REPORT ON

THE ELEVATED-TEMPERATURE PROPERTIES OF STAINLESS STEELS

Issued Under the Auspices of
THE DATA AND PUBLICATIONS PANEL
of
THE ASTM–ASME JOINT COMMITTEE ON
EFFECT OF TEMPERATURE ON THE PROPERTIES OF METALS

Prepared by
WARD F. SIMMONS AND HOWARD C. CROSS

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EFFECT OF TEMPERATURE ON THE PROPERTIES OF METALS

PREPARED BY WARD F. SIMMONS[1] AND HOWARD C. CROSS[1]

This report is essentially a graphical summary of elevated-temperature data for the commercially produced stainless steels. Included are summary curves for tensile strength, 0.2 per cent offset yield strength, per cent elongation, per cent reduction of area, stresses for rupture in 100, 1000, 10,000, and 100,000 hr, and stress for creep rates 0.0001 and 0.00001 per cent per hr (1 per cent in 10,000 and 100,000 hr).

An Appendix is included, which contains the primary data from which the summary curves were drawn. The data sheets in the Appendix also give the chemical composition, processing data, and other pertinent information about the steels included in this survey.

In March, 1950, the American Society for Testing Materials published a report on "The Strength of Wrought Steels at Elevated Temperatures," *Special Technical Publication No. 100.* The data in this report were collected by R. F. Miller and J. J. Heger and made available to the Data and Publications Panel of the ASTM–ASME Joint Committee on Effect of Temperature on the Properties of Metals. This report contains data for ferritic and austenitic steels and was intended by the Data and Publications Panel to supply much-needed information until the present survey reports became available.

On May 19, 1950, a letter requesting information on the stainless steels was sent out by Mr. Ernest L. Robinson, Chairman of the ASTM–ASME Joint Committee on Effect of Temperature on the Properties of Metals. Since this letter contains the complete background of this survey in concise language, it is reproduced below:

"The ASTM–ASME Joint Committee on the Effect of Temperature on the Properties of Metals has been requested by the Boiler Code Committee of The American Society of Mechanical Engineers, the Prime Movers Committee of the Edison Electric Institute, the Committee on Power Generation of the Association of Edison Illuminating Companies, and the Air Force to compile high-temperature data on various metals and alloys used at elevated tempeartures. The Civil Aeronautics Administration of the Department of Commerce, the Research and Development Board, and the Aircraft Industries Association have also indicated their desire for a compilation of this type.

"In 1938, the Joint Committee made a compilation of data then available, which was issued as a Data Book by the sponsor societies, but which is now out of print. During the past 12 years, much additional information has accumulated. The current requests for an up-to-date compilation have resulted in a decision by the Joint Committee to proceed with a new survey, the results of which will be published by the sponsor societies. As in the 1938 Compilation, the individual contributors will be identified only by number. Data supplied for the 1938 survey need not be resubmitted.

"While the Joint Committee intends eventually to survey the high-temperature properties of all types of metals used for elevated-temperature applications, we have adopted the policy of 'limited objectives' and plan to divide the metals into several groups. Information on these materials can then be issued as soon as it becomes available instead of waiting several years for the compilation of a large book covering the materials. It is hoped that this approach will make the task less burdensome both for those supplying the data and for those who will compile and issue the information.

"It has been agreed that the initial effort will be confined to the cast and wrought austenitic chromium-nickel alloys. We would, therefore, appreciate your providing us with any original information which you may have on chromium-nickel stainless steels such as those listed below:

18–8
18–8 Ti
18–8 Cb
18–8 Mo
18–8 Mo Cb
25–12
25–20
25–20 Si
25–20 Cb
15–35

"Data compiled from the literature are not solicited at this time.

"To make this worth-while undertaking a success, your cooperation in supplying data is earnestly solicited."

[1] Battelle Memorial Institute, Columbus, Ohio.

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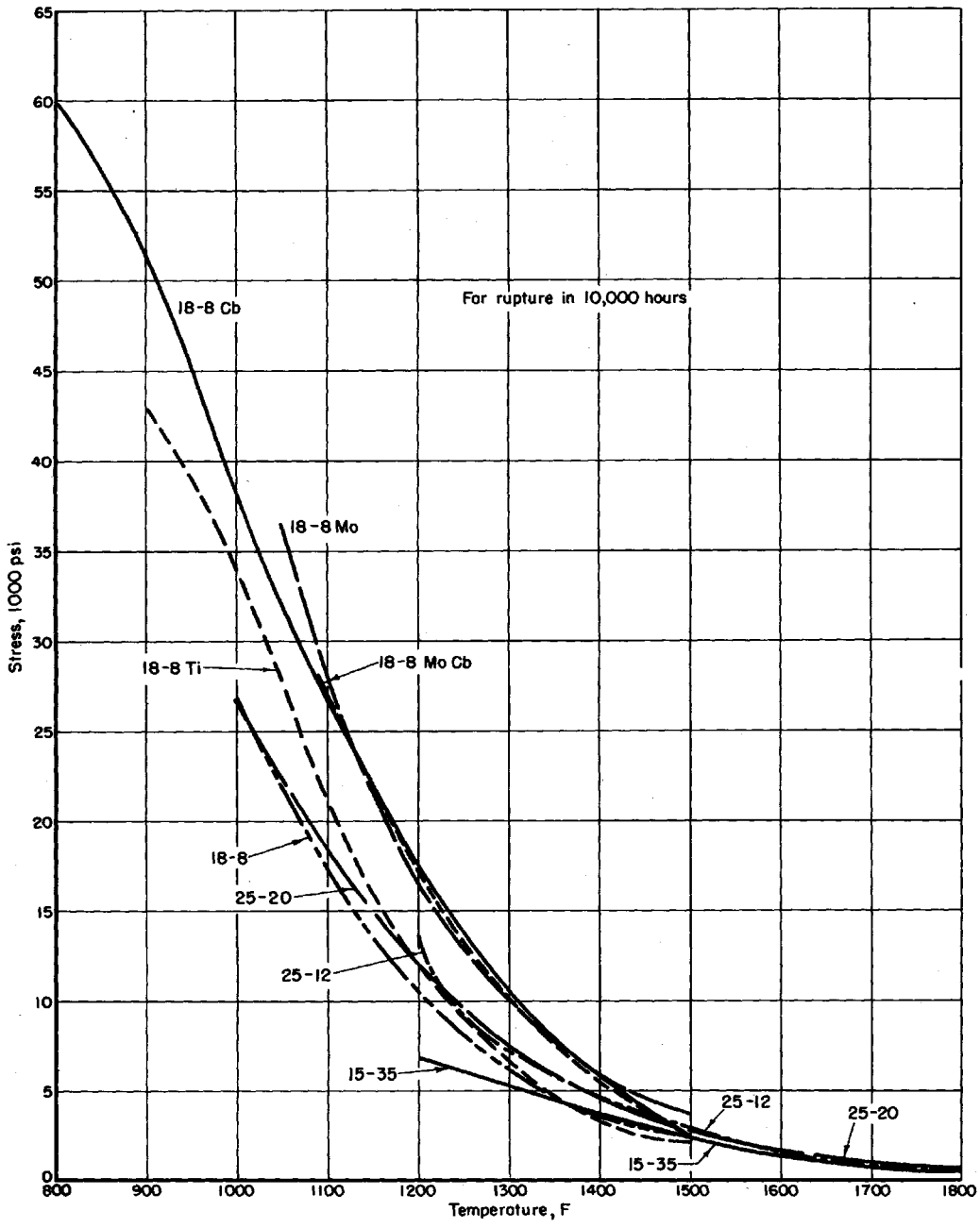


FIGURE 1. RUPTURE-STRENGTH CURVES FOR SEVERAL STAINLESS STEELS IN THE ANNEALED CONDITION

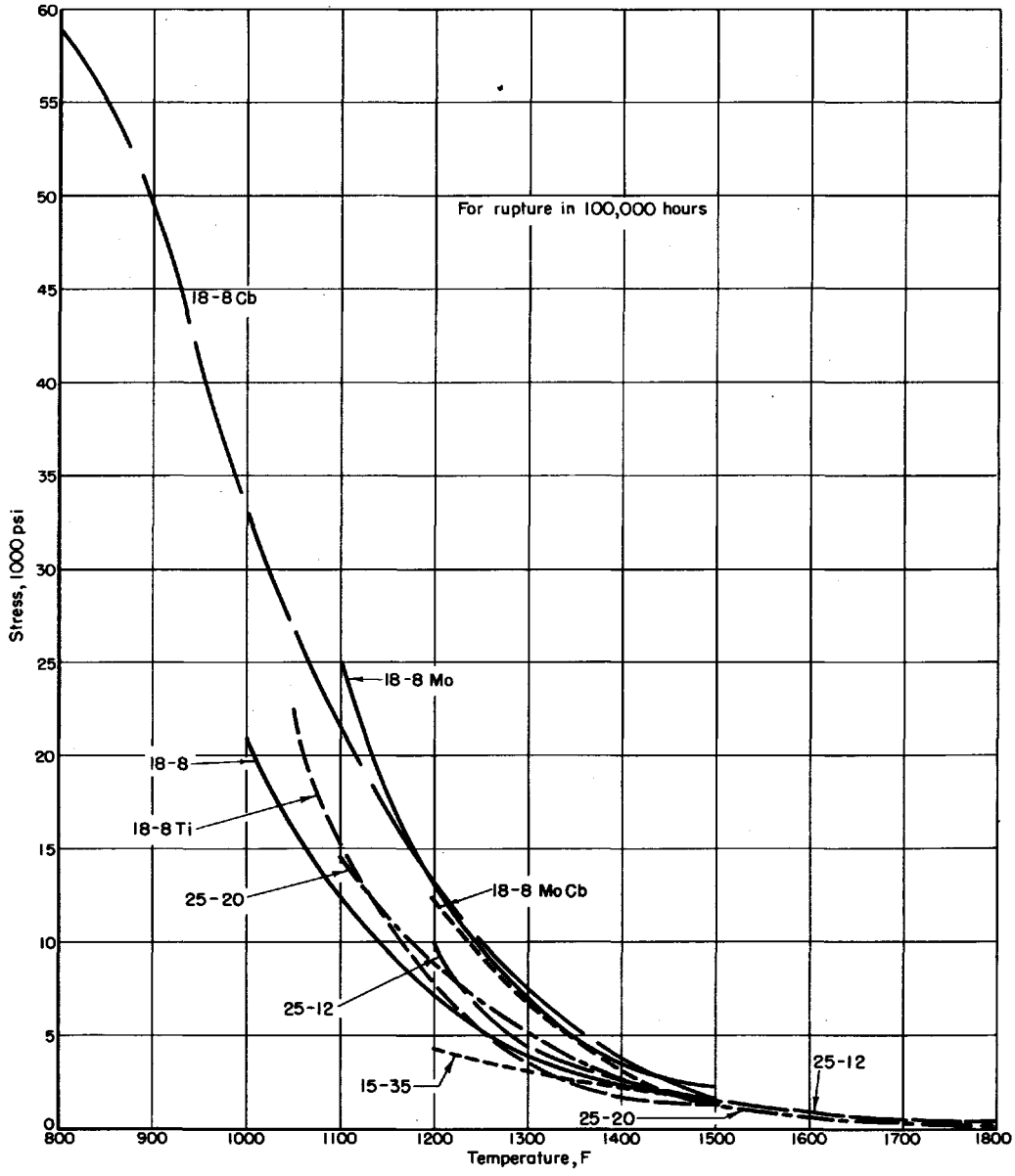


FIGURE 2. RUPTURE-STRENGTH CURVES FOR SEVERAL STAINLESS STEELS IN THE ANNEALED CONDITION

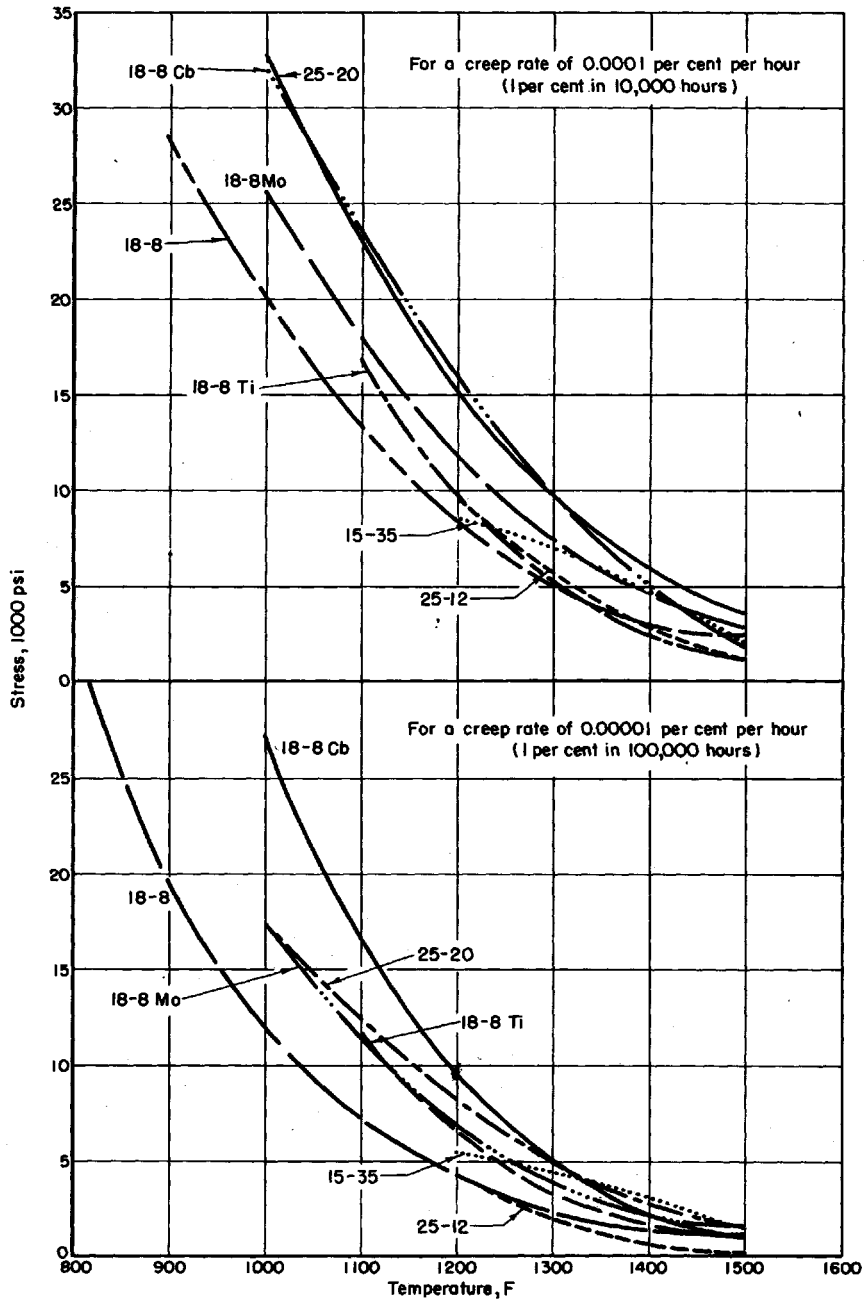


FIGURE 3. CREEP-STRENGTH CURVES FOR SEVERAL STAINLESS STEELS IN THE ANNEALED CONDITION

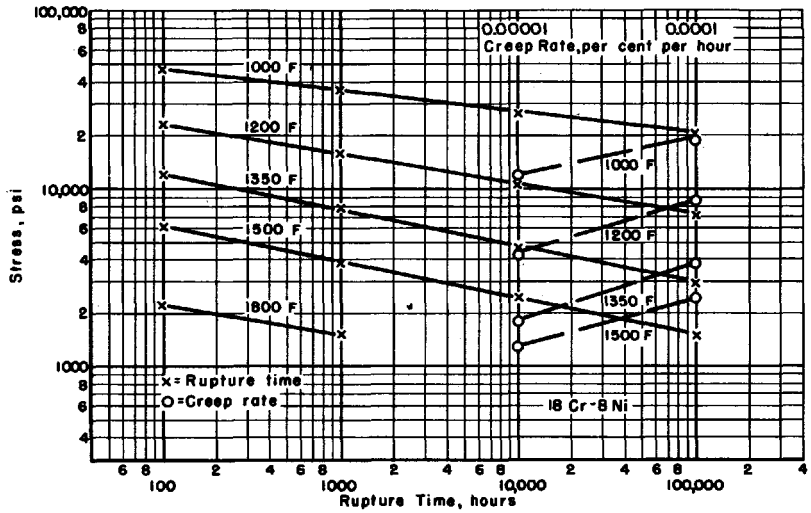


FIGURE 4. STRESS VERSUS RUPTURE-TIME AND CREEP-RATE CURVES FOR 18 Cr-8 Ni, BASED ON AVERAGE DATA FOR ANNEALED BAR STOCK

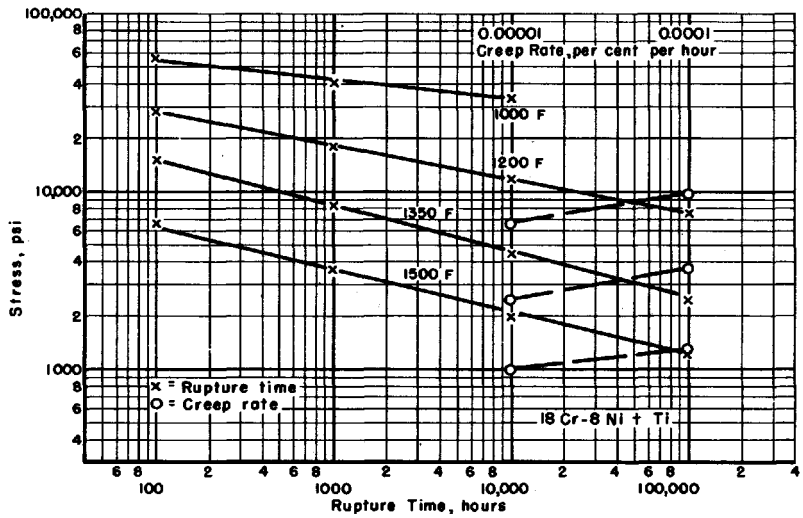


FIGURE 5. STRESS VERSUS RUPTURE-TIME AND CREEP-RATE CURVES FOR 18 Cr-8 Ni + Ti, BASED ON AVERAGE DATA FOR ANNEALED BAR STOCK

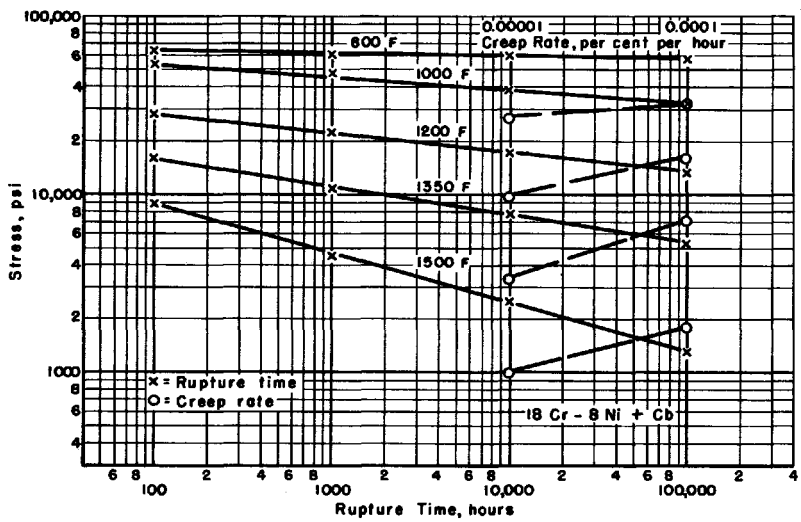
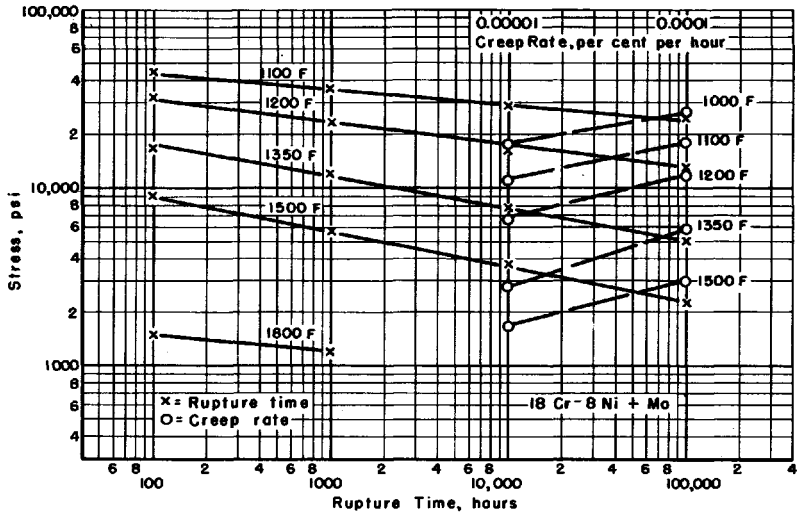


FIGURE 6. STRESS VERSUS RUPTURE-TIME AND CREEP-RATE CURVES FOR 18 Cr-8 Ni + Cb, BASED ON AVERAGE DATA FOR ANNEALED BAR STOCK



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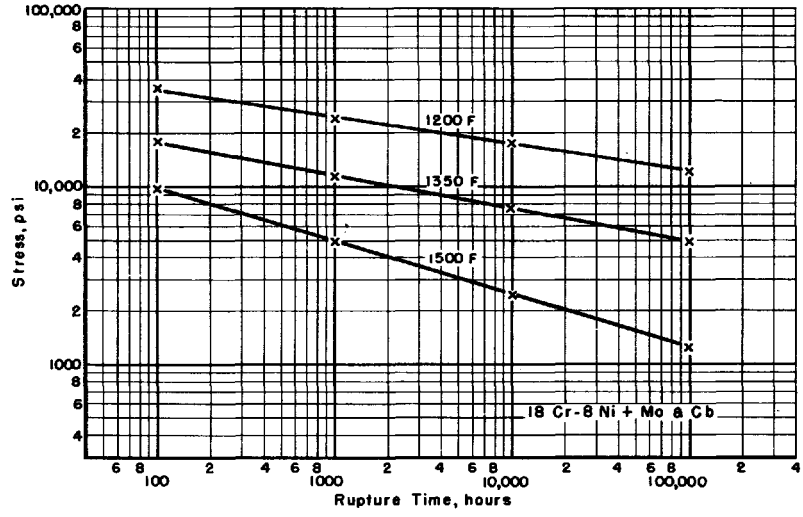

FIGURE 8. STRESS VERSUS RUPTURE-TIME CURVES FOR 18 Cr-8 Ni + Mo & Cb, BASED ON AVERAGE DATA FOR ANNEALED BAR STOCK

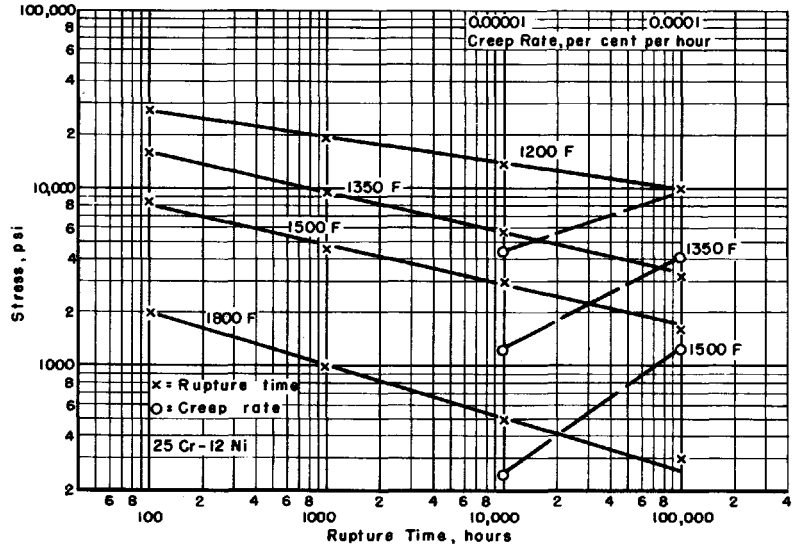

FIGURE 9. STRESS VERSUS RUPTURE-TIME AND CREEP-RATE CURVES FOR 25 Cr-12 Ni, BASED ON AVERAGE DATA FOR ANNEALED BAR STOCK

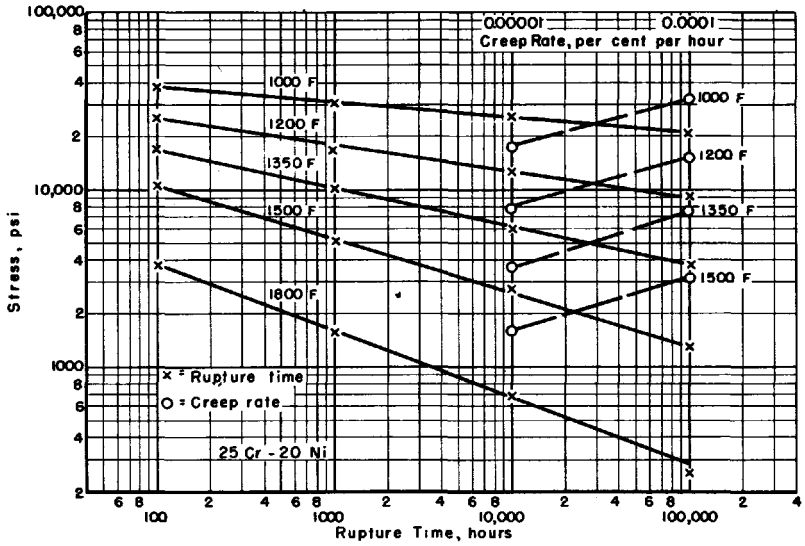

FIGURE 10 STRESS VERSUS RUPTURE-TIME AND CREEP RATE CURVES FOR 25 Cr-20 Ni, BASED ON AVERAGE DATA FOR ANNEALED BAR STOCK

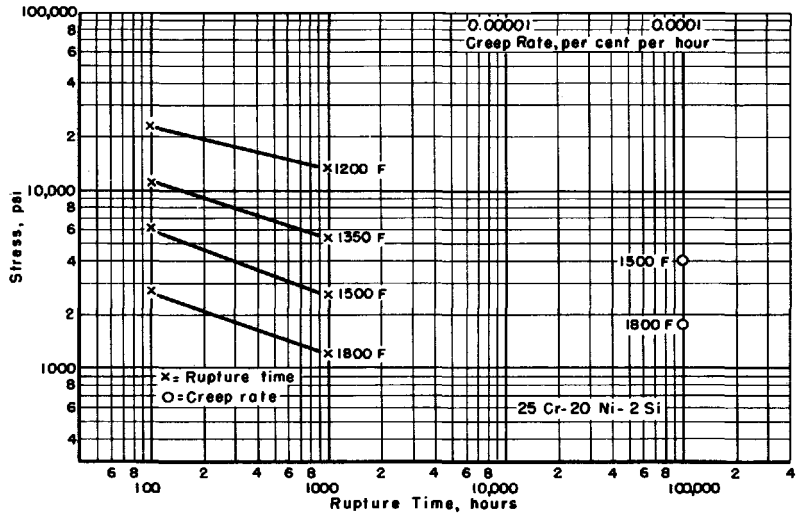

FIGURE 11. STRESS VERSUS RUPTURE-TIME AND CREEP-RATE CURVES FOR 25Cr-20Ni-2 Si, BASED ON AVERAGE DATA FOR ANNEALED BAR STOCK

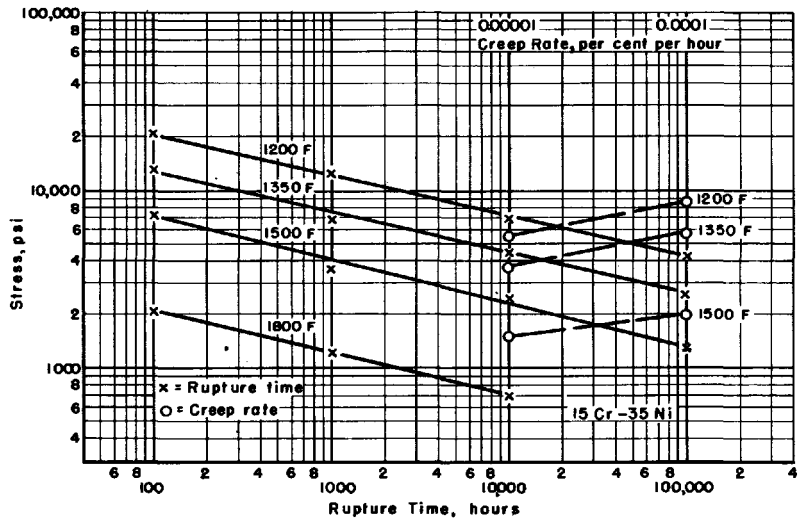

FIGURE 12. STRESS VERSUS RUPTURE-TIME AND CREEP-RATE CURVES FOR 15 Cr-35 Ni, BASED ON AVERAGE DATA FOR ANNEALED BAR STOCK

The response to Mr. Robinson's letter was excellent. Many companies and institutions gave unselfishly of their data and time in supplying information for this compilation. Such a survey as this can be successful only if it receives the support of all who have information on the subject.

The following organizations contributed data on the stainless steels:

Allegheny Ludlum Steel Corp.
American Brake Shoe Co.
Armco Steel Corp.
Babcock and Wilcox Co.
Battelle Memorial Inst.
Boeing Aircraft Co.
Chapman Valve Manufacturing Co.
Cornell Aeronautical Laboratory, Inc.
Crane Co.
Crucible Steel Co.
General Electric Co.
International Nickel Co., Inc.
M. W. Kellogg Co.
National Tube Co.
North American Aviation, Inc.
Timken Roller Bearing Co.
Union Carbide and Carbon Corp.
U. S. Naval Engineering Experiment Station
U. S. Steel Co.
U. S. Steel Corp. of Delaware
University of Michigan
Wright-Patterson Air Force Base

In the presentation of the data, it was desirable to indicate in a general way the processing each material had received. Therefore, the figures were drawn using various symbols for annealed, cold-drawn, cast, etc. These classifications are very broad and are intended to serve only as a guide for those who are not interested in the details of processing.

For those who are interested in detailed information, an Appendix is included which contains the data sheets which were returned by those contributing to this survey. Each data sheet has been numbered and the appropriate numbers are shown at the top of each figure in the same order as the corresponding data points. By this arrangement, the original data used to plot the curves can be referred to quickly or the chemical composition or heat treatment checked. The data sheet numbers are given on the creep and rupture curves but are not shown on the short-time tensile data curves. In a few cases where the data are limited, the data sheet numbers are shown opposite the points, instead of at the top of the figure.

In the creep and rupture data figures, average lines have been drawn for the annealed-bar-stock data points only, and some of these curves are shown in the summary, Figs. 1, 2, and 3, to facilitate a comparison of the alloys. A word of caution here—some of the curves were drawn from very limited data, for example, the creep curves for 15Cr – 35Ni alloy were determined from one set of data and, therefore, should not be considered as an average for the material.

The average data for the annealed bar stock were also plotted on the familiar log-log coordinates. These curves of stress *versus* rupture time and creep rate for various temperatures are shown in Figs. 4 through 12.

The materials included in this survey were classified in a general manner as listed in Mr. Robinson's letter, because, in most cases, sufficient data were not available to classify according to AISI type numbers. Of these materials for which data were requested, the 25Cr–20Ni Cb alloy was the only one for which no replies were received.

In a few instances, when data were available for alloys of a special nature, the data points in the figures were identified. For example, in the 18Cr – 8Ni figures, data points representing the low-carbon variety were marked LC, and points for the high-silicon alloy were marked 302B.

An effort has been made to eliminate errors, typographical and otherwise, from the data sheets. However, in some cases where the data do not appear too logical, but are entirely possible, they have been reproduced as supplied. An example is 18Cr – 8Ni Cb, Data Sheet No. 4, where the tensile strength at 800 F is given as 61,200 psi and the stress for rupture in 100 hr at 800 F as 64,000 psi.

Future Work:

The Data and Publications Panel intends eventually to survey the high-temperature properties of all types of metals used at elevated temperatures. Surveys of the available data on the standard "Super-Alloys" and the chromium-molybdenum steels are now under way. These surveys should be available for publication in 1952.

KEY FOR ALL FIGURES

Bar Stock

○ Annealed

+ Hot rolled

⌖ Cold drawn

⊕ Cold drawn and normalized

□ Heat treatment not known

Sheet

△ Annealed

▲ Cold rolled

Other

● Cast

✦ Weld deposit

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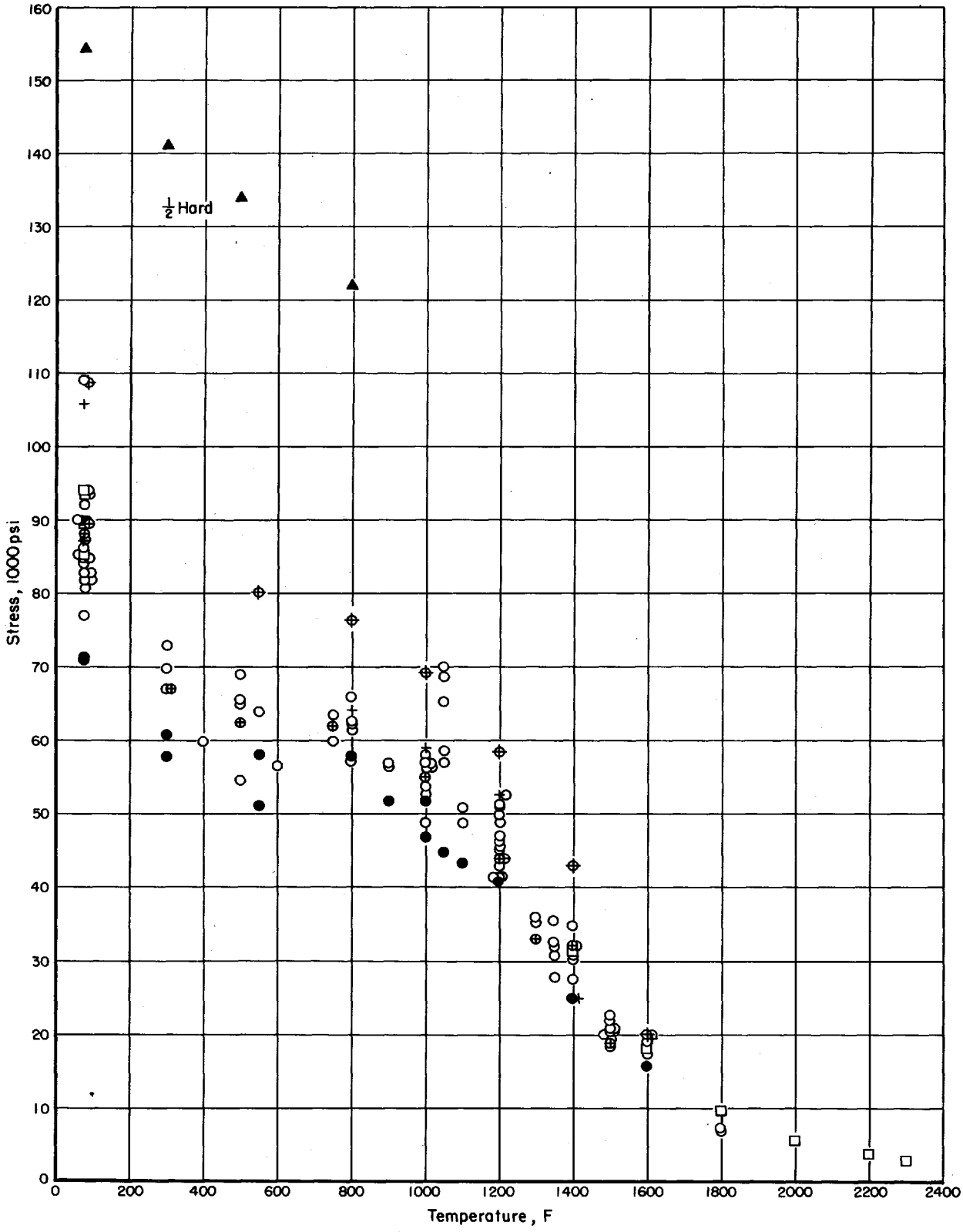
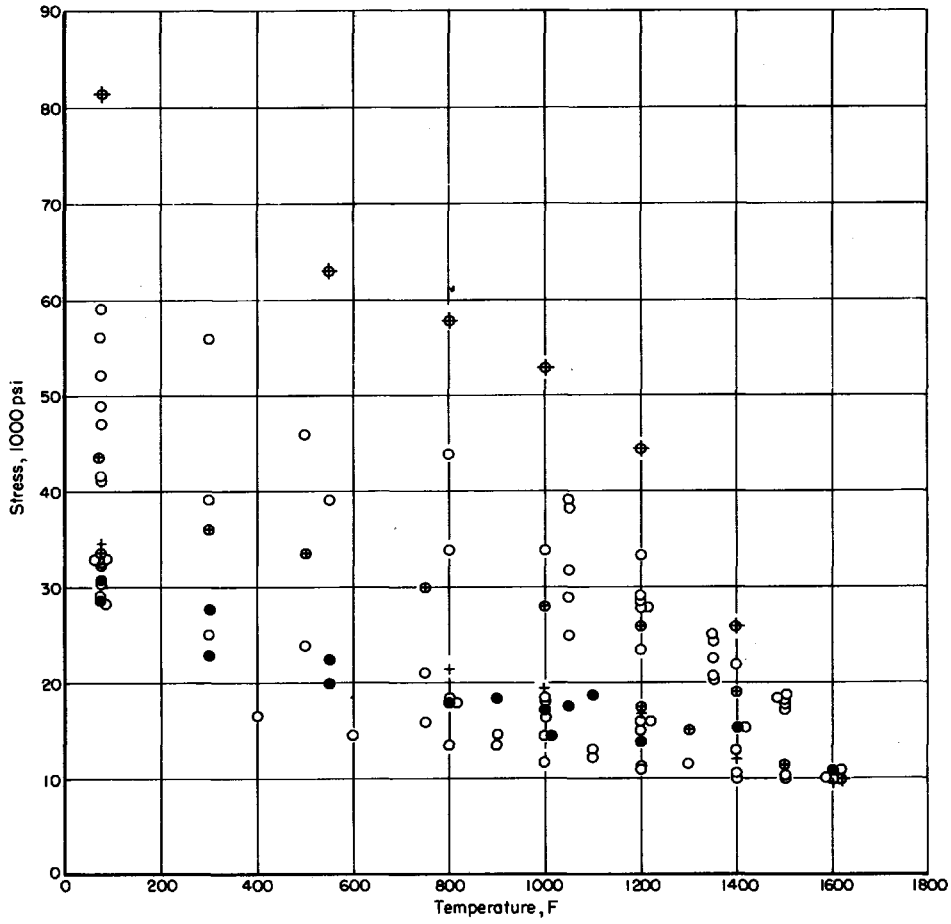
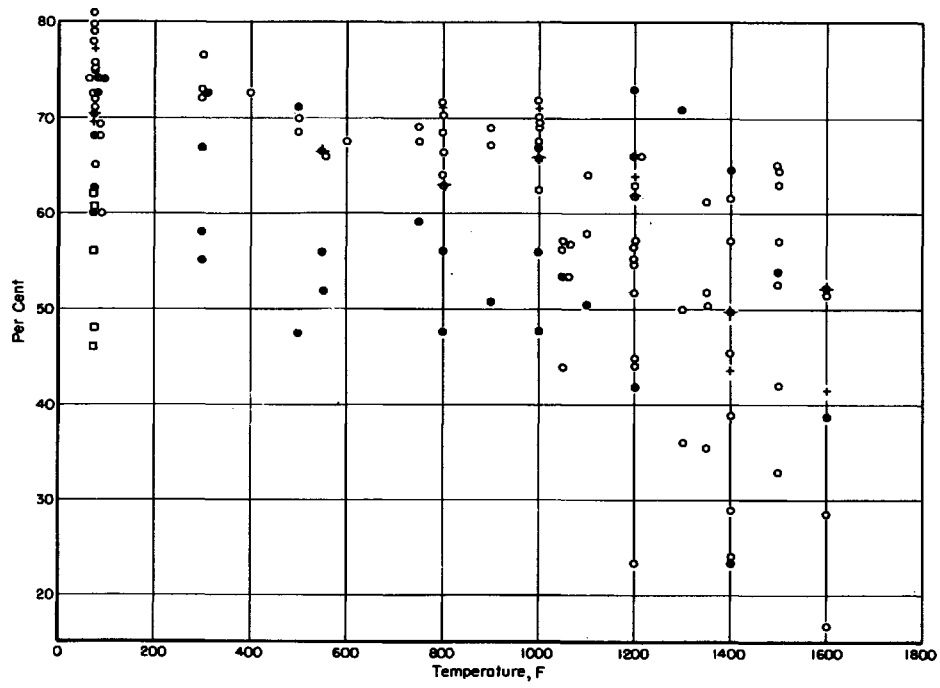


18Cr-8Ni

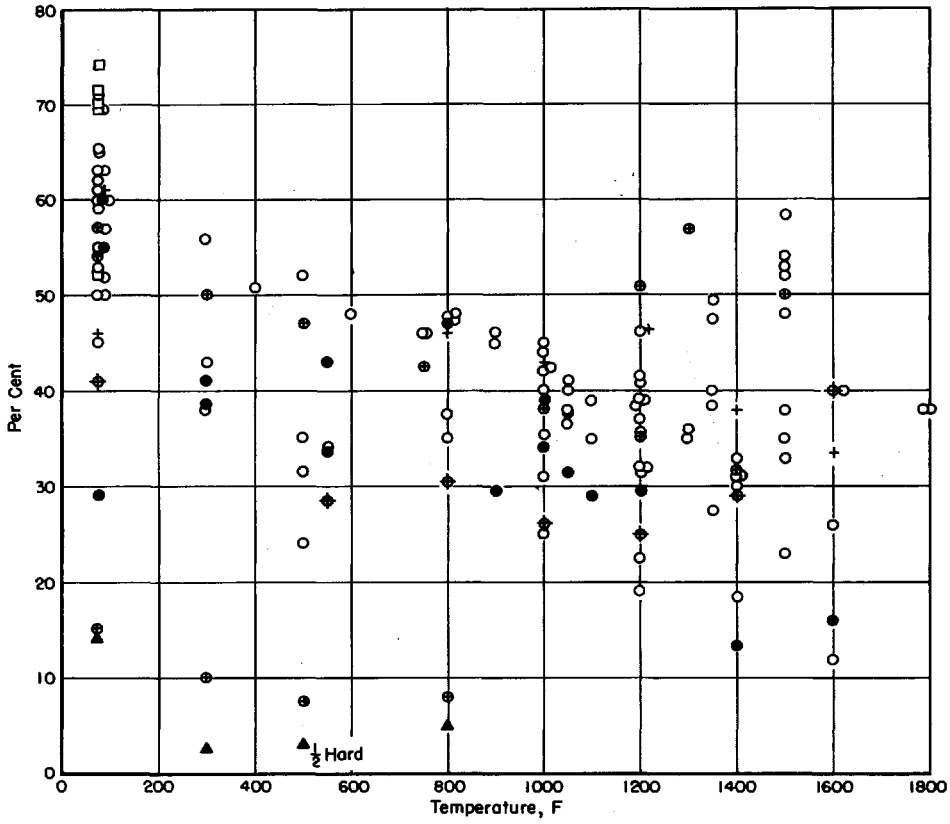
TENSILE STRENGTH



18Cr-8Ni
0.2 PER CENT OFFSET YIELD STRENGTH

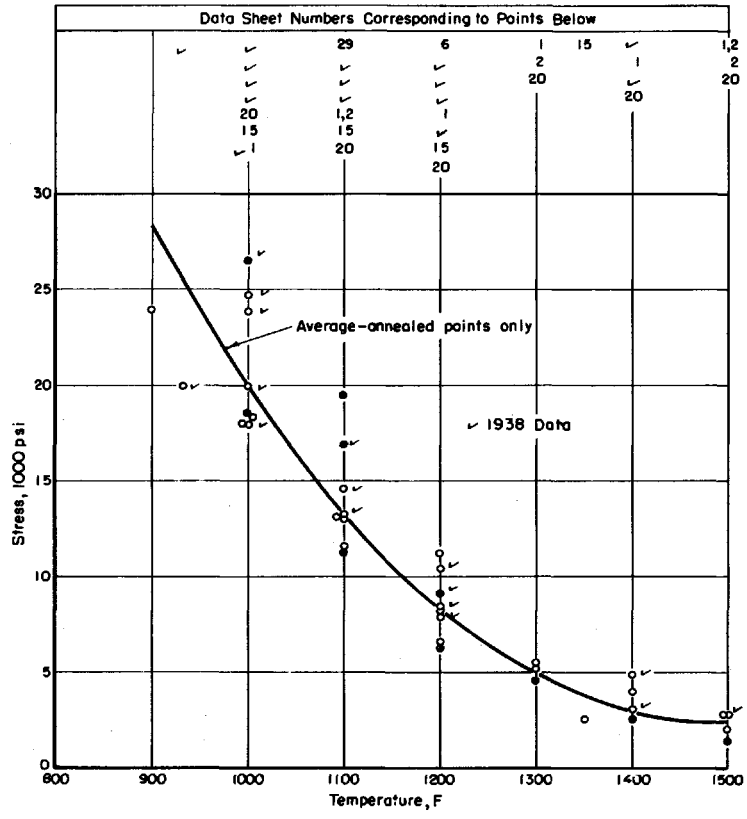


18Cr-8Ni
REDUCTION OF AREA



18Cr-8Ni

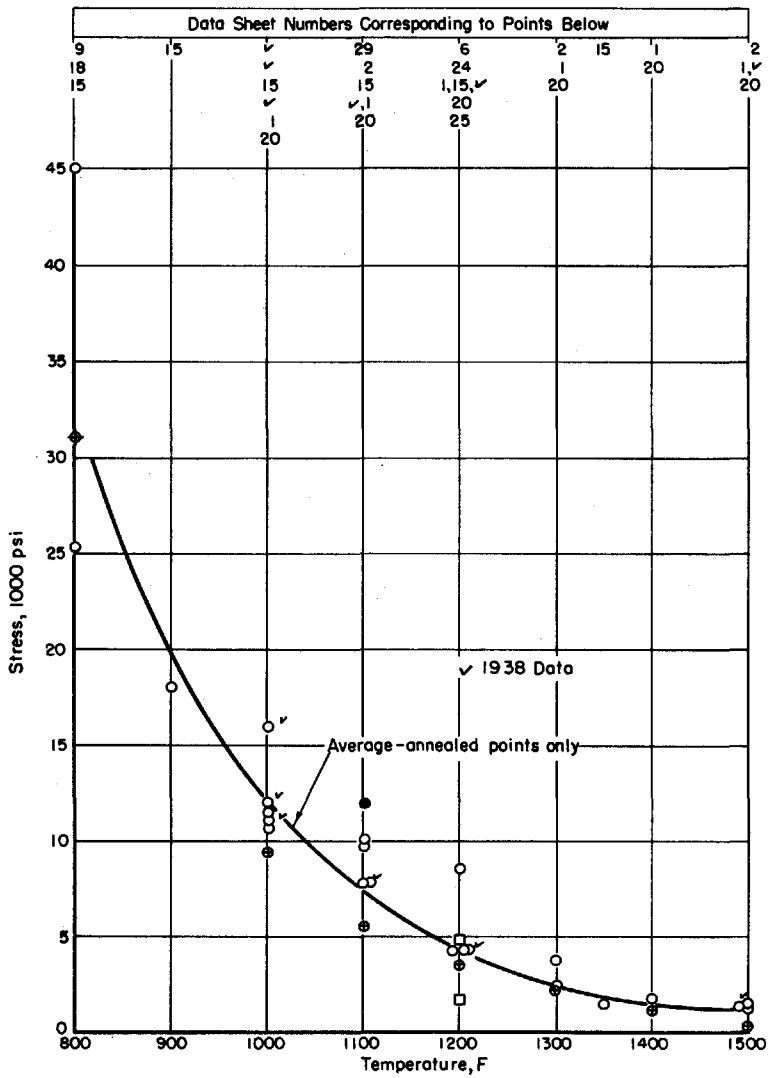
ELONGATION



18Cr-8Ni

CREEP RATE, 0.0001 PER CENT PER HOUR

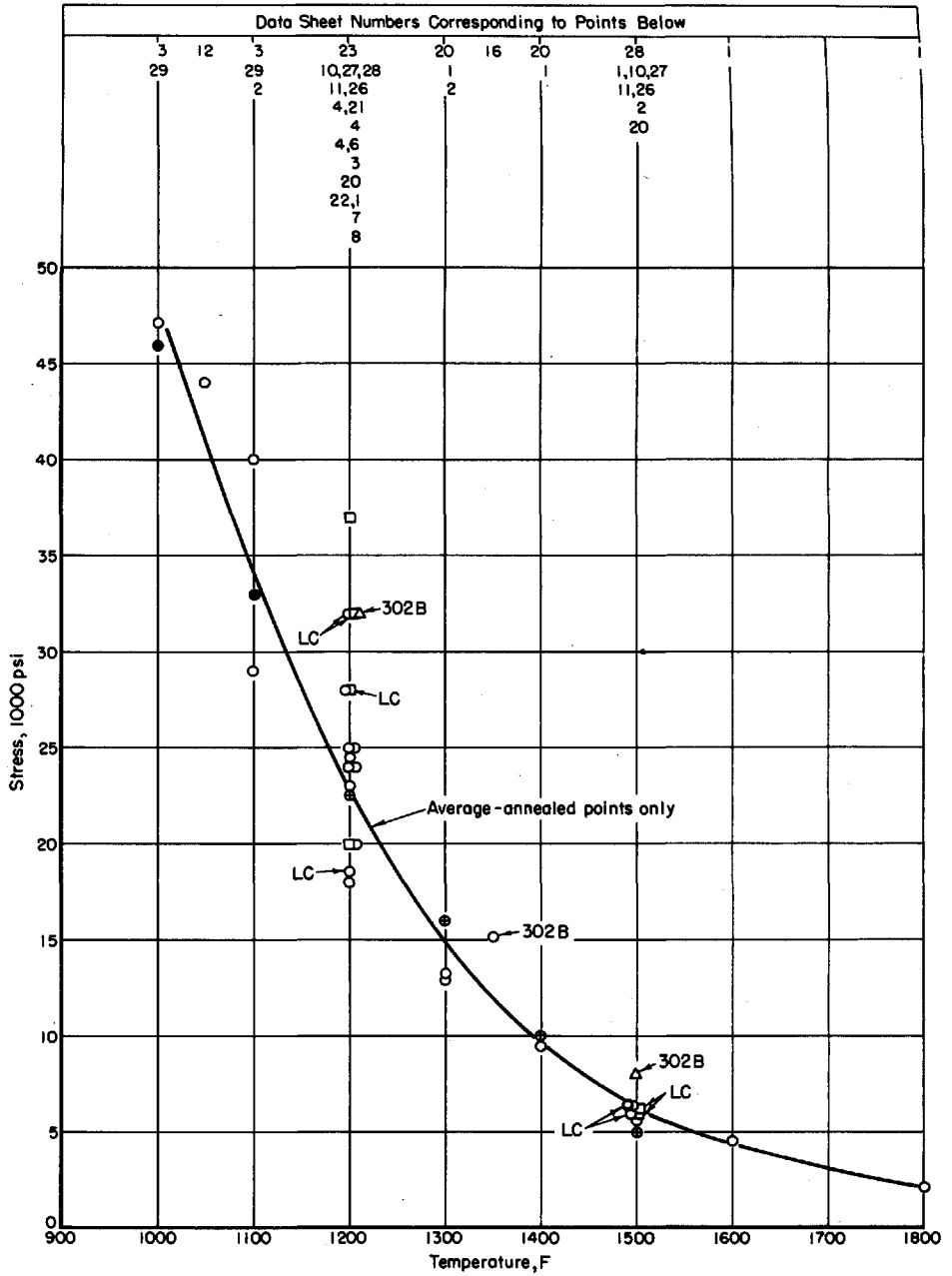
(1 PER CENT PER 10,000 HOURS)



18Cr-8Ni

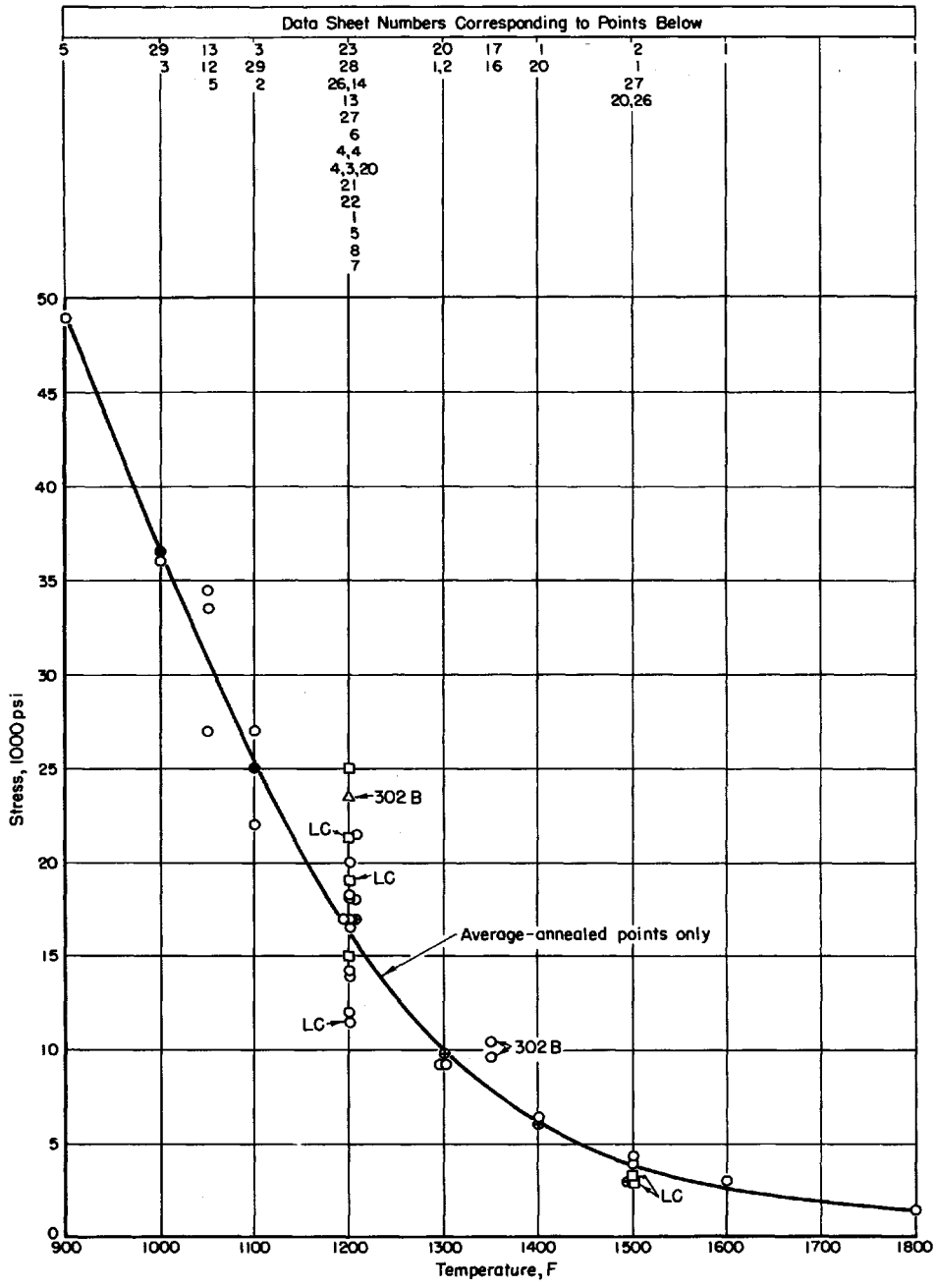
CREEP RATE, 0.00001 PER CENT PER HOUR

(1 PER CENT PER 100,000 HOURS)



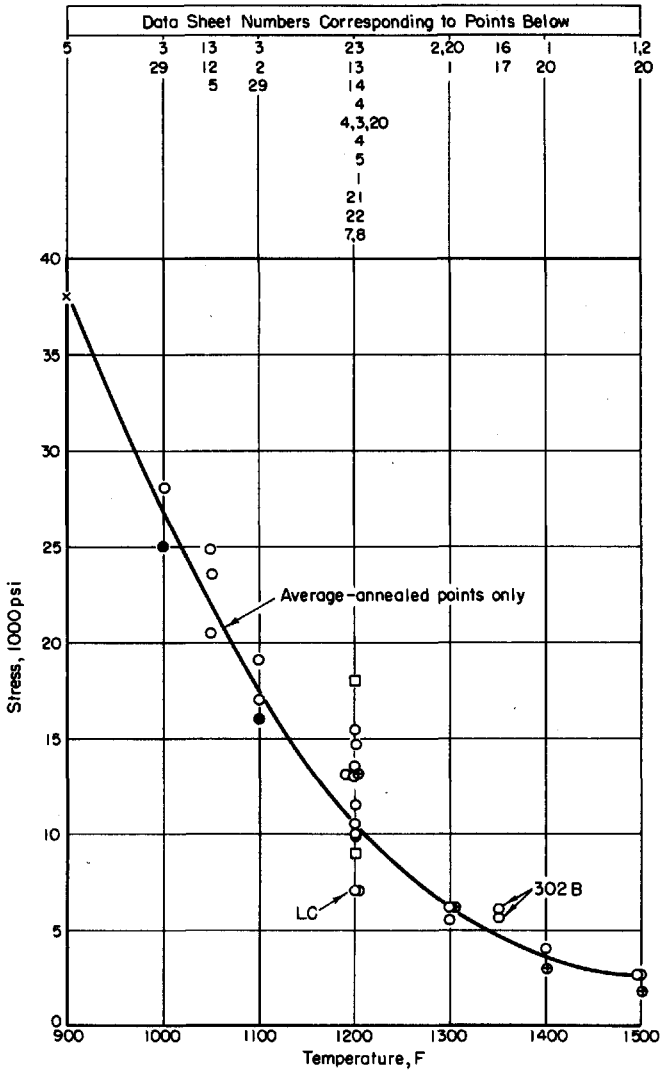
18Cr-8Ni

RUPTURE IN 100 HOURS



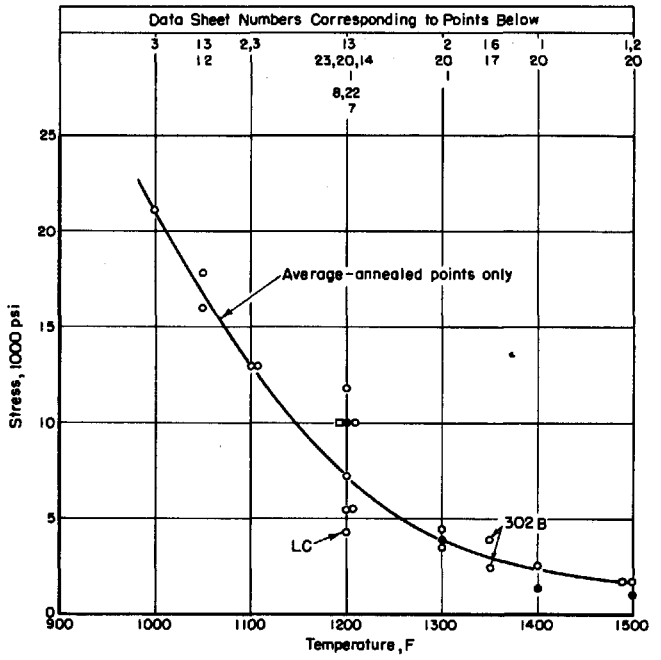
18Cr-8Ni

RUPTURE IN 1000 HOURS



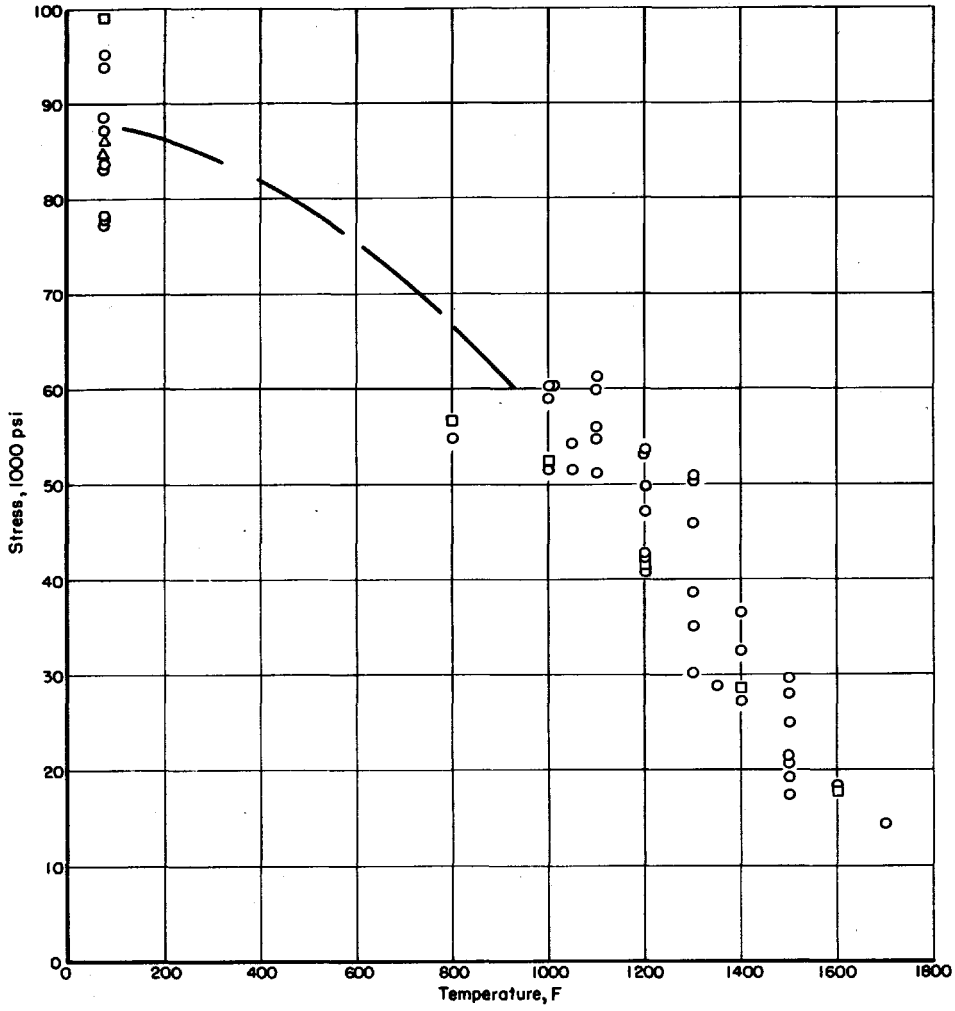
18 Cr-8Ni

RUPTURE IN 10,000 HOURS
(EXTRAPOLATED)

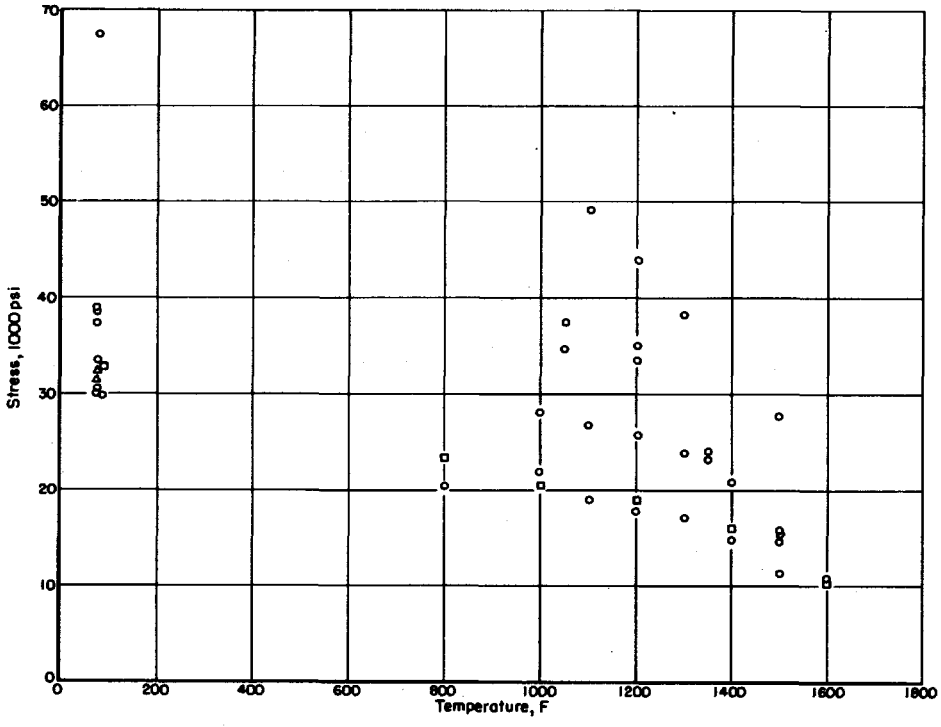


18Cr-8Ni

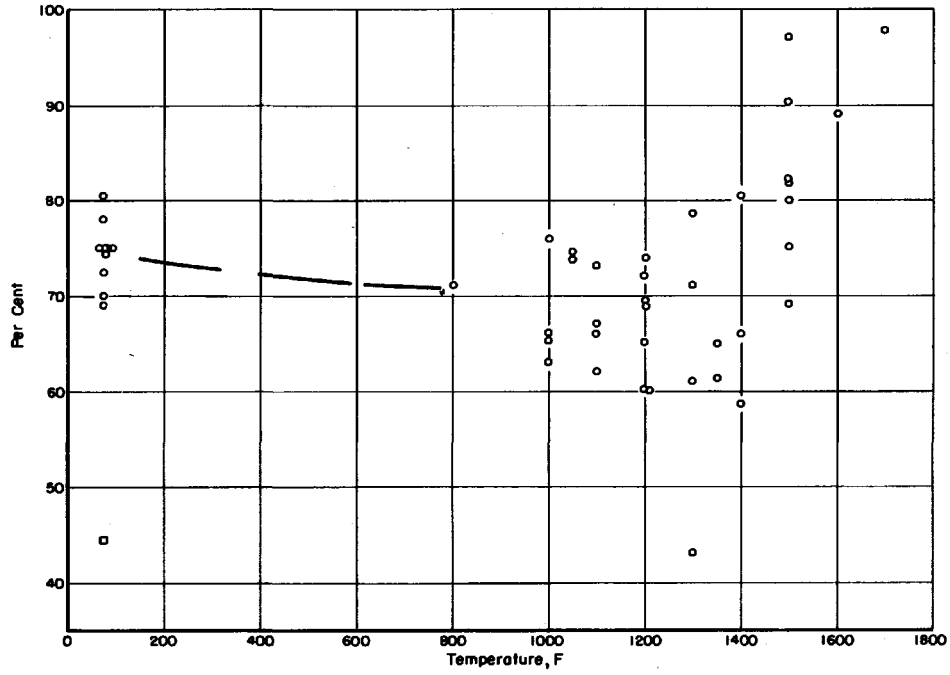
RUPTURE IN 100,000 HOURS
(EXTRAPOLATED)



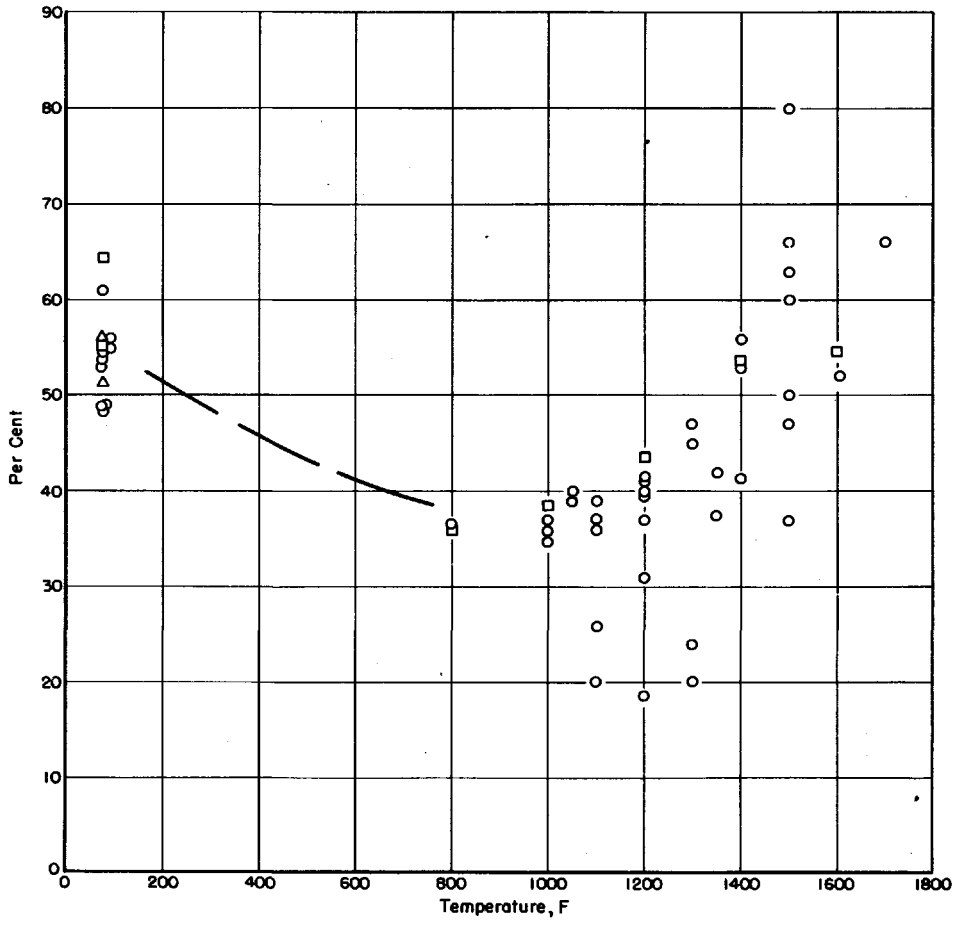
18Cr-8Ni+Ti
TENSILE STRENGTH



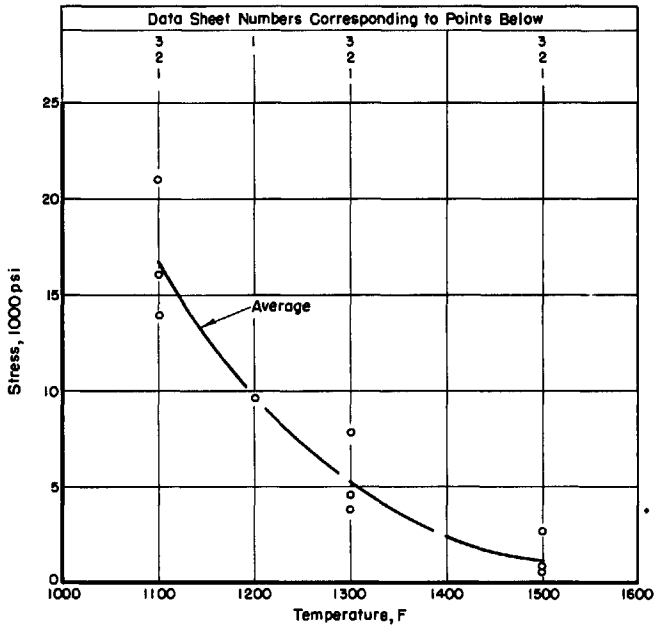
18Cr-8Ni+Ti
0.2 PER CENT OFFSET YIELD STRENGTH



18Cr-8Ni+Ti
REDUCTION OF AREA



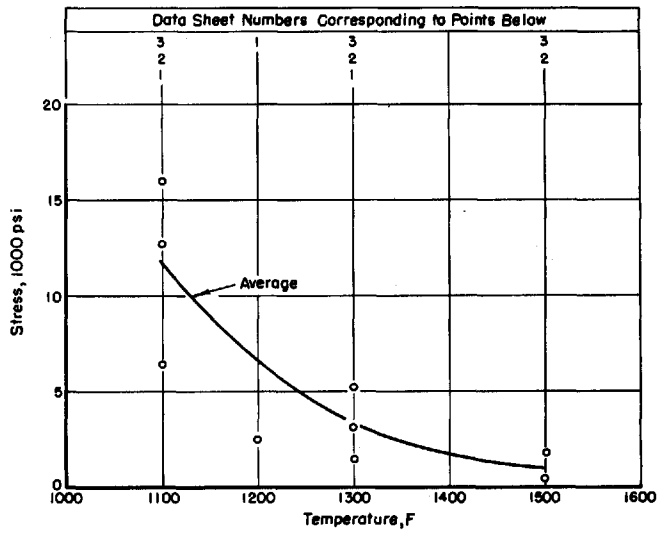
18Cr-8Ni+Ti
ELONGATION



18Cr-8Ni+Ti

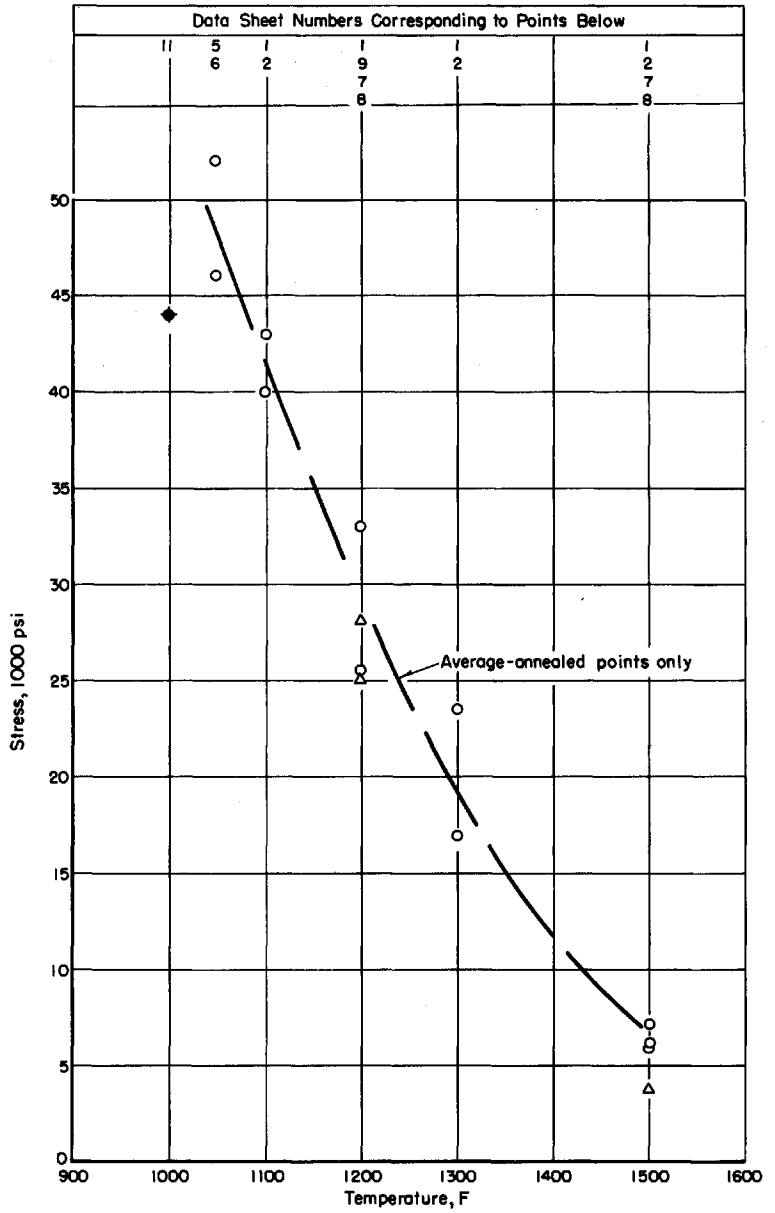
CREEP RATE 0.0001 PER CENT PER HOUR

(1 PER CENT PER 10,000 HOURS)



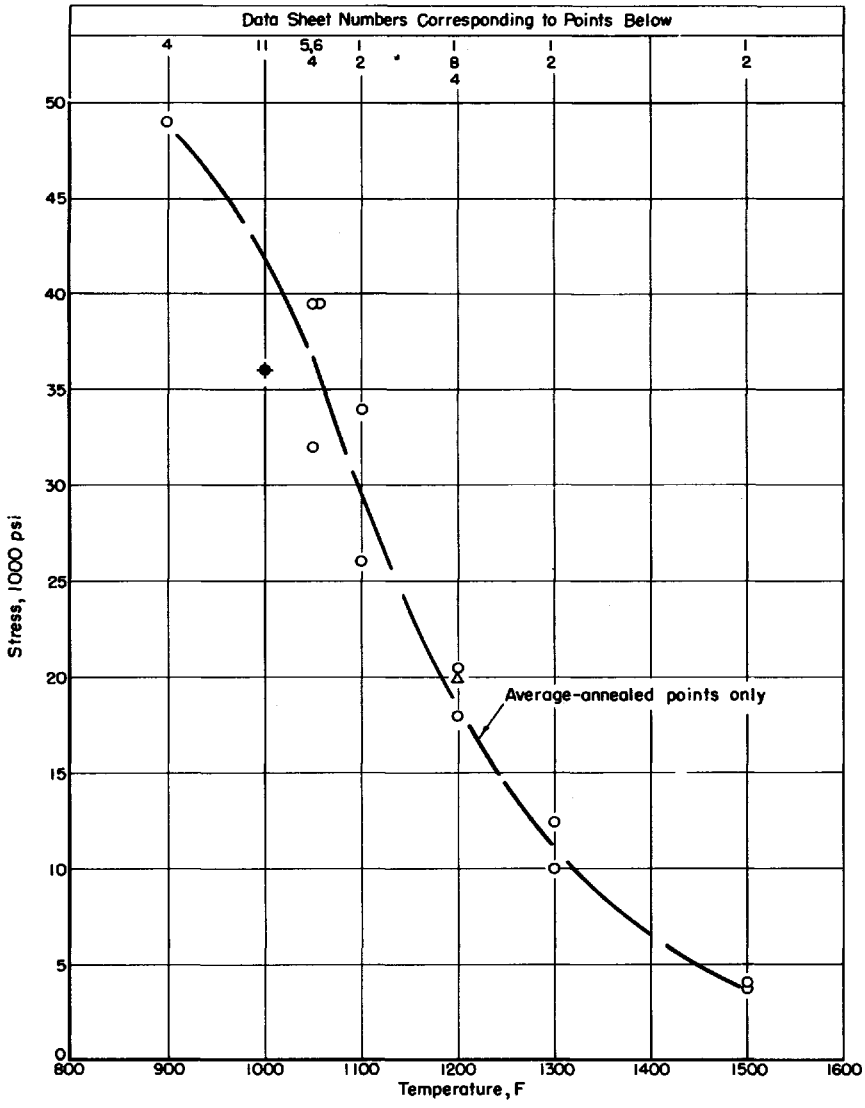
18Cr-8Ni+Ti

CREEP RATE 0.00001 PER CENT PER HOUR



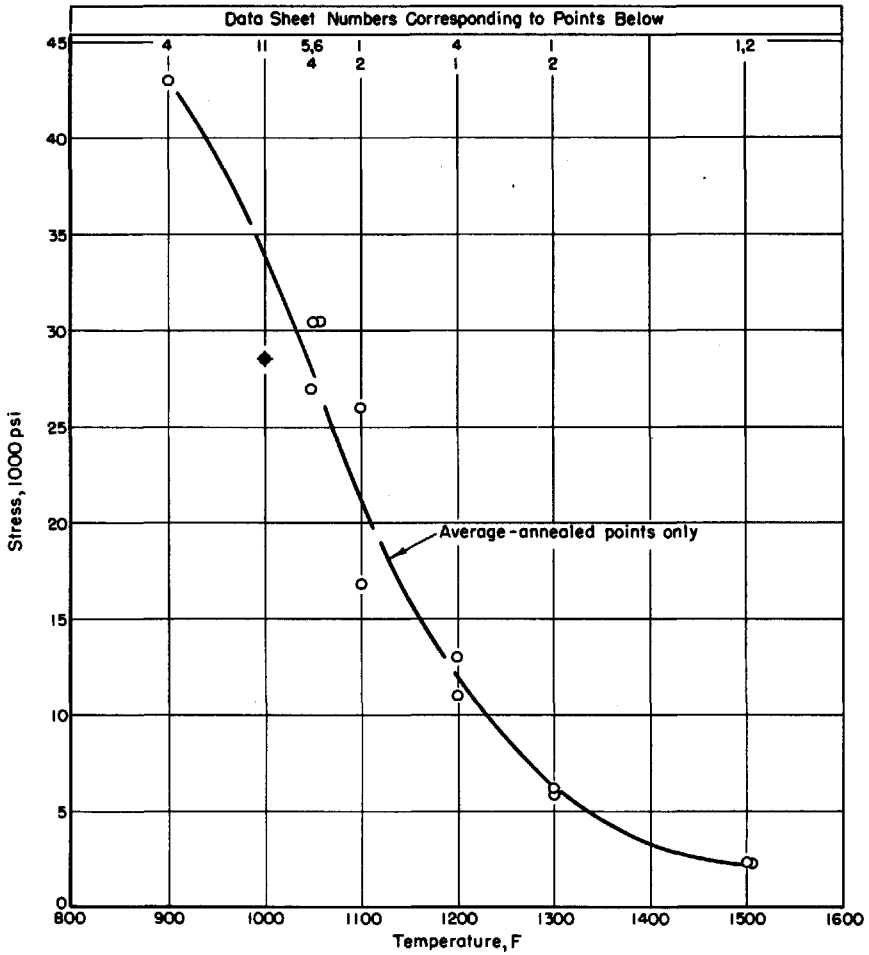
18Cr-8Ni+Ti

RUPTURE IN 100 HOURS



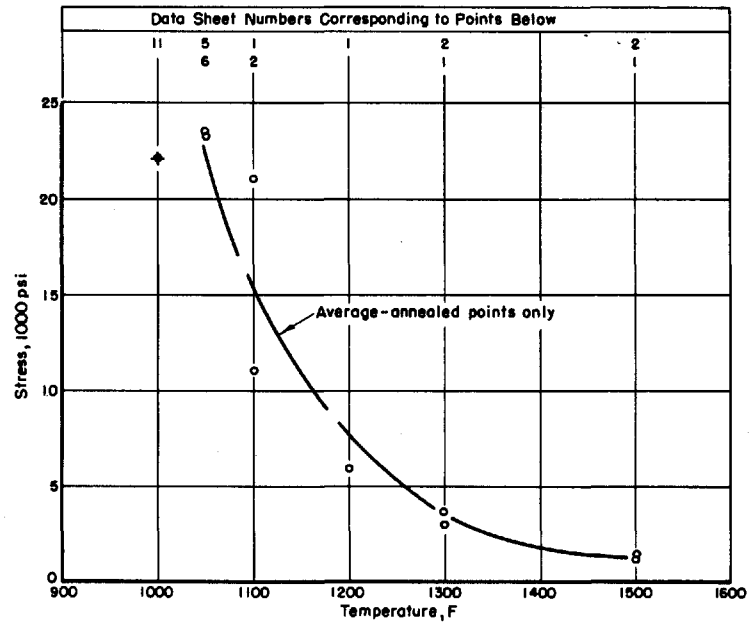
18Cr-8Ni+Ti

RUPTURE IN 1000 HOURS



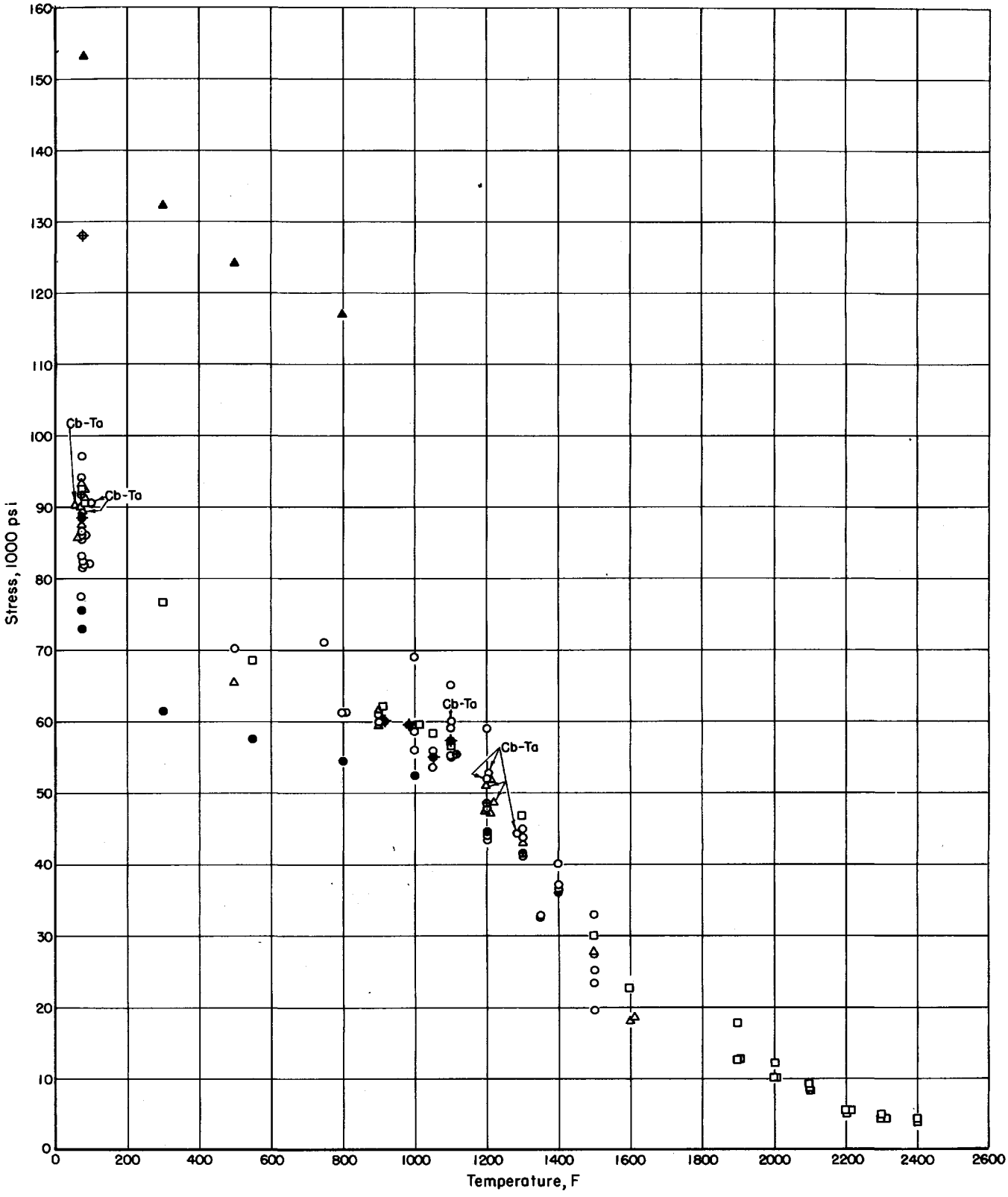
18 Cr-8Ni + Ti

RUPTURE IN 10,000 HOURS
(EXTRAPOLATED)



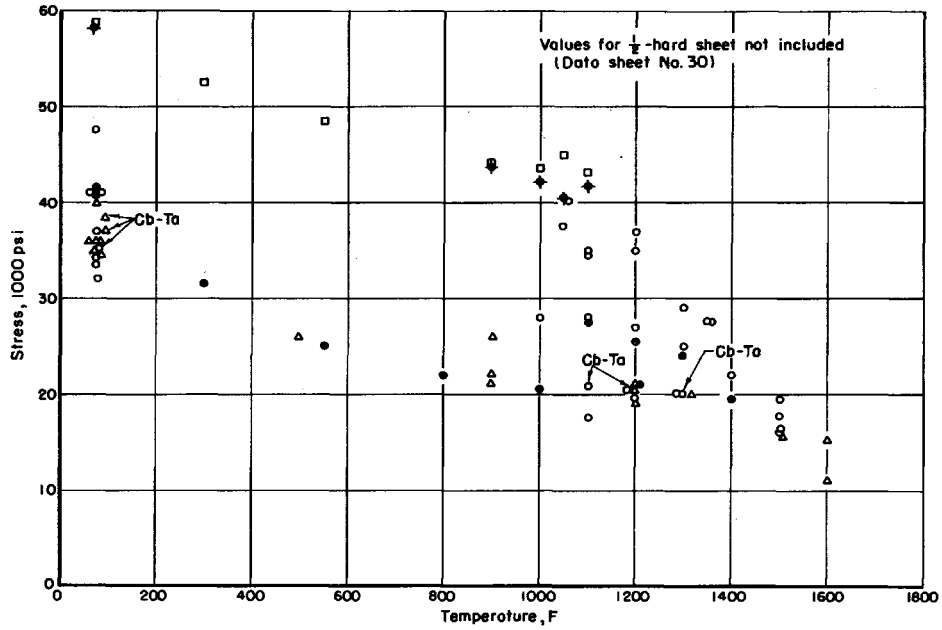
18Cr-8Ni + Ti

RUPTURE IN 100,000 HOURS
(EXTRAPOLATED)



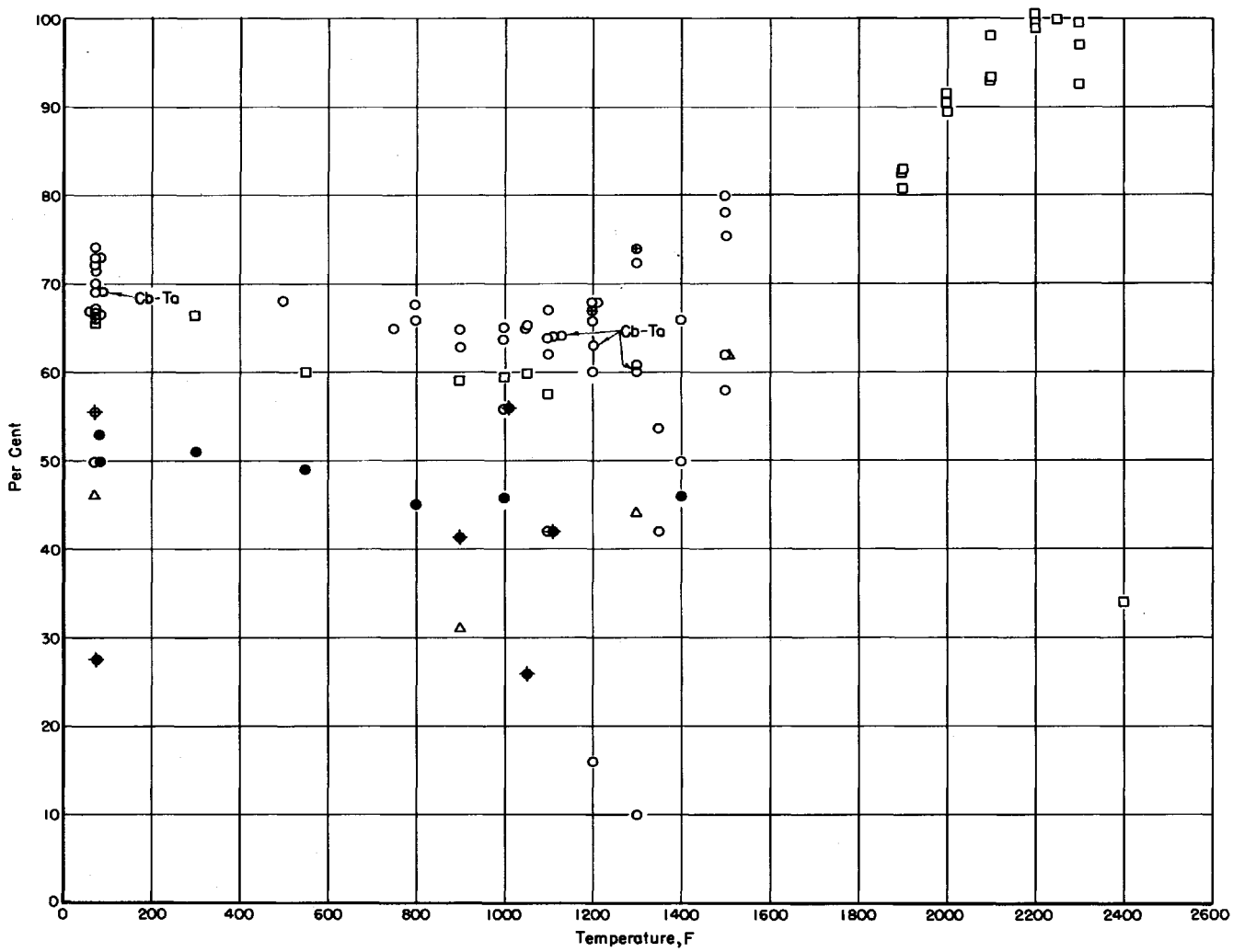
18Cr-8Ni + Cb

TENSILE STRENGTH



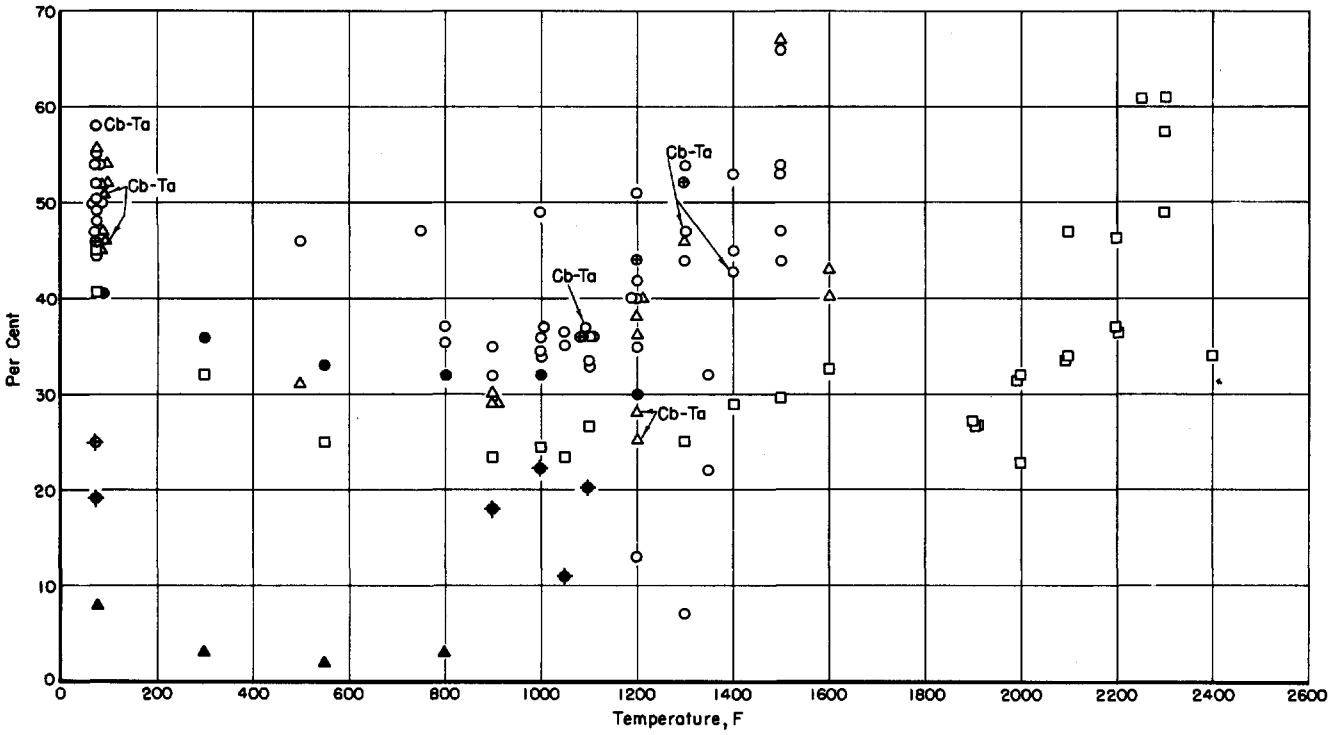
18 Cr-8Ni + Cb

0.2 PER CENT OFFSET YIELD STRENGTH

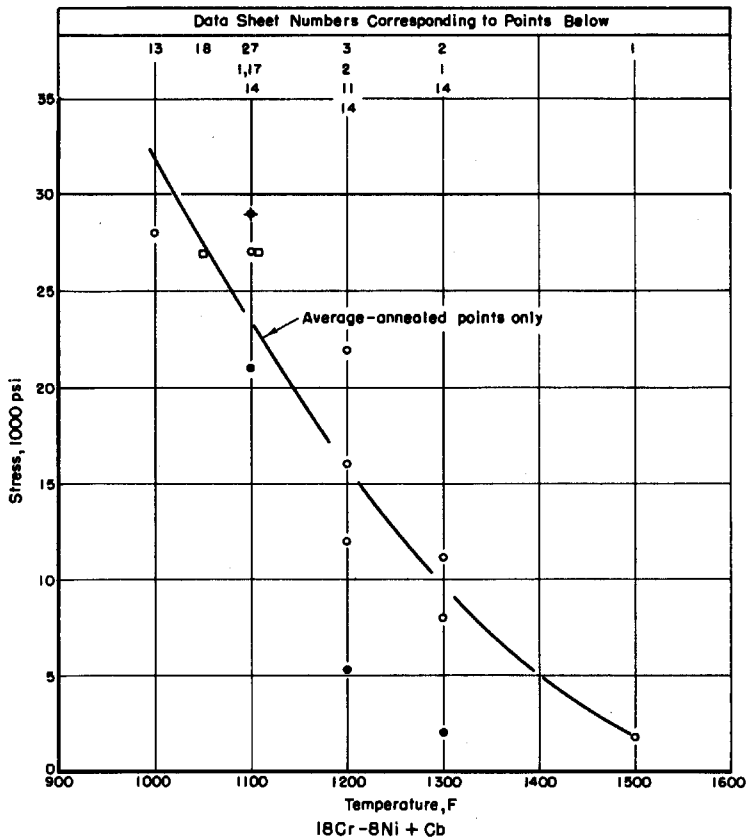


18 Cr-8Ni + Cb

REDUCTION OF AREA



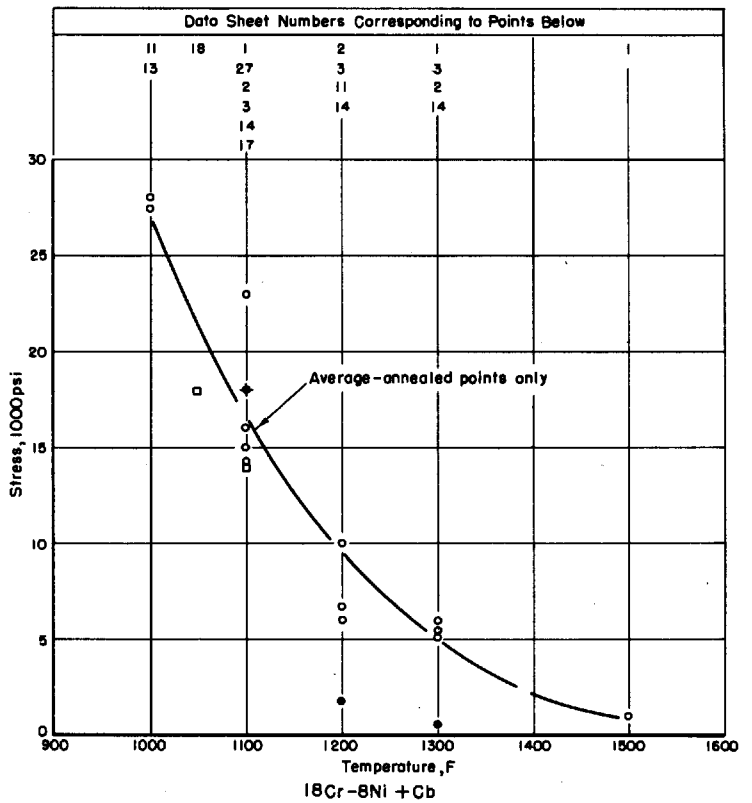
18Cr-8Ni + Cb
ELONGATION



18Cr-8Ni + Cb

CREEP RATE 0.0001 PER CENT PER HOUR

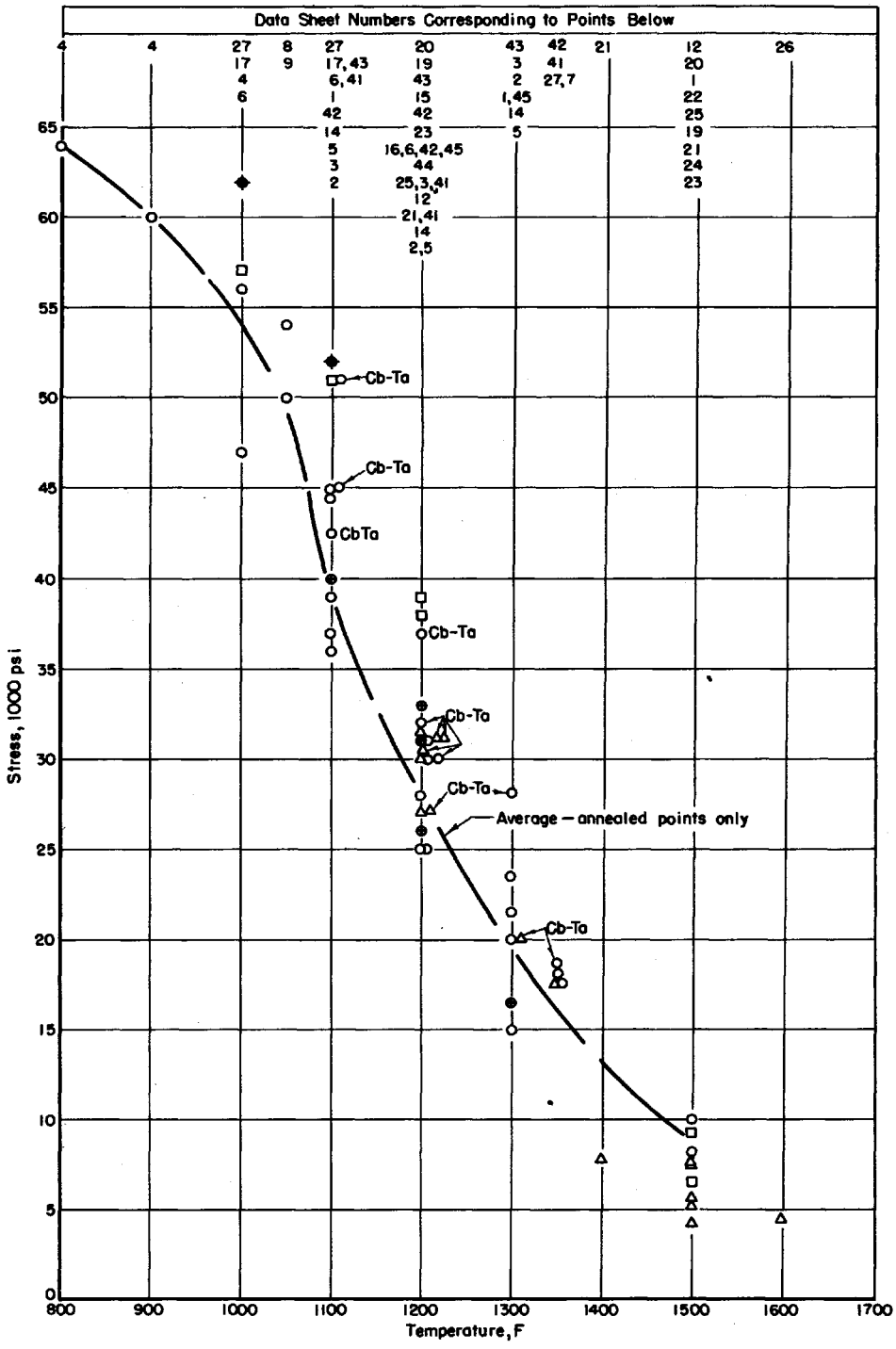
(1 PER CENT PER 10,000 HOURS)



18Cr-8Ni + Cb

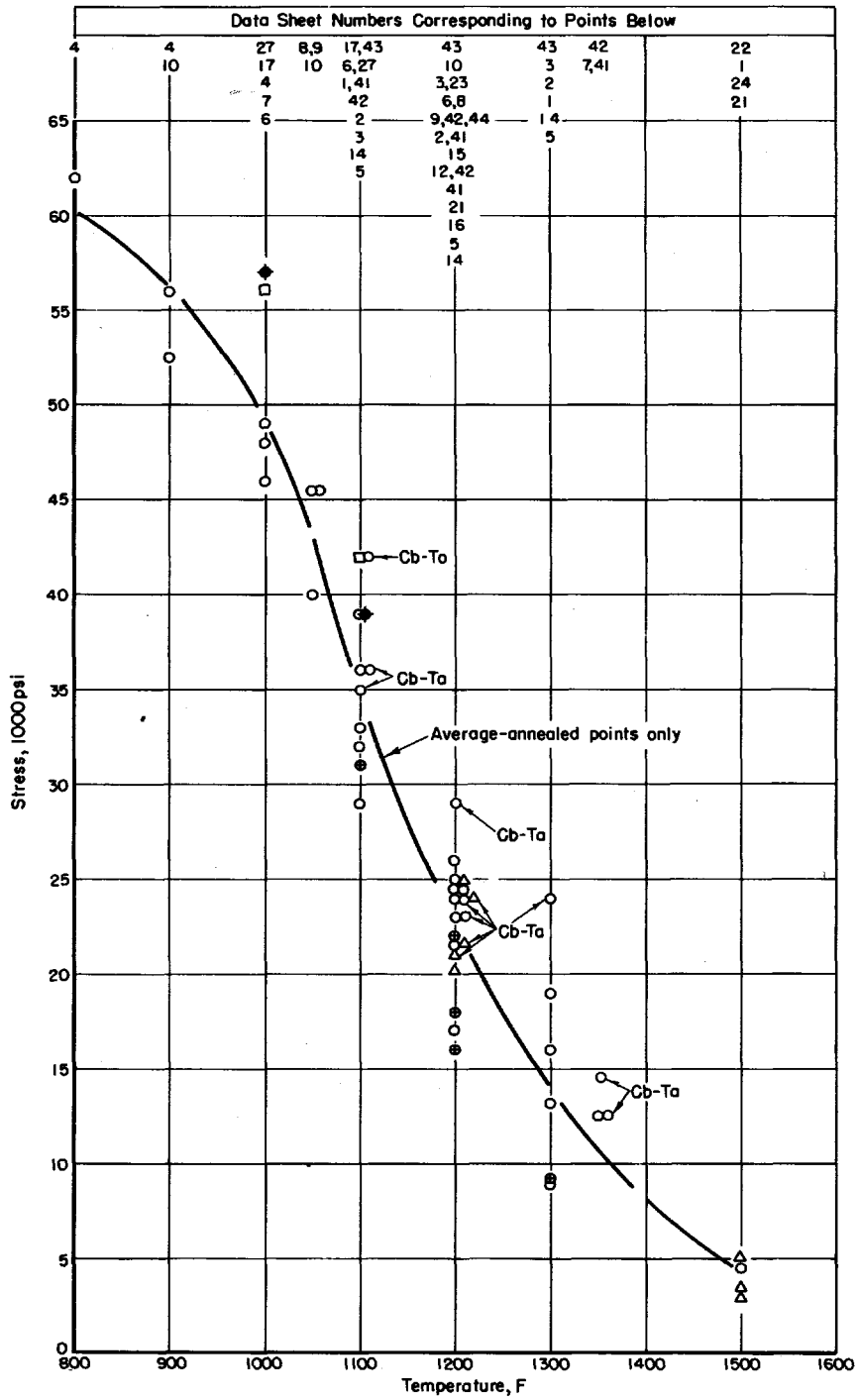
CREEP RATE 0.00001 PER CENT PER HOUR

(1 PER CENT PER 100,000 HOURS)



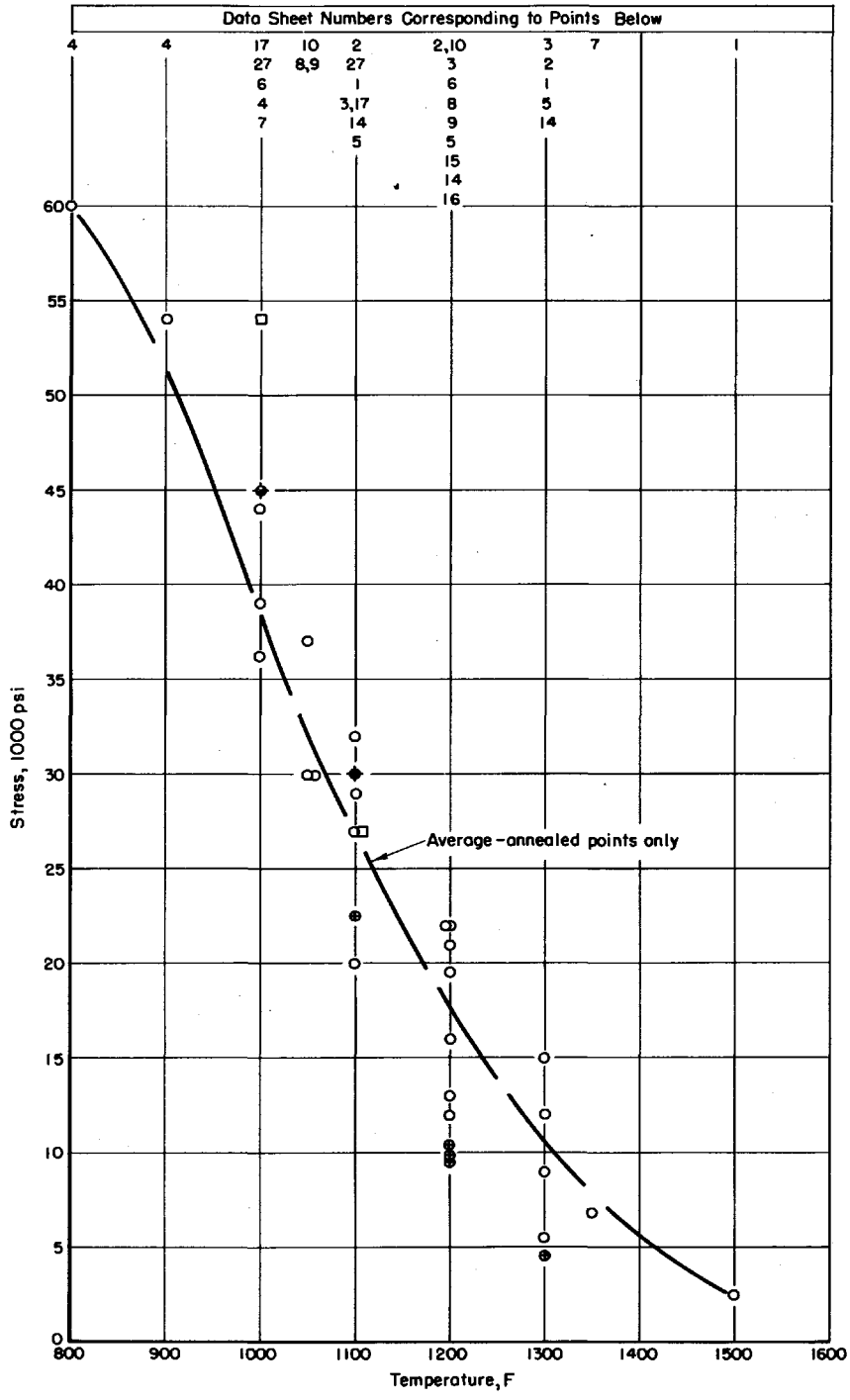
18Cr-8Ni + Cb

RUPTURE IN 100 HOURS



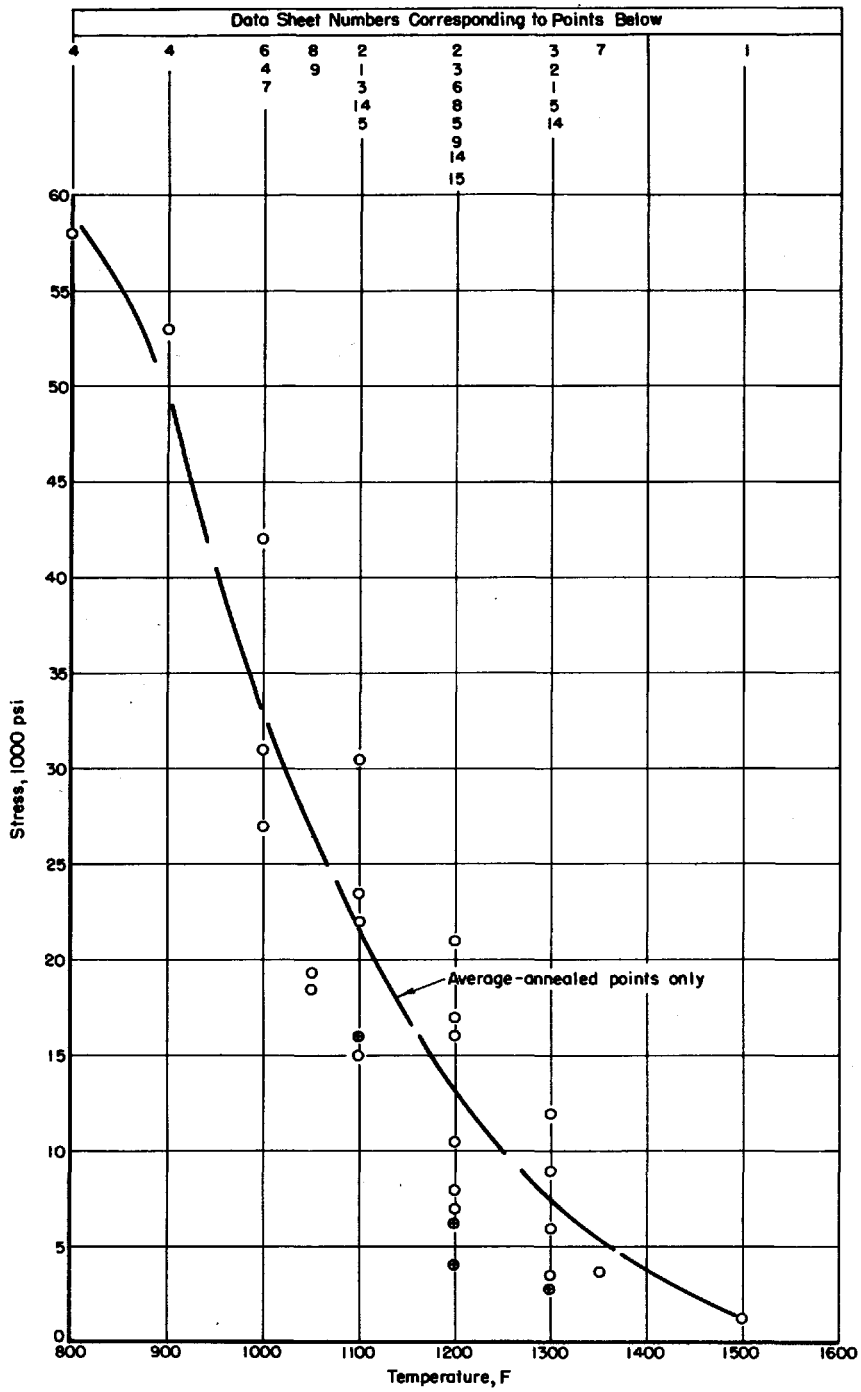
18 Cr-8Ni + Cb

RUPTURE IN 1000 HOURS



18Cr-8Ni + Cb

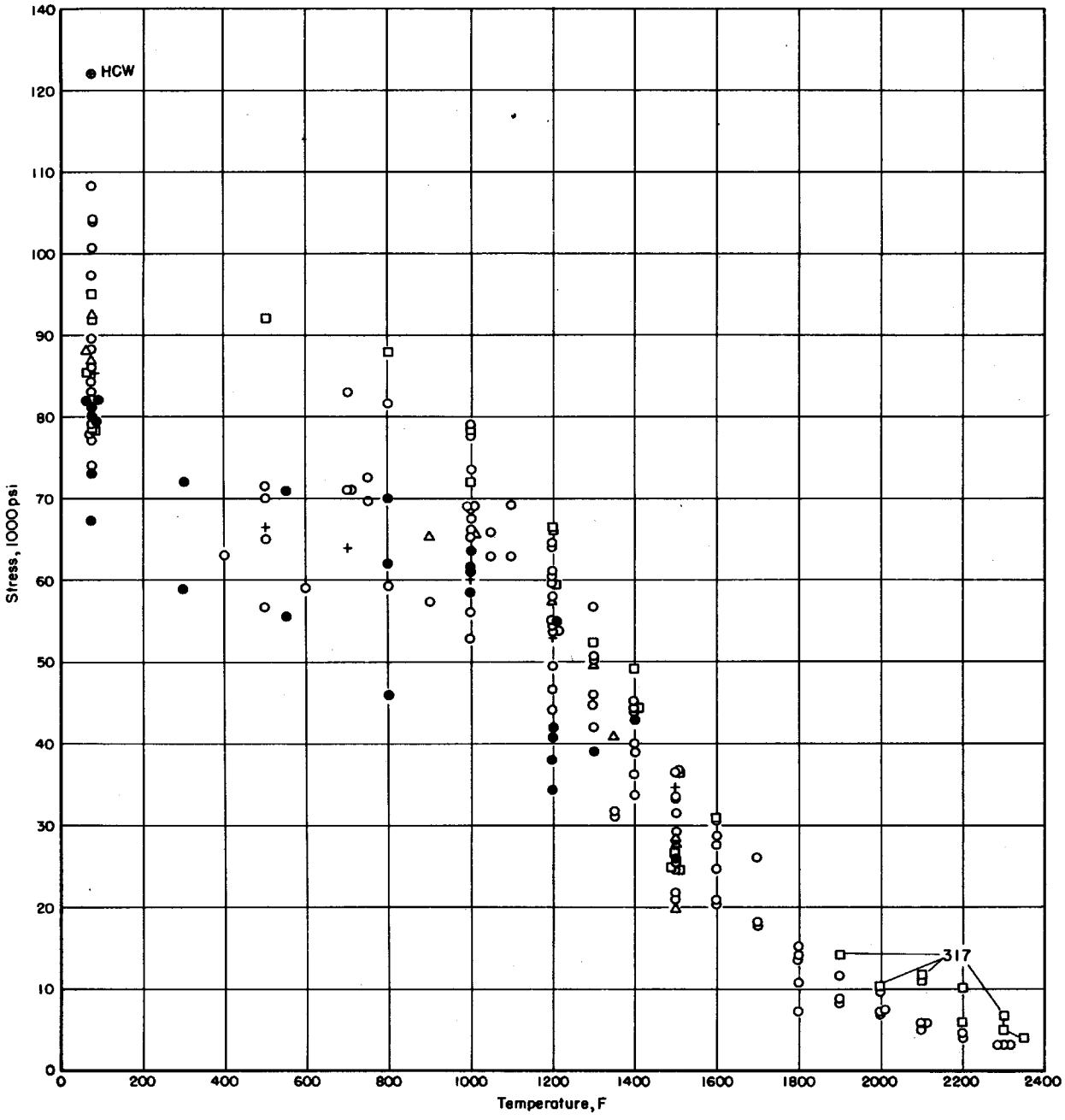
RUPTURE IN 10,000 HOURS
(EXTRAPOLATED)



18Cr-8Ni + Cb

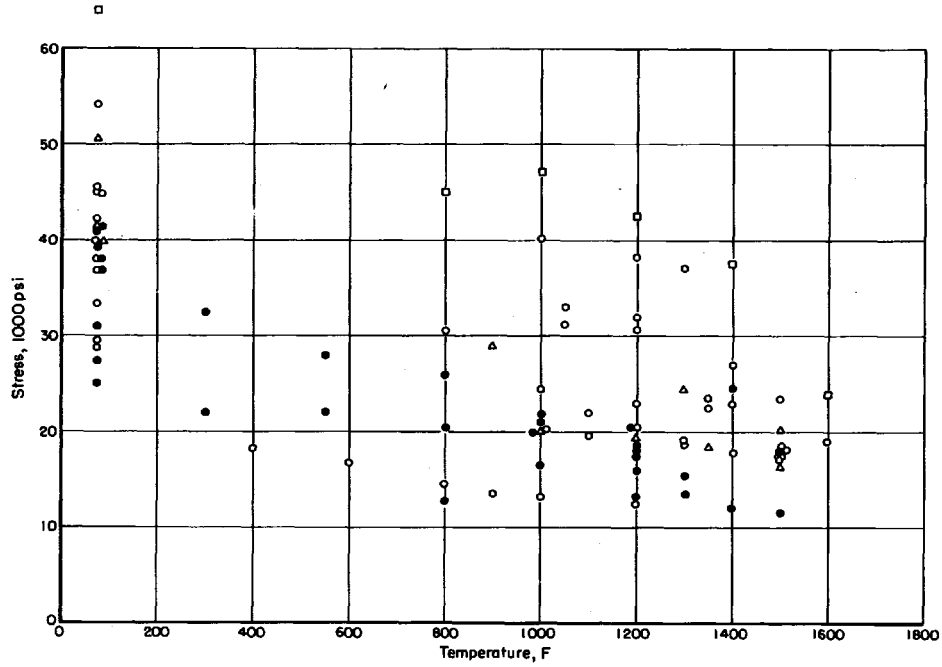
RUPTURE IN 100,000 HOURS

(EXTRAPOLATED)



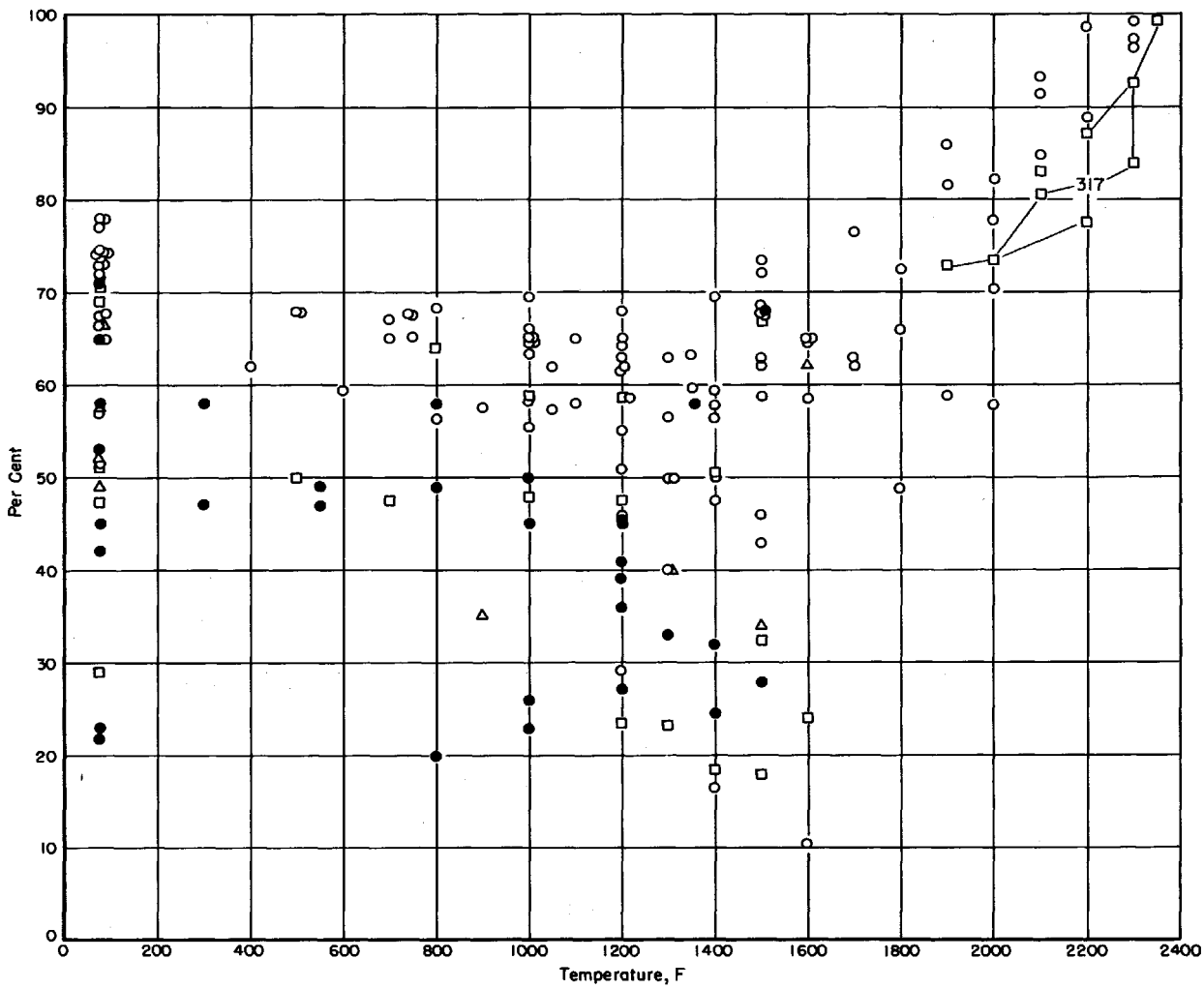
18Cr-8Ni + Mo

TENSILE STRENGTH



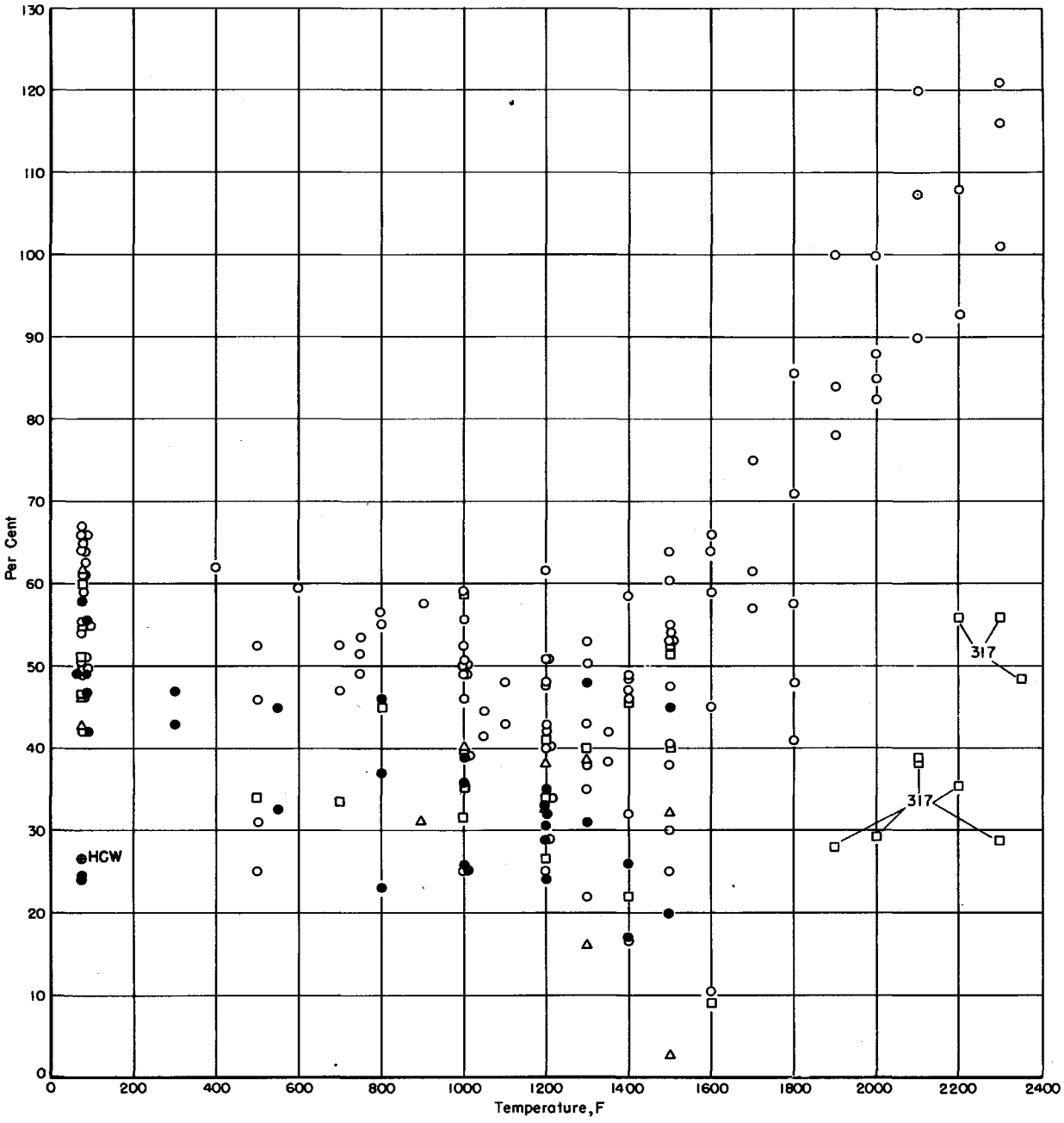
18Cr-8Ni + Mo

0.2 PER CENT OFFSET YIELD STRENGTH



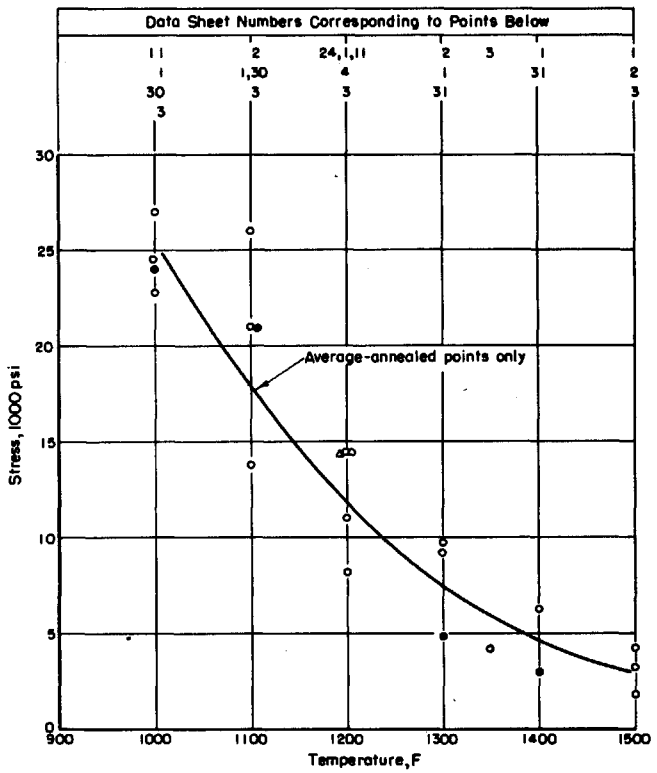
18Cr-8Ni + Mo

REDUCTION OF AREA



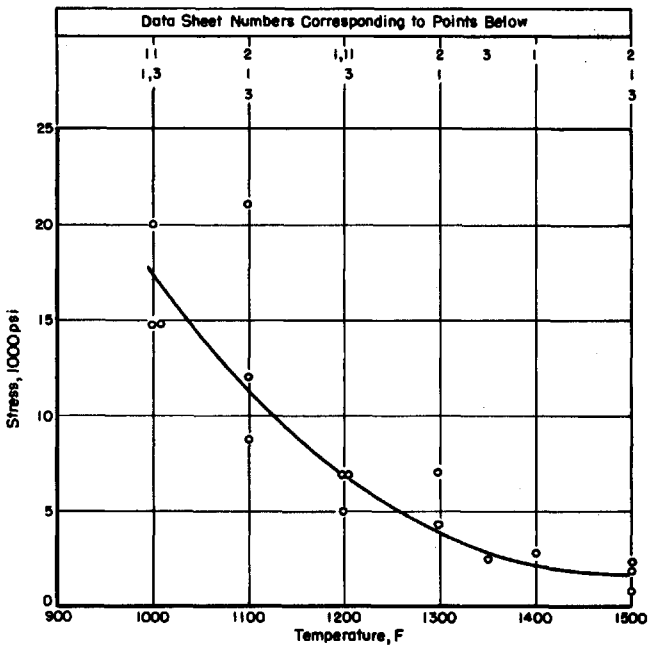
18Cr-8Ni + Mo

ELONGATION



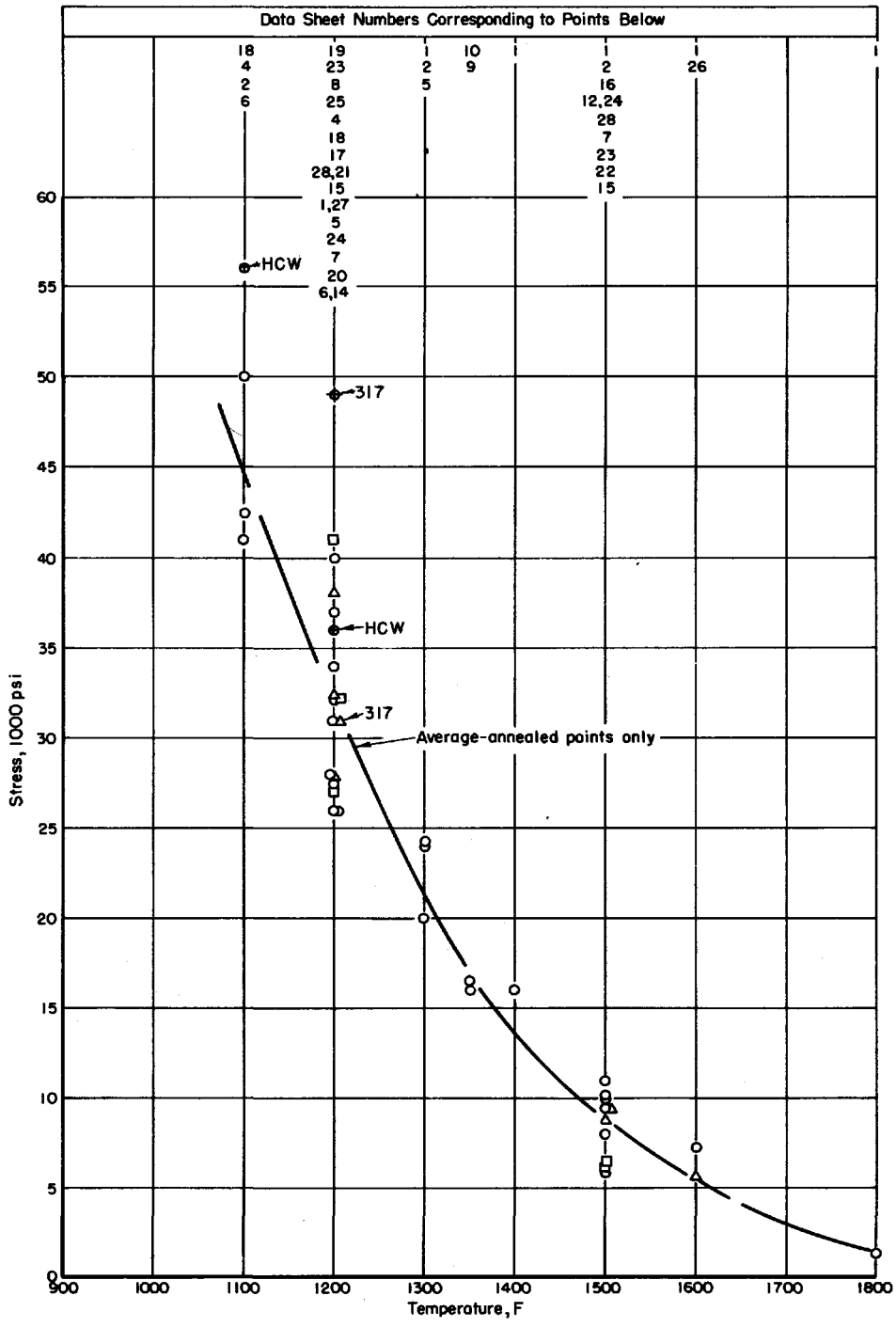
18Cr-8Ni + Mo

CREEP RATE, 0.0001 PER CENT PER HOUR
(1 PER CENT PER 10,000 HOURS)



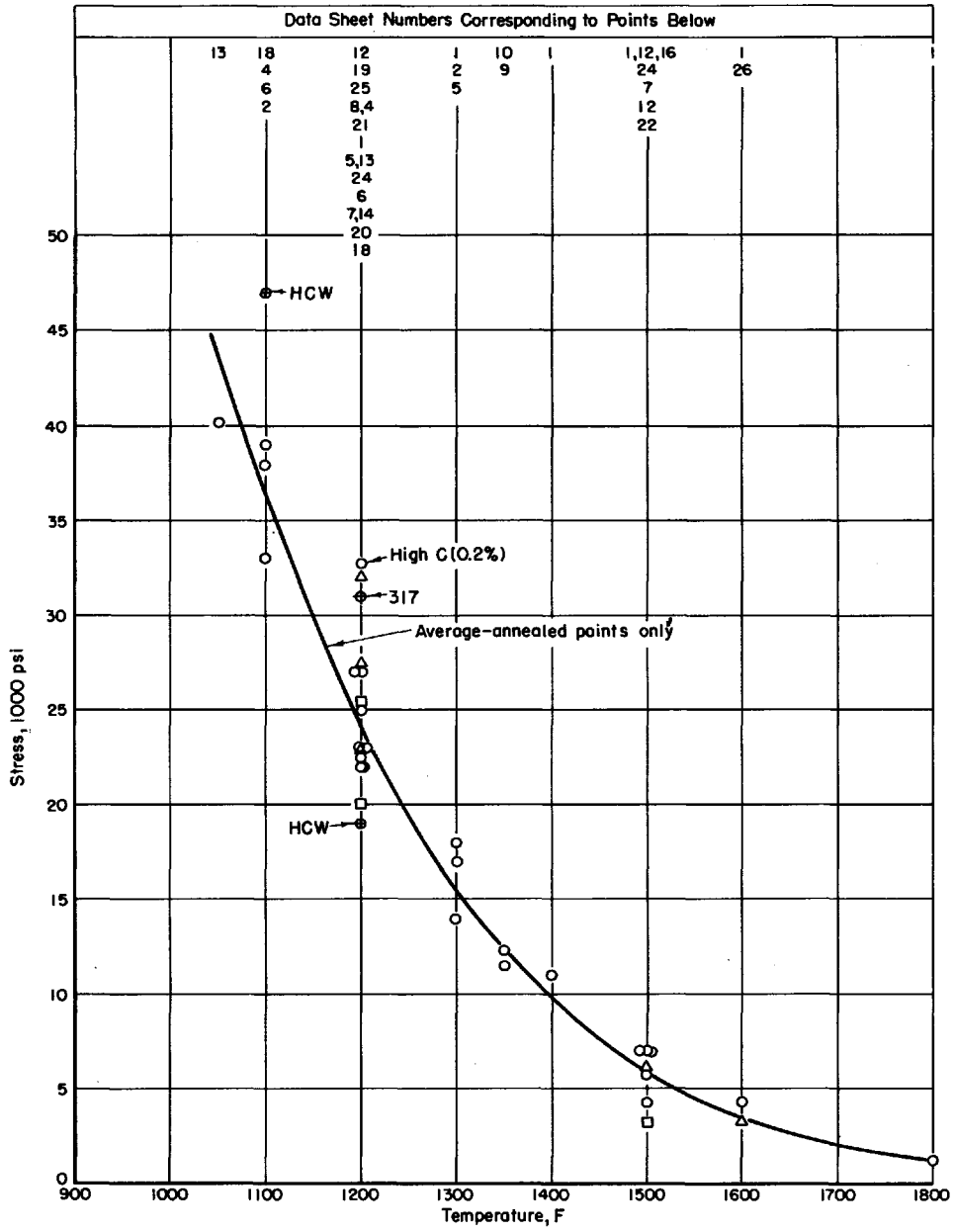
18Cr-8Ni + Mo

CREEP RATE, 0.00001 PER CENT PER HOUR
(1 PER CENT PER 100,000 HOURS)



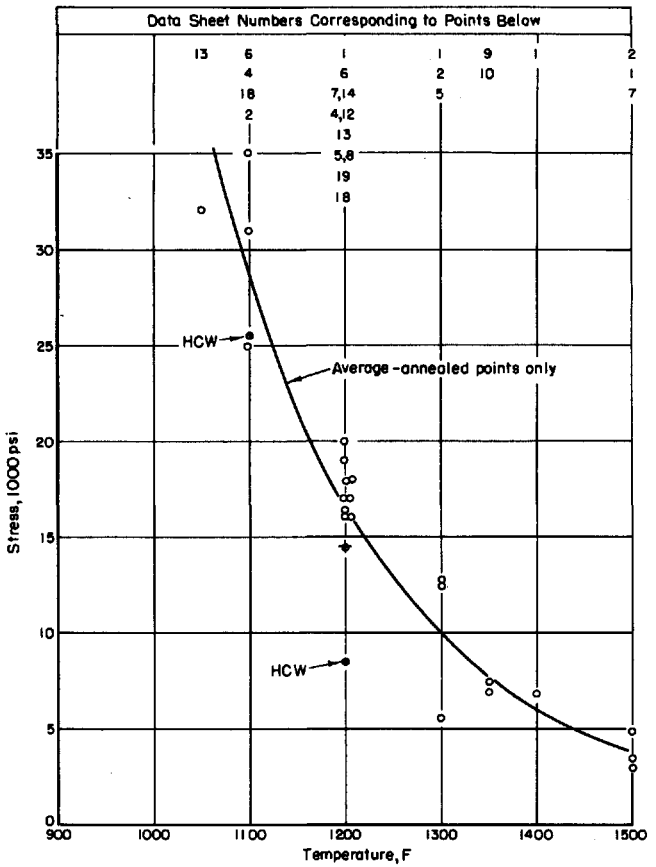
18Cr-8Ni + Mo

RUPTURE IN 100 HOURS



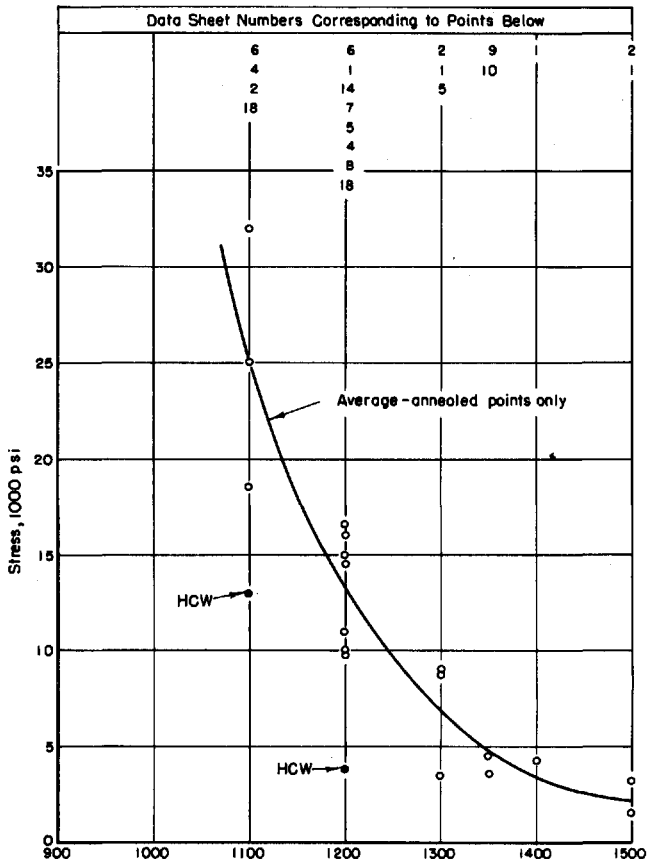
18Cr-8Ni + Mo

RUPTURE IN 1000 HOURS



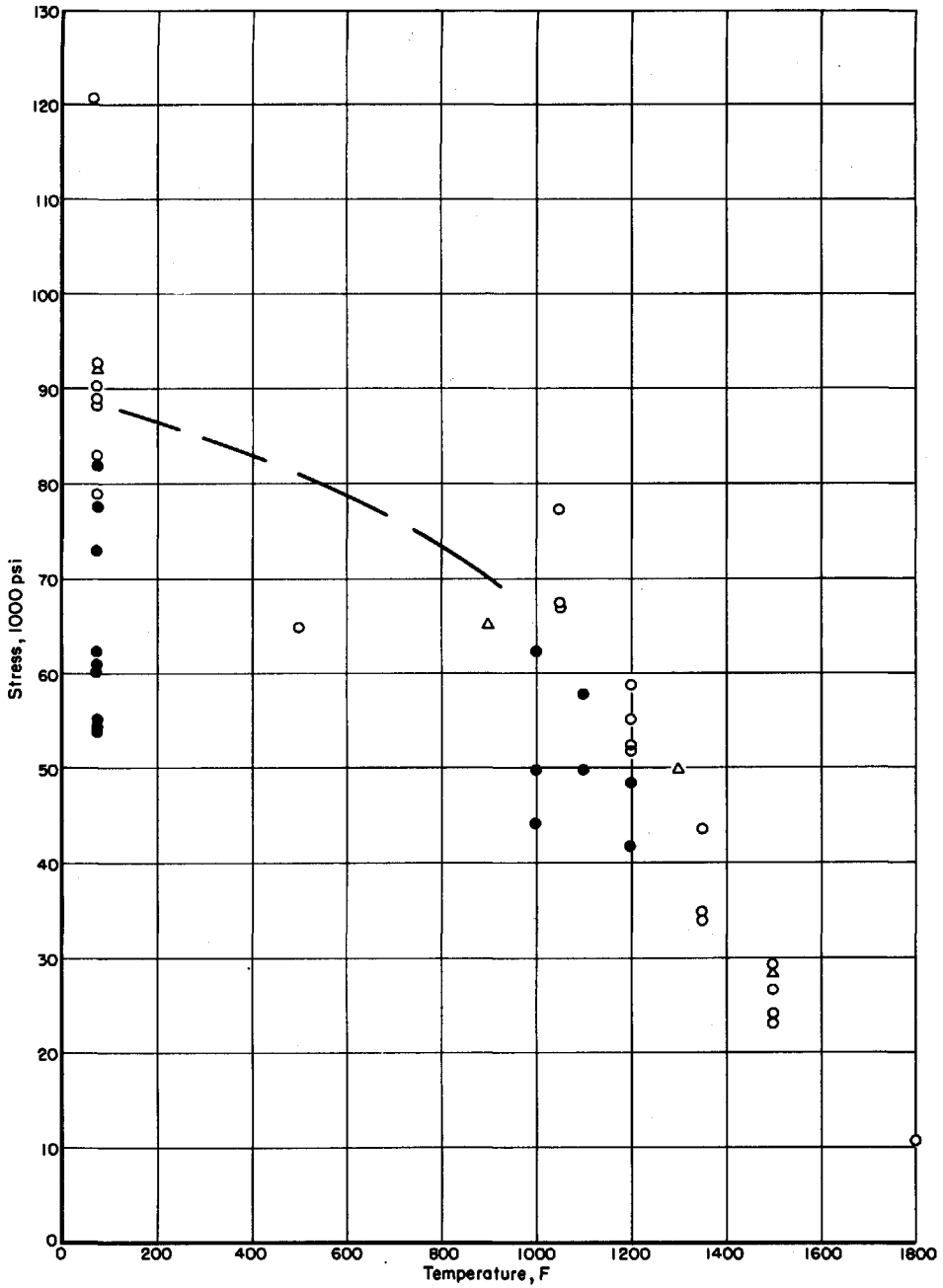
18Cr-8Ni + Mo

RUPTURE IN 10,000 HOURS
(EXTRAPOLATED)



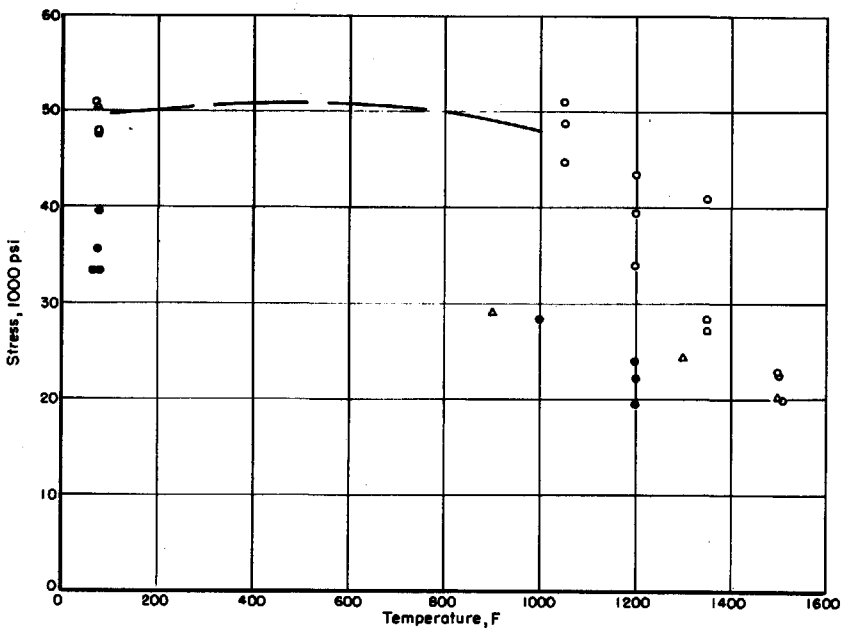
18Cr-8Ni + Mo

RUPTURE IN 100,000 HOURS
(EXTRAPOLATED)



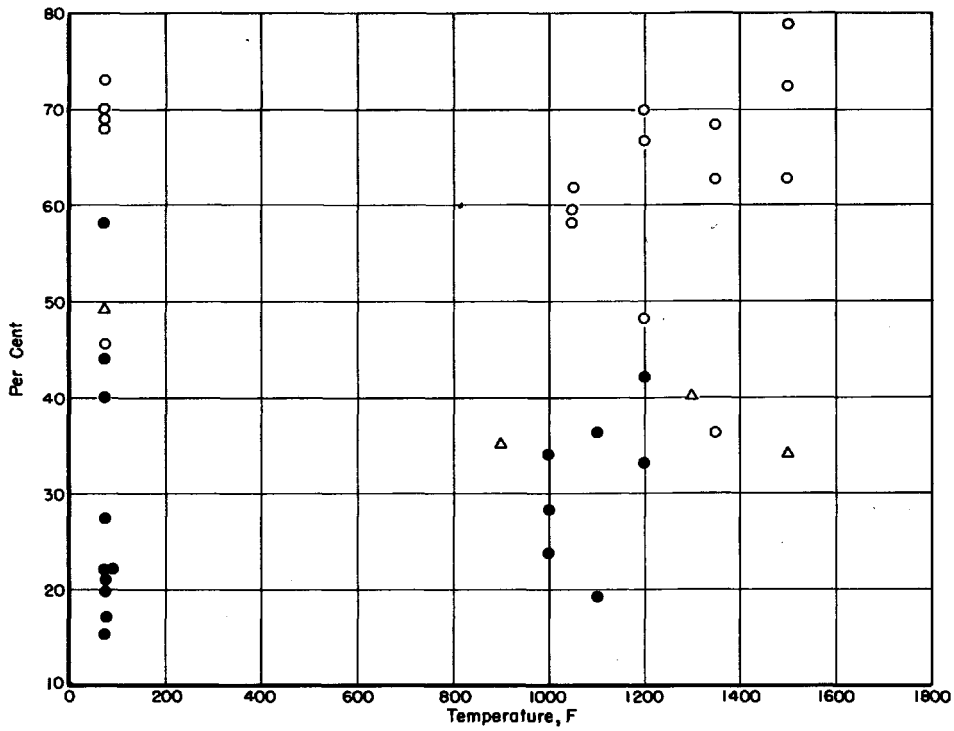
18Cr-8Ni+Mo+Cb

TENSILE STRENGTH

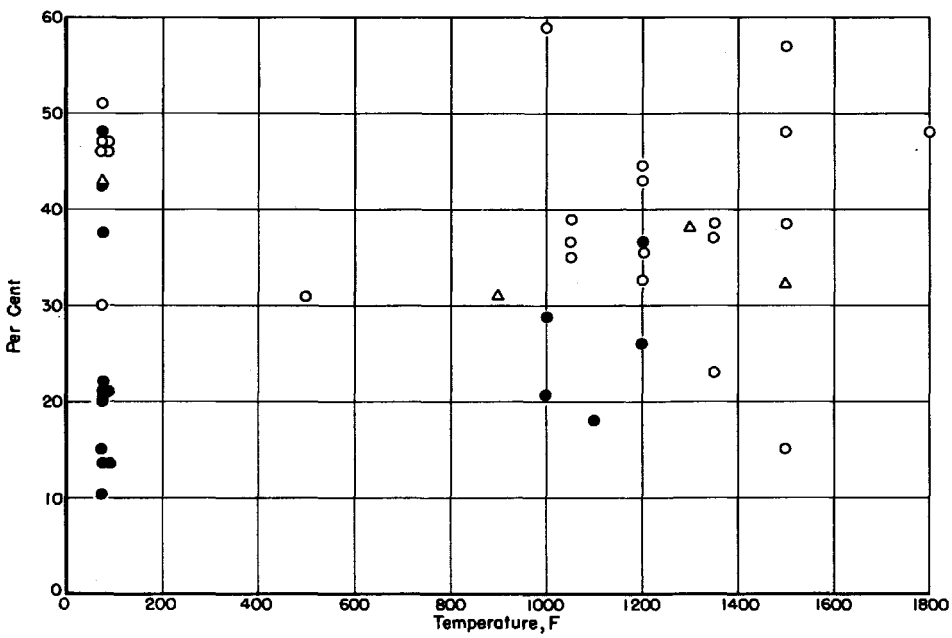


18Cr-8Ni+Mo+Cb

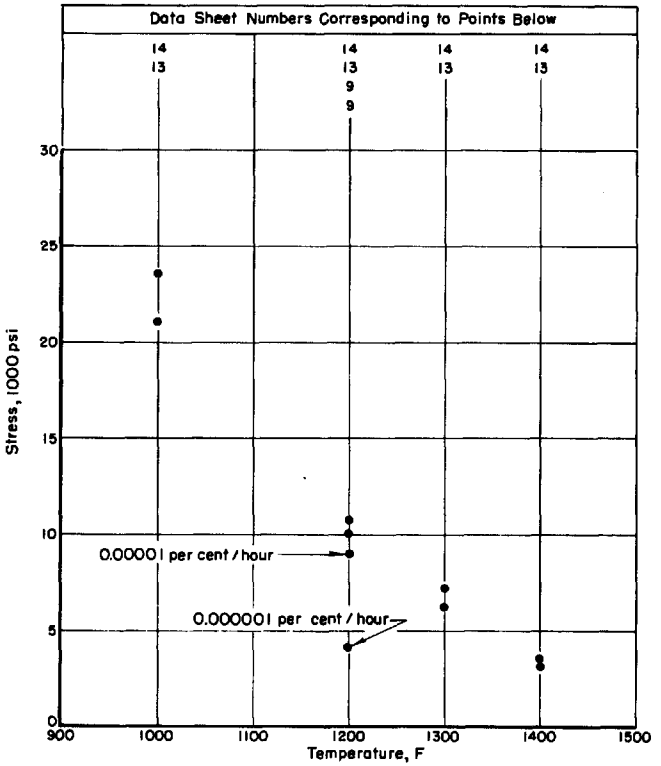
0.2 PER CENT OFFSET YIELD STRENGTH



18Cr-8Ni + Mo + Cb
REDUCTION OF AREA

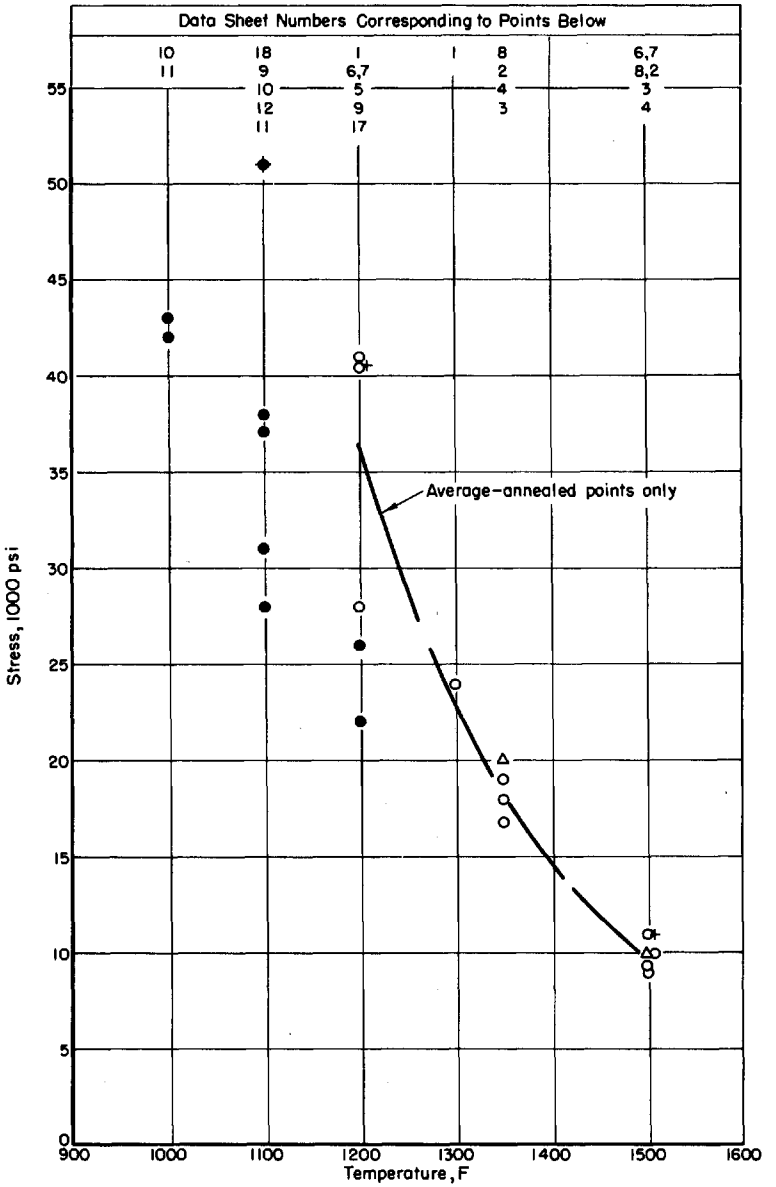


18Cr-8Ni + Mo + Cb
ELONGATION



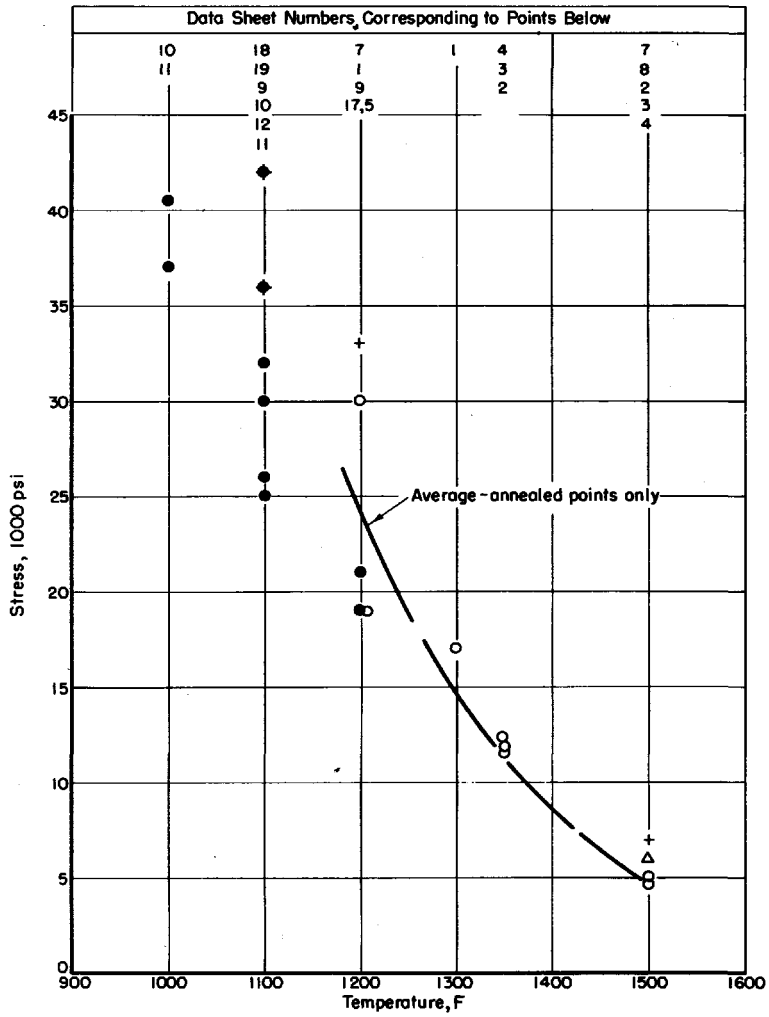
18Cr-8Ni + Mo + Cb

CREEP RATE 0.0001 PER CENT PER HOUR
(1 PER CENT PER 10,000 HOURS)

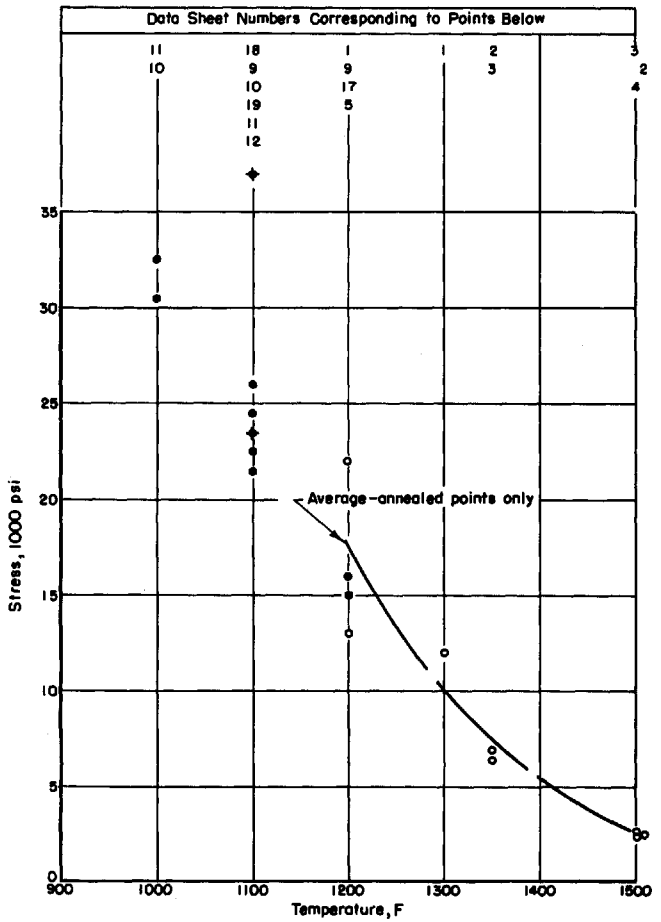


18Cr-8Ni + Mo + Cb

RUPTURE IN 100 HOURS

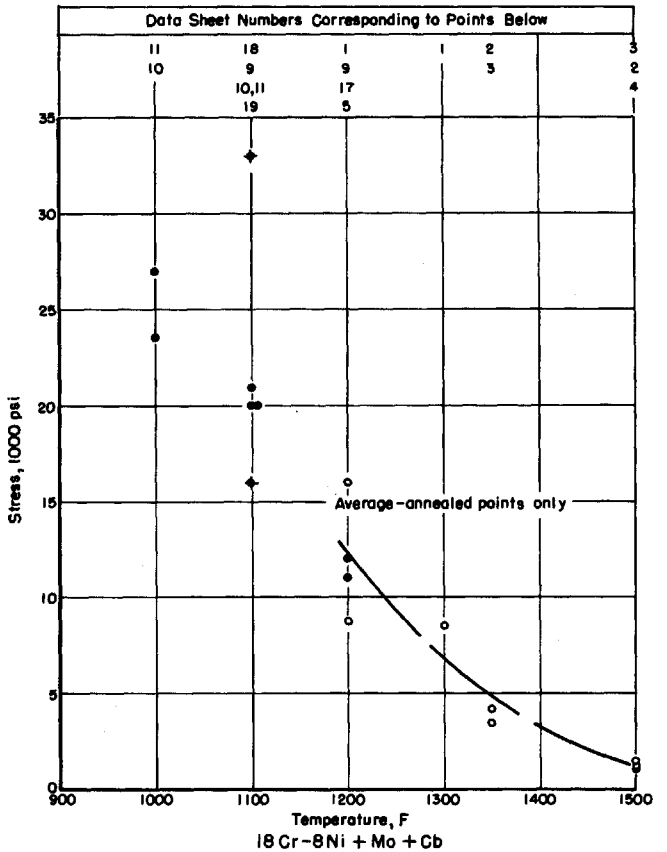


18Cr-8Ni + Mo + Cb
RUPTURE IN 1000 HOURS



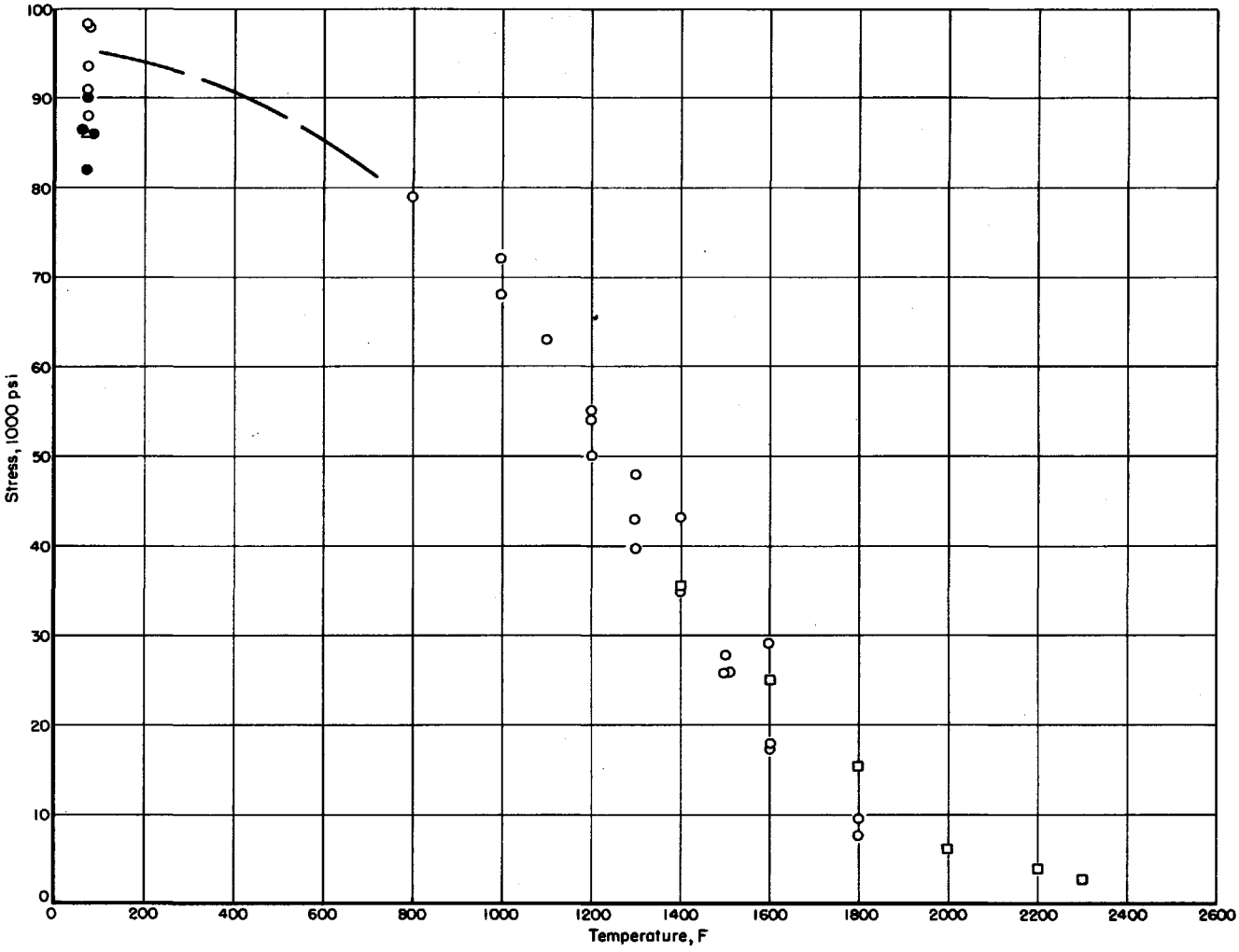
18Cr-8Ni + Mo + Cb

RUPTURE IN 10,000 HOURS
(EXTRAPOLATED)



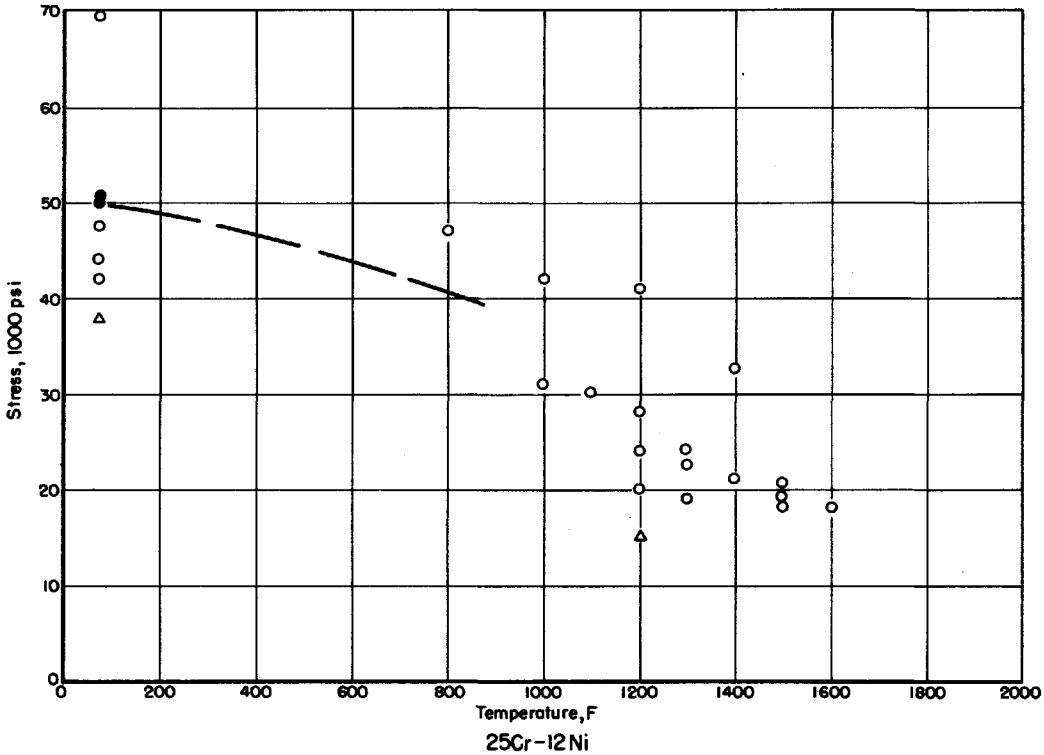
18 Cr-8Ni + Mo + Cb

RUPTURE IN 100,000 HOURS
(EXTRAPOLATED)



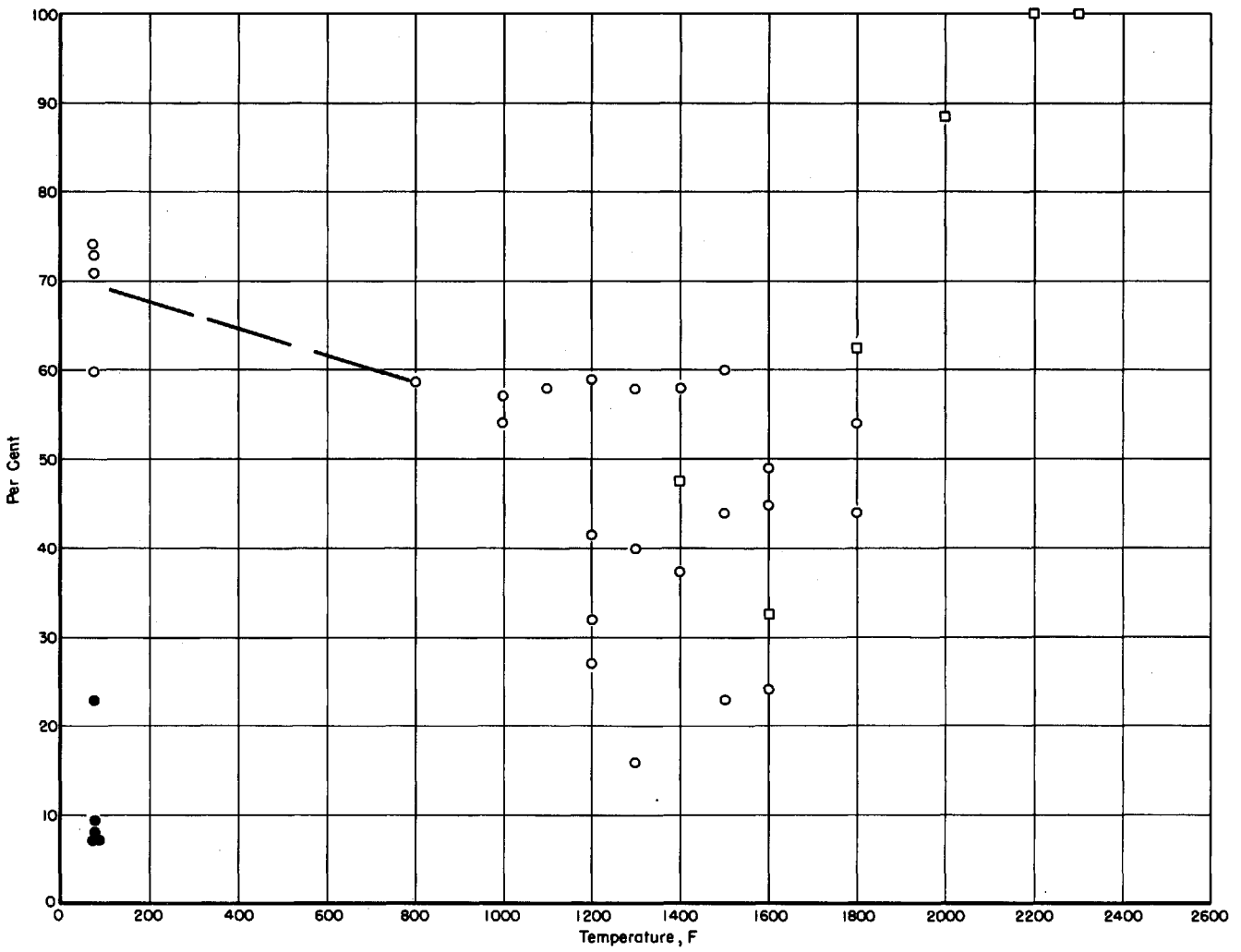
25Cr-12Ni

TENSILE STRENGTH



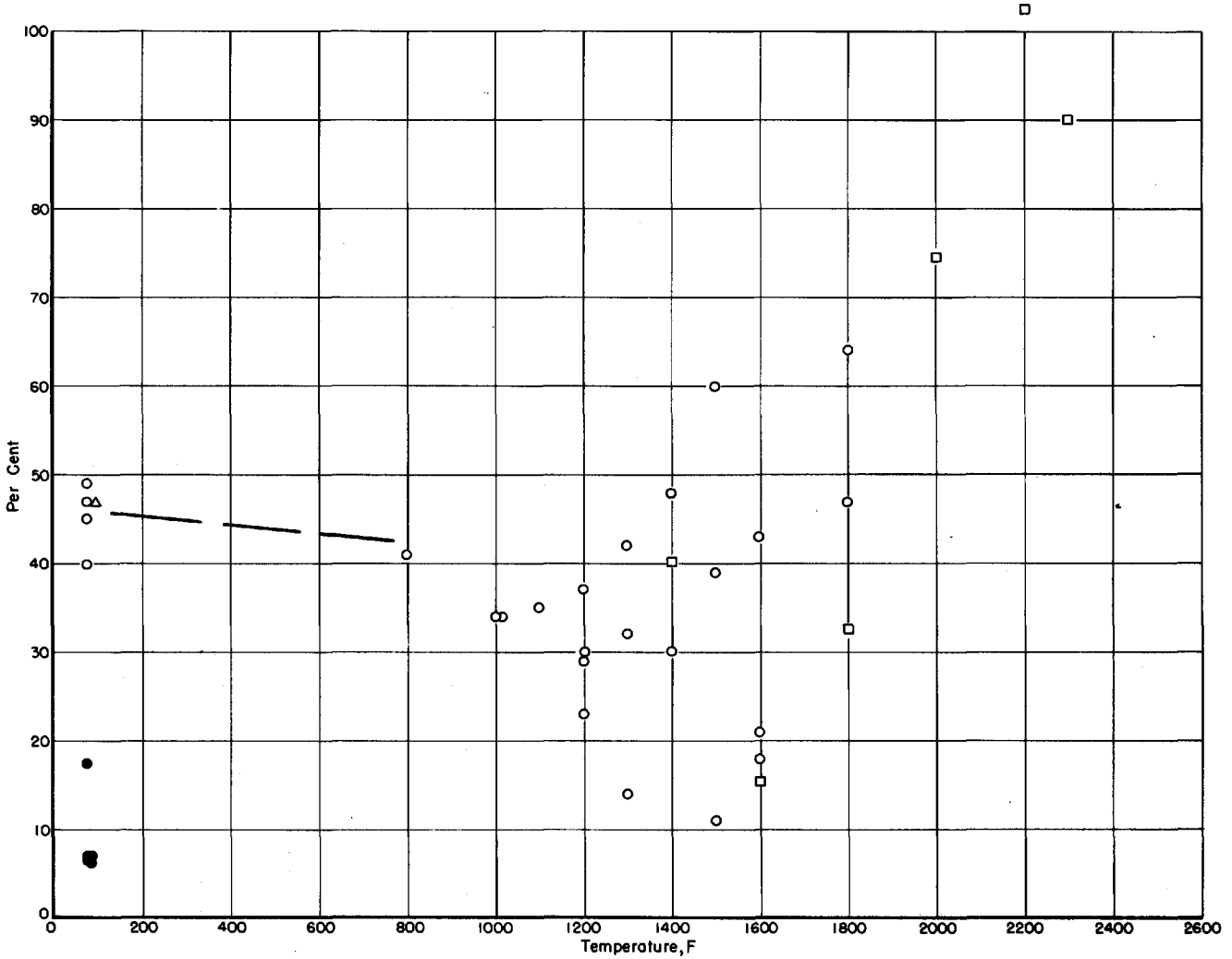
25Cr-12Ni

0.2 PER CENT OFFSET YIELD STRENGTH



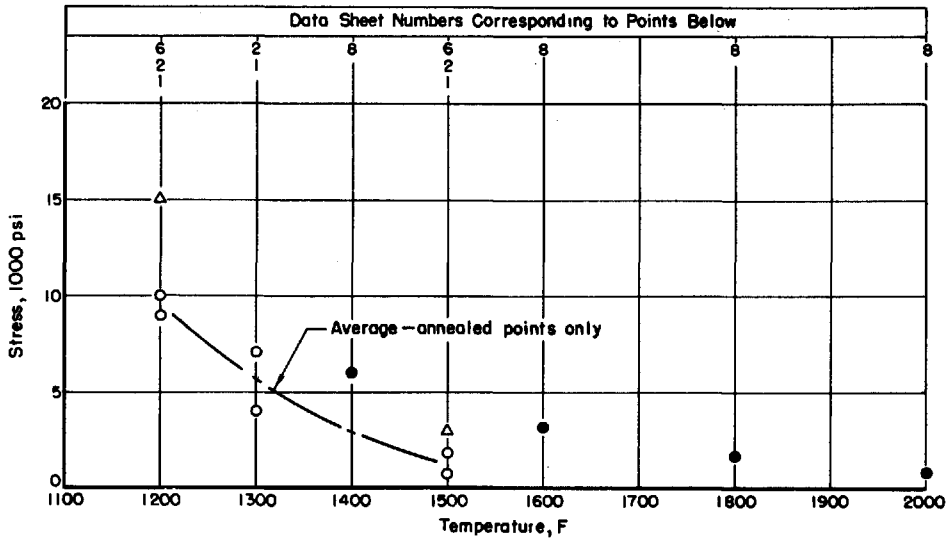
25 Cr—12 Ni

REDUCTION OF AREA

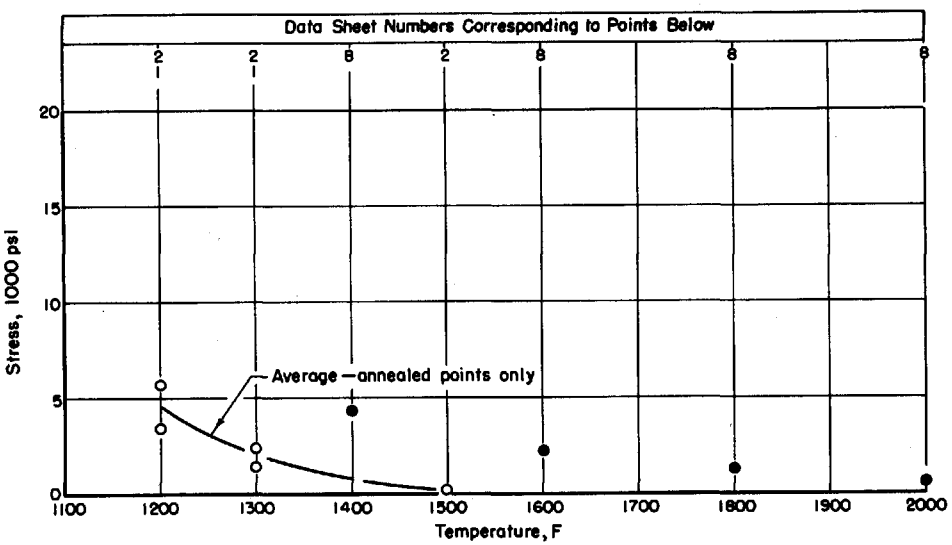


25 Cr – 12 Ni

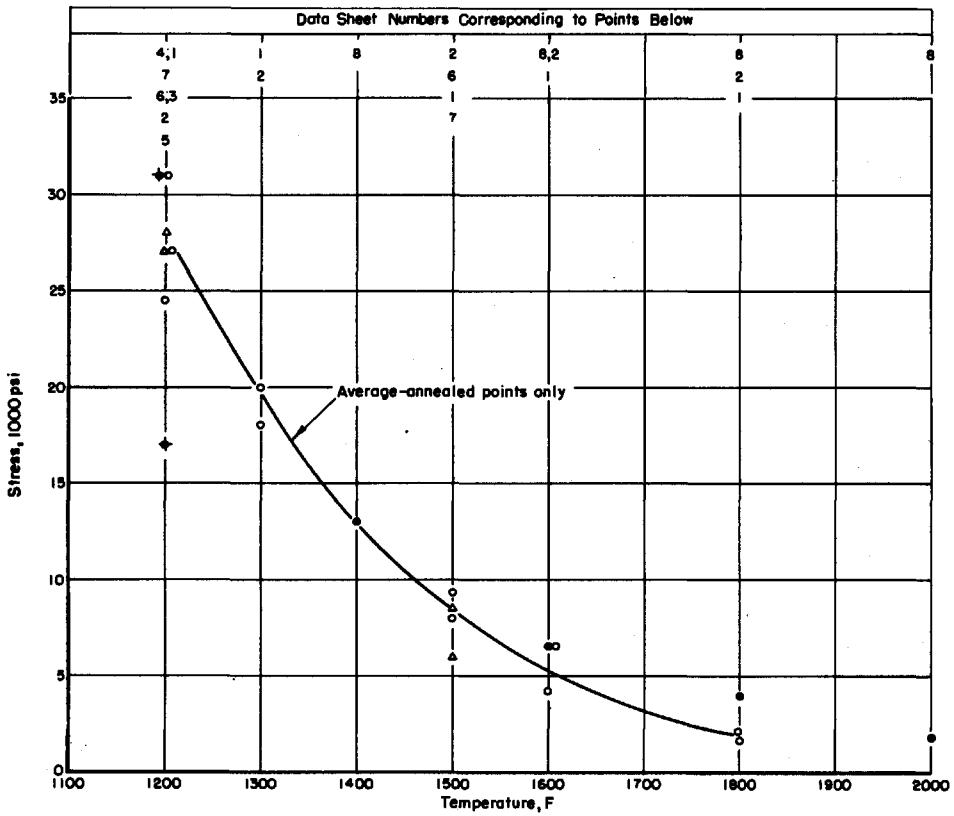
ELONGATION



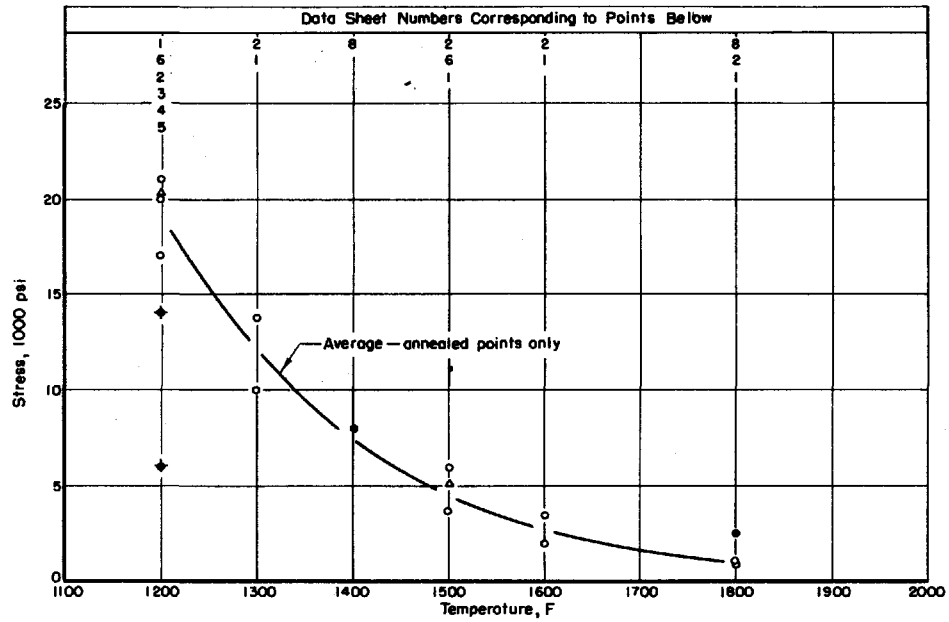
25Cr-12Ni
CREEP RATE, 0.0001 PER CENT PER HOUR
(1 PER CENT PER 10,000 HOURS)



25Cr-12Ni
CREEP RATE, 0.00001 PER CENT PER HOUR
(1 PER CENT PER 100,000 HOURS)

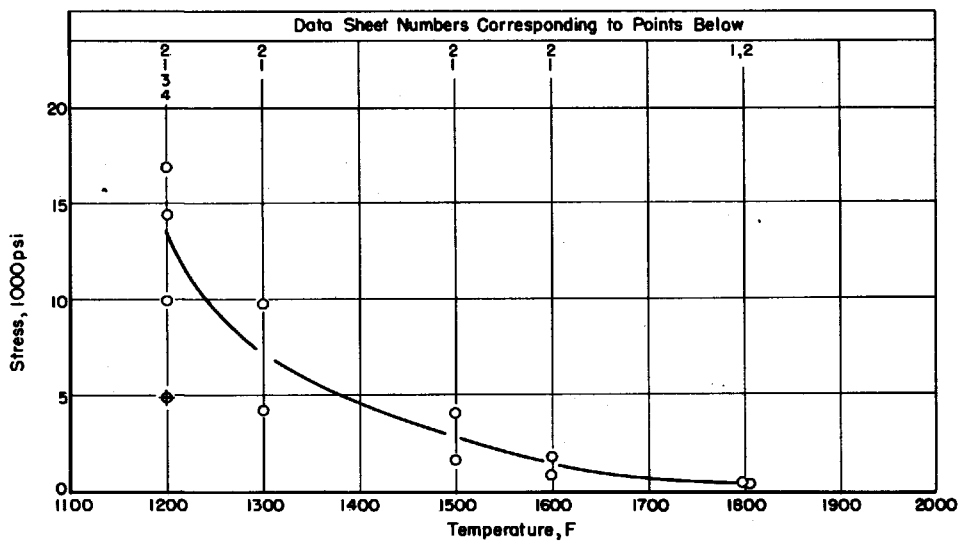


25Cr-12Ni
RUPTURE IN 100 HOURS



25Cr–12Ni

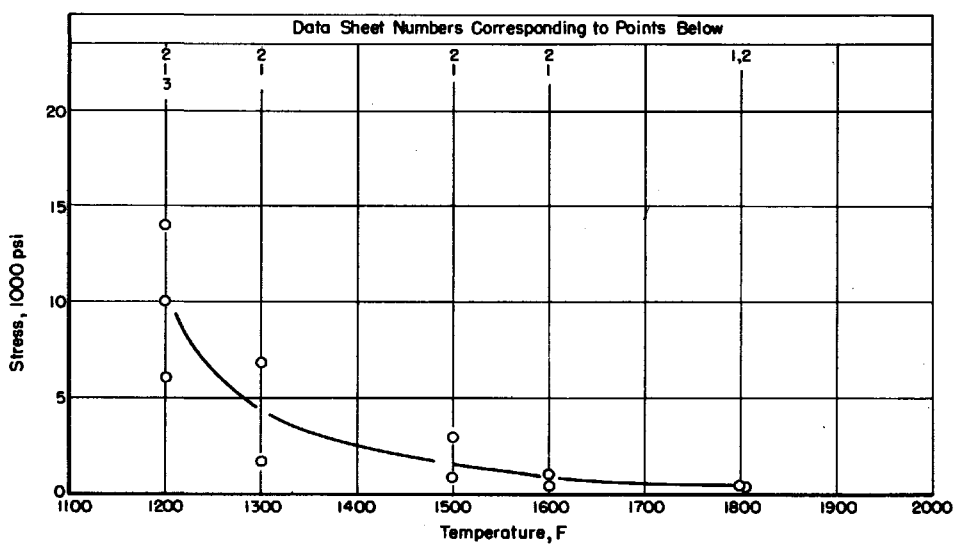
RUPTURE IN 1000 HOURS



25Cr–12 Ni

RUPTURE IN 10,000 HOURS

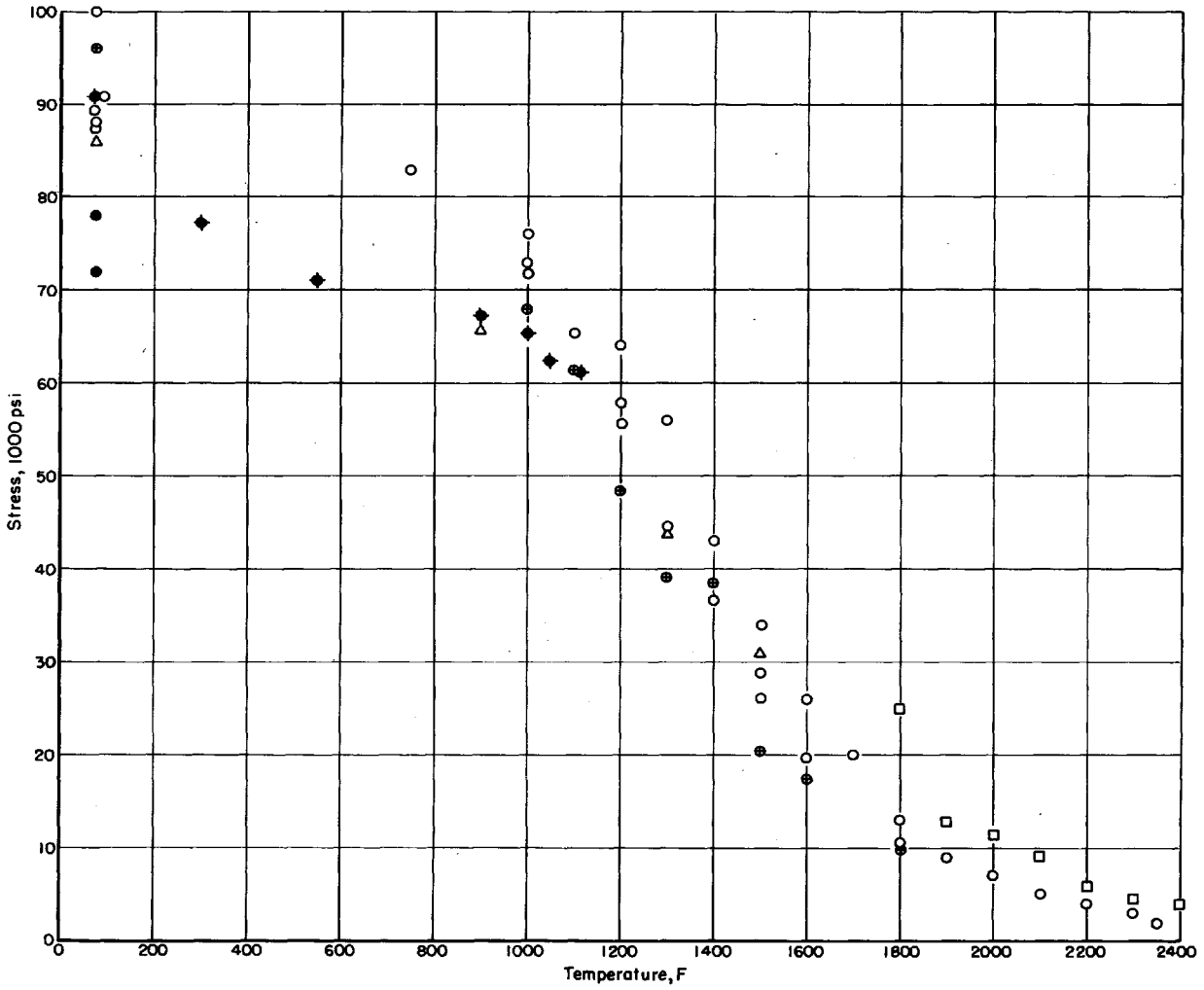
(EXTRAPOLATED)



25Cr–12 Ni

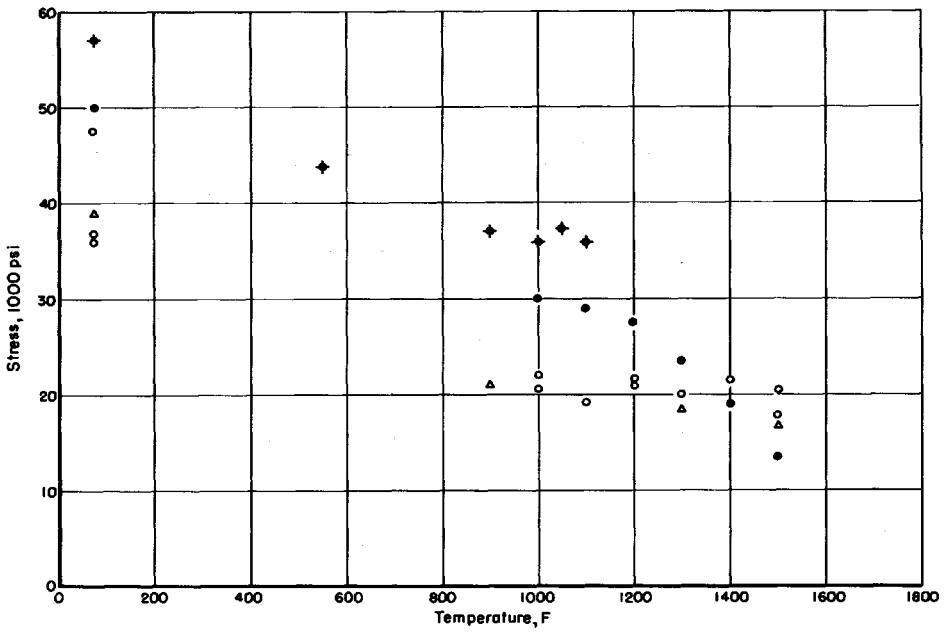
RUPTURE IN 100,000 HOURS

(EXTRAPOLATED)



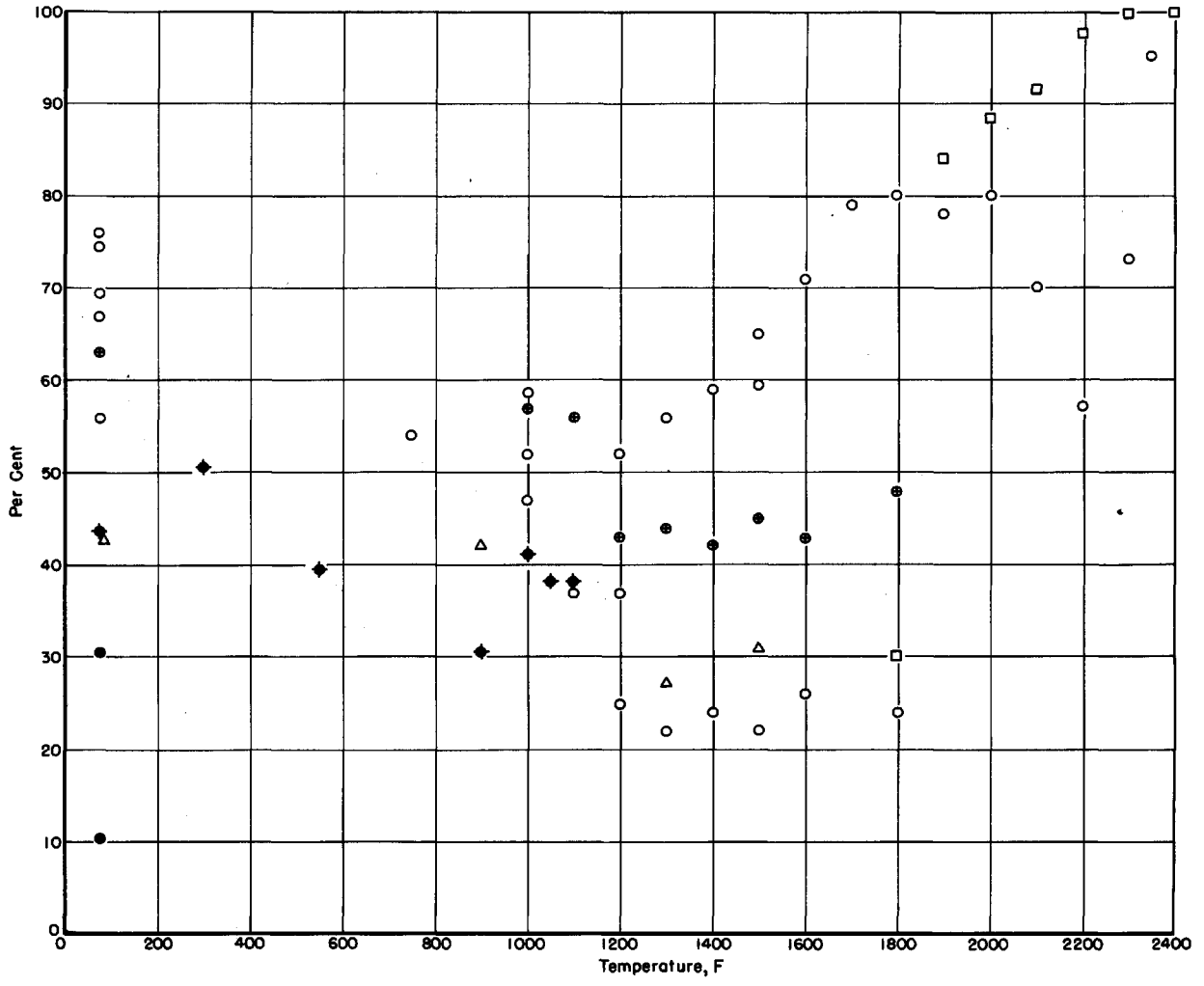
25Cr-20Ni

TENSILE STRENGTH



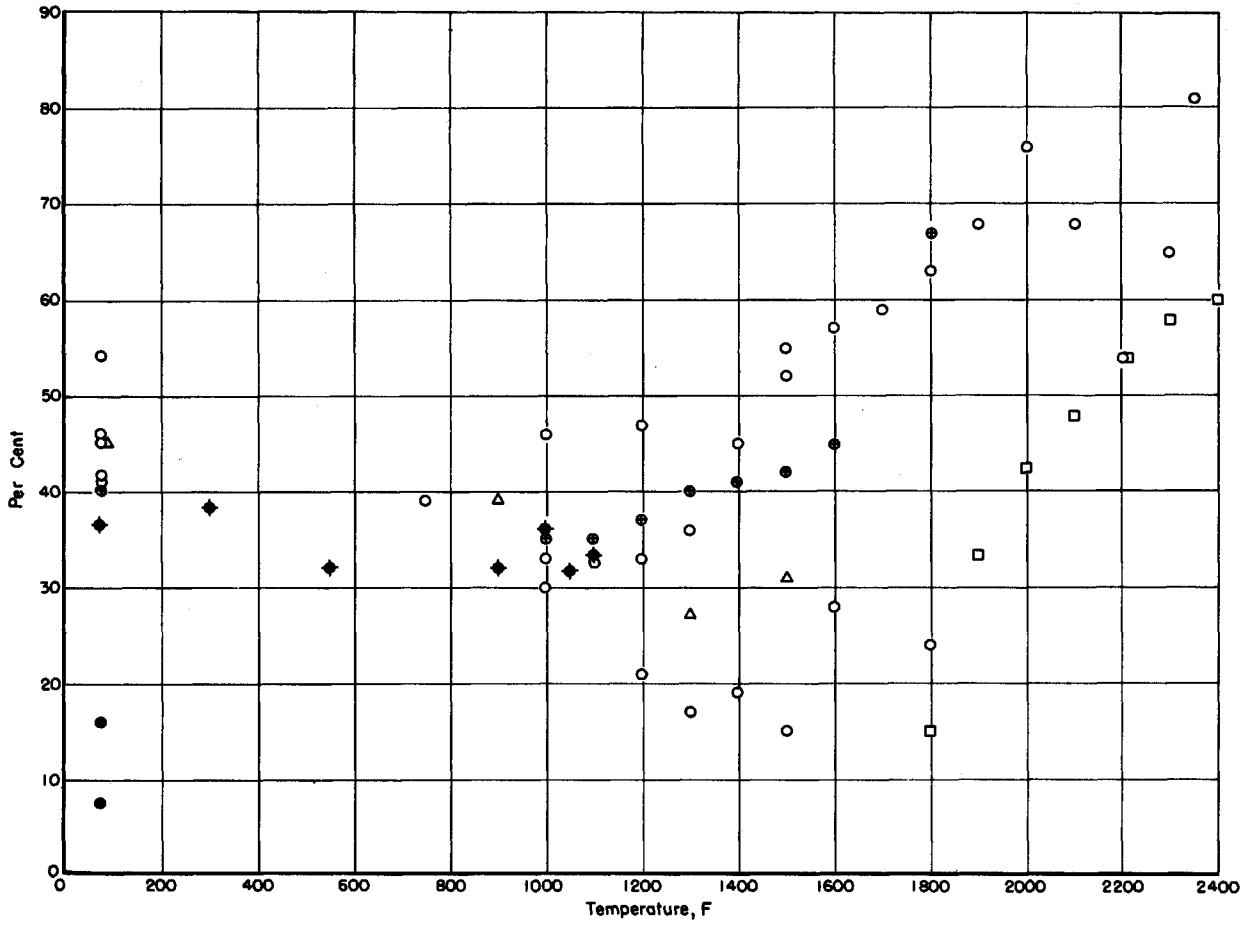
25Cr-20Ni

0.2 PER CENT OFFSET YIELD STRENGTH

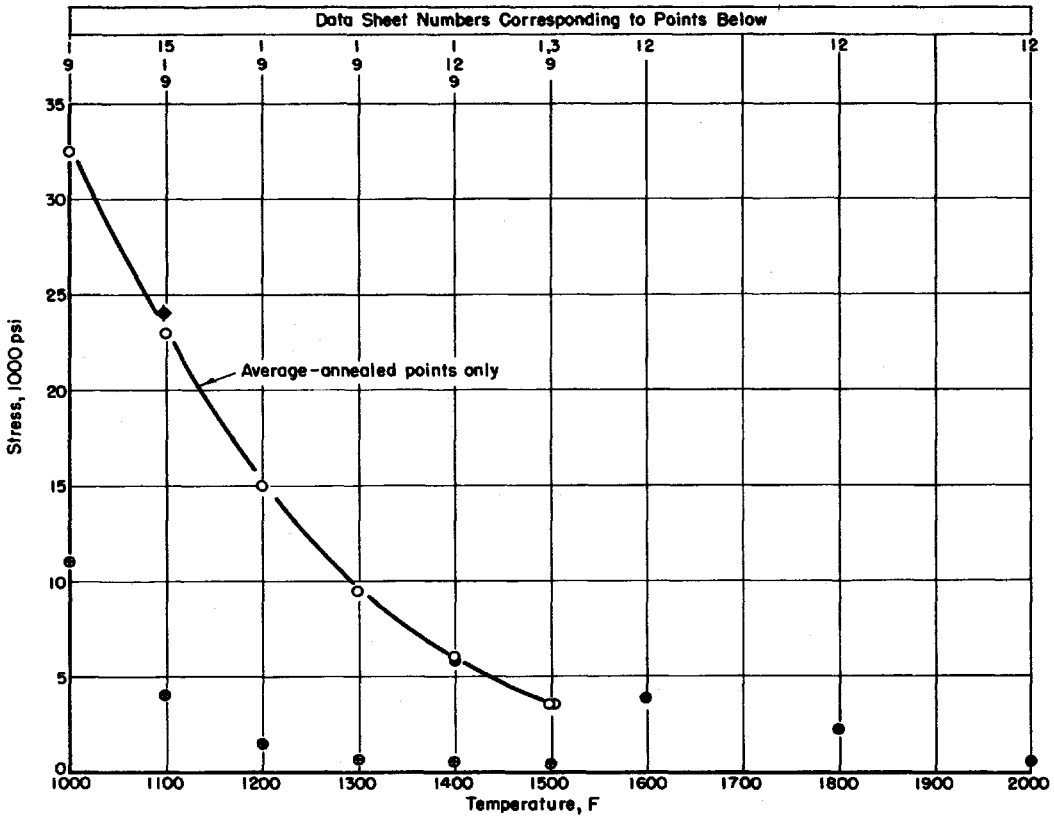


25Cr-20Ni

REDUCTION OF AREA



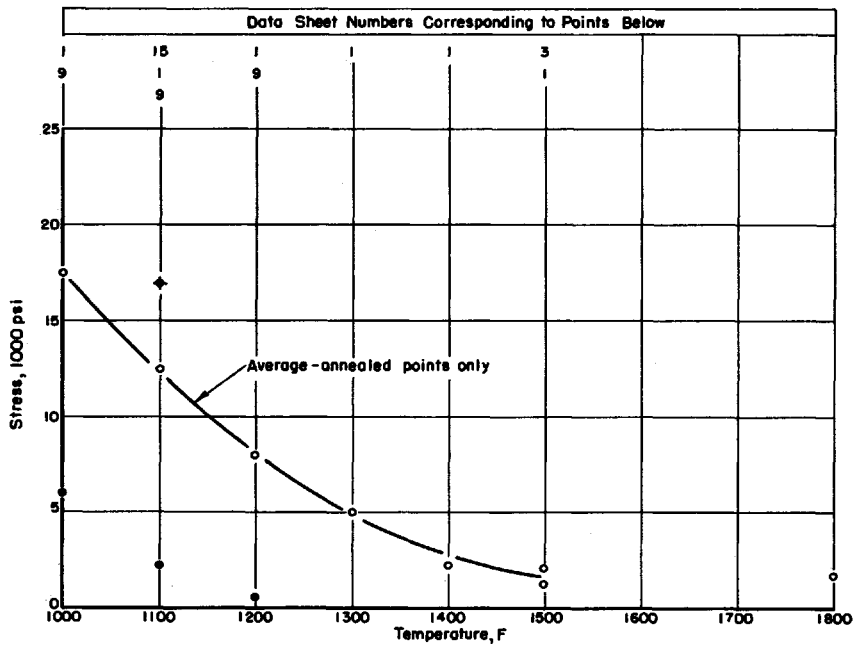
25Cr-20Ni
ELONGATION



25Cr-20Ni

CREEP RATE, 0.0001 PER CENT PER HOUR

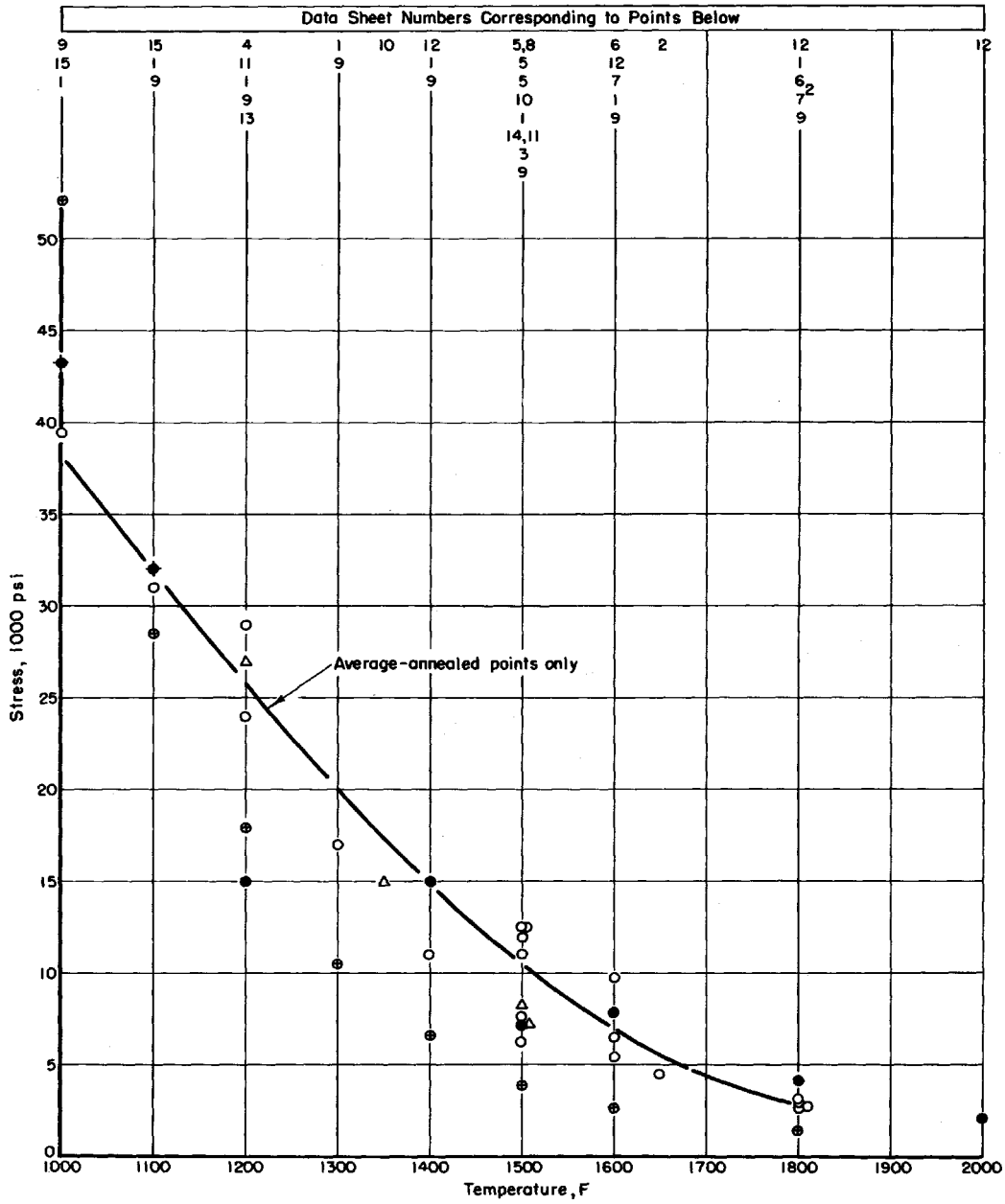
(1 PER CENT PER 10,000 HOURS)



25Cr-20Ni

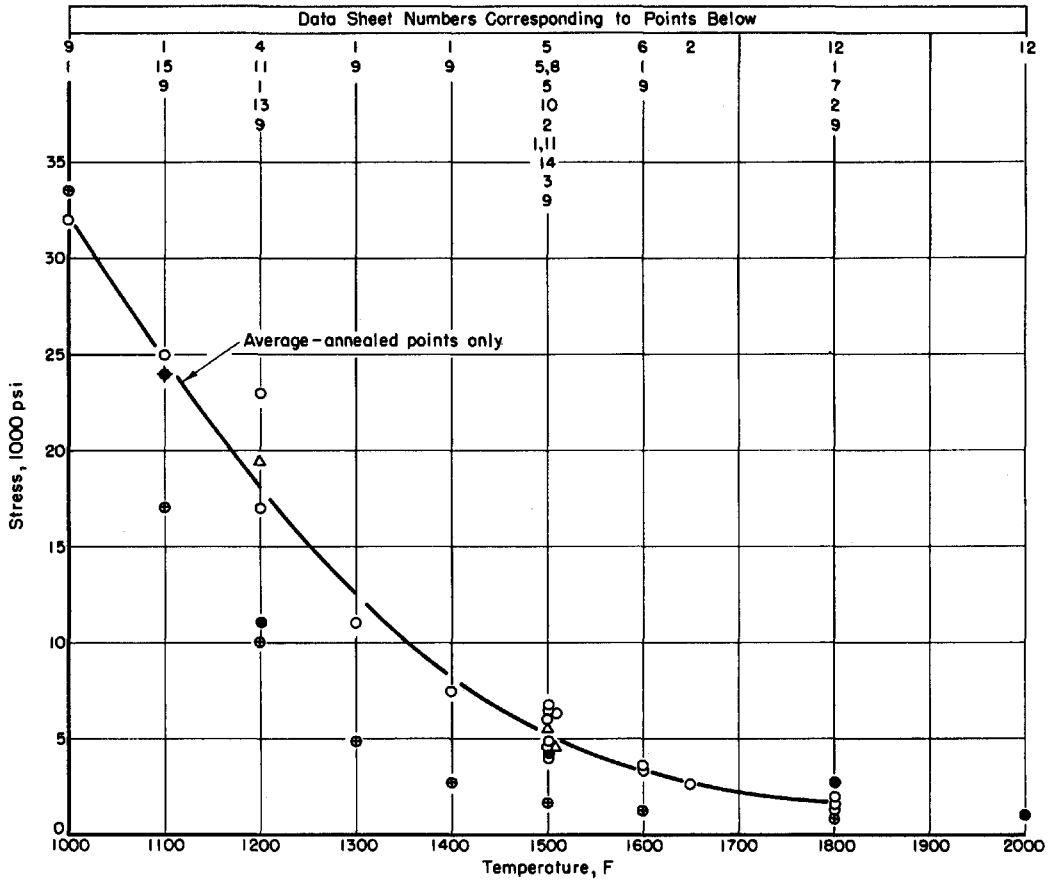
CREEP RATE 0.00001 PER CENT PER HOUR

(1 PER CENT PER 100,000 HOURS)



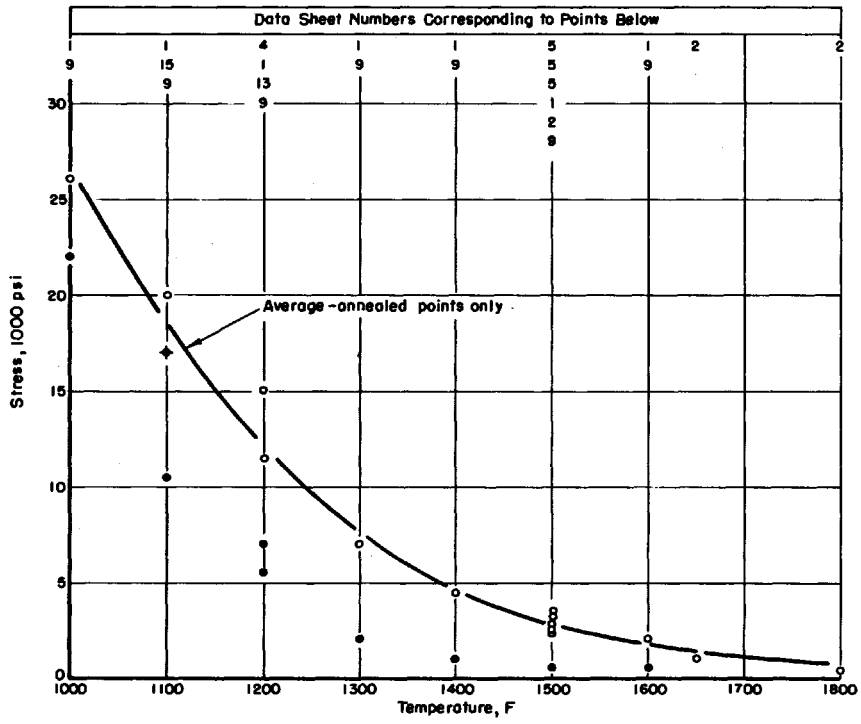
25Cr-20Ni

RUPTURE IN 100 HOURS



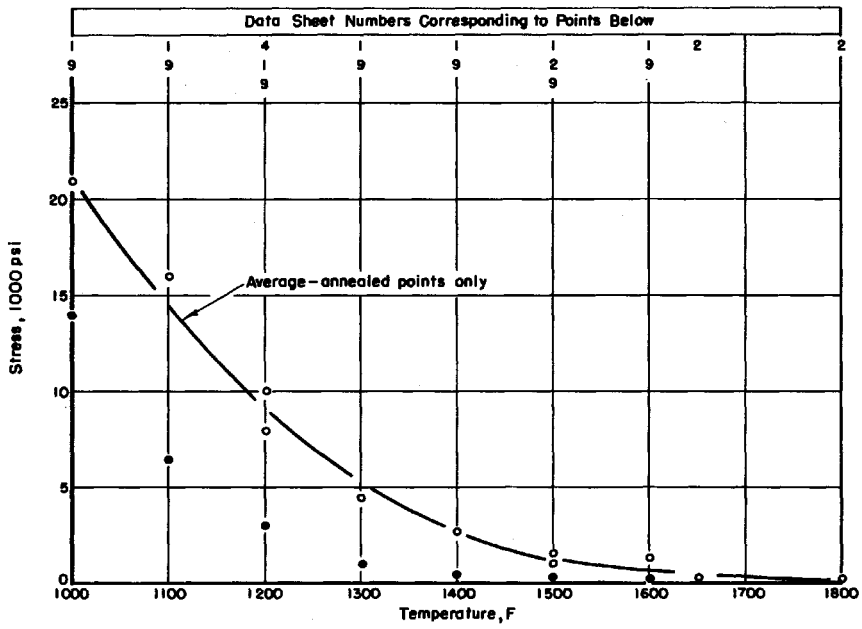
25Cr-20Ni

RUPTURE IN 1000 HOURS



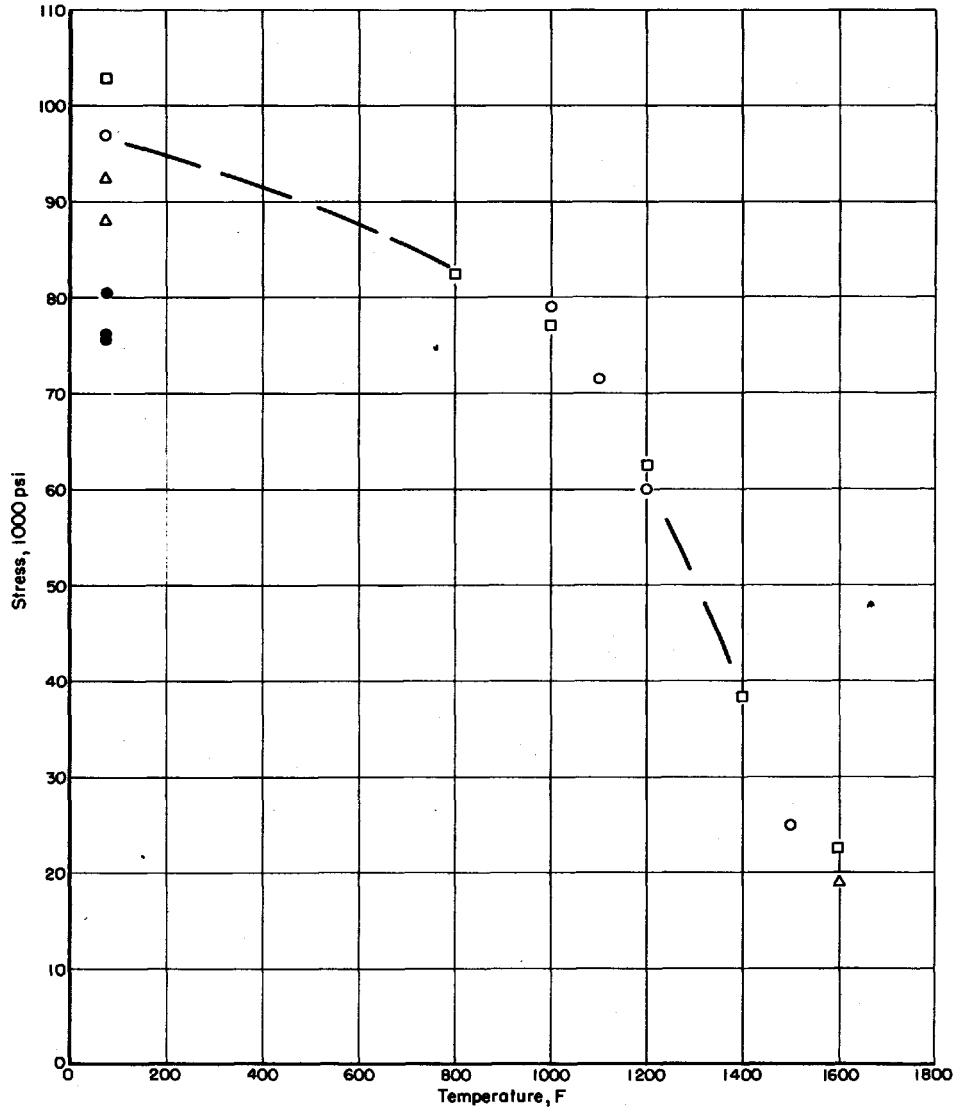
25Cr-20Ni

RUPTURE IN 10,000 HOURS
(EXTRAPOLATED)

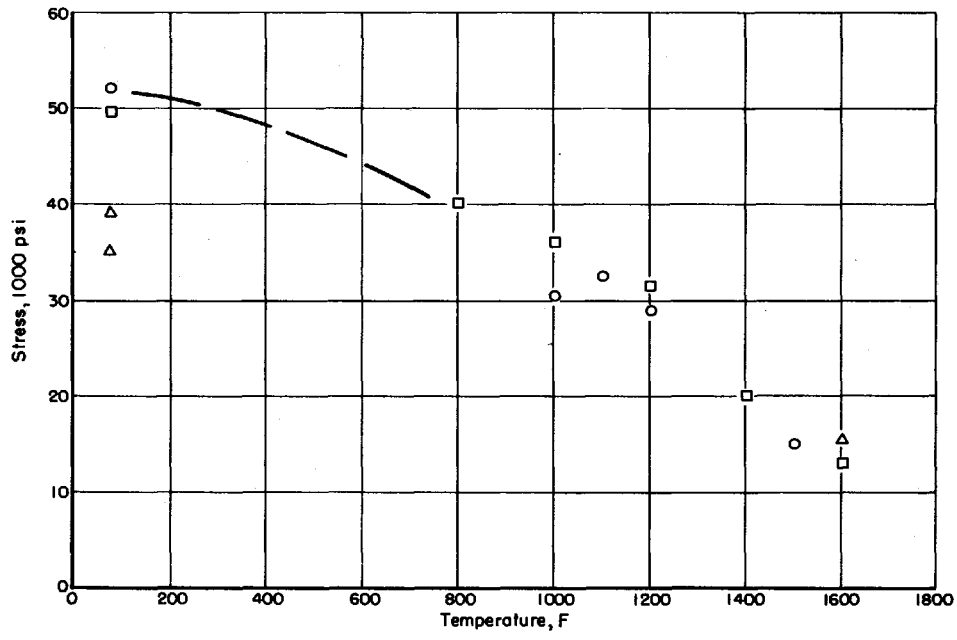


25Cr-20Ni

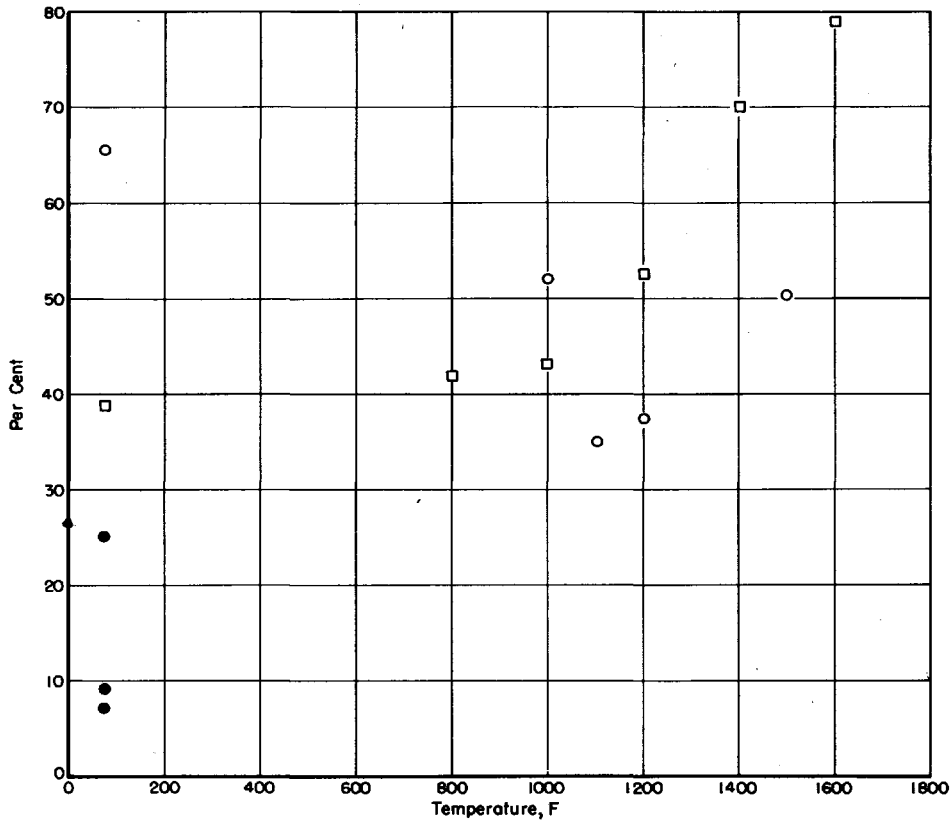
RUPTURE IN 100,000 HOURS
(EXTRAPOLATED)



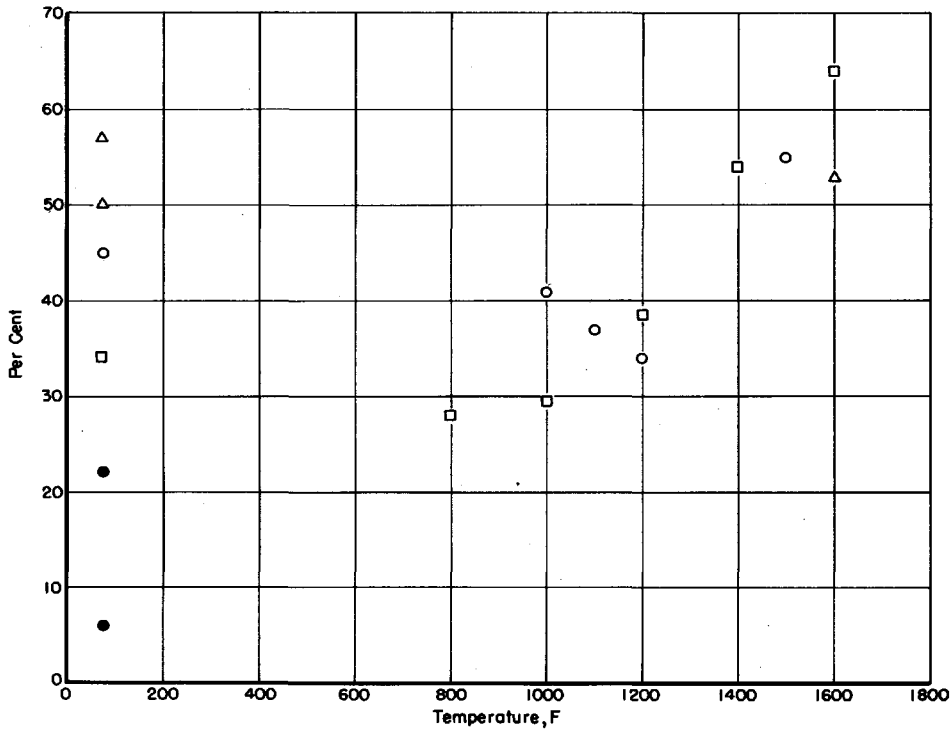
25Cr-20Ni-2 Si
TENSILE STRENGTH



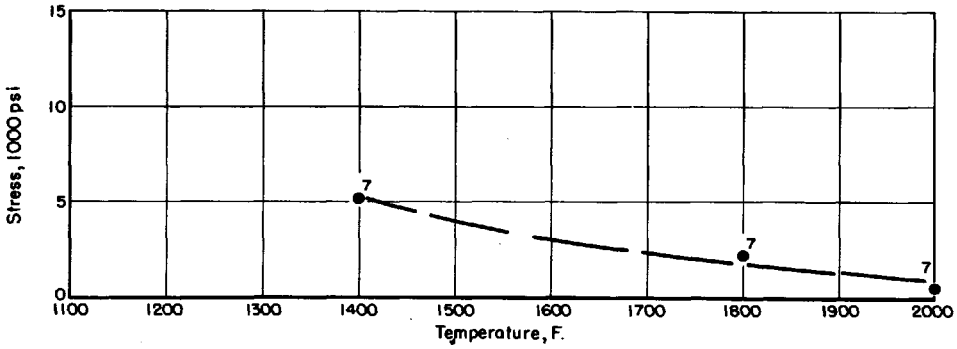
25Cr-20Ni-2 Si
0.2 PER CENT OFFSET YIELD STRENGTH



25Cr-20Ni-2Si
REDUCTION OF AREA



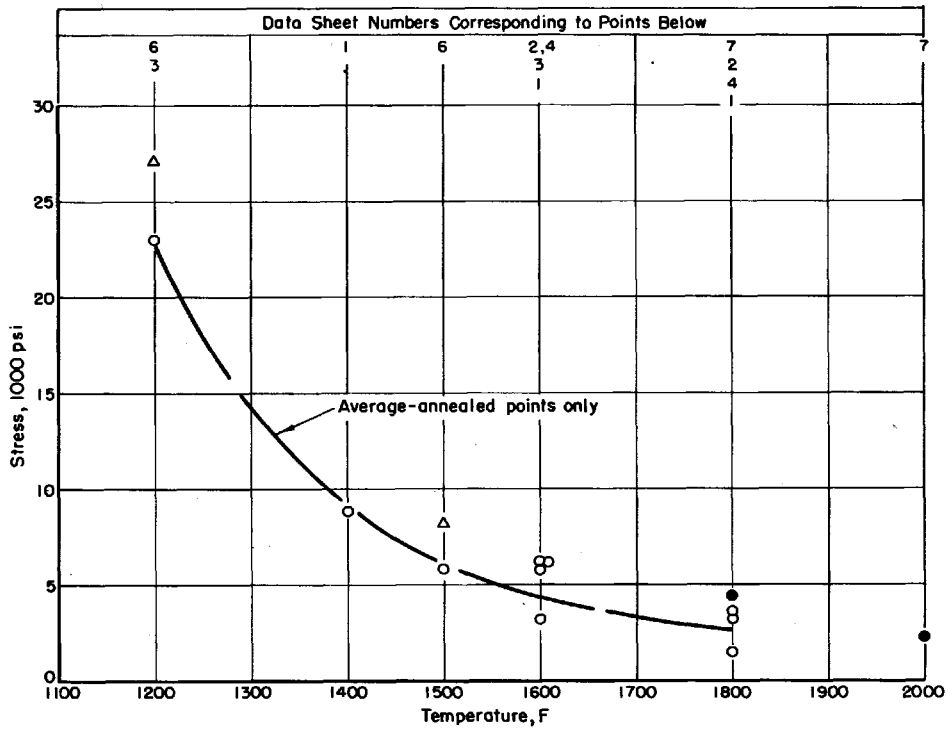
25Cr-20Ni-2Si
ELONGATION



25Cr-20Ni-2Si

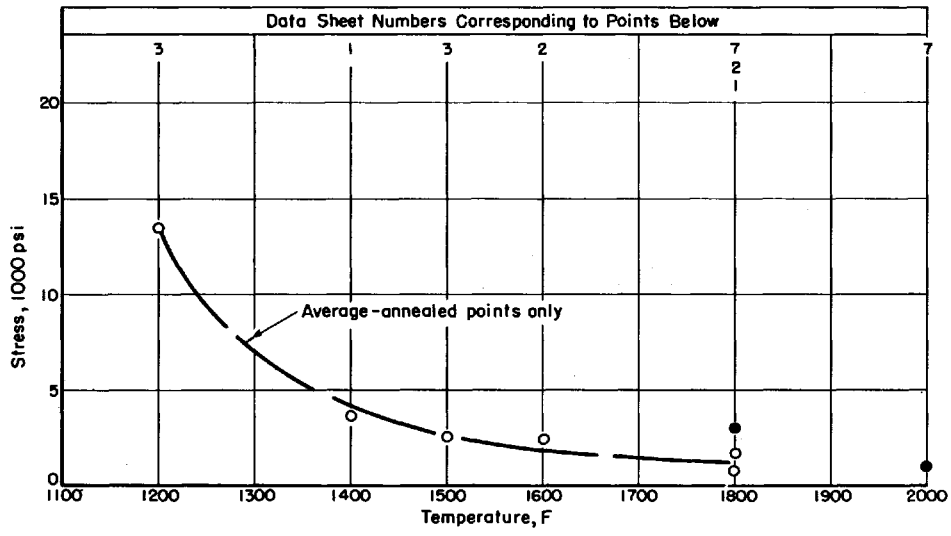
CREEP RATE 0.0001 PER CENT PER HOUR

(1 PER CENT PER 10,000 HOURS)



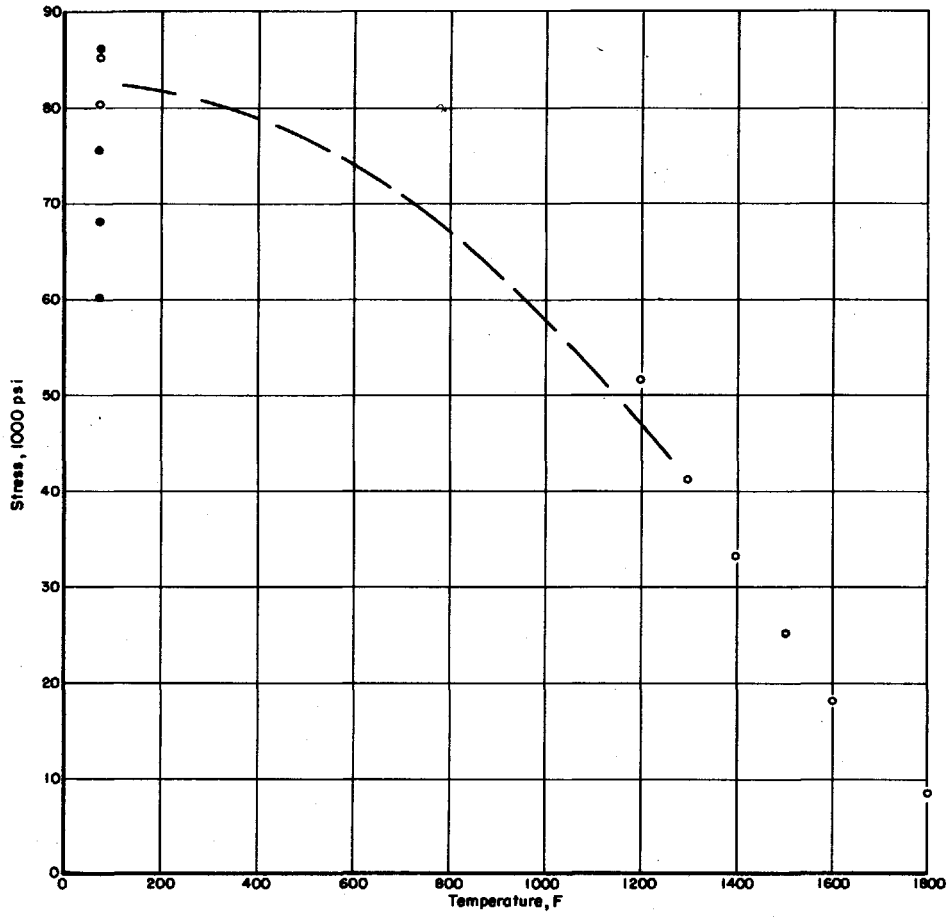
25 Cr-20Ni-2Si

RUPTURE IN 100 HOURS



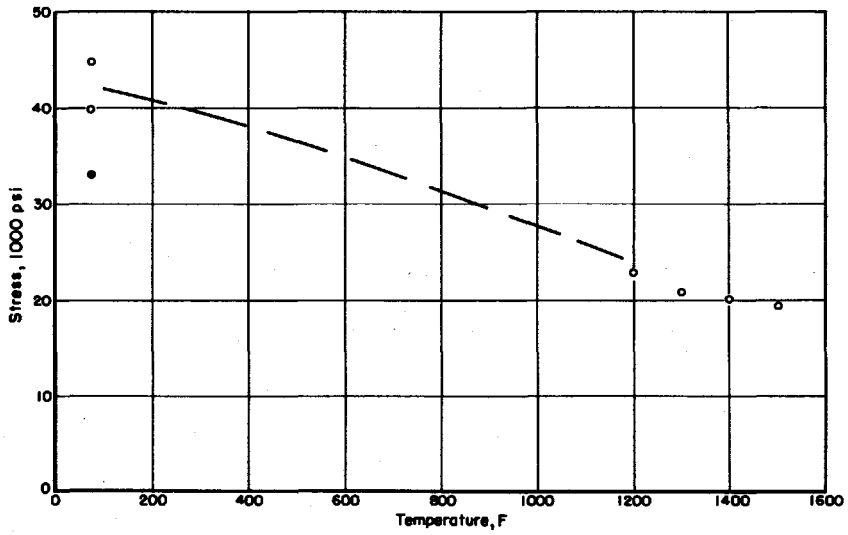
25Cr-20Ni-2Si

RUPTURE IN 1000 HOURS



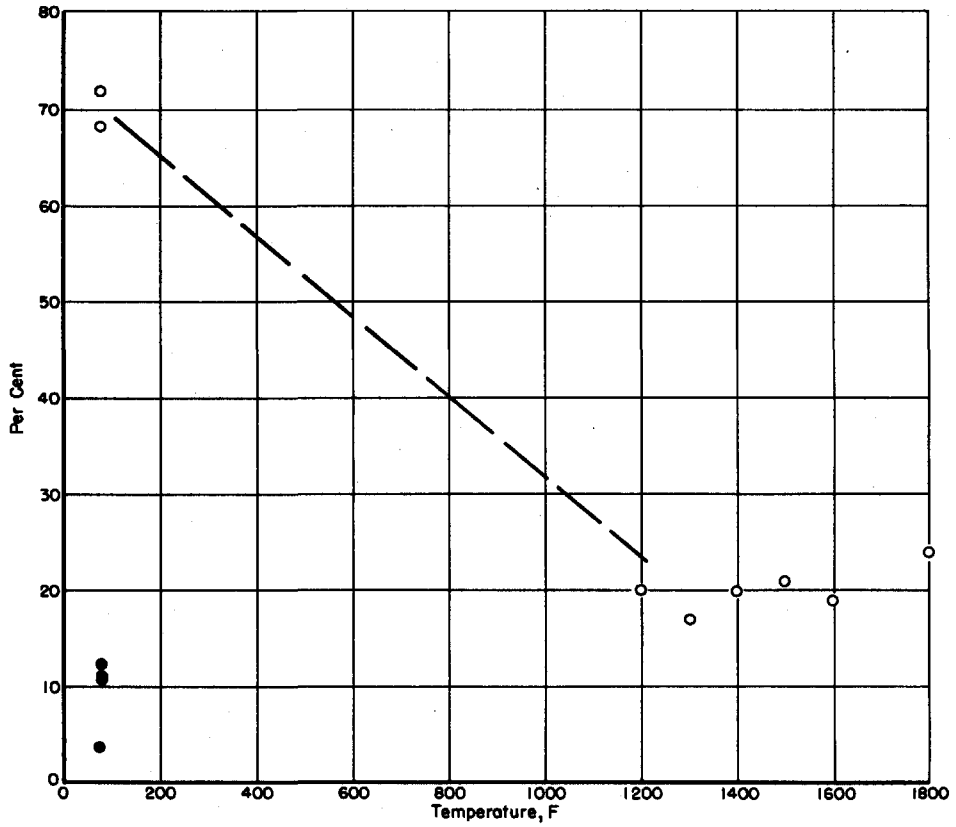
15Cr–35Ni

TENSILE STRENGTH

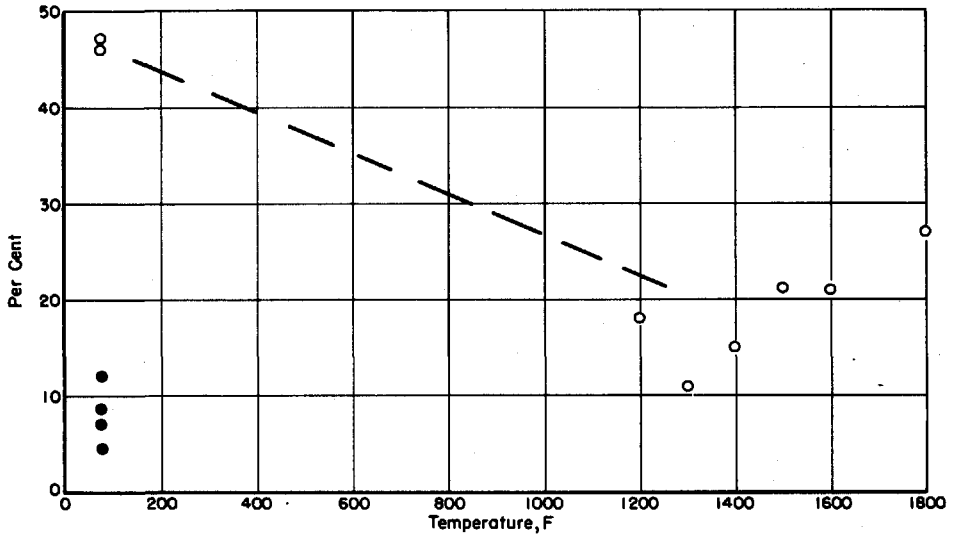


15Cr–35 Ni

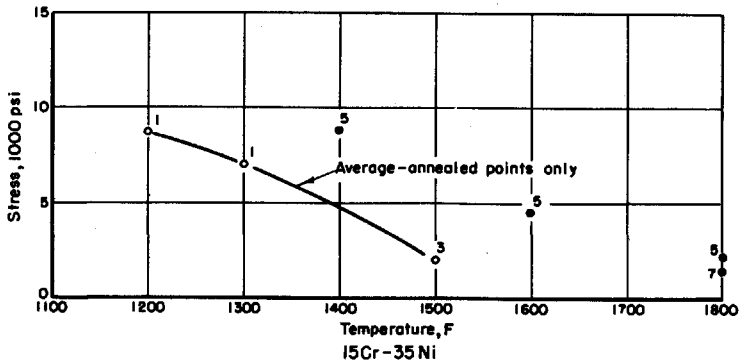
0.2 PER CENT OFFSET YIELD STRENGTH



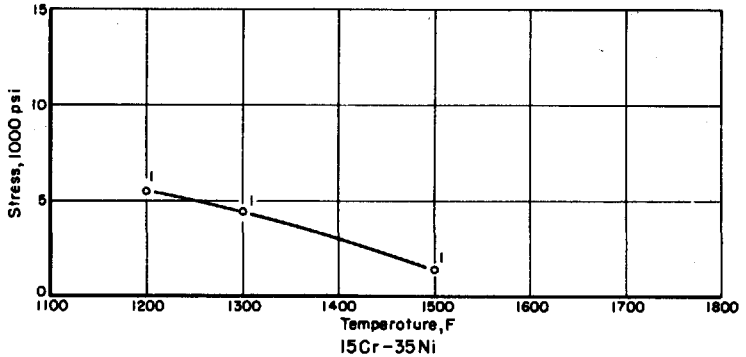
15Cr-35Ni
REDUCTION OF AREA



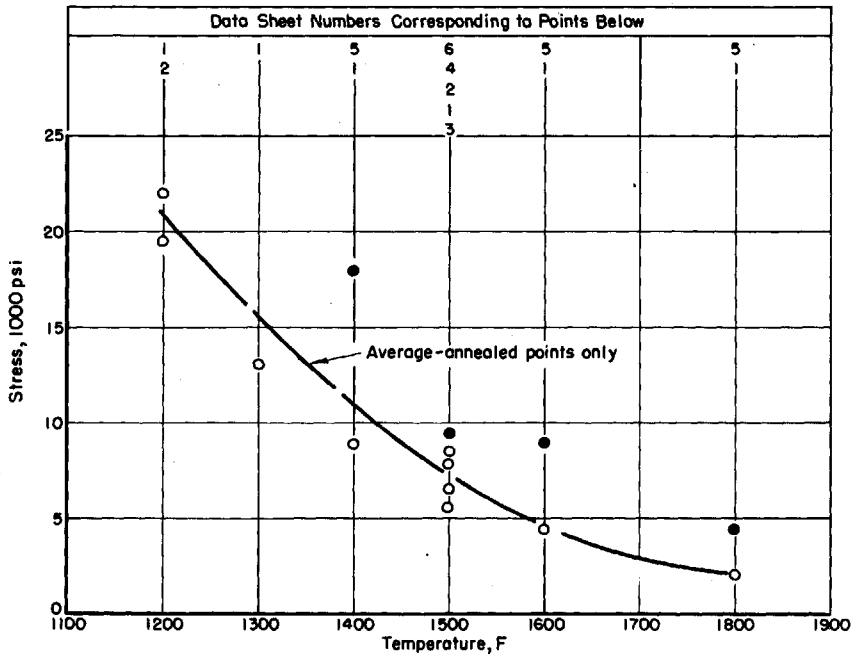
15Cr-35Ni
ELONGATION



15Cr-35Ni
CREEP RATE 0.0001 PER CENT PER HOUR
(1 PER CENT PER 10,000 HOURS)

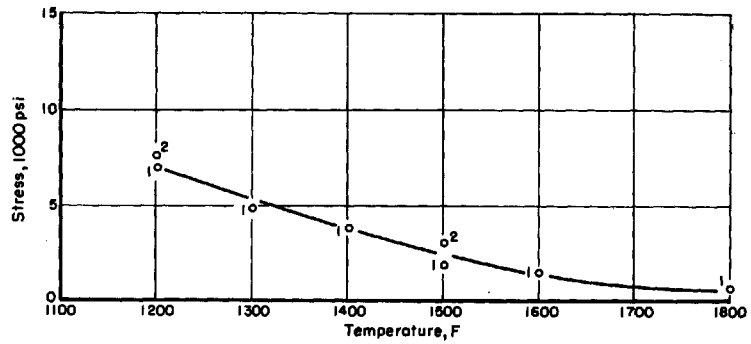


15Cr-35Ni
CREEP RATE 0.00001 PER CENT PER HOUR
(1 PER CENT PER 100,000 HOURS)



15Cr-35Ni

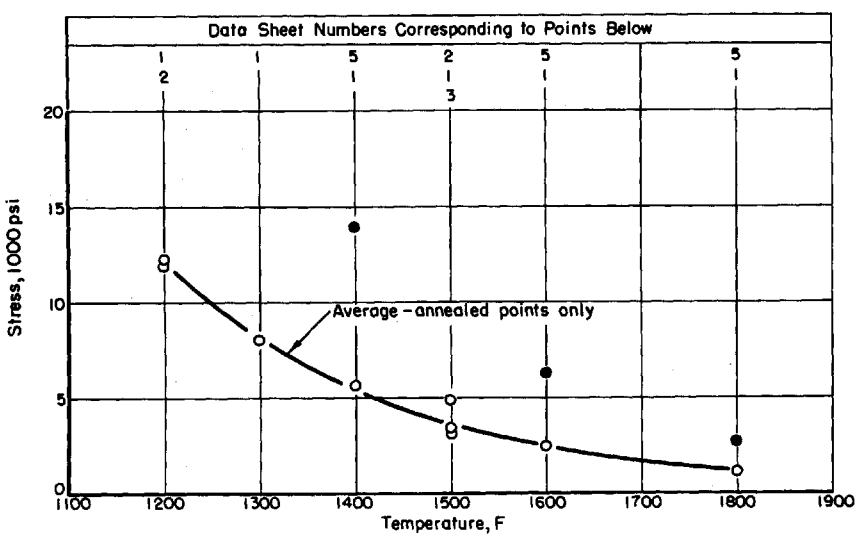
RUPTURE IN 100 HOURS



15Cr-35Ni

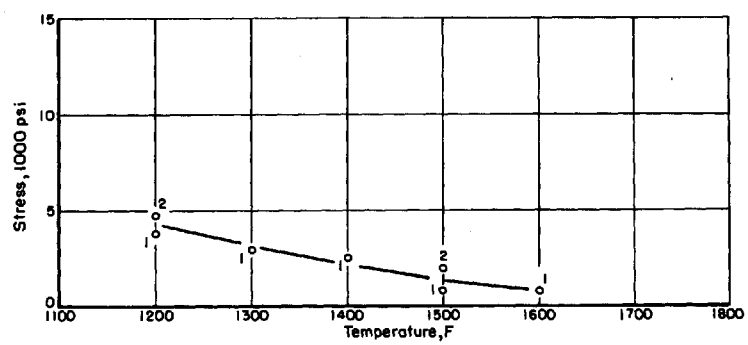
RUPTURE IN 10,000 HOURS

(EXTRAPOLATED)



15Cr-35Ni

RUPTURE IN 1000 HOURS



15Cr-35Ni

RUPTURE IN 100,000 HOURS

(EXTRAPOLATED)

APPENDIX

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18 Cr-8Ni

(1)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 304	TYPE OF MELTING FURNACE Elec.-Arc							SIZE OF HEAT 30 Tons					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.06	.50	.008	.008	.61	17.7	9.25	-	-	-	-		
DEOXIDATION Silicon													
FORM-CAST OR WROUGHT Wrought													
HEAT TREATMENT W. Q. 2000°F.													
MICROSTRUCTURE Equi-Axed Austenitic, Carbide Free													
GRAIN SIZE 2/5 Actual													
HARDNESS 137 BHN													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS x OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
85	29.0	27.9	85.0	61	74
750	24.6	16.0	60.0	46	69
900	23.6	14.7	56.9	45	69
1000	23.0	14.5	53.8	44	70
1100	22.3	12.3	48.8	39	58
1200	21.8	11.0	43.0	37	44
1300	21.2	11.0	35.2	35	36
1400	20.6	10.5	27.6	31	29
1500	20.0	10.2	21.0	33	33
x Determined by a Super Sonic Method.					

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1000						10.7	18.0
1100						7.9	13.2
1200	20.0	14.1	10.0*	7.2*		4.3	8.2
1300	13.1	9.1	5.6*	3.5*		2.5	5.5
1400	9.6	6.4	4.0*	2.6*		1.8	4.0
1500	6.4	4.0	2.6*	1.7*		1.4	2.8
1600	4.6	3.0					
1700							
1800	2.2	1.4*					

(2)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 304	TYPE OF MELTING FURNACE Electric							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.05	.28	.015	.009	.44	18.4	10.1				.003		
DEOXIDATION													
FORM-CAST OR WROUGHT Wrought													
HEAT TREATMENT 1900°F, 0.5 Hr., Quench													
MICROSTRUCTURE Typical Annealed Microstructure													
GRAIN SIZE ASTM 3-5													
HARDNESS 142 DPH													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
75		33.0	88.0	63.0	78.0
1100		13.0	51.0	35.0	64.0
1300		11.5	36.0	36.0	50.0
1500		10.0	22.0	38.0	42.0

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1100	29.0	22.0	17.0*	13.0*		10.0*	13.0
1300	13.0	9.2	6.2*	4.4*		3.8	5.2
1500	5.7	4.2	2.7*	1.7*		1.5	2.1

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1100	13.0	3000	.166	.000085	> 3000	-	-	
1100	15.0	3000	.528	.000213	> 3000	-	-	
1100	45.0	1.45R	17.6	27.2	0.8		33.	
1100	40.0	5.5R	11.8	2.04	4.36			
1100	40.0	6.33R	11.5	1.89	3.9		31.	
1100	30.0	55.0R	8.8	.16	39.6		18.	
1100	24.9	357.R	4.6	.03	348.		16.	
1100	21.0	1446.R	1.3	.008	1409.		14.	
1300	4.0	3000	.062	.0000107	> 3000	-	-	
1300	6.0	3000	.069	.000192	> 3000	-	-	
1300	8.0	3000	.136	.0044	> 500	-	-	
1300	30.0	.37R	8.1	65.	.25		41.	
1300	25.0	1.5R	5.6	14.	1.05		37.	
1300	20.0	9.5R	2.0	2.24	5.95		30.	
1300	15.0	50.5R	.4	.16	24.		28.	
1300	11.0	337.R	.9	.05	279.		28.	
1300	9.0	1227.R	.2	.0129	775.		30.	
1500	1.5	3000	.026	.0000025	> 3000	-	-	
1500	3.0	3000	.08	.000734	> 3000	-	-	
1500	15.0	.75R	3.4	42.1	.50		55.	
1500	13.0	1.87R	1.7	15.1	.76		41.	
1500	10.0	12.75R	1.9	2.16	7.9		42.	
1500	6.97	84.3R	3.0	.224	53.0		34.	
1500	5.3	331.8R	-	.080	242.		30.	
1500	4.2	1153.R	-	.0135	370.		28.	

(3)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.10	.50	.017	.015	.43	18.7	9.05						
DEOXIDATION													
FORM-CAST OR WROUGHT Wrought													
HEAT TREATMENT 1100 C 1 Hr W. Q. 6502 Hr AC													
MICROSTRUCTURE Equi-Axed, Austenitic													
GRAIN SIZE													
HARDNESS 82 Rb													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT			90.0	60.0	72.5

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1000	47.0	36.0	*28.0	*21.0			
1100	40.0	27.0	*19.0	*13.0			
1200	23.0	*17.0	*13.0	-			

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1000	52.0	32R					22.0	
1000	49.0	72R					19.0	
1000	44.0	222R					14.0	
1000	38.0	877R					10.0	
1000	35.0	1093R					7.0	
1000	32.0	3024R					7.0	
1100	50.0	22R					18.0	
1100	40.0	86R					10.0	
1100	36.0	266R					7.0	
1100	32.0	591R					6.0	
1100	28.0	614R					6.0	
1100	24.0	1621R					4.0	
1100	20.0	7514R					2.0	
1200	25.0	57R					5.0	
1200	18.5	596R					3.0	

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

(4)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 304	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Cu	
	.069	1.11	.023	.016	.53	18.49	67					.16	
DEOXIDATION													
FORM-CAST OR WROUGHT Wrought													
HEAT TREATMENT 3/4 hr. 2000 W. Q. 50 hrs. 1400 A. C.													
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS 160 BHN													

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	24.0	17.0	11.5*		(TESTS BY M. W. KELLOGG)		
1200	24.5	18.0	13.5*		(TESTS BY CRANE COMPANY)		
1200	25.0	18.0	13.0*		(TESTS BY BATTELLE)		

(5)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 304	TYPE OF MELTING FURNACE Electric							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N_2	
	.05	.53	.008	.005	.61	18.5	10.7	-	-	-	.005	.028	
DEOXIDATION None													
FORM-CAST OR WROUGHT Forged Plate													
HEAT TREATMENT 1/2 Hr. at 1900 - WQ													
MICROSTRUCTURE													
GRAIN SIZE 3-4 Actual													
HARDNESS													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
75	-	32.0	81.5	71 - 1"	81

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
900		49	38*				
1050		27	20.5*				
1200		14	10.5*				

(6)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 18-8	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.06	1.05	.026	.017	.47	18.7	9.88						
DEOXIDATION													
FORM-CAST OR WROUGHT 1"Dia. Wrought Bars													
HEAT TREATMENT W. Q. - 2000°F - 45 min. Aged - 1400°F - 48 hrs.													
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
1200	20.0	21.8			
1200	15.4	20.2			
1200	19.5	20.7			
1200	13.7				
1200	17.6				
1200	24.0				
1200	14.2				

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	24.0	18.4				8.6	11.2

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	25.0	73R	1.4	.19	18		51.0	
1200	21.0	460R	.70	.031	225		45.0	
1200	17.5	1320R	0	.005	144		50.0	
1200	11.0	1512	.022	.00009	>1512			
1200	9.0	2136	-.02	.000015	>2136			
1200	5.0	744	.008	<.000002	>744			

(7)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 304	TYPE OF MELTING FURNACE Ajax Induction							SIZE OF HEAT 1000 lbs					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.025	.54	.007	.011	.43	18.5	9.22						
DEOXIDATION Silicon													
FORM-CAST OR WROUGHT Wrought Bar Stock													
HEAT TREATMENT 1950°F 1/2 hr WQ													
MICROSTRUCTURE Austenite													
GRAIN SIZE													
HARDNESS													

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	18.5	11.5	7.0*	4.3*			

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	18.0	123.9R					18.5	
1200	17.0	144.0R					17.5	
1200	16.0	199.1R					18.0	
1200	13.0	535.7R					13.5	
1200	11.0	1278.8R					11.0	

(8)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.09	.94	.02	.042	.43	19.2	9.2	.03					
DEOXIDATION													
FORM-CAST OR WROUGHT Wrought													
HEAT TREATMENT Annealed													
MICROSTRUCTURE													
GRAIN SIZE 6													
HARDNESS													

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	18.0	12.0	*7.0	*5.5			

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	12.0	1132R					4.1	
1200	10.0	2880R					2.0	
1200	25.0	12R					14.0	
1200	22.5	28R					12.4	
1200	20.0	55R					12.0	
1200	18.0	87R					10.9	
1200	16.0	198R					9.8	
1200	14.0	496R					8.2	

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *
(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

(9)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.06	.58	.023	.011	.55	17.7	8.42						
DEOXIDATION													
FORM-CAST OR WROUGHT	Wrought, 1/2"Rd.												
HEAT TREATMENT	Annealed												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS	186 BHN												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
75		59	109	50	71
300		56	73	38	73
500		46	69	31.5	68.5
800		44	66*	35	64

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
300					>45		
500					>37		
800					29	45*	

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
300	45	545	.025	0				
500	37	523	.016	0				
800	22	1004	.014	0				
800	35	3018	.034	.0000025				
800	43	3010	.05	.000007				

(10)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	Low N_2 LC-18-8 (304)	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N_2		
	.025					17.8	9.48					.030		
DEOXIDATION														
FORM-CAST OR WROUGHT	Wrought (Strips)													
HEAT TREATMENT	Anneal 1950-2000 F													
MICROSTRUCTURE														
GRAIN SIZE														
HARDNESS														

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT			86.4	59.	
500			54.7	24.	
1000			49.	25.	
1200			41.3	32.	
1500			20.3	52.	
1800			7.0	38.5	

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	32.						
1500	6.3						

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

(11)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	304 (High N_2)	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N_2		
	.018					19.2	11.3					.14		
DEOXIDATION														
FORM-CAST OR WROUGHT	Wrought													
HEAT TREATMENT	Anneal 1950 - 2000 F													
MICROSTRUCTURE														
GRAIN SIZE														
HARDNESS														

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT			84.6	45.	
500			65.5	35.	
1000			56.2	31.	
1200			41.5	19.	
1500			22.7	23.	
1800			7.4	38.	

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	28.						
1500	6.0						

(12)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	304	TYPE OF MELTING FURNACE	Basic Electric						SIZE OF HEAT	48,500 lbs.				
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Cu		
	.076	1.81	.018	.015	.39	18.5	10.0	.18				.12		
DEOXIDATION	18 lbs. of Al poled in the furnace.													
FORM-CAST OR WROUGHT	Wrought (3/4 "Diam. Bar Stock)													
HEAT TREATMENT	2000F, ½hr, W. Q.													
MICROSTRUCTURE	Austenitic, twinned													
GRAIN SIZE	Actual A. S. T. M. 3-4													
HARDNESS	151 V. H. N. (5 Kg. Load)													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
Room		32.5	82.4	69.5	80.0
1050		25.0	70.05	40.0	43.9
1200		23.5	51.35	22.5	23.4
1350		20.4	35.65	27.5	35.5
1500		17.9	20.65	35.0	52.6
Note: (1)	Y. S. at Room Temp. obtained at 0.20% offset.				
(2)	Y. S. at Elevated Temp. determined by string extensometer)				

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1050	44.0	33.5	23.6*	16.0*			

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1050	41.0	173.8 R					14.0	
1050	36.5	509.8 R					14.5	
1050	30.0	2362.0 R					9.5	
1050	27.0	4564.0 R					6.5	

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

(13)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	304	TYPE OF MELTING FURNACE	Basic Electric	SIZE OF HEAT	48,500 lbs.

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.076	1.81	.018	.015	.39	18.5	10.0	.18					

DEOXIDATION	18 lbs. of Al poled in the furnace
FORM-CAST OR WROUGHT	Wrought (3/4 "Diam. Bar Stock)
HEAT TREATMENT	2000F, ½hr, W. Q. 1750, 1hr, A. C.
MICROSTRUCTURE	Equi-axed, some twins
GRAIN SIZE	Actual A. S. T. M. 3-4 (5)
HARDNESS	161 V. H. N. (5 Kg. Load)

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
Room		41.3	82.2	60.0	72.0
1050		29.0	58.65	38.0	57.1
1200		28.5	46.25	39.0	57.0
1350		25.0	30.85	38.5	51.7
1500		17.8	19.15	48.0	57.3

Note: (1) Y. S. at Room Temp. obtained at 0.20% offset.
(2) Y. S. at Elevated Temp. determined by string extensometer.

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1050		34.5	24.8*	17.8*			
1200		20.0	15.4	11.8*			

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1050	41.0	326.1 R					15.5	
1050	30.0	3127.2 R					7.5	
1050	27.0	4201.3 R					6.0	
1200	20.0	1095.2 R					20.5	
1200	16.5	3872.8 R					21.5	
1200	15.5	9752.1 R					18.5	

(14)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	304	TYPE OF MELTING FURNACE	Basic Electric	SIZE OF HEAT	48,500 lbs.

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.076	1.81	.018	.015	.39	18.5	10.0	.18					

DEOXIDATION	18 lbs. of Al poled in the furnace.
FORM-CAST OR WROUGHT	Wrought (3/4"Diam. Bar Stock)
HEAT TREATMENT	2000F, ½hr, W. Q. 1600, 5hrs, F. C.
MICROSTRUCTURE	Austenitic Equi-axed
GRAIN SIZE	Actual A. S. T. M. 3-4
HARDNESS	170 V. H. N. (5 Kg. Load)

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
Room		41.5	82.75	57.0	68.0
1050		32.0	57.15	37.5	56.3
1200		28.0	49.0	41.5	56.5
1350		20.6	27.9	47.5	61.4
1500		17.35	18.5	53.0	65.2

Note: (1) Y. S. at Room Temp. obtained at 0.20% offset.
(2) Y. S. at Elevated Temp. determined by string extensometer.

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200		21.5	14.7	10.0*			

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	20.0	1596.6 R					31.5	
1200	16.5	3651.5 R					41.0	
1200	15.5	7473.6 R					32.5	

(15)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	304	TYPE OF MELTING FURNACE		SIZE OF HEAT	

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.053	.33	.019	.014	.26	17.5	8.70						

DEOXIDATION	
FORM-CAST OR WROUGHT	Wrought
HEAT TREATMENT	Hot Rolled Annealed Bar
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	187 BHN

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
Room Temp.		32.5	95.5	58.0	71.4

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
800						25.3*	
900						18.0*	24.0*
1000						11.5	18.3
1100						7.1*	11.55*
1200						4.25*	6.6*
1350						1.6	2.5

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
650	44.2			.00003				
650	37.2			.000015				
650	30.2			.000005				
1000	18.3			.0001				
1000	14.9			.00004				
1000	12.3			.00001				
1350	3.6			.0007				
1350	3.1			.0003				
1350	2.6			.0001				

(16)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	302-B	TYPE OF MELTING FURNACE	Basic Induction Furnace	SIZE OF HEAT	4,900 lbs.

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.07	1.68	.014	.016	2.11	18.1	12.7	.09					

DEOXIDATION	2 lbs. Al shot in ladle
FORM-CAST OR WROUGHT	Wrought (3/4"Diam. Bar Stock)
HEAT TREATMENT	2000 F, 1/2 hr, W. Q. 1750, 1 hr. A. C.
MICROSTRUCTURE	Austenitic - Duplex
GRAIN SIZE	Actual A. S. T. M. 1-7 Duplex
HARDNESS	159 V. H. N. (5 Kg. Load)

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
Room		48.8	92.3	53.0	65.0
1050		38.4	70.1	41.0	56.9
1200		28.0	52.85	41.0	54.9
1350		22.65	32.65	40.0	50.4
1500		18.4	20.15	54.0	63.1

Note: (1) Y. S. at Room Temp. obtained at 0.20% offset.
(2) Y. S. at Elevated Temp. determined by string extensometer.

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1350	15.2	9.7	6.07*	3.9*			

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *
(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

(16)

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS P.S.I. 1000	DURATION HOURS(3)	INTERCEPT %(4)	MINIMUM CREEP RATE %/HR.	TRANSITION TIME HRS.(5)	TOTAL EXT. CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1350	20.0	10.6R					69.0	
1350	15.0	111.5R					49.0	
1350	12.0	362.3R					43.5	
1350	7.5	3075.3R					12.5	
1350	7.0	5266.0R					12.5	

(17)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 302B	TYPE OF MELTING FURNACE Basic Induction Furnace							SIZE OF HEAT 4900 lbs.					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.07	1.68	.014	.016	2.11	18.1	12.7	.09					

DEOXIDATION 2 lbs. Al shot in ladle.
FORM-CAST OR WROUGHT Wrought (3/4" Diam. Bar Stock)
HEAT TREATMENT 2000 F, 1/2 hr, W. Q. 1600, 5 hr, F. C.
MICROSTRUCTURE Austenitic, Duplex
GRAIN SIZE Actual A. S. T. M. 1-7 (Duplex)
HARDNESS 185 V. H. M. (5 Kg. Load)

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
Room		47.0	93.4	50.0	60.0
1050		39.2	68.75	36.5	53.4
1200		29.1	51.6	38.6	51.7
1350		24.15	32.0	49.5	57.3
1500		18.65	20.95	58.5	64.6

Note: (1) Y. S. at Room Temp. obtained at 0.20% offset.
(2) Y. S. at Elevated Temp. determined by string extensometer.

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1350		10.5	5.7*	2.4*			

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS P.S.I. 1000	DURATION HOURS(3)	INTERCEPT %(4)	MINIMUM CREEP RATE %/HR.	TRANSITION TIME HRS.(5)	TOTAL EXT. CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1350	20.0	12.7R					48.0	
1350	15.0	83.7R					59.5	
1350	12.0	452.5R					45.0	
1350	9.0	2905.9R					21.0	
1350	7.5	4752.6R					17.0	

(18)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE							SIZE OF HEAT Commercial					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.07	.65	.024	.007	.53	19.1	8.49						

DEOXIDATION
FORM-CAST OR WROUGHT Wrought, 1/2" Rd.
HEAT TREATMENT Hard drawn
MICROSTRUCTURE
GRAIN SIZE
HARDNESS 335 BHN

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
75		148	178	15	68
300		126	162	10	55.5
500		118	152	7.5	47.5
800		107	135	8	47.5

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
500					60		
800						31*	73*

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS P.S.I. 1000	DURATION HOURS(3)	INTERCEPT %(4)	MINIMUM CREEP RATE %/HR.	TRANSITION TIME HRS.(5)	TOTAL EXT. CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
500	59	1522	.017	.000001				
500	94.5	1536	.044	.000005				
800	35	3009	.056	.000014				
800	43	3017	.068	.000022				
800	54	2132	.105	.000047				

(19)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE							SIZE OF HEAT Commercial					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.10	.45			.37	19.0	9.15						

DEOXIDATION
FORM-CAST OR WROUGHT Wrought, .031" Sheet
HEAT TREATMENT Half Hard
MICROSTRUCTURE
GRAIN SIZE
HARDNESS

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
75		150	155	14	
300		131	141	2.5	
500		122	134	3.	
800		108	122	5.	

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
800							80

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS P.S.I. 1000	DURATION HOURS(3)	INTERCEPT %(4)	MINIMUM CREEP RATE %/HR.	TRANSITION TIME HRS.(5)	TOTAL EXT. CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
800	80	1800	.06	.000105				

(20)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 304	TYPE OF MELTING FURNACE Elec. Arc							SIZE OF HEAT 30 Tons					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.07	.55	.018	.020	.41	18.8	10.1	-	-	-	-		

DEOXIDATION Silicon
FORM-CAST OR WROUGHT Wrought
HEAT TREATMENT Cold Drawn; Nor. 1700°F.
MICROSTRUCTURE Equi-Axed, Austenitic, Few dispersed carbides
GRAIN SIZE 8 + Actual
HARDNESS 143 BHN

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS x OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
80	29.0	33.5	88.1	57.	74
1200	21.8	17.5	43.9	51	73
1300	21.2	15.0	33.0	57	71
1500	20.0	11.5	18.8	50.	54

x Determined by a Super Sonic Method.

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1000						9.4	18.5
1100						5.6	11.2
1200	22.5	17.0	13.0*	10.0*		3.5	6.3
1300	16.0	9.8	6.1*	3.8*		2.2	4.6
1400	10.0	6.0	3.0*	1.3*		1.2*	2.6*
1500	5.0	3.0	1.8*	1.0*		.3	1.4

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *
(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

(21)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	304	TYPE OF MELTING FURNACE						SIZE OF HEAT						
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
	.05	.51	.028	.012	.40	18.7	9.48							
DEOXIDATION														
FORM-CAST OR WROUGHT	Wrought - Centerless Ground													
HEAT TREATMENT	1550°F. - Air Cooled													
MICROSTRUCTURE														
GRAIN SIZE														
HARDNESS	BHN 163													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70	28.2	33.0	84.0	63.5	74.0
300	25.5	25.0	67.0	56.5	72.0
500	23.5	24.0	65.2	52.0	70.0
750	21.0	21.2	63.5	46.0	67.6
1000	18.5	18.5	57.2	40.0	65.1
1200	16.6	15.0	50.0	35.5	63.0
1400	14.5	10.0	35.0	31.0	61.5

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	25.0	16.5	9.8				

(22)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE						SIZE OF HEAT						
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
						18	8							
DEOXIDATION														
FORM-CAST OR WROUGHT	Wrought													
HEAT TREATMENT	In service 59,000 hrs. at 1000 psi, at 1100-1200°F.													
MICROSTRUCTURE														
GRAIN SIZE														
HARDNESS														

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT			86.0	52.0	56.5

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	20.0	15.0	* 9.0	* 5.5			

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F.	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	25.0	5 R						
	22.5	13 R						
	20.0	188 R						
	17.5	66 R						
	15.0	250 R						
	12.5	3699 R						
	10.0	7132 R						

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *
(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

(23)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE						SIZE OF HEAT						
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
	.10	.50			.45	18.7	8.06							
DEOXIDATION														
FORM-CAST OR WROUGHT	Wrought													
HEAT TREATMENT	As Rec'd													
MICROSTRUCTURE	None													
GRAIN SIZE														
HARDNESS														

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	37.0	25.0	* 18.0	* 10.0			

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F.	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	35.0	41 R					4.0	
	25.0	983 R					4.0	
	22.5	1249 R					3.0	
	18.0	4868 R					4.0	

(24)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE						SIZE OF HEAT						
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
	.06	.33			.164	18.7	10.5		.50					
DEOXIDATION														
FORM-CAST OR WROUGHT	Wrought													
HEAT TREATMENT	As Rec'd													
MICROSTRUCTURE														
GRAIN SIZE														
HARDNESS														

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT			94.1	71.4	46.5

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1202					1.4	4.8	

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F.	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1202	8.0	1220	.016	.000028	--			
1202	4.0	1220	.017	.0000075	--			

(25)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE						SIZE OF HEAT						
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
	.07	.46	.012	.004	.44	17.8	9.14			.45				
DEOXIDATION														
FORM-CAST OR WROUGHT	Wrought													
HEAT TREATMENT	As Rec'd													
MICROSTRUCTURE														
GRAIN SIZE														
HARDNESS														

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT			93.4	70	48

(25)

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F.	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1202	4.000	1220	.013	.000033	--			
1202	2.000	1220	.011	.000012	--			

(26)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	304	TYPE OF MELTING FURNACE						SIZE OF HEAT						
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N_2	FE
	.018					19.2	11.3					.14	69.2
DEOXIDATION													
FORM-CAST OR WROUGHT	Wrought												
HEAT TREATMENT													
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS													

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	28.0	21.3 *					
1500	5.9	3.0					

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F.	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	36.0	16.0 R					3	
"	33.0	19.3 R					3	
"	30.0	60.5 R					3	
"	27.0	89.8 R					2	
"	22.5	789.6 R					4	
1500	14.85	4.8 R					23	
"	12.0	8.1 R					--	
"	8.67	27.1 R					--	
"	5.25	150.7 R					27	
"	3.0	990.2 R					30	

(27)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	304	TYPE OF MELTING FURNACE						SIZE OF HEAT						
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N_2	Fe
	.018					18.9	11.3					.032	Bal.
DEOXIDATION													
FORM-CAST OR WROUGHT	Wrought												
HEAT TREATMENT													
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS													

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	32	19 *					
1500	6.3	3.3 *					

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F.	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	36.	89.1 R					22	
"	36.	43.8 R					-	
"	33.	78.8 R					10	
"	30.	113.0 R					29	
"	25.5	229.0 R					5	
"	22.2	206.0 R					-	
"	18.	-					-	
1500	15.	1.1 R					1.1	
"	12.	5.6 R					9.0	
"	3.	688.4 R					19.	
"	6.	261.5 R					-	

(28)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	302-B	TYPE OF MELTING FURNACE						SIZE OF HEAT						
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
	.10	1.66	.030	.019	2.16	17.8	8.90							
DEOXIDATION														
FORM-CAST OR WROUGHT	.070" sheet 2B finish													
HEAT TREATMENT	2000°F - 30 Minutes - Air Cool													
MICROSTRUCTURE														
GRAIN SIZE														
HARDNESS	85 Rb													

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	32.0	23.5 *					
1500	8.1						

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F.	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	25.0	658 R	4.10	.0060	300		24.	
1200	28.0	250 R	4.80	.031	> 165		24.	
1200	30.0	75 R					38.5	
1200	35.0	51.5 R					20.5	
1200	40.0	10 R					22.5	
1200	45.0	3 R					36.5	
1500	6.0	162	.38	.019	> 162			
1500	7.0	205 R	.10	.14			40.	
1500	8.0	105 R	.90	.182	25		35.	
1500	10.0	33 R	.60	.85			56.	
1500	13.0	7.5 R	.20	4.2	1.0		89.	

(29)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE						SIZE OF HEAT	Commercial					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
	.06	.65	.017	.015	.83	18.8	9.03		.24					
DEOXIDATION														
FORM-CAST OR WROUGHT	Cast Cylinders													
HEAT TREATMENT	Heated to 1850°F. Min - 4 hrs. cooled in air blast Heated to 1512-1622°F - 4 hrs. cooled in air													
MICROSTRUCTURE	Austenitic matrix, columnar structure with ferrite in fine dendritic pattern													
GRAIN SIZE														
HARDNESS	79.0 Rb													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
Room	25.0	28.5	71.0	29.5	60.1
300		23.0	57.8	41.2	66.8
550		22.5	51.3	33.5	56.0
900	19.5	18.3	51.9	29.5	50.9
1000	17.0	17.1	47.0	34.0	56.0
1050	15.5	17.7	44.9	31.5	53.5
1100	14.0	18.8	43.4	29.0	50.5

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1000	46	36.5	* 25.0				
1100	33	25.0	* 16.0			12.0	19.5

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *
(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

(29)

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1000	46.0	101.0 R	.20	.0134	82.0		22.5	
1000	44.0	315.9 R	.46	.0043	315.0		27.0	
1000	40.0	515.2 R	.41	.0016	380.0		19.0	
1000	35.0	1384. R	.58	.0012	1250.0		18.0	
1100	35.0	43.0 R					16.0	
1100	30.0	427. R	.91	.0045	300.0		13.0	
1100	25.0	1048. R	.92	.00083	830.0		7.0	
1100	16.0	2136.	.463	.000025	1900.		.526	
1100	12.0	2016.	.094	.000009			.112	

(30)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	18-8	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
	.06	.47	.010	.010	.65	16.8	8.52							
DEOXIDATION														
FORM-CAST OR WROUGHT	3/4" Dia. Bars-Rolled													
HEAT TREATMENT	W.Q. - 2100°F.													
MICROSTRUCTURE														
GRAIN SIZE														
HARDNESS	74 Rb													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70	27.0	31.0	84.1	67.0	78.1
800		21.0	61.9	47.0	70.8
1200		16.0	43.3	35.5	48.4
1400		15.5	27.6	27.0	33.4

(31)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	303	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
	.04	.60	.025	.152	.48	18.7	9.28							
DEOXIDATION														
FORM-CAST OR WROUGHT	Wrought - Hot Rolled													
HEAT TREATMENT	2000°F - Water Quench													
MICROSTRUCTURE														
GRAIN SIZE														
HARDNESS	180 BHN													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70	28.1	40.0	87.0	55.0	61.6
300	26.2	30.0	65.5	50.5	60.0
500	24.5	30.0	64.0	47.0	58.5
750	22.5	28.5	62.5	42.5	56.8
1000	20.4	26.5	56.5	35.4	55.0
1200	18.6	24.5	45.0	31.0	53.2
1400	17.0	19.0	28.5	26.5	38.5

(32)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	18-8	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
	.04	.50			.70	19.0	9.74							
DEOXIDATION														
FORM-CAST OR WROUGHT	3/4" Dia. Bars, Rolled													
HEAT TREATMENT	W. Q.-2100°F													
MICROSTRUCTURE														
GRAIN SIZE														
HARDNESS	140 BHN, 76 Rb													

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70	22.2	30.4	82.8	65.5	79.3
800	17.4	18.3	62.2	48.0	71.6
1000	15.8, 25.0	18.0	58.6	43.5	71.9
1200	16.0, 17.0	16.0	45.2	39.0	55.0
1400	17.2, 22.0	13.0	30.3	30.0	38.8
1600	17.0, 15.0	11.0	19.2	26.0	28.5

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
900	15.0	168	.013	<.00001				
1000	"	480	.034	.000073				
1100	"	360	.099	.000196				
1200	"	120	0	.0058	>120			Rb 80
1200	10.0	816	.106	.00027	>816			Rb 76
1400	3.0	360	.057	.00006				
	10.0	78	1.90	.0570	> 78			Rb 76
1600	1.0	480	.042	.000062				
	3.0	428 R	.070	.0047	110		4.5	Rb 72

(33)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	18-8	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
	.10	.51			.43	19.8	9.35							
DEOXIDATION														
FORM-CAST OR WROUGHT	3/4" Dia. Bars-Forged													
HEAT TREATMENT	W.Q.-2000°F													
MICROSTRUCTURE														
GRAIN SIZE														
HARDNESS	187 BHN, 88 Rb													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70	31.0, 31.0	56.1, 52.2	94.4, 85.6	52.0, 62.0	69.3, 75.2
300	28.0	39.2	69.9	43.0	76.6
550		39.1	64.1	34.0	66.0
800	17.0, 26.0	34.0	61.8	37.5	66.4
1000	18.5, 23.0	34.0	56.5	35.5	69.1
1200	24.0	33.5	46.8	32.0	66.0
1400	16.0, 18.0	22.0	32.0	33.0	45.4
1600	15.0	10.0	20.2	40.0	52.3

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
800	20.0	408	.040	*.000007				Rb 91
1600	1.0	960	.027	.000067	> 960			Rb 79
1000	10.0	648	.076	*.000032	> 648			Rb 87
1000	20.0	456	.062	*.000041				
	30.0	504	.046	.000190	> 504			Rb 89
1200	3.0	120	.007	<.00002				
	5.0	336	.018	*.000020				Rb 90
1000	20.0	120	.015	<.00002				
	30.0	144	.041	*.00002	> 144			Rb 89
1200	10.0	624	.060	*.000033	> 624			Rb 79
1400	3.0	312	.012	*.000009				
	5.0	1104	.055	.000088	>1104			Rb 84
1400	10.0	580	.055	.00036	> 576			Rb 80
1600	3.0	960 R	0	.0017	120		6.74	Rb 74
*Not necessarily a minimum rate								

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

(34)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 304	TYPE OF MELTING FURNACE Heroult Arc							SIZE OF HEAT 15 Ton					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.028	.64	.011	.010	.43	18.9	9.36	.06					
DEOXIDATION	Silicon												
FORM-CAST OR WROUGHT	Wrought Bar Stock												
HEAT TREATMENT	Annealed												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS	-												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT	--	29.0	77.0	55.0	75.8
400	--	16.5	59.9	50.7	72.6
600	--	14.5	56.6	48.0	67.5
800	--	13.5	57.2	47.8	68.5
900	--	13.4	56.7	46.2	67.0
1000	--	11.7	52.8	45.0	67.5
1200	--	11.3	41.3	46.3	55.3

(35)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 18-8	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.09	.32			.28	17.7	8.54						
DEOXIDATION													
FORM-CAST OR WROUGHT	3/4" Dia. Bars, Rolled												
HEAT TREATMENT	W. Q. 2100 F												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS	147 BHN												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70	24.4	32.9	90.0	65.0	74.7
800		18.0	62.6	47.5	70.3
1000	17.7	16.7	57.0	42.5	69.9
1200	13.0	16.0	45.5	31.5	44.8
1400	10.7	15.5	30.8	18.5	24.1
1600	6.4	10.0	17.5	12.0	16.7

(36)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 18-8	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.06	.47	.010	.010	.65	16.8	8.52						
DEOXIDATION													
FORM-CAST OR WROUGHT	3/4" Dia. Bars - Rolled												
HEAT TREATMENT	A. Q. -1950°F												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS	73 Rb												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70	22.0	28.6	84.2	64.5	74.6
800	20.5	16.0	62.5	47.5	70.8
1200	19.0	13.0	43.8	38.5	50.7
1400		9.5	25.8	32.0	39.1

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *
(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

(37)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 18-8	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.06	.47	.010	.010	.65	16.8	8.52						
DEOXIDATION													
FORM-CAST OR WROUGHT	3/4" Dia. Bars - Rolled												
HEAT TREATMENT													
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS	134 BHN, 73 Rb												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70	27.0	31.0	84.3	65.5	77.7
800	27.0	17.0	62.5	47.5	71.2
1200		12.0	44.1	38.5	50.6
1400		12.0	27.2	32.5	38.9

(38)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 18-8	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.04	.50			.70	19.0	9.74						
DEOXIDATION													
FORM-CAST OR WROUGHT	3/4" Dia. Bars, Rolled												
HEAT TREATMENT	As Rolled												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS	147 BHN, 79-81 Rb												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70	21.4	34.7	87.3	61.0	77.0
800	19.6, 28.0	21.5	64.25	46.0	71.2
900	28.0				
1000	18.0, 25.0	19.5	59.1	43.0	71.1
1100	20.0				
1200	19.4, 24.0	17.0	52.9	46.3	63.9
1400	14.0	12.0	25.0	38.0	43.6
1600		9.5	19.6	33.5	41.5

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
800	15.0	48	0	0				
900	"	360	.023	*.000008				
1000	"	480	.101	*.000044				
1100	"	360	.060	.0007	>360			Rb 80
1200	10.0	504	.109	.00072	>504			Rb 79
1400	"	48	1.40	*.096	> 48			Rb 80
1400	3.0	624	.107	.000057	>624			Rb 79
1600	1.0	456	.050	.00075				
	3.0	165 R	0	.0360	48		9.0	Rb 80
*Not necessarily a minimum rate								

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ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 18-8	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.09	.32			.28	17.7	8.54						
DEOXIDATION													
FORM-CAST OR WROUGHT	3/4" Dia. Bars - Cold Rolled												
HEAT TREATMENT													
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS	217 BHN, 20-22 Rc, 97 Rb												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70	24.7	81.5	108.95	41.0	70.4
550	23.6	63.0	80.2	28.5	66.5
800	25.5	57.9	76.4	30.5	62.9
1000	19.2, 27.0	53.0	69.3	26.0	65.9
1200	12.5, 23.0, 20.	44.5	58.5	25.0	61.7
1300	20.0				
1400	8.3, 7.0	26.0	42.1	29.0	49.7

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1000	10.0	504	.024	*.000042	>504			Rb 98, Rc 20
1200	"	600	.310	.00034	>600			Rb 96, Rc 19
1200	3.0	384	.045	*.000044	>384			
1300	"	192	.007	*.000044	>192			
1400	"	408	.095	.00116	>408			
1500	"	96	0	.0095	> 96			

*Not necessarily a minimum rate

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ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 304	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.04	.59	.023	.013	.59	18.2	9.19						
DEOXIDATION													
FORM-CAST OR WROUGHT	Wrought - Cold Drawn												
HEAT TREATMENT	1550°F. Air Cooled												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS	195 BHN												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70	27.8	43.5	89.5	54.0	74.0
300	26.5	36.0	67.0	50.0	72.5
500	25.0	33.5	62.5	47.0	71.1
750	23.0	30.0	62.0	42.5	69.2
1000	21.1	28.0	55.0	38.0	67.5
1200	19.6	26.0	44.0	35.0	66.0
1400	18.0	19.0	32.0	31.5	64.8

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ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 18-8	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.29	.58			2.51	18.0	9.46						
DEOXIDATION													
FORM-CAST OR WROUGHT	3/4" Dia. Bars												
HEAT TREATMENT													
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS	231 BHN, 101 Rb												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70	30.2	81.8	128.9	38.5	52.6
800	22.8	61.0	90.9	25.0	53.0
1000	22.5	57.5	83.2	25.0	56.0
1200	12.3, 28.	46.0	68.9	31.5	68.2
1400	8.0	26.0	45.9	44.0	74.9
1600	8.0, 10.	15.0	30.4	43.0	81.8

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	10.0	840	.073	.00025	>840			Rb 100
1400	3.0	792	.069	.000093	>792			Rb 100
1400	10.0	438	.080	.0040	168			Rb 98
1600	1.0	552	.135	.000116				
	3.0	168	.090	.0110	96			Rb 92

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *
(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

(42)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 304	TYPE OF MELTING FURNACE Electric Arc							SIZE OF HEAT 35 Tons					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.03	.39	.011	.007	.40	19.1	10.0						
DEOXIDATION													
FORM-CAST OR WROUGHT	Wrought 1" Bars												
HEAT TREATMENT													
MICROSTRUCTURE	Austenitic												
GRAIN SIZE													
HARDNESS													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
1400			31.34	44.7	57.0
1600			18.21	51.0	59.6
1800			9.93	66.5	75.5
2000			5.88	80.5	82.5
2200			4.14	85.2	96.1
2300			3.11	74.5	100

(43)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.06	.42			.53	17.5	9.53						
DEOXIDATION													
FORM-CAST OR WROUGHT	Wrought												
HEAT TREATMENT	As Rec'd												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT			85.4	74.3	62

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1202	8.0	1220	.023	.000010				
1202	4.0	1220	.002	0				

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ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL Cast 18-8	TYPE OF MELTING FURNACE Electric Arc							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.10	.48		.28		18.7	10.0						
DEOXIDATION													
FORM-CAST OR WROUGHT	Cast Keel Blocks Navy Pattern												
HEAT TREATMENT	Water Quench 1900 F												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS	65 to 77 Rb												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70		30.8	71.4	55.0	62.5
300		27.8	60.9	38.5	58.0
550	20.5	20.0	58.1	43.0	51.9
800	16.0	18.0	58.0	47.0	56.2
1000	23.1	14.5	51.8	39.0	47.8
1200		14.0	41.0	29.5	41.8
1400		15.3	24.9	13.5	23.4
1600	14.9	10.8	15.9	16.0	38.8
1200		14.5	>30.0		

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
800	30.0	264	4.2	<.00001				82.8
800	20.0	360	.680	<.00001				
900	20.0	1272	.610	*.000093				
1000	20.0	432	.109	*.000070				
1100	20.0	384R	.091	.000898	312		6	82.5
900	10.0	552	.002	<.00001				
1000	10.0	1008	.048	*.000015				
1100	10.0	504	.028	.000003				
1200	10.0	432	.032	.000005				
1300	10.0	408	.096	<.00001				
1400	10.0	72R					0.25	84.4
1000	3.0	264	.010	<.00001				
1100	3.0	504	.027	<.00001				
1200	3.0	504	.100	.000005				
1300	3.0	360	.025	<.00001				
1400	3.0	408	.031	<.00001				
1500	3.0	624	.026	.000008				
1600	3.0	456R	.048	.000204	300		0.4	72.5

* Not necessarily a minimum rate

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ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE						SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.10					17.2	8.57						
DEOXIDATION													
FORM-CAST OR WROUGHT	Wrought												
HEAT TREATMENT	As Rolled												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS	219 BHN												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
80			105.8	46	69.6

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1022					11.5(a)	15.2(a)	

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ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE						SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.10	.38			.25	17.2	9.49						
DEOXIDATION													
FORM-CAST OR WROUGHT	Wrought												
HEAT TREATMENT	As Rec'd												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT			89.6	69.5	60.5

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1202					4.0(a)	5.8(a)	

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *
(a) Flow Rate Data - Step-down test on single specimen at .002 in/in total strain.

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1202	8.00	1220	.026	.000036		.071		

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ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE						SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.099	.50			.43	18.7	9.05						
DEOXIDATION													
FORM-CAST OR WROUGHT	Cast												
HEAT TREATMENT	1100 C 1 hr. W.Q., 650 C 1 hr. A.C.												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS	82 Rb												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT			90.0	60.0	72.5

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1000					8.6(a)	13.4(a)	16.5(a)

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

18Cr-8Ni + Ti

(1)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	321	TYPE OF MELTING FURNACE	Elec. Arc	SIZE OF HEAT	25 Tons

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al
	.044	1.10	.014	.010	.72	18.6	10.7			.48	

DEOXIDATION	Silicon
FORM-CAST OR WROUGHT	Wrought
HEAT TREATMENT	W. Q. 1900°F.
MICROSTRUCTURE	Equi-Axed, Austenitic, few Ti Carbides.
GRAIN SIZE	8 Actual
HARDNESS	BHN 136

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS A OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
80	28.9	67.7	93.8	49	75
1000	22.5				
1100	21.9	49.1	61.2	26	67
1200	21.2	44.0	53.4	31	60
1300	20.4	38.4	50.5	24	43
1400	19.7				
1500	19.1	28.0	29.7	37	75

(A) Determined by a Supersonic Method.

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1100	43.0	34.0	26.0	21.0		6.4	14.0
1200	33.0	20.5	11.0	5.9		2.5	9.7
1300	23.5	12.5	6.2	3.0		1.5	3.8
1400							
1500	7.2	4.1	2.3	1.3			6

(2)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	321	TYPE OF MELTING FURNACE	Electric	SIZE OF HEAT	

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al
	.05	.53	.017	.010	.41	17.6	10.8			.42	.039

DEOXIDATION	
FORM-CAST OR WROUGHT	Wrought
HEAT TREATMENT	1950°F., 0.5 Hr., Quenched
MICROSTRUCTURE	Typical - with fine undissolved carbides
GRAIN SIZE	ASTM 6-8
HARDNESS	149 DPH

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
75		30.6	83.7	54.5	78.0
1100		19.3	51.2	39.0	73.0
1300		17.3	35.0	64.0	78.5
1500		11.6	20.8	80.0	97.0

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1100	40.0	26.0 *	16.8 *	11.0 *		12.7	16.0
1300	17.0	10.0 *	6.1 *	3.7 *		3.1 *	4.6
1500	6.2	3.8	2.35 *	1.46 *		0.48 *	0.85

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *
(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1100	15.0	3000	.170	.000066	> 3000			
"	13.0	3000	.747	.000021				
"	10.0	3000	0.0865	.0000098	> 3000			
"	13.5	3000	0.093	.000018	> 3000			
"	48.0	4.9 R	17.2	2.24	3.4			
"	45.0	19.9 R	15.3	0.37	12.0			
"	36.0	159.5 R	6.6	0.0368	70.			
"	35.0	262.5 R	5.3	0.056	152.			
"	29.0	607.7 R	3.7	0.00565	275.			
"	26.0	831. R	2.9	0.004	450			
1300	4.3	3000	0.018	.000155	> 3000			
"	4.0	3000	0.03	.000088	> 3000			
"	1.5	3000	0.022	.000028	> 3000			
"	27.	1.65 R	5.8	15.2	0.68			
"	25.	4.7 R	6.3	3.74	1.8			
"	20.	45.7 R	3.3	0.192	23.0			
"	15.	170.5 R		0.038	95.0			
"	15.	132.2 R		0.04	50.0			
"	11.	668. R		0.00624	290.			
1500	1.5	500	0.10	10.0	300			
"	1.05	3000	0.015	6.0	> 3000			
"	0.971	3000	0.018	.00028	750			
"	15.	0.75 R	2.4	22.0	0.2			
"	15.	0.6 R		57.1	0.3			
"	15.	0.57 R						
"	13.	1.8 R	2.1	16.3	0.65			
"	10.	13. R	1.1	1.69	4.0			
"	6.	53.2 R		0.336	14.0			
"	5.12	180.5 R		0.045	35.0			
"	3.82	523. R		0.0181	187			
"	3.12	486.8 R		0.0158	65			

(3)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	321	TYPE OF MELTING FURNACE	Electric	SIZE OF HEAT	

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al
	.09	.46	.012	.007	.63	18.5	11.2			.34	.064

DEOXIDATION	
FORM-CAST OR WROUGHT	Wrought
HEAT TREATMENT	1950°F., 0.5 Hr., Quench
MICROSTRUCTURE	Annealed - with fine carbides undissolved
GRAIN SIZE	ASTM 5-8
HARDNESS	164 DPH

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1100						16.0 *	21.0
1300						5.2 *	7.8
1500						1.8 *	2.7

(4)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	321	TYPE OF MELTING FURNACE	Electric	SIZE OF HEAT	

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N
	.07	.52	.021	.003	.386	17.9	10.4			.58	.069	.011

DEOXIDATION	1.2 pounds Al per ton
FORM-CAST OR WROUGHT	Forged Plate
HEAT TREATMENT	1/2 hr. at 1900°F. - W. Q.; 2 hr. at 1550°F.
MICROSTRUCTURE	
GRAIN SIZE	5-6 Actual
HARDNESS	

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
75		30	77.3	61 - 1"	80.5

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
900		49	43*				
1050		32	27*				
1200		18	13*				

(5)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	321	TYPE OF MELTING FURNACE	Basic Electric	SIZE OF HEAT	48,100 lbs.

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Cu
	.06	1.77	.011	.013	.50	17.8	12.2	.08		.42		.12

DEOXIDATION	18 lbs. Al shot in Ladle
FORM-CAST OR WROUGHT	Wrought (3/4" Diam. Bar Stock)
HEAT TREATMENT	2000°F., 1/2 hr., W. Q. 1750°F., 1 hr., A. C.
MICROSTRUCTURE	Typical
GRAIN SIZE	Actual ASTM 3-7 (Duplex)
HARDNESS	140 VHN (5 Kg. load)

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
Room		38.8	77.8	56.0	75.0
1050		35.0	54.25	39.0	73.8
1200		33.85	42.7	41.5	69.8
1350		24.1	30.75	37.5	61.2
1500		14.9	19.25	47.0	81.7

Note: (1) Y. S. at Room Temp. obtained at 0.20% offset.
(2) Y. S. at Elevated Temp. determined by string extensometer.

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1050	52.0	39.5	30.5	23.5 *			

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1050	50.0	135.4 R					22.0	
1050	43.5	318.5 R					10.0	
1050	38.0	1995.9 R					13.0	
1050	33.5	3895.6 R					11.0	
1050	31.5	8062.6 R					12.0	

(6)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	321	TYPE OF MELTING FURNACE	Basic Electric	SIZE OF HEAT	48,100 lbs.

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Cu
	.06	1.77	.011	.013	.50	17.8	12.2	.08		.42		.12

DEOXIDATION	18 lbs. Al shot in ladle.
FORM-CAST OR WROUGHT	Wrought (3/4" Diam. Bar Stock)
HEAT TREATMENT	2000°F., 1/2 hr., W. Q. 1600°F., 5 hrs. F. C.
MICROSTRUCTURE	Typical
GRAIN SIZE	Actual ASTM 3-6 (Duplex)
HARDNESS	137 VHN (5Kg. load)

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
Room		37.3	78.0	55.0	75.0
1050		37.7	51.5	40.0	74.5
1200		35.25	40.75	39.5	68.8
1350		23.4	28.9	42.0	64.9
1500		15.6	17.5	60.0	82.0

Note: (1) Y. S. at Room Temp. obtained at 0.20% offset.
(2) Y. S. at Elevated Temp. determined by string extensometer.

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1050	46.0	39.5	30.5 *	23.3 *			

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1050	50.0	0.1 R					32.0	
1050	43.5	441.7 R					19.0	
1050	38.0	1232.0 R					14.5	
1050	33.5	4469.0 R					12.5	

(7)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	321	TYPE OF MELTING FURNACE		SIZE OF HEAT	

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al
		.88						.05		.20	

DEOXIDATION	
FORM-CAST OR WROUGHT	0.438 in. Bar
HEAT TREATMENT	1900°F. Anneal
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70		33.5	95.0	49.0	

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	25.5						
1500	6.0 *						

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	31.0	5.5 R					30.0	
1200	25.0	245.0 R						
1500	8.4	13.5 R					49.0	
1500	6.8	51.0 R						
1700	4.4	7.0 R					49.0	
1700	7.5	40.0 R						
1900	3.3	2.0 R					38.0	
1900	1.9	9.6 R						

(8)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	18-8 Ti	TYPE OF MELTING FURNACE		SIZE OF HEAT	

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al
	.08	1.82			.48	17.8	10.2			0.86	

DEOXIDATION	
FORM-CAST OR WROUGHT	Sheet
HEAT TREATMENT	Annealed
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	25.0	20.0 *					
1500	3.8						

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	30.0	34.0 R					10.0	
1200	27.5	28.0 R					6.0	
1200	27.5	43.0 R					10.0	
1200	25.0	259.3 R					20.0	
1200	24.0	113.0 R					6.0	
1200	24.0	75.0 R					14.0	
1200	23.0	165.0 R					12.0	
1200	21.0	215.0 R					12.5	
1500	14.0	3.6 R					25.0	
1500	9.0	20.0 R					22.0	
1500	9.0	24.0 R					21.0	
1500	8.0	63.0 R					16.0	
1500	7.0	21.0 R					16.0	
1500	7.0	22.0 R					20.0	
1500	5.5	44.0 R					18.0	
1500	4.0	90.0 R					12.0	
1500	2.8	160.0 R					9.0	
1500	2.0	209.0 R					20.0	

(9)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	321	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Fe		
						19.0	9.0			.4		Bal.		
DEOXIDATION														
FORM-CAST OR WROUGHT	0.045 in. Sheet													
HEAT TREATMENT	1900°F. Anneal													
MICROSTRUCTURE														
GRAIN SIZE														
HARDNESS														

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70		32.7	84.3	56.0	

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	28						

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	34.3	20.8 R					10.0	
1200	30.7	52.4 R					10.0	

(10)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	321	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Fe		
	.1	2.0	.03	.03		18.0	10.0			.40		Bal.		
DEOXIDATION														
FORM-CAST OR WROUGHT	0.040 in. Sheet													
HEAT TREATMENT	1900°F. Anneal													
MICROSTRUCTURE														
GRAIN SIZE														
HARDNESS														

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70		31.9	86.4	51.2	

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1350	14.0	0.6				.18		
1350	14.0	13.0				.45		
1350	14.0	38.0				.92		
1350	14.0	95.0				4.6		
1350	12.0	7.5				.12		
1350	12.0	42.0				.38		
1350	12.0	84.0				1.4		
1350	12.0	190.0 R					19.0	
1350	10.0	35.0				.15		
1350	10.0	80.0				.35		
1350	10.0	190.0				1.60		
1350	10.0	275.0				5.0		

(11)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
	.058	1.75	.018	.013	.65	19.8	9.86			.22				
DEOXIDATION														
FORM-CAST OR WROUGHT	Weld Deposit													
HEAT TREATMENT	650°C 2 Hrs. F. C.													
MICROSTRUCTURE	None													
GRAIN SIZE														
HARDNESS														

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1000	44.0	36.0	28.5 *	22.2 *			

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1000	46.0	21 R					15.3	
"	42.0	115 R					12.5	
"	36.0	1099 R					5.8	
"	30.0	6901 R					1.5	

(12)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	321	TYPE OF MELTING FURNACE	Heroult Arc						SIZE OF HEAT	16 Ton				
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
	.053	1.18	.028	.026	.89	18.6	8.71			.54				
DEOXIDATION	Aluminum													
FORM-CAST OR WROUGHT	Wrought Bar Stock													
HEAT TREATMENT	1850°F. 1/2 Hr. W. Q.													
MICROSTRUCTURE														
GRAIN SIZE	ASTM G. S. 6-7													
HARDNESS	156 BHN													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT		38.7	87.1	53.7	72.5
1000		28.3	60.4	33.7	65.3
1100		27.5	56.0	36.0	62.0
1200		26.5	50.0	40.0	60.0
1300		24.0	46.0	45.0	61.0
1400		21.0	36.5	53.0	66.0
1500		16.0	25.0	66.0	80.0

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

(13)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	321	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
DEOXIDATION														
FORM-CAST OR WROUGHT														
HEAT TREATMENT	30% Elong. 1800°F. 30 Min. A. C.													
MICROSTRUCTURE														
GRAIN SIZE														
HARDNESS														

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET* YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION* IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT		33.06	90.6	53.98	69.52
RT		32.60	90.1	53.32	71.01
1000		22.20	60.4	34.68	63.04
1100		21.58	54.7	20.0	65.94
1200		19.94	47.20	18.65	71.82
1300		19.03	38.6	20.0	70.74
1400		15.58	32.47	41.35	58.06
1500		13.45	21.385	63.35	90.30
1700			14.320	65.99	97.60

* YS 0.02%, Elongation in 1-1/2 inch.

(14)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	18-8 Ti	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
	.08	.37	.020	.014	.46	18.3	8.55			.42				
DEOXIDATION														
FORM-CAST OR WROUGHT	3/4" Bars Rolled													
HEAT TREATMENT														
MICROSTRUCTURE														
GRAIN SIZE														
HARDNESS	156-163 BHN, 74-77 Rb													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70		32.7	88.7	55.0	74.9
800		23.5	56.5	36.0	71.8
1000		20.5	52.3	38.5	78.1
1200		19.0	41.7	43.5	78.1
1400		16.2	28.4	53.0	77.3
1600		10.5	17.8	54.5	95.1
1300	16.0				

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1100	3.0	312	0	< .000006				
1200	"	240	.032	< .000008				
1300	"	264	.031	< .000008				
1400	"	696	0	< .000015				
1500	"	528	.050	< .000006				
1600	"	1800 R	0	.00037	1080		1.5(a)	Rb 67
1300	10.0	624	.068	.000023*				
1400	"	1248	0	.00044	456	Not fractured at 6.5%		

* Not necessarily the minimum rate.

(a) Fractured in threads.

(15)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	18-8 Ti	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
	.08	.37	.020	.014	.46	18.3	8.55			.42				
DEOXIDATION														
FORM-CAST OR WROUGHT	3/4" Bars, Rolled													
HEAT TREATMENT	W. Q. - 1800°F.; Reheat - 1600°F. (2Hrs.)													
MICROSTRUCTURE														
GRAIN SIZE														
HARDNESS	137-143 BHN, 74-77 Rb													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70		29.7	88.6	53.0	74.9
800		20.5	54.8	36.5	71.2
1000		22.0	51.7	36.0	75.9
1200		18.0	42.2	41.0	73.9
1400		15.0	27.3	56.0	80.4
1600		11.0	18.1	52.0	88.8

(16)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	18-8 Ti	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
	.10	.49	.010	.010	.49	17.1	11.2			.38				
DEOXIDATION														
FORM-CAST OR WROUGHT	1-1/2" Diam. Bars													
HEAT TREATMENT														
MICROSTRUCTURE														
GRAIN SIZE														
HARDNESS	181 BHN, 89 Rb													

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1350	8.0	2496 R	.056	.000276	1056		5.5	Rb 84

(17)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
	.09	.53	.012	.004	.39	17.3	10.3			.33				
DEOXIDATION														
FORM-CAST OR WROUGHT	Wrought													
HEAT TREATMENT	As Rec'd													
MICROSTRUCTURE														
GRAIN SIZE														

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1202	2,000	1220	.01	.000026		0.047		

(18)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	321	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
DEOXIDATION														
FORM-CAST OR WROUGHT	Wrought													
HEAT TREATMENT	1/2 Hr. at 1950°F.													
MICROSTRUCTURE														
GRAIN SIZE														
HARDNESS														

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET* YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION* IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT		24.	83.0	48.	69.
1000			59.0	37.	66.
1200			51.0	37.	65.
1500			28.0	50.	69.

* YS 0.02% offset, Elongation in 1-1/2 inch.

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY #
(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

18Cr-8Ni + Cb

(1)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 347	TYPE OF MELTING FURNACE Electric							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.06	1.61	.016	.006	.32	18.1	11.1		.78		.023		
DEOXIDATION													
FORM-CAST OR WROUGHT	Wrought												
HEAT TREATMENT	1950°F., 0.5 Hr., Quench												
MICROSTRUCTURE	Typical - with fine undissolved carbides												
GRAIN SIZE	ASTM 8												
HARDNESS	165 DPH												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
75		47.5	97.0	44.5	72.0
1100		34.5	59.1	33.0	67.0
1300		29.0	43.7	47.0	72.5
1500		19.5	27.3	47.0	58.0

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1100	44.5	36.0	29.0 *	23.5 *		23.0	27.0
1300	20.0	13.2	9.0 *	6.0 *		5.9 *	8.0
1500	8.2	4.5 *	2.4 *	1.3 *		1.1 *	1.8

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1100	25.	3000	.322	.000041	> 3000			
"	29.	3000	.356	.000234	900			
"	27.	3000		.000130	1200			
"	27	3000		.000240	1700			
"	19.	3000	.176	.000014	> 3000			
"	25.	3000	.560	.000024	> 3000			
"	19.	3000	.211	.000021	> 3000			
"	15.	3000	.470	.000005	> 3000			
"	62.	0 R					36.	
"	57.	.003 R					33.	
"	55.	6.7 R	19.8	1.68	3.8		45.	
"	50.	41.0 R	5.7	.154	22.		22.	
"	44.	129.5 R	5.5	.0584	95.		30.	
"	36.	1072.8 R	1.5	.00304	770.		23.	
1300	5.0	3000	.140	.000014	2100			
"	8.0	3000	.181	.000178	1750			
"	32.	2.5 R	3.5	6.9	1.1		48.	
"	32.	2.5 R	3.4	4.8	1.4		41.	
"	25.	24.5 R	1.0	.244	11.6		39.	
"	22.	65. R		.0685	27.0		45.	
"	16.	379. R	0.3	.009	110.		66.	
"	12.5	1513. R	0.28	.00646	350.		49.	
1500	1.5	3000	.191	.0000415	2300			
"	2.2	3000	.187	.000225	1750			
"	4.0	250	.10	.00318				
"	20.0	0.33R	1.2	92.8	0.3		77.	
"	15.0	5.0 R	0.7	3.33	2.0		75.	
"	13.0	6.5 R	1.0	3.04	2.15		63.	
"	10.0	46.4 R	0.8	.312	18.0		61.	
"	5.8	362. R		.0232	130.		31.	

(2)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 347	TYPE OF MELTING FURNACE Electric Arc							SIZE OF HEAT 25 Tons					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.07	1.68	.013	.014	.55	17.7	12.7		.88				
DEOXIDATION	Silicon												
FORM-CAST OR WROUGHT	Wrought												
HEAT TREATMENT	W. Q. 1900°F.												
MICROSTRUCTURE	Equi-Axed, Austenitic, with Cb Carbides												
GRAIN SIZE	4/6 Actual												
HARDNESS	144 BHN												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS + OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
80	28.9	33.5	82.4	54.0	73

+ Determined by a Supersonic Method.

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1100	36.0	33.0*	32.0*	30.5*		1.0	
1200	25.0	23.0	22.0*	21.0*		10.0	16.0
1300	21.5	16.0*	12.0*	9.0*		5.2	11.2

(3)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 347	TYPE OF MELTING FURNACE Electric Arc							SIZE OF HEAT 25 Tons					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.07	1.68	.013	.014	.55	17.7	12.7		.88				
DEOXIDATION	Silicon												
FORM-CAST OR WROUGHT	Wrought												
HEAT TREATMENT	W. Q. 2250°F.												
MICROSTRUCTURE	Equi-Axed, Austenitic with Cb Carbides												
GRAIN SIZE	2/4 Actual												
HARDNESS	148 BHN												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS + OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
80	28.9	32.0	81.7	54	73
1000	22.8				
1100	22.0	17.5	65.0	36	42
1200	21.4	19.5	48.0	13	16
1300	20.7	20.0	41.0	7	10

+ Determined by a Supersonic Method

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1100	37.0	32.0	27.0*	22.0*		15.0	
1200	30.0	25.0	21.0*	17.0*		6.7	22.0
1300	23.5	19.0	15.0*	12.0*		5.4	

(4)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.06	1.8	.017	.016	.35	18.5	10.9		.63				
DEOXIDATION													
FORM-CAST OR WROUGHT	Wrought												
HEAT TREATMENT	1950°F., W. Q.												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET* YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT		36.4	85.4	50.0	67.3
800	23.1	23.75	61.2	37.0	67.7
900	22.8	27.5	61.0	35.0	64.9
1000	22.4	26.7	59.5	34.5	63.8

* YS 0.02% Offset

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
800	64.0	62.0	60.0 *	58.0 *			
900	60.0	56.0	54.0	53.0 *			
1000	56.0	49.0	39.0 *	31.0 *			

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.

(2) EXTRAPOLATED VALUES INDICATED BY *

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).

(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.

(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
800	68.0	Broke on	Loading					
800	60.0	7518					Removed	
800	59.0	2213					Removed	
900	66.0	Broke on	Loading				25	
900	58.0	Broke on	Loading				25	
900	58.0	Broke on	Loading				21	
900	54.0	8527 R	Test Discontinued. Loaded to 7000 psi - Broke					
900	56.0	9935	Still Running					
1000	60.0	Broke on	Loading					
1000	58.0	Broke on	Loading					
1000	56.0	196 R					18.4	
1000	59.0	398 R					19.8	
1000	50.0	889 R					13.0	
1000	47.0	1451 R					10.5	
1000	42.0	4812 R					8.2	
800	25.5	1859	.080	.0000026	None			
800	26.0	1504	.087	.0000009	None			
800	25.5	4060	.078	.0000029	None			
900	26.0	1194	.092	.0000092	None			
900	25	2298	.096	.0000025	None			
1000	23.5	7010	.081	.0000025				
1000	26.0	378	.16	.0000142				

(5)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE				SIZE OF HEAT							
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.07	.53			.27	19	9.14		.76				
DEOXIDATION													
FORM-CAST OR WROUGHT	Wrought												
HEAT TREATMENT	1000°C., 2 Hrs., A. C.												
MICROSTRUCTURE													
GRAIN SIZE	6-8												
HARDNESS													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT			94	47.0	69

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1100	39.0	29.0	20.0 *	15.0 *			
1200	25.0	17.0	12.0 *	8.0 *			
1300	15.0	9.0	5.6 *	3.5 *			

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1100	40.0	106 R					14.6	
1100	32.5	376 R					8.3	
1100	30.0	658 R					5.2	
1100	27.5	1607 R					3.5	
1200	30.0	19 R					8.3	
1200	27.5	65 R					5.5	
1200	25.0	129 R					5.2	
1200	20.0	447 R					3.5	
1200	18.0	914 R					2.8	
1300	27.5	3 R					17.2	
1300	25.0	5 R					17.2	
1300	20.0	20 R					10.4	
1300	15.0	90 R					4.7	
1300	13.0	174 R					7.0	
1300	10.0	740 R					9.3	
1300	8.0	1871 R					2.3	

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

(6)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE				SIZE OF HEAT							
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.06	1.18	.017	.011		18.1	11.0		.80				
DEOXIDATION													
FORM-CAST OR WROUGHT	Wrought												
HEAT TREATMENT	1900°F. W. Q., 1650°F. A. C.												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT			77.4	52.0	49.8

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1000	47.0	46.0	44.0 *	42.0 *			
1100	45.0 *	39.0					
1200	31.0	24.5	19.5 *	16.0 *			

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1000	49.0	0 R						
1000	48.0	0 R						
1000	47.0	2183 R					19.0	
1000	46.0	1615 R					15.8	
1000	45.0	3192 R					13.8	
1100	44.0	149 R					16.0	
1100	40.0	683 R					10.0	
1100	38.0	715 R					9.0	
1100	35.0	1060 R					6.8	
1200	32.0	125 R					6.7	
1200	30.0	84 R					5.0	
1200	28.0	325 R					5.4	
1200	25.0	705 R					3.2	
1200	23.0	3040 R					2.8	
1200	21.0	6020 R					2.0	

(7)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 347		TYPE OF MELTING FURNACE Basic Electric				SIZE OF HEAT 55,725 lbs.							
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Cu	
	.064	1.70	.012	.015	.47	17.3	12.9	.10	.72			.10	
DEOXIDATION	20 lbs. Al poled in furnace: 15 lbs. Al added in ladle.												
FORM-CAST OR WROUGHT	Wrought (3/4" Diam. Bar)												
HEAT TREATMENT	1800°F. for 2 Hrs. then raised to 2000°F. for 1/2 Hr. W. Q.												
MICROSTRUCTURE	Completely Austenitic with duplex grain size												
GRAIN SIZE	Actual ASTM 2-6												
HARDNESS													

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1000		48.0	36.2 *	27.0 *			
1350	17.5	12.5	6.8 *	3.7 *			

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1000	63.5	1.0 R					29.3	
1000	62.5	150.0 R					23.8	
1000	60.0	208.0 R					22.5	
1000	55.0	344.0 R					21.3	
1000	50.0	598.0 R					15.0	
1000	45.0	2076.0 R					11.3	
1000	40.0	4505.0 R					12.6	
1350	20.0	68.0 R					32.3	
1350	17.5	108.0 R					37.0	
1350	15.0	524.0 R					34.0	
1350	12.5	983.0 R					43.5	
1350	10.0	2370.0 R					33.3	
1350	5.0	15150						

(8)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	347	TYPE OF MELTING FURNACE	Basic Electric	SIZE OF HEAT	50,825 lbs.

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Cu
	.058	1.68	.013	.016	.24	17.2	12.4	.13	.75			.07

DEOXIDATION	30 lbs. Al poled in Furnace
FORM-CAST OR WROUGHT	Wrought (3/4" Diam. Bar Stock)
HEAT TREATMENT	2000°F., 1/2 Hr., W. Q.; 1750°F., 1 Hr., A. C.
MICROSTRUCTURE	Typical Austenitic
GRAIN SIZE	Actual ASTM 6-7 (5)
HARDNESS	144 VHN (5Kg. Load)

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
Room		40.5	82.0	49.0	67.0
1050		40.1	55.5	36.5	65.4
1200		36.9	44.5	35.0	65.9
1350		29.75	32.75	32.0	53.6
1500		17.7	21.75	44.0	75.3
Note: (1)	Y.S. at Room Temp. obtained at 0.20% offset.				
(2)	Y.S. at Elevated Temp. determined by string extensometer.				

CREEP AND RUPTURE STRENGTHS

TEMP, °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1050	54.0	45.5	30.0 *	19.3 *			
1200		24.5	16.0 *	10.5 *			

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1050	52.0	263.3 R					22.5	
1050	45.0	1248.3 R					12.5	
1050	40.0	2168.0 R					9.0	
1050	35.0	4553.1 R					8.0	
1200	22.5	1596.9 R					6.5	
1200	19.0	3451.5 R					9.0	
1200	17.5	6200.2 R					12.0	

(9)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	347	TYPE OF MELTING FURNACE	Basic Electric	SIZE OF HEAT	50,825 lbs.

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Cu
	.058	1.68	.013	.016	.24	17.2	12.4	.13	.75			.07

DEOXIDATION	30 lbs. Al poled in furnace
FORM-CAST OR WROUGHT	Wrought (3/4" Diam. Bar Stock)
HEAT TREATMENT	2000°F., 1/2 Hr., W. Q.; 1600°F., 5 Hrs., F. C.
MICROSTRUCTURE	Typical Austenitic
GRAIN SIZE	Actual ASTM 6-7 (5)
HARDNESS	149 VHN (5Kg. Load)

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
Room		41.0	83.0	48.0	67.0
1050		37.5	53.6	35.0	65.2
1200		35.0	43.5	40.0	67.7
1350		27.75	31.5	22.0	41.9
1500		16.25	19.5	54.0	78.2
Note: (1)	Y.S. at Room Temp. obtained at 0.20% offset.				
(2)	Y.S. at Elevated Temp. determined by string extensometer.				

CREEP AND RUPTURE STRENGTHS

TEMP, °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1050	50.0	45.5	30.0 *	18.5 *			
1200		24.0	13.0 *	7.0 *			

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1050	52.0	3.8 R					29.5	
1050	45.0	1408.9 R					12.0	
1050	40.0	2539.7 R					7.5	
1050	35.0	4798.1 R					7.5	
1200	22.5	1318.0 R					7.5	
1200	19.0	2352.6 R					9.5	
1200	17.5	2966.6 R					5.5	
1200	13.5	8589.4 R					12.5	

(10)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	347	TYPE OF MELTING FURNACE	Electric	SIZE OF HEAT	

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N
	.06	1.43	.018	.006	.444	17.8	11.1	-	.77	-	.010	.027

DEOXIDATION	Straight Silicon
FORM-CAST OR WROUGHT	Forged Plate
HEAT TREATMENT	1/2 Hr. 1900°F. - W. Q.; 2 Hr. 1550°F.
MICROSTRUCTURE	
GRAIN SIZE	7-8 Actual
HARDNESS	

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
75	-	34.2	86.5	54.5 - 1"	71.5

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
900		52.5	-				
1050		40	37 *				
1200		26	22 *				

(11)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	347	TYPE OF MELTING FURNACE	Basic Electric	SIZE OF HEAT	51,600 lbs.

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al
	.08	1.47	.012	.010	.41	17.7	12.8	.06	.87	-	-

DEOXIDATION	20 lbs. Al poled in furnace:- 15 lbs. Al added to ladle
FORM-CAST OR WROUGHT	Wrought 7/8" Diam. Bars
HEAT TREATMENT	1975 F., W. Q.
MICROSTRUCTURE	Completely Austenitic
GRAIN SIZE	6-7
HARDNESS	161 BHN

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
Room		35.2	83.4	52	68.1

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1000						28.0	
1200						6.0	12.0

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1000	40	10,050		.0003000				
	30	13,530		.0001480				
	20	13,850		.0000340				
	12	13,810		.0000188				
1200	15	13,390		.0025300				
	12	11,700		.0012600				
	9	12,550		.0002130				
	6	12,410		.0001000				

(12)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 347	TYPE OF MELTING FURNACE	SIZE OF HEAT

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Fe	
	.07	1.43			.28	19.5	10.5		.72			Bal.	

DEOXIDATION	
FORM-CAST OR WROUGHT	
HEAT TREATMENT	1950 F
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	28	21.5					
1500	10						

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	36.0	31.9 R					5	
"	33.0	8.3 R					5	
"	33.0	27.7 R					8	
"	28.5	107.0 R					6	
"	25.5	205.7 R					4	
1500	15.0	20.6 R					27	
	12.25	51.0 R					10	
	10.15	101.8 R					19	
	7.5	178.9 R					8	

(13)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE	SIZE OF HEAT

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.073	1.26	.025	.018	.59	17.9	10.1		.90				

DEOXIDATION	
FORM-CAST OR WROUGHT	Wrought
HEAT TREATMENT	1850 W. Q.
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET .02% YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT		29.9	81.4	50.5	66.5
800		24.6	61.2	35.5	65.9
900		23.9	59.9	32.0	63.0
1000		25.1	58.6	36.0	56.0
1100		23.9	55.4	33.5	64.0

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1000					27.0	27.5	28.0

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1000	27.5	3657	.092	.0000018	None			
"	28.5	119	.094	.00031	"			
"	61.0	1 R					25.0	
"	59.0	0 R						
"	50.0	6874						
"	57.0	1224						

(14)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 347	TYPE OF MELTING FURNACE Elec. Arc	SIZE OF HEAT 25 Tons

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.08	1.72	.008	.011	.58	18.2	12.9	—	.88	—	—		

DEOXIDATION	Silicon
FORM-CAST OR WROUGHT	Wrought
HEAT TREATMENT	Cold Drawn Nor. 1700°F
MICROSTRUCTURE	Equi-Axed, Austanitic with Cb carbides
GRAIN SIZE	8 Actual
HARDNESS	163 BHN

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS+ OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
80	28.9	41.5	91.7	46	66
1000	22.8				
1100	22.0	27.5	55.5	36	64
1200	21.4	25.5	48.7	44	67
1300	20.7	24.0	41.5	52	74
1400	20.0				
1500	19.4				

+ Determined by a Supersonic Method

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1100	40.0	31.0	22.5	16.0		14.2	21.0
1200	26.0	16.0	9.8	6.2		1.7	5.3
1300	16.5	9.2	4.6	2.8		.6	2.0

(15)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE	SIZE OF HEAT

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.06	1.71			.40	20.0	12.7		.96				

DEOXIDATION	
FORM-CAST OR WROUGHT	Wrought
HEAT TREATMENT	Cold Rolled - 650 C 2 Hrs AC
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT			127.9	25	55.5

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	33.0	22.0	*10.3	*4.2			

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	44.0	21 R				-	11.0	
	36.0	60 R					12.0	
	22.0	935 R					20.3	
	16.0	3360 R					13.4	
	14.0	4507 R					13.0	

(16)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	347	TYPE OF MELTING FURNACE	Electric Arc	SIZE OF HEAT	35 Tons

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N
	0.07	1.18	0.01	.008	.34	17.9	10.6	--	.77	--	--	.02

DEOXIDATION	
FORM-CAST OR WROUGHT	Wrought
HEAT TREATMENT	Cold-Reduced 30 per cent
MICROSTRUCTURE	Cold Rolled Structure
GRAIN SIZE	
HARDNESS	

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	31.0	18.0	9.5*				

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	48.4	1.6 R	--	2.1	--		1.0	
1200	38.4	12.8 R	--	0.038	--		2.0	
1200	33.0	57.5 R	--	0.017	--		1.0	
1200	27.5	126.0 R	--	0.0085	--		1.0	
1200	23.5	388.5 R	--	0.0052	--		2.5	
1200	18.0	1016.0 R	--	0.0027	--		3.5	

(17)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	347	TYPE OF MELTING FURNACE		SIZE OF HEAT	Commercial

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al
	.09	1.69	.020	.010	.39	18.1	12.3		.80		

DEOXIDATION	
FORM-CAST OR WROUGHT	Seamless Tube
HEAT TREATMENT	Stabilized at 1550°F as a final operation
MICROSTRUCTURE	Austenitic containing columbium carbides. Evidence of cold working.
GRAIN SIZE	
HARDNESS	ASTM 4

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
Room	28.9	58.9	90.6	40.5	65.5
300	28.5	52.5	76.5	32.0	66.5
550	28.0	48.5	68.5	25.0	60.0
900	25.5	44.3	61.8	23.5	59.1
1000	23.7	43.6	59.6	24.5	59.5
1050	22.2	45.0	58.4	23.8	59.9
1100	20.3	43.4	56.6	26.7	57.7

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1000	57	56	54*				
1100	51	42	27*			14	27

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1000	60	11.0R					27.5	Rb 99
1000	58	11.2R					34.0	Rb 99
1000	55	560.6R					17.5	
1000	55	5075R	1.55	.0001	3000		16.0	Rb 97
1100	50	125R	2.01	.0133	80		19.5	Rb 96
1100	45	754R	.42	.00014	525		15.0	Rb 92
1100	40	331R	.36	.0009	120		9.0	Rb 94
1100	35	2578R	.07	.00009	1150		7.0	Rb 94
1100	22	2472	.006	.000030	1300			Rb 93
1100	15	2040	.009	.000009				Rb 93
1100	10	2040	.020	.000010				Rb 92
1100	7.5	2064	.013	.000006				Rb 92

(18)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE	SIZE OF HEAT

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al
	.07	.43	.030	.010	.39	18.6	9.90		.64		

DEOXIDATION	
FORM-CAST OR WROUGHT	3/4" Dia. Bars
HEAT TREATMENT	
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	Core-170, Skin-223BHN

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
80	28.8	55.0	94.4	46.5	71.8
1050	18.0				
"	17.0				
1300	18.0				

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1050						18.0	27.0

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1050	10.0	696	0	<.000003	> 696			
	20.0	2376	.016	.000012	>2376			
	30.0	3336 R	.043	.00010	1440		1.5	
1050	15.0	2664	.024	.000003	>2664			
	25.0	8400 R	.063	.00001	4992		0.4	
1300	10.0	552 R	.040	.0013	120		2.3	

(19)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	L.C. 347	TYPE OF MELTING FURNACE		SIZE OF HEAT	

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N_2	FC
	.020					16.6	11.0		.30			.13	71.8

DEOXIDATION	
FORM-CAST OR WROUGHT	Wrought
HEAT TREATMENT	
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	.38						
1500	6.6						

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	50.25	23.9 R					16	
"	45.00	42.1 R					13	
	42.00	64.0 R					10	
	37.5	114.4 R					3	
	34.75	108.2 R					9	
1500	25.5	0.4 R					4	
	22.5	0.7 R					7	
	16.5	2.0 R					4	
	14.25	3.8 R					8	
	10.925	11.1 R					10	
	8.25	26.4 R					2	
	5.25	334.1 R					15	

(20)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL L. C. 347	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N_2	
	.016					17.1	11.0		.33			.029	
DEOXIDATION													
FORM-CAST OR WROUGHT Wrought													
HEAT TREATMENT													
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS													

CREEP AND RUPTURE STRENGTHS

TEMP, °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.00001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	39.0						
1500	9.3						

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	60.	0.1 R					21	
"	50.25	12.5 R					16	
"	45.0	43.5 R					14	
"	42.0	14.3 R					4	
"	38.25	41.3 R					8	
"	33.0	1465.2 R					5	
1500	25.5	1.4 R					8	
"	22.5	3.8 R					3	
"	20.25	2.4 R					-	
"	17.25	9.1 R					5	
"	12.00	36.9 R					13	
"	9.00	123.0 R					33	

(21)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 347	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Cu	
	.074	1.62	.015	.018	.35	17.6	11.0		.77			.08	
DEOXIDATION													
FORM-CAST OR WROUGHT .051" Hot Rolled Sheet													
HEAT TREATMENT As received 2B Finish													
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS 83 Rb													

CREEP AND RUPTURE STRENGTHS

TEMP, °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.00001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	27.0	20.2*					
1400	7.8*						
1500	5.7	2.9*					

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	22,500	310	.07	.0033				
1200	25,000	210R	.41	.0094	150		3.5	
1200	28,000	88R	1.30	.0277	53		6.0	
1200	33,700	18R					6.0	
1200	39,200	5.8R		.96			15.0	
1500	4000	360R	.02	.025	25		35.	
1500	5000	149R	.02	.029	8		16.5	
1500	7000	55R	0	.060	1.5		11.0	
1500	10,000	11.5R	.01	.30	1.5		13.5	
1500	12,500	4.5R	0	1.27	.3		22.5	

(22)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 347	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.09	1.65	-	-	.25	18.0	11.1		.95				
DEOXIDATION													
FORM-CAST OR WROUGHT .050 sheet													
HEAT TREATMENT Mill Annealed													
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
Room		40.0	87.5	47	46
900		21.2	59.5	29	31
1300		20.0	43.2	46	44
1500		15.5	27.5	68	62

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.00001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1350	17.5						
1500	7.7	5.0*					

(23)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 18-8 Cb	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	0.06	1.55			0.33	17.7	10.1		0.82				
DEOXIDATION													
FORM-CAST OR WROUGHT Sheet													
HEAT TREATMENT Annealed													

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.00001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	31.5	25.0*					
1500	4.3						

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	40.0	8.0R					13.5	
1200	35.0	28.0R					12.0	
1200	32.0	102.0R					23.0	
1200	30.0	165.0R					9.0	
1200	28.0	193.0R					12.0	
1500	15.0	16.7R						
1500	12.0	4.0R					28.0	
1500	10.0	20.0R					28.0	
1500	7.0	68.0R					28.0	
1500	6.0	66.0R					36.0	
1500	5.0	76.0R					36.0	
1500	3.0	161.0R					29.0	

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

(24)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 347	TYPE OF MELTING FURNACE Arc							SIZE OF HEAT 45 tons					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.08	1.72	.019	.018	.40	17.1	11.5		.88				
DEOXIDATION													
FORM-CAST OR WROUGHT	Wrought - .07" Sheet												
HEAT TREATMENT	2050 F - Air Cool												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS													

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1500 F	5.2	3.4*					

ORIGINAL CREEP AND RUPTURE DATA

Type 347 - Heat 210447

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1500	15	3R					56	
1500	12	7R					29	
1500	9	26R					30	
1500	5	249R					28	

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ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 347	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
		1.8						.02	.57				
DEOXIDATION													
FORM-CAST OR WROUGHT	0.045 in. sheet												
HEAT TREATMENT	1900 F Anneal												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70		35.0	93.0	52.0	

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	30.0						
1500	7.5						
1700	-						

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	34.5	7.0 R					24.0	
1200	30.0	89.0 R						
1500	11.8	4.3 R					25.0	
1500	8.4	54.0 R						
1700	6.9	4.7 R					22.0	
1700	5.2	17.0 R						
1900	3.5	4.6 R					32.0	
1900	2.8	16.0 R						

(26)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 347	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Fe	
	.1	2.0	0.3	.03		18.	10.		.8			Bal.	
DEOXIDATION													
FORM-CAST OR WROUGHT	0.035 in. sheet												
HEAT TREATMENT	Annealed												
MICROSTRUCTURE													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70		36.2	90.0	55.5	
1600		15.3	18.6	43.0	

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1600	4.5						

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1600	5.5	2.0				0.17		
1600	5.5	6.0				0.68		
1600	5.5	25.0				4.0		
1600	5.5	49.0 R					14.0	
1600	3.7	3.5				0.12		
1600	3.7	17.0				0.7		
1600	3.7	80.0				4.1		
1600	3.7	190.0 R					18.0	
1600	2.0	14.0				0.1		
1600	2.0	40.0				0.3		
1600	2.0	90.0				0.79		
1600	2.0	200.0				2.1		

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ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 347	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.09	1.55	.020	.015	.49	19.0	10.7		.87				
DEOXIDATION													
FORM-CAST OR WROUGHT	Weld Metal												
HEAT TREATMENT	Stabilized at 1550°F, final operation												
MICROSTRUCTURE	Austenitic, large grained with ferrite in coarse dendritic pattern.												
GRAIN SIZE													
HARDNESS	95 Rb												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
Room		58.1	88.0	19.2	27.5
900		43.9	59.9	18.0	41.3
1000		42.2	59.6	22.2	55.8
1050		40.7	55.0	11.0	25.8
1100		41.8	57.2	20.2	42.0

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1000	62.0	57.0	* 45.0				
1100	52.0	39.0	* 30.0			18.0	29.0

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1000	64.0	15.0 R					14.0	
1000	60.0	664.7 R	1.1	.0012	525.0		12.0	
1000	55.0	1531.0 R	1.9	.0004	1530.		5.0	
1100	50.0	146.1 R	.73	.0056	130.0		6.5	
1100	45.0	358.5 R	.73	.0015	280.0		3.0	
1100	40.0	954.0 R	.62	.0003	900.0		2.0	
1100	25.0	2442.0	.047	.000043	2442. +			
1100	20.0	2164.0	.084	.000016	1650.			

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *
(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

(28)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 347	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.049	1.57	.026	.009	.57	18.5	10.9		.79				
DEOXIDATION	Aluminum												
FORM-CAST OR WROUGHT	Wrought Bar Stock												
HEAT TREATMENT	1950°F - ½ hr WQ												
MICROSTRUCTURE	Austenite and large Cb carbides and small intergranular carbides												
GRAIN SIZE													
HARDNESS	ASTM G. S. 7												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
R. T.		37.0	86.0	50	70
1000		28.0	56.0	34	65
1100		28.0	55.0	36	62
1200		27.0	52.0	40	60
1300		25.0	45.0	44	61
1400		22.0	37.0	53	66
1500		16.0	25.0	66	80

(29)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 347	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
DEOXIDATION													
FORM-CAST OR WROUGHT	Wrought												
HEAT TREATMENT	½ Hr at 1950 F												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET* YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION* IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT		26.5	86.0	55.	74.0
500			70.0	46.	68.0
750			71.0	47.	65.0
1000			69.0	49.	--
1200			59.0	51.	68.0
1400			40.0	45.	50.0
1500			33.0	53.	62.0

* YS 0.02% Offset, Elongation in 1.5 in.

(30)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE							SIZE OF HEAT Commercial					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.06	1.39	.023	.011	.44	17.6	9.90		.59				
DEOXIDATION													
FORM-CAST OR WROUGHT	0.023" sheet												
HEAT TREATMENT	Half Hard (rolled)												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
75		140	153	8	
300		121	132	3	
500		106	124	2	
800		92	117	3	

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F.	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
800	80	1800	.063	.000015				

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

(31)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 18-8 Cb	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.05	1.28	.011	.020	.41	17.8	11.0	-	.70	-	-		
DEOXIDATION													
FORM-CAST OR WROUGHT													
HEAT TREATMENT													
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION* IN 2", PER CENT	REDUCTION IN AREA, PER CENT
1900			17.8	26.7	80.8
2000			12.2	22.7	89.4
2100			8.0	40.7	98.2
2200			5.2	46.3	99.9
2300			4.4	49.0	92.7

* Elongation in 6 in.

(32)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 347	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.04	1.47	.015	.013	.52	18	10.7	.04	.75				
DEOXIDATION													
FORM-CAST OR WROUGHT	Wrought												
HEAT TREATMENT													
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION* IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT			92.8	45.2	
1300 F			46.88	25.2	
1400 F			36.54	29.0	
1500 F			30.10	29.5	
1600 F			22.69	32.5	

* Elongation in 4 in.

(33)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 18-8 Cb	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.04	1.32	.008	.014	.49	17.7	11.5	-	.80				
DEOXIDATION													
FORM-CAST OR WROUGHT													
HEAT TREATMENT													
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION* IN 2", PER CENT	REDUCTION IN AREA, PER CENT
1900			12.6	26.8	82.9
2000			10.0	31.7	90.6
2100			8.6	33.7	93.4
2200			5.4	37.0	99.1
2250			5.0	61.7	99.8
2300			4.4	57.3	97.0

* Elongation in 6 in.

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

(34)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 18-8 Cb	TYPE OF MELTING FURNACE Electric Arc							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.04	1.32	.008	.014	.49	17.7	11.5		.80				
DEOXIDATION													
FORM-CAST OR WROUGHT													
HEAT TREATMENT													
MICROSTRUCTURE													
GRAIN SIZE													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION* IN 2", PER CENT	REDUCTION IN AREA, PER CENT
1900			12.5	27.0	82.5
2000			10.0	32.0	91.5
2100			9.0	34.0	93.0
2200			5.5	37.0	99.0
2300			4.5	61.0	99.5
2400			4.0	34.0	34.0

* Elongation in 6 in.

(35)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 347	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Fe	
	.1	2.0	.03	.03		18.	10.		.8			Bal	
DEOXIDATION													
FORM-CAST OR WROUGHT 0.040 in. sheet													
HEAT TREATMENT 1900 F Anneal													
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70		34.3	85.6	54.0	
1200		19.0	47.0	36.0	

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	20.0	1.6				.56		
1200	20.0	17.0				.76		
1200	20.0	160.0				1.05		
1200	20.0	480.0				1.30		
1200	18.5	1.0				.15		
1200	18.5	9.5				.32		
1200	18.5	85.0				.52		
1200	18.5	420.0				.65		
1200	17.0	2.1				.10		
1200	17.0	7.4				.17		
1200	17.0	25.0				.26		
1200	17.0	150.0				.35		
1350	14.0	2.6				.15		
1350	14.0	18.0				.36		
1350	14.0	62.0				1.4		
1350	14.0	160				7.6		
1350	12.0	16.0				.14		
1350	12.0	70.0				.51		
1350	12.0	190.0				2.2		
1350	12.0	320.0				5.6		
1350	10.0	36.0				.16		
1350	10.0	77.0				.26		
1350	10.0	190.0				.60		
1350	10.0	330.0				1.1		
1500	10.0	.2				.2		
1500	10.0	2.1				1.4		
1500	10.0	8.6				4.5		
1500	10.0	25.0R					22.0	
1500	7.5	8.5				.16		

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1500	7.5	24.0				.37		
1500	7.5	85.0				2.0		
1500	7.5	155.0				7.0		
1500	5.0	16.0				.13		
1500	5.0	43.0				.25		
1500	5.0	160.0				.66		
1500	5.0	350.0				1.7		

(36)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 347	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
DEOXIDATION													
FORM-CAST OR WROUGHT 0.045 in. sheet													
HEAT TREATMENT 1900 F anneal													
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70					
1200		20.5	47.5	40.0	

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	15.0	110				.22		
1200	15.0	225				.33		
1200	15.0	385				.37		
1200	15.0	480				.40		
1200	15.0	590				.44		

(37)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 347	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
DEOXIDATION													
FORM-CAST OR WROUGHT 0.092 in. sheet													
HEAT TREATMENT Annealed													
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
75		36.05	91.35	45	
900		26.15	61.35	29	

(38)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 347	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Fe	
	.07					19.	9.		.8			Bal	
DEOXIDATION													
FORM-CAST OR WROUGHT 0.045 in. sheet													
HEAT TREATMENT 1950 F Anneal													
MICROSTRUCTURE													

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
75		36.0	92.5	52.0	
500		26.0	65.5	31.0	
900		22.0	61.0	30.0	
1200		21.0	52.0	38.0	
1600		11.0	18.0	40.0	

(39)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE Electric Arc						SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.04	.84	.014	.010	.94	19.8	10.8		.75				
DEOXIDATION													
FORM-CAST OR WROUGHT	Cast 3 H Type Blocks												
HEAT TREATMENT	Air Quench 1950 F												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
80	20.4	38.0, 43.5	73.5, 75.6	36.0, 45.0	50.0, 53.0
300	20.5	31.75	61.5	36.0	51.0
550	21.2	25.0	57.5	33.0	49.0
800	19.1	22.0	54.5	32.0	45.0
1000	20.5	20.5	52.5	32.0	46.0
1200	19.0	>20.0	>20.0		
1200	17.9	21.0	44.5	30.0	46.0
1400		19.5	36.5		

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1100	20.0	8160	.500	.000051	>8160			
1100	25.0	2544 R	1.42	.00042	2208		5.0	
1200	20.0	3432 R	.800	.00044	1488		7.5	

(40)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 18-8 Cb		TYPE OF MELTING FURNACE Electric Arc						SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.10	.66	.042	.012	.53	19.6	9.27		1.03				
DEOXIDATION													
FORM-CAST OR WROUGHT	Cast Keel Blocks Navy Pattern												
HEAT TREATMENT	Water Quench 1900 F												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS	75 to 80 Rb												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
80	20.0	34.75	78.2	35.0	34.3
1200	12.8				
1250	18.0				
1300	15.3				
1350	8.0				
1350	17.7				

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	15.0	2520	.088	.000003				
1250	15.0	1872	.012	.000029				
1300	15.0	672 R	.192	.00079	360		4.5	Rb 80
1300	10.0	3648	.042	.000001				
1350	10.0	650 R	.075	.00045	-		15.0	
1350	7.5	6648 R	.100	.000001	1728		7.0	

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

(41)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE Induction						SIZE OF HEAT 17 lb.					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Ta	
	.057	1.5			0.4	18.5	10.7		0.60			0.25	
DEOXIDATION	Silicon												
FORM-CAST OR WROUGHT	Wrought												
HEAT TREATMENT	10 Min. 1900°F. A.C.												
MICROSTRUCTURE	Austenite plus CbC												
GRAIN SIZE	7-8												
HARDNESS													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
0.06" Sheet					
R.T.		37.1	90.3	51.0	
1200			51.2	25.0	

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
0.25" Dia. Bar							
1100	45.0	36.0					
1200	30.0	23.0					
1350	18.0	12.5					
0.06" Sheet							
1200	27.0	21.0					

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
0.25" Dia. Bar								
1100	40.0	475 R					9.0	
1100	45.0	149 R					8.5	
1200	25.0	437 R					6.0	
1200	30.0	95 R					12.0	
1200	35.0	41 R					39.0	
1200	40.0	7 R					20.8	
1350	15.0	194 R					23.0	
1350	20.0	38 R					23.0	
1350	25.0	5 R					19.9	
0.06" Sheet								
1200	25.0	131 R					4.5	
1200	30.0	70 R					17.0	
1200	35.0	21 R					8.0	

(42)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE Induction						SIZE OF HEAT 17 lb.					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Ta	
	.057	1.5			0.40	18.5	10.7		1.00			0.40	
DEOXIDATION	Silicon												
FORM-CAST OR WROUGHT	Wrought												
HEAT TREATMENT	10 Min. 1900°F., A.C.												
MICROSTRUCTURE	Austenite plus CbC												
GRAIN SIZE													
HARDNESS	7-8												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
0.06" Sheet					
R.T.		38.5	89.4	46.0	
1200			48.7	28.0	

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
0.25" Dia. Bar							
1100	42.5	35.0					
1200	32.0	24.0					
1350	18.5	14.5					
0.06" Sheet							
1200	31.0	21.5					

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
0.25" Dia. Bar								
1100	40.0	268 R					13.0	
1100	45.0	67 R					12.5	
1100	50.0	17 R					19.0	
1200	25.0	640 R					21.0	
1200	30.0	257 R					26.0	
1200	35.0	66 R					14.0	
1200	40.0	21 R					28.0	
1350	15.0	647 R					27.0	
1350	20.0	49 R					21.0	
1350	25.0	7 R					28.0	
0.06" Sheet								
1200	25.0	308 R					11.0	
1200	30.0	93 R					18.0	
1200	30.0	94 R					21.0	
1200	35.0	28 R					33.0	

(43)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 347 + Ta		TYPE OF MELTING FURNACE Induction						SIZE OF HEAT 2500 lb.						
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Ta		
	.06	.80	.011	.019	.73	18.5	10.8		.86			.29		
DEOXIDATION														
FORM-CAST OR WROUGHT Wrought - 5/8" Sq.														
HEAT TREATMENT 1950°F. - O.Q.														
MICROSTRUCTURE														
GRAIN SIZE														
HARDNESS														

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
R.T.		35	90	58	69
1100		21	60	37	64
1200		20	53	42	63
1300		20	44.2	47	60

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1100	51	42*					
1200	37	29*					
1300	28	24*					

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1100	55	39 R					21	
1100	50	138 R					23	
1100	45	544 R					19	
1200	42	37 R					--	
1200	38	78 R					35	
1200	35	105 R					16	
1200	30	904 R					20	
1300	34	4 R					22	
1300	30	51 R					30	
1300	27	227 R					13	

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

(44)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 18 - 8 Cb - Ta		TYPE OF MELTING FURNACE						SIZE OF HEAT						
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb-Ta	Ti	Al			
	.075	1.69	.02	.015	.61	17.8	10.6		.66					
DEOXIDATION														
FORM-CAST OR WROUGHT Sheet														
HEAT TREATMENT Annealed 1950°F.														
MICROSTRUCTURE														
GRAIN SIZE														
HARDNESS														

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	30.5	24.0					

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	36.0	25.7 R					13.5	
1200	29.0	143.2 R					13.0	
1200	27.0	341.8 R					15.0	

(45)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 347 + Ta		TYPE OF MELTING FURNACE Arc						SIZE OF HEAT 45 Tons						
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Ta		
	.049	1.57	.022	.019	.48	18.7	10.6		.57			.16		
DEOXIDATION														
FORM-CAST OR WROUGHT Wrought - .125" Plate														
HEAT TREATMENT Annealed														
MICROSTRUCTURE														
GRAIN SIZE														
HARDNESS														

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	31						
1300	20						

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1100	50	78 R					20	
1200	35	46 R					18	
1200	30	137 R					14	
1300	27	13 R					45	
1300	24	37 R					17	
1300	20	98 R					23	
1500	8	46 R					56	

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

18Cr-8Ni + Mo

(1)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 316	TYPE OF MELTING FURNACE Elec. Arc.	SIZE OF HEAT 30 Tons

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al
	.08	1.40	.012	.011	.45	16.4	13.4	2.81	-	-	-

DEOXIDATION Silicon
FORM-CAST OR WROUGHT Wrought
HEAT TREATMENT W. Q. 2000°F.
MICROSTRUCTURE Equi-Axed, Austenitic, Carbide Free
GRAIN SIZE 5/7 Actual
HARDNESS 152 BHN

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS x OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
80	28.5	36.7	103.9	59	77
1000	23.4	20.2	73.5	46	65
1100	22.8	19.6	69.1	48	65
1200	22.4	20.5	60.5	40	51
1300	22.0	18.7	50.2	43	50
1400	21.6	17.9	39.0	49	58
1500	21.3	17.5	31.5	54	63
1600			24.6	59	65
1800			14.0	41	49
2000			7.1	85	58

x Determined by A supersonic Method.

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1000						14.7	24.5
1100						12.0	21.0
1200	31.0	25.0	20.0	16.0		6.8	14.5
1300	24.2	18.0	12.7	8.9		4.3	9.2
1400	16.0	11.0	6.8	4.2		2.8	6.3
1500	11.0	7.0	3.4	1.6		1.8	4.2
1600	7.4	4.3					
1800	2.7	1.2					

(2)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 316	TYPE OF MELTING FURNACE Electric	SIZE OF HEAT

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al
	.08	1.63	.017	.014	.37	17.8	12.5	2.55	-	-	.004

DEOXIDATION
FORM-CAST OR WROUGHT Wrought
HEAT TREATMENT 2000°F, 0.5 Hr., Quench
MICROSTRUCTURE Typical Annealed
GRAIN SIZE ASTM 4-6
HARDNESS 145 DPH

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
75	-	40.0	85.0	65.0	78.0
1100	-	22.0	63.0	43.0	58.0
1300	-	19.0	46.0	38.0	50.0
1500	-	17.0	28.0	38.0	43.0

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1100	42.5	33.0*	24.9*	18.5*	-	21.0*	26.0
1300	24.0	17.0*	12.4*	9.0*	-	7.1*	9.7
1500	10.2	7.1*	4.9*	3.3*	-	2.3	3.2

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *
(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1100	25.0	3000	0.244	0.000102	> 3000	-	-	
1100	65.0	1.1R	39.3	1.88	0.4		47.0	
1100	60.0	4.8R	35.1	0.744	1.2		42.0	
1100	58.0	8.5R	23.1	0.328	3.0		25.0	
1100	56.0	11.6R	22.0	0.288	7.0		25.0	
1100	54.0	14.7R	20.9	0.216	6.6		26.0	
1100	48.0	38.1R	11.7	0.6	30.0		17.0	
1100	40.0	162.7R	8.3	0.0116	150		12.0	
1100	36.0	593.2R	6.4	0.00256	500		12.0	
1300	11.0	3000	0.22	0.000218	> 3000	-	-	
1300	8.0	3000	0.194	0.0000426	> 3000	-	-	
1300	40.0	0.63R	10.0	39.7	0.2		54.0	
1300	37.0	3.8R	9.1	4.57	2.1		56.0	
1300	32.0	12.2R	6.3	1.13	5.2		46.0	
1300	24.0	92.7R	2.2	0.154	43.5		68.0	
1300	20.0	327.2R		0.0446	139.0		82.0	
1500	4.0	3000	.084	0.000236	> 3000	-	-	
1500	1.5	3000	.018	0.0000096	> 3000	-	-	
1500	25.0	0.25R	8.6	100.0	0.1		81.0	
1500	24.0	0.4R	1.8	89.0	0.2		82.0	
1500	20.0	1.8R	.38	14.4	0.8		86.0	
1500	12.0	43.2R	.26	0.581	11.8		91.0	
1500	9.0	251.2R		0.0892	145		73.0	
1500	7.5	742.2R		0.0213	375		25.0	

(3)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 316	TYPE OF MELTING FURNACE Basic Electric	SIZE OF HEAT 14,000 lbs.

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al
	.074	.36	.010	.013	.35	16.7	13.8	2.66			

DEOXIDATION
FORM-CAST OR WROUGHT Wrought (1" Diam. Bar)
HEAT TREATMENT 1725 F., 1 hr., A. C.
MICROSTRUCTURE Typical Austenitic
GRAIN SIZE
HARDNESS 156 BHN

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
Room		45.0	89.5	49.5	67.7
1000		40.25	70.75	39.5	58.3
1200		38.25	54.4	43.0	64.2
1300		37.2	41.9	53.0	63.0
1400		27.0	36.15	48.5	59.4
1500		23.5	25.45	47.5	46.0

Note: Y. S. taken where stress/deformation ceased to be a straight line.

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1000						14.8	22.8
1100						8.7	13.8
1200						5.0	8.2
1350						2.5	4.2
1500						.9	1.8

ORIGINAL CREEP AND RUPTURE DATA

B&W Serial No. 233

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1000	40.0	1050		.00450	450			
1000	25.0	4150	0.8	.00018				
1000	15.0	1050	0.077	.000011				
1200	19.0	1550	2.7	.00940	1100			
1200	10.0	1550	0.22	.000296				
1200	8.5	1850	0.167	.000115				
1200	7.0	3350	0.12	.000029				
1200	6.0	1500	0.06	.000028				
1200	4.5	1350	0.043	.000013				
1350	9.5	1000	0.3	.0107	500			
1350	6.0	2700	0.2	.00044				
1350	4.5	1500	0.115	.00009				
1350	3.0	1500	0.04	.00003				

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1500	3.0	1600		.00350				
1500	2.0	1300	0.52	.00013				
1500	1.0	2500	0.43	.000013				

(4)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE						SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N_2	
	.11	1.77			.38	15.9	13.3	3.01				.18	
DEOXIDATION													
FORM-CAST OR WROUGHT	Wrought												
HEAT TREATMENT	1100 C 1 Hr. W. Q. - 750 C 2 Hrs. A. C.												
MICROSTRUCTURE													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT			104.2	49.0	68.6

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1100	50.0	39.0	*31.0	*25.0			
1200	37.0	27.0	*17.0	*10.0	5.2 (a)	6.7 (a)	10.8 (a)

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1100	50.0	126R					13.0	
1100	45.0	218R					10.5	
1100	40.0	781R					9.5	
1100	32.0	8437R					6.0	
1200	42.0	35R					18.3	
1200	32.0	318R					22.5	
1200	25.0	1597R					38.3	
1200	20.0	2056R					28.8	
1200	20.0	4236R					16.8	

(5)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE						SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.065	1.5			.59	18.7	13.3	3.35					
DEOXIDATION													
FORM-CAST OR WROUGHT	Wrought												
HEAT TREATMENT	1000 C 2hr A. C.												

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	28.0	23.0	*16.0	*11.0			
1300	20.0	14.0	* 5.6	* 3.5			

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	30.0	50R					8.8	
1200	25.0	327R					8.3	
1200	22.5	1244R					7.3	
1200	20.0	2605R					5.8	
1300	25.0	18R					10.4	
1300	20.0	167R					19.2	
1300	18.0	258R					8.3	
1300	16.0	570R					8.4	
1300	13.0	1141R					3.1	
1300	10.0	2638R					3.2	

(6)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE						SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.08	1.0			.5	18	13	2.5					
DEOXIDATION													
FORM-CAST OR WROUGHT	Wrought												
HEAT TREATMENT	2100 F. 1 hr. A. C. - 1400 F. 2 hrs. A. C.												
MICROSTRUCTURE													
GRAIN SIZE	2-3												
HARDNESS	72 Rb												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT			77.9	62.5	71.6

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1100	*41.0	38.0	35.0	32.0			
1200	26.0	22.5	19.0	16.7			
1200					7.0 (a)	8.5 (a)	10.4 (a)

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1100	40.0	274R					13.0	
1100	38.0	395R					13.0	
1100	34.0	15793R					4.0	
1200	27.0	67R					13.0	
1200	24.0	308R					12.0	
1200	22.0	1723R					6.8	
1200	20.0	5540R					4.0	
1200	10,000	3157	.109	.0000108	-	0.145		
1200	7,143	3157	.009	.000006	-	0.024		
1500	5000	147	0	.015	-	2.18		

(7)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 316		TYPE OF MELTING FURNACE Heroult Arc						SIZE OF HEAT 16 Ton					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Cu	
	.056	1.85	.026	.013	.30	17.4	13.5	2.12				.11	
DEOXIDATION	Silicon												
FORM-CAST OR WROUGHT	Wrought Bar Stock												
HEAT TREATMENT	2000°F. 1 hr WQ												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS													

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1500	8.0	5.8	3.0*	--			
1200	27.5	22.0	18.0*	14.5*			

(a) Flow Rate Data - Step-Down Test on Single Specimen at .002 in/in Total Strain.

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.

(2) EXTRAPOLATED VALUES INDICATED BY *

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).

(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.

(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1500	11.0	27.5R					33.0	
1500	11.0	30.0R					36.6	
1500	11.0	26.0R					34.0	
1500	9.0	53.5R					36.6	
1500	9.0	52.5R					38.0	
1500	9.0	58.7R					32.5	
1500	9.0	60.4R					31.2	
1500	7.0	142.6R					32.6	
1500	7.0	210.8R					28.6	
1500	7.0	202.0R					24.5	
1500	5.5	1118.5R					38.5	
1500	5.5	1127.7R					45.0	
1500	5.5	1142.0R					24.0	
1500	4.8	1798.0R					30.3	
1500	4.8	1801.3R					31.8	
1500	4.8	1775.9R					37.5	
1200	28.0	74.0R					12.0	
1200	28.0	80.5R					14.0	
1200	28.0	85.2R					12.7	
1200	26.0	142.0R					12.0	
1200	26.0	156.0R					12.0	
1200	26.0	150.0R					10.9	
1200	24.0	405.5R					14.0	
1200	23.8	494.0R					10.0	
1200	22.0	1374.6R					14.0	

(8)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE	SIZE OF HEAT

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N_2
	.11	1.77			.38	15.9	13.3	3.01				.18

DEOXIDATION

FORM-CAST OR WROUGHT Wrought

HEAT TREATMENT 1200 C. 1 hr W.Q. 815 C. 5 hr A.C.

GRAIN SIZE

HARDNESS

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT			100.9	50.5	57.0

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	40.0	27.0	*16.0	*9.8	4.15(a)	6.8(a)	11.0(a)

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	34.0	293R					17.8	
1200	30.0	556R					14.5	
1200	25.0	1759R					14.8	
1200	20.0	4254R					18.3	

(9)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 316	TYPE OF MELTING FURNACE Basic Electric	SIZE OF HEAT 45,298 lbs.

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al
	.07	1.73	.019	.014	.43	16.8	13.4	2.38			

DEOXIDATION 18 lbs. Al poled in Furnace.

FORM-CAST OR WROUGHT Wrought (3/4" Diam. Bar Stock)

HEAT TREATMENT 2000 F, 1/2 hr, W.Q. 1750, 1 hr, A.C.

MICROSTRUCTURE Typical Austenitic

GRAIN SIZE Actual A.S.T.M. 4-5

HARDNESS 145 V.H.N. (5 Kg. Load)

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.

(2) EXTRAPOLATED VALUES INDICATED BY *

(a) Flow Rate Data - Step Down Tests on Single Specimen at .002 in/in Total Strain.

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).

(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.

(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
Room		42.3	82.5	55.0	72.0
1050		31.3	65.8	44.5	62.0
1200		35.75	53.75	42.0	55.0
1350		23.5	31.2	38.5	63.3
1500		17.9	21.5	60.5	72.1

Note: (1) Y. S. at Room Temp. obtained at 0.20% offset.
(2) Y. S. at Elevated Temp. determined by string extensometer.

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1350	16.0	11.6	7.4*	4.6*			

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1350	16.5	89.2R					83.0	
1350	15.0	218.1R					77.0	
1350	11.5	1080.4R					44.0	
1350	9.5	2865.2R					30.0	

(10)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 316	TYPE OF MELTING FURNACE Basic Electric	SIZE OF HEAT 45,850 lbs.

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al
	.07	1.73	.019	.014	.43	16.8	13.4	2.38			

DEOXIDATION 18 lbs. Al poled in Furnace.

FORM-CAST OR WROUGHT Wrought (3/4" Diam. Bar Stock)

HEAT TREATMENT 2000 F, 1/2 hr, W.Q. 1600, 5 hr, F.C.

MICROSTRUCTURE

GRAIN SIZE Actual A.S.T.M. 3-5

HARDNESS 156 VHN (5 Kg. load)

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
Room		40.5	82.85	51.0	65.0
1050		33.0	63.0	41.5	57.3
1200		32.0	49.4	34.0	58.6
1350		22.5	31.5	42.0	59.8
1500		18.5	20.5	55.5	68.6

Note: (1) Y. S. at Room Temp. obtained at 0.20% offset.
(2) Y. S. at Elevated Temp. determined by string extensometer.

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1350	16.5	12.3	6.95*	3.7*			

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1350	20.0	37.0R					76.0	
1350	16.5	93.4R					70.0	
1350	15.0	283.8R					70.0	
1350	11.5	1560.5R					64.0	
1350	9.5	3137.0R					44.5	

(11)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 316	TYPE OF MELTING FURNACE Heroult Arc	SIZE OF HEAT 12 Tons

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al
	.027	1.70	.028	.012	.54	17.4	12.2	2.26			

DEOXIDATION Silicon

FORM-CAST OR WROUGHT Wrought Bar Stock

HEAT TREATMENT 1950°F. 1/2 hr WQ

MICROSTRUCTURE

GRAIN SIZE

HARDNESS

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1000						20.0	27.0
1200						6.8	14.5

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1000	20.0	3030.7	.563	.000009				
1000	25.0	3621.9	2.314	.000045				
1200	8.0	3049.8	.065	.000012				
1200	11.0	3648.4	.215	.000020				

(12)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 316	TYPE OF MELTING FURNACE	SIZE OF HEAT

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.20	1.76	.037	.018		18.2	12.4	2.06					

DEOXIDATION	
FORM-CAST OR WROUGHT	Wrought
HEAT TREATMENT	1 Hr. at 1900°F W. Q.
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200		32.8	17.0*				
1500	9.4	4.3					

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	19.875	5656.6 R					13	
"	29.8	1583.7 R					6	
"	39.0	528.1 R					4	
1500	9.0	113.5 R					16	
"	6.75	292.1 R					19	
"	4.00	1272.8 R					32	
"	5.25	548.7 R					25	

(13)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 316	TYPE OF MELTING FURNACE Electric	SIZE OF HEAT

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N	
	.07	1.32	.013	.011	.315	18.2	10.5	2.16	-	-	.009	.030	

DEOXIDATION	Straight Silicon
FORM-CAST OR WROUGHT	Forged
HEAT TREATMENT	1950 W. Q.
MICROSTRUCTURE	
GRAIN SIZE	2-4 Actual
HARDNESS	

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
75	-	38.0	88.3	67 - 1"	78

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1050		40.2	32*				
1200		23	16.3*				

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1050	63	10.2 R		-			43	
"	60	14.5 R		.64			35	
"	50	114.2 R		.026			30	
"	45	273.2 R		.01			14	
"	39.6	1140.2 R		.00187			10	
1200	45	2.6 R		6.28			35	
"	38	11.63R		1.26			38	
"	35	46.9 R		.4			43	
"	30	168.2 R		.0613			40	
"	24.5	606.5 R		.015			25	

(14)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 316	TYPE OF MELTING FURNACE Heroult Arc	SIZE OF HEAT 17 Ton

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Cu	W
	.028	1.28	.027	.022	.49	17.3	13.7	2.20				.15	Less .05

DEOXIDATION	Silicon
FORM-CAST OR WROUGHT	Wrought Bar Stock
HEAT TREATMENT	Annealed
MICROSTRUCTURE	Austenite
GRAIN SIZE	
HARDNESS	

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT	--	28.7	77.0	47.5	66.5
400	--	18.2	63.5	51.7	62.0
600	--	16.7	59.0	47.5	59.5
800	--	14.6	59.3	47.0	56.5
900	--	13.4	57.35	46.0	57.7
1000	--	13.2	56.15	51.0	55.6
1200	--	12.3	46.6	49.1	61.6

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	26.0	22.0	18.0*	15.0*			

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	29.0	26.7 R					45.0	
1200	27.0	78.6 R					46.5	
1200	24.0	225.0 R					24.0	
1200	21.0	1606.5 R					26.0	

(15)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 316 (low N_2)	TYPE OF MELTING FURNACE	SIZE OF HEAT

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N_2	
	.026	.				17.3	13.1	2.33				.031	

DEOXIDATION	
FORM-CAST OR WROUGHT	Wrought
HEAT TREATMENT	Anneal 1975 - 2000 F
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT			74.0	42.0	
500			56.6	25.0	
1000			52.8	25.0	
1200			44.0	40.0	
1500			21.0	30.0	
1800			7.2	57.5	

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	32.3						
1500	5.8						

(16)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 316	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.05	1.73			.43	17.3	12.3	3.04					
DEOXIDATION													
FORM-CAST OR WROUGHT Wrought													
HEAT TREATMENT 1950°F													

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1500	10.0	7.0*					

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1500	20.25	8.1 R					28	
	15.00	8.4 R					30	
	12.00	37.2 R					30	
	9.00	224.6 R					34	
	6.75	532.5 R					36	
	10.50	-						

(17)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 316	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Fe	
	.07					18.	13.	2.5				Bal.	
DEOXIDATION													
FORM-CAST OR WROUGHT Wrought													
HEAT TREATMENT 20 hrs. at 1950 F, A. C.													
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS													

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	34						

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	37.2	31.2R					8	
1200	35.2	120.0R					8	
1200	32.3	53.0R					8	
1200	30.4	389.1R					4	
1200	27.2	1030.0R					4	
1200	25.8	194.3R						

(18)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.08	1.0			.5	18	13	2.5					
DEOXIDATION													
FORM-CAST OR WROUGHT Wrought													
HEAT TREATMENT 2100 F 1 hr. A.C., 15% H.C.W. at 1200 F, 1200 F F.C.													
MICROSTRUCTURE Cold Worked Structure													
GRAIN SIZE													
HARDNESS 103 Rb													

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *
(a) Flow Rate Data - Step-down test on single specimen at .002 in/in total strain.

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT			121.9	26.5	51.6

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1100	56.0	47.0	*25.5	*13.0			
1200	36.0	19.0	*8.4	*3.8			
1200					*4.5(a)	8.9(a)	17.0(a)

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1100	62.0	22R					.8	
"	50.0	398R					0	
"	40.0	2019R					.5	
"	35.0	3256R					.7	
1200	45.0	35R					1.3	
"	35.0	55R					.5	
"	28.0	318R					1.3	
"	20.0	839R					1.8	
"	18.0	975R					3.4	
"	14.0	2570R					4.5	
"	12.0	2592R					4.3	
"	10.0	6000R					11.8	
1200	10.0	3157	.036	.00008	1100	0.267		

(19)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 317	TYPE OF MELTING FURNACE Electric Arc							SIZE OF HEAT 7 tons					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N	
	0.05	1.36	0.02	0.01	0.40	18.8	13.2	3.05	--	--	--	0.05	
DEOXIDATION													
FORM-CAST OR WROUGHT wrought													
HEAT TREATMENT cold-reduced 30 per cent													
MICROSTRUCTURE -- cold-rolled structure													

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	49.0	31.0	14.5*				

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	78.4	0.17 R	--	--	--		12.5	--
1200	68.2	1.8 R	--	1.8	--		17.5	--
1200	59.5	16.0 R	--	0.4	--		22.0	--
1200	48.8	108.5 R	--	0.036	--		9.5	--
1200	43.7	272.5 R	--	0.012	--		6.5	--
1200	38.8	487.0 R	--	0.0058	--		5.5	--
1200	33.4	778.0 R	--	0.0018	--		3.0	--

(20)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 316	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	27.1	20.1*					

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	39.8	5.8 R					32	
	30.4	34.8 R					26	
	23.8	302.1 R					36	
	27.0	69.2 R					48	

(21)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	316	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N_2	Fe	
	.026					17.3	13.1	2.30				.031	Bal	
DEOXIDATION														
FORM-CAST OR WROUGHT	Wrought													
HEAT TREATMENT														

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	32.3*	25.5*					

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	36	19.2 R					26	
"	33	80.3 R					17	
"	30	53.5 R						
"	24							

(22)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	316	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N_2		
	.026					17.3	13.1	2.30				.031		
DEOXIDATION														
FORM-CAST OR WROUGHT	Wrought													
HEAT TREATMENT														

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1500	5.8	3.35*					

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1500	16.075	2.0 R						
	12.75	115						
	12.00	5.4 R					26	
	6.75	36.1 R					20	
	25.5	0.3 R					30	
	3.0							

(23)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	L.C. 316	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N_2		
	.027					17.6	13.1	2.4				.13		

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	41						
1500	6.5						

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	45.0	58.5R					9	
"	42.0	145.7R					13	
1500	22.500	1.2R					25	
"	18.35	4.3R					16	
"	12.225	14.0R					19	
"	9.0	42.3R					6	
"	6.0	120.5R					19	

(24)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	316	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
	.05	1.55	.030	.018	.84	17.8	13.0	2.34	-	-	-			
DEOXIDATION	-													
FORM-CAST OR WROUGHT	.062" sheet 2B Finish													
HEAT TREATMENT	2000°F - 30 Min. - Air Cool													
MICROSTRUCTURE														
GRAIN SIZE														
HARDNESS	69 Rb													

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	27.8	22.8 *					14.5 *
1500	9.3	6.0					

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	17,000	523	1.48	.00035				
1200	18,000	432	1.92	.00040				
1200	25,000	360 R	5.16	.0050			10.	
1200	30,000	32.5R					12.	
1200	35,000	6.5R					15.	
1500	6000	1072 R	1.14	.0117	450		17.5	
1500	8000	192 R	.80	.079			17.	
1500	10,000	73 R	.70	.30	30		31	
1500	14,000	7 R	.20	3.3	2.0		42	

(25)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	316	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Fe		
	.08					18.	13.	2.5				Bal		
DEOXIDATION														
FORM-CAST OR WROUGHT	Wrought-Strip													
HEAT TREATMENT	1/3 Hr. at 1950 F. A. C.													
MICROSTRUCTURE														

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	38.2	27.5					

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	35.5	184.6 R					31	
"	33.2	269.0 R					24	
"	32.1	281.0 R					28	
"	29.3	526.7 R					12	
"	27.7	886.7 R					12	
"	26.1	891.1 R					8	
"	37.3	30.0 R					12	

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

(26)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 316	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Fe	
	0.1	2.0	.03	.03		17.0	12.0	2.5				Bal.	
DEOXIDATION													
FORM-CAST OR WROUGHT	0.053 in. sheet												
HEAT TREATMENT	Annealed												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70		34.1	85.0	66.5	
1600		13.7	20.5	62.0	

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1600	5.7*	3.4*					

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1600	5.5	1.3				0.16		
1600	5.5	4.2				0.9		
1600	5.5	23.0				3.9		
1600	5.5	120.0 R					25.0	
1600	3.7	9.0				0.14		
1600	3.7	63.0				0.85		
1600	3.7	250.0				4.0		
1600	3.7	680.0 R					18.0	
1600	2.0	115.0				0.1		
1600	2.0	210.0				0.17		
1600	2.0	440.0				0.37		
1600	2.0	780.0				0.78		

(27)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 317	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Fe	
		2.0				19	12	3.5		.4		Bal	
DEOXIDATION													
FORM-CAST OR WROUGHT	0.035 in. sheet												
HEAT TREATMENT	1900 F Anneal												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70		39.9	86.7	61.5	

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	31						

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	39.4	5.9 R					39.0	
1200	34.4	17.1 R					-	
1200	28.8	310.0 R					29.0	

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

(28)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 316	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Fe	
						18.0	11.0	2.5				Bal.	
DEOXIDATION													
FORM-CAST OR WROUGHT	0.052 in. sheet												
HEAT TREATMENT	1900 F Anneal												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70		35.5	86	57	

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	32						
1500	8.8						

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	36.	14.8 R					13.0	
1200	32	94.7 R					12.0	
1500	11.3	24.1 R					-	
1500	9.3	67.7 R					-	

(29)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 316	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Fe	
	.10	2.0	.03	.03		17.0	12.0	2.5				Bal.	
DEOXIDATION													
FORM-CAST OR WROUGHT	0.028 in. sheet												
HEAT TREATMENT	1900 F anneal												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70		36.0	86.2	53.2	

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1350	14.0	1.0				.10		
1350	14.0	10.0				.65		
1350	14.0	85.0				4.7		
1350	12.0	5.0				.15		
1350	12.0	31.0				.81		
1350	12.0	120.0				2.5		
1350	10.0	65.0				.55		
1350	10.0	120.0				.95		
1350	10.0	155.0				1.5		

(30)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.05	.72	.028	.010	1.44	19.3	9.70	2.75					
DEOXIDATION													
FORM-CAST OR WROUGHT	Cast												
HEAT TREATMENT	2000° F. Water Quench												

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

CREEP AND RUPTURE STRENGTHS

TEMP, °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1000						11.0	24.0
1100						8.8	21.0

(31)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	18 - 13 - 2	TYPE OF MELTING FURNACE	Induction	SIZE OF HEAT	200 lbs.

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.10	1.96	.019	.015	.82	18.1	13.02	.27					

DEOXIDATION	
FORM-CAST OR WROUGHT	Cast Keel Blocks
HEAT TREATMENT	2 h 2000°F - WQ
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	130 BHN

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
80	24.5	27.4	67.3	48.1	42.0
1200	14.5	13.1	37.9	33.0	45.0

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1300							4.9
1400							3.0

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1000	20.0	2784	5.17	.000106	> 2784			
1100	10.0	1176	.097	.000022	> 1176			
1100	20.0	936	1.464	.00364	240			
1200	10.0	6048 R	.04	.00049	1488		8.0	
1300	5.0	1248	.0217	.000118	> 1248			
1300	10.0	840 R	.0000	.0155	50		32.	
1400	3.0	1248	.0000	.000091	> 1248			
1400	5.0	1440 R	.0000	.0036	240		9.0	
1500	5.0	265 R	.0000	.0314	50		7.0	

(32)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE	SIZE OF HEAT

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N_2	
	.06	1.70			.37	18.4	7.20	2.54				.22	

DEOXIDATION	
FORM-CAST OR WROUGHT	Wrought
HEAT TREATMENT	1950 F Anneal
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
R. T.		54.25	108.30	61.0	73.9
750			82.97	51.5	65.2
1000			69.35	50.1	69.5
1200			64.00	48.0	63.0
1300			56.75	35.0	40.1
1400			43.70	47.0	56.5
1500			36.85	53.0	67.0
1600			30.57	64.0	65.2
1700			26.17	57.0	63.0
1800			15.22	71.0	65.9
1900			11.72	78.0	58.8
2000			9.55	88.0	77.8
2100			4.92	90.0	84.9
2200			4.52	93.0	98.6
2300			3.20	101.0	97.1

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

(33)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	316	TYPE OF MELTING FURNACE		SIZE OF HEAT	

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		

DEOXIDATION	
FORM-CAST OR WROUGHT	Wrought
HEAT TREATMENT	½ Hr. at 1950 F
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET * YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
R. T.		26.5	86.0	54.	74
500			70.0	46.	68
700			71.0	47.	65
1000			69.0	49.	--
1200			58.0	51.	68
1400			40.0	46.	50
1500			33.0	53.	62.

* YS 0.02% Offset

(34)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	316	TYPE OF MELTING FURNACE		SIZE OF HEAT	

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.08	1.76	.029	0.22	-	18.4	12.2	2.08					

DEOXIDATION	
FORM-CAST OR WROUGHT	Wrought
HEAT TREATMENT	½ Hr at 1950 F
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET * YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
R. T.		24.900	82.05	64	73.90
500		18.750	71.5	52.5	67.91
700		16.500	71.0	52.5	67.02
1000		15.500	67.5	49.	65.16
1200		14.600	59.5	47.5	61.81
1500		12.800	36.5	53.5	67.81

* YS 0.02% Offset

(35)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE	SIZE OF HEAT

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N_2	
	.07	1.54			.60	19.1	12.9	2.22				.049	

DEOXIDATION	
FORM-CAST OR WROUGHT	Wrought
HEAT TREATMENT	1950 F Anneal

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT		29.5	82.9	64.0	74.1
750			72.75	53.5	67.7
1000			68.70	52.5	66.1
1200			53.57	51.0	65.2
1300			44.70	50.5	56.5
1400			33.62	58.5	69.5
1500			24.32	64.0	73.7
1600			20.25	66.0	64.9
1700			17.90	61.5	62.3
1800			13.42	86.5	72.5
1900			8.65	100.0	81.7
2000			7.32	99.0	82.3
2100			5.77	120.0	91.4
2200			3.97	108.0	88.7
2300			3.25	116.0	99.3

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

(36)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE						SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N_2	
	.07	1.56			.55	19.1	12.9	2.12				.049	
DEOXIDATION													
FORM-CAST OR WROUGHT	Wrought												
HEAT TREATMENT	1950 F Anneal												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
R. T.		33.300	84.250	61.0	74.5
750			69.52	49.0	67.5
1000			65.52	50.0	64.7
1200			61.00	25.0	45.8
1300			50.17	22.0	--
1400			44.27	32.0	47.5
1500			33.32	43.5	58.8
1600			27.55	45.0	58.6
1700			17.67	75.0	76.5
1800			-	-	-
1900			8.30	84.0	91.0
2000			7.20	82.5	70.4
2100			5.97	107.5	93.3
2300			3.10	121.0	96.5

(37)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 316		TYPE OF MELTING FURNACE						SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Cu	
	.054	1.69	.023	.019	.49	17.7	12.5	2.31				.26	
DEOXIDATION	Silicon												
FORM-CAST OR WROUGHT	Wrought Bar Stock												
HEAT TREATMENT	1950°F ½ hr WQ												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS	147 BHN												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT	--	45.0	82.2	56.0	72.9
1000	--	--	66.3	39.3	63.3

(38)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE						SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.19	.53			.26	16.2	9.13	2.60					
DEOXIDATION													
FORM-CAST OR WROUGHT	3/4"Dia. Bars												
HEAT TREATMENT	Annealed												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS	163 BHN, 85 Rb												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70	23.6	45.5	97.4	66.0	74.1
800	21.4	30.5	81.7	55.0	68.4
1000	12.0	24.5	79.1	50.5	64.7
1200	11.1	23.0	64.5	29.0	29.2
1400	20.6	23.0	45.1	16.5	16.5
1600	17.3	19.0	28.7	10.5	10.5
1100	19, 22.				
1200	21.				
1300	19.				
1350	17.				
1400	19.				
1450	17.				

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *
(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1100	20.0	96	.010	<.00002				
1200	"	144	.011	<.00001				
1300	"	96	.033	.0012	>72			
1000	15.0	96	.006	<.00002				
1100	"	168	.005	<.00001				
1200	"	72	.014	<.00002				
1300	"	312	.085	*.000042	>312			Rb 99
1200	10.0	96	.0	0				
1300	"	168	.033	<.00002				
1350	"	264	.028	*.000026				
1400	"	264	.016	.000032				
1450	"	336	.008	.000045				
1500	"	360	.017	.000059	264			Rb 96
1600	1.0	264	.004	*.000018				
	3.0	288	.028	*.000115				
	5.0	984	0	.00046	>984			

* Not necessarily the minimum rate

(39)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 13-8 Mo		TYPE OF MELTING FURNACE Electric Arc						SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.06	1.43	.029	.022	.26	18.5	13.1	3.20	-	-	-	-	-
DEOXIDATION													
FORM-CAST OR WROUGHT	Wrought Slab												
HEAT TREATMENT	As Rolled												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
1900			14.2	28.0	72.8
2000			12.6	29.3	73.5
2100			11.7	38.3	80.7
2200			10.0	35.5	77.6
2300			6.6	28.8	83.8

(40)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE						SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Fe	
	.024	.62			.63	18.4	14.4	2.58				63	
DEOXIDATION													
FORM-CAST OR WROUGHT	Forged CW 1400 F												
HEAT TREATMENT	2 Hrs at 1200 F A. C.												

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	34.8	45.4 R					8	
"	30.0	150 R					-	

(41)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE						SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.16	.57			.73	17.9	9.90	3.92					
DEOXIDATION													
FORM-CAST OR WROUGHT	3/4"Dia. Bars-Forged												
HEAT TREATMENT													
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS	183 BHN, 87 to 96 Rb												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70	31.0	64.0	95.2	49.0	70.6
800	27.1	45.0	80.8	45.0	64.2
1000	23.9	47.0	78.3	35.0	58.8
1200	12.3	42.5	66.2	34.0	58.6
1400	7.9	37.5	49.3	22.0	50.6
1600	4.8	24.0	31.0	9.0	24.1

(42)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	316	TYPE OF MELTING FURNACE							SIZE OF HEAT	Laboratory				
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
	.06	1.17			.35	17.1	12.1	1.48						
DEOXIDATION														
FORM-CAST OR WROUGHT	Wrought													
HEAT TREATMENT	(See Below)													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
R. T.	As Rec'd	29.202	77.50	55	69.5
1500	As Rec'd	-	24.29	40	37.5
R. T.	500 Hrs at 1500F	21.63	77.15	58.5	68.5
1500	500 Hrs at 1500F		24.76	62.5	55.9

(43)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	315 316	TYPE OF MELTING FURNACE							SIZE OF HEAT	Laboratory				
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
	.09	1.32			.41	18.5	16.2	2.28						
DEOXIDATION														
FORM-CAST OR WROUGHT	Wrought													
HEAT TREATMENT	(See Below)													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
R. T.	As Rec'd	23.46	78.70	51.0	72.0
1500	As Rec'd		27.75	58.5	49.5
R. T.	500 hrs at 1500F	27.15	77.80	51.5	64.5
1500	500 hrs at 1500F		26.54	68.5	54.28

(44)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	316	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
	.08	1.76	.029	.022		18.4	12.2	2.08						
DEOXIDATION														
FORM-CAST OR WROUGHT	Wrought													
HEAT TREATMENT	500 Hrs. at 1500 F													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
R. T.		23.62	85.5	46.5	47.15
500		16.5	66.5	34.	49.73
700		13.9	64.0	33.5	47.44
1000		13.1	60.0	31.5	46.89
1200		12.7	53.5	26.5	47.73
1500		10.9	34.5	52.5	66.80

(45)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	316	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET* YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
R. T.		27.25	85.62	60.	29
1200		13.3	59.32	41.	23.6
1300		14.1	52.45	40	23.1
1400		13.2	44.27	46.5	18.4
1500		12.67	36.10	51.5	18.1

* YS 0.02% Offset.

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

(46)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	18 - 8 Mo	TYPE OF MELTING FURNACE	Electric Arc						SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
	.05	1.17	.014	.010	.48	18.2	10.7	3.50						
DEOXIDATION														

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
2100			11.0	39.0-6"	83.0
2200			6.0	56.0-6"	87.0
2300			5.0	56.0-6"	92.5
2350			4.0	48.5-6"	99.5

(47)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	316	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	V		
	.08	2.00			.52	18.3	14.0	2.05				.25		
DEOXIDATION														
FORM-CAST OR WROUGHT	.046" Strip													
HEAT TREATMENT														

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
R. T.		41.45	88.15	46.	
1000		20.12	65.55	40.	
1200		19.47	57.70	38.	
1350		18.50	40.86	16.	
1500		16.35	19.69	2.7	

(48)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE	Induction						SIZE OF HEAT	600 lb.				
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
	.05	.75	.026	.012	.70	18.8	8.99	2.77						
DEOXIDATION														
FORM-CAST OR WROUGHT	Cast Keel Blocks 3/4"x 1½" x 6"													
HEAT TREATMENT	W. Q. - 1975° F													
MICROSTRUCTURE														
GRAIN SIZE														
HARDNESS	181 - 212 VPN/30													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
80	21.1	41.0	82.1	46.8	58.0
1000	17.0, 19.0	20.0, 20.0	60.8	35.7	95.2
1200	16.9, 17.4	19.8, 16.0	30.0, 38.4	35.0	45.5

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1000	20.0	2664	.043	.000106	> 2664			
1100	10.0	2208	.030	.000057	> 2208			
1100	10.0	2112	.013	.000015	> 2112			
1200	10.0	9048 R	.461	.000075	> 6240		3.0	
1200	20.0	336 R	.563	.056	268		26.0	
1200	20.0	147 R	.200	.050	48		18.0	
1300	5.0	1848	.0137	.000059	> 1848			
1300	7.5	1824	.050	.00084	1640			
1300	10.0	3624 R	.73	.00039	2160		4.6	
1200	30.0	76 R	-	.043	-		14.8	

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

(49)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE Electric Arc							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.25	.63			.79	20.0	8.96	1.56					
DEOXIDATION													
FORM-CAST OR WROUGHT	Cast Keel Blocks 7/8" x 1½" x 6"												
HEAT TREATMENT													
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS	160 BHN												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70	26.0	41.3	80.0	24.5	21.9
1000	7.8	21.9	63.5	25.0	26.1
1200	7.2	20.4	54.8	24.0	27.1
1400	6.4	24.6	42.9	17.0	24.7

(50)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL Cast - 16 - 13 -3	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.10	.54			.29	17.4	13.7	1.44					
DEOXIDATION													
FORM-CAST OR WROUGHT	As Cast												
HEAT TREATMENT													
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS	128 BHN												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
300	20.0	21.9	59.0	47.5	58.
550	20.3	22.0	55.5	45.0	47.
800	15.9	12.7	45.8	46.0	58.

(51)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL Cast - 16 - 13 - 3	TYPE OF MELTING FURNACE Electric Arc							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.09	.50	.020	.008	1.03	18.1	13.7	3.00					
DEOXIDATION													
FORM-CAST OR WROUGHT	Cast												
HEAT TREATMENT	WQ - 2000°F												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS	143 BHN												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70		36.8	73.0	42.0	45.0
1300		15.5	39.0	48.0	
1360		15.5	38.0	38.0	58.0
1500		17.9	26.0	45.0	68.0

(52)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE Induction							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Mo	
	.08					16.6	13.3	3.00					
DEOXIDATION													
FORM-CAST OR WROUGHT	Cast												
HEAT TREATMENT	WQ - 1900°F												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS	117 - 125 BHN												

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70		31.0		49.0	53.0
1200		16.0		29.0	36.0
1300		13.5		31.0	33.0
1400		12.0		26.0	32.0
1500		11.5		20.0	28.0
1350	7.6				

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS P.S.I. 1000	DURATION HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1300	5000	312	.032	.000028				
1300	8000	168	.036	.000516				
1350	8000	1824 R	.000	.00207	1320		6.0	

(53)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE Induction							SIZE OF HEAT 600 lb.					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.07	.84	.028	.015	.89	19.18	8.93	2.80					
DEOXIDATION													
FORM-CAST OR WROUGHT	Cast Keel Blocks 3/4" x 1½" x 6"												
HEAT TREATMENT	W. Q. - 1975 + Drawn 1575°F for 24 hours.												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
80	26.8	25.0	82.0	24.0	23.0
800	14.0	20.5	62.0	23.0	20.0
1000	17.3	16.5	58.5	26.0	33.0

(54)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE Induction							SIZE OF HEAT 600 lb.					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.07	.84	.028	.015	.89	19.1	8.93	2.80					
DEOXIDATION													
FORM-CAST OR WROUGHT	Cast Keel Blocks 3/4" x 1½" x 6"												
HEAT TREATMENT	W. Q. 1975F												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS	170 - 191 VPN/30												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
80	21.4	37.8	79.5	55.4	71.0
800	20.3	26.0	70.0	37.0	49.0
1000	16.8	20.0	61.6	38.9	50.0
1200	20.0	17.5	41.9	32.0	39.0

(55)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE Induction							SIZE OF HEAT 600 lb.					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.07	.84	.028	.015	.96	18.9	9.25	2.68					
DEOXIDATION													
FORM-CAST OR WROUGHT	Cast Keel Blocks 3/4" x 1½" x 6"												
HEAT TREATMENT	W. Q. - 1975F												
HARDNESS	174 BHN												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
80	21.4	39.1	81.1	57.9	65.0
1200	17.2	18.5	40.7	30.5	41.0
300	23.3	32.5	72.0	43.0	47.0
550	21.3	28.0	70.8	32.5	49.0

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

18Cr-8Ni + Mo + Cb

(1)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE	SIZE OF HEAT

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.07	1.76	.021	.017	.42	16.7	14.0	2.46	.72				

DEOXIDATION	
FORM-CAST OR WROUGHT	Wrought
HEAT TREATMENT	1100 C 2 Hrs. W. Q., 675 2 Hrs. A. C.
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	83 Rb

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT			83.4	51.0	73.2

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	41.0	30.0	*22.0	*16.0			
1300	24.0	17.0	*12.0	* 8.5			

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	45.0	53 R						
	40.0	115 R						
	35.0	175 R						
	30.0	802 R						
	25.0	4302 R						
1300	30.0	21 R						
	25.0	84 R						
	22.5	203 R						
	20.0	300 R						
	17.5	746 R						
	15.0	2159 R						

(2)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 318	TYPE OF MELTING FURNACE Basic Electric	SIZE OF HEAT 45,197 lbs.

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.07	1.62	.011	.017	.51	17.1	14.9	2.07	.72				

DEOXIDATION	21 lbs. of Al poled in furnace - 16 lbs. Al shot in ladle.
FORM-CAST OR WROUGHT	Wrought (3/4" Diam. Bar Stock)
HEAT TREATMENT	2000 F, 1/2 hr, W. Q. 1600, 5 hr, F. C.
MICROSTRUCTURE	
GRAIN SIZE	Actual A.S.T.M. 7-8 (5)
HARDNESS	167 V.H.N. (5 Kg. Load)

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
Room		47.9	89.3	46.0	68.0
1050		44.75	67.0	36.5	59.5
1200		39.5	52.5	43.0	66.7
1350		28.4	34.0	37.0	62.7
1500		20.0	23.1	57.0	78.8

Note: (1) Y. S. at Room Temp. obtained at 0.20% offset.
(2) Y. S. at Elevated Temp. determined by string extensometer

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1350	19.0	11.5	6.85*	4.2*			
1500	10.0	5.0	2.5 *	1.24*			

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *
(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1350	22.0	57.0 R					56.5	
1350	18.0	110.0 R					44.9	
1350	16.5	221.2 R					60.5	
1350	13.0	433.7 R					56.5	
1350	11.0	1256.5 R					57.5	
1500	15.0	7.5 R					65.5	
1500	10.0	55.5 R					59.5	
1500	8.0	204.5 R					69.5	
1500	5.5	798.5 R					41.0	
1500	4.5	777.5 R					60.5	
1500	3.3	4811.6 R					57.0	
1500	2.8	5975.2 R					53.0	

(3)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 318	TYPE OF MELTING FURNACE Basic Electric	SIZE OF HEAT 45,197 lbs.

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.07	1.62	.011	.017	.51	17.1	14.9	2.07	.72				

DEOXIDATION	21 lbs. of Al poled in Furnace - 16 lbs. Al shot in ladle
FORM-CAST OR WROUGHT	Wrought (3/4" Diam. Bar Stock)
HEAT TREATMENT	2000 F, 1/2 hr, W. Q.
MICROSTRUCTURE	
GRAIN SIZE	Actual A.S.T.M. 7-8 (6)
HARDNESS	168 V.H.N. (5 Kg. Load)

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
Room		51.0	90.4	47.0	70.0
1050		48.75	75.75	39.0	58.2
1200		43.5	59.0	35.5	48.1
1350		41.0	43.75	23.0	36.3
1500		23.0	26.75	38.5	62.9

Note: (1) Y. S. at Room Temp. obtained at 0.20% offset.
(2) Y. S. at Elevated Temp. determined by string extensometer

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1350	16.8	11.75	6.42*	3.45*			
1500	9.3	4.85	2.6 *	1.4 *			

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1350	22.0	14.0 R					70.0	
1350	18.0	186.0 R					35.3	
1350	16.5	110.0 R					42.1	
1350	13.0	474.0 R					57.0	
1350	11.0	1379.4 R					49.0	
1500	15.0	9.0 R					70.0	
1500	10.0	61.3 R					50.5	
1500	8.0	150.7 R					60.5	
1500	5.5	662.2 R					39.0	
1500	4.5	1032.4 R					73.0	
1500	3.3	5167.5 R					69.0	
1500	2.8	4882.9 R					59.5	

(4)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	318	TYPE OF MELTING FURNACE	Basic Electric					SIZE OF HEAT	45,197 lbs.				
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.07	1.62	.011	.017	.51	17.1	14.9	2.07	.72				
DEOXIDATION	21 lbs. of Al. poled in furnace, 16 lbs. Al. shot in ladle.												
FORM-CAST OR WROUGHT	Wrought (3/4" Diam. Bar Stock)												
HEAT TREATMENT	2000 F, 1/2 hr, W. Q. 1750, 1 hr, A. C.												
MICROSTRUCTURE													
GRAIN SIZE	Actual A.S.T.M. 7-8 (6)												
HARDNESS	165 V.H.N. (5 kg. load)												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
Room		47.5	88.4	47.0	69.0
1050		51.0	67.5	35.0	61.8
1200		34.0	52.0	44.5	69.9
1350		27.2	35.0	38.5	68.4
1500		22.9	24.2	48.0	72.3

Note: (1) Y. S. at room temp. obtained at 0.20% offset.
(2) Y. S. at elevated temp. determined by string extensometer

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1350	18.0	12.3					
1500	9.0	4.65	2.45*	1.1*			

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1350	22.0	41.5 R					69.0	
1350	18.0	61.0 R					69.0	
1350	16.5	147.5 R					48.7	
1350	13.0	806.0 R					54.5	
1350	11.0	3416.9 R					46.0	
1350	9.0	3073.6 R					48.0	
1500	15.0	8.0 R					64.5	
1500	10.0	57.2 R					66.5	
1500	8.0	196.0 R					50.0	
1500	5.5	546.5 R					61.0	
1500	4.5	1054.4 R					50.5	
1500	3.3	3827.6 R					55.5	
1500	2.8	6228.7 R					83.5	

(5)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE						SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.05	.27			2.18	18.2	8.06	3.06	.51				
DEOXIDATION													
FORM-CAST OR WROUGHT	Wrought												
HEAT TREATMENT	1100 C 2 Hr. W. Q.; 675 C 1 Hr. A. C.												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS	100 Rb												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT			120.7	30.0	45.6

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	28.0	19.0	*13.0	* 8.8			

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *
(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	25.0	127 R					47.0	
	20.0	845 R					40.0	
	15.0	3611 R					21.0	

(6)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	316 + Cb	TYPE OF MELTING FURNACE						SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N_2	
	.025					18.4	13.7	2.16	.36			.028	
DEOXIDATION													
FORM-CAST OR WROUGHT	Wrought												
HEAT TREATMENT	1875-1900 F Anneal												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT			79.0	46.0	
500			65.0	31.0	
1000				59.0	
1200			55.3	32.5	
1500			29.3	15.0	
1800			10.8	48.0	

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	40.5						
1500	11.0						

(7)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	316 + Cb	TYPE OF MELTING FURNACE						SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N_2	
	.025					18.4	13.7	2.16	.36			.028	
DEOXIDATION													
FORM-CAST OR WROUGHT	Wrought												
HEAT TREATMENT													
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS													

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	40.5	33.0*					
1500	10.9	6.9*					

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	39.8	15.9 R					-	
"	36.0	440.7 R					2	
"	40.5	128.7 R					2	
"	42.0	147.4 R					6	
"	39.0	-						
1500	18.0	7.9 R					7	
"	16.5	4.4 R					-	
"	13.5	33.8 R					11	
"	12.0	60.0 R					-	
"	6.75	444.5 R					5	
"	9.0	323.7 R					4	

(8)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	316 - Cb	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
	.06	2.17	.013	.010	.40	18.2	13.9	2.20	.95					
DEOXIDATION														
FORM-CAST OR WROUGHT	.050" Sheet													
HEAT TREATMENT	Mill Annealed													
MICROSTRUCTURE														
GRAIN SIZE														
HARDNESS														

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
Room		50.7	92.1	43.0	49.0
900		29.0	65.2	31.0	35.0
1300		24.5	49.8	38.0	40.0
1500		20.2	28.5	32.0	34.0

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1350	20.0						
1500	10.0	6.0*					

(9)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
	.12	1.44	.01	.02	1.02	19.0	13.9	1.97	.39					
DEOXIDATION														
FORM-CAST OR WROUGHT	Cast - In Heavy Section													
HEAT TREATMENT	1050 C W. Q.													
MICROSTRUCTURE	Very Coarse Cast Structure													
GRAIN SIZE														
HARDNESS														

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
.RT			54.5	13.5	19.8

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1100	38.0	32.0	26.0	*21.0	10.8(a)	12.8(a)	
1100					11.0(a)	14.0(a)	
1200	26.0	21.0	*16.0	*12.0	4.2	9.2	

(a) Flow Rate Data - Step-down test on single test specimen at .002 in/in total strain.

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1000	6000	13164	.008	0		0.008		
1000	8000	12945	.013	.0000004		0.022		
1100	44.0	10 Min R					18.0	
"	40.0	352 R					16.0	
"	38.0	57 R					13.8	
"	38.0	132 R					11.8	
"	30.0	1675 R					12.3	
"	26.0	10556 R					8.3	
1200	30.0	31 R					13.3	
"	24.0	643 R					18.5	
"	22.0	695 R					19.8	
"	20.0	1196 R					17.8	
"	18.0	3844 R					12.5	
1200	3.0	4365	-.001	-.0000006		-0.012		
"	7.0	4365	.016	.0000048		0.026		
"	12.0	4365	.055	.0000249		0.151		

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

(10)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
	.11	.80			.96	17.1	13.7	1.95	.96					
DEOXIDATION														
FORM-CAST OR WROUGHT	Cast													
HEAT TREATMENT	1050 C 10 Hrs AC to <400C; 850 C 10 Hrs FC to 260 C													
MICROSTRUCTURE	Coarse equiaxed structure from center of heavy section.													
GRAIN SIZE														
HARDNESS														

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET * YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT		33.7	53.9	13.5	17.0
1000		16.8	49.9	20.0	23.7
1100		17.3	49.9	18.0	19.2
* Y.S. 0.1% offset.					

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1000	43.0	40.5	30.5	*23.5			
1100	37.0	30.0	*24.5	*20.0			

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1000	45.0	Broke on Loading					16.3	
"	45.0	4 R					13.7	
"	42.0	845 R					15.6	
"	40.0	1080 R					15.5	
"	34.0	2652 R					10.1	
"	29.0	15447 R					Still in Test	
1100	39.0	105 R					12.7	
	36.0	143 R					12.0	
	30.0	696 R					12.8	
	25.0	7558 R					11.4	
997	15.9	2869	.57	.000026	None	0.61		

(11)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
	.11	.80			.96	17.1	13.7	1.95	.96					
DEOXIDATION														
FORM-CAST OR WROUGHT	Cast													
HEAT TREATMENT	1050 C 10 Hrs AC to <400 C; 850 C 10 Hrs FC to 260 C													
MICROSTRUCTURE	Coarse columnar structure from near surface of heavy section.													
GRAIN SIZE														
HARDNESS														

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET * .01% YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT		27.7	55.2	20.5	27.5
1000		16.7	44.3	21.0	28.3
1100		12.21	57.9	22.0	36.3
* Y.S. 0.01% offset.					

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1000	42.0	37.0	32.5	*27.0			
1100	28.0	25.0	22.5	*20.0			

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1000	40.0	285 R					16.0	
"	38.0	792 R					17.4	
"	36.0	3765 R					12.5	
"	35.0	1766 R					15.0	
"	35.0	2389 R					15.3	
"	33.0	10948 R					Discontinued	
1100	39.0	2.2R					23.4	
	35.0	4 R					26.7	
	30.0	35 R					14.7	
	22.0	13422 R					9.7	
997	16.0	2869	.35	0	None			

(12)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE						SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.09	.50	.013	.015	.18	15.4	13.6	2.5	.98				
DEOXIDATION													
FORM-CAST OR WROUGHT	Cast												
HEAT TREATMENT	1040-1090 C 10 Hrs AC to 400 C; 850-900 C 10 Hrs to 260 C												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT			61.0	15.0	22.0

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1100	31.0	26.0	*21.5				

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1100	35.0	18 R					12.7	
	30.0	168 R					20.0	
	26.0	Broke on Loading						
	26.0	1026 R					9.6	
	23.0	Broke on Loading						
	23.0	918 R					8.0	
	22.0	743 R					In Test	

(13)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE Induction						SIZE OF HEAT 600 lb.					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.07	.77	.030	.012	.91	18.5	9.01	2.72	.91				
DEOXIDATION													
FORM-CAST OR WROUGHT	Cast Keel Blocks 3/4" x 1 1/2" x 6"												
HEAT TREATMENT	W. Q. - 1975°F												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS	191 to 212 DPN (30 Kg load)												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
80	24.1	39.5	81.9	37.6	44.0
1000	14.8	28.5	62.5	28.9	34.5
1200	16.1, 17.2	24.0, 22.3	41.9	26.0	33.0

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1000							21.2
1200							10.0
1300							6.2
1400							3.2

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1000	20.0	2760	.120	.000054	> 2760			
1200	10.0	12936 R	.16	.000103	5280		4.0	
1200	20.0	319 R	.510	.00572	240		3.5	
1300	5.0	1440	.098	.000027	> 1440			
1300	10.0	1080 R	.143	.00132	360		7.0	
1400	5.0	1200	.025	.000742	864			
1200	30.0	18 R	-	.2			8.8	

(14)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE Induction						SIZE OF HEAT 200 lb.					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.06	1.40	.014	.010	1.10	18.7	12.9	2.32	.87				
DEOXIDATION	Si & Mn												
FORM-CAST OR WROUGHT	Cast Navy Keel Block & 2" Tee												
HEAT TREATMENT	Air quench 2000°F												
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS	156 to 165 BHN												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
(2" Tee) 80	23.9	35.6	73.0	20.0	22.0
" 80	25.1	33.4	62.4	10.3	15.2
(Navy Keel) 80	23.0	33.4	77.6	42.6	40.0
" 1200	17.8	19.6	48.7	36.6	42.0

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1000							23.5
1200							10.8
1300							7.2
1400							3.6

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1000	20.0	2640	.052	.000015	>2640			
1200	10.0	215 R	.1148	.00146	144		2.0	
1200*	10.0	1344	.0015	.000049	>1344			
1200*	20.0	240 R	.28	.0227	120		10.0	
1300*	5.0	1800	.020	.000023	>1800			
1300*	10.0	2280	.38	.000375	>2280			
1400	3.0	2184	0.00	.000056	>2184			
* Tex								

(15)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE						SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.12	1.44			1.01	19.0	13.9	1.94	.39				
DEOXIDATION													
FORM-CAST OR WROUGHT	Wrought												
HEAT TREATMENT	1050 C 2 Hrs AC; 870 C 4 Hrs AC												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT			92.4	48.5	58.1

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1350	5000	5034	.267	.000015		0.34		
1350	8000	5034	.36	.000296		1.90		

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

(16)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE	SIZE OF HEAT

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.09	.77			.85	16.4	14.2	2.2	.95				

DEOXIDATION	
FORM-CAST OR WROUGHT	Cast
HEAT TREATMENT	1050 C 10 Hrs AC to 400 C; 850 C 10 Hrs FC to 260 C
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT			60.4	21.0	21.0

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
997	8.000	2869	.015	0	None	.015		
997	11.000	2869	.015	0	"	.015		
997	16.000	2869	.025	0	"	.25		
1000	7.0	11586	.017	.0000005	"	.021		
1100	6.0	3721	0	.0000004	"	.005		
1100	9.0	3721	0	.0000004	"	.001		
1100	10.6	11081	0	.00000044	"	.005		

(17)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE	SIZE OF HEAT

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
		1.0				15.0	13.0	3.0	.8				

DEOXIDATION	
FORM-CAST OR WROUGHT	Cast
HEAT TREATMENT	As Cast
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	22.0	19.0	*15.0	*11.0			

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1100	30.0	237 R					7.0	
1200	24.0	32 R					9.0	
"	20.0	718 R					6.0	
"	17.0	1754 R					4.0	

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

(18)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE	SIZE OF HEAT

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.076					18.9	12.8	1.89	.50 .53				

DEOXIDATION	
FORM-CAST OR WROUGHT	Weld Deposit
HEAT TREATMENT	As Welded
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1100	51.0	42.0	*37.0	*33.0	*18.0(a)	24.8(a)	28.3(a)

(a) Flow Rate Data - Step-down tests on single specimen at .002 in/in total strain.

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1100	50.0	129 R					12.5	
	45.0	326 R					2.0	
	42.0	1045 R					2.8	
	39.0	4341 R					3.4	

(19)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE	SIZE OF HEAT

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.096 .110	1.76	.020	.010	.72	19.5	9.57	.20	1.15				

DEOXIDATION	
FORM-CAST OR WROUGHT	Weld Deposit
HEAT TREATMENT	As Welded
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1100		36.0	*23.5	*16.0	13.2(a)	18.4(a)	23.8(a)

(a) Flow Rate Data - Step-down test on single specimen at .002 in/in total strain.

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1100	42.0	297 R					1.6	
"	35.0	1202 R					.9	
"	32.0	2018 R					1.0	
"	27.0	5578					Removed	

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

25 Cr-12 Ni

(1)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 309	TYPE OF MELTING FURNACE Elec. Arc.							SIZE OF HEAT 25 Tons					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.06	1.55	.011	.017	.42	24.9	13.4	-	-	-	-		
DEOXIDATION	Silicon												
FORM-CAST OR WROUGHT	Wrought												
HEAT TREATMENT	W. Q. 1900°F												
MICROSTRUCTURE	Equi-Axed, Austenitic, Few dispersed carbides, trace of free ferrite												
GRAIN SIZE	5/7 (Actual)												
HARDNESS	183 BHN												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS x OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
80	29.0	47.5	98.0	40	73
1200	21.8	24.0	54.2	30	32
1300	21.2	22.5	48.0	32	40
1500	19.8	20.5	26.0	39	44
1600	19.2		17.4	43	49
1800			7.7	64	54

x Determined by a Super Sonic Method.

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	31.0	21.0	14.5*	10.0*		3.4	9.0
1300	20.0	10.0	4.3*	1.7*		1.5	4.0
1500	8.0	3.7	1.7*	.8*			.7
1600	4.2	2.0	1.0*	.5*			
1800	1.7	1.0	.6*	.4*			

(2)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 309	TYPE OF MELTING FURNACE Elec. Arc.							SIZE OF HEAT 25 Tons					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.06	1.55	.011	.017	.42	24.9	13.4	-	-	-	-		
DEOXIDATION	Silicon												
FORM-CAST OR WROUGHT	Wrought												
HEAT TREATMENT	W. Q. 2200°F.												
MICROSTRUCTURE	Equi-Axed, Austenitic, Carbide Free, Trace of free ferrite												
GRAIN SIZE	3/5 Actual												
HARDNESS	178 BHN												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS x OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
80	29.0	44.0	93.6	49	74
1200	21.8	20.0	50.0	23	27
1300	21.2	19.0	39.7	14	16
1500	19.8	19.0	26.0	11	23
1600	19.2		18.9	21	24
1800			9.5	47	44

x Determined by a Super Sonic Method.

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	24.5	20.0	17.0*	14.0*		5.7	10.0
1300	18.0	13.8	9.8*	6.8*		2.4	7.0
1500	9.3	5.9	4.2*	2.9*		.2	1.8
1600	6.6	3.5	1.9*	1.0*			
1800	2.1	1.1*	.6*	.3*			

(3)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.14	.89	.02	.025	.52	24.	13.4	.13					
DEOXIDATION													
FORM-CAST OR WROUGHT	Wrought												
HEAT TREATMENT	Annealed												
MICROSTRUCTURE													
GRAIN SIZE	ASTM 6-8												

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

(3)

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	30.0	66R					10.2	
1200	27.5	102R					10.1	
1200	22.5	253R					5.3	
1200	20.0	431R					5.2	
1200	17.5	617R					3.6	
1200	15.0	1340R					5.6	
1200	12.5	3433R					4.1	

(4)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 309 Cb	TYPE OF MELTING FURNACE Electric Arc							SIZE OF HEAT 7 tons					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N	
	0.07	1.88	0.02	0.01	0.37	23.1	13.7	--*	0.66	--	--	0.04	
DEOXIDATION													
FORM-CAST OR WROUGHT	Wrought												
HEAT TREATMENT	cold-reduced 30 per cent												
MICROSTRUCTURE	cold-rolled structure												
GRAIN SIZE	--												
HARDNESS	--												

*-- means not determined

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	31.0	14.0	5.0*				

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	68.0	3.2R	--	0.80	--		7.0	--
1200	58.0	7.8R	--	0.215	--		4.5	--
1200	48.0	11.3R	--	0.09	--		2.5	--
1200	48.5	16.3R	--	0.11	--		2.0	--
1200	33.0	79.7R	--	0.033	--		4.0	--
1200	23.0	323.0R	--	0.0076	--		8.5	--
1200	18.5	479.0R	--	0.005	--		8.0	--
1200	15.0	820.0R	--	0.0034	--		10.0	--

(5)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.16	.93	.02	.029	1.08	28.0	11.5						
DEOXIDATION													
FORM-CAST OR WROUGHT	Wrought												
HEAT TREATMENT	Cold Drawn												

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	17.0	*6.0	-	-			

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	35.0	7R					19.3	
1200	25.0	19R					24.0	
1200	22.5	27R					28.0	
1200	20.0	53R					29.0	
1200	17.5	86R					31.0	
1200	15.0	154R					38.0	
1200	12.5	198R					50.0	
1200	10.0	471R					80.0	

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

(6)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 309	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.06	1.54	.022	.010	.40	23.6	14.1						
DEOXIDATION													
FORM-CAST OR WROUGHT .062" Hot Rolled Sheet													
HEAT TREATMENT 2000°F - 30 Min. - Air Cool													
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS 71 R6													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
1200	16.	15.	-	-	-

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	27	20.5*					15.0*
1500	8.4	5.1*					3.1*

ORIGINAL CREEP AND RUPTURE DATA

309 Stainless Steel — 2000°F - 30 min. - Air Cool.

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	17,000	335	.85	0.00166		1.45		
1200	20,000	427	3.30	0.00142				
1200	25,000	200R	4.40	0.058	65.		23.5	
1200	30,000	20.5R	6.0	0.49			22.	
1200	35,000	9.R		3.0			37	
1500	6000	507R	.15	0.0132	100		13.5	
1500	6930	282R	1.11	0.052	160		22.	
1500	8120	128R	.20	0.109			17.5	
1500	10,100	32.3R	1.30	0.60			25.	
1500	12,920	6.5R	.40	3.75	2.		36.	

(7)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 309	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Fe	
						25.0	12.0					Bal	
DEOXIDATION													
FORM-CAST OR WROUGHT 0.039 in. sheet													
HEAT TREATMENT 1900 F Anneal													
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70		38.2	86.0	47.0	

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	28.0						
1500	6.0						

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	44.3	2.17R					41.0	
1200	26.2	161.0R					10.0	
1500	15.0	3.3R					56.0	
1500	7.5	45.4R					39.0	
1900	4.2	.7R					60.0	
1900	2.7	5.0R					43.5	

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

(8)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE Arc							SIZE OF HEAT 1000 lbs.					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	0.32	0.46			0.45	25.9	11.5					0.16	
DEOXIDATION None - Except Late Silicon Addition													
FORM-CAST OR WROUGHT Cast													
HEAT TREATMENT None (As Cast)													
MICROSTRUCTURE Austenite and Carbides													
GRAIN SIZE													
HARDNESS 156 BHN													

(8)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
DEOXIDATION													
FORM-CAST OR WROUGHT													
HEAT TREATMENT													
MICROSTRUCTURE													
GRAIN SIZE													
HARDNESS													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
Room Temp.			82	17.5	23.7
Room Temp. *	23.5	50.5	86	6.5	7.0
Room Temp. *	22.5	50.0	86.5	6.5	7.0
Room Temp. *			90	7.0	9.4
Room Temp. *			88	7.0	8.2
* Aged 1400 F, 24 hrs. F. C.					

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1400	13	8.1				4.3*	6.0
1600	6.6*					2.3*	3.2
1800	4	2.6*				1.25*	1.75
2000	1.8*					0.57*	0.8

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1400	25	2.5R		1.99			7.8	
1400	20	13.9R		0.26			5.5	
1400	15	60.3R		0.038			3.0	
1400	8	1070R	0.20	0.00047	890		1.0	
1400	6	1150	0.086	0.000112	>1150	0.19		
1600	12	3.2R		0.74			4.5	
1600	8	41.4R		0.04			4.0	
1600	3	1640	0.11	0.000062	>1640	0.19		
1800	8	1.7R		5.7			21.9	
1800	6	16.6R		0.4			12.2	
1800	3	530R	0.1	0.0039	1807		6.0	
1800	3	440R	0.1	0.0025	190		4.0	
1800	2	1140	0.08	0.00025	>1150			
1800	1.5	1631	0.026	0.00003	>1631			
2000	3	6.0R		0.81			20.0	
2000	2	69.3R		0.046			9.0	
2000	1	1050	0.03	0.00045	330	2.6		
2000	0.5	1511	0.01	0.000005	?			

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

(9)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	309 Cb	TYPE OF MELTING FURNACE	-	SIZE OF HEAT	10 Ton

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N
	.075	2.02	.015	.005	.54	22.4	15.3		.93			.064

DEOXIDATION	Silicon
FORM-CAST OR WROUGHT	Wrought Bar Stock
HEAT TREATMENT	1950°F ½hr WQ
MICROSTRUCTURE	
GRAIN SIZE	ASTM G.S. 7
HARDNESS	

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT	-	42.0	91.0	45	71
1000	-	31.0	68.0	34	57
1100	-	30.0	63.0	35	58
1200	-	28.0	55.0	37	59
1300	-	24.0	43.0	42	58
1400	-	21.0	35.0	48	58
1500	-	18.0	28.0	60	60

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.

(10)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	25 Cr, 12 Ni	TYPE OF MELTING FURNACE		SIZE OF HEAT	

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al
	.17	2.04			.47	22.9	12.6				

DEOXIDATION	
FORM-CAST OR WROUGHT	3/4"Dia. Bars, Rolled
HEAT TREATMENT	W.Q. -2100°F
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	197 BHN, 86-98 Rb

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
80	31.0	69.5	98.3	47.0	59.8
800	19.3	47.0	79.1	41.0	58.6
"	27.0				
1000	18.2	42.0	72.2	34.0	54.1
"	23.0				
1200	16.0	41.0	54.5	29.0	41.6
1400	14.2	32.5	43.2	30.0	37.3
1600	10.6	18.0	29.2	18.0	44.9

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

(11)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	25Cr-12Ni	TYPE OF MELTING FURNACE	Electric Arc	SIZE OF HEAT	

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al
	.09	1.66	.013	.010	1.02	21.8	13.3	-	-	-	-

DEOXIDATION	
FORM-CAST OR WROUGHT	Wrought 1" round
HEAT TREATMENT	
MICROSTRUCTURE	Austenitic
GRAIN SIZE	
HARDNESS	

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
1400			35.26	40.0	47.5
1600			25.21	15.5	32.5
1800			15.50	32.7	62.3
2000			6.35	74.5	88.4
2200			4.14	102.5	100
2300			2.97	90.0	100

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
800	30.0	240	0	0				
900	"	1224	.044	.000041				
1000	"	312	.028	*.000028				
1100	"	696	.030	.00040	> 696			Rb 102
1000	10.0	168	.018	<.00001				
1100	"	360	.008	*.00001				
1200	"	432	0	0				
1300	"	1704	.022	.000044	> 1704			Rb 96
1100	3.0	264	-.020	*-.00007				
1200	"	792	.010	*.000005				
1300	"	1200	.004	.000033				
1400	"	480	.029	.000146	> 480			Rb 100

* Not necessarily the minimum rate

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

25Cr-20Ni

(1)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	3/O	TYPE OF MELTING FURNACE	Elec. Arc	SIZE OF HEAT	25 Tons

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al
	.11	.58	.009	.011	.75	23.6	20.6				

DEOXIDATION	Silicon
FORM-CAST OR WROUGHT	Wrought
HEAT TREATMENT	W.Q. 2150°F.
MICROSTRUCTURE	Equi-Axed, Austenitic, Carbide Free
GRAIN SIZE	3/4 Actual
HARDNESS	143 BHN

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I. +	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
80	29.0	36.0	87.5	54	76
1000	23.0	20.5	73.0	46	52
1100	22.4	19.2	65.5	32	37
1200	21.8	21.5	58.0	21	25
1300	21.2	20.0	44.5	17	22
1400	20.5	21.5	36.7	19	24
1500	19.8	20.5	26.2	15	22
1600	19.2	--	19.8	28	26
1800	--	--	10.2	24	24

+Determined by a supersonic method

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1000	39.5	32.0	26.0*	21.0*		17.5	32.5
1100	31.0	25.0	20.0*	16.0*		12.5	23.0
1200	24.0	17.0	11.5*	7.8*		8.0	15.0
1300	17.0	11.0	7.0*	4.4*		5.0	9.4
1400	11.0	7.4	4.4*	2.8*		2.2	6.0
1500	7.7	4.6	2.7*	1.6*		1.2	3.5
1600	5.4	3.3	2.1*	1.3*			
1800	3.2	1.7*					

(2)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	310	TYPE OF MELTING FURNACE	Basic Electric	SIZE OF HEAT

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al
	.084	2.00	.018	.014	.31	24.8	20.9				

DEOXIDATION	Refinement carried out under reducing Al-Si slags
FORM-CAST OR WROUGHT	Wrought
HEAT TREATMENT	1950°F., 1 hr., W.Q.
MICROSTRUCTURE	Completely Austenitic
GRAIN SIZE	Actual A.S.T.M. (4-6)
HARDNESS	161 BHN

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1500		4.8	2.5*	1.0*			
1650	4.6	2.65	1.0	0.24*			
1800	2.72	1.375	0.5	0.18*			

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1350	27.5	100 R					41.1	
1350	15.0	214 R					37.8	
1350	12.0	212 R					31.5	
1350	12.0	547 R					17.8	
1350	10.0	352 R					27.8	
1350	10.0	561 R					19.1	
1350	9.0	1429 R					16.2	
1350	8.0	2127 R					13.3	
1350	8.0	2968 R					13.6	
1350	6.0	3429 R					12.2	
1350	5.0	3685 R					18.8	
1350	4.0	18634					Still in Test	
1500	5.5	569 R						
1500	5.0	795 R						
1500	4.5	848 R						
1500	4.0	2586 R					37.5	
1500	3.5	4360 R					40.5	

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1500	3.0	6310 R					34.5	
1650	6.0	30 R					20.3	
1650	5.0	50 R					23.1	
1650	4.5	115 R					27.7	
1650	4.0	329 R					18.8	
1650	3.0	625 R					14.5	
1650	2.5	1260 R					13.2	
1650	2.0	3320 R					14.0	
1650	1.0	10083 R					10.8	
1800	3.0	68 R					23.6	
1800	2.5	149 R					28.5	
1800	2.0	427 R					23.6	
1800	1.5	853 R					52.2	
1800	1.0	1833 R					14.0	
1800	0.5	10080 R					19.4	

(3)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	310	TYPE OF MELTING FURNACE	Induction	SIZE OF HEAT	30 lbs.

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N
	0.11	1.05			0.71	24.6	21.3					0.04

DEOXIDATION	Ferro Silicon
FORM-CAST OR WROUGHT	Wrought, 3/4" Dia.
HEAT TREATMENT	2000°F.-A.C. + 2250°F.-1 hr.- W.Q. + 1550°F. - 8 hrs.- W.Q.

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1500	6.3	3.9			1.4*	2.1	3.6

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1500	15	1.4 R					7.5	
1500	8	37.5 R					5.0	
1500	5	261.9 R					3.0	
1500	3.5	1760 R					--	
1500	3.5	1760	.0145	.000084	350			
1500	2	2465	.0080	.000008	750			

(4)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE		SIZE OF HEAT

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al
						25	20				

DEOXIDATION	
FORM-CAST OR WROUGHT	Wrought
HEAT TREATMENT	1050°C, 1 Hr. A.C.; 675°C, 1 Hr. A.C.

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT			89.4	41.5	66.9

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	29.0	23.0	15.0*	10.0*			

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	35.0	19 R					5.0	
1200	25.0	642 R					3.0	
1200	20.0	2202 R					1.0	
1200	17.5	4404 R					3.0	

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *
(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

(5)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	310	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT		C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Cu	
		.126	1.53			.57	24.0	19.5					.09	
DEOXIDATION														
FORM-CAST OR WROUGHT	Wrought													
HEAT TREATMENT	3/4 Hr. 2150°F., W.Q. - 50 Hrs. 1400 A.C.													

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1500	11.0	6.0	3.2*	(Tests by M. W. Kellogg)			
1500	12.5	6.6	3.1*	(Tests by Crane Company)			
1500	12.0	6.4	3.5*	(Tests by Battelle)			

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1500	11.5	102.6 R					2	
1500	11.5	88.0 R					3	
1500	11.5	74.4 R					1.5	
1500	11.5	60.5 R					3.5	
1500	8	344.1 R					2	
1500	8	334.2 R					2.5	
1500	6	970.3 R					.5	
1500	6	920.3 R					2.0	

(6)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	310	TYPE OF MELTING FURNACE							SIZE OF HEAT					
		Arc							25 Tons					
CHEMICAL COMPOSITION, PER CENT		C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
		.13	.53	.029	.014	1.33	24.9	20.3						
DEOXIDATION														
FORM-CAST OR WROUGHT	Wrought - 1" Rd.													
HEAT TREATMENT	2000°F. - W. Q.													

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1600	9.8	3.5*					
1800	3						

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1600	6	96 R					59	
1600	4	603 R					30	
1800	4	47 R					33	
1800	2.5	160 R					32	

(7)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	310	TYPE OF MELTING FURNACE							SIZE OF HEAT					
		Arc							25 Tons					
CHEMICAL COMPOSITION, PER CENT		C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
		13	.53	.029	.014	1.33	24.9	20.3						
DEOXIDATION														
FORM-CAST OR WROUGHT	Wrought - 1" rd.													
HEAT TREATMENT	2100°F. - W.Q.													

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1600	6.6	--					
1800	2.7	1.6*					

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1600	8	39 R					32	
1600	6	198 R					9	
1800	3.5	79 R					32	
1800	2	443 R					25	

(8)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT		C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
		.11	1.38	.020	.019	.54	24.4	20.0						
DEOXIDATION														
FORM-CAST OR WROUGHT	Wrought, 1" Dia. Bars													
HEAT TREATMENT	W.Q. - 2150°F. - 45 Min.; Aged - 1400°F. - 48 Hrs.													
MICROSTRUCTURE														
GRAIN SIZE														
HARDNESS														

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
1500	16.2				
1500	15.0				
1500	17.5				
1500	18.8				
1500	17.1				
1500	14.0				

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1500	12.6	6.3					

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1500	11.5	146 R	.02	.0022	75		3.0	
1500	8.0	576 R	.013	.00011	150		2.0	
1500	8.0	648 R	.009	.00011	275		.5	
1500	7.0	793 R	-.018	.00006	360		2.0	
1500	6.0	1272 R	.008	.00004	320		.5	
1500	2.8	624	-.040	-.000002	>624			

(9)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	310	TYPE OF MELTING FURNACE							SIZE OF HEAT					
		Elec. Arc							25 Tons					
CHEMICAL COMPOSITION, PER CENT		C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
		.11	.58	.009	.011	.75	23.6	20.6						
DEOXIDATION	Silicon													
FORM-CAST OR WROUGHT	Wrought													
HEAT TREATMENT	Cold Drawn, Normalized 1700° F													
MICROSTRUCTURE	Equi-Axed, Austenitic, Dispersed Carbides													
GRAIN SIZE	8 + Actual													
HARDNESS	159 BHN													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS + OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
85	29.0	50.0	96.0	40	63
1000	23.0	30.0	68.0	35	57
1100	22.4	29.0	61.5	35	56
1200	21.8	27.5	48.5	37	43
1300	21.2	23.5	39.2	40	44
1400	20.5	19.0	28.5	41	42
1500	19.8	13.5	20.5	42	45
1600	19.2		17.4	45	43
1800			9.8	67	48

+Determined by a supersonic method

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

CREEP AND RUPTURE STRENGTHS

TEMP, °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1000	52.0	33.5	22.0*	14.0*		6.0	11.0
1100	28.5	17.0	10.5*	6.4*		2.2	4.0
1200	18.0	10.0	5.6*	3.1*		.6	1.5
1300	10.5	4.8	2.1*	.9*			.7
1400	6.7	2.7	1.1*	.4*			.5
1500	3.9	1.6	.7*	.3*			.4
1600	2.7	1.2	.6*	.2*			
1800	1.4	.8*					

(10)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	310	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
	.06	1.92			.49	24.2	21.1							
DEOXIDATION														
FORM-CAST OR WROUGHT	.065 sheet													
HEAT TREATMENT	Mill Annealed													
MICROSTRUCTURE														
GRAIN SIZE														
HARDNESS														

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET .2% YIELD (1). STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
Room		39.0	86.0	45	43
900		21.0	65.7	39	43
1300		18.5	43.9	27	27
1500		16.7	30.8	31	31

CREEP AND RUPTURE STRENGTHS

TEMP, °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS. *	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1350	15.0						
1500	8.2	5.5					

(11)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	25 - 20 Si	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
	.092	0.82			1.84	24.6	19.3							
DEOXIDATION														
FORM-CAST OR WROUGHT	Sheet													
HEAT TREATMENT	Annealed													

CREEP AND RUPTURE STRENGTHS

TEMP, °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	27.0	19.5*					
1500	7.2	4.6*					

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS (3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS. (5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	45.0	2.7 R					14.0	
1200	40.0	7.9 R					13.5	
1200	35.0	19.0 R					30.0	
1200	30.0	35.0 R					22.5	
1200	28.0	50.0 R					26.0	
1200	27.0	156.0 R					36.0	
1200	25.0	73.0 R					40.0	
1200	23.0	319.8 R					9.0	
1200	20.0	809.6 R					22.0	
1500	10.0	20.0 R					26.0	
1500	8.0	57.0 R					21.5	
1500	7.0	117.0 R					27.5	
1500	6.0	300.0 R					29.0	
1500	5.0	608.0 R					28.0	

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

(12)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE	Induction					SIZE OF HEAT	220 lbs.					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N		
	0.30	0.53			1.21	26.3	19.7					0.11		
DEOXIDATION	None - Except Late Silicon Addition													
FORM-CAST OR WROUGHT	Cast													
HEAT TREATMENT	None (As Cast)													
MICROSTRUCTURE	Austenite and Carbides													
GRAIN SIZE														
HARDNESS	170 BHN													

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD (1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
Room Temp.			72	16.0	30.5
Room Temp.*			78	7.5	10.4

*Aged 1400°F., 24 Hrs. F.C.

CREEP AND RUPTURE STRENGTHS

TEMP, °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1400	15.0						5.8
1600	7.8						3.9
1800	4.2	2.7*				1.75*	2.3
2000	2.2	1.05					0.73*

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS (3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS. (5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1400	20	23.0 R		0.17			8.0	
1400	15	97.2 R		0.047			8.5	
1400	6	1006	0.175	0.00012	>1006	0.27		
1600	10	18.3 R		0.23			6.0	
1600	8	83 R	0.40	0.029	30		10.0	
1600	4	809	0.14	0.00014	>809	0.23		
1800	6	16.9 R		0.38			14.5	
1800	4	194 R	0.18	0.006	80		3.0	
1800	3	539 R	0.17	0.0023	140		3	
1800	2	1002	0.06	0.000033	>1002	0.078		
2000	25	70.6 R		0.011			8.0	
2000	10	1175 R	0.03	0.00033	450		17±	

(13)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al			
	.10	1.1			1.4	24.2	19.4							
DEOXIDATION														
FORM-CAST OR WROUGHT	Cast													
HEAT TREATMENT	As Cast													
MICROSTRUCTURE	None													

CREEP AND RUPTURE STRENGTHS

TEMP, °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	15.0	11.0	7.0*				

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	16.25	50 R					12.0	
1200	13.3	485 R					7.0	
1200	10.0	978 R					3.0	
1200	8.9	3008 R					2.0	

(14)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	25-20	TYPE OF MELTING FURNACE				SIZE OF HEAT						
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	
	.04					20.6	17.2					
DEOXIDATION												
FORM-CAST OR WROUGHT	Cast											

CREEP AND RUPTURE STRENGTHS

TEMP, °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1500	7.2	4.2*					

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1500	6.31	194.7 R					1.07	
1500	5.36	347.6 R					6	
1500	8.25	54.6 R					30	
1500	11.25	15.7 R					13	
1500	13.7	4.5 R					21	

(15)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE				SIZE OF HEAT						
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	
	.14	1.78	.013	.013	.43	25.8	21.8	.02				
DEOXIDATION												
FORM-CAST OR WROUGHT	All Weld Metal, Longitudinal Welds											
HEAT TREATMENT	Stabilized at 1550°F, as final operation											
MICROSTRUCTURE	Austenitic - coarse grained, cored dendritic - containing fine carbides well distributed											
GRAIN SIZE												
HARDNESS	92 Rb											

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
Room	20.1	57.5	91.0	36.7	43.7
300	22.2		77.2	38.2	50.6
550	20.1	43.9	71.1	32.0	39.6
900	20.8	37.1	67.3	32.2	30.5
1000	17.4	36.1	65.4	36.2	41.2
1050	15.4	37.4	62.7	31.8	38.1
1100	14.3	36.0	61.2	33.5	38.2

CREEP AND RUPTURE STRENGTHS

TEMP, °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1000	43.0						
1100	32.0	24.0	17.0*			17.0	24.0

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1000	50.0	32.0 R					16.0	
1000	45.0	73.6 R					12.0	
1100	45.0	6.5 R					13.0	
1100	35.0	68.3 R					2.5	
1100	30.0	162.9 R	.02	.0019	100.0		3.5	
1100	23.0	1464.9 R	.07	.00011	1400.0		3.0	
1100	25.0	504.0 R						
1100	20.0	2187.	.062	.000023	2187+			

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

(16)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	310	TYPE OF MELTING FURNACE				SIZE OF HEAT						
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	
	.18	1.42	.024	.013	.46	24.6	20.4					
DEOXIDATION												
FORM-CAST OR WROUGHT	Wrought											
HEAT TREATMENT	1950°F. Anneal											

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
R.T.		36.	100.	41.	56.
750		25.	83.	39.	54.
1000		24.	76.	33.	47.
1200		21.	64.	33.	52.
1300		19.	56.	36.	56.
1400		17.	43.	45.	59.
1500		15.	34.	52.	65.
1600			26.	57.	71.
1700			20.	59.	79.
1800			13.	63.	80.
1900			9.	68.	78.
2000			7.	76.	80.
2100			5.	68.	70.
2200			4.	54.	57.
2300			3.	65.	73.
2350			2.	81.	95.

(17)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	310	TYPE OF MELTING FURNACE	Heroult Arc			SIZE OF HEAT	12 Tons					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Cu
	.086	1.78	.023	.017	.43	24.3	19.6	.13				.13
DEOXIDATION	Aluminum											
FORM-CAST OR WROUGHT	Wrought Bar Stock											
HEAT TREATMENT	1950°F. - 1/2 Hr. W.Q.											
MICROSTRUCTURE	Austenite											
GRAIN SIZE												
HARDNESS												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
R.T.		36.8	88.2	45.0	69.7
1000		22.0	71.8	30.0	58.7
1200		21.3	55.7	47.0	36.8
1500		17.8	28.8	55.5	59.5

(18)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	25 Cr - 20 Ni	TYPE OF MELTING FURNACE	Electric Arc			SIZE OF HEAT						
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N_2
	.05	1.98	.015	.015	.49	24.6	20.4					.12
DEOXIDATION												
FORM-CAST OR WROUGHT												
HEAT TREATMENT												
MICROSTRUCTURE												
GRAIN SIZE												
HARDNESS												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
1800			25.0	15.0	30.0
1900			13.0	33.5	84.0
2000			11.5	42.5	88.5
2100			9.0	48.0	91.5
2200			5.8	54.0	97.5
2300			4.5	58.0	99.5
2400			4.0	60.0	100.0

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

25Cr-20Ni +2Si

(1)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	314	TYPE OF MELTING FURNACE	Arc	SIZE OF HEAT	10 tons

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.16	1.52	.021	.015	2.22	25.02	20.91						

DEOXIDATION	
FORM-CAST OR WROUGHT	Wrought - 1" Rd.
HEAT TREATMENT	2000 F - W.Q.
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1400	8.8	3.7*					
1600	3.2	--					
1800	1.5	.78*					

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1400	10	59R					34	
1400	8	132R					35	
1400	4.5	588R					32	
1600	15	.4R					48	
1600	10	2.5R					49	
1600	6	28R					54	
1600	3	118R					70	
1600	2	265R					159	
1800	3	18R					44	
1800	1.5	72R					179	
1800	1	414R					178	

(2)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	314	TYPE OF MELTING FURNACE	Induction	SIZE OF HEAT	

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.10	1.35			2.30	25.3	19.9						

DEOXIDATION	
FORM-CAST OR WROUGHT	Wrought - 1" Rd.
HEAT TREATMENT	2100 F - W. Q.
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1600	6.2	2.4 *					
1800	3.6	1.7 *					

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1600	10	9 R					16	
1600	7	49 R					10	
1600	5.5	187 R					13	
1600	4	357 R					13	
1800	5	14 R					6	
1800	4	69 R					20	
1800	2	649 R					51	

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

(3)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	314	TYPE OF MELTING FURNACE	Heroult Arc	SIZE OF HEAT	

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.11	71.84	.011	.009	2.03	24.3	20.3						

DEOXIDATION	Aluminum
FORM-CAST OR WROUGHT	Wrought Bar Stock
HEAT TREATMENT	1950°F ½ hr WQ + 1350°F 5 hrs WQ
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	88 Rb

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	19	230.3 R					17.5	
1200	17	413.6 R					14.0	
1500	6	92.7 R					18.7	
1500	4	290.1 R					20.0	

(4)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	314	TYPE OF MELTING FURNACE	Arc	SIZE OF HEAT	10 tons

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.16	1.52	.021	.015	2.22	25.0	20.9						

DEOXIDATION	
FORM-CAST OR WROUGHT	Wrought - 1" Rd.
HEAT TREATMENT	2100 F - W. Q.
MICROSTRUCTURE	
GRAIN SIZE	

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1600	6.2						
1800	3.2						

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1600	10	10 R					15	
1600	7	55 R					10	
1600	6	120 R					12	
1600	5	213 R					21	
1800	3	105 R					39	
1800	2.5	151 R					32	

(5)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	314	TYPE OF MELTING FURNACE		SIZE OF HEAT	

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Fe	
	.25	2.0	.03	.03	2.0	25.0	20.0					Bal.	

DEOXIDATION	
FORM-CAST OR WROUGHT	0.035 in. sheet
HEAT TREATMENT	Annealed
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70		35.3	88.0		50.0
1600		15.5	19.0		53.0

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1600	5.5	0.9				0.18		
1600	5.5	2.4				0.56		
1600	5.5	13.0				4.0		
1600	5.5	42.0R					25.0	
1600	3.75	9.0				0.2		
1600	3.75	20.0				62.0		
1600	3.75	64.0				3.3		
1600	3.75	200.0				22.0		
1600	2.0	32.0				0.15		
1600	2.0	82.0				0.48		
1600	2.0	270.0				2.3		
1600	2.0	780.0				8.2		

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ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 314	TYPE OF MELTING FURNACE	SIZE OF HEAT

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Fe
					2.0	25.0	20.0					Bal

DEOXIDATION	
FORM-CAST OR WROUGHT	0.040 in. Sheet
HEAT TREATMENT	1900 F Anneal

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70		39.0	92.5	57	

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.00001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	27.0						
1500	8.2*						

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	32.4	30.6 R					37.0	
1200	26.4	135.6R					15.0	
1500	15.1	1.6 R					41.0	
1500	8.7	71.7					60.0	
1900	5.3	.4 R					28.0	
1900	2.7	7.6 R					-	

7

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE Induction	SIZE OF HEAT 220 lbs.

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N
	0.31	0.58			2.12	26.6	20.1					0.10

DEOXIDATION	None- Except Late Silicon Addition
FORM-CAST OR WROUGHT	Cast
HEAT TREATMENT	None (As Cast)
MICROSTRUCTURE	Austenite and Carbides
GRAIN SIZE	
HARDNESS	163 BHN

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
Room Temp.			76.5	22.0	25.1
Room Temp.*			75.8	6.0	9.2
Room Temp.*			80.5	6.0	7.0
* Aged 1400 F, 24 hrs., F.C.					

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.00001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1400							5.2*
1800	4.4	3.0*					2.2
2000	2.35	1.05					0.6*

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1400	20	11.4 R		0.66			16	
"	6	958	0.13	0.00023	720	0.34		
1600	12	6.5 R		0.91			15	
1800	8	2.3 R		2.6			14	
"	6	18.7 R		0.098			10.5	
"	4	163 R	0.54	0.0079	115		8.5	
"	2	1001	0.05	0.000055	>1001	0.09		
2000	4	3.3 R		0.78			39	
"	2.5	81.4 R		0.0026			4	
"	1.0	1057 R	0.059	0.00034	380		9	

8

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 314	TYPE OF MELTING FURNACE Ajax Induction	SIZE OF HEAT

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al
	.143	1.82	.007	.006	2.18	25.1	20.6				

DEOXIDATION	Silicon
FORM-CAST OR WROUGHT	Wrought Bar Stock
HEAT TREATMENT	1950° F ½Hr WQ
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT	--	52.0	96.9	45.0	65.5
1000	--	30.5	79.8	41.0	52.0
1100	--	32.5	71.5	37.5	35.0
1200	--	29.0	60.0	34.0	37.5
1500	--	15.0	25.0	55.0	50.5

9

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE	SIZE OF HEAT

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al
	.25	.58			2.34	24.9	20.4				

DEOXIDATION	
FORM-CAST OR WROUGHT	3/4"Dia. Bars
HEAT TREATMENT	
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	183 BHN, 90 Rb

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70	30.8	49.8	102.7	34.0	38.7
800	23.5	40.0	82.3	28.0	41.9
1000	24.5	36.0	77.0	29.5	43.1
1200	20.5, 15.0	31.5	62.45	38.5	52.5
1400	9.2, 14.0	20.0	38.3	54.0	70.3
1600	2.8	13.0	22.25	64.0	78.8

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	3.0	624	.067	.00018	>624			Rb 89.
1200	10.0	312	0	.0046	>312			Rb 90.
1400	3.0	288	.100	.0064	>288			Rb 92.
1600	1.0	456	.105	.0045	360			Rb 92.

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

15Cr-35Ni

(1)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	35 Ni-15 Cr	TYPE OF MELTING FURNACE	Elec. Arc	SIZE OF HEAT	2000 lbs.

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.04	.59	.010	.014	1.16	16.0	35.7	-	-	-	-		

DEOXIDATION	Silicon
FORM-CAST OR WROUGHT	Wrought
HEAT TREATMENT	W.Q. 2000°F.
MICROSTRUCTURE	Equi-Axed, Austenitic, Carbide Free
GRAIN SIZE	3/5 (Actual)
HARDNESS	143 BHN

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
80		40.0	85.2	46	72
1200		23.0	51.5	18	20
1300		21.0	41.0	11	17
1400		21.0	33.0	15	20
1500		19.5	25.0	21	21
1600			18.0	21	19
1800			8.3	27	24

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1200	22.0	12.2	6.9*	3.8*		5.5	8.7
1300	13.0	8.0	4.8*	2.9*		4.4	7.0
1400	8.8	5.7	3.8*	2.5*			
1500	6.6	3.4	1.8*	1.0*		1.5	
1600	4.4	2.6	1.4*	.7*			
1800	2.0	1.2	.7*				

(2)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	330	TYPE OF MELTING FURNACE	Ajax Induct.	SIZE OF HEAT	530 lbs.

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.052	1.81	.006	.006	.62	15.3	35.1						

DEOXIDATION	Silicon
FORM-CAST OR WROUGHT	Wrought Bar Stock
HEAT TREATMENT	2000°F. - 1/2 hr. W.Q.
MICROSTRUCTURE	Austenite
GRAIN SIZE	
HARDNESS	

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
Rm. Temp.	-	44.8	80.3	47	68.3

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1500	7.8	4.9	3.1*	2.0*			
1200	19.5	12.0	7.5*	4.7*			

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1500	8.0	97.0 R					18.2	
1500	6.0	335.9 R					18.2	
1500	4.0	2974.8 R					4.8	
1200	35.0	2.8 R					15.0	
1200	30.0	11.5 R					11.5	
1200	28.0	14.5 R					11.0	
1200	20.0	88.2 R					7.5	
1200	13.5	545.2 R					6.5	

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

(3)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL		TYPE OF MELTING FURNACE	Induction	SIZE OF HEAT	30 lbs.

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N	
	0.11	1.08	-	-	0.64	16.0	35.4	-	-	-	-	0.05	

DEOXIDATION	Ferro Silicon
FORM-CAST OR WROUGHT	Wrought, 3/4" Dia.
HEAT TREATMENT	2000°F. A.C. + 2250°F. - 1 hr. - W.Q.; 1550°F. - 8 hrs. - W. Q.
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1500	5.6	3.1*					2.0

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1500	6	88.2 R					3.0	
1500	5	130.9 R					1.5	
1500	4	288 R					5.5	
1500	3.5	498 R					-	
1500	3.5	498	.0080	.000510	160			
1500	2.0	2080	.0040	.000110	550			

(4)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	330+Cb	TYPE OF MELTING FURNACE	Induction	SIZE OF HEAT	2500 lbs.

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.10	1.41			.91	15.0	33.7		1.21				

DEOXIDATION	
FORM-CAST OR WROUGHT	Wrought - 5/8 in. sq.
HEAT TREATMENT	2000°F. - W.Q.
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	76 Rb

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1500	8.5						

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1500	11	21 R					61	
1500	8	156 R					26	

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

(5)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE Induction	SIZE OF HEAT 220 lbs.

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	N
	0.56	0.80			1.27	15.9	34.8					0.04

DEOXIDATION	None - Except Late Silicon Addition
FORM-CAST OR WROUGHT	Cast
HEAT TREATMENT	None (As Cast)
MICROSTRUCTURE	Austenite and Carbides
GRAIN SIZE	
HARDNESS	187 BHN

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
Room Temp.			68	8.5	10.7
Room Temp.*			86	4.5	3.7

*Aged 1400°F., 24 Hrs., F. C.

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1400	18.0	14.0*					8.8*
1600	9.0	6.3*					4.6*
1800	4.5	2.8*					2.2*

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1400	30	1.10 R		7.2			17.0	
1400	20	52.1 R		0.16			20.5	
1400	15	392. R	0.54	0.0086	200		7.	
1400	10	1002	0.43	0.00031	>1002	0.70		
1600	10	51.5 R		0.088			11.0	
1600	7	506 R	0.10	0.00098	300		2.	
1600	5	1002	0.15	0.00018	>1002	0.31		
1800	8	6.7 R		0.41			24.0	
1800	6	31.6 R		0.05			15.0	
1800	3	645. R	0.06	0.00081	185		2.0	

(6)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 15-35	TYPE OF MELTING FURNACE	SIZE OF HEAT

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Fe
	.40	2.46			1.26	16.1	35.6					46.

DEOXIDATION	
FORM-CAST OR WROUGHT	Cast
HEAT TREATMENT	
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	197 BHN

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	.02% YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
R.T.		23.21	75.500	12	11

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1500	9.4						

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1500	25.4	0.2 R					22	
1500	8.72	162.6 R					38	

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

(7)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE H. F. Induction	SIZE OF HEAT

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al
	.46	1.47			1.22	15.1	34.7				

DEOXIDATION	Ferrosilicon
FORM-CAST OR WROUGHT	Cast, 3/4" keel block
HEAT TREATMENT	As cast
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	187 BHN

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
RT		33	60	7	12.4

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I. (2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I. (2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1800							1.5

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1800	1.5	2800	.008	.00001				

(8)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	TYPE OF MELTING FURNACE	SIZE OF HEAT Commercial

CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al
	.57	1.50			1.50	15.8	35.8				

DEOXIDATION	
FORM-CAST OR WROUGHT	Cast
HEAT TREATMENT	As Cast
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1800	1	1800	.025	.000016	1500			

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

MISCELLANEOUS

(1)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 16Cr - 13Ni - 3Mo	TYPE OF MELTING FURNACE Electric Arc							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.13	.36	.019	.002	.19	15.0	13.4	3.07	-	-	-		

DEOXIDATION	
FORM-CAST OR WROUGHT	Wrought 1" round
HEAT TREATMENT	
MICROSTRUCTURE	Austenitic
GRAIN SIZE	
HARDNESS	

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
1400			39.17	19.0	30.2
1600			35.92	27.5	52.2
1800			19.29	10.2	26.1
2000			7.66	60.0	64.4
2200			4.23	76.7	74.1
2300			3.36	92.5	98.5

(2)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 16Cr - 13Ni -3Mo	TYPE OF MELTING FURNACE Electric Arc							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.12	1.77	.021	.005	.43	16.0	13.6	2.68	-	-	-		

DEOXIDATION	
FORM-CAST OR WROUGHT	Wrought 1" round
HEAT TREATMENT	
MICROSTRUCTURE	Austenitic
GRAIN SIZE	
HARDNESS	

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
1400			39.37	29.0	31.5
1600			26.36	25.0	37.0
1800			16.28	16.7	32.1
2000			7.65	57.0	61.3
2200			4.97	81.2	99.0
2300			3.27	96.5	100.0

(3)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 21 Cr	TYPE OF MELTING FURNACE Electric Arc							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.09	.47	.010	.009	.46	20.6	.07	.15					

DEOXIDATION	
FORM-CAST OR WROUGHT	
HEAT TREATMENT	
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", * PER CENT	REDUCTION IN AREA, PER CENT
1900			9.5	28.0	98.5
2000			7.5	48.0	86.0
2100			3.0	51.0	97.0
2200			3.0	52.0	99.0
2300			3.5	54.0	99.5
2400			5.0	61.0	99.8

*Elongation in 8 inches

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

(4)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 20Cr - 10Ni	TYPE OF MELTING FURNACE Acid Arc							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Se	
	.13	.62	.033	.011	1.81	20.9	10.5					.27	

DEOXIDATION	
FORM-CAST OR WROUGHT	Cast
HEAT TREATMENT	2000°F. Water Quench
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	Brinell 159

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70	22.0	35.5	81.0	40.0	45.8
300	21.2	25.5	71.0	36.0	48.6
500	20.0	23.5	69.0	35.8	49.5
900	19.0	23.0	67.5	35.0	46.6
1000	16.5	20.3	62.6	30.5	44.0
1200	15.5	17.6	45.1	22.0	37.0
1400	12.5	17.0	33.9	21.0	39.6

(5)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 7Cr, 25 Ni	TYPE OF MELTING FURNACE							SIZE OF HEAT					
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al		
	.25	.68			1.65	7.18	24.5						

DEOXIDATION	
FORM-CAST OR WROUGHT	1" Dia. Bar, Wrought
HEAT TREATMENT	Annealed
MICROSTRUCTURE	
GRAIN SIZE	
HARDNESS	Rb 83

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70		38.5	91.05	37.5	58.5
300	17.6	34.5	81.9	34.5	59.9
550	25.4	31.0	78.8	31.5	57.4
800	13.7	29.0	75.0	31.5	55.5
1000	10.7	26.5	68.7	32.0	57.6
1200	11.5	23.5	52.8	42.5	58.4
1400	11.8	16.6	32.9	49.0	53.4

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1000	15.0	96	.04	*<.0001				
	20.0	72	0.0	*.0030				
	25.0	96	.20	*.0087				
	30.0	219	.52	.0220	>219			Rb 85
1200	1.5	120	-.05	—				
	3.0	72	.01	*<.0001				
	5.0	96	.04	*<.0001				
	7.0	120	0.0	*.0022				
	10.0	900 R	.20	.0170	600		26.5	Rb 73
1400	.1	256	-.12	—				
	.2	168	.01	*<.00001				
	.5	96	.01	*<.00002				
	1.0	96	.007	*<.00001				
	2.0	168	.040	.00028				
	3.0	144	0.0	*.0028				
	4.0	48	0.0	*.0100				
	5.0	157 R	0.0	.0380	60		14.0	Rb 71
1600	1.0	696	0.0	.00023				
	3.0	116 R	0.0	.0320	48		6.0	Rb 71

* Not necessarily the second-stage creep rate.

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

(6)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 17Cr, 25Ni	TYPE OF MELTING FURNACE							SIZE OF HEAT				
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	
	.25	.47			3.05	16.8	24.8					
DEOXIDATION												
FORM-CAST OR WROUGHT	3/4" Dia. Bars, Wrought											
HEAT TREATMENT												
MICROSTRUCTURE												
GRAIN SIZE												
HARDNESS	Brinell: 262 Rb 104											

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70	31.6	103.4	129.2	24.0	48.9
800	22.8	89.0	113.0	22.0	41.4
1000	20.5	83.5	103.7	21.0	45.8
1200	10.1, 12	42.0	77.0	23.0	48.2
1400	8.0	25.0	47.0	38.5	68.0
1600	7.2	11.0	22.5	61.0	84.2

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	10.0	840	.280	.00042	>840			Rb 98
1400	3.0	816	0.0	.0015	264			Rb 87
1600	1.027	312	.385	.0020	>312			Rb 88
1600	1.0	624	.071	.00046				
	3.0	192	0.0	.0800	72			Rb 82

(7)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 18Cr, 23 Ni	TYPE OF MELTING FURNACE							SIZE OF HEAT				
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Cu
	.19	.59			1.75	17.2	23.0					.14
DEOXIDATION												
FORM-CAST OR WROUGHT	1" Dia. Bar, Wrought											
HEAT TREATMENT	Annealed											
MICROSTRUCTURE												
GRAIN SIZE												
HARDNESS												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70	30.6	70.5	116.7	28.5	46.8
300	23.7	53.3	93.2	30.5	52.0
550	25.7	52.5	92.9	25.5	47.7
800	23.0	42.0	85.5	29.5	48.3
1000	25.6	40.0	81.45	30.0	50.8
1200	12.8	32.5	63.2	43.5	59.8

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1200	5.0	16						
	3.0	216	.015	<.00001				
	5.0	240	.034	*.00021				
	7.5	188	.140	*.0016				
	10.0	24						
	12.5	48	0.0	*.0310				
	15.0	170 R	1.0	.0550	144		20.0	
1400	1.2	112	.006	<.00001				
	3.0	312	.065	.00034				
	5.0	144	.030	.0040				
	7.5	24	0.0	*.0270				
	10.0	47	.1	.1200	13			Rb 89
1600	1.0	480	0.0	.00035				
	3.0	360	0.0	.0220	100 Not fractured at 7%			

* Not necessarily the second-stage creep rate.

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

(8)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 15Cr, 15Ni, 5W	TYPE OF MELTING FURNACE							SIZE OF HEAT				
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	W
	.29				.96	14.5	15.0					4.86
DEOXIDATION												
FORM-CAST OR WROUGHT	3/4" Dia. Bars, Wrought											
HEAT TREATMENT												
MICROSTRUCTURE												
GRAIN SIZE												
HARDNESS	Brinell: 170 Rb 86 - 93											

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
70	27.0	47.8	103.1	56.0	71.4
800	20.0	36.5	97.0	44.5	53.9
1000	24.0, 22.0	30.0	90.8	36.0	34.2
1100	24.0				
1200	21.0, 20.0, 23.0	35.5	72.8	20.5	21.3
1300	20.0				
1400	14.8, 24.0	26.0	45.4	28.0	36.7
1600	13.0	17.0	28.2	52.0	76.0

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1000	20.0	624	.013	.000156	>624			Rb 93
1000	20.0	144	.020	*.000021				
	30.0	480	.238	.000132	>480			Rb 87
1200	15.0	552	.182	.00033	>552			Rb 91
1200	10.0	672	.089	*.000010	>672			
1000	15.0	264	.004	<.00001				
1100	"	240	.010	*.000012				
1200	"	360	.090	*.000017				
1300	"	22	0.0	*.0017		Holder Broke		Rb 98
1400	3.0	336	.036	*.00008				
	10.0	624	.046	.00037	>624			Rb 89
1600	1.0	312	.018	.00007				
	3.0	648	0.0	.00144	480			Rb 86

* Not necessarily the second-stage creep rate.

(9)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 20Cr - 80Ni	TYPE OF MELTING FURNACE							SIZE OF HEAT				
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	
						20	80		.4			
DEOXIDATION												
FORM-CAST OR WROUGHT	Cast											
HEAT TREATMENT	As Cast											
MICROSTRUCTURE												
GRAIN SIZE												
HARDNESS												

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1100	30.0	24.0	*20.0				
1200	22.0	15.0	* 7.8				

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG (RUPTURE TEST), %	HARDNESS AFTER TESTING
1100	34.0	25 R					12.0	
	25.0	798 R					4.0	
1200	24.0	71 R					2.8	
	20.0	144 R					3.0	
	14.0	1782 R					3.0	
	11.0	3069 R					1.5	

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

(10)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	18Cr - 8 Mn	TYPE OF MELTING FURNACE	Electric Arc	SIZE OF HEAT	
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Cu
	.08	8.87	.032	.006	.38	18.2	1.15	-	-	-	-	.86
DEOXIDATION												
FORM-CAST OR WROUGHT	Wrought 1" round											
HEAT TREATMENT												
MICROSTRUCTURE	70% Austenite, 30% Ferrite											
GRAIN SIZE	Actual											
HARDNESS												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
1400			29.15	32	59.8
1600			18.14	56.5	75.1
1800			8.24	61.7	73.5
2000			4.78	53	83.4
2200			2.18	97.3	99.0
2300			.92	106.5	100

(11)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	17-14 Cu-Mo	TYPE OF MELTING FURNACE	Heroult Arc	SIZE OF HEAT	15 Ton
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Cu
	.124	.88	.023	.007	.32	16.2	13.6	2.33	.38	.18		3.13
DEOXIDATION	Silicon											
FORM-CAST OR WROUGHT	Wrought Bar Stock											
HEAT TREATMENT	2250 F ½ hr WQ + 1350 F hrs WQ											
MICROSTRUCTURE												
GRAIN SIZE												
HARDNESS												

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1050	56.0	49.0	45.0*	-	45.0+	-	
1200	43.0	37.0	32.0*	-	19.0	24.0	
1350	26.0	20.5	16.5*	-	10.0	16.0	
1500	16.5	12.0	7.6*	-	6.8	11.0	

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1050	62.0	43.5 R					20.3	
1050	60.0	40.2 R					22.4	
1050	55.0	178.0 R	9.9	.00128	130		13.6	
1050	50.0	782.0 R	7.79	.000127	600		12.2	
1200	44.0	94.2 R					8.2	
1200	44.0	123.1 R	6.6		100		10.8	
1200	41.0	168.7 R	4.7		140		9.4	
1200	41.0	175.4 R	6.1					
1200	41.0	235.0 R						
1200	38.0	639.1 R	2.8		550		14.1	
1200	38.0	1113.0 R	3.7	.0007	700		7.5	
1350	25.0	305.1 R	.5		150		19.6	
1350	23.0	535.9 R	.3		210		9.5	
1350	22.0	757.7 R	.2	.00033	550		4.1	
1500	17.0	132.1 R			75		4.1	
1500	15.0	346.1 R	.19		150		4.1	
1500	14.0	485.1 R	.15		350		4.1	
1500	13.0	674.8 R	.15		500		2.7	
1500	12.0	1473.7 R	.10	.00023	1100		2.7	
1500	7.0	5224.5 R	.072	.000009			1.3	
1200	26.0	4296.6	.39	.000022				
1200	20.0	1393.0	.156	.00001				
1350	10.0	4673.0	.155	.000013				

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *

(12)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	17-14 Cu-Mo	TYPE OF MELTING FURNACE	Heroult Arc	SIZE OF HEAT	15 ton
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Cu
	.076	1.45	.026	.009	.49	17.2	14.0	2.87	.36	.22		3.14
DEOXIDATION	Silicon											
FORM-CAST OR WROUGHT	Wrought Bar Stock											
HEAT TREATMENT	2250-½ hr WQ + 1200-5 hrs WQ											
MICROSTRUCTURE												
GRAIN SIZE												
HARDNESS												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
R. T.	-	42.0	86.0	45	63
600	-	30.0	75.0	35	55
900	-	27.0	73.0	35	41
1000	-	28.0	72.0	32	45
1200	-	27.0	64.0	30	40
1350	-	26.0	53.0	29	37
1500	-	25.5	34.0	29	34

(13)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL	17-14 Cu-Mo	TYPE OF MELTING FURNACE	Heroult Arc	SIZE OF HEAT	15 Ton
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Cu
	.124	.88	.023	.007	.32	16.2	13.6	2.33	.38	.18		3.13
DEOXIDATION	Silicon											
FORM-CAST OR WROUGHT	Wrought Bar Stock											
HEAT TREATMENT	2050 ½ hr WQ + 1350 F 5 hrs WQ											
MICROSTRUCTURE												
GRAIN SIZE												
HARDNESS												

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1050	59.0	51.0	42.0*	38.0*		31.0	39.0
1200	40.0	34.0	29.0*	25.0*		17.0	24.0
1350	24.0	16.8	11.2*	9.0*		6.0	11.0
1500	12.0	7.2	4.4*	3.5*			

ORIGINAL CREEP AND RUPTURE DATA

TEMP. °F	STRESS, P.S.I. 1000	DURATION, HOURS(3)	INTERCEPT, %(4)	MINIMUM CREEP RATE, %/HR.	TRANSITION TIME, HRS.(5)	TOTAL EXT. (CREEP TEST), %	TOTAL ELONG. (RUPTURE TEST), %	HARDNESS AFTER TESTING
1050	60.0	95.2 R	13.0	.021	90		16.3	
1050	55.0	505.9 R	9.0	.0026	450		13.9	
1050	52.0	811.7 R	7.55	.0013	750		9.58	
1200	43.0	35.4 R					21.7	
1200	40.0	146.1 R	5.0	.015	45		17.7	
1200	37.0	487.7 R	3.2	.0067	75		19.0	
1200	34.0	1424.6 R	1.3	.0033	900		19.0	
1350	24.0	159.8 R		.027	35		24.5	
1350	22.0	253.5 R	.40	.0079	75		24.5	
1350	20.0	534.7 R	.25	.0023	200		27.2	
1350	17.0	1326.5 R	.15	.0005	400		20.4	
1500	15.0	31.8 R					23.1	
1500	13.0	126.0 R			25		16.3	
1500	11.0	284.5 R	.075		75		10.9	
1500	11.0	326.2 R	.13		75		13.6	
1500	9.0	769.8 R	.07		350		10.9	
1050	40.0	6603.0	2.95	.000066				
1200	18.0	3323.4	.145	.000008				
1200	25.0	2030.1	.350	.000065				
1350	8.0	3095.6	.180	.0000127				
1350	12.0	2694.9	.125	.000104				

(3) DURATION OF TEST (RUPTURE TEST INDICATED BY R).
(4) THE INTERCEPT IS THE PROJECTION BACK TO ZERO TIME FROM THE PORTION OF THE TEST SHOWING THE MINIMUM OR SECOND-STAGE CREEP RATE.
(5) THE TRANSITION TIME IS THE BEGINNING OF THE THIRD STAGE, OR AN ACCELERATING CREEP RATE.

(14)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 17-14 Cu-Mo	TYPE OF MELTING FURNACE Ajax Induct.							SIZE OF HEAT 1000 lbs.				
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Cu
	.088	1.26	.013	.009	.66	16.7	14.1	2.75	.42	.28		3.01
DEOXIDATION	Silicon											
FORM-CAST OR WROUGHT	Wrought Bar Stock											
HEAT TREATMENT	2050-½ hr WQ + 1350-5 hrs WQ											
MICROSTRUCTURE												
GRAIN SIZE												
HARDNESS												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
R. T.		41.0	89.0	45	59
600		29.0	75.0	40	65
900		-	74.0	39	60
1000		26.0	71.0	38	60
1200		26.0	62.0	37	65
1350		24.0	47.0	52	71
1500		21.0	33.0	64	72

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.

(15)

ASTM-ASME JOINT COMMITTEE ON EFFECT OF TEMPERATURE ON PROPERTIES OF METALS

TYPE OF MATERIAL 17-14 Cu-Mo	TYPE OF MELTING FURNACE							SIZE OF HEAT				
CHEMICAL COMPOSITION, PER CENT	C	Mn	P	S	Si	Cr	Ni	Mo	Cb	Ti	Al	Cu
	.086	.78	.025	.012	.53	16.0	14.3	2.37	.68	.33		3.03
DEOXIDATION												
FORM-CAST OR WROUGHT	.050" sheet											
HEAT TREATMENT	Sol. H.T. - 2050 F WQ											
MICROSTRUCTURE												
GRAIN SIZE												
HARDNESS												

SHORT TIME TENSILE PROPERTIES

TEMPERATURE, °F	MODULUS OF ELASTICITY, 1,000,000 P.S.I.	OFFSET YIELD(1) STRENGTH, 1000 P.S.I.	TENSILE STRENGTH, 1000 P.S.I.	ELONGATION IN 2", PER CENT	REDUCTION IN AREA, PER CENT
Room		43.5	86.4	40	47
900		40.0	63.2	29	32
1300		29.7	46.6	28	27
1500		21.0	32.5	15	20

CREEP AND RUPTURE STRENGTHS

TEMP., °F	STRESS FOR RUPTURE IN TIMES INDICATED, 1000 P.S.I.(2)				STRESS FOR DESIGNATED CREEP RATE, 1000 P.S.I.(2)		
	100 HRS.	*1000 HRS.	10,000 HRS.	100,000 HRS.	0.000001 %/HR.	0.00001 %/HR.	0.0001 %/HR.
1350	22,000						
1500	11,500	8,000 *					

(1) 0.2 PER CENT OFFSET UNLESS OTHERWISE INDICATED.
(2) EXTRAPOLATED VALUES INDICATED BY *