MSAR 62-126

Progress Report 25
September 1962

to

U. S. Atomic Energy Commission
Chicago Operations Office
Lemont, Illinois

EFFECT OF 1200°F SODIUM ON AUSTENITIC AND FERRITIC STEELS

Physical Properties of Materials

Contract AT(11-1)-765
Modification No. 1

October 19, 1962

MSA Research Corporation

Subsidiary of Mine Safety Appliances Company

Callery, Pennsylvania

DISCLAIMER

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SUMMARY

The two sodium loops, for testing Type 316 stainless steel and 2 1/4 Cr - 1 Mo steel specimens, are still in operation with the majority of the tests having been completed. In Loop One (stainless steel specimens) only the pre-exposed stress rupture specimens remain in progress. Loop Two (Cr-Mo specimens) has an extra creep specimen and a long time stress rupture test still in progress. Completion of the tests in progress will finish the first test series in which pre-exposed and unexposed Type 316 stainless and 2 1/4 Cr - 1 Mo steel specimens were tested in 1200 F and 1100 F sodium, respectively, under stress-to-rupture, creep and fatigue conditions. Also in this series are stress-to-rupture, creep, tensile and fatigue tests in air and helium at their respective temperatures of 1100 F and 1200 F. These tests are still in progress and all but the fatigue tests are being conducted at the University of Michigan.

The results are of a preliminary nature at this time, but the sodium and air stress-to-rupture tests with 316 ss specimens show excellent agreement indicating no noticeable effect of sodium. The creep tests of 316 ss specimens resulted in higher creep rates in sodium than in air, which may indicate the shape of the creep curve to be different in sodium than in air. The fatigue tests are not complete but preliminary results indicate Type 316 ss has a longer fatigue life in helium and sodium than in air, especially under lower cyclic strain (longer test periods).

The Cr-Mo stress rupture results show a slight difference between the air and sodium tests with indications that sodium might be expected to shorten the stress rupture life of 2 1/4 Cr - 1 Mo steel at these high temperatures. Higher creep rates were also experienced in sodium than in air, indicating the possibility of different shaped creep curves in sodium than in air. The fatigue tests show no difference between sodium and helium tests but both show longer fatigue life than tests in air.

Completion of additional tests and further metallurgical studies will permit more specific conclusions.

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Progress Report 25

EFFECT of 1200°F SODIUM ON AUSTENITIC AND FERRITIC STEELS

PHYSICAL PROPERTIES OF MATERIALS

1. INTRODUCTION

This report is submitted as the regularly scheduled progress report; however, in an attempt to aid in the design of sodium equipment, presently being contemplated, the report has been made complete in itself. Little, if any, reference to other reports is needed by the reader. The data obtained to date has been presented in what is believed a simple straightforward manner for ease in interpretation. The comments of both Dr. Freeman and MSA Research concerning this data are presented.

The test program for this phase (testing of Type 316 ss at 1200°F in air, helium and sodium, and 2 1/4 Cr - 1 Mo at 1100°F in air, helium and sodium) is as described in AEC Contract AT(11-1)-765 and as modified by letter from Fred C. Mattmueller (Director, Contracts Division) to Dr. Robert C. Werner (MSAR), dated February 12, 1962. The University of Michigan, under the direction of Dr. James Freeman, is conducting the stress to rupture, creep and tensile tests in air and helium under subcontract AEC765-2 (Prime Contract AT(11-1)-765).

2. TEST PROGRAM

The finalized test program is summarized in Table 1. For clarity, only the specimens being tested in sodium with helium cover gas, air and helium are listed. Future tests under different conditions (sodium saturated with carbon, sodium with nitrogen cover gas, and sodium with 200-300 ppm oxygen) will require similar test specimens with the exception that unexposed specimens and tests will not be required in air and helium.

Stress to rupture tests of 2 1/4 Cr - 1 Mo in 1100°F air were dropped from the program by this revised contract since it was believed the surface oxidation would have considerable effect on the rupture times because of the relatively thin specimens being tested. Since that time it has been learned that tests conducted by the Electric Boat Company on 1 1/2 Cr - 1/2 Mo showed surprisingly little effect by air. Therefore, these tests have been reactivated with the exception of pre-exposed tests in air. Believing this test series had been eliminated, only sufficient specimens for the stress rupture in helium tests were exposed.

TABLE 1 - REVISED MECHANICAL TEST PROGRAM - MARCH 26, 1962

Loop No. 1 - Type 316 ss - 1200 F

Test Conditions*	Creep Test UE #1	Creep Test UE #2	Creep Test UE #3	Creep Test E	Tensile Test UE	Tensile Test PE	Tensile Test UE RT	Tensile Test PE RT	Stress to Rupture PE #1	PE #2	PE #3	Uniformity #1	Uniformity #2	Uniformity #3	UE #1	UE #2	UE #3	UE #4	UE #5	UE #6	Fatigue 1000 Cycles	10,000 Cycles	100,000 Cycles	100,000 Cycles E	PE 1,000 Cycles
Na, He	1	1	1	21		3			1	1	1				1	1	1	1	1	1	3	3	3	9-3	3
				6	6	3 3																		3 3	
Air	1	1	1		3				1	1	1	2	2	2	1	1	1	1	1	1	3	3	3		3
Helium	1	1	1		3	6	3	6	1	1	1				1	1	1	1	1	1	3	3	3		3

Loop No. 2 - 2-1/4 Cr - 1 Mo 1100 F

Test Conditions*	Creep Test UE #1	Creep Test UE #2	Creep Test UE #3	Creep Test E	Tensile Test UE	Tensile Test PE	Stress to Rupture PE #1	PE #2	PE #3	UE #1	UE #2	UE #3	UE #4	UE #5	UE #6	Fatigue 1,000 Cycles	10,000 Cycles	100,000 Cycles	100,000 Cycles E	PE 1,000 Cycles
Na, He	1	1	1	12-3			1	1	1	1	1	1	1	1	1	3	3	3	9-3	-3
				6 3															3 3	
Air	1	1	1		3											3	3	3		3
Helium	1	1	1		3	6	1	1	1	1	1	1	1	1	1	3	3	3		3

UE - Unexposed
E - Unstressed Specimens Being Exposed
RT - Room Temperature
PE - Pre-exposed
- Stress Values
* - For clarity, only specimens for test conditions (NA, He) (Air) and (helium) are shown at this time.

Creep tests were to determine the load necessary to produce 1% deformation in 10,000 hours at test temperature. Duration of the tests was scheduled for 4000 hours and a series of three stresses were to be run for each material.

Three standard tensile tests were to be run in both air and helium at test temperature. Also six unstressed specimens that had been exposed to sodium for 4000 hours during the creep tests were to be tensile tested at test temperatures. Three were to be washed following exposure; three were not to be cleaned. In addition, for Type 316 ss, three non-exposed and six pre-exposed specimens were to be tensile tested at room temperature.

Six stress to rupture tests were to be performed to establish a curve; the longest test was not to exceed 4000 hours. Three specimens being pre-exposed were also to be stress to rupture tested for comparison. In the Type 316 ss test program, six additional specimens were to be tested to check the uniformity of the metal specimens.

Fatigue tests were to be conducted at three different strain levels with pre-exposed specimens being tested at the highest level.

3. SPECIMEN DESCRIPTION

All Type 316 ss specimens were made from the same heat of 16 gage stock. The sheet had been fully annealed, with an ASTM grain size of 5-7. The creep, stress to rupture and tension test specimens are identical with the exception of the stress to rupture specimens having a shorter (1 in.) gage length (see Fig. 1). The fatigue specimens are of the cantilever type, Fig. 2, being bent over a mandrel.

The 2 1/4 Cr - 1 Mo specimens were identical in size to the 316 ss specimens and were fabricated from one heat of 16 gage stock. The sheet was normalized (1575°F) and had a grain size of ASTM 5-7.

Control specimens were chemically analyzed for each of the two materials, the results of which appear in Table 2.

All specimens were removed from the sheet stock in direction of rolling. Blanks of 7 5/8 in. x 1 5/8 in. were cut from the stock for the creep, stress to rupture and tension tests. Blanks of 6 1/8 in. x 5/8 in. were cut for the fatigue tests. The blanks were then milled to within 0.002 in. of the dimension shown and the final 0.002 in. over the gage length was removed by wet grinding techniques in small increments until finished. This method gave a surface finish of 32 RMS or better and a minimum of residual stresses.

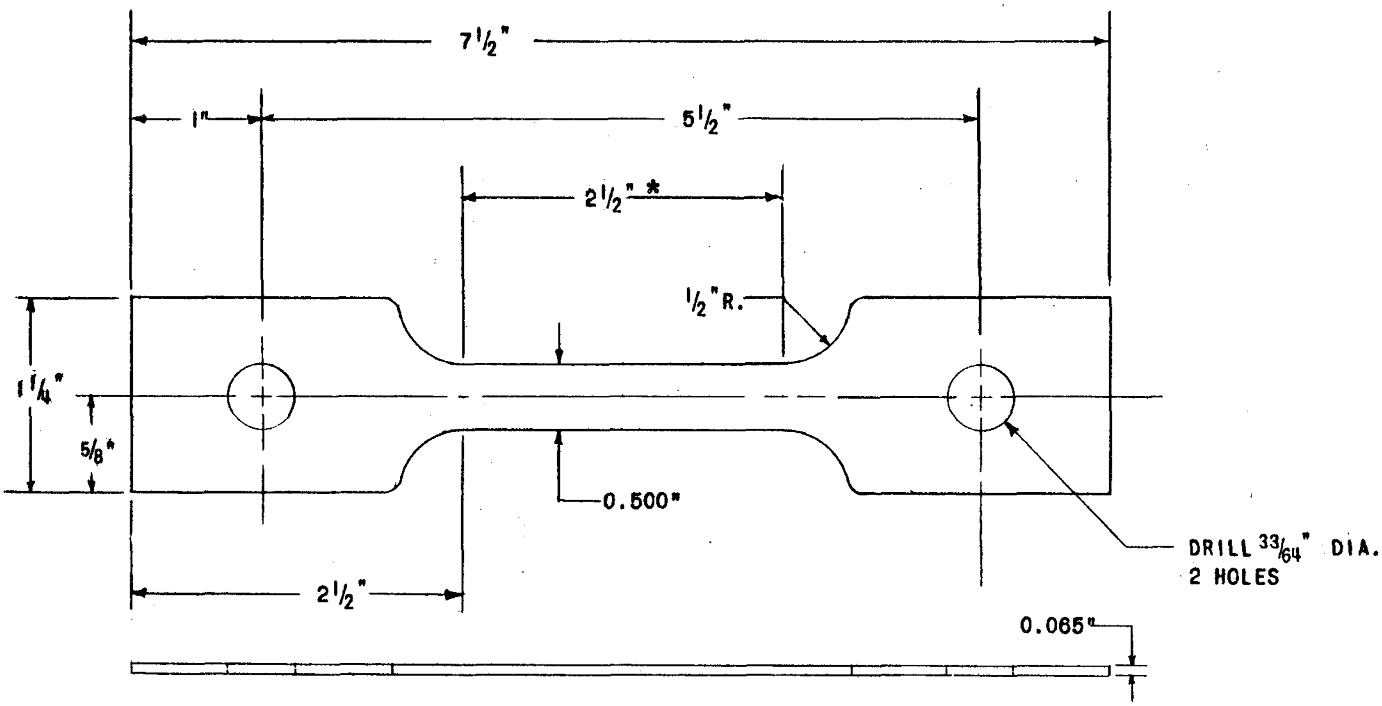


FIG. 1 - CREEP, TENSILE AND STRESS RUPTURE SPECIMEN
(* Stress rupture gage lengths are 1 inch)

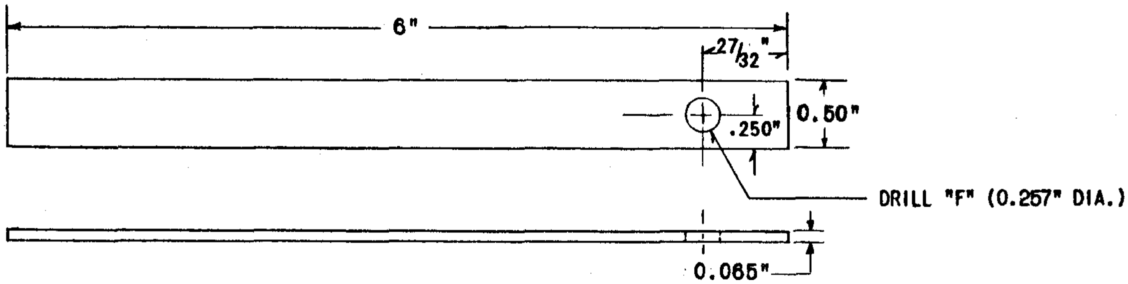


FIG. 2 - FATIGUE SPECIMEN

Table 2 - Chemical Analysis of Control Specimens

	C	Mn	P	S	Si	Cr	Ni	Mo
316 ss Certificate of Analysis	.047	2.02	.020	.014	.46	18.24	12.57	2.19
316 ss Additional Analysis	.045	1.94	.019	.012	.45	18.00	12.84	2.33
Cr-Mo Certificate of Analysis	.097	.56	.007	.022	.33	2.17	-	1.01
Cr-Mo Additional Analysis	.086	.64	.010	.024	.33	2.19	-	.99

4. TEST LOOPS AND MACHINES

Two identical test loops are being used during the test program. Both loops are constructed of Type 316 ss with Loop 1 used for Type 316 ss test specimens and Loop 2 for the 2 1/4 Cr - 1 Mo test specimens. Fig. 3 shows a schematic of the loops. A detailed descriptive report of the system design will be issued as a separate report at a later date.

The sodium creep and stress to rupture machines are identical and are shown in Fig. 4. The working mechanism of the air, helium, and sodium fatigue machines are identical with a few minor changes in methods of heating and containment vessels for the air-helium tests. Fig. 5 shows the sodium fatigue machine. More detailed information concerning the test machine designs will be found in a separate report to be issued at a later date.

5. HELIUM TESTS

The University of Michigan and MSAR have both experienced discoloring of the Cr - Mo and Type 316 ss specimens during tests in helium atmospheres. Dr. Freeman has located and eliminated minute leaks and improved outgassing techniques until he obtained bright Cr - Mo specimens throughout the test, but the Type 316 ss specimens were still discolored. Tests then proceeded on Cr - Mo using helium passed through a NaK bubbler with some slight discoloration. Tests were run on Type 316 ss using cold trapped helium with specimen remaining bright throughout the test. Tests are being run using these techniques but some discoloration is noted occasionally.

MSAR conducted a series of tests using a Minoxo oxygen indicator capable of measuring traces of oxygen (0-100 ppm) in inert gases. The instrument has two ranges, a high range of 0-100 ppm and a low range of 0-10 ppm. The sensitivity is 0.5 ppm with an accuracy of ±5% of full scale over a 24 hour period.

The helium supply for the fatigue test machine was tested directly from the supply cylinder to the Minoxo indicator. An oxygen concentration of 2.1 ppm was indicated. Helium from this tank was then passed through a NaK bubbler, and effluent was checked over a four hour period with an oxygen indication of 0.8 ppm. Following the purification unit, helium enters the fatigue test machine containing zirconium chips. The effluent gas from this machine was recorded continuously for eight days. The results averaged out to less than 0.4 ppm oxygen. The Type 316 ss and Cr - Mo test specimens in the machine during these tests were both tarnished at the end of this period. Based on the above tests and the results to date, MSAR does not feel that tarnishing of the specimens affects the results of the tests.

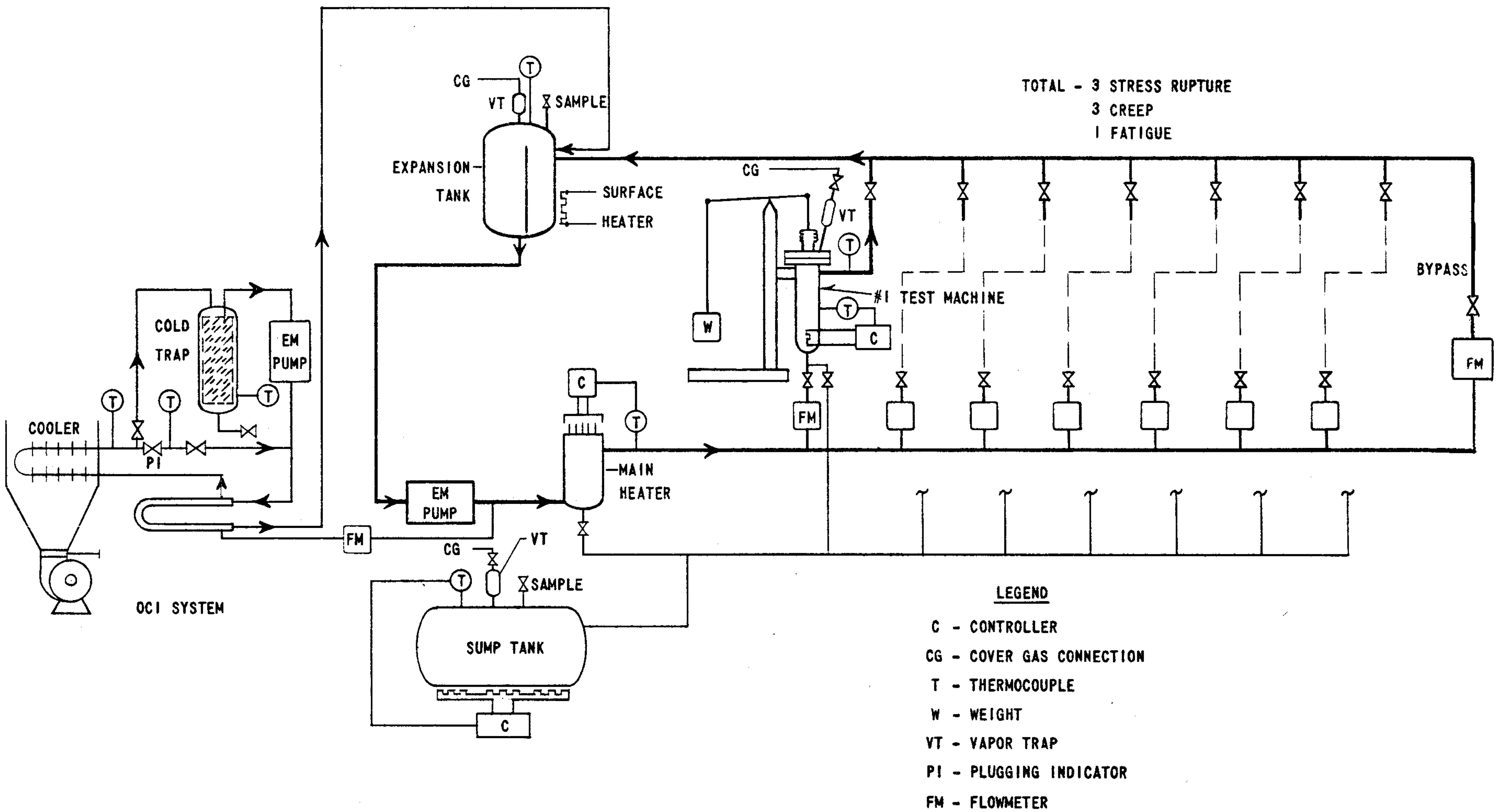


FIG. 3 - FLOW SHEET OF PHYSICAL PROPERTIES TEST LOOP

R-1363

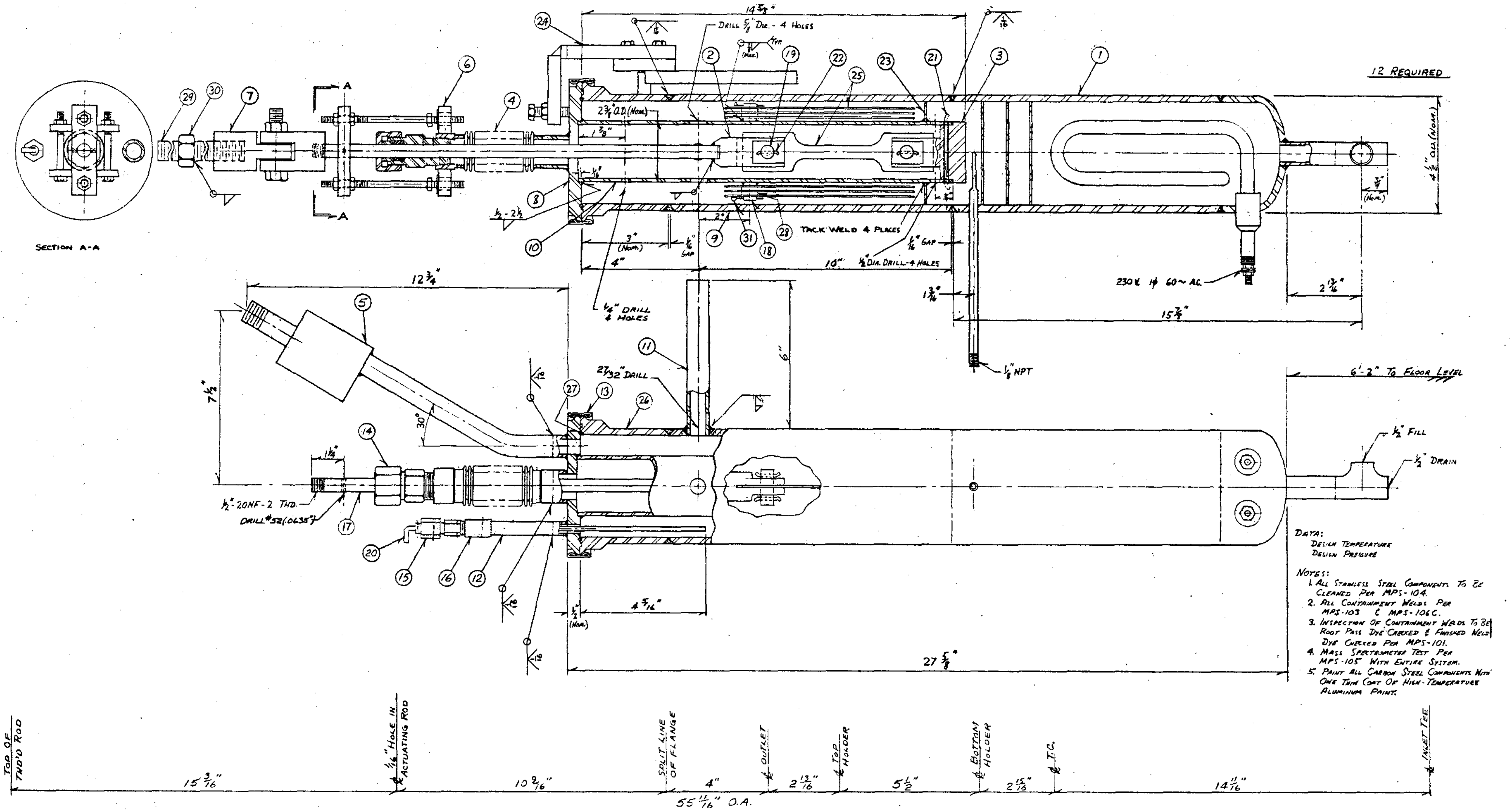
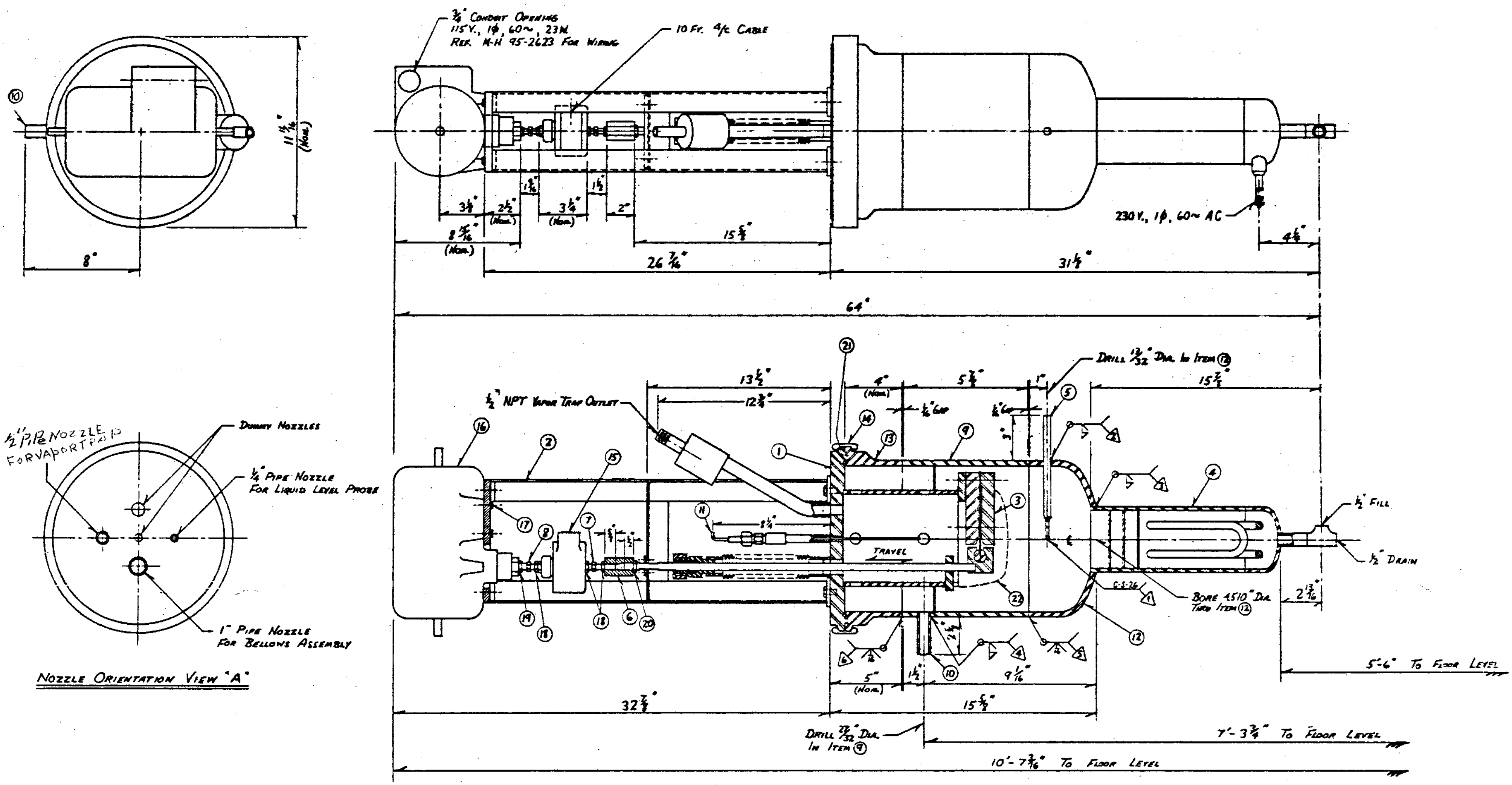


FIG. 4 - CREEP AND STRESS POT ASSEMBLY



NOTE:
VAPOR TRAP & LIQUID LEVEL PROBE ASSEMBLIES ARE NOT SHOWN IN THEIR PROPER LOCATION.
SEE VIEW "A" FOR CORRECT ORIENTATION.

FIG. 5 - FATIGUE TEST POT ASSEMBLY

6. PHYSICAL PROPERTY STUDY OF TYPE 316 STAINLESS STEEL TEST SPECIMENS

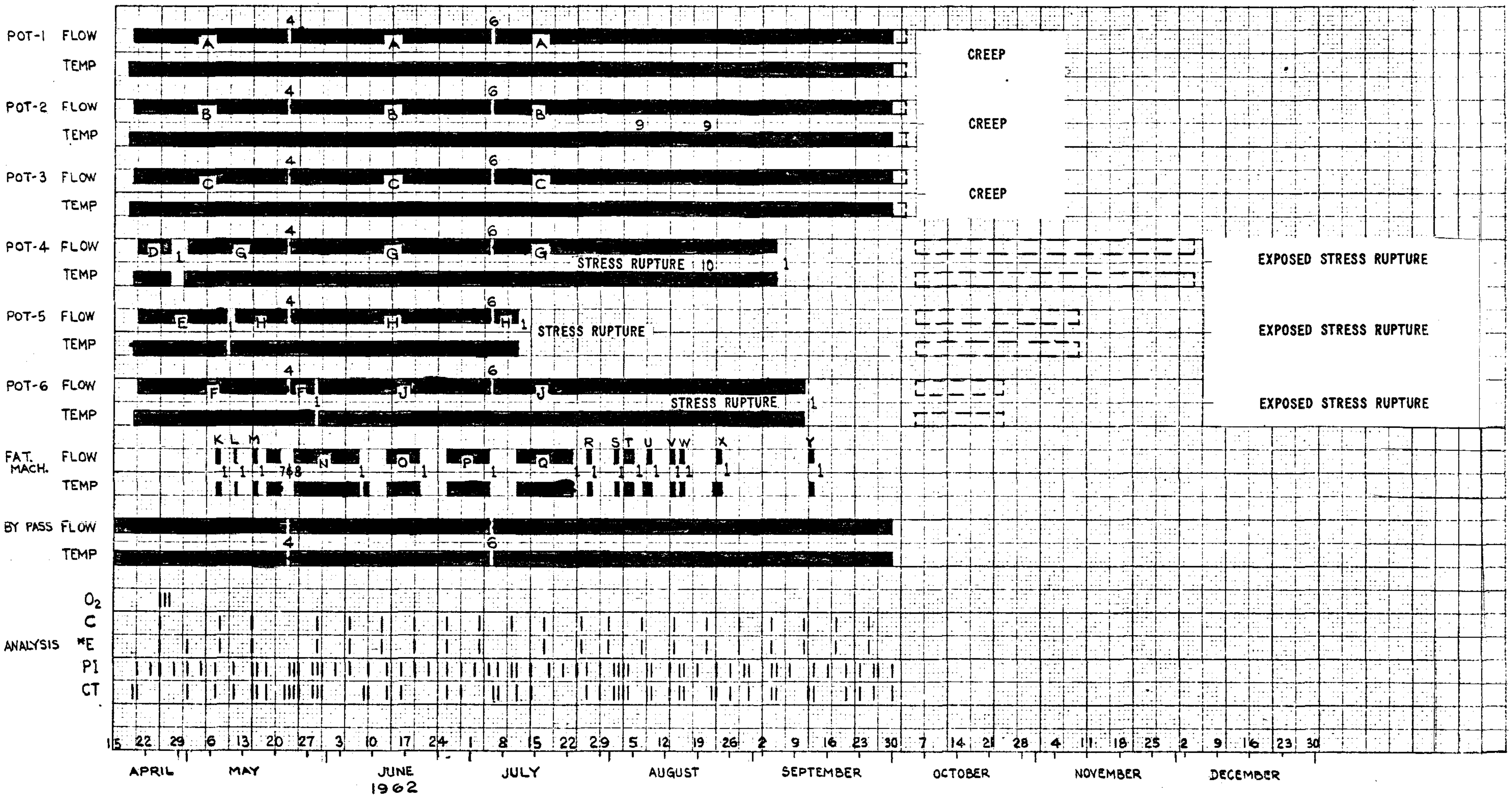
6.1 TYPE 316 SS TEST OPERATION

The testing of Type 316 ss in sodium at 1200°F began after charging the system and circulating through each of the test machines in order to check out the instrumentation and capabilities of the system. During this time it was found additional heat was necessary to maintain operating temperatures while cold trapping and making oxide determination runs. After this was corrected the system was drained completely to remove any contaminants. The bypass system was then charged, test specimens installed, and the pots put on line. The system was drained twice during the creep tests because of sodium leaks. One leak was due to a valve bellows failure and the other apparently to an imperfection in a 1/2 in. pipe. In both cases the system was repaired and recharged in a day. During this time the individual test pots were not drained and the test temperatures were maintained without flow. As the stress to rupture specimens failed, the pot was drained without disturbing the system and a new test started. On two occasions the heater leads to one of the creep pots became oxidized and final temperature control to this pot was lost which resulted in a temperature drop of 20° for about a two hour period. A controller failure caused a 20° temperature loss in a stress to rupture pot for a four hour period. With exception of these occasions, test temperatures were maintained.

Variations in cover gas pressure to the pots have resulted in level changes in the pots. This has caused erratic data from the dial gages which are used in obtaining elongation measurements. Careful control has held pressure variations to a minimum. A change in design of the cover gas system at the end of these tests will help eliminate this problem. A bar graph history of the operation is shown in Fig. 6. Bellows failure was the main difficulty in operation of the fatigue machine.

6.2 STAINLESS STEEL FATIGUE TESTS

The fatigue tests conducted throughout this program are based on bending the specimens over a mandrel having a specific controlled radius. This technique is based on the assumptions that contact between the specimen and mandrel will not affect its fatigue life and that the strain distribution in bending will be as predicted by fundamentals of strength materials. The definition of cyclic strain used in this program is derived from page 119 of Elements of Strength of Materials by Timoshenko and MacCullough, 3rd Edition, 1949.



1. TEST COMPLETED
2. FLANGE LEAK
3. FATIGUE MOTOR FAILURE
4. VALVE LEAK
5. BELLOW FAILURE
6. PIPE FAILURE
7. IMPROPER SPECIMEN INSTALLATION
8. TEST NOT COMPLETED
9. HEATER LEAD FAILURE
10. CONTROLLER FAILURE

* EMISSION SPEC.

A-3ALX1
B-3ALX2
C-3ALX3
D-3CLX1
E-3CLX2
F-3CLX3
G-3DLX1
H-3DLX2
J-3DLX3
K-3FLX1
L-3FLX2
M-3FLX3
N-3JLX1
O-3JLX2
P-3JLX3
Q-EXPOSED SAMPLES
R-3HLL1
S-3HLL2
T-3HLL3
U-3GLX1
V-3GLX2
W-3GLX3
X-3GLX4
Y-3FLX4

FIG. 6 - OPERATIONAL HISTORY OF LOOP 1 (TYPE 316 SS TEST SPECIMENS)

The strain is depicted therein as $Y/\rho = e_x$ where Y equals one-half the thickness and ρ equals radius of curvature on the mandrel. In this case, where bending is reversed using two mandrels, the strain must be multiplied by two to obtain the cyclic strain. Therefore, the cyclic strain in our case can be obtained by dividing the specimen thickness by the radius of the mandrel or, $T/\rho = e_x$ where T equals thickness of specimen. Three strain levels were to be run and after preliminary testing, mandrels having radii of 3.125, 6.75 and 12 in. were chosen to give a high, medium and low level strain respectively.

To date, a minimum of three specimens have been run in each of three mediums (air, helium and sodium) using the 3.125 in. radius mandrel. Also a minimum of three specimens, having been exposed in 1200°F sodium for 286 hours, were tested over this high strain mandrel.

A minimum of three specimens have been tested using the 6.75 in. radius mandrels in air and sodium with only the three specimens to be tested in helium left to be run in this group.

Three specimens have been tested using the 12 in. radius mandrel in both sodium and helium. Two specimens in air had been tested earlier with a 12 in. radius mandrel but the design of the mandrel has been changed slightly since that time and it may be necessary to rerun these.

The results of these tests to date are shown in Table 3, and a plot of all the data to date as % cyclic strain vs cycles appears in Fig. 7. A minimum of three specimens were run at each condition. For clarity the results of these tests were averaged and the averaged results shown in Fig. 8. This plot includes both plastic and elastic strain and therefore does not appear as a straight line function.

Although tests are not complete it would appear from Fig. 8 that both sodium and helium extend the life of 316 ss at the lower strain levels, compared to that in air. As the strain is increased the difference is not as evident.

Specimens were pre-exposed to 1200°F sodium for a time equivalent to the length of the low cyclic strain conditions tests. In this case this time length is 286 hours. Triplicate pre-exposed specimens were then tested in the three mediums (air, helium and sodium) under the high cyclic strain conditions. The results of these tests indicate that this relatively short exposure did not appreciably affect the test results in sodium or helium, but it appeared to decrease the cyclic life of the tests in air under high cyclic strain by 50%.

Table 3 - Test Data Summary

A. Fatigue Tests

316 ss	Condition	Specimen Thickness In.	% Cyclic Strain	Cycles to Failure	Time at Temperature Hrs
3FAX2	Air-1200 F	.0680	2.18	599	14.7
3FAX3	Air-1200 F	.0680	2.18	600	15.5
3FAX4	Air-1200 F	.0680	2.18	570	16.6
*3HAL1	(1)Air-1200 F	.0660	2.11	296	1.8
*3HAL2	(1)Air-1200 F	.0663	2.12	302	2.5
*3HAL3	(1)Air-1200 F	.0662	2.12	326	2.0
3FHX4	He-1200 F	.0665	2.13	1325	17.7
3FHX5	He-1200 F	.0685	2.19	848	5.5
3FHX6	He-1200 F	.0670	2.14	1122	7.5
3HHL1	(1)He-1200 F	.0665	2.13	1116	16.8
3HHL2	(1)He-1200 F	.0675	2.16	1223	7.0
3HHL3	(1)He-1200 F	.0660	2.11	749	4.5
3FLX1	Na-He-1200 F	.0675	2.16	615	17.5
3FLX2	Na-He-1200 F	.0680	2.18	275	2.0
3FLX3	Na-He-1200 F	.0678	2.16	492	20.0
*3FLX4	Na-He-1200 F	.0675	2.16	475	14.0
3HLL1	(1)Na-He-1200 F	.0680	2.18	700	21.8
3HLL2	(1)Na-He-1200 F	.0675	2.16	751	42.0
3HLL3	(1)Na-He-1200 F	.0675	2.16	545	65.5
*3GAX7	Air-1200 F	.0680	1.00	1498	8.5
*3GAX8	Air-1200 F	.0680	1.00	1663	9.5
*3GAX9	Air-1200 F	.0675	1.00	1500	8.5
3GHX					
3GHX					
3GHX					
3GLX1	Na-He-1200 F	.0665	.985	2385	32.5
3GLX2	Na-He-1200 F	.0675	1.00	2110	22.5
3GLX3	Na-He-1200 F	.0672	.995	3914	23.5
3GLX4	Na-He-1200 F	.0682	1.01	4112	44.0

(1) Specimen pre-exposed to 1200 F sodium for 286 hours

Table 3 - Test Data Summary - Cont'd

316 ss	Condition	Specimen Thickness In.	% Cyclic Strain	Cycles to Failure	Time at Temperature Hrs
3JAX3	(2) Air-1200 F	.0685	.571	10,359	70.3
3JAX4	(2) Air-1200 F	.0665	.554	16,161	91.4
3JAX					
3JHX1	He-1200 F	.0670	.558	50,004	277.8
3JHX2	He-1200 F	.0685	.571	38,804	217.5
3JHX3	He-1200 F	.0688	.573	37,011	230.5
3JLX1	Na-He-1200 F	.0680	.565	55,925	333.5
3JLX2	Na-He-1200 F	.0668	.556	29,400	160.0
3JLX3	Na-He-1200 F	.0670	.558	33,055	212.5
2-1/4 Cr-1 Mo					
2FAX1	Air-1100 F	.0685	2.15	474	16.5
2FAX2	Air-1100 F	.0675	2.16	392	16.5
2FAX3	Air-1100 F	.0678	2.17	365	28.2
*2HAL1	(3) Air-1100 F	.0670	2.14	353	2.5
*2HAL2	(3) Air-1100 F	.0670	2.14	371	2.5
*2HAL3	(3) Air-1100 F	.0670	2.14	449	2.8
2FHX5	He-1100 F	.0670	2.14	1725	15.8
2FHX6	He-1100 F	.0672	2.15	2360	10.5
2FHX7	He-1100 F	.0670	2.14	2440	14.3
2HHL1	(3) He-1100 F	.0675	2.16	843	5.0
2HHL2	(3) He-1100 F	.0675	2.16	2129	11.8
2HHL3	(3) He-1100 F	.0675	2.16	196	2.0
2HHL					
2HHL					
2FLX1	Na-He-1100 F	.0672	2.15	1931	34.0
2FLX2	Na-He-1100 F	.0675	2.16	2134	41.5
*2FLX3	Na-He-1100 F	.0672	2.15	2280	17.5
2HLL1	(3) Na-He-1100 F	.0675	2.16	2448	33.8
2HLL2	(3) Na-He-1100 F	.0672	2.15	1770	21.5
2HLL3	(3) Na-He-1100 F	.0672	2.15	2140	25.5

(2) Previously coded 3GAX3 and 3GAX4.
(3) Specimen pre-exposed to 1100 F sodium for 323 hours.

Table 3 - Test Data Summary - Cont'd

2-1/4 Cr-1 Mo	Condition	Specimen Thickness In.	% Cyclic Strain	Cycles to Failure	Time at Temperature Hrs
*2GAX1	Air-1100 F	.0675	1.00	998	5.8
*2GAX2	Air-1100 F	.0675	1.00	1011	5.5
*2GAX3	Air-1100 F	.0672	.995	1017	6.0
2GHX					
2GHX					
2GHX					
*2GLX1	Na-He-1100 F	.0672	.995	6727	94.0
*2GLX2	Na-He-1100 F	.0672	.995	7300	42.0
*2GLX3	Na-He-1100 F	.0672	.995	9249	64.5
2JAX					
2JAX					
2JAX					
*2JHX1	He-1100 F	.0675	.560	18,454	104.0
*2JHX2	He-1100 F	.0675	.560	32,390	185.8
2JHX					
2JHX					
2JLX1	Na-He-1100 F	.0672	.560	44,458	305.0
2JLX2	Na-He-1100 F	.0668	.556	42,555	256.0
2JLX3	Na-He-1100 F	.0672	.560	53,400	323.0

B. Tensile Tests

316 ss	Condition	Tensile Str. (Psi)	0.2% Offset Yield Strength (Psi)	Elong %	Reduction of Area %
3BAX4	Air-1200 F	49,400	26,100	43	47
3BAX3	Air-1200 F	50,250	25,650	41	48
3BAX1	Air-1200 F	51,200	26,300	47	44
2-1/4 Cr-1 Mo					
2BAX4	Air-1100 F	49,170	25,800	28	64
2BAX1	Air-1100 F	56,800	28,800	32	57
2AAX4	Air-1100 F	59,400	29,370	32	62

Table 3 - Test Data Summary - Cont'd

C. Creep Tests

316 ss	Condition	Stress Psi	Rate %/1000 hrs
*3AAX2	Air-1200 F	13,000	0.215 Terminated 3692 hrs
*3BAX2	Air-1200 F	12,500	0.15 (IP 1581 hrs)
*3AAX3	Air-1200 F	11,500	0.035 (IP 3384 hrs)
*3ALX1	Na-He-1200 F	13,500	0.67 Terminated 4000 hrs
*3ALX2	Na-He-1200 F	12,500	0.31 Terminated 4000 hrs
*3ALX3	Na-He-1200 F	11,500	0.17 Terminated 4000 hrs
2-1/4 Cr-1 Mo			
*2BAX2	Air-1100 F	8,000	.395 Terminated 3957 hrs
*2AAX2	Air-1100 F	6,000	.12 (IP 3555 hrs)
2ALX1	Na-He-1100 F	10,000	**Terminated 1839 hrs
2ALX2	Na-He-1100 F	8,000	**Terminated 4000 hrs
*2ALX3	Na-He-1100 F	6,000	.28 Terminated 4000 hrs
*2ALX4	Na-He-1100 F	8,000	**(IP 800 hrs)

D. Stress-Rupture Tests

316 ss	Condition	Stress (Psi)	Elong %	Reduction of Area %	Rupture Time (Hrs)
*3CAX10	Air-1200 F	27,500	61	--	173.6
3CAX2	Air-1200 F	27,500	58	--	152.8
3CAX9	Air-1200 F	27,500	52	--	146.5
3CAX3	Air-1200 F	27,500	63	60	143.0
3CAX4	Air-1200 F	24,000	40	38	476.2
3CAX6	Air-1200 F	24,000	60	--	426.2
3CAX7	Air-1200 F	24,000	44	--	349.7
3CAX1	Air-1200 F	22,000	33	--	863.0
3CAX8	Air-1200 F	21,500	33	--	1000.6
3CAX5	Air-1200 F	21,500	35	--	971.0
3DAX3	Air-1200 F	20,500	35	--	1387.8
3DAX1	Air-1200 F	18,500	34	--	2363.0
*3DAX2	Air-1200 F	17,750		--	1969.5
*3AAX4	Air-1200 F	17,750			IP (1060)

Table 3 - Test Data Summary - Cont'd

316 ss	Condition	Stress (Psi)	Elong %	Reduction of Area %	Rupture Time (Hrs)
*3CAX4	He-1200 F	27,500	63	--	166.3
*3CHX2	He-1200 F	27,500	53	--	152.8
*3CHX3	He-1200 F	24,000	48	--	697.7
*3DHX3	He-1200 F	24,000		--	IP (292)
*3CHX1	He-1200 F	21,500		--	IP (183)
3CLX1	Na-He-1200 F	27,500	74	50	144.6
3CLX2	Na-He-1200 F	24,000	62	49	445.0
3CLX3	Na-He-1200 F	21,500	70	53	890.7
3DLX2	Na-He-1200 F	20,000	53	36	1437.0
*3DLX3	Na-He-1200 F	18,500	33	17	2489.5
3DLX1	Na-He-1200 F	17,750	27	16	2942.2
2-1/4 Cr-1 Mo					
2CAX4	Air-1100 F	20,000	64	58	90.8
2CAX2	Air-1100 F	17,500	42	36	139.2
2CAX3	Air-1100 F	15,000	41	32	302.3
*2CAX1	Air-1100 F	12,000	23	--	1390.5
*2CHX1	He-1100 F	20,000	55	--	108.0
*2CHX3	He-1100 F	20,000	56	--	86.5
*2DHX1	He-1100 F	16,500	47	--	246.6
*2DHX3	He-1100 F	16,500	47	--	98.4
*2DAX1	He-1100 F	14,500	36	--	303.8
2CLX1	Na-He-1100 F	20,000	88	66	30.1
2CLX4	Na-He-1100 F	20,000	68	60	71.7
2CLX5	Na-He-1100 F	20,000	77	60	41.9
2CLX2	Na-He-1100 F	16,500	71	58	146.6
2CLX3	Na-He-1100 F	14,000	53	58	298.8
2DLX1	Na-He-1100 F	12,000	34	36	1116.0
*2DLX2	Na-He-1100 F	10,000	36	28	2106.6
*2DLX3	Na-He-1100 F	7,500			IP (4700)
2ELL2	(4)Na-He-1100 F	16,500	67	53	20.0
2ELL1	(4)Na-He-1100 F	14,000	53	42	71.7
*2ELL3	(4)Na-He-1100 F	12,000	56	41	159.7
*2ELL4	(4)Na-He-1100 F	10,000			IP (760)

* - Results obtained since last report
** - Creep rate too high to determine a minimum rate
IP - Indicates tests in progress for indicated time
(4) - Specimen pre-exposed to 1100 F sodium for 4000 hours

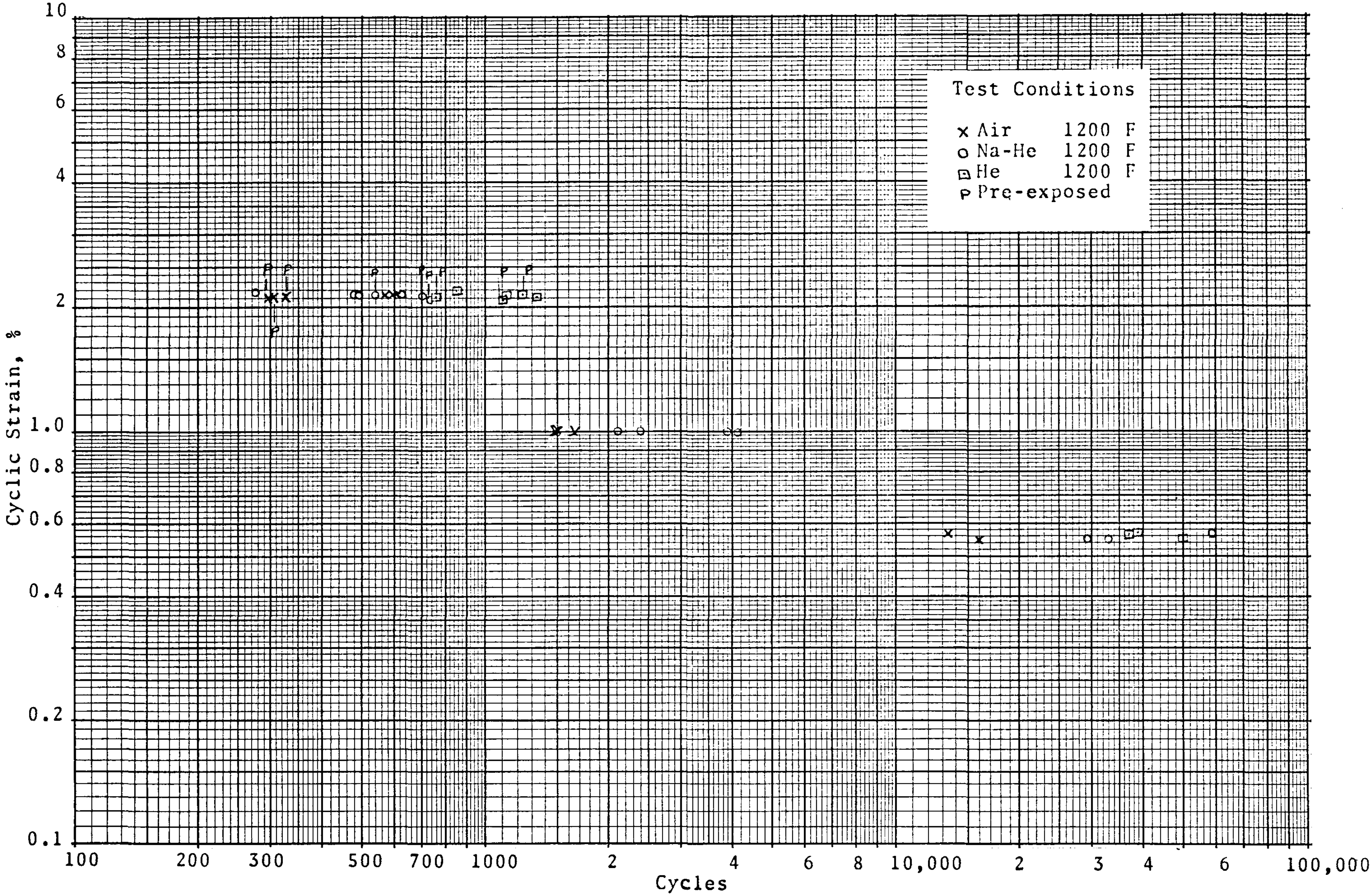


FIG. 7 - FATIGUE TESTS OF 316 STAINLESS STEEL SPECIMENS

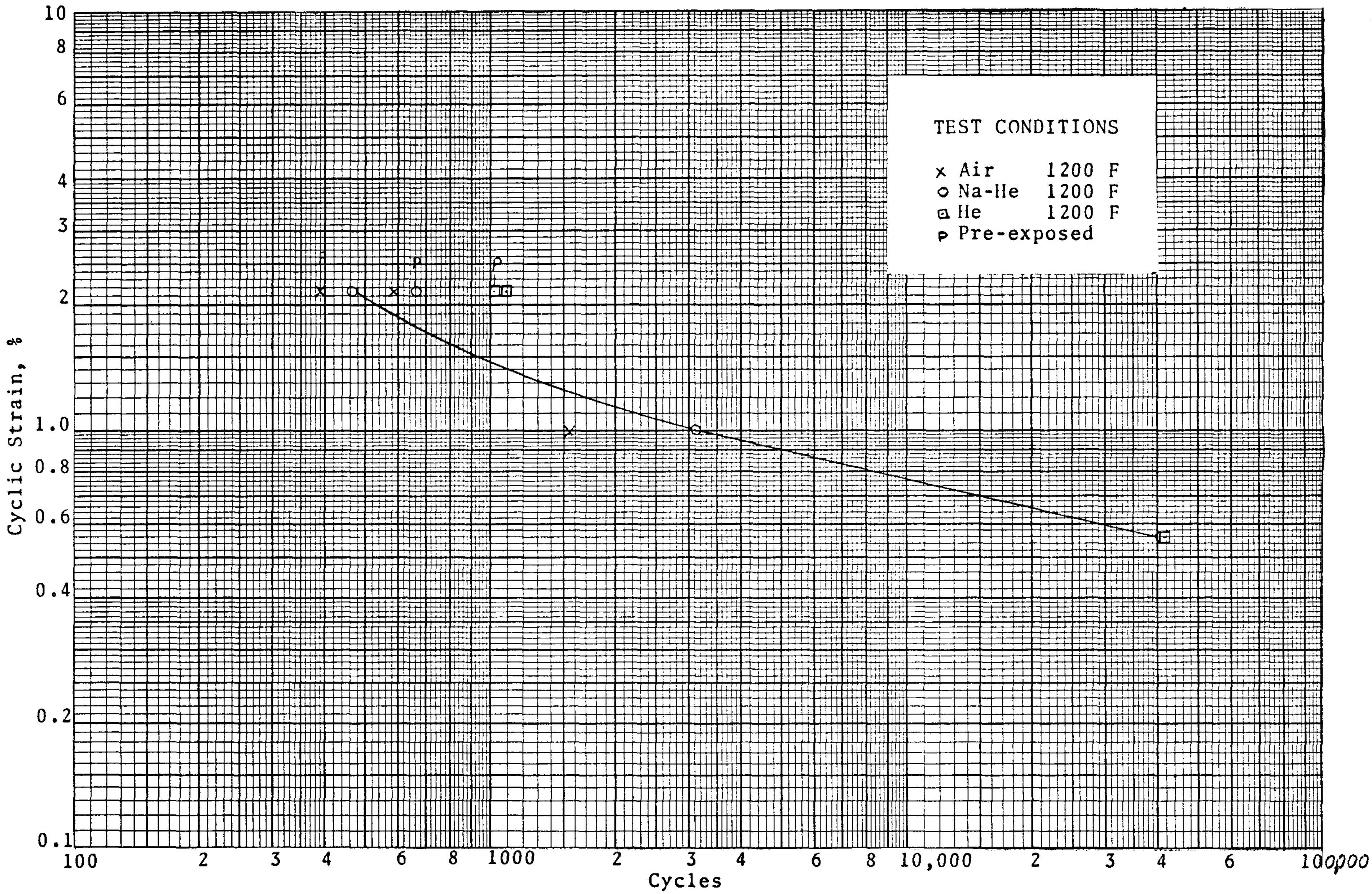


FIG. 8 - FATIGUE CURVES OF AVERAGED DATA FOR 316 STAINLESS STEEL FATIGUE TESTS

6.3 STAINLESS STEEL STRESS TO RUPTURE TESTS

Six specimens were to be tested at various stress levels in air, helium and sodium to cover a range from 100 to 4000 hours. These levels were selected by Dr. Freeman of the University of Michigan who is conducting the air and helium tests.

To date six specimens have been completed in sodium at various stress levels. Thirteen tests have been run in air with one test still in progress. The increase in the number of air tests was to serve as a check on the uniformity of the 316 ss specimens. Three specimens have been tested in helium with two tests in progress. Three additional tests will be started in the near future. Nine specimens that have pre-exposed in 1200°F sodium for 4000 hours remain to be tested. Three each in air, helium and sodium.

The results of these tests to date are reported in Table 3 and Fig. 9 shows all the data graphically. The agreement between air and sodium tests is excellent and it is too early to determine the effects of helium. The pre-exposed specimens are still in progress at this time. There is little doubt that these tests indicate little or no effect due to sodium. It is difficult, however, to determine if the stress vs time curve is a straight line with normal scatter of test data, or if the data indicates a slight breaking away in a downward direction for the lower stress level. Dr. Freeman believes the data indicates a downward break in the curve. The significance of this uncertainty is the ability of extrapolating this curve to determine stress rupture in 10,000 hours within 15%.

6.4 STAINLESS STEEL CREEP TESTS

The creep tests were to find the stress necessary to produce a creep rate of 1%/10,000 hours and the tests were to run a maximum of 4000 hours. Three tests in air have been run by Dr. Freeman. One test at a load of 13,000 psi was terminated after 3692 hours. Two other tests are in progress with loads of 12,500 psi and 11,500 psi respectively.

Three creep specimens were tested by MSAR under loads of 13,500, 12,500 and 11,500 psi respectively. These tests were terminated at the end of 4000 hours.

Three creep tests to be run in helium have not been started due to the delay caused by the oxidizing of Type 316 ss and Cr - Mo specimens during the helium tests. These tests will be started in the near future.

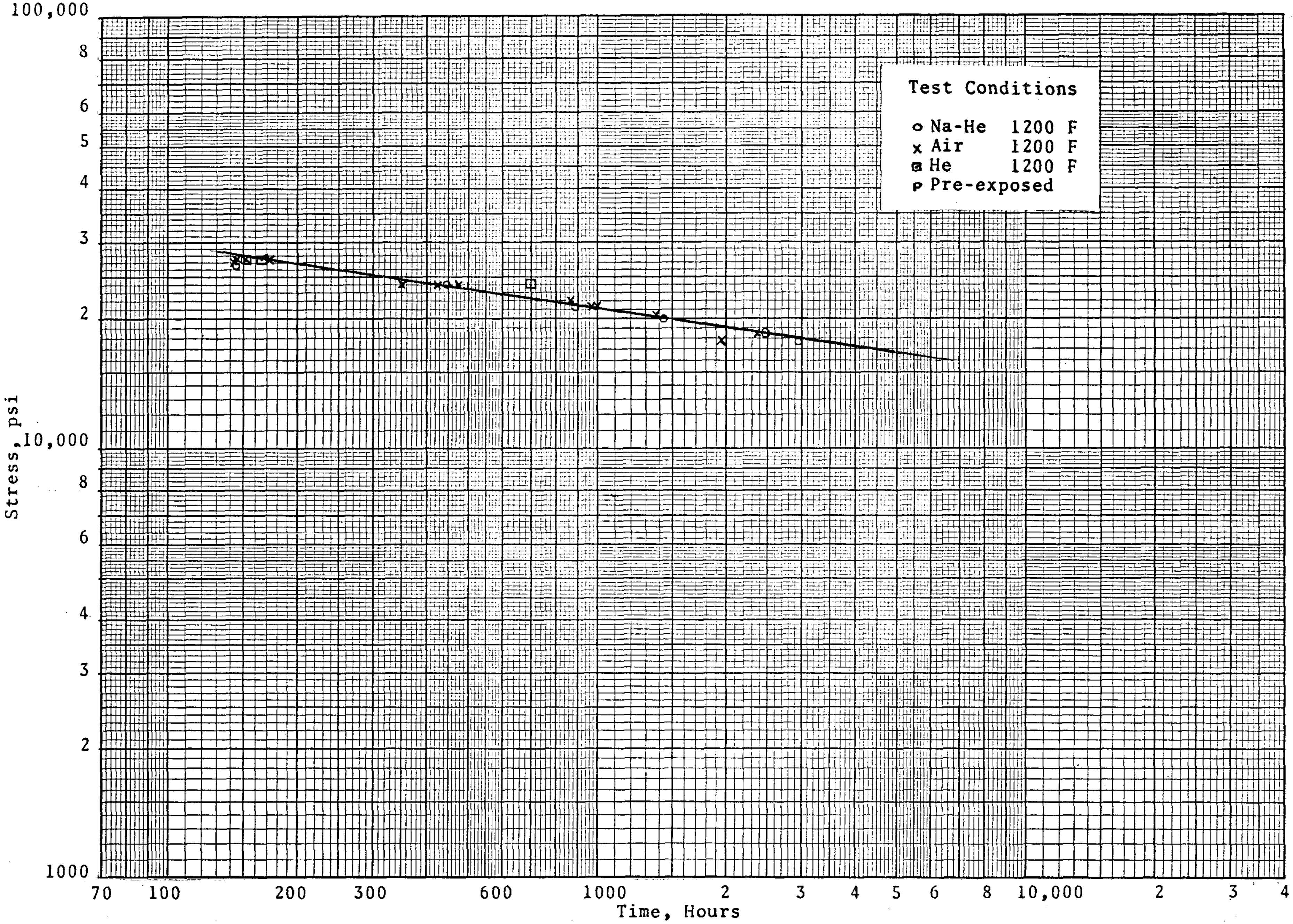


FIG. 9 - STRESS - RUPTURE OF 316 STAINLESS STEEL SPECIMENS

The results of the air and sodium tests are found in Table 3. A graph showing a comparison of the creep rates is included as Fig. 10.

The comparison of the test results in air and sodium indicate significantly higher creep rates in sodium than in air.

Stress - psi	Creep Rate %/1000 Hours	
13,000 (air)	0.215	Terminated 3692 hrs
12,500 (air)	0.15	(IP 1581 hrs)
11,500 (air)	0.035	(IP 3384 hrs)
13,500 (Na)	0.67	Terminated 4000 hrs
12,500 (Na)	0.31	Terminated 4000 hrs
11,500 (Na)	0.17	Terminated 4000 hrs

The stress rupture indicated no such difference; therefore, the shape of the creep curve must be changed in sodium. Dr. Freeman found this interesting and had not predicted any such change. Some doubt is always cast on creep results obtained by the use of dial gages, and in this case the actual measurement is a considerable distance, relatively speaking, from the actual specimen. However, while the data was erratic at times it was consistent. It has been impossible to date to compare total elongation of all the air specimens vs the sodium specimens, but one such comparison indicated considerably more elongation in the sodium test than the air test. This would tend to verify the higher creep rates in sodium. This comparison will be made when the data are available.

6.5 TYPE 316 STAINLESS STEEL TENSILE TESTS

Tensile tests are to be carried out by Dr. Freeman in air and helium.

Three specimens have been tensile tested in air at test temperature. Three unexposed, three cleaned exposed, and three uncleaned exposed specimens still are to be tested in helium at test temperature. Also, three unexposed and six exposed specimens are to be tested at room temperature.

The results of the three specimens tested in air are located in Table 3.*

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* See page 13.

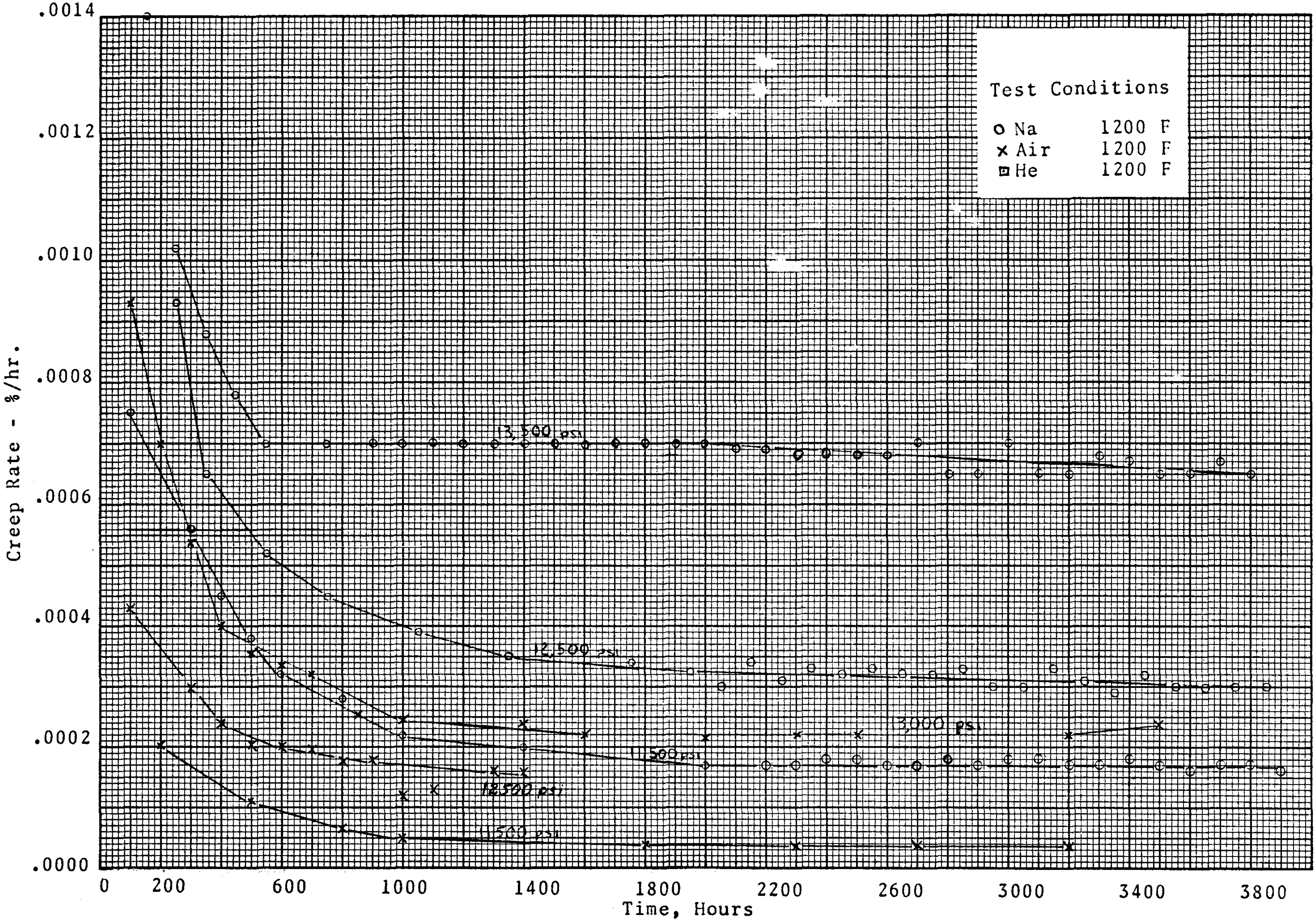

FIG. 10- CREEP RATES, 316 STAINLESS STEEL SPECIMENS

6.6 ANALYTICAL SAMPLING OF LOOP 1 (TYPE 316 SS SPECIMENS)

6.6.1 Oxygen

The oxygen level is controlled at an equivalent saturation temperature of 300°F. Periodical (a maximum of every three days) plugging indicator tests determine the oxygen level, and if this level exceeds 300°F, cold trapping is initiated until it is 300°F or lower. In addition to the regular schedule, the cold trap is operated each time a test pot is put back on line following replacement of specimens. The oxygen level is brought within specifications usually within four hours. No difficulties are being experienced in maintaining an oxide level at 300°F or lower for two or three week periods without cold trapping, if test pots are not being put on the line during this period. The operational history graph (Fig. 6)* shows the frequency of plugging runs and cold trap operations.

6.6.2 Analyses of Sodium in Loop 1 (Type 316 ss Specimens)

A sample of the sodium is taken from the instream expansion tank once a week. The results of the analyses of these samples are tabulated in Table 4. The amount of nickel in solution shows considerable variation; however, the samples were originally taken in nickel buckets. Special titanium buckets have been fabricated to avoid nickel contamination and are now being used, which explains the recent variation in titanium content.

Considerable attention has been given to the carbon concentration since the future program calls for a series of tests in 1200 F sodium saturated with carbon. Low concentrations of carbon are difficult to analyze and considerable time has been spent establishing a reliable technique. Samples are dipped from the flowing sodium stream and transferred to a reaction flask where the sodium is reacted with water at 0°C. After reaction, an aliquot of the sample is transferred to a reaction vessel, acidified to remove carbonate and evaporated to dryness. The dried sample is placed in an oxidation vessel and heated up to 1200 F for 40 minutes under an atmosphere of purified oxygen. This procedure oxidizes carbon to CO_2 which is collected in a one meter gas cell. The CO_2 content is measured with an infrared spectrometer and the values converted to carbon concentration in the sodium.

Van Slyke oxidizing solution was used originally as the oxidizing medium. However, difficulties in reducing and maintaining the carbon background at a low level made this technique unattractive. Oxygen purification has proven less demanding than Van Slyke purifications. Samples of Na_2SO_4 spiked with known amounts of carbon have shown that direct oxidation by heating in an oxygen atmosphere quantitatively oxidizes carbon to CO_2.

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* See page 11.

Table 4 - Chemical Analysis of Sodium From Loop 1 (ss Test Specimens) - in ppm

Date	Fe	B	Co	Mn	Al	Mg	Sn	Cu	Pb	Cr	Si	Ti	Ni	Mo	V	Ca	Ag	Be	Ba	Sr	Zr
3-15-62	3	<5	<5	<1	<1	<2	<5	<2	<5	<1	<10	<5	<1	<5	<1	2	<1	<1	<2	<1	<10
4-25-62	8	<5	<5	1	<1	5	<5	3	<5	<1	35	<5	300	<5	<1		<1	<1			<10
5-1-62	7	<5	<5	<1	5	4	<5	1	<5	<1	30	<5	40	<5	<1		<1	<1			<10
5-8-62	4	<5	<5	1	<1	<2	<5	1	<5	<1	30	<5	100	<5	<1		<1	<1			<10
5-15-62	6	<5	<5	1	2	3	<5	5	<5	<1	30	<5	60	<5	<1		<1	<1			<10
5-29-62	1	<5	<5	<1	4	5	<5	2	<5	<1	25	<5	<1	<5	<1			<1			<10
6-5-62	2	<5	<5	3	3	2	<5	50	<5	<1	20	<5	.1%	<5	<1			<1			<10
6-12-62	1	<5	<5	1	2	4	<5	50	<5	<1	25	<5	8	<5	<1			1			<10
6-14-62	<1	<5	<5	<1	1	<1	<5	9	<5	<1	10	<5	<1	<5	<1	<1	<1	<1	<3	<1	<10
6-26-62	<1	<5	<5	<1	<1	<1	<5	3	<5	<1	<10	<5	<1	<5	<1	<1	<1	<1	<3	<1	<10
7-3-62	1	<5	<5	<1	1	<1	<5	10	<5	<1	12	<5	<1	<5	<1	<1	<1	<1	<3	<1	<10
7-10-62	<1	<5	<5	<1	1	<1	<5	<1	<5	<1	30	<5	2	<5	<1	<1	<1	<1	<3	<1	<10
7-17-62	25	<5	<5	50	<1	2	<5	5	<5	<1	10	<5	<.1%	<5	<1		<1	<1			<10
7-25-62	1	<5	<5	3	<1	1	<5	12	<5	<1	10	<5	150	<5	<1		<1	<1			<10
7-31-62	<1	<5	<5	<1	6	5	<5	<1	<5	<1	25	5	<1	<5	<1		<1	<1			<10
8-7-62	2	<5	<5	1	<1	1	<5	<1	<5	<1	10	<5	<1	<5	<1		<1	<1			<10
8-14-62	1	<5	<5	<1	5	30	<5	<1	<5	<1	75	7	110	<5	<1		<1	<1			<10
8-21-62*	1	<5	<5	<1	4	3	<5	<1	<5	<1	15	80	<1	<5	<1		<1	<1			<10
8-28-62*	1	8	<5	<1	4	4	<5	1	<5	<1	15	50	<1	<5	<1		<1	<1			<10
9-4-62*	2	<5	<5	1	2	4	<5	<1	<5	1	15	20	<1	<5	<1		<1	<1			<10

* Results obtained since last report.

During the initial start up of the loop, the analytical procedure had not been completely established. Samples have been taken every week since start up, but were not analyzed at the time. These samples are now being analyzed and reported in Table 5.

6.7 METALLURGICAL EXAMINATION OF TYPE 316 STAINLESS STEEL SPECIMENS

Microscopic examination of the Type 316 stainless steel specimen structure has shown no change in microstructure of any of the fatigue specimens tested in air, helium or sodium at the comparatively short testing times (less than 300 hours). The primary and secondary cracks which occurred on fatigue testing have appeared along grain boundaries.

The 4000 hours pre-exposed in sodium specimens and the stress rupture specimens are being completed and are now available for further study.

7. PHYSICAL PROPERTY STUDY OF 2 1/4 Cr - 1 Mo STEEL TEST SPECIMENS

7.1 2 1/4 Cr - 1 Mo TEST OPERATION

The test operations began in this loop after considerable operation using dummy specimens. This period was spent in orienting the operators to the system, its purpose and operation. All phases of the operation were entered into and all design checked. During this trial run changes were made in the loop design to improve operation. These design changes were also made in Loop 1 but prior to its start up. After this trial period, the loop was drained, test specimens installed, and operation begun. A pressure variation between pots caused a high level in one creep pot. A sodium leak developed around the pot flange. This pot was isolated from the system and drained.

Table 5 - Carbon Content of Sodium Samples Removed From Loop 1 (ss Specimens)

Date	Carbon Content - ppm
5-1-62	43
5-8-62	127
5-15-62	61
5-29-62	40
6-5-62	123
6-12-62	64
6-19-62	48
6-26-62	56
7-3-62	47
7-10-62	10
8-7-62	43
8-14-62	152
8-21-62	>59
*8-28-62	50
*9-4-62	41
*9-11-62	29
*9-17-62	65

*Results obtained since last report

This necessitated changing of specimens since temperature and flow were lost across these specimens. New specimens were installed and tests continued. Valve bellows leaks on two other occasions made it necessary to drain the main system but the pots were isolated and held at temperature until repairs could be made. On one other occasion a heater lead oxidized and caused a loss of 20° for a two hour period in one of the creep machines. When a stress to rupture test ended that pot was drained independently of the others and the specimen removed. A new specimen was installed and the test begun. A graph showing the operational history is shown in Fig. 11. During the early operation of this loop pressure changes gave variations in elongation measurements due to level changes in the pots. These level changes were due to high flow rates and pressure differentials while taking samples. By lowering the flow rates and closely monitoring the pressures, level changes were held to a minimum. It was decided to complete Phase I of the tests before making changes to further eliminate the problem.

7.2 2 1/4 Cr - 1 Mo FATIGUE TESTS

After preliminary tests, it was decided to use the same mandrels as the Type 316 ss tests. A discussion of the underlying theory on which the fatigue tests are based can be found in Section 6.2.

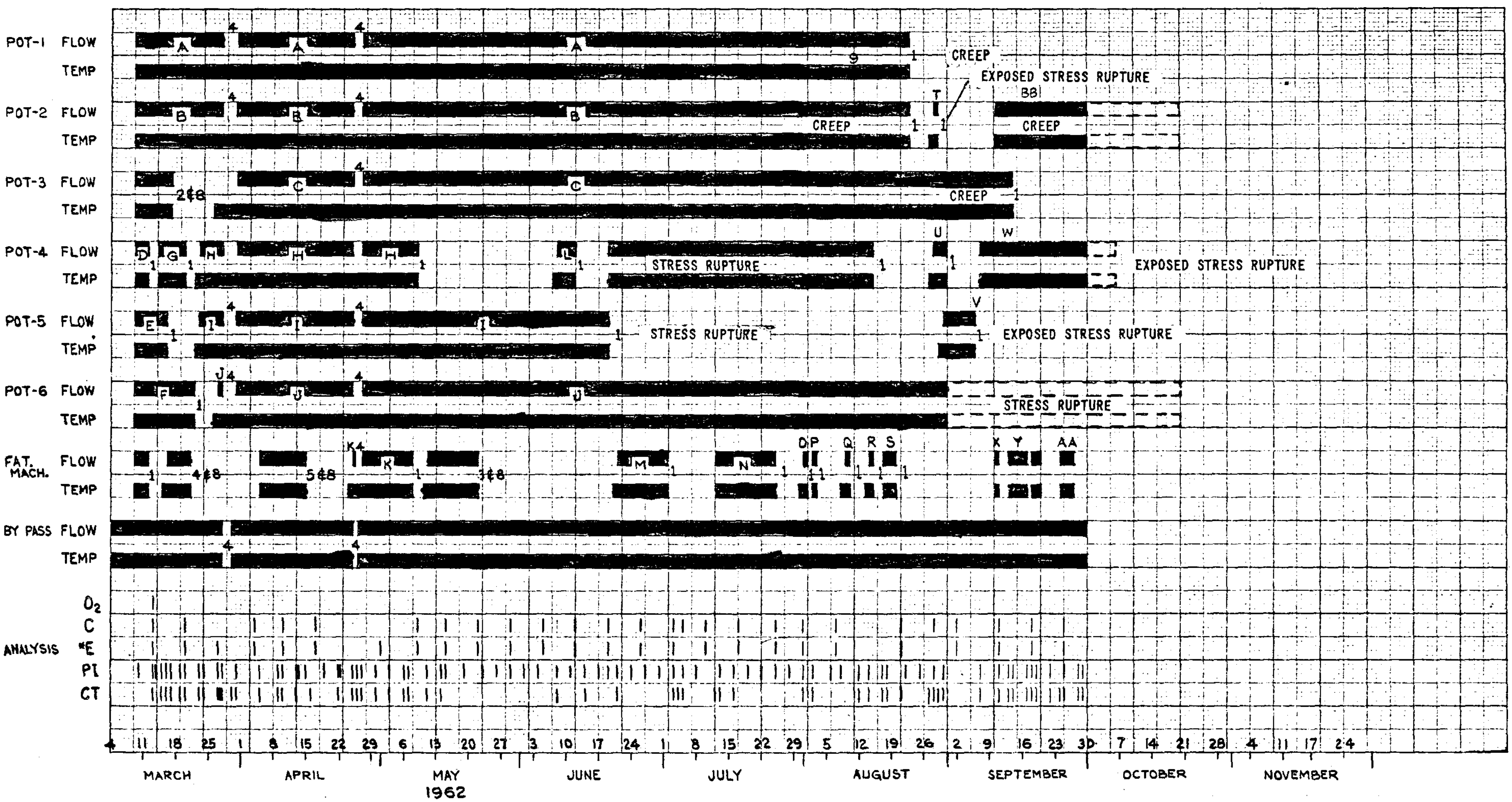
Three specimens have been tested using the 3.125 in. radius mandrel in air, helium and sodium. Nine specimens that were exposed to 1100°F sodium for 323 hours were tested, three each in air, helium and sodium. Additional tests will have to be run on the exposed specimens tested in helium since these results were so erratic.

Three specimens have been tested in both air and sodium using the 6.75 in. radius mandrels. Three remain to be tested in helium at this strain level.

Three specimens have been tested in sodium and two specimens in helium using the 12 in. radium mandrels. Three tests in air using this mandrel and two additional tests in helium will be run since there is some doubt as to the validity of one of the previously run helium tests. The results of the tests to date are in Table 3* and all the data to date is shown graphically as cyclic strain vs number of cycles in Fig. 12. Averages of the test results are shown in Fig. 13 to help illustrate trends. As in the case of the Type 316 ss tests, both the elastic and plastic strain are included.

Based on the data to date, it appears that there is no effective difference between sodium and helium at high strain levels and that both increase the life over that of air considerably. There appears to be little effect of relatively short time exposure to sodium on specimens tested in air and sodium.

*See page 13.



1. TEST COMPLETED
2. FLANGE LEAK
3. FATIGUE MOTOR FAILURE
4. VALVE LEAK
5. BELLOW FAILURE
6. PIPE FAILURE
7. IMPROPER SPECIMEN INSTALLATION
8. TEST NOT COMPLETED
9. HEATER LEAD FAILURE
10. CONTROLLER FAILURE

*EMISSION SPEC.

A-2ALX1
B-2ALX2
C-2ALX3
D-2CLX1
E-2CLX2
F-2CLX3
G-2CLX4
H-2DLX1
I-2DLX2
J-2DLX3
K-2JLX1
L-2CLX5
M-2JLX2
N-238 & EXPOSED SAMPLES

O-2HLL1
P-2HLL2
Q-2HLL3
R-2FLX1
S-2FLX2
T-2ELL2
U-2ELL1
V-2ELL3
W-2ELL4
X-2FLX3
Y-2GLX1
Z-2GLX2
AA-2GLX3
BB-2HLX4

FIG. 11 - OPERATIONAL HISTORY OF LOOP 2 (Cr - Mo TEST SPECIMENS)

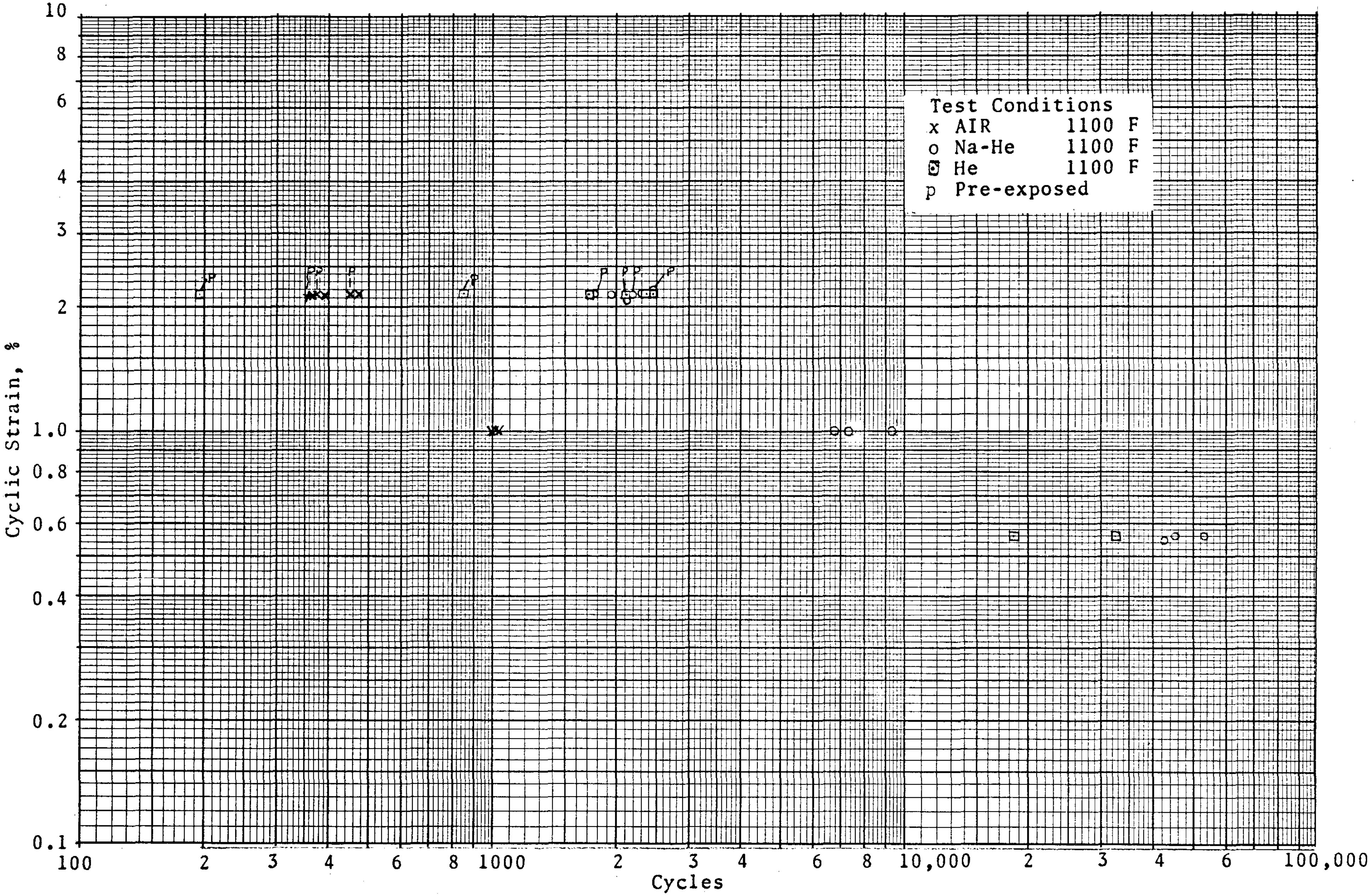


FIG. 12- FATIGUE TESTS — 2 1/4 Cr - 1 Mo SPECIMENS

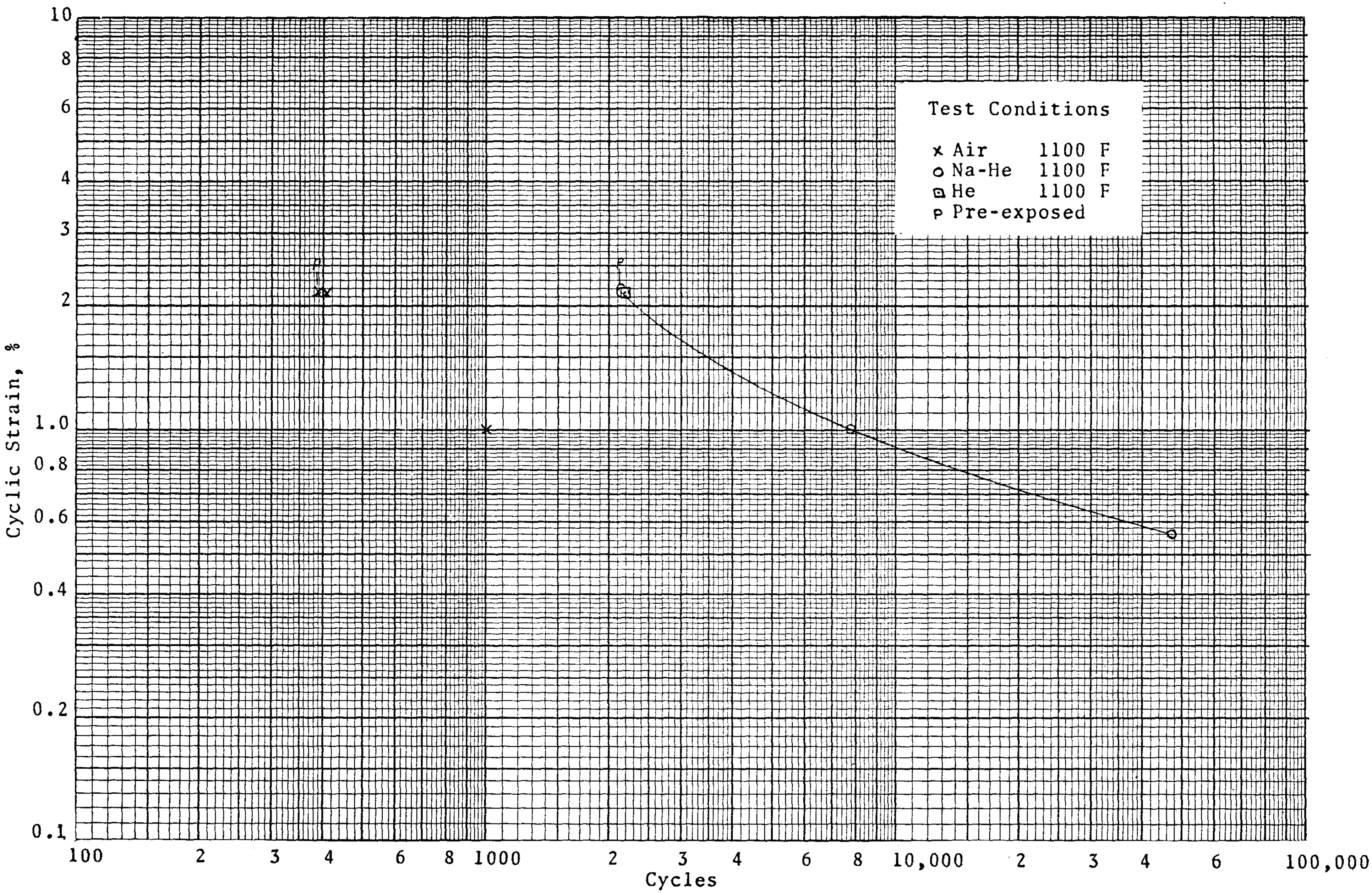


FIG. 13 - FATIGUE CURVES OF AVERAGED DATA FOR 2 1/4 Cr - 1 Mo CARBON STEEL FATIGUE TESTS

7.3 2 1/4 Cr - 1 Mo STRESS TO RUPTURE TESTS

Six stresses were selected by Dr. Freeman to cover the range from 100 to 4000 hours.

Four specimens have been tested in air at various stress levels. No exposed specimens will be run in air since this test was not included at the start of the test program and specimens were not exposed.

Seven specimens have been tested in sodium. The highest stress level was run in triplicate since it fell so far from the air curve expected by Dr. Freeman. The lowest stress level specimen is still under test and may be terminated before failure. Additional data obtained since this test was started indicates that the specimen could reach 10,000 hours before rupture will occur.

Three specimens that were exposed to 1100°F sodium for 4000 hours were tested at three intermediate low stress levels. Since the data obtained could not be interpreted as to whether it was scatter in data or a break in the curve, an additional specimen was installed at a lower stress and is under test at the present time.

Five specimens have been tested in helium and a minimum of three additional specimens are to be run. Also, three of the sodium exposed specimen are yet to be tested in helium.

The results of these tests are given in Table 3 and Fig. 14 is a curve of stress vs time to rupture.

The stress rupture data for air and sodium do not agree and it would appear that the difference is outside of normal data scatter. Fig. 14 has been plotted showing the air and sodium as separate results. Dr. Freeman indicated, based on past experience with 2 1/4 Cr - 1 Mo steel, the curves would not be expected to break but would appear as straight lines. Based on these assumptions it would seem that sodium does have the effect of reducing the life expectancy of 2 1/4 Cr - 1 Mo. To illustrate this trend, the life of a specimen would be reduced by approximately 55% at 20,000 psi; 43% at 15,000 psi and by 34% at 10,000 psi.

The helium data to date shows considerable scatter but some of these were early tests with questionable helium purity. Additional tests can be expected to clear up this scatter.

The results of the stress rupture tests on specimens exposed to sodium for 4000 hours at 1100°F indicate a considerable decrease in life expectancy. Dr. Freeman points out that this

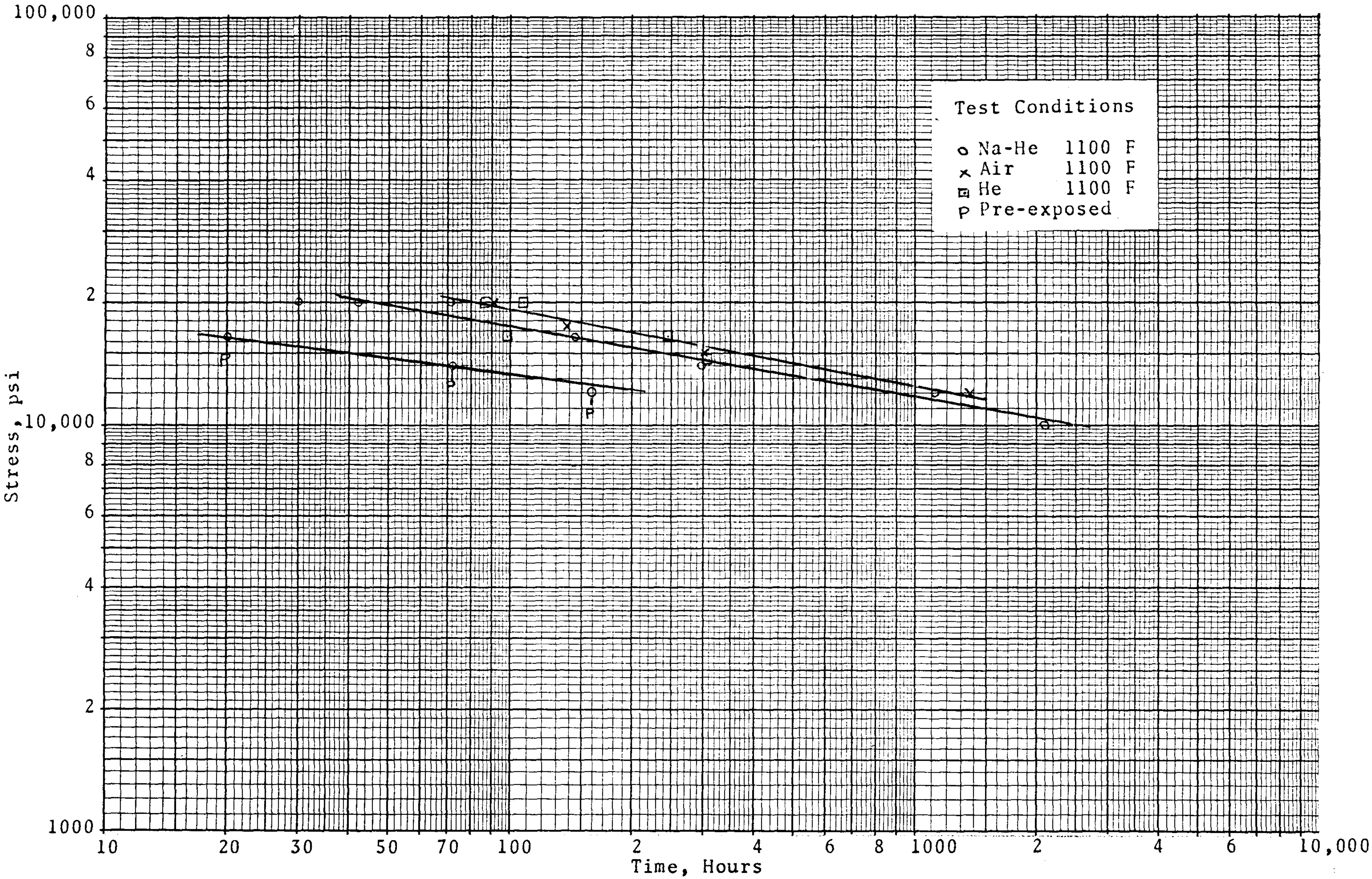


FIG. 14 - STRESS TO RUPTURE - 2 1/4 Cr - 1 Mo SPECIMENS

was predictable and is not unusual for exposed specimens. How much of this decrease is directly due to sodium is impossible to determine.

7.4 2 1/4 Cr - 1 Mo CREEP TESTS

The creep tests were to find the stress necessary to produce a creep rate of 1% in 10,000 hours and the tests were to run a maximum of 4000 hours. Dr. Freeman selected stresses of 10,000, 8000 and 6000 psi, respectively. Two tests were run by Dr. Freeman, one at a stress of 8000 psi which was terminated after 3957 hours, and a second at 6000 psi which is in progress.

Three tests were run in sodium all of which have been terminated after 4000 hours. The Cr - Mo creep rates are considerably higher in sodium than in air.

Stress - psi	Creep Rates - %/1000 hrs
8000 (air)	0.395 Terminated 3957 hrs
6000 (air)	0.120 (IP 3555 hrs)
10,000 (Na)	Too high to reach a minimum rate
8000 (Na)	Too high to reach a minimum rate
8000 (Na)	(IP 800 hrs)
6000 (Na)	0.28 Terminated 4000 hrs

The 8000 and 10,000 psi specimens appeared to be more like stress rupture tests than creep. These rates were so high that an additional 8000 psi specimen was started to verify the first test and also to gain more information on the creep rate during the first few hundred hours. This test is still in progress, but Fig. 15 shows the second test is in agreement with the first test and also shows the general shape of this rapid creep curve. Total elongation of the specimens tested in sodium and air will be compared for some verification of these high rates.

The creep tests in helium have been delayed but the results of these tests are expected in the near future.

7.5 2 1/4 Cr - 1 Mo TENSILE TESTS

The tensile tests were to be the same as for the 316 ss except for the fact that no specimens were to be tested at room temperature.

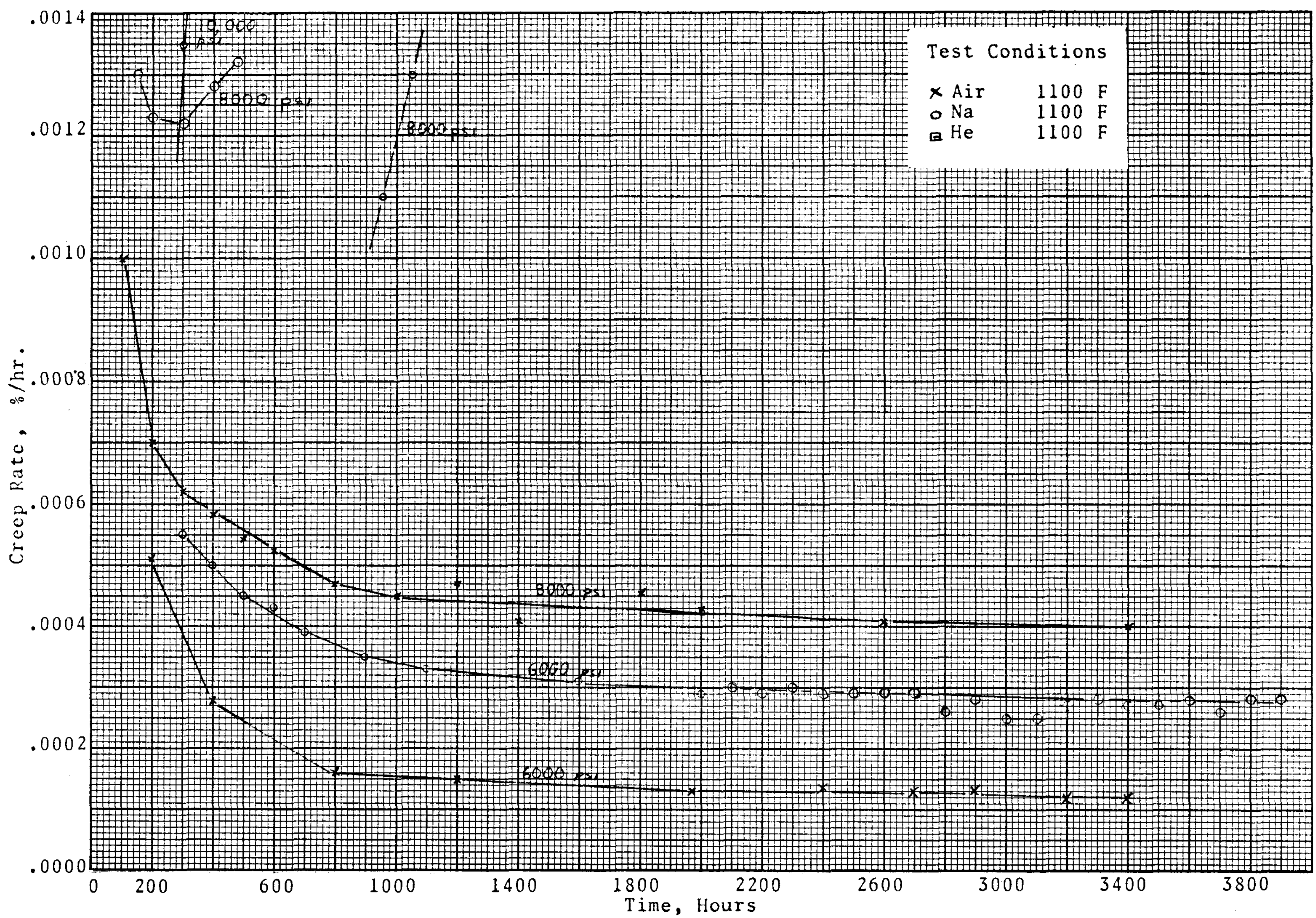


FIG. 15 - CREEP RATES - 2 1/4 Cr - 1 Mo CARBON STEEL

Three specimens have been tested in air and the three unexposed and six exposed specimens remain to be tested.

The results of these tests are shown in Table 3.

7.6 ANALYTICAL SAMPLING OF LOOP 2 (Cr-Mo SPECIMENS)

7.6.1 Oxygen

The control of oxygen in Loop 2 is identical to Loop 1 as discussed in Section 6.6.1. Frequency of cold trapping and plugging runs can be seen in the operational history graph. It has been noted that it is taking longer to bring the saturation temperature below 300°F. This may be due to the build up of oxide in the cold trap, decreasing the efficiency of the unit.

7.6.2 Analyses of Sodium in Loop 2 (Cr-Mo Specimens)

A sample of sodium is removed weekly from the instream expansion tank. The analyses of these samples are found in Table 6. Titanium buckets are also being used in this loop to prevent nickel contamination of the samples.

Carbon analyses are performed by an analytical technique described in Section 6.6.2. The results of these analyses to date are shown in Table 7.

7.7 METALLURGICAL EXAMINATION (Cr-Mo SPECIMENS)

Microscopic examination of the 2 1/4 Cr - 1 Mo alloy steel structure has shown no appreciable change in microstructure of any of the short time stress rupture specimens in sodium or the fatigue specimens tested in air, helium or sodium at comparatively short testing times (less than 300 hours) which so far have been available for investigation. The stress rupture and fatigue specimens tested in sodium have shown a very slight decarburization condition along the edges of approximately 0.005 inch depth.

The 4000 hour pre-exposed in sodium specimen and long time stress rupture specimens are completed and are now available for study.

Table 6 - Chemical Analysis of Sodium From Loop 2 (Cr-Mo Test Specimens) - in ppm

Date	Fe	B	Co	Mn	Al	Mg	Sn	Cu	Pb	Cr	Si	Ti	Ni	Mo	V	Ca	Ag	Be	Ba	Sr	Zr
Drum	40	50	<5	5	150	20	<5	<2	<5	7	.1%	6	<5	<5	<5	75	<1	<1	20	<1	
2-1-62	10	700	<5	<1	100	1	<5	<2	<5	<5	.1%	<5	<5	<5	<5	2	<1	<1	<3	<1	
3-13-62	2	<5	<5	<1	<1	<2	<5	<2	<5	<1	30	<5	<1	<5	<1	1	<1	<1	2	<1	<10
3-20-62	2	<5	<5	<1	<1	<2	<5	8	<5	<1	10	<5	25	<5	<1	3	<1	<1	<2	<1	<10
3-27-62	3	100	<5	<1	80	<2	<5	<1	<5	<1	400	<5	<1	<5	<1		<1	<1			<10
4-3-62	12	<5	<5	3	<1	<2	<5	2	<5	<1	25	<5	1	<5	<1		<1	<1			<10
4-10-62	3	<5	<5	<1	<1	<2	<5	<1	<5	<1	<10	<5	4	<5	<1		<1	<1			<10
4-17-62	6	<5	<5	2	<1	<2	<5	4	<5	<1	40	<5	350	<5	<1		<1	<1			<10
5-1-62	<1	<5	<5	<1	<1	3	<5	1	<5	<1	30	<5	<1	<5	<1		<1	<1			<10
5-8-62	4	<5	<5	<1	<1	<2	<5	3	<5	<1	50	<5	25	<5	<1		<1	<1			<10
5-15-62	<1	<5	<5	<1	<1	<2	<5	<1	<5	<1	30	<5	1	<5	<1		<1	<1			<10
5-22-62	4	<5	<5	<1	<1	3	<5	3	<5	<1	35	<5	<1	<5	<1		<1	<1			<10
5-29-62	2	<5	<5	1	3	5	<5	<1	<5	<1	30	<5	7	<5	<1			<1			<10
6-5-62	1	<5	<5	<1	1	5	<5	3	<5	<1	20	<5	<1	<5	<1			<1			<10
6-12-62	1	<5	<5	<1	1	3	<5	2	<5	<1	20	<5	10	<5	<1			<1			<10
6-19-62	10	<5	<5	1	<1	<2	<5	<1	<5	<1	20	<5	400	<5	<1	3	<1	<1	<3	<1	<10
6-26-62	2	<5	<5	<1	<1	<2	<5	5	<5	1	15	<5	2	<5	<1	2	<1	<1	<3	<1	<10
7-3-62	20	<5	<5	<1	1	<2	<5	2	<5	<1	15	<5	250	<5	<1	2	<1	<1	<3	<1	<10
7-10-62	1	<5	<5	<1	<1	<2	<5	25	<5	<1	20	<5	1	<5	<1	1	<1	<1	<3	<1	<10
7-17-62	15	15	<5	90	<1	2	<5	75	<5	2	120	200	<.5%	<5	<1		<1	<1			<10
7-25-62	2	<5	<5	<1	<1	<1	<5	85	<5	<1	15	<5	300	<5	<1		<1	<1			<10
7-31-62	<1	<5	<5	<1	<1	<1	<5	<1	<5	<1	25	40	<1	<5	<1		<1	<1			<10
8-7-62	1	<5	<5	<1	<1	1	<5	<1	<5	<1	20	50	<1	<5	<1		<1	<1			<10
8-14-62	<1	<5	<5	<1	<1	1	<5	<1	<5	<1	25	100	<1	<5	<1		<1	<1			<10
8-21-62*	1	5	<5	<1	10	2	<5	2	5	1	10	25	<1	<5	<1		<1	<1			<10
8-28-62*	25	7	<5	3	8	3	<5	3	5	3	15	100	<1	<5	<1		<1	<1			<10
9-4-62*	4	<5	<5	<1	<1	2	<5	1	<5	<1	10	10	100	<5	<1		<1	<1			<10

* Results obtained since last report.

Table 7 - Carbon Content of Sodium Samples
Removed From Loop 2 (Cr-Mo Specimens)

Date	Carbon Content - ppm
5-1-62	212
5-8-62	57
5-15-62	109
5-22-62	96
5-29-62	74
6-5-62	61
6-19-62	59
6-26-62	55
7-3-62	79
7-5-62	85
7-10-62	32
*7-17-62	33
*7-25-62	26
7-31-62	45
8-7-62	Lost
8-14-62	46
8-21-62	130
*8-28-62	35
*9-4-62	24
*9-11-62	31
*9-17-62	41

*Results obtained since last report