
SAMPLE REMOVAL DATE _____ ACCUMULATED TEST TIME 2792 HRS.
 $T_{\max}$ 1200 F ΔT 500 F
SODIUM FLOW 0.5 gpm OXIDE LEVEL 27-55 ppm O_2

CORROSION SAMPLES

SAMPLE NO.	6101	6102	6103*	6175		
LOCATION & MATERIAL	H1-5Cr	H1-5Cr	H1-5Cr	H1-5Cr		
TEMPERATURE, °F	1000	1000	1000	1000		
VELOCITY, fps	5	5	5	15		
HARDNESS, R_B	67	66	68	67		
INITIAL WEIGHT, g	4.04692	4.01889	3.93884	4.02537		
FINAL WEIGHT, g	4.04191	4.01363	3.93495	4.01668		
WEIGHT CHANGE, mg	-5.01	-5.26	-3.89	-8.69		
CORROSION RATE, $mg/dm^2\text{-mo}$	-14.3	-15.0	-22.3	-24.9		

* Loaded at 1397 hours.

APPEARANCE AFTER TEST:

Low velocity samples 6101, 6102, and 6103 had small areas of black film. All specimens were gray in color with evidence of plier mark at top.

METALLOGRAPHIC EXAMINATION:

6101 }
6102 } No change from standard specimen. Good surface.
6103 }
6175 }

CORROSION SAMPLES

SAMPLE. NO.	6200	6201	6202	6275		
LOCATION & MATERIAL	H2-5Cr	H2-5Cr	H2-5Cr	H2-5Cr		
TEMPERATURE, °F	1100	1100	1100	1100		
VELOCITY, fps	5	5	5	15		
HARDNESS, R _B	65	68	68	65		
INITIAL WEIGHT, g	3.73125	3.99732	4.08911	4.01042		
FINAL WEIGHT, g	3.71832	3.98716	4.07983	3.98849		
WEIGHT CHANGE, mg	-12.93	-10.16	-9.28	-21.93		
CORROSION RATE, mg/dm ² -mo	-37.2	-29.2	-26.6	-63.0		

APPEARANCE AFTER TEST:

Samples 6201, 6200, and 6275 partially covered with black film. Sample 6202 appeared clean. Slight plier mark evident at top of specimen.

METALLOGRAPHIC EXAMINATION:

6200 } No change from standard specimen. Good surface.
 6275 }

6201 } No change from standard specimen. Surface attack 0.296 mil.
 6202 }

CORROSION SAMPLES

SAMPLE NO.	6601	6602	6603*	6700	6701	6702
LOCATION & MATERIAL	C1-5Cr	C1-5Cr	C1-5Cr	C2-5Cr	C2-5Cr	C2-5Cr
TEMPERATURE, °F	1100	1100	1100	1000	1000	1000
VELOCITY, fps	5	5	5	5	5	5
HARDNESS, R _B	64	63	71-1/2	64	66-1/2	64
INITIAL WEIGHT, g	3.94193	4.00685	3.98547	3.93373	3.92983	4.00429
FINAL WEIGHT, g	3.95675	4.01797	3.99700	3.94066	3.94085	4.01403
WEIGHT CHANGE, mg	+14.82	+11.12	+11.53	+6.93	+11.02	+9.74
CORROSION RATE, mg/dm ² -mo	+42.5	+32.0	+66.2	+19.9	+31.6	+27.9

* Loaded at 1397 hours

APPEARANCE AFTER TEST:

Except for 6603 all specimens were partially covered with a black film. Plier marks noted on 6700, 6702, and 6601.

METALLOGRAPHIC EXAMINATION:

6601	}	No change from standard specimen. Surface attack 6601, 6602 - 0.689 mil. 6603, 6700 } - Negligible 6701, 6702 }
6602		
6603		
6700		
6701		
6702		

CORROSION SAMPLES

SAMPLE NO.	6901	6904	6906**	6907**	6908*	6909*
LOCATION & MATERIAL	C3-5Cr	C3-5Cr	C3-5Cr	C3-5Cr	C3-5Cr	C3-5Cr
TEMPERATURE, °F	700	700	700	700	700	700
VELOCITY, fps	5	5	5	5	5	5
HARDNESS, R _B	65-1/2	65	70	65	65	68
INITIAL WEIGHT, g	3.94937	3.95051	3.87271	3.89890	3.88787	3.82329
FINAL WEIGHT, g	3.95300	3.95362	3.87409	3.90139	3.09013	3.82529
WEIGHT CHANGE, mg	+3.63	+3.11	+1.38	+2.49	+2.26	+2.00
CORROSION RATE, mg/dm ² -mo	+10.4	+8.83	+5.26	+9.50	+12.9	+11.5

* Loaded at 1397 hours

** Loaded at 696 hours

APPEARANCE AFTER TEST:

Varying amounts of gray and black scale noted on samples. Plier marks on 6901 and 6906.

METALLOGRAPHIC EXAMINATION:

6901	}	No change from standard specimen. Good surface.
6904		
6906		
6907		
6908		
6909		

CORROSION SAMPLES

SAMPLE NO.	6300	6301	6302	6800	6801	6802
LOCATION & MATERIAL	H3 Pipe 5 Cr	H3 Pipe 5 Cr	H3 Pipe 5 Cr	C3 Pipe 5 Cr	C3 Pipe 5 Cr	C3 Pipe 5 Cr
TEMPERATURE, °F	1200	1200	1200	700	700	700
VELOCITY, fps	0.8	0.8	0.8	0.3	0.3	0.3
HARDNESS, R _B	77	-	-	81-1/2	-	-
INITIAL WEIGHT, g	7.42958	7.42742	7.37108	7.36912	7.44720	7.32164
FINAL WEIGHT, g	7.43050	7.42814	7.37124	7.37182	7.45008	7.32442
WEIGHT CHANGE, mg	+0.92	+0.72	+0.16	+2.70	+2.88	+2.78
CORROSION RATE, mg/dm ² -mo	+1.58	+1.24	+0.28	+4.66	+4.96	+4.80

APPEARANCE AFTER TEST:

Radium deposit over samples obscured appearance of surface.

METALLOGRAPHIC EXAMINATION:

6300 No change from standard specimen. Surface attack - 0.492 mil.

6800 No change from standard specimen. Good surface.

6301 }
6302 }
6801 } Return to loop.
6802 }

SODIUM ANALYSIS

SAMPLE NO.	S19a		S28a		S29a***	
TEST TIME, HRS.	1397		2677		2726	
COMPOSITION, ppm	CHEM.	SPEC.	CHEM.	SPEC.	CHEM.	SPEC.
Ca	18.8	<3	<12.7		<15.9	
Cr	0.57	<15	0.63		0.56	
Co		<9				
Fe	0.2	<6	10.8		3.6	
Li	147		152		156	
Mn		<3				
Mo		<6				
Ni	1.8	<8	5.1		4.1	
K	334		303		347	
Si		9				
Ti		15				

*** Sample from surge tank.

PLUG. INDICATOR DATA

Test Time, hrs.	1510	1532**	1865	1866**	2133	2560	2655**
Plug Temp., °F	415	450	400	460	425	380	455
Oxide Conc.*, ppm O ₂	38	50	33	55	40	27	53

REMARKS:

* Based upon KAPL data, TID 5277, p.7.

** After refilling from dump tank at 600F-650F for about 1/2 hour.

SODIUM MASS TRANSFERAR No. 6-2-1Page 1 of 2ANALYSIS REPORTRun No. 2 Issued by G. Billuris / F. Hetzler Date 7-7-61Sample Removal Date 7-3-61 Accumulated Test Hours 710 T_{max} 1200 °F ΔT 500 °F Flow 0.45 gpm Oxygen Level 10 ppmCORROSION SAMPLES

SAMPLE NO.	6104	6482	6505	6604	6910	6913
LOCATION & MATERIAL	H1-5Cr	H3-5Cr	H3R-5Cr	C1-5Cr	C3-5 Cr	C3-5Cr
TEMPERATURE, °F	1000	1200	1200	1100	700	700
VELOCITY, fps	4.5	13.5	4.5	4.5	4.5	4.5
HARDNESS, R_B	Before	66	66	59	68	66
	After	66	63	61	61	66
INITIAL WEIGHT, g	4.01016	3.93455	3.83513	3.85024	3.89933	3.95168
FINAL WEIGHT, g	4.00998	3.92777	3.83400	3.85200	3.90365	3.95384
WEIGHT CHANGE, mg	-0.18	-6.78	-1.13	+1.76	+4.32	+2.16
CORROSION RATE, mg/dm ² -mo	-2.11	-76.0	-12.7	+19.8	+48.5	+24.2

APPEARANCE AFTER TEST:

6482, 6104 - Clean and shiny - no scale

6505, 6604, 6913 - Clean, light gray color

6910 - Approx. 1/2 the sides were coated with gray coating up to 2 to 3 mils thick which is not soluble in alcohol or water.

METALLOGRAPHIC EXAMINATION:

All samples bear a micro structure similar to the standard unexposed specimen.

No change except for:

6482 } Intergranular attack to a maximum depth of
6505 }
6910 } Carburized case to a depth of 4 mil.

AK No. 6-2-1Page 2 of 2SODIUM ANALYSIS

SAMPLE NO.	6-2-5	6-2-6		
TEST TIME, HRS.	68	681		
SAMPLING TEMP., °F	680	670		
SAMPLING LOCATION	Surge	Surge		
COMPOSITION, ppm	(later)			
Ca		< 11		
Cr		< 0.05		
Fe		1.7		
K		331		
Li		< 11		
Mn		< 1.2		
Mo		< 0.2		
Ni		1.2		

PLUG INDICATOR DATA

Test Time, hrs.	72	236**	460	546	686**		688
Plug Temp., °F	305	350	305	310	350		315
Oxide Conc.* ppm O ₂	11	20	11	12	20		13

REMARKS:

** Cold trapped at 300°F to reduce Na₂O concentration.

* Based upon KAPL data, TID 5277, p. 7.

SODIUM MASS TRANSFER

AR No. 6-2-2

Page 1 of 3

ANALYSIS REPORT

Run No. 6-2 Issued by G. Billuris/ Date 8-11-61

F. Hetzler

Sample Removal Date 8/4/61 Accumulated Test Hours 1400

T_{max} 1200 °F ΔT 500 °F Flow 0.45 gpm Oxygen Level 10 ppm

CORROSION SAMPLES

SAMPLE NO.	6105	6481	6506			
LOCATION & MATERIAL	H1-5Cr	Outlet H3-5Cr	H3R-5Cr			
TEMPERATURE, °F	1000	1200	1200			
VELOCITY, fps	4.5	13.5	4.5			
HARDNESS, R _B	Before	66	63	64		
	After	70	68	68		
INITIAL WEIGHT, g	4.01208	4.00865	3.98517			
FINAL WEIGHT, g	4.01209	4.00275	3.98458			
WEIGHT CHANGE, mg	+0.01	-5.90	-0.59			
CORROSION RATE, mg/dm ² -mn	+0.056	-33.1	-3.31			

APPEARANCE AFTER TEST: 6105 - Undrained sampleholder-Could not observe sample.
 6481 - Light gray color, one small area, 2 1/8" Sq., of black discoloration.
 6506 - Fairly clean, light gray.

METALLOGRAPHIC EXAMINATION:

6105 - No change in microstructure.
 6481 - No change in microstructure
 Intergranular attack to 0.9 mil.
 6506 - No change in microstructure.
 Intergranular attack to 1.2 mil.

CORROSION SAMPLES

SAMPLE NO.	6605	6606*	6608*	6911	6914	
LOCATION & MATERIAL	C1-5Cr	C1-5Cr	C1-5Cr	inlet C3-5Cr	outlet C3-5Cr	
TEMPERATURE, °F	1100	1100	1100	700	700	
VELOCITY, fps	4.5	4.5	4.5	4.5	4.5	
HARDNESS, R _B Before	65	-	-	65	64	
HARDNESS, R _B After	72	-	-	71	75	
INITIAL WEIGHT, g	3.89557	3.91419	3.89720	3.86017	3.97029	
FINAL WEIGHT, g	3.89849	3.91728	3.89771	3.86595	3.97490	
WEIGHT CHANGE, mg	+ 2.92	+ 3.09	+ 0.51	+ 5.78	+ 4.61	
CORROSION RATE, mg/dm ² -mo	+ 16.4	+ 17.3	+ 5.81	+ 32.4	+ 25.8	

* Samples reloaded in loop after cleaning and weighing; Sample 6608 initially loaded at 710 hrs.

APPEARANCE AFTER TEST: 6605 }
 6606 } Fairly clean. Light to medium gray.
 6608 }
 6911 } Medium to dark gray color, no scale.
 6914 }

METALLOGRAPHIC EXAMINATION:

6605 - No change in microstructure. Intergranular attack 0.7 mils.
 6911 - No change in microstructure.
 6914 - No change in microstructure.

SODIUM ANALYSIS

SAMPLE NO.	6-2-5	6-2-6	6-2-7	
TEST TIME, HRS.	68	681	1383	
SAMPLING TEMP., °F	680	670	675	
SAMPLING LOCATION	Surge	Surge	Surge	
<u>COMPOSITION, ppm</u>				
Ca	<10	< 11		
Cr	0.8	<0.05		
Fe	2.6	1.7		
K	361	331		
Li	< 9	< 11		
Mn	< 2.0	<1.2		
Mo	< 0.3	<0.2		
Ni	2.7	1.2		

PLUG. INDICATOR DATA

Test Time, hrs.	826**	1019	1198	1342**
Plug Temp., °F	335	305	310	330
Oxide Conc.*, ppm O ₂	17	11	12	16

REMARKS:

** Cold trapped at 300°F after plugging determination.

* Based upon KAPL data, TID 5277, p. 7.

SODIUM MASS TRANSFER

AR No. 6-2-3

ANALYSIS REPORT

Page 1 of 1

Run No. 6-2 Issued by J. Damon Date 10/25/61

F. Hetzler

Sample Removal Date 8/31/61 Accumulated Test Hours 330*

T_{max} 1200 °F ΔT 500 °F Flow 0.50 gpm Oxygen Level 14 ppm

CORROSION SAMPLES

SAMPLE NO.	6108	6484	6509	6609	6919	6920
LOCATION & MATERIAL	H1-5Cr	H3-5Cr	H3R-5Cr	C1-5Cr	inlet C3-5Cr	outlet C3-5Cr
TEMPERATURE, °F	1003	1197	1184	1091	705	705
VELOCITY, fps	5.5	16.5	5.5	5.5	5.5	5.5
HARDNESS, R _B	Before	70	70	70	68	70
	After	70	70	70	68	70
INITIAL WEIGHT, g	3.78823	3.85808	3.91439	3.91473	3.78608	3.90177
FINAL WEIGHT, g	3.78895	3.85810	3.91470	3.91560	3.79045	3.90310
WEIGHT CHANGE, mg	+0.72	+0.02	+0.31	+0.87	+3.37	+1.33
CORROSION RATE, mg/dm ² -mo	+17.1	+0.48	+7.37	+20.7	+80.1	+31.6

APPEARANCE AFTER TEST: 6108))
 6484)- Clean, still shiny)
 6509))
 6609 - Light gray) No film or scale observable.
 6919))
 6920)- Medium gray)

METALLOGRAPHIC EXAMINATION:

All samples - No apparent change in microstructure.

6484)- Intergranular penetration - 0.1 mil.
 6509)- " " - 0.1 mil.

* Corresponds to loop exposure from 1400 to 1730 hours. These samples were removed after the loop was shut down to repair a leak in the #2 heater. This short time, mid run data provides additional information on the ageing effect.

ANALYSIS REPORTRun No. 6-2 Issued by J. Damon/F. Hetzle Date 10/24/61Sample Removal Date 10/20/61 Accumulated Test Hours 2805T_{max} 1200 °F ΔT 500 °F Flow 0.40 gpm Oxygen Level 13 ppmCORROSION SAMPLES

SAMPLE NO.	6106	6107	6109	6176		
LOCATION & MATERIAL	H1-5 Cr	H1-5 Cr	H1-5 Cr	H1-5 Cr		
TEMPERATURE, °F	1003	1003	1003	1003		
VELOCITY, fps	4.40	4.45	4.19	13.2		
HARDNESS, R _B Before	67	69	68	63		
After	67	71	70	68		
INITIAL WEIGHT, g	3.87888	3.93803	3.93063	3.85187		
FINAL WEIGHT, g	3.87838	3.93732	3.92987	3.85269		
WEIGHT CHANGE, mg	-0.50	-0.71	-0.76	+ 0.82		
CORROSION RATE, mg/dm ² -mo	-1.40	-2.69	-5.55	+2.29		

APPEARANCE AFTER TEST:

6106 - Medium gray - Surface 50% covered with dark gray film.

6107 - Light gray - One small area of black film.

6109 - Slight to medium gray - One small streak of black film.

6176 - Light to medium gray.

METALLOGRAPHIC EXAMINATION:

All samples-no apparent change in microstructure.

6106 - Intergranular penetration - 0.2 mil

6107 - " " - 0.2 mil

6109 - " " - None

6176 - " " - 0.2 mil

CORROSION SAMPLES

SAMPLE NO.	6203	6204	6205	6276		
LOCATION & MATERIAL	H2-5 Cr	H2-5 Cr	H2-5 Cr	H2-5 Cr		
TEMPERATURE, °F	1101	1101	1101	1101		
VELOCITY, fps	4.4	4.4	4.4	13.2		
HARDNESS, R _B	Before	67	67	66	57	
	After	70	71	70	70	
INITIAL WEIGHT, g	3.98089	3.96142	3.79113	3.99608		
FINAL WEIGHT, g	3.97956	3.96027	3.78936	3.99895		
WEIGHT CHANGE, mg	-1.33	-1.15	-1.77	+2.87		
CORROSION RATE, mg/dm ² -mo	-3.72	-3.22	-4.95	+8.04		

Samples were removed at 269 hours and reloaded

APPEARANCE AFTER TEST:

6203 } - Light gray with streaks of dark gray film.
6204 }
6205 - Light gray
6276 - Medium gray with streaks of black scale.

METALLOGRAPHIC EXAMINATION:

All samples - no apparent change in microstructure.

6203 - Intergranular penetration - 0.2 mils
6204 - " " - 0.2 mils
6205 - " " - 0.2 mils
6276 - " " - 0.4 mils

CORROSION SAMPLES

SAMPLE NO.	6483	6485	6507	6508	6510	(Foil) 6576
LOCATION & MATERIAL	inlet H3-5Cr	outlet H3-5Cr	H3R-5Cr	H3R-5Cr	H3R-5Cr	H3R-5Cr
TEMPERATURE, °F	1197	1197	1184	1184	1184	1184
VELOCITY, fps	13.4	12.6	4.40	4.45	4.19	13.2
HARDNESS, R _B	Before	69	67	68	71	67
	After	70	70	71	72	71
INITIAL WEIGHT, g	3.75538	3.96932	3.91842	3.83486	3.75984	0.43393
FINAL WEIGHT, g	3.74814	3.96712	3.91757	3.83076	3.75928	0.43985
WEIGHT CHANGE, mg	-7.24	-2.20	-0.85	-4.10	-0.56	+ 5.92
CORROSION RATE, mg/dm ² -mo	-27.4	-16.1	-2.38	-15.5	-4.07	+ 18.3

APPEARANCE AFTER TEST: 6483) - Light gray with streaks of black film
6485) -Light gray with scattered flecks of scale
6507) -Light gray - Clean
6508)
6576 Medium gray - 50% of surface covered with black film

METALLOGRAPHIC EXAMINATION:

All samples - No apparent change in microstructure.

6483 - Intergranular penetration - None
6485 - " " - 0.2 mil
6507 - " " - None
6508 - " " - 0.1 mil
6510 - " " - None

CORROSION SAMPLES

SAMPLE NO.	6606	6608	6610	6703	6704	6705
LOCATION & MATERIAL	C1-5Cr	C1-5Cr	C1-5Cr	C2-5Cr	C2-5Cr	C2-5Cr
TEMPERATURE, °F	1091	1091	1091	1004	1004	1004
VELOCITY, fps	4.40	4.45	4.19	4.40	4.40	4.40
HARDNESS, R _B	Before	67	71	65	65	64
	After	70	70	70	71	71
INITIAL WEIGHT, g	3.91419	3.89720	3.95746	3.88300	3.90533	3.87769
FINAL WEIGHT, g	3.91863	3.89960	3.95848	3.88737	3.90990	3.88264
WEIGHT CHANGE, mg	+4.44	+2.40	+1.02	+4.37	+4.57	+4.95
CORROSION RATE, mg/dm ² -mo	+12.4	+9.10	+7.46	+12.3	+12.8	+13.9

APPEARANCE AFTER TEST: 6606)
6608)
6610)
6703) Light to medium gray
6704)
6705)

METALLOGRAPHIC EXAMINATION:

All samples - No apparent change in microstructure

6606 - intergranular penetration - 0.1 mil
6608 - " " - None
6610 - " " - 0.1 mil
6703 - " " - 0.2 mil
6704 - " " - 0.2 mil
6705 - " " - 0.2 mil

CORROSION SAMPLES

SAMPLE NO.	6912	6916	6917	6918	6921	6922
LOCATION & MATERIAL	inlet C3-5Cr	outlet C3-5Cr	inlet C3-5Cr	outlet C3-5Cr	inlet C3-5Cr	outlet C3-5Cr
TEMPERATURE, °F	705	705	705	705	705	705
VELOCITY, fps	4.40	4.40	4.45	4.45	4.19	4.19
HARDNESS, R _B	Before 64	Before 67	Before 69	Before 71	Before 68	Before 67
	After 71	After 71	After 75	After 75	After 75	After 71
INITIAL WEIGHT, g	3.91500	3.76303	3.93538	3.95422	3.98441	3.93189
FINAL WEIGHT, g	3.93080	3.77314	3.95300	3.96185	3.99327	3.93706
WEIGHT CHANGE, mg	+15.80	+10.11	+17.62	+7.63	+8.86	+5.17
CORROSION RATE, mg/dm ² -mo	+44.3	+28.3	+98.5	+28.9	+64.6	+37.8

APPEARANCE AFTER TEST:

All samples were medium to dark gray with some evidence of black film or scale.

METALLOGRAPHIC EXAMINATION:

All samples - No apparent change in microstructure - No intergranular penetration

AR No. 6-2-4 APage 1 of 1SODIUM ANALYSIS

SAMPLE NO.	6-2-5	6-2-6	6-2-7	6-2-8	
TEST TIME, HRS.	68	681	1383	2788	
SAMPLING TEMP., °F	680	670	675	695	
SAMPLING LOCATION	Surge	Surge	Surge	Surge	
COMPOSITION, ppm					
Ca	< 10	< 11	< 19	< 15	
Cr	0.8	< 0.05	0.6	0.2	
Fe	2.6	1.7	3.5	4.5	
K	361	331	185	319	
Li	< 9	< 11	< 10	< 35	
Mn	< 2.0	< 1.2	< 1.7	-	
Mo	< 0.3	< 0.2	< 0.2	-	
Ni	2.7	1.2	2.2	1.6	
C	23	17	13	*	

* Analysis not completed

AVERAGE FLOW AND PLUGGING INDICATOR DATA

TEST TIME, HRS.	0-700	0-1400	0-2800	700-2800	1730-2800
AVERAGE FLOW, gpm	0.387	0.397	0.400	0.405	0.381
AVERAGE PLUGGING TEMP., °F	324	322	316	314	303
OXIDE CONC. *, ppm O ₂	15	14	13	13	11

REMARKS:

* Based upon KAPL data, TID 5277, p.7