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EIGHTH PROGRESS REPORT

TO

MATERIALS LABORATORY

WRIGHT AIR DEVELOPMENT CENTER

ON

EFFECT OF PRIOR CREEP ON MECHANICAL PROPERTIES OF AIRCRAFT STRUCTURAL METALS

by

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SUMMARY

This report covers progress under Contract AF 33(616)-3368 for the period from January 1, 1958 to March 31, 1958 on a study of the effect of prior creep on the short-time mechanical properties of aircraft structural sheet metals. The materials under study include 17-7PH (RH 950 condition) precipitation hardening stainless steel and a titanium alloy, Ti-2.5 Al-16V.

During this report period a Summary Report on studies of 17-7PH (TH 1050 condition) was reproduced and distributed and a Summary Report on C110M titanium was written and submitted to the Materials Laboratory, WADC, for approval.

Experimental work accomplished during this period included continuation of development of stress-strain recording equipment for use in tension-impact tests and the initiation of studies of 17-7PH in the RH 950 condition. The base properties of this alloy have been established in tension at room temperature, 600°, 800°, and 900°F. Exposure of this material for 10 or 100 hours at 600°, 800°, or 900°F indicates that the room temperature tensile and yield strengths were increased and the ductility decreased.

The creep-deformation characteristics of 17-7PH (RH 950) have been established at 600°, 800°, and 900°F for deformations from 0.2 to 2.0 percent in time periods up to 100 hours. Room temperature tensile tests on completed creep specimens indicate severe losses in ductility followed prior creep at 600°F.

INTRODUCTION

The eighth progress report to be issued under Air Force Contract AF 33(616)-3368 covers the period from January 1, 1958 to March 31, 1958 and is the first report to be issued under Supplemental Agreement No. 3(58-1715) to the basic contract.

The purpose of this investigation is to study the effects of prior elevated-temperature creep-exposure on the mechanical properties of aircraft structural sheet alloys. Previous phases of this contract included systematic evaluations on 2024-T86 aluminum, (Ref. 1) 17-7PH (TH 1050 condition) stainless steel, (Ref. 2), and C110M titanium (Ref. 3).

Under the present supplement to the contract, background data are to be accumulated on the 17-7PH stainless steel in the RH 950 condition and on a Ti-2.5 Al-16V alloy. These studies will permit evaluation of the effects of initial heat treatment on a given material (17-7PH stainless steel) and of the characteristics of two different titanium-base alloys. In addition, analyses of previous data and special experiments are to be undertaken in order to elucidate the basic principles governing the influence of prior creep on mechanical properties.

The evaluation of the two new materials is to be conducted in approximately the same manner as the three materials previously studied. That is, specimens are to be exposed either unstressed or stressed for periods up to 10C hours at temperatures either low, intermediate, or high in the creep range. It is expected that the temperatures to be used will be 600°, 800°, or 900°F. In either case, exploratory tests, metallurgical analyses and practical service conditions may dictate substitution of other temperatures.

The primary exposures will be to zero, 0.2, 0.5, 1.0, and 2.0 percent nominal creep deformations in time periods of 10, 50, or 100 hours. This practice represents a change from previous evaluations which were based on total deformations of 0.5 , 1.0, 2.0, and 3.0 percent. Loading deformations will also be determined, thus permitting the calculation of total deformation. The emphasis of the investigation on creep deformation will focus attention on the effects of smaller amounts of plastic strain than were previously studied. In a few cases, however, it is anticipated that there may be appreciable plastic strain in loading. Thus, it may prove worthwhile to correlate some results in terms of total plastic strain or to attempt to separate effects of short-time plastic strain from those due to creep strain.

Due to inherent variations between specimens and in testing procedures the basic exposure will employ the average stress determined to give the required creep in the specified time period. Correlations will then be made on the basis of actual deformation in all cases.

Following the exposures the following mechanical properties are to be determined: Tensile properties, compression yield strength, tension-impact strength and cold-bend ductility. The tensile, compression, and tension-impact tests will be conducted at room temperature and at the temperature of creep-exposure.

The properties of the exposed material are to be compared with the properties of unexposed material as established by six or more tests of samples chosen at random from the various sheets of the 0.064-inch thick test stock. The specimen blanks are to be cut from the sheets in the nominally weaker direction. Thus, the stainless steel is to be tested transverse to the sheet rolling direction, while the titanium alloy is to be tested parallel to the sheet-rolling direction.

The Ti-2.5 Al-16V alloy is to be tested in the aged condition as furnished by the manufacturer, while the 17-7PH alloy is heat treated to the RH 950 condition at the University. This treatment involves a solution treatment, refrigeration and an aging treatment.

For greater ease in the planning and reporting of the research, the program has been arranged so that it can be carried out to provide information on a series of topics. Each topic or sub-project, may or may not provide enough data to warrant individual reporting; however, such separation of the over-all effort will facilitate the focussing of attention on individual factors which affect the mechanical behavior of materials after exposure to creep conditions.

The following list indicates the nature of the topics under consideration:

1. Relation of Heat Treatment to Alteration by Prior Creep of Mechanical Properties of a Heat Treatable Stainless Steel (A study of 17-7PH (RH 950 condition) with comparison to the TH 1050 condition).

2. Metallurgical Characteristics of Titanium Sheet Alloys Governing Alteration of Mechanical Properties by Prior Creep (A study of Ti-2.5 Al-16V with comparison to C110M).

3. Anamalous Effects of Prior Creep on Compressive and Tensile Stress Strain Characteristics of Aircraft Structural Sheet Alloys (A further investigation of Bauschinger-type effects previously observed).

4. Evaluation of the Influence of Prior Creep on the Tensile and Cold-Bend Test Ductility of Aircraft Structural Metals.

5. Tension-Impact Stress-Strain Characteristics of Aircraft Structural Sheet Alloys After Prior Exposure to Creep.

6. Metallurgical Factors Controlling the Influence of Prior Creep on Mechanical Properties of Aircraft Structural Metals.

7. The Role of Creep Recovery in Aircraft Structural Sheet Alloys Exposed to Creep.

TEST MATERIALS AND SPECIMEN PREPARATION

The materials specified to be tested in this investigation are 17-7PH in the RH 950 condition and Ti-2.5 Al-16V alloy in the solution-treated and aged condition. Treatment details for the two materials are given below.

The specimen blanks are sampled at random from among the various sheets of test stock. The repetition of a basic panel sampling and numbering scheme enables identification to be made of the original location of any test specimen. The details of this scheme were given previously (Ref. 2) and will not be repeated.

All specimens for exposure are machined slightly oversize in the gage section. The excess stock is then removed prior to mechanical testing in order that edge effects, if any, associated with the exposure could be eliminated.

17-7PH (RH 950)

Sixteen sheets of 17-7PH precipitation hardening stainless steel were purchased from the Armco Steel Corporation in the early part of 1956. All material received was from Heat No. 55651. The material was supplied in sheets 0.064-inches thick by 36 inches by 120 inches in No. 2D finish and in Condition A. Condition A consists of annealing at 1925°F followed by air cooling.

The certified chemical analysis furnished for this material follows:

Element	Nominal (percent)	Actual (percent)
Carbon	0.09 Max	0.072
Manganese	1.00 Max	0.55
Phosphorus	0.04 Max	0.018
Sulfur	0.03 Max	0.011
Silicon	1.00 Max	0.33
Chromium	16.00-18.00	17.03
Nickel	6.50- 7.50	7.25
Aluminum	0.75- 1.50	1.28
Iron	Balance	Balance

For tests conducted on the TH 1050 condition of this alloy, (Ref. 2) sheets numbered 1, 2, and 3 were completely consumed, while sheets 4, 5, and 6 were partially consumed. The balance of the untreated specimen blanks from sheets 4, 5, and 6 have been treated to the RH 950 condition, while additional specimens are to be prepared from sheets 7 and 8.

Heat treatment to the RH 950 condition was carried out at the University using the following sequence on batches consisting of six bundles, each containing six one-inch wide specimen blanks 22 inches long.

1. Condition A material heated in a gas-fired furnace for 10 minutes at 1750°F ± 15°F; followed by Air Cooling.
2. 2-hour delay
3. Refrigeration at -100°F for 8 hours. (This step accomplished in a 36-inch deep stainless steel Dewar Flask containing a saturated acetone-dry ice mixture.)
4. 30-minute delay
5. Reheat at 950°F ± 10°F for 1 hour in a recirculating air furnace; followed by Air Cooling.

The time delays employed in steps 2 and 4 were adopted merely for consistency in processing and ease in scheduling. Heat treatment studies carried out by the producer of the material to develop optimum properties (Refs. 4 and 5) showed that delay times were not especially critical.

<u>Ti-2.5 Al-16V</u>

The Ti-2.5 Al-16V alloy is to be obtained from stock produced by the Mallory-Sharon Metals Corporation for the Department of Defense Sheet Rolling Program. Notification of expected delivery date has not yet been received. Three sheets of material 0.063-inches thick by 36 inches wide by 96 inches long have been allocated for the present investigation. The material is specified to be furnished in the solution treated and aged condition following hot rolling, annealing, and cleaning. Heat treatment temperatures and times are not yet available.

EQUIPMENT AND PROCEDURES

Wherever applicable, ASTM Recommended Practices are adhered to in test procedures. Other testing details follow practices developed at the University of Michigan. Details of the equipment and procedures for creep-exposure, tensile, compression, tension-impact, and bend tests have been discussed in previous reports (Refs. 1, 2, 3) and will not be repeated.

Work has continued on the development of stress-strain recording equipment for tension-impact testing. This is discussed on page 10.

RESULTS AND DISCUSSION

Experimental work accomplished during the period covered by this report included heat treatment of 17-7PH strips to the RH 950 condition, determination of base condition tensile properties, determinations of creep deformation properties, the initiation of unstressed exposure tests, and continuation of development of tensile impact stress-strain recording equipment. In addition, the Summary Report on the TH 1050 condition was reproduced and distributed (Ref. 2) and a summary report covering studies of the C110M titanium alloy was written and a draft copy submitted to the Materials Laboratory, WADC, for approval.

Project 1: Relation of Heat Treatment to Alteration by Prior Creep of Mechanical Properties of a Heat Treatable Stainless Steel

Tensile Properties of 17-7PH (RH 950 Condition). Tensile tests at room temperature, 600°, 800°, and 900°F were conducted to establish the average properties of as-treated 17-7PH in the RH 950 condition. The test data are summarized in Table 1 and plotted as a function of test temperature in Figure 1. The six tests run at each test temperature consisted of two specimens from each of the three sheets of material that were heat treated. An additional specimen at each temperature will be run on material from either sheet 7 or 8.

Increasing the test temperature caused a drop of about the same order of magnitude in both the ultimate tensile and yield strengths. Ductility values from the 600°F tests were slightly lower than those obtained at room temperature and then increased substantially at 800° and 900°F. This behavior was very similar to that observed for the TH 1050 condition.

The room temperature properties developed in this heat by the RH 950 treatment compare favorably with those reported by the producer (Ref. 5). This is indicated by the following tabulation:

Treatment and Heat No.	Ult. Tensile Strength (psi)	Yield Strength (psi)	Elongation (%)	Hardness R"C"
TH 1050 "AVG"	193,200	177,800	9.4	42
"DESIGN"	200,000	185,000	10	--
Heat 55651	203,000	193,910	6.7	43.8
RH 950 "AVG"	230,400	216,000	7.2	46
"DESIGN"	236,000	219,000	7	--
Heat 55651	237,650	222,480	8.2	48.2

Notes: "AVG" - average for 5 heats of 0.050-inch Sheet - Ref. 5, p. 95
"DESIGN" - from design curves - Ref. 5, p. 96B
Heat 55651 - U. of M. average values from 3 sheets of 0.064-inch sheet.

The variation of tensile and yield strength with test temperature also show generally good agreement.

Treatment and Heat No.	Test Temp. (°F)	Ult. Tensile Strength (psi)	Yield Strength (psi)	Elongation (%)
RH 950 "DESIGN"	600	190,000	175,000	6
	800	170,000	150,000	8
	900	142,000	130,000	11
Heat 55651	600	199,000	171,830	7.8
	800	166,783	148,000	14.4
	900	137,433	121,233	17.9

The ductility of Heat 55651 became higher in relation to the "design" values as the test temperature was increased. This was reflected in appreciably lower strengths only at 900°F and at this temperature the maximum deviation in the strengths was still only 7 percent.

It appears, therefore, that the properties developed in the present material by the RH 950 treatment were commensurate with the capabilities of the alloy.

Unstressed Exposure of 17-7PH (RH 950 Condition)

Tensile tests at room temperature or at the temperature of exposure are in process on samples of 17-7PH (RH 950 condition) subjected to exposure without stress for 10, 50, or 100 hours at 600°, 800°, and 900°F. The presently available results of these studies are summarized in Table 2.

The data for room temperature tensile tests indicate that increases in tensile and yield strengths and decreases in ductility follow exposure at 800° or 900°F. The maximum observed increase in strength was not over 10 percent above the base value for unexposed material.

Ductility at room temperature was substantially reduced by the exposures at 900°F and somewhat reduced by the 600° or 800°F exposures.

The effect of exposure time does not appear to be especially significant nor were hardness changes large.

The elevated temperature tensile data indicate that changes in these properties were confined principally to increases in yield strength. The largest effects occurred at 800°F where 100 hours exposure caused an increase in yield strength of about 15 percent over the base value at 800°F. The tensile strength in this case was increased about 10 percent. The 600° and 900°F yield strengths increased somewhat as the result of exposure. Tensile strength at 600°F was not affected by exposure, while a slight decrease in tensile strength followed 100 hours exposure at 900°F.

Ductility changes in elevated temperature tests were confined to small decreases as the time of exposure was increased.

Tests following 50 hours exposure and several duplicate tests for checking purposes remain to be performed in order to complete this portion of the experimental program.

Creep Tests of 17-7PH (RH 950 Condition)

Curves of stress versus time to reach creep deformation of 0.2, 0.5, 1.0, and 2.0 percent at 600°, 800°, or 900°F were determined to aid in the selection of stresses for creep-exposure tests. Six or seven tests were run at each test temperature with the higher stress tests allowed to run until fracture occurred. The test specimens removed from the creep units before fracture were tested in tension at room temperature in order to gain some idea of the effects to be expected from creep-exposure. The data from these studies are summarized in Table 3.

The curves of stress-time for creep deformation are plotted in Figure 2. The slopes of these curves generally follow the slope of the rupture curve at the same temperature. Several inconsistencies in the data were observed in the 600°F tests and the curves drawn at this temperature are average values. The data obtained at 800° and 900°F exhibited much better consistency although a deviation was noted between duplicate tests at 800°F and 90,000 psi.

Plastic deformation during loading occurred in all tests at 600°F and the majority of tests at 800°F. Hardness increases of one or two points Rockwell "C" were observed in most specimens.

Tensile tests of completed creep specimens revealed that increases in tensile and yield strength and decreases in ductility took place as a result of exposure to stress and temperature. Figure 3 is a plot of total plastic deformation versus room temperature tensile properties for several specimens creep tested at 600°F for times between 331 and 437 hours. Indicated in this plot is the fraction of the total plastic strain that occurred during loading.

The plot shows that a severe drop in elongation occurred following prior creep. Increases in tensile and yield strength of as much as 18 percent over the base value were noted. In addition, the yield strength was found to be equal to the ultimate strength for the three specimens tested after 600°F creep.

Although the data are fragmentary, similar effects appear to follow creep at 800° and 900°F.

Project 5: Tension-Impact Characteristics of Aircraft Structural Alloys After Prior Exposure to Creep

Development of Equipment. The necessary components for display and recording of the stress and strain data in tension-impact testing have been borrowed from the Mechanical Engineering Department. These consist of a dual-beam oscilloscope, a strain-gage bridge and amplifying unit, and a Land camera attachment for photographic recording of the oscilloscope traces. The data recorded consist of separate curves of stress-versus time and strain-versus time, from which a stress-strain curve can be derived. The oscilloscope is set for a driven sweep and is triggered externally. The triggering voltage is produced by a circuit which is closed when the impact-machine pendulum head makes contact with a phosphor bronze strip just prior to the impact blow. The sweep speed is selected to conform as nearly as possibly to the velocity of the pendulum at the point of impact.

Two arrangements each have been considered for the stress and strain pickups. One method for stress measurement consisted of mounting SR-4 strain gages in a four-arm bridge configuration on one of the impact-machine jaws. The compressive force in the jaw was taken to equal the tensile force in the specimen. This method was abandoned due to the difficulties in calibration and in jaw alignment that would be necessary in order to insure an equal force distribution between the two jaws. The method adopted for stress measurement uses a tension link of high proportional limit steel threaded between the pendulum head and the impact specimen grips. This places the stress measurement directly in the impact train. The sensing elements on the tension link are four SR-4 strain gages.

For strain measurements, experiments were made with a linear differential transformer. The transformer body was mounted on the rear of the pendulum head and the movable core attached to a rod which was in turn attached to the rear impact grip. As the specimen fractured, the rear grip would separate from the impact train and the transformer core would be pulled from the transformer body. Moderate success has been obtained with this method, although space requirements necessitated vertical displacement of the transformer from the center line of the impact specimen. This resulted in lever arm effects which, although considered of second order importance, nevertheless, would be of serious import if bending should occur preceding fracture of the specimen. In addition, corrections would be necessary for the inclusion of the specimen support areas in the gage length.

Experiments are now under way with another method of strain measurement using a relatively cheap, disposable extensometer. This consists of a set of miniature collars attached directly to the reduced section of the specimen. Attached between the collars is a double length of fine-gage nichrome wire, which forms one side of a two-arm bridge. This method avoids the expense and time delays inherent in cementing conventional strain gages to the gage section and holds promise of being more easily converted to elevated temperature strain measurements.

Calibration of the system will be completed when the various components have been made to function properly.

FUTURE WORK

Work planned for the near future includes the following:

Project 1

a. Completion of tensile tests on 17-7PH (RH 950) following unstressed exposure.

b. Determination of compression properties of 17-7PH (RH 950)

c. Initiation of creep-exposure tests on 17-7PH (RH 950)

Project 3

a. Studies of orientation effects in C110M Sheet.

Project 5

a. Continuation of development work on tension-impact stress-strain measuring equipment.

Project 6

a. Studies of physical metallurgy of 17-7PH (RH 950)

REFERENCES

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3. Gluck, J. V., Voorhees, H. R., and Freeman, J. W., "Effect of Prior Creep on Mechanical Properties of Aircraft Structural Metals," WADC Technical Report 57-150 Part III, January 1958.

4. Armco Steel Corporation Report, "Armco Precipitation Hardening Stainless Steels -- Mechanical and Physical Properties of 17-7PH in Condition RH 950," February 6, 1956.

5. Marshall, M. W., Perry, D. C., and Harpster, N. R., "Enhanced Properties in 17-7 Stainless" Metal Progress, V. 70, No. 1, p. 94-98 (July 1956).

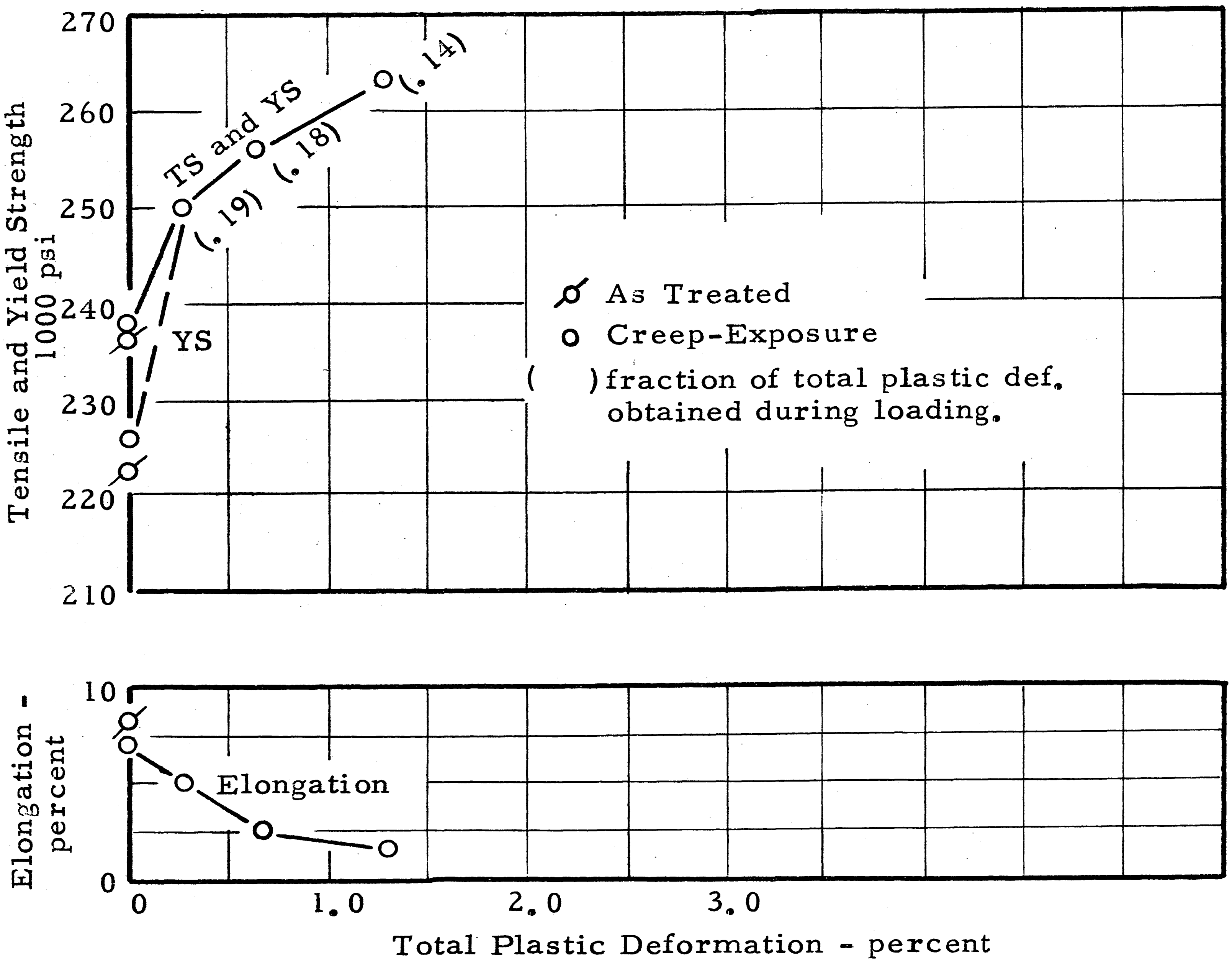

Figure 3. - Effect of Creep Exposure at 600°F for 331-437 Hours on Room Temperature Tensile Properties of 17-7PH (RH 950).

TABLE 3

RUPTURE AND CREEP DEFORMATION DATA FOR

17-7PH (RH 950 CONDITION)

Test Temp. (°F)	Spec. No.	Stress (psi)	Rupture Time (hr)	Elongation (%/2 inches)	Reduction of Area (%)	Hardness After Test R"C"	Total Load. Def. (%)	Plastic Load. Def. (%)	Time to Reach Indicated Creep Deformation (hrs) 0.2	0.5	1.0	2.0	Final Creep Deformation (%)	Total Plastic Deformation (%)	Subsequent Room Temperature Tensile Properties: Ult. Tensile Strength (psi)	0.2% Offset Yield Strength (psi)	Elongation (%/2 inches)	Reduction of Area (%)	Modulus, E (10^6 psi
600	4C4	183,000	310.7	12	22	50.4	0.95	0.30	0.1	0.8	8.2	41	> 7.95	--	---	---	---	---	---
	5A6	178,000	in progress				0.80	0.20	0.5	7.5	43	218							
	6P4	175,000	1180.4	13	26	50.5	0.95	0.21	1	4	24	136	>>3.4	--	---	---	---	---	---
	4S4	172,500	673*	--	--	49.4	0.66	0.11	8	105	640	--	1.02	1.13	267,000	267,000	3.0	9.8	30.7
	4S2	170,000	437*	--	--	47.9	0.83	0.18	12	44	310	--	1.12	1.30	263,000	263,000	1.5	11.0	29.0
	5G1	160,000	331.1*	--	--	49.2	0.69	0.12	23	272	--	--	0.53	0.65	256,000	256,000	2.5	12.1	30.3
	6TT5	150,000	361*	--	--	49.4	0.55	0.05	248	--	--	--	0.21	0.26	250,000	250,000	5.0	11.0	29.0
800	4D5	132,000	27.5	16	31	51.3	0.61	0.06	.15	.8	3.3	8.4	10.9**	--	---	---	---	---	---
	6P6	125,000	74.1	19	33	51.9	0.47	0.04	0.8	3.5	11.5	28.5	>>3.6	--	---	---	---	---	---
	4D2	110,000	247.5	13	31	51.8	0.46	0.05	5.5	32	101	169	>>2.4	--	---	---	---	---	---
	6C4	100,000	437.1*	--	--	51.3	0.38	0.02	16	100	425		2.11	2.13	265,000	260,000	<2.0	1.2	29.5
	5A4	90,000	381.7*	--	--	51.9	0.36	nil	9	140	346	--	1.11	1.11	>266,000	263,000	---	---	29.2
	6C1	90,000	in progress				0.36		29	250									
	5J-T3	80,000	575.2*	--	--	51.0	0.31	nil	140	558	--	--	0.52	0.52	---	264,000	<1.0	nil	30.3
900	5G3	72,000	48.6	34	43	50.0	0.28	0.03	0.7	2.6	5.6	13.5**	>>2.0	--	---	---	---	---	---
	4S3	70,000	70±6	46	51	50.0	0.28	nil	off scale-reference point lost				>>1.7	--	---	---	---	---	---
	6C2	60,000	194.9	40	54	50.2	0.22	nil	3	8	18	38	>>3.3	--	---	---	---	---	---
	5G5	50,000	613.9	38	53	49.3	0.21	nil	7.5	25	62	134	> 9.5	--	---	---	---	---	---
	4D6	35,000	336.5*	--	--	49.8	0.14	nil	20	108	315	--	1.04	1.04	247,000	243,000	4.0	7.3	28.2
	5A3	20,000	843*	--	--	49.1	0.10	nil	94	1100**	--	--	0.43	0.93	236,000	232,000	4.0	16.0	29.1

> greater than
>> much greater than
< less than
* stopped at
** estimate

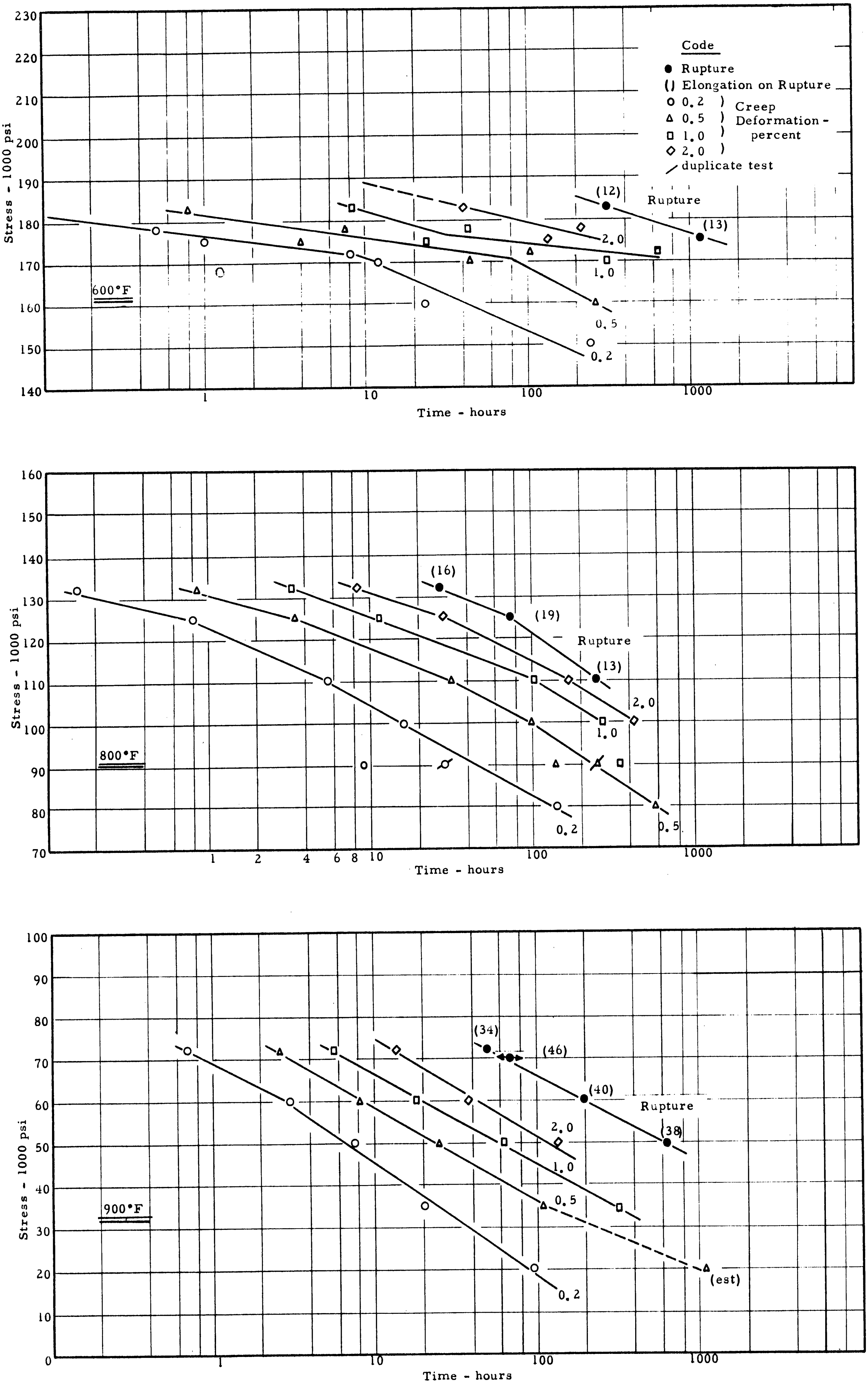

Figure 2. - Stress-Rupture Time and Stress-Time for Creep Deformation Curves for 17-7PH (RH 950 Condition) at 600°, 800°, and 900°F.

TABLE 1

TENSILE DATA FOR 17-7PH ALLOY (RH 950 CONDITION)

Test Temp. (°F)	Spec. No.	Ult. Tensile Strength (psi)	0.2% Offset Yield Strength (psi)	Elongation (%/2 inches)	Reduction of Area (%)	Modulus, E (10^6 psi)	Hardness R"C"
Room	4D-T3	237,500	224,500	8.5	16.2	27.8	49.2
	4S-T5	237,500	218,500	8.0	15.2	29.8	49.2
		237,500	221,500	8.2	15.7	28.8	49.2
	5A-T5	242,500	227,500	8.0	11.5	28.8	47.4
	5G-T2	237,500	223,500	8.0	15.0	28.0	47.0
		240,000	225,500	8.0	12.8	28.4	47.2
	6C-T6	235,400	221,400	8.0	15.3	28.4	47.2
	6P-T6	235,500	219,500	9.0	17.0	29.3	49.4
		235,950	220,450	8.5	16.2	28.8	48.3
Average - 6 Tests		237,650	222,480	8.2	15.0	28.7	48.2
600	4S-T6	200,000	178,000	9.0	16.4	28.1	
	4B-T4	205,000	174,000	8.5	12.1	28.0	
		202,500	176,000	8.8	14.2	28.0	
	5G-T6	200,000	173,000	8.0	16.0	28.4	
	5Q-T1	198,000	167,000	6.5	12.5	28.0	
		199,000	170,000	7.2	14.2	28.2	
	6D-T2	199,000	170,000	5.5	14.2	28.4	
	6H-T2	192,000	169,000	9.3	14.0	29.2	
		195,500	169,500	7.4	14.1	28.8	
Average - 6 Tests		199,000	171,830	7.8	14.2	28.4	
800	4D-T6	171,000	157,000	10.0	29.4	27.4	
	4H-T4	163,000	140,000	13.0	29.0	21.2	
		167,000	148,500	11.5	29.2	24.3	
	5A-T2	171,200	151,000	17.3	28.4	25.5	
	5R-T6	162,000	142,000	13.3	27.5	29.1	
		166,600	146,500	15.0	28.0	27.3	
	6P-T2	167,500	147,000	19.5	33.0	22.6	
	6L-T4	166,000	151,000	13.0	31.6	24.8	
		166,750	149,000	16.2	32.3	23.7	
Average - 6 Tests		166,783	148,000	14.4	29.8	25.1	
900	4D-T1	131,800	114,000	19.0	36.0	23.0	
	4E-T5	142,000	116,000	11.8	33.4	23.6	
		136,900	115,000	15.4	34.7	23.3	
	5C-T1	140,000	126,000	14.5	33.8	24.5	
	5M-T1	135,000	125,000	18.0	38.2	21.8	
		137,500	125,500	16.2	36.0	23.2	
	6C-T5	131,800	122,400	25.8	45.4	25.6	
	6S-T1	144,000	124,000	18.3	31.6	23.5	
Average - 6 Tests		137,433	121,233	17.9	36.4	23.7	

TABLE 2

EFFECT OF UNSTRESSED EXPOSURE ON TENSILE PROPERTIES OF

17-7PH (RH 950 CONDITION)

	Exposure Conditions			Tensile Properties After Exposure						
Spec. No.	Temp. (°F)	Stress (psi)	Time (hr)	Test Temp. (°F)	Ult. Tensile Strength (psi)	0.2% Offset Yield Strength (psi)	Elongation (%/2 inches)	Reduction of Area (%)	Modulus, E (10^6 psi)	Hardness R"C"*
4E-T2	600	None	10	Room	241,000	226,000	7	14.5	30.0	48.9
5M-T6		None	100	Room	238,000	226,000	7	10.4	28.5	49.0
5R-T1	800	None	10	Room	244,000	233,000	5	16.4	29.2	49.0
6T-T6	900	None	10	Room	258,000	242,000	2.8	6.7	31.5	47.9
5J-T6		None	100	Room	254,000	246,000	2.8	8.5	29.4	46.5
5C-T6	600	None	10	600	198,000	183,000	6	15.7	25.2	49.4
6D-T6		None	100	600	203,000	184,500	7	14.2	29.5	45.0
4N-T5	800	None	10	800	174,000	157,000	11.5	23.6	22.9	51.4
5Q-T2		None	100	800	185,000	169,000	8.5	21.0	25.2	50.8
4P-T1	900	None	10	900	142,000	130,400	18.5	36.8	20.5	51.1
4K-T1		None	100	900	132,000	127,000	14.0	35.2	20.3	50.0

* Rockwell "C" hardness at room temperature.

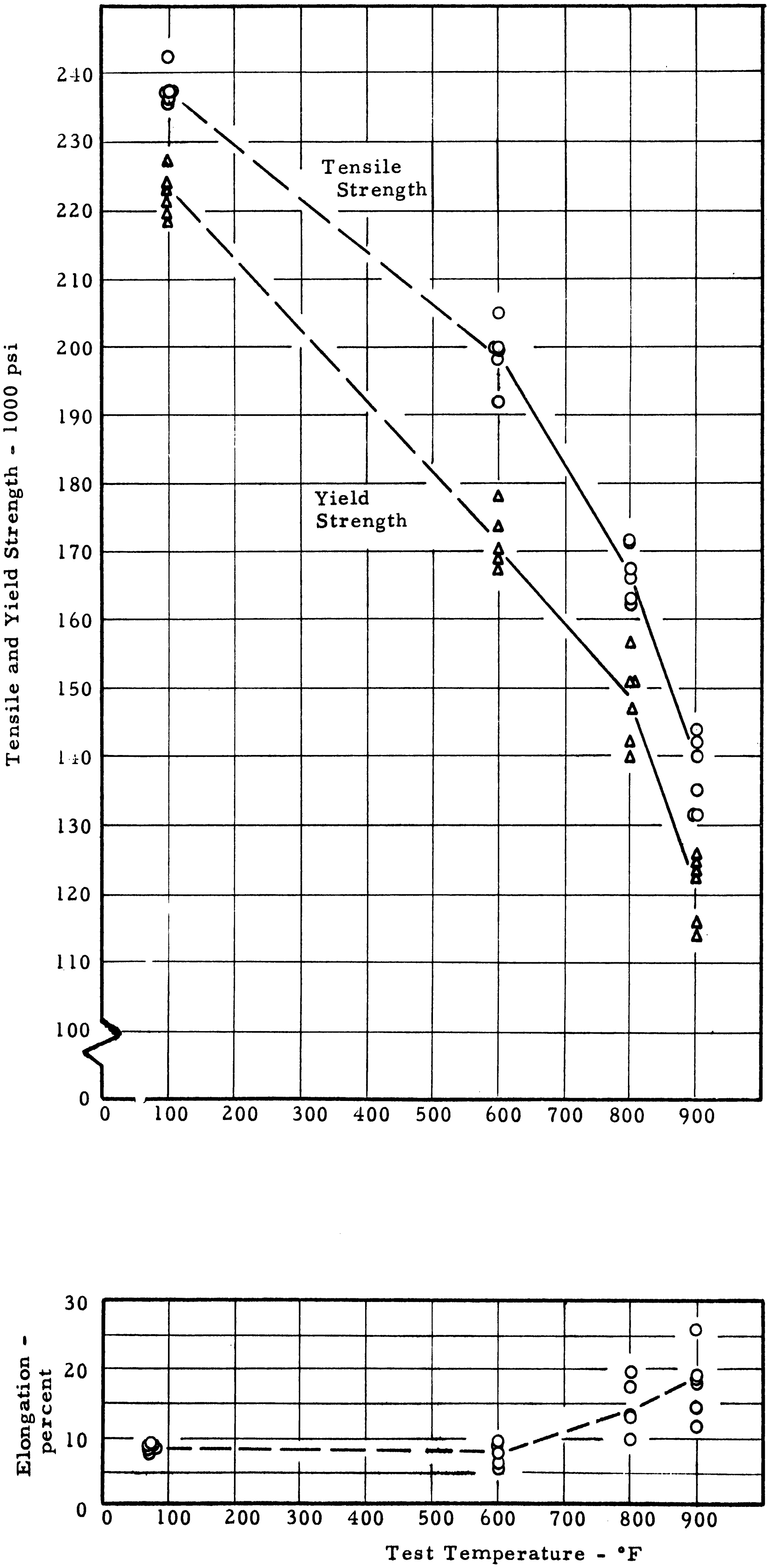

Figure 1. - Effect of Test Temperature on Tensile Properties of 17-7PH (RH 950 Condition) As Heat-Treated.