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**ADVANCED GAS COOLED NUCLEAR REACTOR
MATERIALS EVALUATION AND DEVELOPMENT
PROGRAM**

**PROGRESS REPORT
FOR PERIOD**

October 1, 1978 - December 31, 1978

**BY
PROJECT STAFF**

**GENERAL ELECTRIC
ENERGY SYSTEMS PROGRAMS DEPARTMENT
SCHENECTADY, NEW YORK 12345**

March 9, 1979

**Prepared for
THE U.S. DEPARTMENT OF ENERGY
Under Contract No. EY-76-C-02-2975**

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FOREWORD

The Advanced Gas Cooled Nuclear Reactor Materials Evaluation and Development Program is being conducted for the Nuclear Power Development Division, U.S. Department of Energy, by the Energy Systems Programs Department, General Electric Company, Schenectady, New York 12345 under Contract EY-76-C-02-2975. The Program is under the direction of Mr. J. E. Fox, DOE Program Manager, and is being managed for the General Electric Company by Mr. R. G. Frank, Manager, Materials Technology. The Principle Investigator, with responsibility for overall technical coordination of the Program, is Dr. O. F. Kimball, Manager, Gas Reactor Materials, assisted by Dr. J. F. Stubbins, Materials Engineer, Gas Reactor Materials. Other major contributors to the Program are:

Mr. T. K. Redden, Aircraft Engine Business Group,
Cincinnati, Ohio
Project Manager - Materials for Direct Cycle Helium
Turbine (DCHT) - (Mr. E. Ross)
Program Data Analysis - (Dr. R. B. Hand)

Dr. S. Yukawa, Large Steam Turbine-Generator Operation,
Schenectady, New York
Project Manager - Materials for Nuclear Process Heat
Systems (NPH) - (Mr. S. Z. Hayden)

Mr. C. L. Ehde, Advanced Energy Programs, Cincinnati, Ohio
Project Engineer - Simulated Reactor Helium Gas Supply
System

Mr. R. W. Stepien, Large Steam Turbine-Generator Operation,
Schenectady, New York
Project Manager - Materials Testing in Simulated Reactor
Helium (Dr. D. H. Baldwin, Mr. R. K. Elton)

Dr. A. W. Urquhart, Corporate Research and Development Center,
Schenectady, New York
Project Manager - Project Support for Simulated Reactor
Helium Gas Chemistry (Dr. H. S. Spacil) and
Corrosion (Dr. D. W. McKee)

ABSTRACT

This report presents the results of work performed from October 1, 1978 through December 31, 1978 on the Advanced Gas Cooled Nuclear Reactor Materials Evaluation and Development Program. The objectives of this program are to evaluate candidate alloys for Very High Temperature Reactor (VHTR) Nuclear Process Heat (NPH) and Direct Cycle Helium Turbine (DCHT) applications, in terms of the effect of simulated reactor primary coolant (helium containing small amounts of various other gases), high temperatures, and long time exposures, on the mechanical properties and structural and surface stability of selected candidate alloys. A second objective is to select and recommend materials for future test facilities and more extensive qualification programs.

Work covered in this report includes the activities associated with the characterization of the materials for the screening test program, and the status of the simulated reactor helium supply system, testing equipment, and gas chemistry analysis instrumentation and equipment. Finally, the status of the data management system is presented.

OTHER REPORTS IN THIS SERIES

QUARTERLY PROGRESS REPORTS

September 23, 1976 to December 31, 1976	C00-2975-3
January 1, 1977 to March 31, 1977	C00-2975-10
April 1, 1977 to June 30, 1977	C00-2975-13
July 1, 1977 to September 30, 1977	C00-2975-17
October 1, 1977 to December 31, 1977	C00-2975-20
January 1, 1978 to March 31, 1978	C00-2975-21
April 1, 1978 to June 30, 1978	C00-2975-22
July 1, 1978 to September 30, 1978	C00-2975-25

TOPICAL REPORTS

1. Selection of Candidate Alloys C00-2975-16
 - Volume 1 - Advanced Gas Cooled Reactor
Systems Definition by M. Marvin
 - Volume 2 - Selection of Alloys for Screening
Creep and Structural Stability
Studies by R.M. Goldhoff, R.V. Hillery,
and S. Yukawa
 - Volume 3 - Selection of Surface Coating/
Substrate Systems for Creep and
Structural Stability Studies
by D.A. Grey

Section 1.0

INTRODUCTION

ADVANCED GAS COOLED NUCLEAR REACTOR
MATERIALS EVALUATION AND DEVELOPMENT PROGRAM

1.0 INTRODUCTION

The Very High Temperature Reactor (VHTR) Nuclear Process Heat (NPH) and Direct Cycle Helium Turbine (DCHT) Systems are being developed to provide an expanded nuclear power capability. In both cases the use of high temperature helium-cooled reactors will require a knowledge of the long term properties of reactor primary coolant containment materials and of the materials used in constructing related hardware. Because of the very high temperatures required for NPH and DCHT applications, the need is evident for materials testing in the proper helium environment in the temperature range from 750° - 1050°C (1382° - 1922°F) on those alloys which might serve as materials of construction for heat exchangers, ducting, turbine buckets and vanes and other high temperature structural components.

The objectives of the Advanced Gas Cooled Nuclear Reactor Materials Evaluation and Development Program are to:

1. Evaluate candidate alloys for Very High Temperature Reactor (VHTR) Nuclear Process Heat (NPH) and Direct Cycle Helium Turbine (DCHT) applications, in terms of the effect of the primary exposure and thermal exposure on:
 - Surface stability ("corrosion" resistance) in 10,000 hours.
 - Structural stability in 10,000 hours - changes in microstructure and tensile, impact and fatigue properties.
 - Creep properties in 15,000 hours.
 - Stress rupture properties in 10,000 hours.
 - Fatigue properties
 - Low Cycle 10^3 to 10^5 cycle
 - High Cycle 10^5 to 10^7 cycle
2. Select and recommend materials for future test facilities and more extensive qualification programs.

The data base will permit the selection of materials of construction and should provide a reliable level of design data for the construction of various items of development hardware leading to the successful development of NPH and DCHT systems. The present lack of an accurate measure of materials capabilities under these high temperature helium environments is a factor which is currently limiting the development of the NPH/DCHT systems. This program is intended to provide such initial information.

Section 2.0

PROGRAM STATUS

2.0 PROGRAM STATUS

The Advanced Gas Cooled Reactor Materials Evaluation and Development Program is organized into nine (9) tasks which are designed to accomplish the program objectives listed in Section 1.0 of this report. The task structures (Program Work Breakdown Structure) and a brief description of each task (Program Work Statement) have been included in the first Quarterly Report covering the period September 23, 1976 - December 31, 1976, report number C00-2975-3.

2.1 TASK 1 - SELECTION OF CANDIDATE ALLOYS

The selection of alloys for the screening phase of the program has been completed. A list of the alloys selected for the program was presented in the Quarterly Report for the period July 1, 1977 - September 30, 1977, report number C00-2975-17.

2.2 TASK 2 - MATERIALS PROCUREMENT AND CHARACTERIZATION

2.2.1 Nuclear Process Heat (NPH) Alloys - (S.Z. Hayden and R.A. Ellis)

2.2.2.1 Materials Procurement

The procurement of all NPH alloys and coated specimens was completed by September 1978.

2.2.1.2 Materials Characterization

The chemical compositions of all of the NPH alloys are presented in Table 2.1. Check analyses from an independent testing laboratory were completed and are reported along with the values from the vendors' materials certifications which were reported previously. With the exception of the Si content of two centrifugally cast alloys, IN-519 and Mo-Re 2, the results for all elements analyzed were within material specifications. The Si values determined by the independent laboratory were slightly above specification levels (1.16% vs. 1.0% max. for the IN-519 alloy and 0.82% vs. 0.3% max. for the Mo-Re 2 tube). These discrepancies were discussed with the material vendor (Duraloy Blaw-Knox). Duraloy expressed confidence with regard to their Si determinations, 0.94% for IN-519 and 0.30% for Mo-Re 2. These two results will be checked by a third

TABLE 2.1

CHEMICAL COMPOSITION OF NUCLEAR PROCESS HEAT ALLOYS

Alloy	Element (Weight-%)																				Other
	C	Ni	Fe	Cr	Mn	Si	Mo	Co	W	Nb	Ta	Al	Ti	Cu	V	Zr	Y	B	P	S	
Alloy 800H(a)	0.07	32.03	Bal	19.79	1.00	0.18	--	--	--	--	--	0.38	0.45	0.60	--	--	--	--	--	0.003	--
Alloy 800H(c)	0.078	32.80	44.82	20.20	0.99	0.211	--	--	--	--	--	0.487	0.440	--	--	--	--	--	--	--	--
Incoloy 802(a)	0.27	30.78	Bal	20.10	0.71	0.08	--	--	--	--	--	--	--	0.43	--	--	--	--	--	0.004	--
Incoloy 802(c)	0.257	31.13	45.43	20.71	0.87	0.195	--	--	--	--	--	0.499	0.82	--	--	--	--	--	--	--	--
Incoloy 807(a)	0.065	39.4	Bal	20.6	0.78	0.49	<0.10	8.1	5.08	1.02	0.01	0.34	0.46	0.06	--	--	--	--	--	0.003	Pb 0.00018 Mg 0.011
Incoloy 807(c)	0.083	38.20	24.23	21.31	0.63	0.58	--	7.56	4.57	1.09	--	0.56	0.219	--	--	--	--	--	--	--	--
Incoloy DS(a)	0.065	35.3	Bal	18.35	1.08	2.30	--	0.07	--	--	--	--	0.05	0.07	--	--	--	--	--	0.005	--
Incoloy DS(c)	0.045	35.23	43.13	18.02	1.15	2.13	--	0.092	--	--	--	<0.005	0.054	--	--	--	--	--	--	--	--
HD-556(a)	0.11	22.45	Bal	21.83	0.87	0.50	3.51	18.10	2.31	0.12	0.65	0.13	--	--	--	0.040	--	0.002	0.021	<0.002	N 0.136 La 0.011
HD-556(c)	0.105	22.21	28.89	22.27	0.98	0.351	3.32	18.26	2.19	0.114	0.74	0.202	0.021	--	--	0.013	--	--	--	--	N 0.1479 La 0.040 O 0.0096 H 0.0020
Manaurite 36XS(b)	0.39	36.0	32.1(d)	24.8	1.30	1.92	<0.10	0.18	1.5	1.05	<0.10	<0.1	<0.1	<0.05	<0.10	<0.10	<0.10	--	0.026(b)	0.018(b)	--
Manaurite 36XS(a)	0.38	34.05	Bal	25.56	1.28	1.68	--	--	1.50	1.12	--	--	--	--	--	--	--	--	0.026	0.018	--
Manaurite 36XS(c)	0.177	33.79	35.81	25.18	0.98	1.49	--	--	1.29	1.09	--	0.074	0.021	--	--	--	--	--	--	--	--
Manaurite 900(b)	0.12	34.8	40.1(d)	22.4	0.99	0.74	<0.10	<0.10	<0.1	--	--	<0.1	<0.1	<0.05	<0.1	<0.1	<0.1	--	0.024(b)	0.018(b)	--
Manaurite 900(a)	0.105	32.65	Bal	21.62	1.06	0.66	0.01	--	--	1.09	--	--	--	--	--	--	--	--	0.024	0.018	--
Manaurite 900(c)	0.126	32.30	43.59	21.21	1.04	0.72	0.042	--	--	1.04	--	<0.005	<0.005	--	--	--	--	--	--	--	--
HK-40(a)	0.42	19.50	Bal	25.45	0.86	1.56	<0.04	--	--	--	--	--	--	0.15	--	--	--	--	0.022	0.015	Pb<0.005 Sn<0.010
HK-40(c)	0.441	19.96	52.43	24.90	0.94	1.57	0.050	--	--	--	--	<0.005	<0.005	--	--	--	--	--	--	--	--
IN-519(a)	0.30	23.60	Bal	24.60	0.80	0.94	<0.04	--	--	1.58	--	--	--	0.15	--	--	--	--	0.022	0.015	Pb<0.005 Sn<0.010
IN-519(c)	0.318	24.15	47.13	24.70	0.87	1.16	--	--	--	1.79	--	<0.005	<0.005	--	--	--	--	--	--	--	--
Hastelloy X(a)	0.080	Bal	18.86	21.38	0.64	0.47	8.94	1.79	0.70	--	--	--	--	--	--	--	--	0.004	0.017	0.002	--
Hastelloy X(c)	0.085	48.11	18.38	21.03	0.58	0.446	8.88	1.81	0.59	--	--	0.070	<0.005	--	--	--	--	--	--	--	--
Inconel 617(a)	0.06	Bal	0.53	21.74	0.02	0.18	8.91	12.32	--	--	--	1.11	0.30	0.11	--	--	--	0.003	--	0.002	--
Inconel 617(c)	0.054	52.96	0.53	23.22	0.034	0.257	9.09	12.14	--	--	--	1.31	0.363	--	--	--	--	--	--	--	--
Inconel 618E(a)	0.05	Bal	14.79	22.50	0.09	0.21	--	0.25	5.85	--	--	0.01	--	0.04	--	--	--	--	--	0.005	--
Inconel 618E(c)	0.058	56.99	14.25	22.61	0.061	0.112	--	0.249	5.25	--	--	0.033	0.350	--	--	--	--	--	--	--	--
Mo-Re 2(a)	0.22	50.2	0.18	32.70	0.28	0.30	<0.04	--	15.3	--	--	<0.05	--	--	--	--	--	--	0.015	0.01C	Pb<0.005 Sn<0.010
Mo-Re 2(c)	0.205	51.26	0.340	31.83	0.284	0.82	--	--	16.01	--	--	0.179	<0.005	--	--	--	--	--	--	--	--
MA-956E(a) LCWZ	--	--	Bal	19.04	--	--	--	--	--	--	--	4.63	0.31	--	--	--	--	--	--	--	Y ₂ O ₃ 0.46, O 0.20, N 0.44
MA-956E(c) LCWZ	0.031	--	75.55	19.43	0.135	0.094	--	--	--	--	--	4.96	0.310	--	--	--	--	--	--	--	H 0.0003 O 0.1713 Y ₂ O ₃ 0.489 N 0.0367
MA-956E(a) ZDCR	--	--	Bal	18.7	--	--	--	--	--	--	--	4.58	0.32	--	--	--	--	--	--	--	Y ₂ O ₃ 0.50, O 0.20, N 0.046
MA-956E(c) ZDCR	0.031	--	75.74	19.32	0.142	0.095	--	--	--	--	--	4.88	0.311	--	--	--	--	--	--	--	H 0.0003 O 0.1494 Y ₂ O ₃ 0.489 N 0.0319

NOTES: (a) Values from producer certifications
 (b) Values determined by International Nickel Research Laboratories for General Atomic Co.
 (c) Values determined by J. Dirats and Company Inc.
 (d) Balance of alloy content obtained by difference

party; however, the tubes have been accepted for use in the program and the results of these analyses are not expected to have an impact on the program.

Materials acceptance and characterization testing has been completed for all the alloys; the only tests still in progress are a few high-temperature, long-time creep-rupture tests which are being run in addition to the 300-hour stress verification tests. The longer term tests are being performed to improve the data base for setting stress levels for the screening creep tests.

Results from room temperature tensile testing are shown in Table 2.2 along with the available vendor values and the material specification minimum values. Results for coated* Inconel 617 and coated** Alloy 800H are also given. The data not previously reported include tensile results obtained by GE for IN-519, Mo-Re 2 and coated Alloy 800H. The GE results for IN-519 and Mo-Re 2 are within the specification requirements.

The tensile properties of coated Alloy 800H show that the yield and ultimate tensile strengths are unaltered by either the coating or the coating process. However, there is a degradation of tensile ductility, as shown by significant drops in the values reported for elongation and reduction of area. Nevertheless, it should be noted that the elongation value for the coated Alloy 800H specimen (44%) is well above the minimum specification value of 30% for uncoated Alloy 800H.

Similar behavior was reported for coated Inconel 617 in the last quarterly, C00-2975-25.

Short-time characterization creep-rupture testing in air of all of the NPH alloys has been completed. The results are shown in Table 2.3. (The samples shown as "In Test" are long-time tests (~1000 hours) being run in addition to the short-time characterization tests to improve extrapolation to long exposure times.) Stresses were selected to produce rupture in approximately 300 hours, and creep data were recorded during each test.

All of the characterization creep-rupture tests on four materials; IN-519, Mo-Re 2, coated Inconel 617 and coated Alloy 800H, were conducted during this quarter. In addition, new data for Incoloy 802 at 950°C (1742°F), for Incoloy

*Inconel 617 is coated with an aluminide coating similar to Codep B,
**Alloy 800H is coated with a platinum-chromium-aluminide type coating similar to RT-22.

TABLE 2.2

TENSILE ACCEPTANCE TEST RESULTS FOR NPH ALLOYS

Material	Condition For Test	Test Temp	ULTIMATE TENSILE STRENGTH						0.2% OFFSET YIELD STRENGTH						ELONGATION			REDUCTION OF AREA	
			Min. MPa	Spec. ksi	Vendor MPa	ksi	GE MPa	ksi	Min. MPa	Spec. ksi	Vendor MPa	ksi	GE MPa	ksi	Min. %	Spec. %	Vendor %	Vendor %	GE %
Alloy 800H	S.A. 1232°C	RT	450	65.0	520	75.5	515	74.8	170	25.0	186	27.0	153	22.2	30	55	52.0	69	69.3
		RT	450	65.0	-	-	531	77.0	170	25.0	-	-	158	22.9	30	-	59.0	-	65.4
Alloy 800H* (Coated)	S.A. 1232°C	RT	-	-	-	-	534	77.4	-	-	-	-	154	22.4	-	-	44.2	-	53.9
		RT	-	-	-	-	532	77.2	-	-	-	-	154	22.4	-	-	44.5	-	59.4
Incoloy 802	S.A. 1271-1282°C	RT	517	75.0	620	90.0	610	88.5	207	30.0	252	36.5	221	32.0	18	47	47.0	52	58
		RT	517	75.0	-	-	613	88.9	207	30.0	-	-	221	32.0	18	-	49.0	-	59
Incoloy 807	S.T. 1230°C/5min. WQ	RT	620	89.9	666	96.6	662	96.1	250	36.2	286	41.5	255	37.0	30	53.1	53.0	-	61.0
		RT	620	89.9	-	-	662	96.0	250	36.2	-	-	255	37.0	30	-	53.0	-	61.4
Incoloy DS	S.A. 1150°C/5min. AC	RT	480	69.6	600	87.0	600	87.0	170	24.6	227	32.9	221	32.0	30	53.1	54.0	-	73.1
		RT	480	69.6	-	-	600	87.0	170	24.6	-	-	221	32.0	30	-	53.0	-	73.1
HD-556	S.T. 1177°C/30min. WQ	RT	689	100.0	793	115.0	810	117.6	324	47.0	379	55.0	371	53.9	40	57.0	57.0	70	64.2
		RT	689	100.0	-	-	808	117.2	324	47.0	-	-	373	54.2	40	-	61.0	-	70.7
Manaurite 36XS	As-Cast	RT	441	64.0	534	77.5	569	82.5	245	35.6	310	44.9	269	39.0	8	15.5	15.3	-	15.4
		RT	441	64.0	-	-	585	84.8	245	35.6	-	-	268	38.8	8	-	16.0	-	16.2
Manaurite 900	As-Cast	RT	441	64.0	499	72.4	541	78.5	186	27.0	205	29.7	190	28.0	25	42.5	42.0	-	43.4
		RT	441	64.0	475	68.8	543	78.7	186	27.0	194	28.2	190	28.0	25	44	39.0	-	43.4
HK-40	As-Cast	RT	448	65.0	616	89.3	667	96.8	241	35.0	332	48.2	309	44.8	15	21	23.0	10.4	22.4
		RT	448	65.0	-	-	643	93.3	241	35.0	-	-	309	44.8	15	-	23.0	-	22.4
IN-519	As-Cast	RT	552	80.0	648	94.0	688	99.8	241	35.0	307	44.5	288	41.8	25	20	26.0	15.6	24.6
		RT	552	80.0	-	-	686	99.5	241	35.0	-	-	288	41.4	25	-	26.0	-	25.2
Hastelloy X	S.T. 1177°C/31min.	RT	689	100.0	765	111.0	776	112.5	276	40.0	345	50.0	358	52.0	35	49.0	49.0	53.0	61.0
		RT	689	100.0	-	-	772	112.0	276	40.0	-	-	357	51.8	35	-	49.0	-	60.5
Inconel 617	S.A. 1204°C (a)	RT	620	90.0	755	109.5	781	113.3	207	30.0	317	46.0	318	46.0	35	75	67.0	56.0	58.4
		RT	620	90.0	-	-	780	113.1	207	30.0	-	-	318	46.0	35	-	64.0	-	56.4
Inconel 617** (Coated)	S.A. 982°C	RT	-	-	-	-	767	111.3	-	-	-	-	324	47.0	-	-	44.8	-	45.9
		RT	-	-	-	-	776	112.6	-	-	-	-	329	47.7	-	-	41.4	-	37.4
Inconel 618E	S.T. 1232°C/1hr. WQ	RT	-	-	-	-	633	91.8	-	-	-	-	269	39.0	-	-	60.0	-	67.1
		RT	-	-	-	-	633	91.8	-	-	-	-	248	36.0	-	-	63.0	-	73.1
Mo-Re 2	As-Cast	RT	586	85.0	542	78.6	585	84.9	241	35.0	380	55.1	351	50.9	5	11.4	13.0	-	15.0
		RT	586	85.0	523	75.8	590	85.5	241	35.0	381	55.3	351	50.9	5	10.0	12.4	-	11.6
		RT	586	85.0	519	75.3	-	-	241	35.0	353	51.2	-	-	5	11.4	-	-	-
		RT	586	85.0	563	81.7	-	-	241	35.0	414	60.0	-	-	5	11.0	-	10.7	-
		RT	586	85.0	554	80.3	-	-	241	35.0	342	49.6	-	-	5	7.8	-	7.6	-
MA-956E ^(b)	S.A. 1330°C/1hr. AC	RT	-	-	-	-	796	115.5	-	-	-	-	786	114.0	-	-	13.0	-	41.6
		RT	-	-	-	-	800	116.0	-	-	-	-	786	114.0	-	-	12.0	-	39.1

(a) The solution annealing temperature is listed correctly as 1204°C; not 982°C which appeared in the previous quarterly report, C00-2975-25.

(b) A second heat was also procured, but will not be used for screening testing.

*Alloy 800H is coated with a platinum-chromium-aluminide type coating similar to RT-22.

**Inconel 617 is coated with an aluminide coating similar to Codep B.

TABLE 2.3

**CREEP-RUPTURE TEST RESULTS FOR LONG TIME
STRESS VERIFICATION FOR NPH ALLOYS**

Alloy	Condition For Tests (a)	Temp	Test Stress		Time to 1% Total Strain	Rupture Life	Elongation (%)	Reduction In-Area (%)
		(°C)	(MPa)	(Ksi)	(Hours)	(Hours)		
Alloy 800H	S.A. 1232°C	750	97	14.0	7.8	286.9 ^(d)	35.6	41.0
		850	45	6.5	3.6	306.8	62.9	64.1
		950	21	3.1	155	464.5	39.6	36.0
		1050	10	1.5	380	1005.4 Disc. (b)	7.7	5.5
		1050	14	2.1	4.6	141.3	26.5	22.9
Incoloy 802	S.A. 1271-1282°C	750	152	22.0	480	480.6	2.7	8.5
		850	86	12.5	350	433.7	3.7	5.6
		950	38	5.5	--	767.6	3.7	11.0
		1050	21	3.0	215	1493.2	13.5	15.8
		1100	12	1.8	145	820.8	11.9	40.7
Incoloy 807	S.T. 1230°C/5 min., W.Q.	950	55	8.0	~260	272.5	4.5	12.2
		750	145	21.0	2.7	100.2	85.8	73.0
		850	55	8.0	115	2257.4	34.4	43.5
		950	19	2.7	210	1002.7 Disc.	2.5	--
		1050	7	1.0	145	1103.3 Disc.	7.1	5.5
Incoloy DS	S.T. 1150°C/5 min., A.C.	1100	6	0.9	--	769.5 Disc.	--	--
		1050	12	1.8	77	409.9	10.1	9.6
		750	62	9.0	11.5	299.4	34.2	37.0
		850	32	4.7	97	495.1	28.9	30.6
		950	17	2.5	91	445.1	24.2	34.0
HD-556	S.T. 1177°C/30 min., W.Q.	1050	10	1.4	10.5	377.4	65.0	39.8
		850	38	5.5	9.7	194.3	36.2	34.4
		1050	6	0.9	--	In Test	--	--
		750	165	24.0	19	535 Disc.	51.0	57.1
		850	103	15.0	4.0	104 Disc.	67.4	75.8
HK-40	As-Cast	950	35	5.1	220	1535.0	34.9	48.2
		1050	17	2.5	128	543.1	28.4	39.2
		1100	10	1.5	20.5	469.5	36.3	40.0
		850	62	9.0	2.8	38.6	80.6	89.3
		750	103	15.0	815	1014.0	8.2	3.5
Manaurite 36XS	As-Cast	850	62	9.0	250	296.1	2.9	4.3
		950	28	4.0	240	530.1	2.0	3.3
		1050	17	2.5	225	346.9	2.5	4.3
		1100	15	2.2	73	94.8	8.5	5.3
		1100	7	1.0	--	In Test	--	--
Inconel 617	S.A. 1204°C	750	110	16.0	4.8	127	32.8	34.0
		850	97	9.0	11.7	369.7	29.6	32.3
		950	36	5.2	42.5	346.1	28.9	41.1
		1050	21	3.0	38	171.9	37.3	48.4
		1100	14	2.0	38.5	258.8	35.1	48.5
Hastelloy X	S.T. 1177°C/31 min., W.Q.	1100	9	1.3	--	In Test	--	--
		750	200	29.0	97	625.4	19.6	24.8
		850	72	10.5	20.5	1126.0	58.3	60.9
		950	48	7.0	6.7	333.6	46.9	46.9
		1050	21	3.0	125	1146.2	23.2	35.4
MA-956E	S.T. 1330°C/1 hr., A.C.	1100	15	2.2	70	722.5	34.9	33.9
		750	138	20.0	9.1	279.1	93.4	87.0
		850	69	10.0	22.5	417.3	84.8	91.0
		950	29	4.2	71	547.6	65.8	67.0
		1050	12	1.8	20	287.4	59.0	56.0
IN-519	As-Cast	1100	6	0.9	--	1088.7	65.4	63.1
		750	90	13.0	0.07% @ Disc	2733.2 Disc (c)	--	--
		850	79	11.5	~1000	1168.6	4.4	16.3
		950	69	10.0	130	1254.6	4.5	1.8
		1050	69	10.0	0.04 @ 10.0 hrs.	20.0	2.3	3.2
Mo-Re 2	As-Cast	1100	69	10.0	0.36 @ 35.3 hrs.	37.5	2.1	1.2
		1050	63	9.2	1350	2040.5 Disc.	--	--
		1100	57	8.3	~900	1034.0	2.1	3.5
		750	117	17.0	125	313.0	6.7	6.9
		850	68	9.8	90	311.6	5.4	11.2
Alloy 800H* Coated	S.A. 1232°C	950	37	5.3	530	717.9	4.9	8.8
		1050	18	2.6	170	744.3	11.4	27.6
		1100	11	1.6	140	666.3	19.5	29.7
		1100	7	1.0	--	In Test	--	--
		750	248	36.0	<0.1	7.2	22.9	29.4
Inconel 617** Coated	S.A. 1204°C	850	114	16.5	1.9	35.5	32.6	45.9
		950	51	7.4	17	159.3	17.0	24.0
		1050	23	3.4	95	285.1	6.7	6.5
		1100	17	2.5	125	200.8	4.6	7.6
		1100	10	1.5	--	In Test	--	--
Alloy 800H* Coated	S.A. 1232°C	750	97	14.0	0.7	203.4	50.2	59.1
		850	45	6.5	1.7	167.9	76.6	73.6
		950	21	3.1	3.8	387.8	46.8	37.9
		1050	14	2.1	4.3	101.6	24.5	23.6
		1050	10	1.5	--	581.4	22.8	23.9
Inconel 617** Coated	S.A. 1204°C	750	200	29.0	5.5	452.4	64.6	62.3
		850	72	10.5	7.5	In Test	--	--
		950	48	7.0	1.5	66.3	60.6	66.5
		1050	21	3.0	--	138.2	75.0	72.4
		1100	15	2.2	2.9	117.9	73.2	79.2

(a) S.A. - Solution Annealed
S.T. - Solution Treated

(b) Discontinued.

(c) Step loaded.

(d) Incorrectly reported as 333.8 in the last quarterly, C00-2975-25.

*Alloy 800H is coated with a platinum-chromium-aluminide type coating similar to RT-22.

**Inconel 617 is coated with an aluminide coating similar to Codep B.

807, Incoloy DS and HD-556 at 850°C (1562°F), and for MA-956E at 1050°C (1922°F) are reported.

The test results obtained for the Mo-Re 2 and IN-519 specimens agree reasonably well with the data supplied by the manufacturers. It should be noted that the ductility of the Mo-Re 2 specimens decreased greatly as the test temperature increased.

The time to rupture and the time to reach 1% total strain for coated Inconel 617 specimens were significantly less than those for uncoated specimens tested at the same temperature and stress. The time to reach 1% strain was also significantly less for coated Alloy 800H specimens than for uncoated specimens; the rupture lives for coated Alloy 800H samples were consistently shorter than for uncoated ones, but the decrease was much less severe than that observed for Inconel 617. Additional tests and microstructural studies are underway to further define the differences between the uncoated and coated specimens. Although degradation of base alloy properties would be unacceptable for commercial applications, the coated specimens will be tested in the screening program to determine the effectiveness of coating to reduce potential carburization or oxidation of the base alloys.

2.2.1.3 Materials Joining Studies

Varestraint tests were completed during this quarter for all eleven (11) alloys included in the joining studies program. These tests were performed to evaluate the tendency for hot cracking in autogeneously welded specimens. Analysis of the results indicate that, in order of decreasing resistance to hot cracking, the ranking of the alloys is as follows:

<u>Alloy</u>	<u>Hot Cracking Sensitivity</u>
Inconel 617	Least sensitive to hot cracking
Incoloy 802	
IN-519	
Manaurite 36XS	} comparable
Incoloy 807	
Incoloy 800H	} comparable
Hastelloy X	
HD-556	
HK-40	
Incoloy DS	
Mo-Re 2	Most sensitive to hot cracking

The fabrication of the eleven weldments for long time thermal exposure in the screening program has been completed, as previously reported.

2.2.2 Direct Cycle Helium Turbine (DCHT) Alloys - (E.W. Ross)

2.2.2.1 Materials Procurement

Alloys/Processes - The procurement of all DCHT alloys/processes was completed by June 1978.

Surface Treatments (Coatings and Preoxidation) - All of the remaining surface treatments for DCHT alloys were completed during this quarter. Seven (7) TZM alloy creep specimens and twenty (20) structural stability pins have been received following the application of the W3 coating by Chromalloy American Corporation. Preoxidation treatments of Rene' 80, M-21 and coated (Codep B) Alloy 713LC structural stability specimens have been completed. The specimens were exposed for 10 hours at 1050°C (1922°F) in a hydrogen atmosphere with a specified dew point of -42°C (-45°F). The dew point was measured at -46°C (-50°F), in line with the desired exposure conditions. These dew points, which are the equivalent of a H₂ to H₂O ratio of ~ 10,000:1, should allow Al and Ti rich oxides to form, but not Cr oxides. These oxides will be stable in the atmosphere to be used for screening testing, where the oxidation potential is considerably higher.

2.2.2.2 Materials Characterization

This subtask was completed and final results reported in the Progress Report for July 1, 1978 to September 30, 1978, report number C00-2975-25.

2.3 TASK 3 - TESTING AND ANALYSIS FACILITIES AND EQUIPMENT - (D.H. BALDWIN)

2.3.1 Testing Equipment

2.3.1.1 Multi-Specimen Screening Creep Equipment

Equipment for load calibrations of multi-specimen creep stands is in place. Six miniature load cells have been procured and calibrated against traceable standards. Threaded rod substitute load bars and universal joints allow these load cells to be installed inside the retort in place of specimen strings. This set-up permits the system to be calibrated directly to the desired test loads with all strings loaded simultaneously and all sliding seals in position. This system was chosen because it best simulates actual testing conditions.

A number of temperature surveys have been made in empty multi-specimen creep test stand retorts in order to verify hot-zone length. As anticipated, the axial position of control thermocouples inside the retort relative to the

controlled heater elements outside the retort is critical in determining the temperature profile. The temperature measurements were made with a He flow of 10 l/min., which is the planned flow rate for testing. A maximum hot-zone length of 99 cm (39 in.) in which the temperature varied by no more than $\pm 2^{\circ}\text{C}$ ($\pm 3.6^{\circ}\text{F}$) was found. Care was taken to obtain these temperature measurements at radial locations corresponding to specimen stringer centerlines. No attempt has been made to date to determine radial temperature distributions, since it is expected that these will be strongly influenced by the presence of specimens and couplings.

The device for measuring length changes in multi-specimen creep specimens was completed during the report period. Preliminary calibration of the complete device indicates linearity and accuracy are within 0.0025 mm (0.0001 in.) as expected. Final calibration will be carried out early in the next quarter. The length change measurements allow creep strain to be calculated.

2.3.1.2 Thermal Stability Testing Equipment

Axial temperature profiles have been established for the eight structural stability retorts by placing the control thermocouples at positions to maximize the hot-zone length. As expected, control thermocouple location within the retort is critical. Temperatures were measured in a stainless steel tube temporarily installed at approximately the radial position corresponding to the outermost position to be occupied later by test specimens. A hot-zone length of 96.5 cm (38 in.) within $\pm 3^{\circ}\text{C}$ ($\pm 5.5^{\circ}\text{F}$) could be attained. Temperature profiles will now be made in the radial direction for these stands. For these measurements, the furnaces will be loaded with dummy specimens to better simulate actual operating conditions.

Three of four furnaces required for the parallel thermal stability tests for specimens exposed in air have been set up. Temperature profiles for these vertical tube furnaces will be measured during the next quarter.

It was found necessary to make a small revision to the lower end cap of each thermal stability test retort. The change was the addition of a gas stream deflector over the helium inlet. The original construction was such that a jet of cold helium was produced to a considerable height into the retort, causing difficulties in temperature distribution and control. A small stainless steel gas stream diverter has proven completely satisfactory.

2.3.1.3 Single Specimen Creep/Rupture Equipment

During the report period, the last five single specimen creep/rupture test stands were delivered, assembled, and set in place. Furnace control panels for 31 of the 45 test stands have been installed.

2.3.2 Retort Bakeout and Conditioning Tests

2.3.2.1 Bakeout Tests

The first bakeout test performed was on a structural stability retort and afforded the opportunity to establish the rate and amount of moisture driven off when a cold ceramic retort is heated after being open to atmosphere at room temperature. As expected, maximum H_2O removal begins at $\sim 100^\circ C$ ($212^\circ F$) and decreases as temperature increases.

More detailed tests involving constant monitoring of retort exhaust by gas chromatography revealed that in addition to moisture bakeout, trace amounts of CH_4 , CO , and CO_2 are driven off during heating. These latter evolutions occur in the temperature ranges $227-1050^\circ C$ ($441-1922^\circ F$), $227-663^\circ C$ ($441-1225^\circ F$), and $437-597^\circ C$ ($787-1107^\circ F$), respectively.

2.3.2.2 Conditioning Tests

Preoxidation, or conditioning, of the single creep stand retorts was initiated. The conditioning is accomplished by bubbling H_2 through distilled water, cooled to obtain H_2 to H_2O ratios between 160:1 and 80:1. This range is consistent with the oxidation potential to be used in screening testing. The method provides sufficient water to preoxidize a retort in two to six hours.

The conditioning process is controlled by monitoring the relative H_2O level in the retort outlet gas. When it approaches its initial value (i.e., the retort inlet value), the conditioning is assumed to be finished. The conditioning gas is flushed through the retort for a sufficient time to assure that the reaction is substantially completed.

A test was run with conditioned couplings to see if the preoxidation treatment would prevent specimen bonding at temperature under load. A conditioned ST retort was loaded with a Hastelloy X specimen, purged, baked out and ramped to $1050^\circ C$ ($1922^\circ F$) under He with ~ 440 ppm H_2 . The sample was stressed at 10.34 MPa (1.5 ksi) and held for over 160 hours at temperature under load. No detectable diffusion bonding was found on disassembly.

2.3.3 Analysis Equipment

2.3.3.1 Gas Chromatograph for Loop No. 1

The Antek Model 320D gas chromatograph was received back from repair by the vendor. The repairs included equipping the unit with leaktight fittings and new detector foils and bodies. The detector was reinstalled in the console, and the sensitivity was shown to be satisfactory.

2.3.3.2 Portable Gas Analysis Station

Calibration of the Carle 111 gas chromatograph has been performed by analyzing He containing ppm concentrations of H_2 , Ar, N_2 , CO, and CH_4 . The assumption is made that peak area is directly proportional to concentration for each gas species. With this method, the threshold detection limits are 10 ppm for H_2 and 1-2 ppm for the other named gases.

Also, it has proven feasible to utilize this instrument to measure high concentrations of H_2O (0.1-3%). This requires elevated column temperature (105°C) and involves comparatively long elution times (8 mins.), but has proven very useful in the control of retort conditioning.

2.4 TASK 4 - SIMULATED REACTOR HELIUM ENVIRONMENT FACILITIES AND EQUIPMENT

2.4.1 Helium Distribution System - (D.H. Baldwin)

2.4.1.1 Pumping, Purification, and Analysis Station (PP&A) No. 1

Operation of the PP&A during shakedown and commissioning tests has indicated some areas where improvements in the facilities would increase operational efficiency or circumvent potential problems. These are summarized in the following paragraphs:

- Water Injection Cooling System

Water additions to the He supply are accomplished by passing a small amount of loop He through a canister containing hydrated oxalic acid. The amount of moisture added to the He depends on the oxalic acid temperature,

since the temperature establishes saturation conditions (pressure is fixed). The refrigeration unit originally designed for controlling the canister temperature (by cooling an ethylene glycol bath) was found to be unreliable and difficult to adjust to maintain a fixed bath temperature. A new self-contained refrigeration unit was selected to solve these difficulties. This unit has a thermostatically controlled pump which can respond to varying heat loads to keep the bath cooled to a specific operating temperature.

- Purification Canister Temperature Control

The completed helium distribution system (two loops) will contain several heated purification canisters: two containing Cu in each PP&A; one containing CuO in each PP&A; and two containing Ridox* in the back-up gas purification stand, for a total of eight canisters. Each of these is controlled by a separate temperature controller. During shakedown operations one of these controllers failed, causing a Cu containing canister in PP&A No. 1 to overheat.

As a result of this incident, it was decided to equip each purification canister heater with an independent over-temperature controller. In addition, a readout device will be added, permitting periodic checking of furnace temperature. Necessary parts have been obtained and will be installed during the next quarter.

- Impurity Gas Addition

The impurity gas addition system is arranged with parallel legs for each of the four impurity species, H_2 , CO, CH_4 and CO_2 , as is shown in Figure 2.1a. The parallel leg system was designed to allow a small steady flow of impurity gases through each leg with a single micrometering valve (MV) and larger, pulsed additions, when necessary, through each leg with a second micrometering valve (MV) and solenoid valve (SV) in series. Preliminary characterization of valves MV-1 through MV-8 identified a response time problem. When one of these valves was opened momentarily to admit a "burst" of impurity gas to the He, several hours were required for all of the gas to be injected, despite the existence of a 1 atm. pressure differential across the valve. Apparently the impurity gas molecules were concentrating in the "dead" volume of the downstream side of the addition valves and the interconnecting tubing, then diffusing into the He stream over long periods. It was felt that this situation would make gas composition control difficult or impossible during

*Registered Trademark; high surface area Cu.

A. ORIGINAL CONSTRUCTION

B. REVISED CONSTRUCTION

KEY:

	MICROMETERING VALVE (MV)		FLOW METER
	SOLENIOD VALVE (SV)		PRESSURE GAUGE

Figure 2.1. Impurity Gas Addition System Schematic

periods of major perturbations such as the addition or removal of large retorts to the dynamic loop. Accordingly it was decided to revise the gas addition plumbing so as to provide a continuous fast flow of loop He through all downstream regions of the impurity addition valves and their connecting piping. Modifications to the impurity addition valves themselves as well as piping were required and were completed.

Valves were modified by the addition of an inlet port to the downstream side of the valve body. A flow of He into this port and out through the existing outlet of the valve provides a continuous sweep of all the impurity gas molecules which the valve passes into the helium stream. Figure 2.1 shows the total plumbing revisions to the impurity gas addition system. Note that the original design added impurity gases to the He supply header. The revised design routes impurity additions to the return receiver. This means that additions are diluted by both return and discharge receiver contents (~100 l of He) before reaching either a test retort or an analysis point in the system. This greatly reduces the chance of a test retort seeing a concentration spike of impurity gas.

Also note that the solenoid valves have been located upstream of the metering valves. This was done to reduce dead volume between the metering and solenoid valve seats and thereby reduce the volume of impurity gas available to bleed through the metering valve when the solenoid valves are cycled. This change in dead volume is not apparent from the schematic diagram in Figure 2.1. Finally, it was possible to accomplish the indicated replumbing without changing the positions of the various components in the graphic panel, so the appearance of the control console is unchanged and operation logic also is unchanged. Post-revision tests indicated that impurity additions to the system are fully diluted within ten minutes of addition valve closure, so the revisions are considered completely successful.

2.4.1.2 Helium Loop No. 2

Although commissioning of Loop No. 1 has received highest priority during the report period, progress has been made on installation of Loop No. 2. A list of constructional activities follows:

- Electrical installation of PP&A No. 2.
- Plumbing connections to PP&A No. 2 He, impurity gases, compressed air, and cooling H₂O).

- Partial revisions of original construction of PP&A No. 2 to improve problem areas identified in PP&A No. 1. This includes welding of threaded joints in main He supply line and initial steps of impurity gas flow path modifications.
- Installation of utility frame subassemblies for the remaining 35 of 45 single specimen creep/rupture stands.
- Connection of cooling water system to all test stands.
- Installation of 21 of 35 furnace control panels.

2.4.2 Equipment Characterization and Commissioning - (R.K. Elton)

2.4.2.1 Calibration of the Gas Chromatograph for Loop No. 1

The response of the Loop No. 1 gas chromatograph (Antek Model 320D) to large variations in impurity gas concentrations was characterized in a series of exponential dilution experiments. The ranges where the detector response is a linear function of impurity gas concentrations are shown below:

<u>Gas</u>	<u>Concentration Range</u>
H ₂	1000 to 60 μ atm
N ₂	50 to 0.4
CH ₄	200 to 0.8
CO	200 to 1.0
O ₂	100 to 0.2

The CO₂ level is measured with a separate column (the detector has two columns); also, it is now possible to measure H₂O along with CO₂. For routine operation, the gas chromatograph will be calibrated with two calibration gas mixtures, one with impurity gas levels higher than the loop gas and the other with lower impurity levels. Preparations are now being made to accomplish this.

The reproducibility of the gas chromatograph readings has been improved by constraining the detector foils from rotating and operating the detector at a voltage at which it is not sensitive to small voltage variation.

2.4.2.2 Impurity Gas Addition Rate Characterization

Initial experiments with the loop included the characterization of the impurity gas addition valves. This was first attempted by adding gases at known valve settings for known times to the circulating He in the loop. Changes in impurity gas levels in the loop then enabled a calculation of flow rate through

the valve. The response time to detect a change in impurity gas levels in the loop after a valve setting was made was extremely slow. This led to the positive valve flushing system described in Section 2.4.1.1. Once the detection response time was reduced, it became apparent that the gas additions were not reproduced by returning the valve stem to given settings. The valves were tested by connecting a vacuum chamber to their outlet. The valve stem was then positioned at a setting and the pressure rise in the chamber monitored. It was determined that for most of the valves, widely varying non-linear flow was normal. Disassembly of the valves revealed that scratches on the internal portion of the valve stem were the apparent cause of their irreproducible response. New valves were procured to replace the defective ones, characterized using the vacuum chamber method and plumbed into place in the loop. Testing has shown that the new valves are an effective improvement. They operate in a reproducible manner and are characterized by simple valve setting versus flow rate (impurity gas addition rate) curves.

2.4.2.3 Gas Purification System Characterization

Tests to characterize the getter performance were initiated. For given loop by-pass flow rates, the changes in loop impurity gas levels were monitored with specific getters or combinations of getters in operation. It was determined that the molecular sieves remove only CO_2 and H_2O with good efficiency, that H_2 is removed, along with other gas, with a freshly regenerated activated charcoal trap, and that, while CH_4 is not efficiently removed by the molecular sieves, it is efficiently removed by the liquid nitrogen-cooled, activated charcoal trap.

The characterization tests were run with higher flow rates than are anticipated for loop operation. The removal efficiencies for all getters were more than adequate. They will be even better at the slower flow rates for operation.

2.4.2.4 Attainment of Specified Loop Gas Chemistry

Once some experience with the gas addition and purification systems had been gained, the loop was brought to a dynamic gas chemistry with impurity gases being added through the metering valves and removed at the same rate by the purification system. This was achieved by bringing the loop gas to the desired composition, and then opening a getter. The change in concentration for each gas was then compensated for by changing the setting on the micrometering

valve in the impurity gas addition system. Following this procedure, six days were needed to bring all the getters on line while maintaining a balanced loop chemistry. The loop was run at the dynamic equilibrium for five days further without problem.

After this initial operating period, a single specimen (ST) retort was brought on line at 650°C (1200°F). Slight amounts of CH₄, H₂O, and CO₂ were depleted during the initial stages, but all were adequately controlled and overall loop chemistry maintained for a period of seven more days.

At this point, another single specimen (ST) retort at 1050°C (1920°F) and then a multi-specimen creep (MS) retort at 850°C (1562°F) were put on line. Significant depletion of CO₂, H₂O, and CH₄ was noted during this period of operation.

Preparations are being made to bring additional retorts on line in the next few weeks.

2.5 TASK 5 - MECHANICAL PROPERTIES EVALUATION

2.5.1 Test Specimen Machining

Machining of all of the test specimens required for the screening test program was completed by September 1978.

2.5.2 Selection of Stresses for Screening Creep Tests

Based on the 300-hour creep and rupture test results, stresses were selected for the following three types of screening creep tests:

1. Stress for 1% total strain in 100,000 hours; tested for 10,000 hours.
2. Stress for 1% total strain in 6,000 hours; tested for 6,000 hours.
3. 80% of the stress for rupture in 10,000 hours; tested for 3,000 hours.

During the screening tests the amount of creep on each sample will be measured at 1,000 hour intervals, following which the samples will be rehung at the same load unless excessive creep is occurring. In this case, the specimen will be removed from test and replaced in the stringer by a new specimen.

2.5.2.1 Direct Cycle Helium Turbine (DCHT) Alloys - (E.W. Ross)

The selection of stresses for all DCHT alloys was completed and reported in the Quarterly Report for the previous quarter, July 1, 1979 to September 30, 1979, report number C00-2975-25.

2.5.2.2 Nuclear Process Heat (NPH) Alloys - (S.Z. Hayden and R.A. Ellis)

A partial listing of stresses selected for NPH alloys was included in the previous quarterly report. Table 2.4 shows an appended listing based on new data available from materials stress verification testing completed during this quarter. Since, in addition to the scheduled 300-hour stress verification testing, a few longer term creep-rupture tests are being run at 850°, 950° and 1050°C (1562°, 1742° and 1922°F) for a limited number of alloys, further minor revisions may be appropriate when those results are available.

New desired stresses for screening creep testing were selected and are shown for Alloy 800H, Incoloy 807, IN-519, Mo-Re 2 coated Alloy 800H and coated Inconel 617. In addition, test stress levels were established for MA-956E, which exhibited very low creep strain during stress verification testing (i.e., essentially all of the elongation occurred just prior to rupture). To take this into account, the stresses for 1% total strain in 100,000 and 6,000 hours at all temperatures have been estimated as 80% of the stress required for rupture in those times.

Based on the desired stress levels for each alloy, loading schedules for screening (multispecimen) creep testing will be laid out. The actual testing stress will be set as near as possible to the desired stress levels for all specimens in any specimen stringer. Since there will be up to 15 specimens per stringer, all at the same stress, specimens will be grouped accordingly. The loading schemes will be completed during the next quarter.

2.6 TASK 9 - DATA MANAGEMENT AND PROGRAM MANAGEMENT

2.6.1 Data Management - (R.B. Hand)

2.6.1.1 Data Acquisition Procedures

During this reporting period, two PAMMED updates were issued. These replaced the When-Where-What and Environmental History forms with Specimen

TABLE 2.4

CALCULATED STRESSES FOR NPH SCREENING CREEP TESTS*

Alloy	Temperature °C	Stress for 1% ϵ_T in 100,000 Hours				Stress for 1% ϵ_T in 6,000 Hours				Stress for 80% σ_R in 10,000 Hours			
		Original		Final		Original		Final		Original		Final	
		MPa	KSI	MPa	KSI	MPa	KSI	MPa	KSI	MPa	KSI	MPa	KSI
Alloy 800H	750	34	5	34	5	48	7	48	7	48	7	48	7
	850	21	3	14	2	28	4	21	3	21	3	21	3
	950	3	0.4	2	0.3	7	1	7	1	7	1	7	1
Incoloy 802	750	55	8	55	8	83	12	83	12	69	10	90	13
	850	21	3	21	3	48	7	34	5	28	4	41	6
	950	7	1	7	1	14	2	14	2	14	2	14	2
Incoloy 807	750	41	6	41	6	69	10	62	9	69	10	69	10
	850	14	2	14	2	28	4	28	4	28	4	28	4
	950	5	0.7	3	0.6	7	1	7	1	14	2	14	2
	1050	1	0.2	1	0.1	3	0.4	3	0.4	3	0.4	4	0.6
Incoloy DS	750	14	2	21	3	28	4	34	5	28	4	34	5
	850	7	1	7	1	14	2	14	2	14	2	14	2
	950	3	0.4	3	0.4	5	0.7	5	0.7	7	1	7	1
HD-556	750	48	7	41	6	33	12	62	9	76	11	96	14
	850	14	2	21	3	34	5	28	4	34	5	48	7
	950	5	0.7	6	0.9	14	2	14	2	14	2	21	3
	1050	1	0.2	1	0.2	3	0.4	4	0.6	4	0.6	6	0.8
Manganese 36XS	750	41	6	41	6	62	9	55	8	62	9	55	8
	850	21	3	21	3	28	4	34	5	34	5	34	5
	950	7	1	7	1	14	2	14	2	14	2	14	2
	1050	2	0.3	3	0.4	6	0.8	6	0.9	7	1	7	1
HK-40	750	55	8	48	7	90	13	69	10	48	7	62	9
	850	21	3	21	3	34	5	34	5	28	4	34	5
	950	7	1	7	1	14	2	14	2	14	2	14	2
	1050	3	0.4	3	0.4	5	0.7	6	0.9	7	1	7	1
IN-519	750	48	7	55	8	69	10	76	11	62	9	69	10
	850	21	3	28	4	41	6	34	5	34	5	34	5
	950	7	1	7	1	21	3	21	3	14	2	14	2
	1050	3	0.4	2	0.3	7	1	7	1	7	1	6	0.8
Hastelloy X	750	34	5	34	5	55	8	55	8	62	9	69	10
	850	14	2	14	2	21	3	28	4	28	4	28	4
	950	4	0.6	4	0.6	7	1	7	1	14	2	14	2
	1050	1	0.1	1	0.1	2	0.3	3	0.4	3	0.4	3	0.5
Inconel 617	750	55	8	62	9	83	12	90	13	96	14	96	14
	850	21	3	28	4	34	5	41	6	41	6	48	7
	950	7	1	14	2	14	2	21	3	21	3	21	3
	1050	4	0.6	3	0.4	7	1	7	1	7	1	7	1
Mo-Re2	750	34	5	55	8	48	7	76	11	131	19	90	13
	850	21	3	28	4	28	4	41	6	55	8	48	7
	950	14	2	14	2	21	3	21	3	21	3	21	3
	1050	7	1	6	0.8	14	2	7	1	7	1	7	1
MA-956E	850	55	8	48	7	62	9	55	8	69	10	55	8
	950	48	7	41	6	55	8	48	7	55	8	48	7
	1050	34	5	34	5	41	6	41	6	48	7	41	6
Alloy 800H** Coated	750	34	5	21	3	48	7	28	4	48	7	41	6
	850	21	3	7	1	28	4	14	2	21	3	14	2
	950	3	0.4	1	0.1	7	1	3	0.4	7	1	7	1
Inconel 617*** Coated	750	55	8	34	5	83	12	55	8	96	14	76	11
	850	21	3	14	2	34	5	28	4	41	6	34	5
	950	7	1	6	0.8	14	2	14	2	21	3	14	2
	1050	4	0.6	1	0.2	7	1	4	0.5	7	1	7	1
Test Time		10,000 Hrs.				6,000 Hrs.				3,000 Hrs.			

*Stresses for 850, 950 and 1050°C may be revised based on the results of long-time, high-temperature creep-rupture tests now in progress.

**Alloy 800H is coated with a platinum-chromium-aluminide type coating similar to RT-22.

***Inconel 617 is coated with an aluminide coating similar to Codep B.

History, Machine History and Gas Composition History forms to facilitate use by laboratory personnel and provide an improved way of tracking specimens. A Vareststraint Weld form also was provided. Additional codes were added for weld alloys, vendors and processes.

2.6.1.2 Data Storage and Retrieval Procedures

The development of a complex data retrieval program has been circumvented by taking advantage of the GE Information Service Company's Mark III commercial time-sharing system which provides such a program in their DMS II Data Management System.

2.6.1.3 Data Analysis

Several available time-sharing data plotting, curve plotting and data analysis programs which will be useful for this program have been identified. Instructions for the use of these programs will be written and issued to program personnel.

2.6.2 Program Management

Seven program coordination meetings were held with the High Temperature Reactor Materials Testing Laboratory personnel during the reporting period; three in October, two in November and two in December 1978. In addition, four program review meetings were held for General Electric Company management including a meeting with the Vice President and General Manager of the Energy Systems and Technology Division on October 17, 1979.

Other meetings relative to the program that were held during the reporting period were:

- October 13 Schenectady, NY, Dr. A. Naoumidus, Kernforschungsanlage, IRW, Julich, FRG Program Review and discussion of structural analysis techniques.
- October 18 Schenectady, NY, Dr. Sainfort, Commissariat A L'Energie Atomique, Grenoble, France and 4 colleagues from Saclay to review the French Advanced TGR Program.

- October 23 Schenectady, NY, Program Review for DOE (J.E. Fox, Program Manager and E. Gallagher, COO), GCRA (S. Penfield). Discussion of DOE TGR program redirection.
- October 25 Schenectady, NY, Dr. D. Lupton, Kernforschungsanlage/IRW, "Julich, FRG Program, Review/Exchange.
- October 26 Schenectady, NY, Dr. Bauer, Brown, Boveri and Cie, Mannheim, FRG Program, Review/Exchange.
- October 30 Washington, DC, DOE Headquarters/International Program Review.
- October 31 Schenectady, NY, Dr. P. Rittenhouse, Kernforschungsanlage/IRW, "Julich, FRG, Program Review, International Program.
- November 27,28 Schenectady, NY, Dr. G. Henrich, Kernforschungsanlage/PTH and Dr. F. Schubert, Kernforschungsanlage/IRW, International Program Review.
- December 5 Washington, DC, DOE Headquarters, Discussion of DOE TGR Program redirection.

A planning document incorporating program recommendations for the Advanced Gas Cooled Nuclear Reactor Materials Program was prepared and forwarded to DOE and GCRA on November 10, 1978.

The Program Master Schedule is presented in Figure 2.2.

Section 3.0

WORK TO BE COMPLETED DURING THE NEXT QUARTER

3.0 WORK TO BE COMPLETED NEXT QUARTER

- Multi-specimen screening creep furnace loading plans will be finalized.
- Commissioning tests for Loop No. 1 will be completed.
- Installation of Loop No. 2 will be continued.
- The screening creep and structural stability test program will be initiated.
- Weekly data input to the data management system will be initiated.