

UNCLASSIFIED

AD 4 3 8 7 1 8

DEFENSE DOCUMENTATION CENTER

FOR

SCIENTIFIC AND TECHNICAL INFORMATION

CAMERON STATION, ALEXANDRIA, VIRGINIA



UNCLASSIFIED

REPRODUCTION QUALITY NOTICE

This document is the best quality available. The copy furnished to DTIC contained pages that may have the following quality problems:

- **Pages smaller or larger than normal.**
- **Pages with background color or light colored printing.**
- **Pages with small type or poor printing; and or**
- **Pages with continuous tone material or color photographs.**

Due to various output media available these conditions may or may not cause poor legibility in the microfiche or hardcopy output you receive.

☐ **If this block is checked, the copy furnished to DTIC contained pages with color printing, that when reproduced in Black and White, may change detail of the original copy.**

NOTICE: When government or other drawings, specifications or other data are used for any purpose other than in connection with a definitely related government procurement operation, the U. S. Government thereby incurs no responsibility, nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

438718

AD NO.

438718

DDC FILE COPY

⑤ 552 850
Martin Marietta Corp.
Denver, Colo.

64-13

①

PB 171809-6

⑥ CRYOGENIC MATERIALS DATA HANDBOOK.

✓

⑨

PROGRESS REPORT

on 14 and 15
and 16 and 17

AIR FORCE MATERIALS LABORATORY
RESEARCH AND TECHNOLOGY DIVISION
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

⑫

PROJECT 7381, TASK 738103

⑪

MAY 13 1964

⑩

CONTRACT NO. AF33(627)-9161

⑨

by F.R. SCHWARTZBERG, S.H. OSGOOD, R.D. KEYS
AND T.F. KIEFER

6-12

118 \$11.00

FOREWORD

The enclosed inserts for the Cryogenic Materials Data Handbook are issued as the third semiannual progress report on Air Force Contract AF33(657)-9161. This handbook of data on solid materials at low temperatures was initially prepared under the sponsorship of the Air Force Ballistic Missile Division by personnel of the Cryogenic Engineering Laboratory, National Bureau of Standards, Boulder, Colorado. During the performance of this work, the responsibility for the handbook was transferred to the Aeronautical Systems Division. The eleventh quarterly report, dated 15 February 1962, was the final addition to the handbook prepared by the National Bureau of Standards.

The contract to continue the generation, assimilation, and presentation of data for the handbook was awarded to the Materials Research Section of Martin Company, Denver Division, in June 1962.

The handbook's scope was increased so that additional properties and materials could be included. The index insert page shows the current scope of materials. It appears that some confusion exists regarding the use of the index. The index, pages iii and iv, identifies those materials that have been coded for inclusion in the handbook and the properties desired for those materials. To determine which data are now included in the handbook, refer to the accumulative index, page vi. This index identifies the latest progress report containing data for a specific material and property.

This progress report contains considerable tensile data obtained by Martin Company under the subject contract effort. These data are identified by reference number 1115. Data obtained from other RTD programs, such as General Dynamics/Astronautics work on pressure vessel materials for cryogenic application [Contract AF33(616)-7719] and Narmco's work on the performance of plastic laminates under cryogenic temperatures [Contract AF33(616)-8289], are included. References 1122 and 1124, respectively, identify data from these programs. A number of graphs replotted the original National Bureau of Standards data are also included. Reference 137 identifies this work.

Plans to issue a completely revised handbook in early 1964 have been altered. The revision has been rescheduled to be completed in mid-year. The revised handbook will be issued as a replacement

for the existing document. All data will be replotted in the new format. All copies of the handbook will be punched for a standard three-hole binder. Obsolete data will be deleted and the reference numbering system will be streamlined. Inserts to keep the new handbook current will still be issued semiannually.

To make the forthcoming handbook as complete as possible, users are urged to submit appropriate data for inclusion in the handbook. Information can be forwarded to the following address:

Fred R. Schwartzberg, Mail No. L-10
Martin Company
P.O. Box 179
Denver, Colorado 80201

INDEX

MATERIAL

- A. Aluminum
 - 1. Tens-50
 - 2. 356
 - 3. 1100
 - 4. X2020
 - 5. 2024
 - 6. 6061
 - 7. 7075
 - 8. 2014
 - 9. 2219
 - 10. 5052
 - 11. 5456
 - 12. 7039
- B. Cobalt
 - 1. Elgiloy
 - 2. Stellite 3
 - 3. L-605 (HS25)
- C. Copper
 - 1. Beryllium Copper
 - 2. 70/30 Brass
 - 3. Copper
- D. Iron
 - 1. Invar 36
 - 2. 34% Manganese Steel
 - 3. Ni-Span C
 - 4. Vascojet 1000 or Unimach #1
 - 5. 17-4 PH
 - 6. 17-7 PH
 - 7. A-286
 - 8. 301
 - 9. 302
 - 10. 303
 - 11. 304
 - 12. 310
 - 13. 321
 - 14. 347
 - 15. 410
 - 16. 440C
 - 17. 440C
 - 18. 1075
 - 19. 2800 (9% Ni)
 - 20. 4340
 - 21. AM-355
- E. Nickel
 - 1. Inconel
 - 2. Inconel X
 - 3. K Monel
 - 4. S Monel
 - 5. Nickel
 - 6. Rene 41
 - 7. Hastelloy B
 - 8. D-979
 - 9. R-235
- F. Titanium
 - 1. Ti-5Al-2.5Sn
 - 2. Ti-13V-11Cr-3Al
 - 3. Ti-6Al-4V
 - 4. Ti-8Al-1Mo-1V
- G. Carbides
 - 1. Titanium Carbide
 - 2. Tungsten Carbide
- H. Nonmetals
 - 1. Ice
 - 2. Kel-F
 - 3. Mylar
 - 4. Nylon
 - 5. Teflon
 - 6. Epoxy-Fiberglas Laminate
 - 7. Phenolic-Fiberglas Laminate
 - 8. Polyester-Fiberglas Laminate
 - 9. High Temperature Polyester-Fiberglas Laminate
 - 10. Silicone-Fiberglas Laminate
- I. Miscellaneous Metals and Alloys
 - 1. Beryllium
 - 2. Molybdenum
- J. Comparisons
- K. Monographs
- L. References

INDEX

PROPERTIES

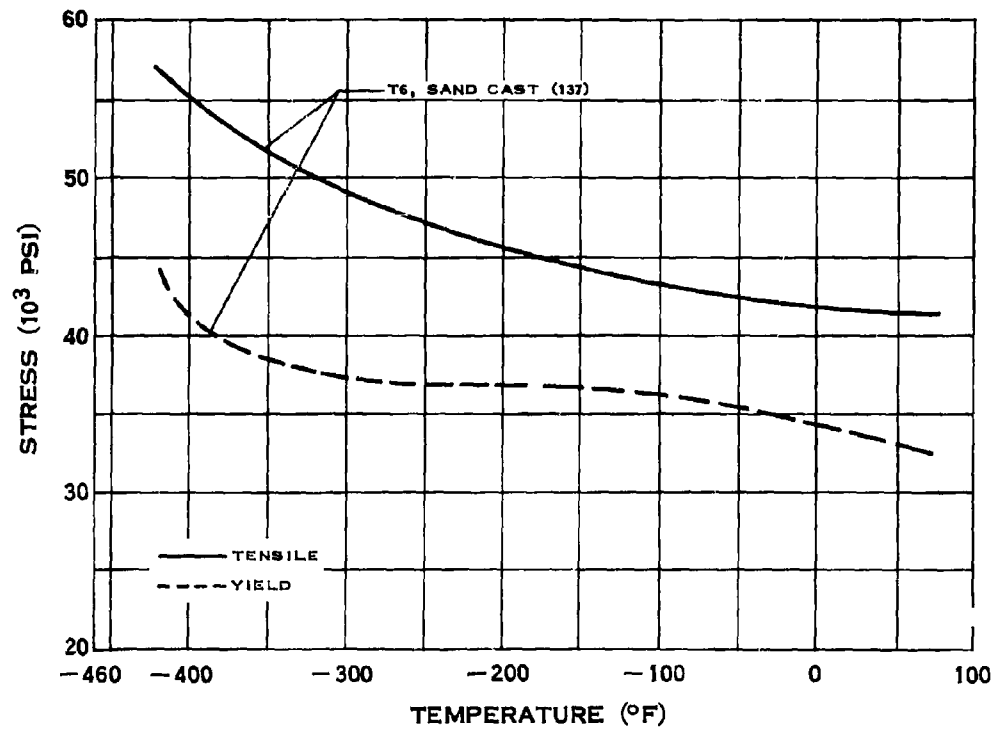
- | | |
|------------------------------------|--|
| a. Yield Strength
(0.2% Offset) | n. Fatigue Behavior and Strength |
| b. Tensile Strength | o. Creep Behavior and Stress-
Rupture |
| c. Elongation | p. Thermal Expansion |
| d. Reduction of Area | q. Poisson's Ratio |
| e. Stress-Strain Diagram | r. Thermal Conductivity |
| f. Modulus of Elasticity | s. Mechanical Hysteresis |
| g. Impact Energy | t. Electrical Resistivity |
| h. Hardness | u. Magnetic Properties |
| i. Compressive Yield Strength | v. Compression Set |
| j. Compressive Strength | w. Compression Modulus |
| k. Shearing Yield Strength | x. Flexural Strength |
| l. Shearing Strength | y. Flexure Modulus |
| m. Modulus of Rigidity | |

ACCUMULATIVE INDEX

The letters and numbers in the left column denote the general group and specific material as listed in the index. The letters of the top row denote a property, and the numbers within the squares refer to the last report in which data represented by the coordinates was issued. Numbers through 11 refer to quarterly reports issued by the National Bureau of Standards under the previous contract. Numbers 12 and over refer to semiannual progress reports issued by Martin under Air Force Materials Laboratory sponsorship.

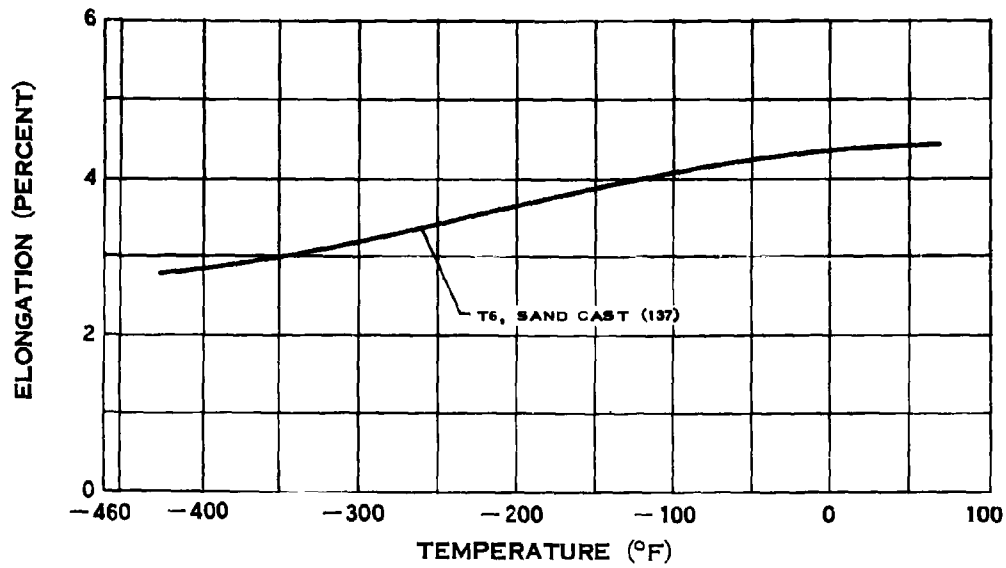
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z
A.1	14	14	14	14	14	14	14	14																		
A.2	14	14	14	14	14	14	14	14	11																	
A.3	10	10	10	10	14	10	10	10					10		10	10	14		11		10					
A.4	8	8	14	14	14	14	14	14								11	14									
A.5	11	11	8	8	8	11	11	11	11	11		10		10	10	14	11	11								
A.6	13	13	13	10	10	14	10	10								11	10	14								
A.7	10	10	10	10	10	8	8	8	8			10		10	10	14		9								
A.8	13	14	12			14											14									
A.9	13	13	13			14						13					14									
A.10	12	12	12			12																				
A.11	13	13	13			14											14									
A.12	14	14	14									14					14									
B.1	14	14	14	14	14	14							14				14		8							
B.2							11										10									
B.3	11	11	11				11										14		8							
C.1	10	10	10	10	14	11	11							8	12		11									
C.2	8	8	8	8	11	11	11							8	12	8	14		11							
C.3	11	11	11	11	10	11	11								8		8		8		8					
D.1	8	8	8	8	11	11	11	8						8			10									
D.2																										
D.3	8	8	8	8	8	11	11							8	12		10									
D.4	10	10	10	10	10	10	10	8							8		8									
D.5	9	9	9	9	9	11	11		11					11			14									
D.6	9	9	9	9	9	11	11		10			10	10	12		14		8								
D.7	13	13	13	13	10	11	11										14									
D.8	10	10	9	9	9	11	11	11	8				8		12		8				8					
D.9	10	10	11	11	8	11	11	11	8				8	8	10		14	8	8		8					
D.10	10	10	10	10	10	11	11										14		10		8					
D.11	12	12	12	11	10	12	11	10	10					10	10		14	9	9		10					
D.12	10	10	10	10	10	11	11								10		14	8	8		8					
D.13	11	11	10	10	10	11	10	10	8				8	10			14	8	10		10					
D.14	8	8	8	8	10	11	11								11	12		14	9	9		8				
D.15	9	9	9	9	9	11	11								8	8		8	9	9		9				
D.16	9	9	9	9	9		11										14									
D.17							11										14									
D.18	9	9	9	9	9	11	11								8	11		14								
D.19	8	8	8	8	11	11	11	8								12		14								
D.20	8	8	8	8		8	11	8								8		14			8					
D.21	12	12	12			12																				
E.1	10	10	10	10	10	11	11	8						8	12		14		9		11					
E.2	13	13	13	13	9	11	11	8	8				8	8	12		14	10	10		8					
E.3	11	11	11	11	11	11	11	11	11							11	12									
E.4	9	9	9	9	9	11	11										14									
E.5	8	8	8	8	8	11	11								11	12		14		9		9				
E.6	14	14	14	14	14	10	10										14									
E.7	13	13	13														14									
E.8	13	13	13														14									
E.9	14	14	14																							
F.1	13	13	13	11	10	11	11	11	10					8		8		14		11		11				
F.2	11	11	9	9	9	11	11	9					9		10		14		8							
F.3	13	13	13	11	8	11	11	8	8					8	12		14		8		8					
F.4	14	14	14														14									
G.1							11										11									
G.2							11	11									8									
H.1	8	8											8				8									
H.2	11	11	11		11	11	11			11			11	11		11	11					11	11	11		
H.3	11	11	11			11								11												
H.4	11	11	11			11	11			11				11			11							11		
H.5	11	11	11		11	11	11			11	11			11			11						11	11	11	
H.6																	14									
H.7																	14									
H.8																	14									
H.9																	14									
H.10																	14									
I.1	11	11	11	8	8	8	8	8	8								8		8		8					
I.2	11	11	8	8	8	8	8	8	8				8	8			8		8		8					

A.1.ab

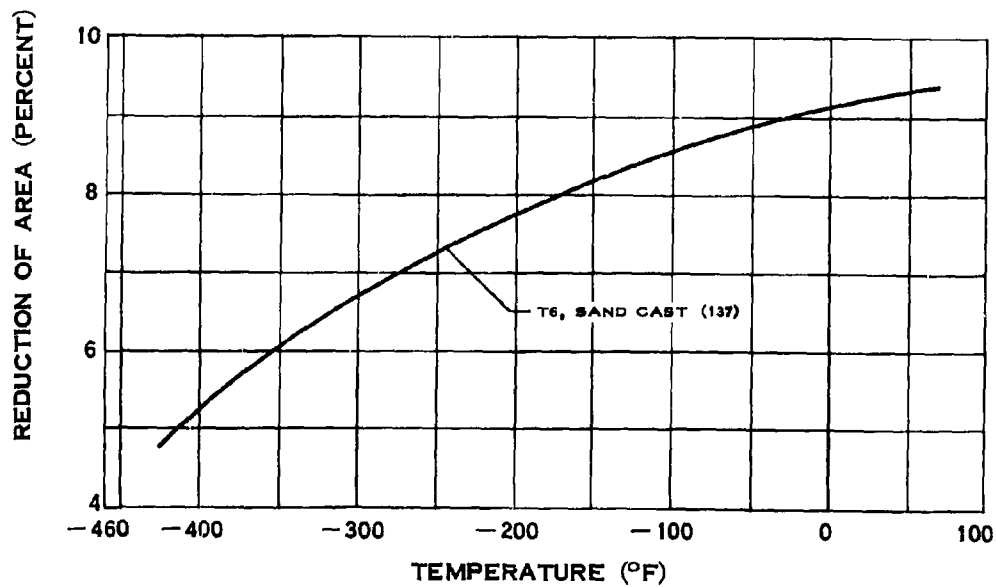


STRENGTH OF TENS-50 ALUMINUM

A.1.cd

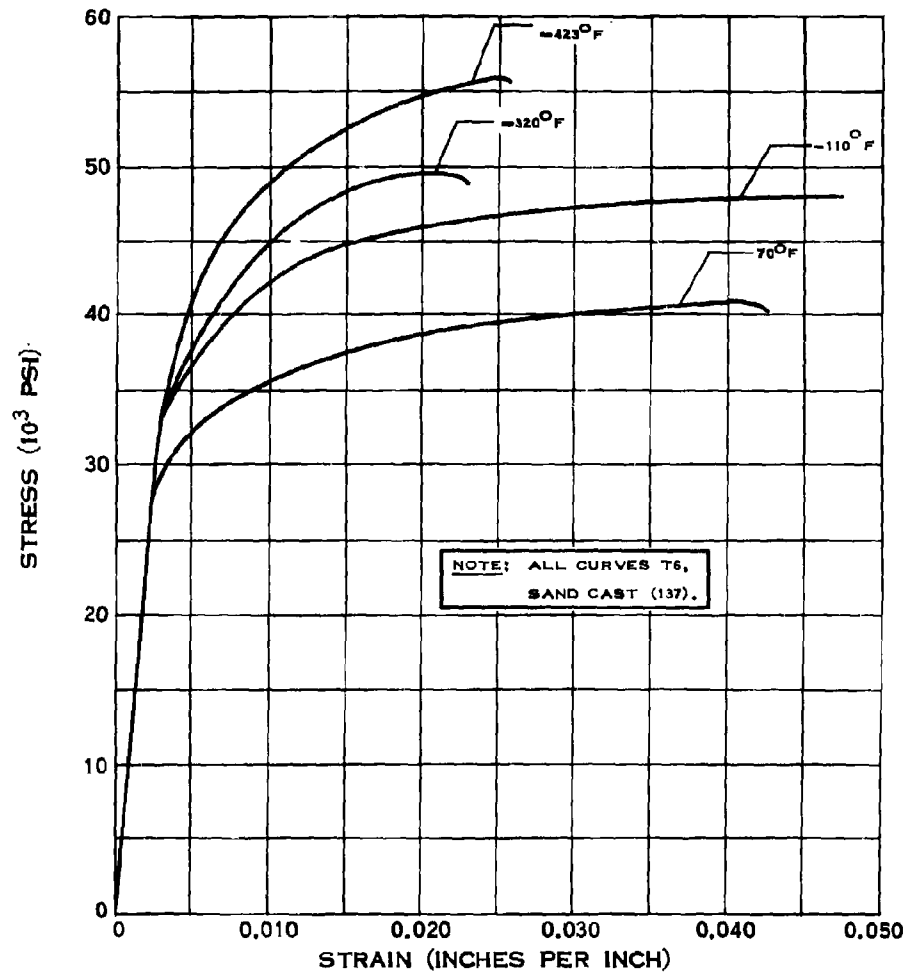


ELONGATION OF TENS-50 ALUMINUM



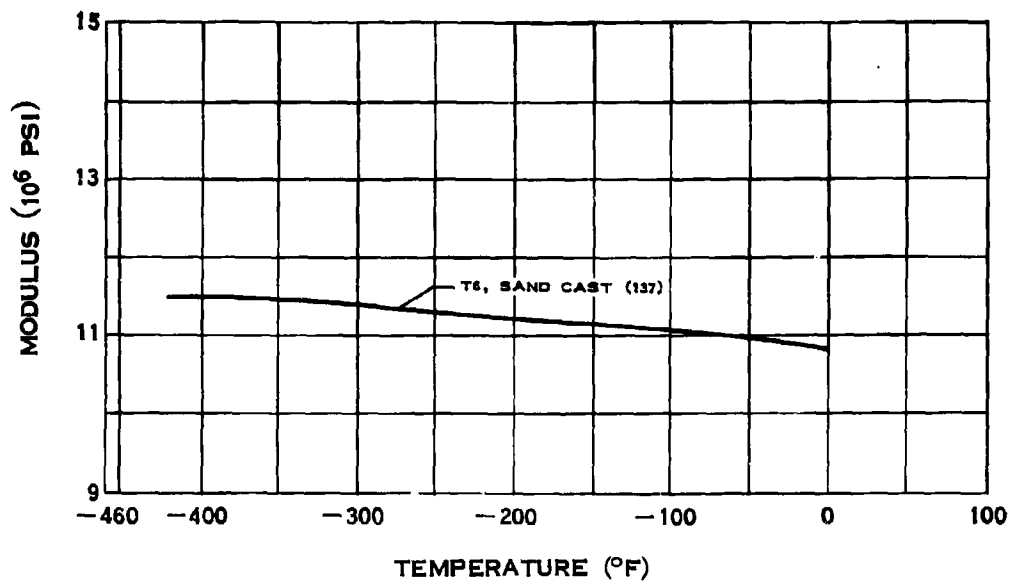
REDUCTION OF AREA OF TENS-50 ALUMINUM

A.1.e

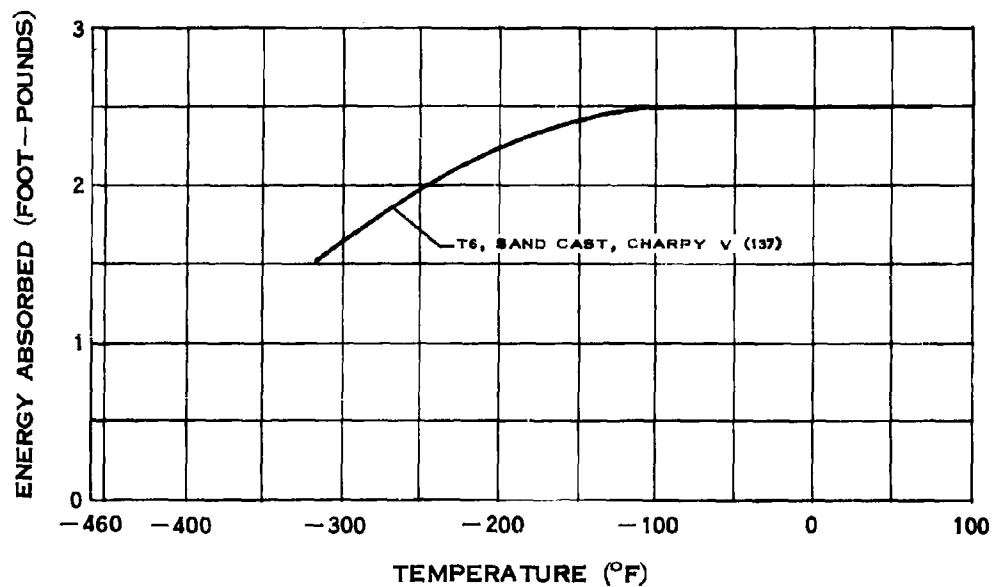


STRESS-STRAIN DIAGRAM FOR TENS-50 ALUMINUM

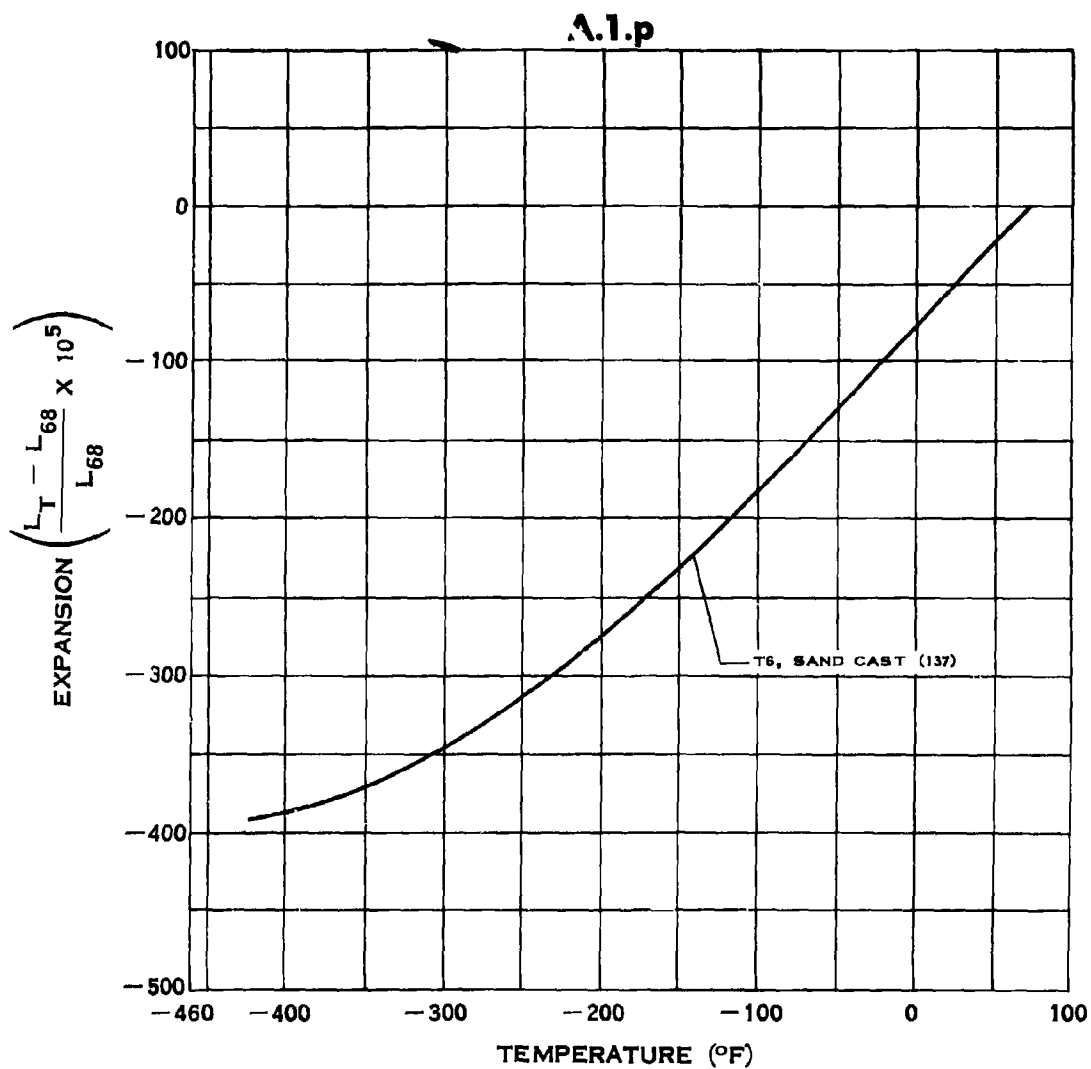
A.1.fg



MODULUS OF ELASTICITY OF TENS-50 ALUMINUM

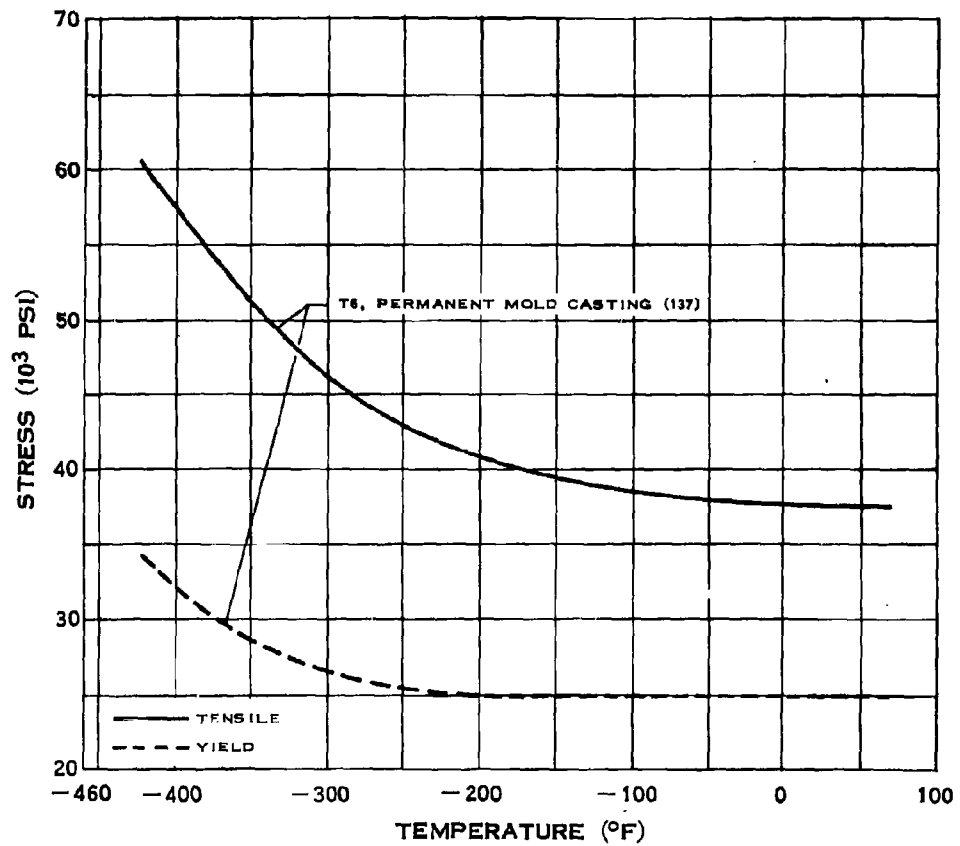


IMPACT ENERGY OF TENS-50 ALUMINUM



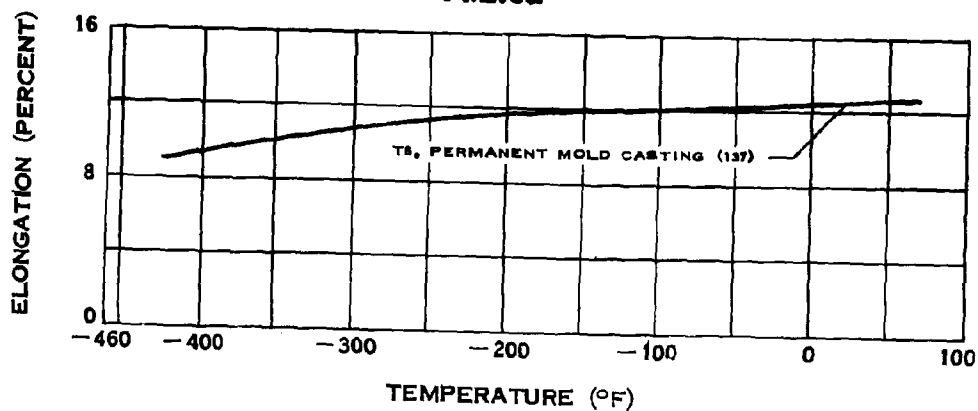
THERMAL EXPANSION OF TENS-50 ALUMINUM

A.2.ab

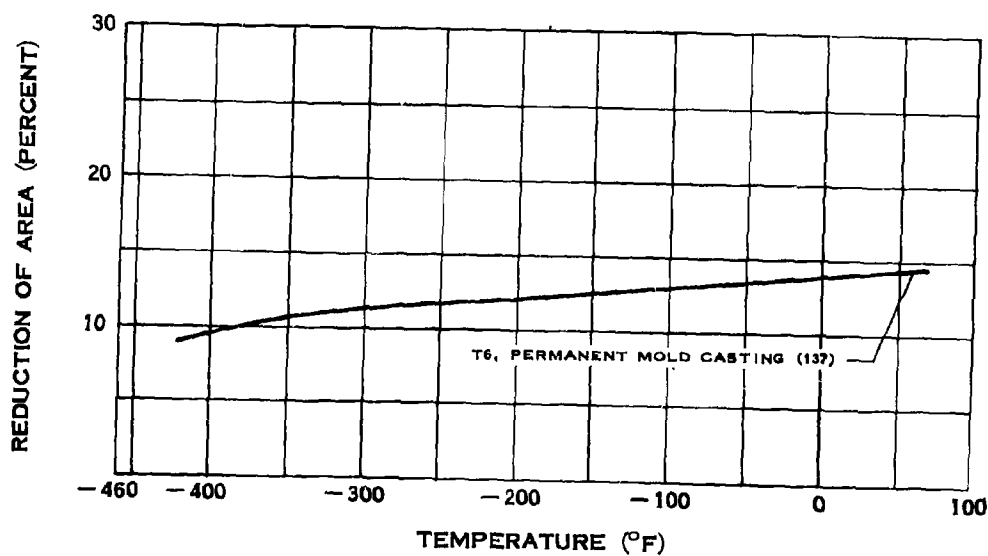


STRENGTH OF 356 ALUMINUM

A.2.cd

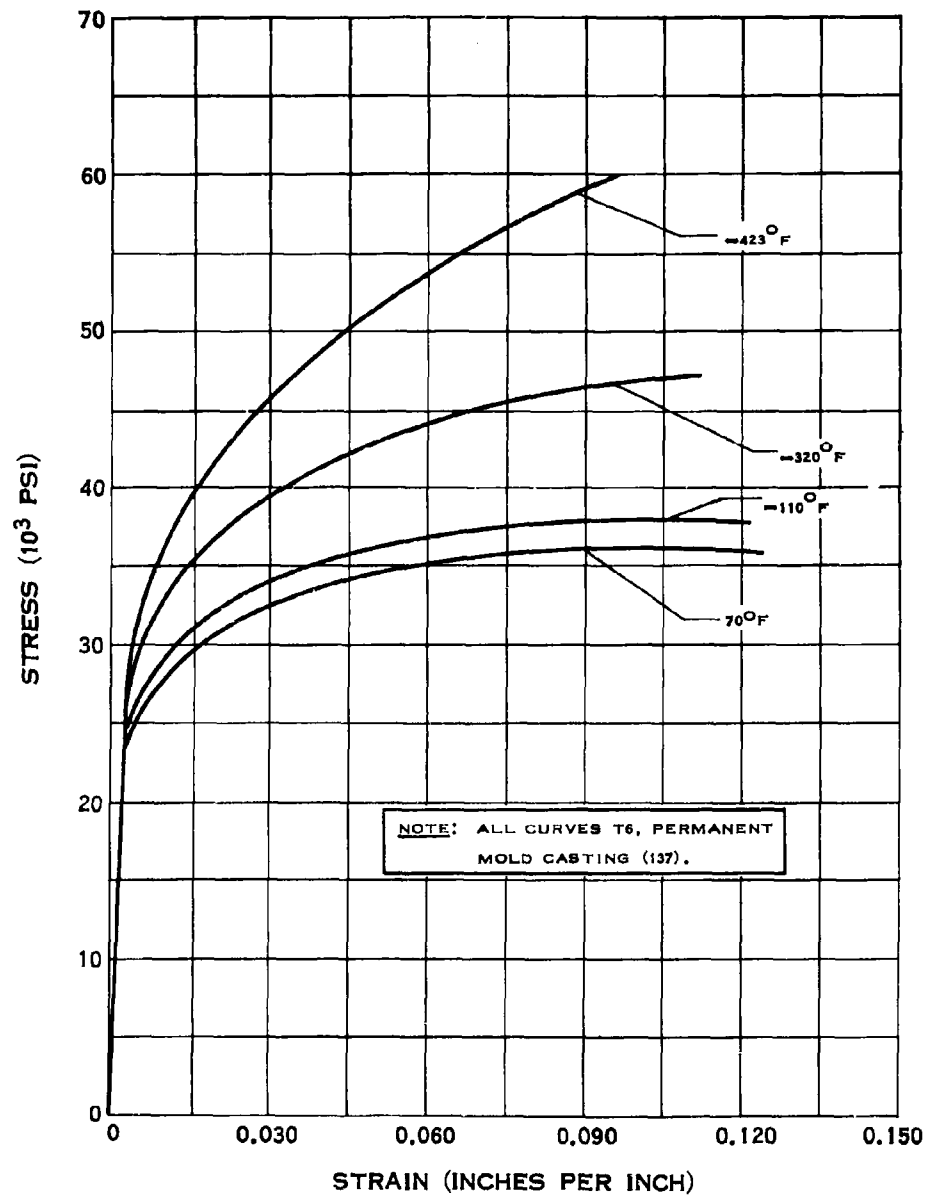


ELONGATION OF 356 ALUMINUM



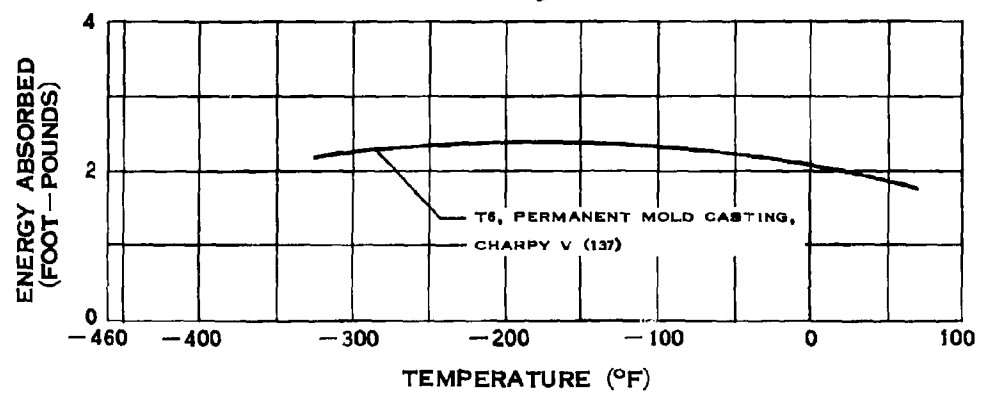
REDUCTION OF AREA OF 356 ALUMINUM

A.2.e

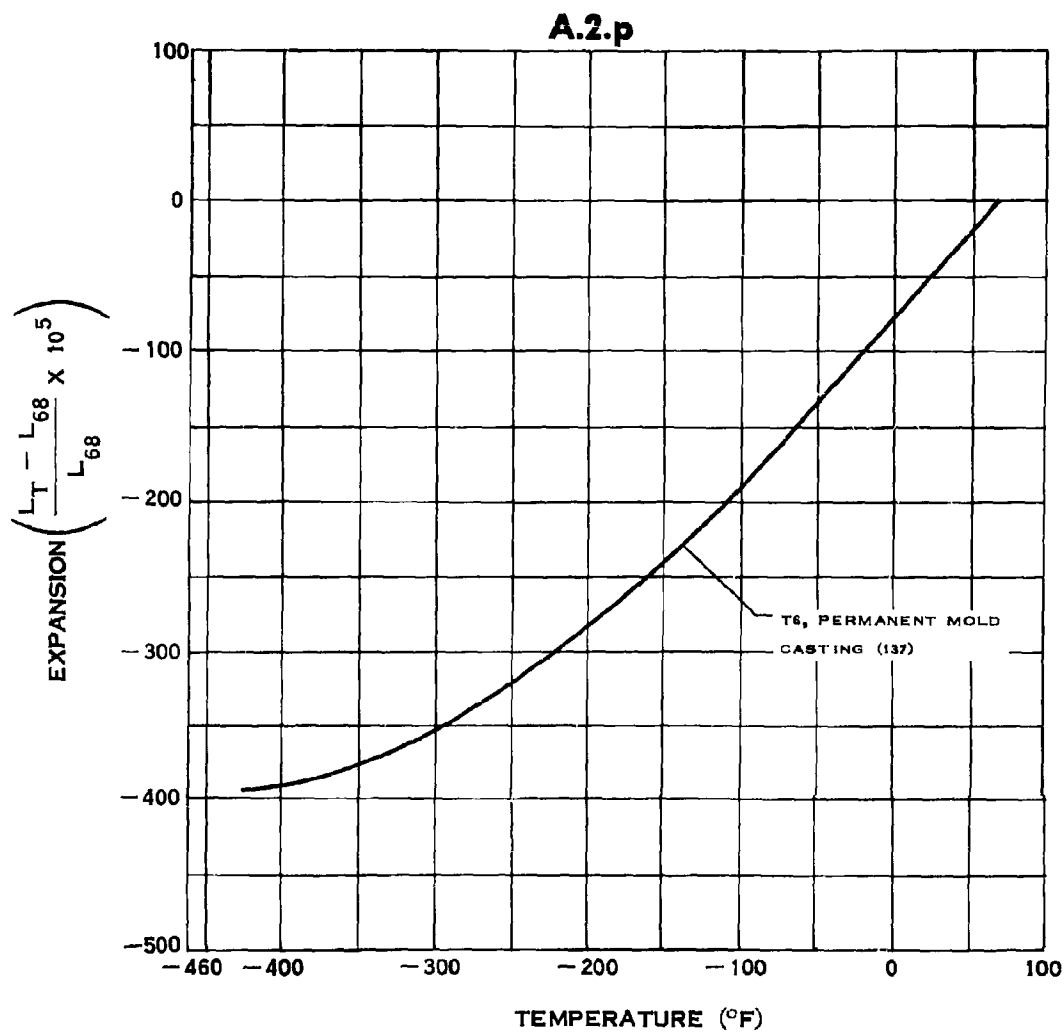


STRESS-STRAIN DIAGRAM FOR 356 ALUMINUM

A.2.g

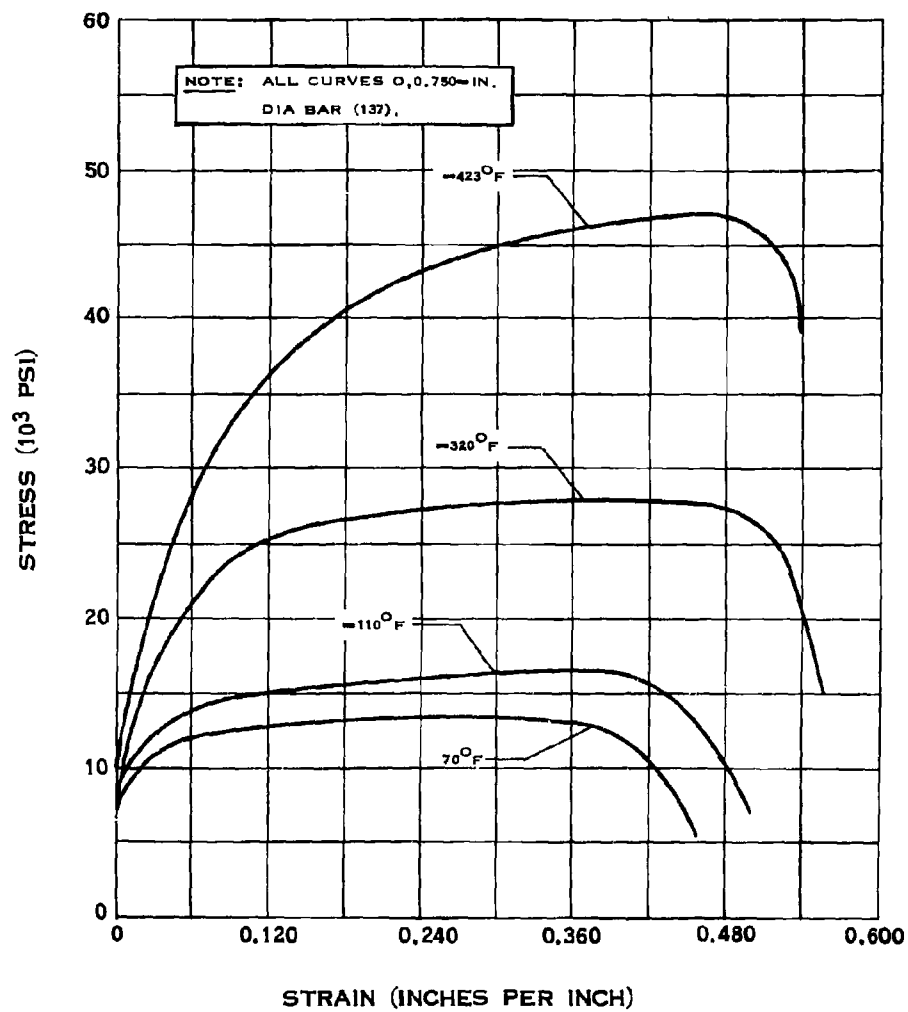


IMPACT ENERGY OF 356 ALUMINUM



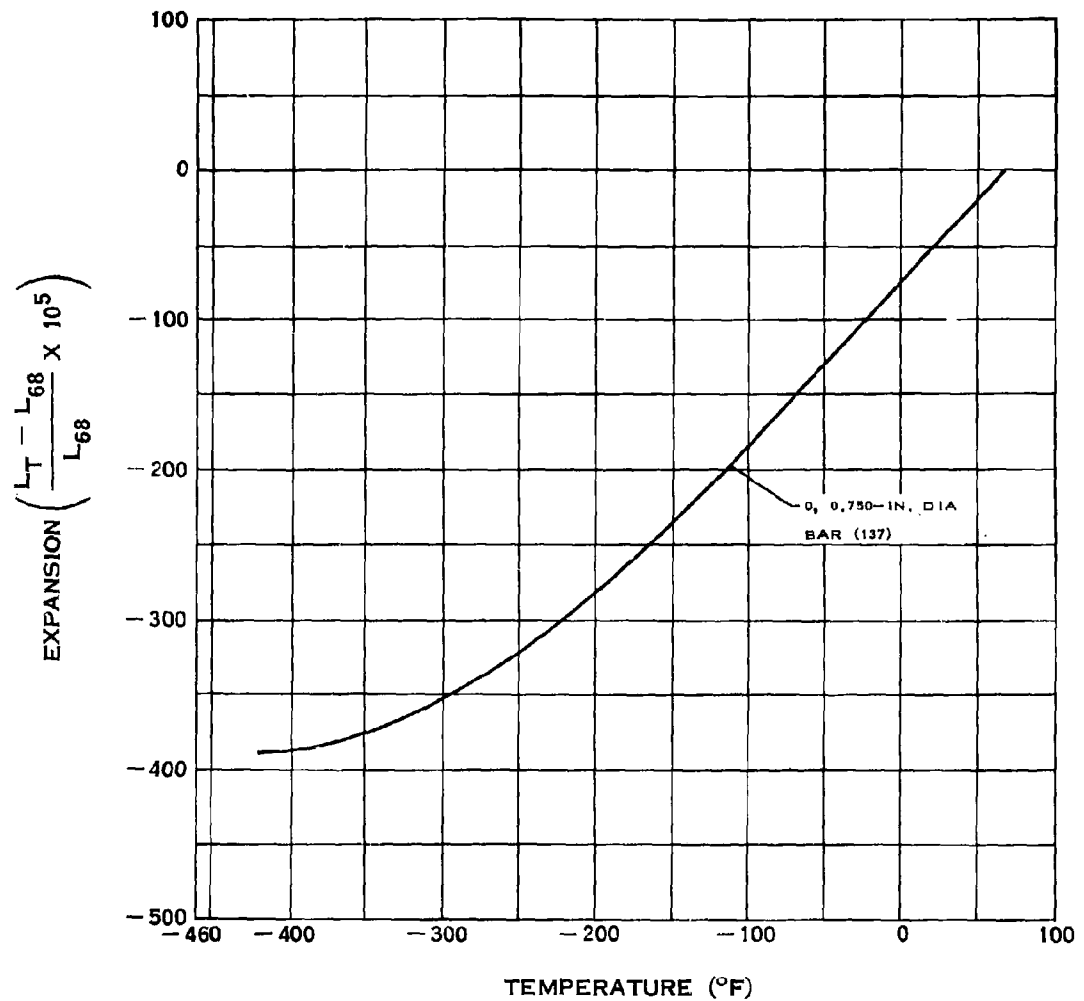
THERMAL EXPANSION OF 356 ALUMINUM

A.3.e



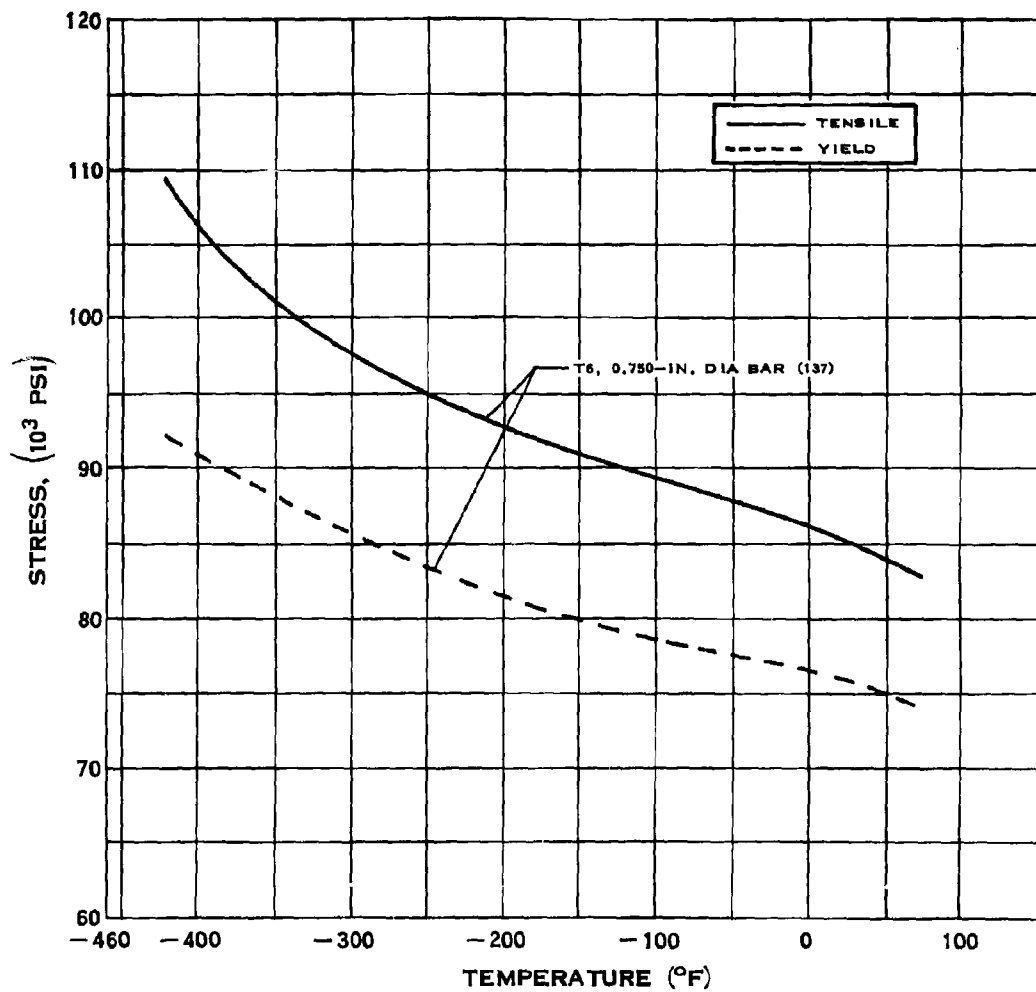
STRESS-STRAIN DIAGRAM FOR 1100 ALUMINUM

A.3.p



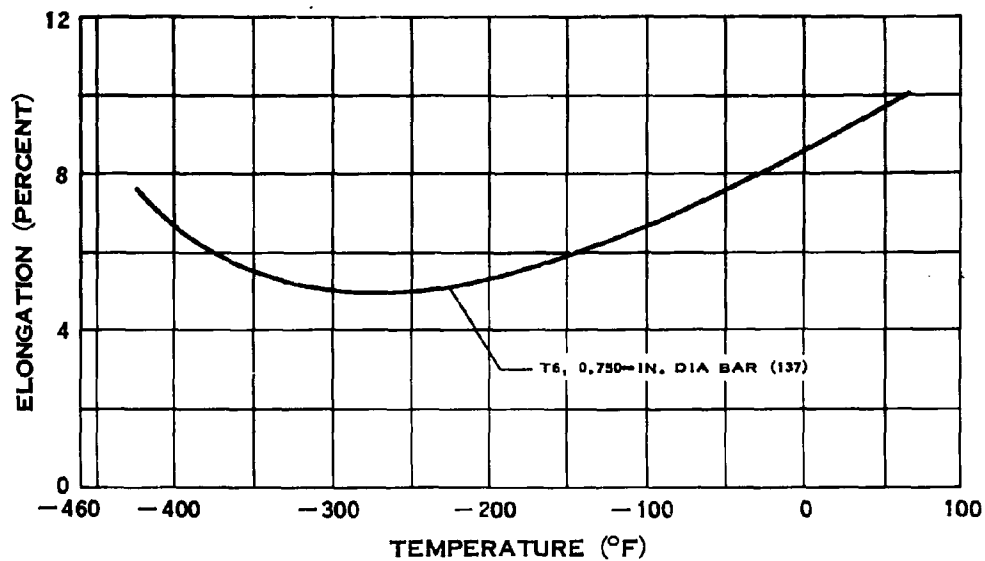
THERMAL EXPANSION OF 1100 ALUMINUM

A.4.ab

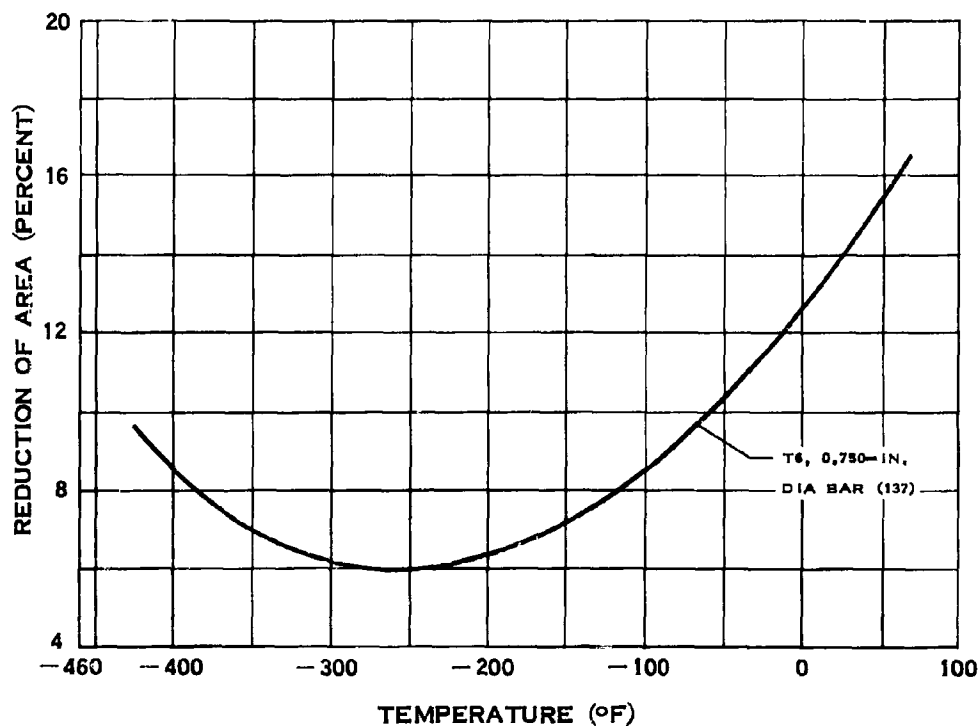


STRENGTH OF 2020 ALUMINUM

A.4.cd

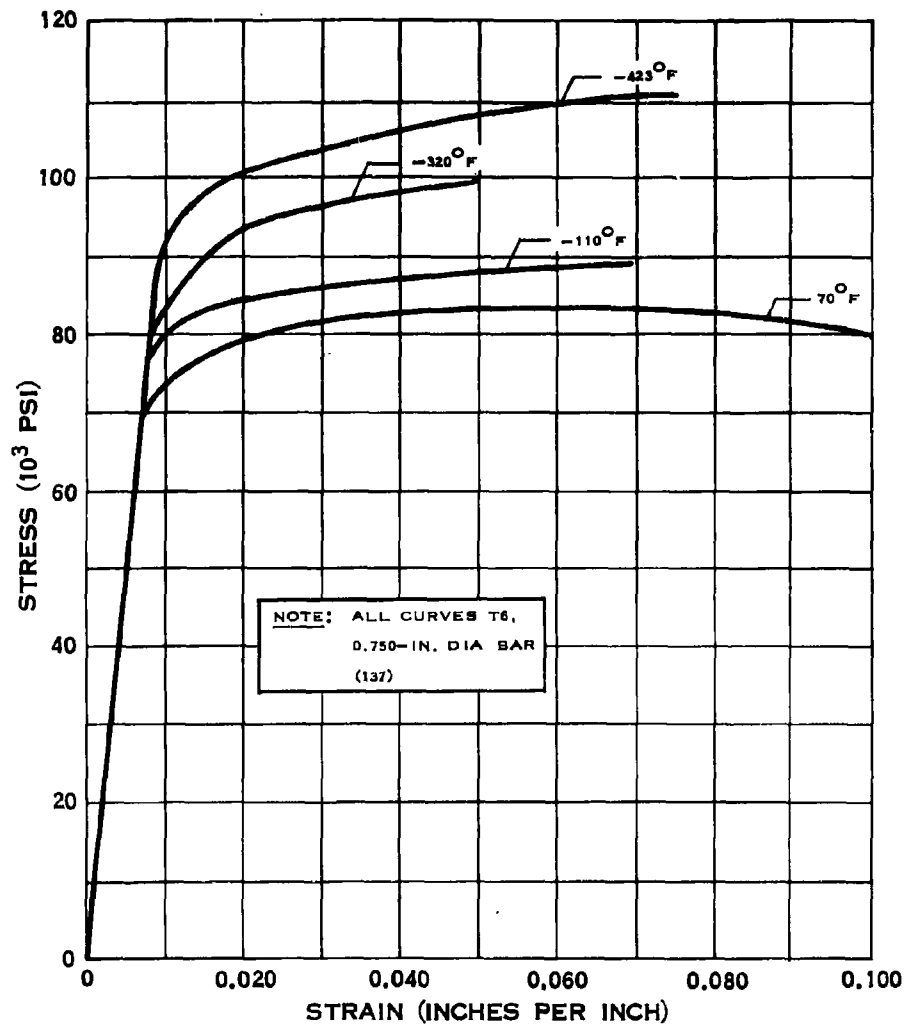


ELONGATION OF 2020 ALUMINUM



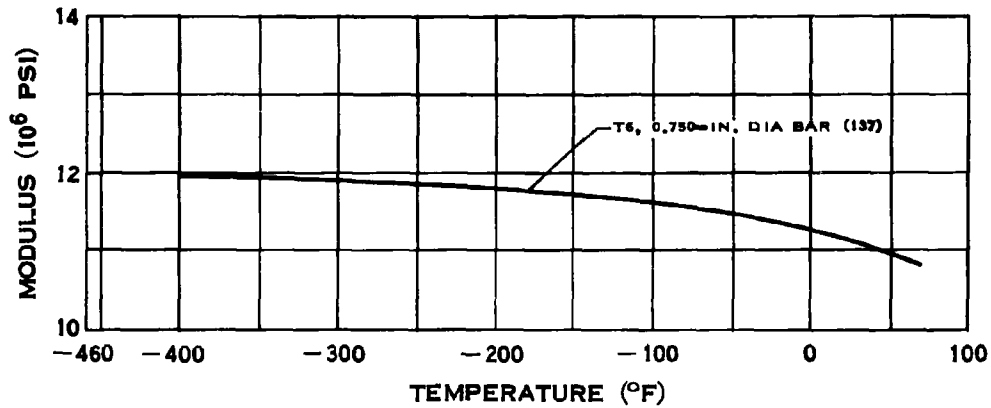
REDUCTION OF AREA OF 2020 ALUMINUM

A.4.e

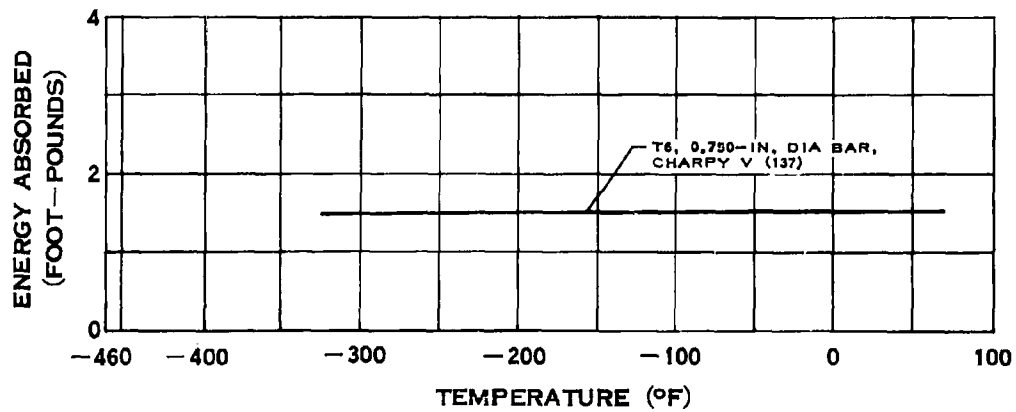


**STRESS - STRAIN DIAGRAM FOR 2020
ALUMINUM**

A.4.fg

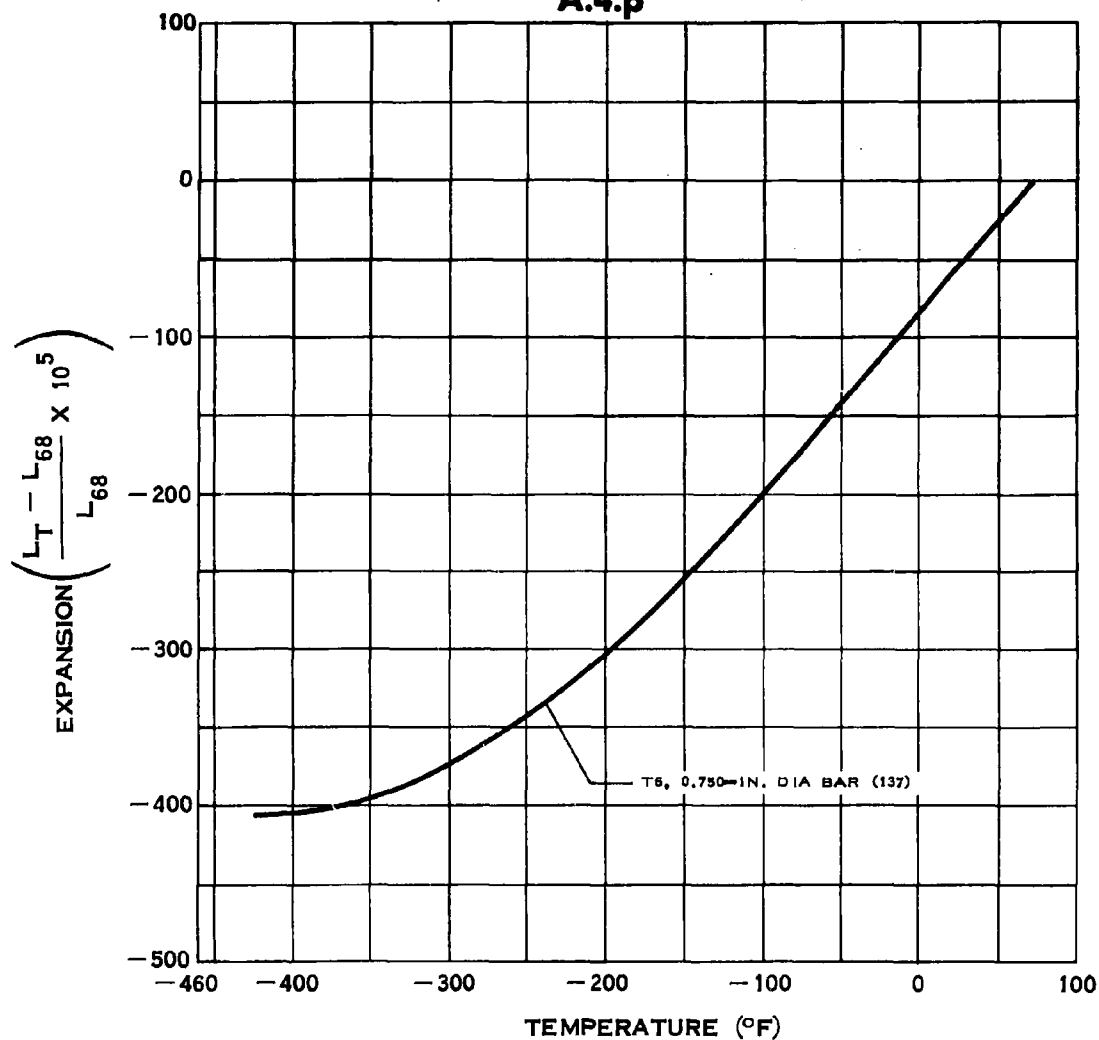


MODULUS OF ELASTICITY OF 2020 ALUMINUM



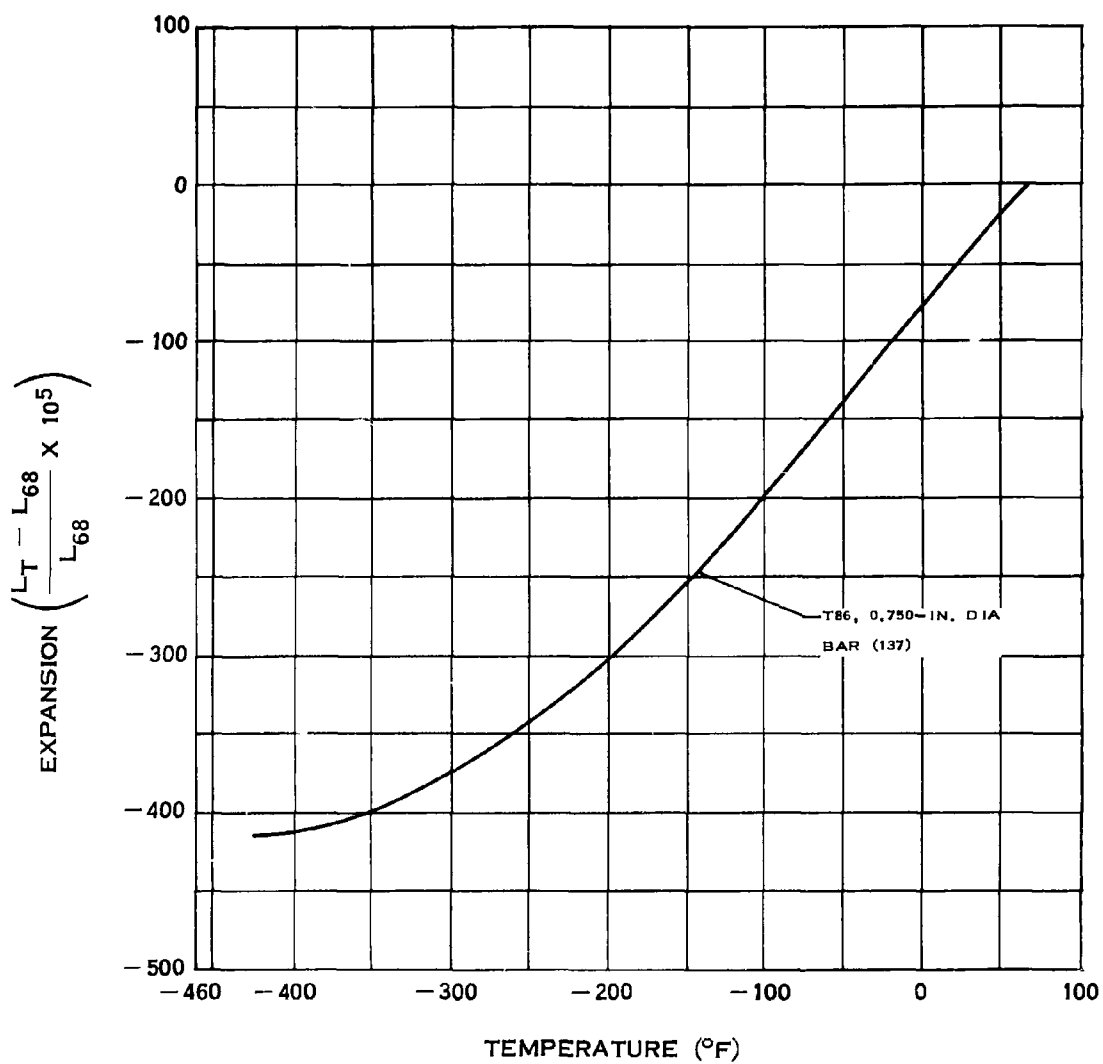
IMPACT ENERGY OF 2020 ALUMINUM

A.4.p



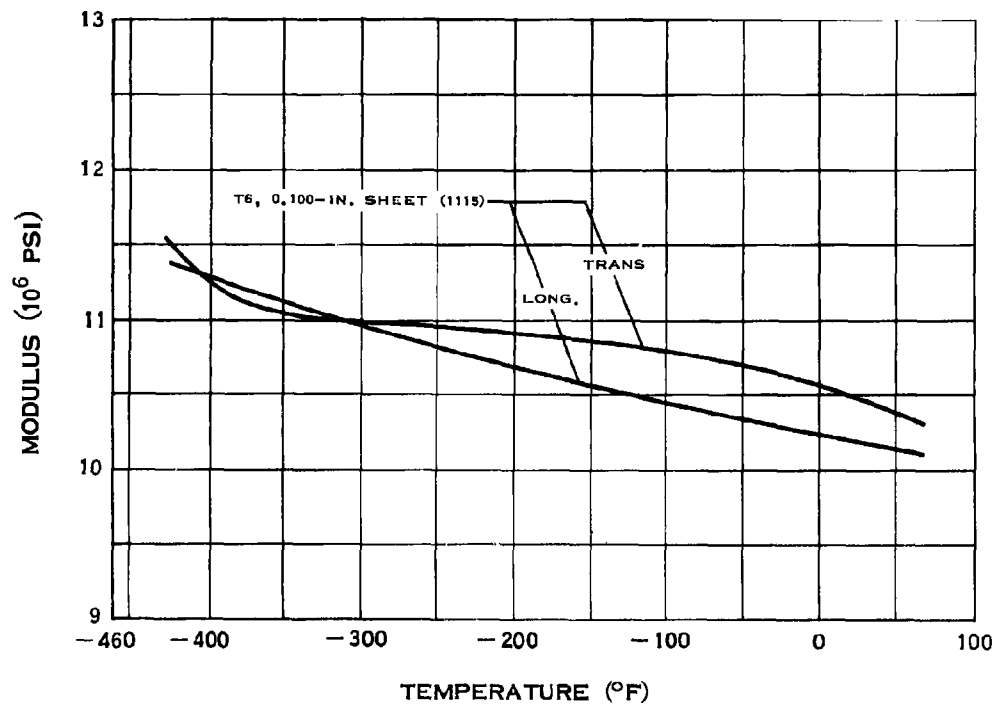
THERMAL EXPANSION OF 2020 ALUMINUM

A.5.p



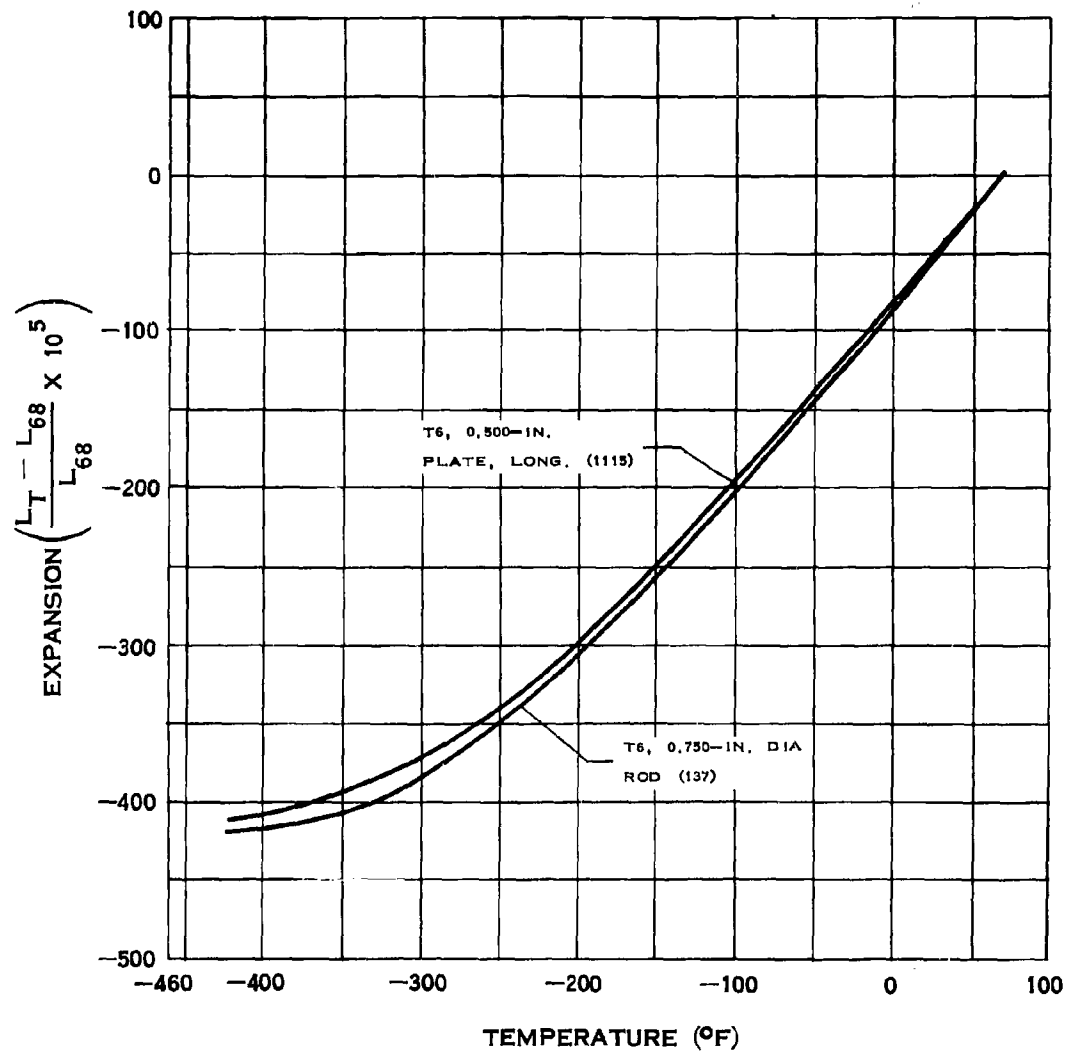
THERMAL EXPANSION OF 2024 ALUMINUM

A.6.f



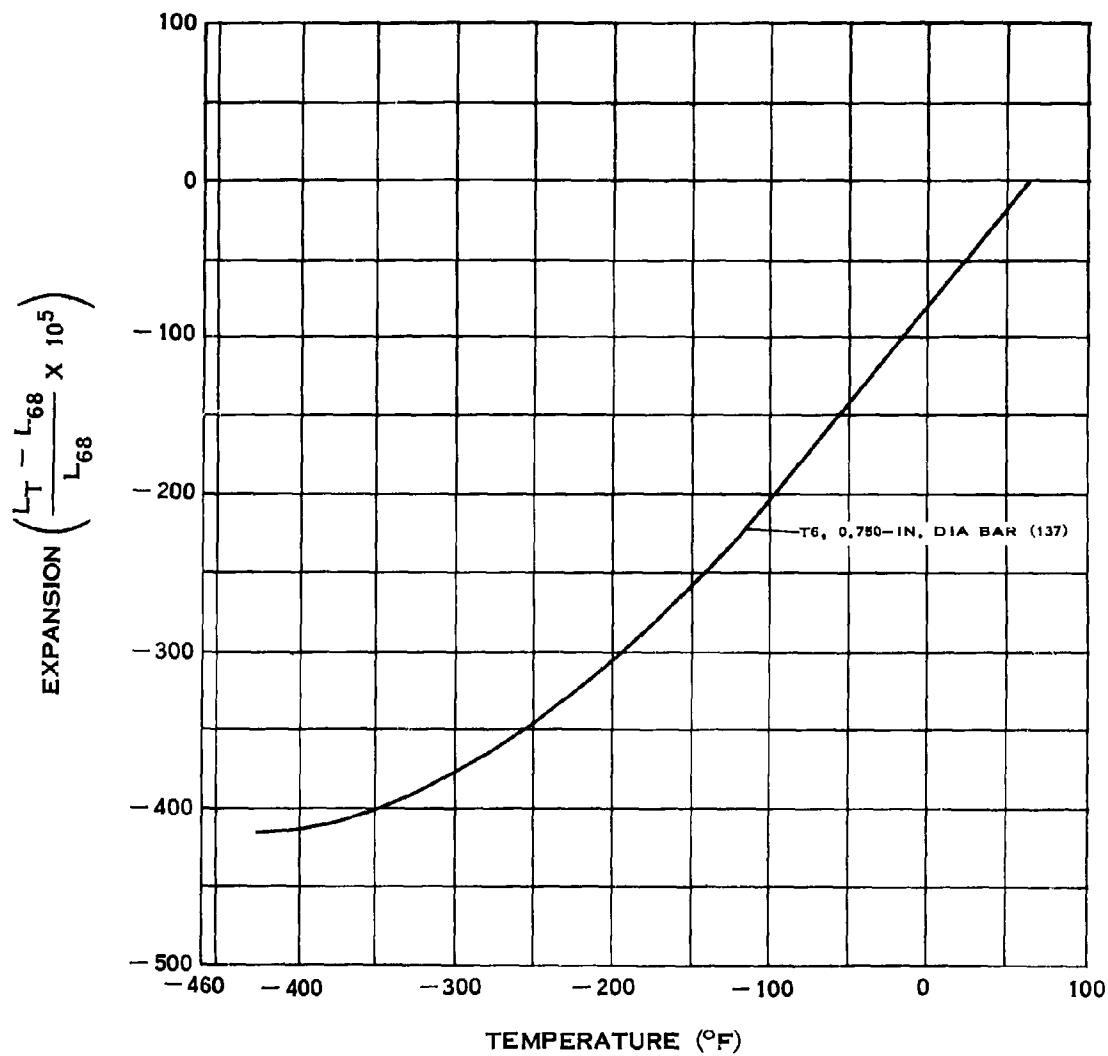
MODULUS OF ELASTICITY OF 6061 ALUMINUM

A.6.p



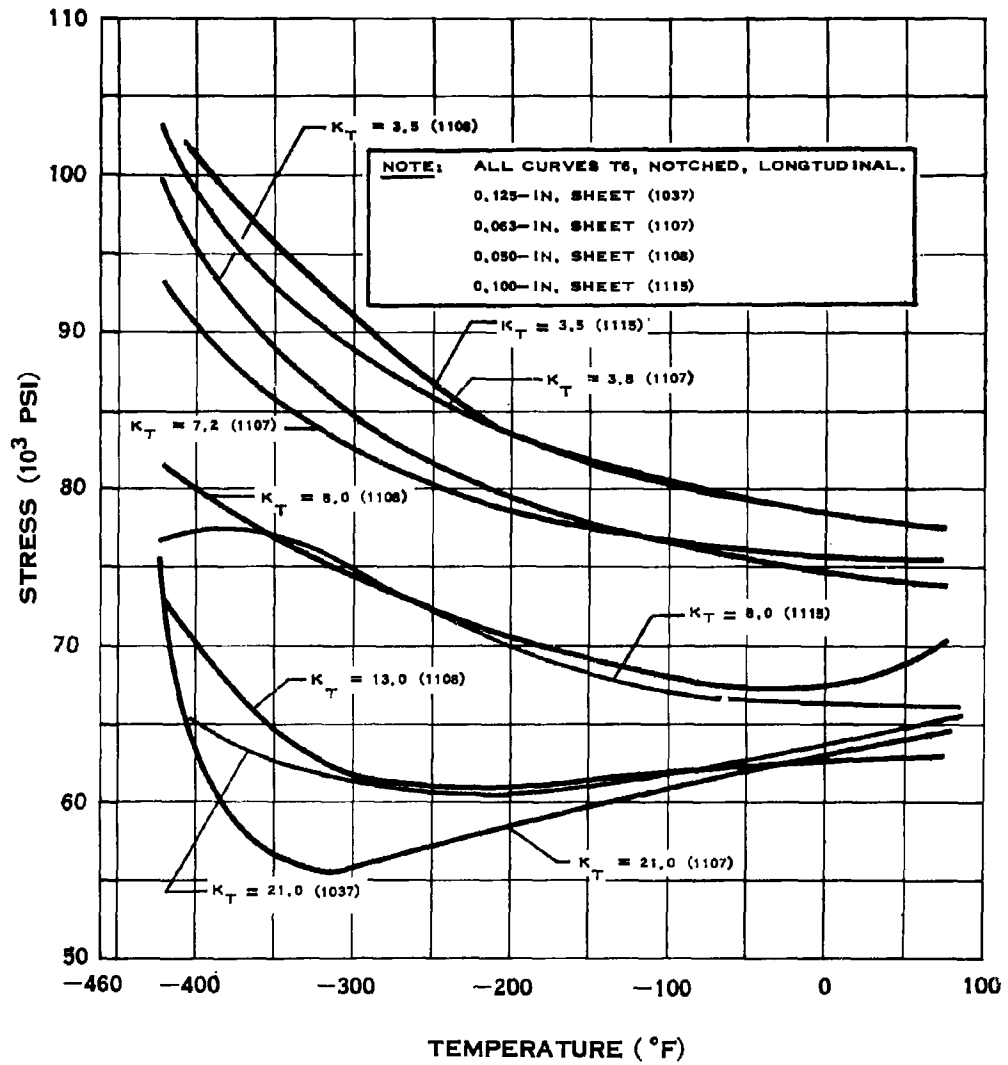
THERMAL EXPANSION OF 6061 ALUMINUM

A.7.p



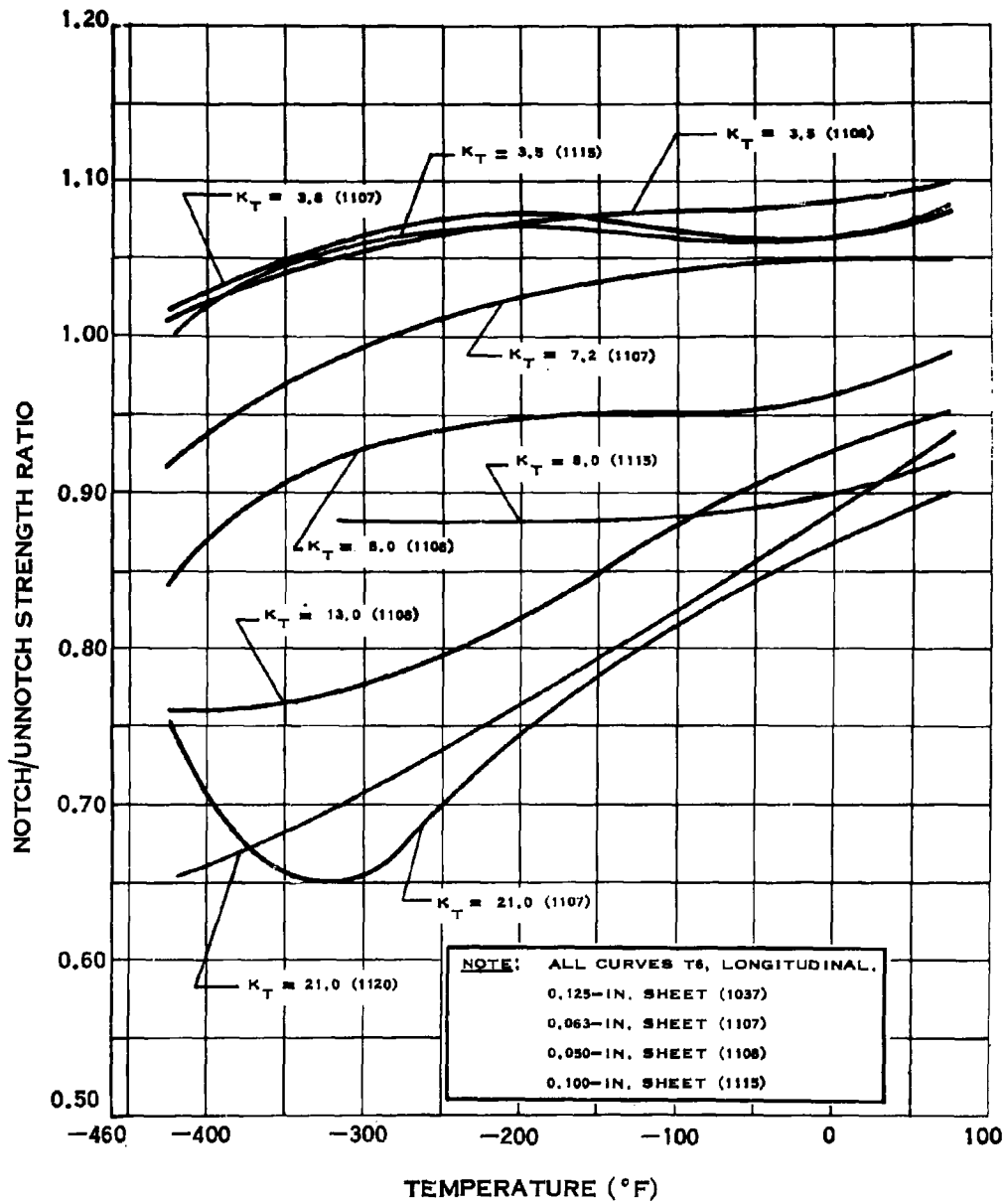
THERMAL EXPANSION OF 7075 ALUMINUM

A.8.b-1



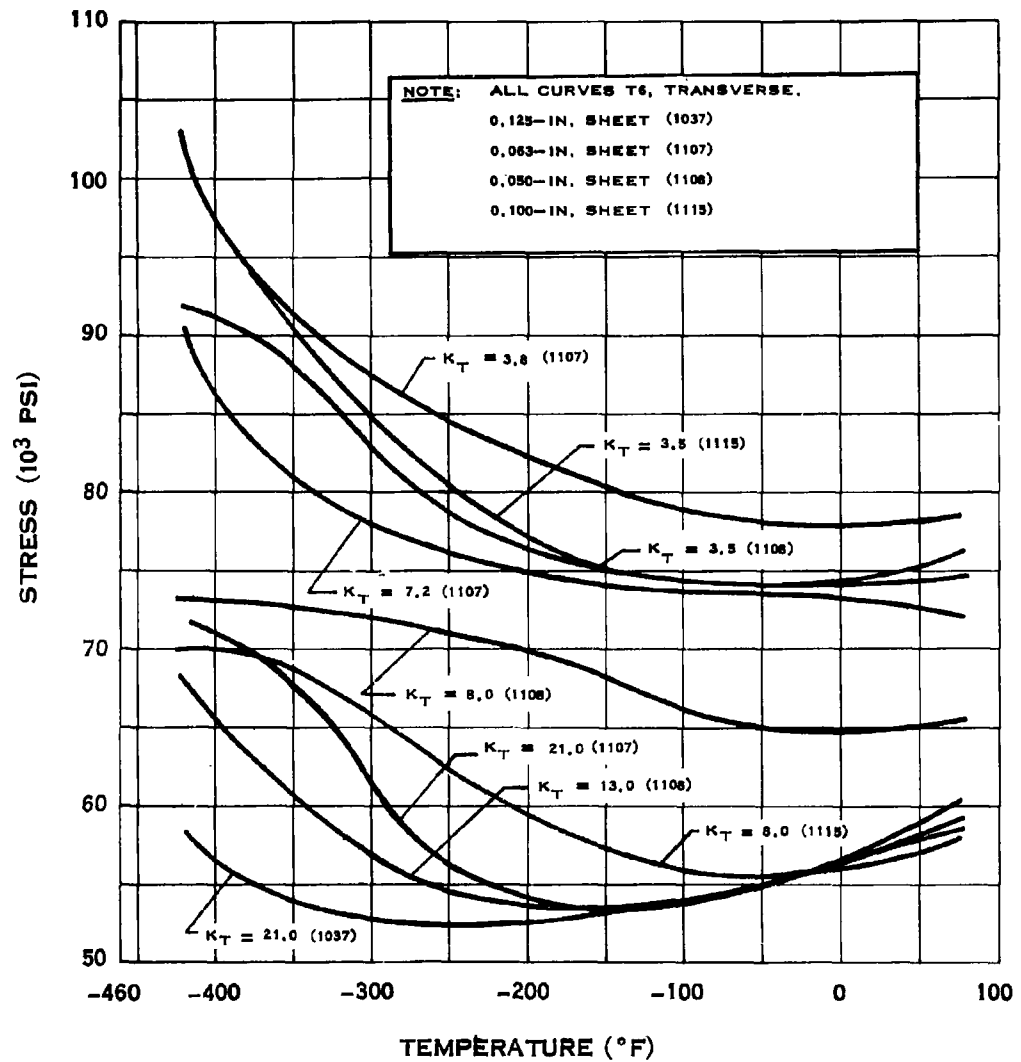
NOTCH TENSILE STRENGTH OF 2014 ALUMINUM

A.8.b-2



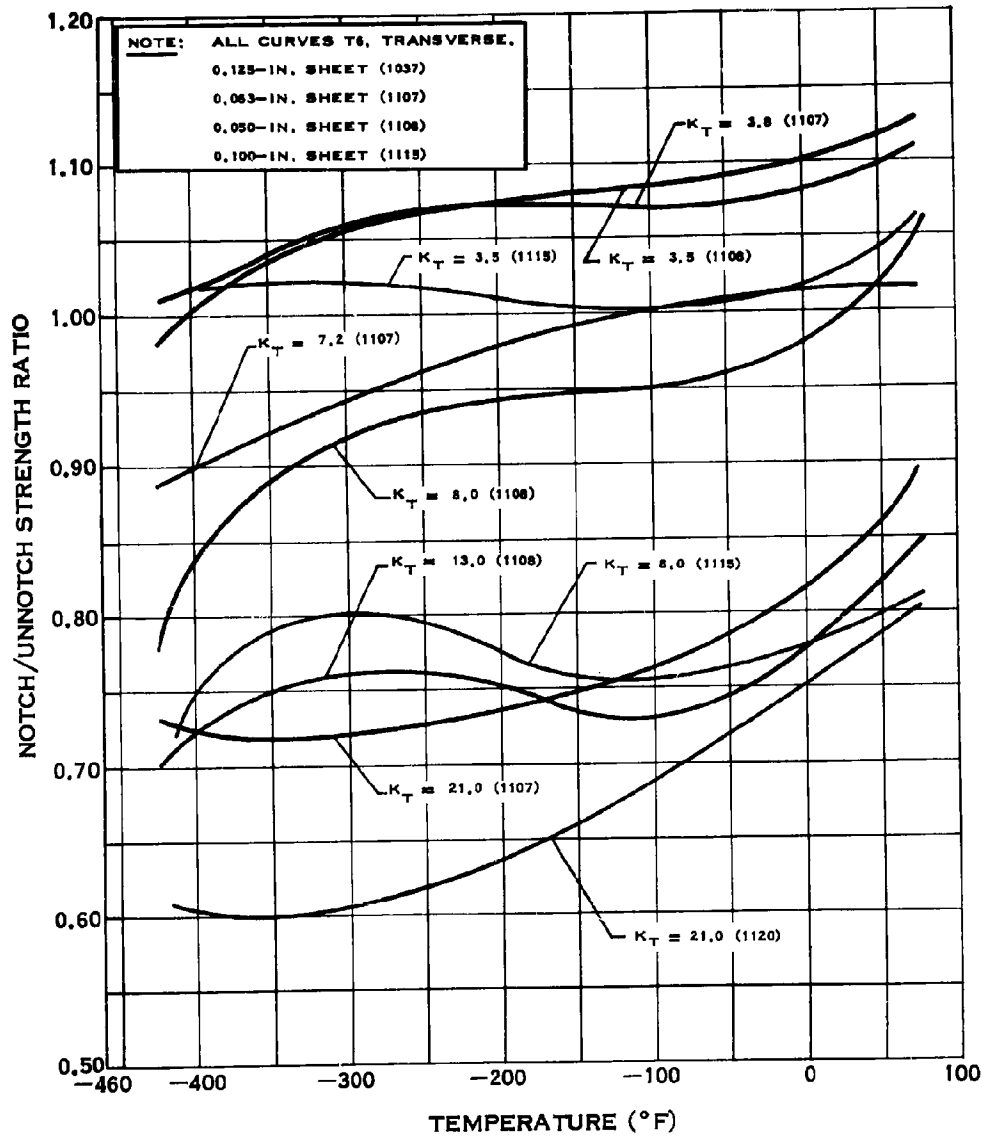
NOTCH STRENGTH RATIO OF 2014 ALUMINUM

A.8.b-3



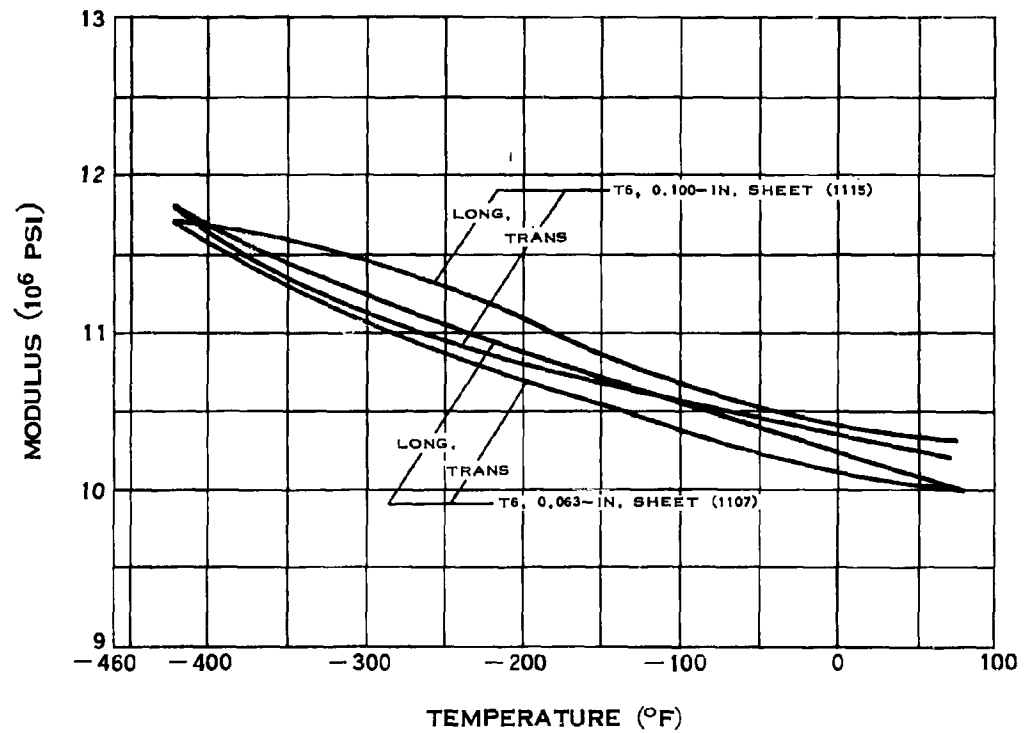
NOTCH TENSILE STRENGTH OF 2014 ALUMINUM

A.8.b-4



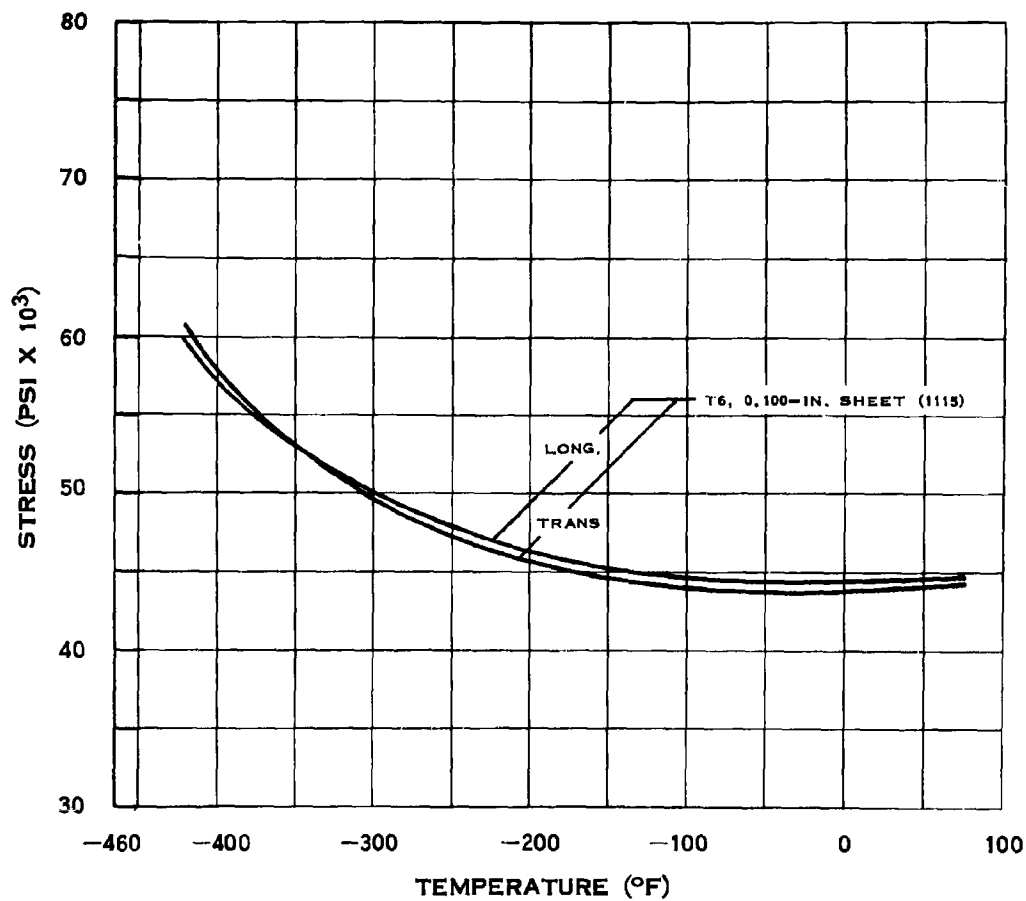
NOTCH STRENGTH RATIO OF 2014 ALUMINUM

A.8.f



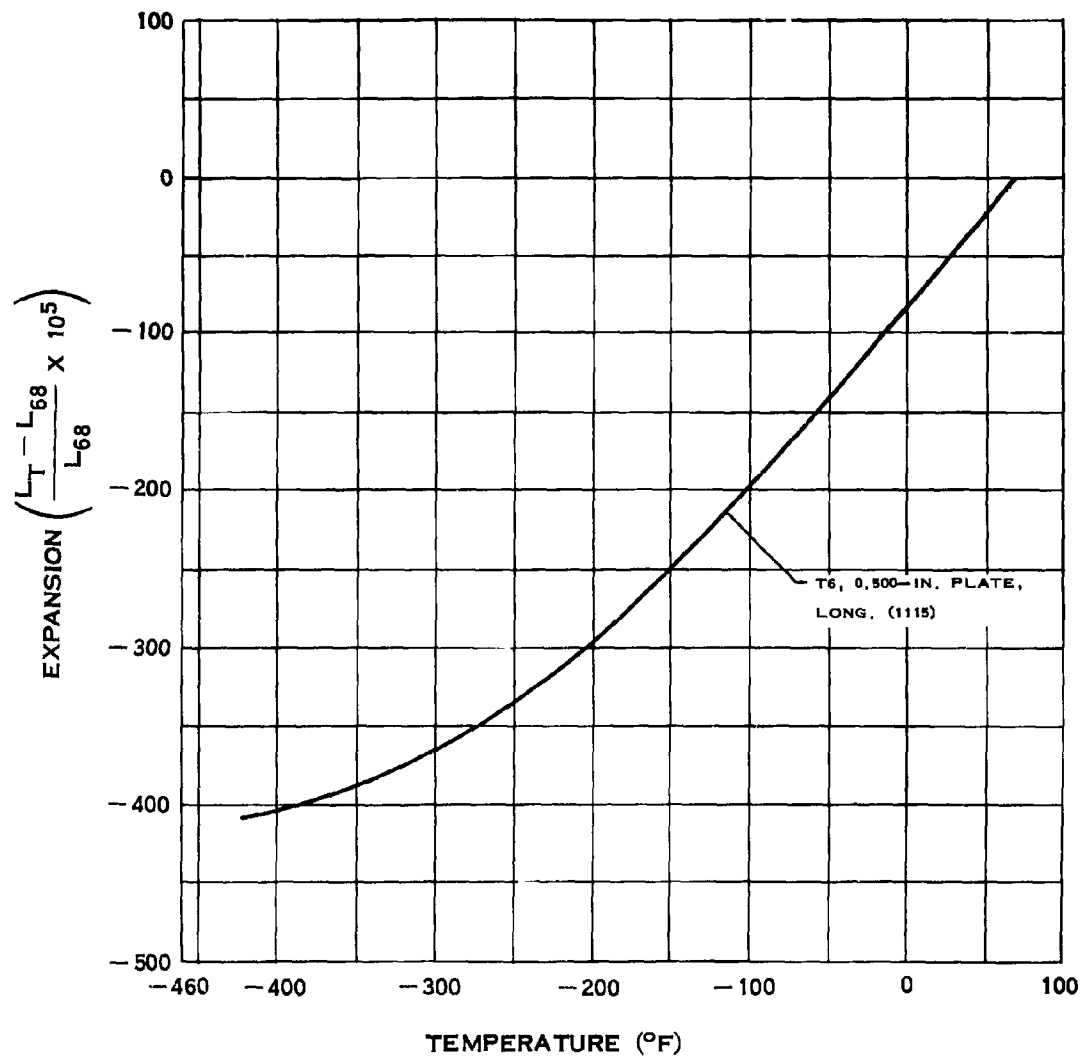
MODULUS OF ELASTICITY OF 2014 ALUMINUM

A.8.1



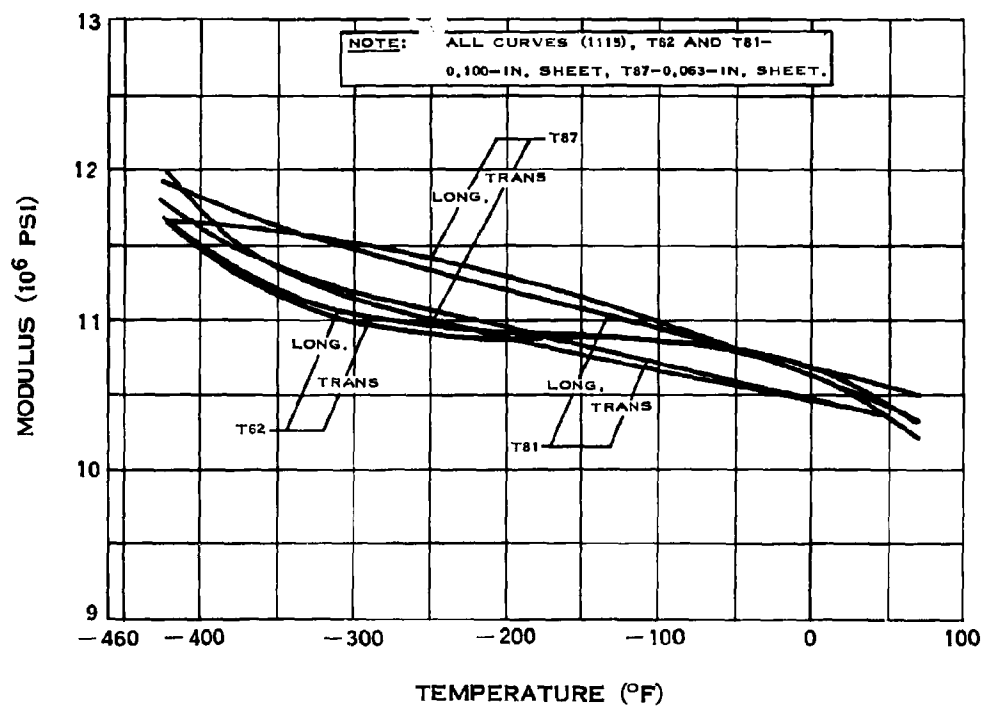
SHEAR STRENGTH OF 2014 ALUMINUM

A.8.p



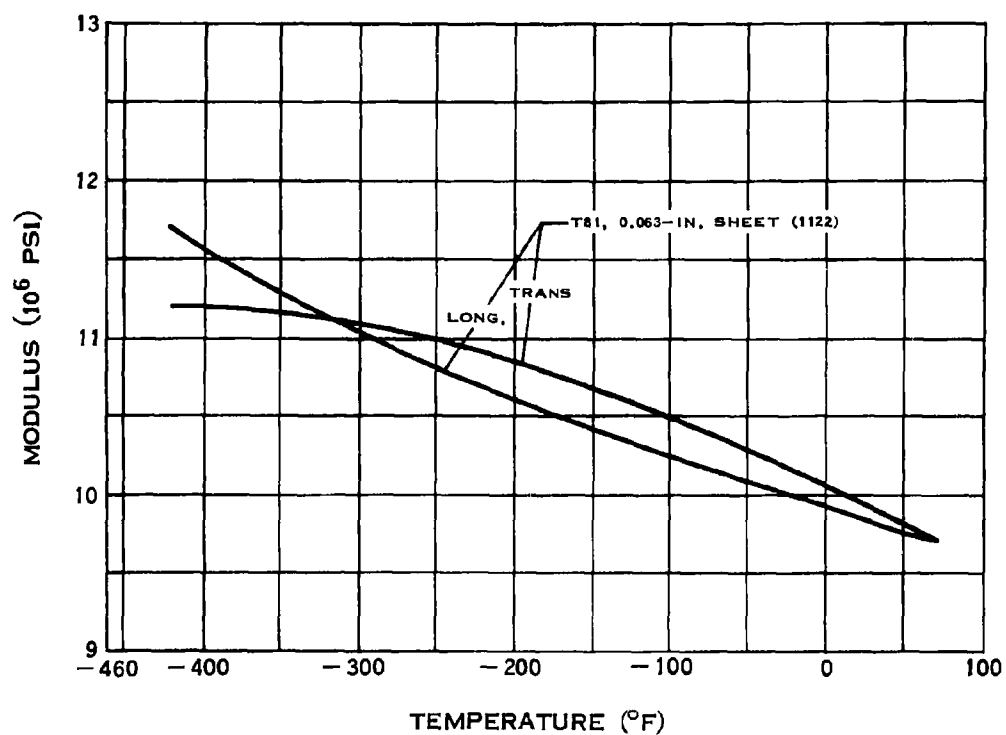
**THERMAL EXPANSION OF 2014
ALUMINUM**

A.9.f



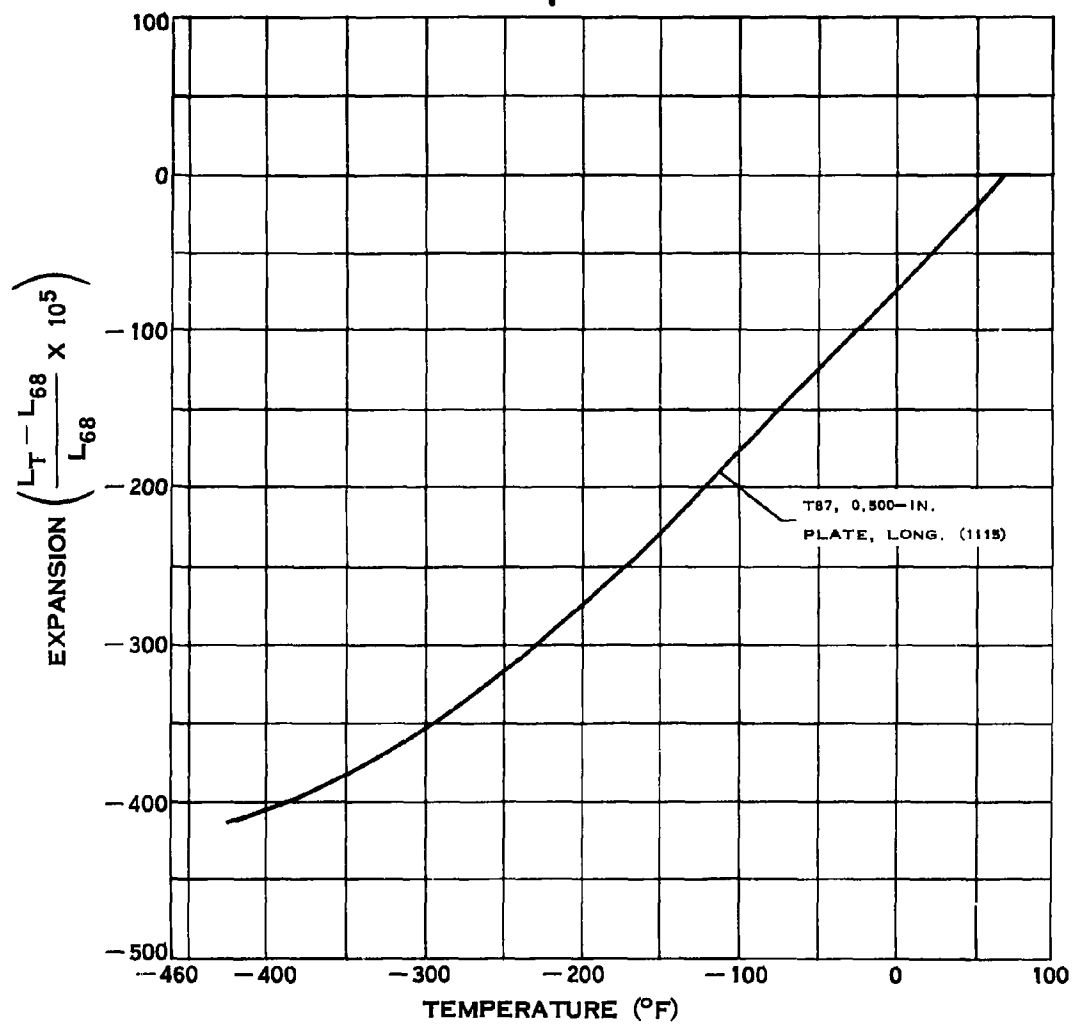
MODULUS OF ELASTICITY OF 2219 ALUMINUM

A.9.f-1



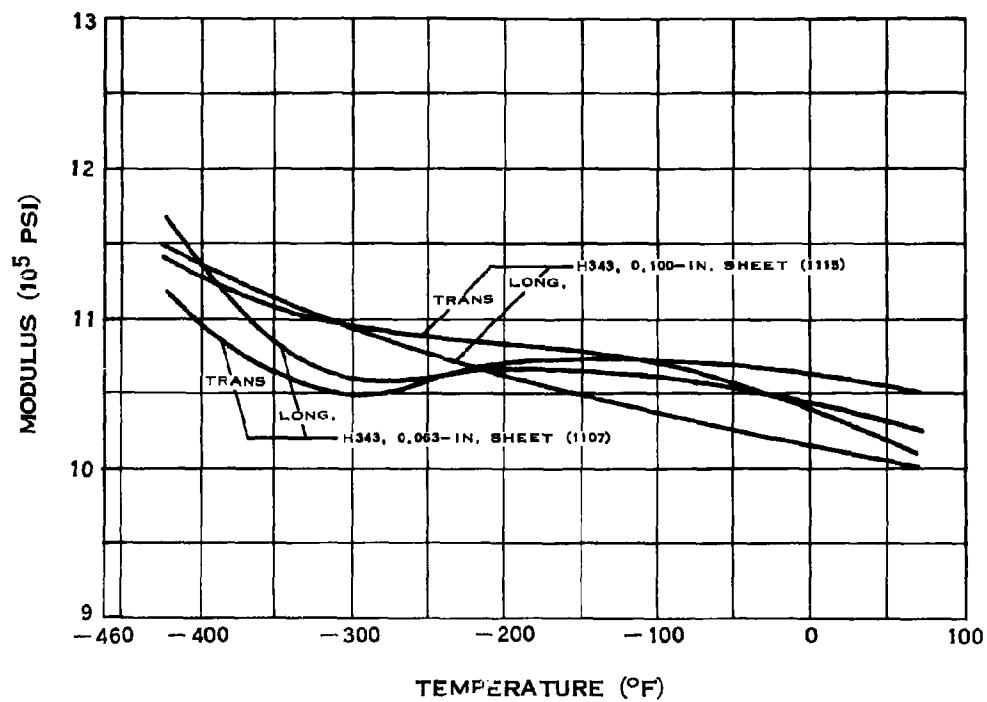
MODULUS OF ELASTICITY OF 2219 ALUMINUM

A.9.p

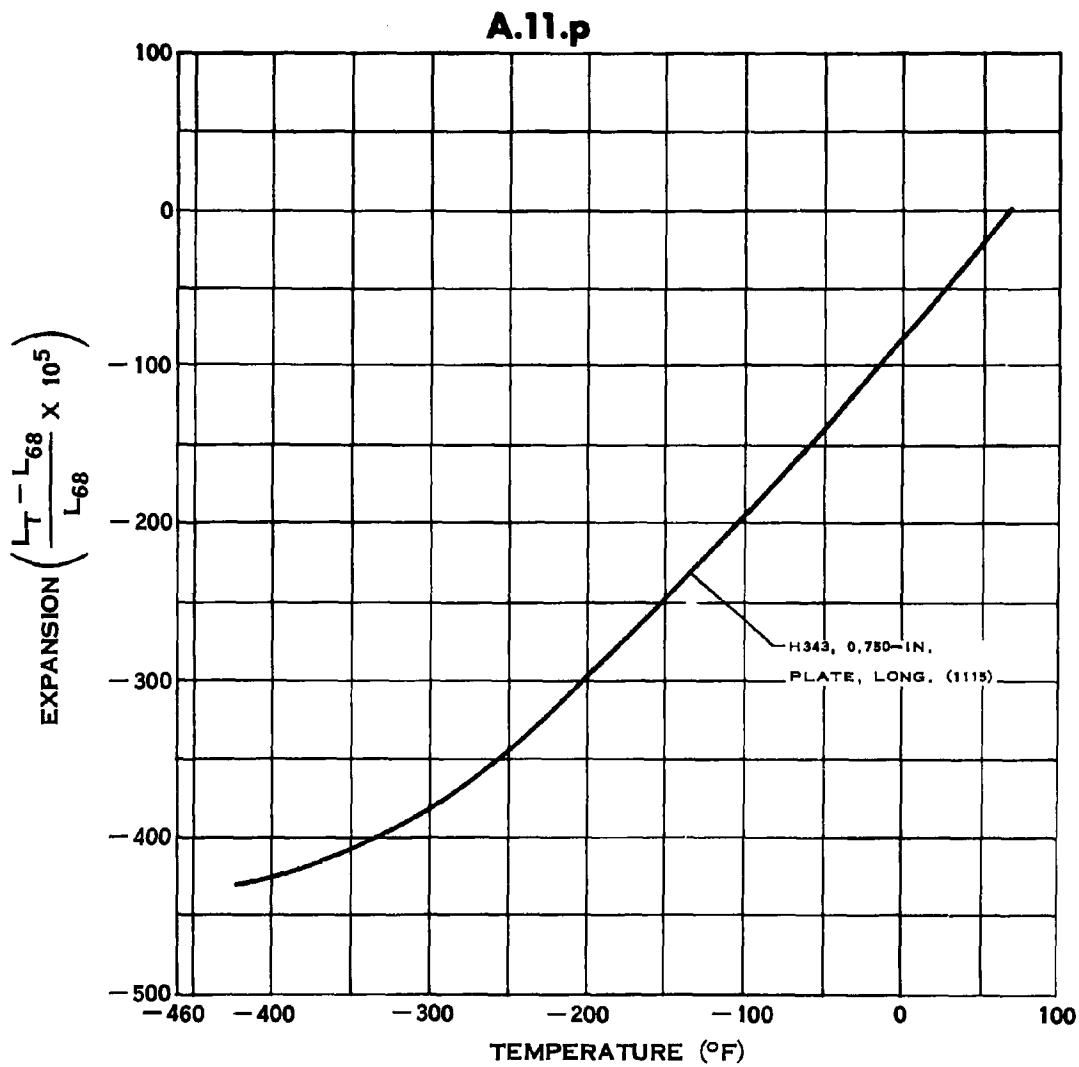


THERMAL EXPANSION OF 2219 ALUMINUM

A.11.f

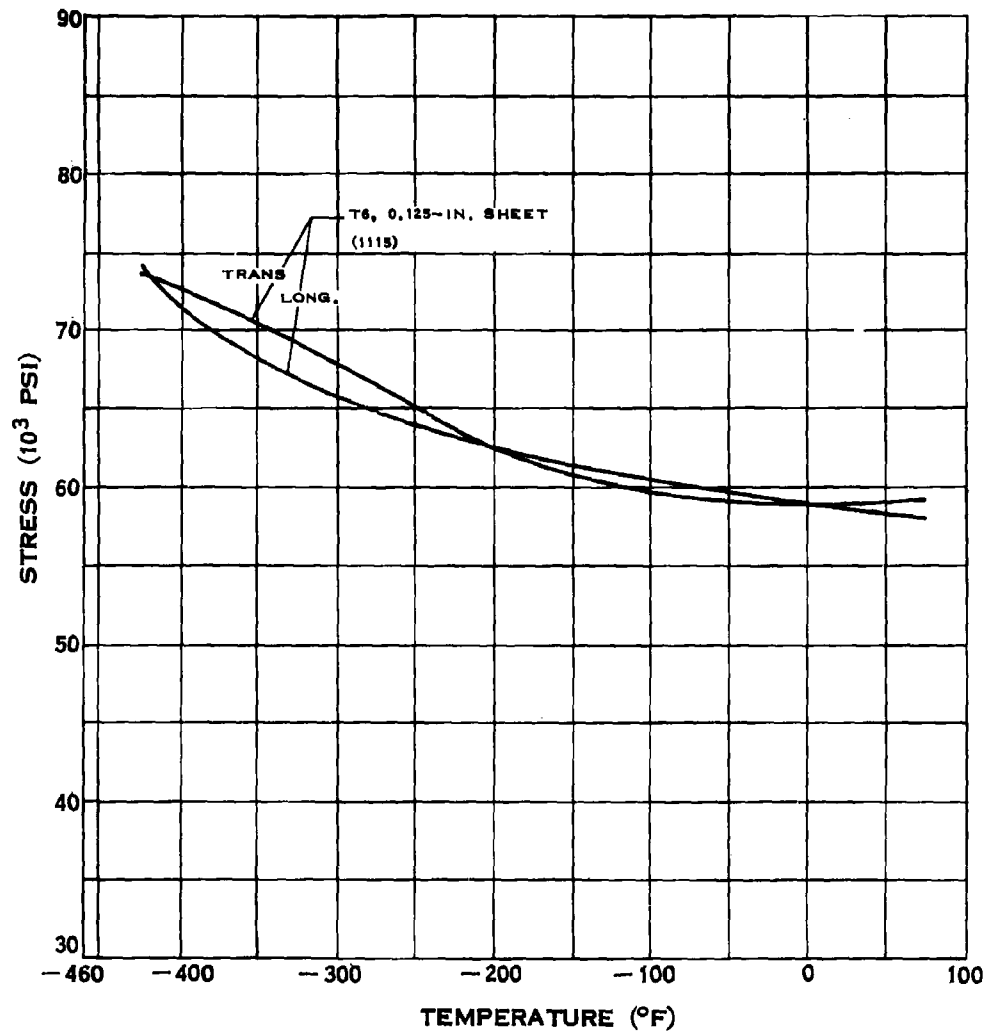


MODULUS OF ELASTICITY OF 5456 ALUMINUM

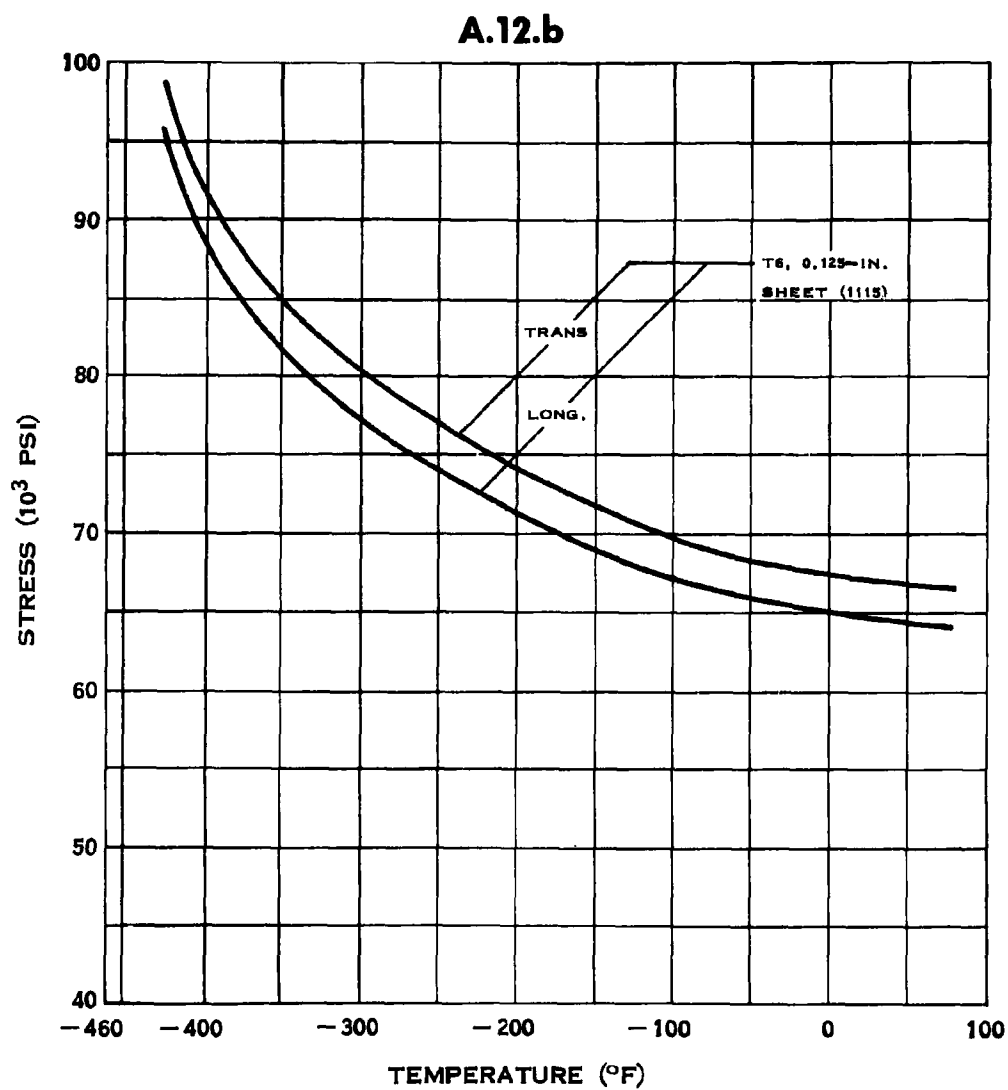


**THERMAL EXPANSION OF 5456
ALUMINUM**

A.12.a

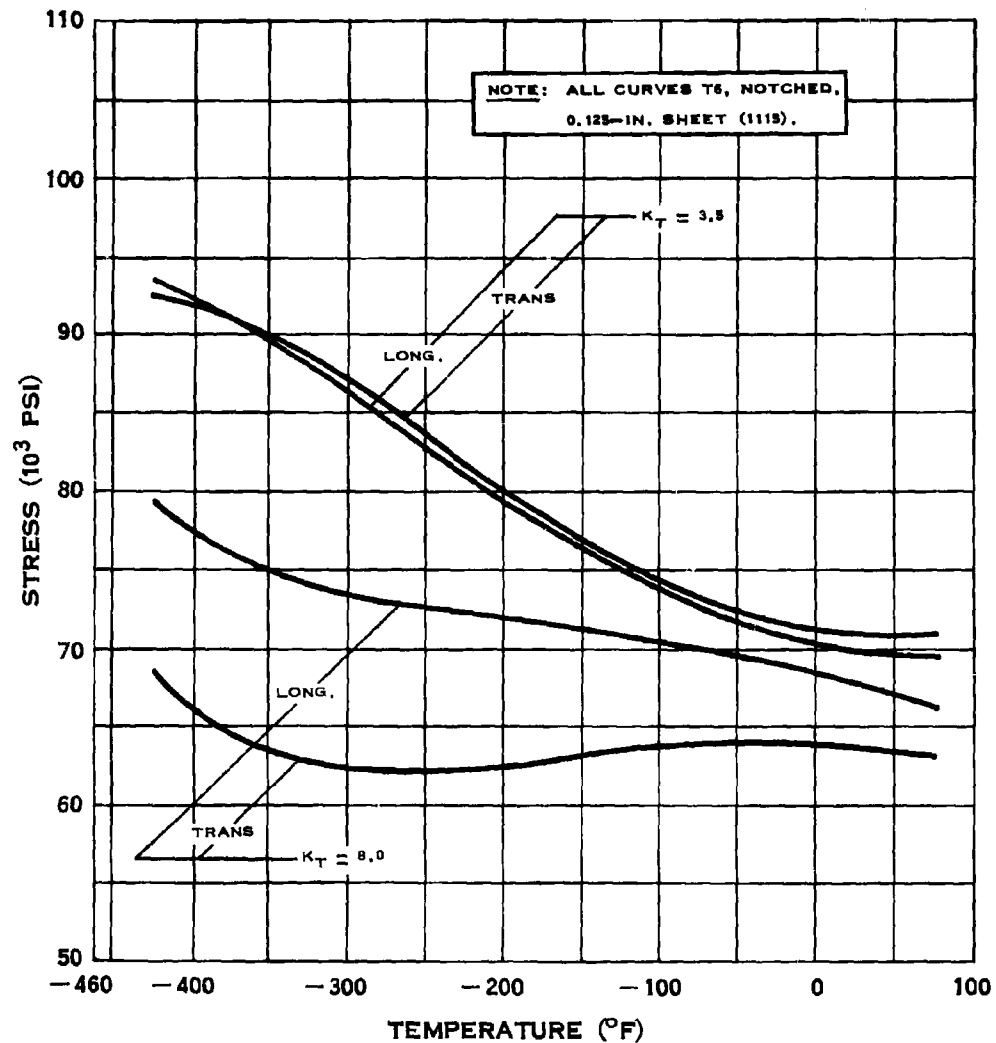


YIELD STRENGTH OF 7039 ALUMINUM

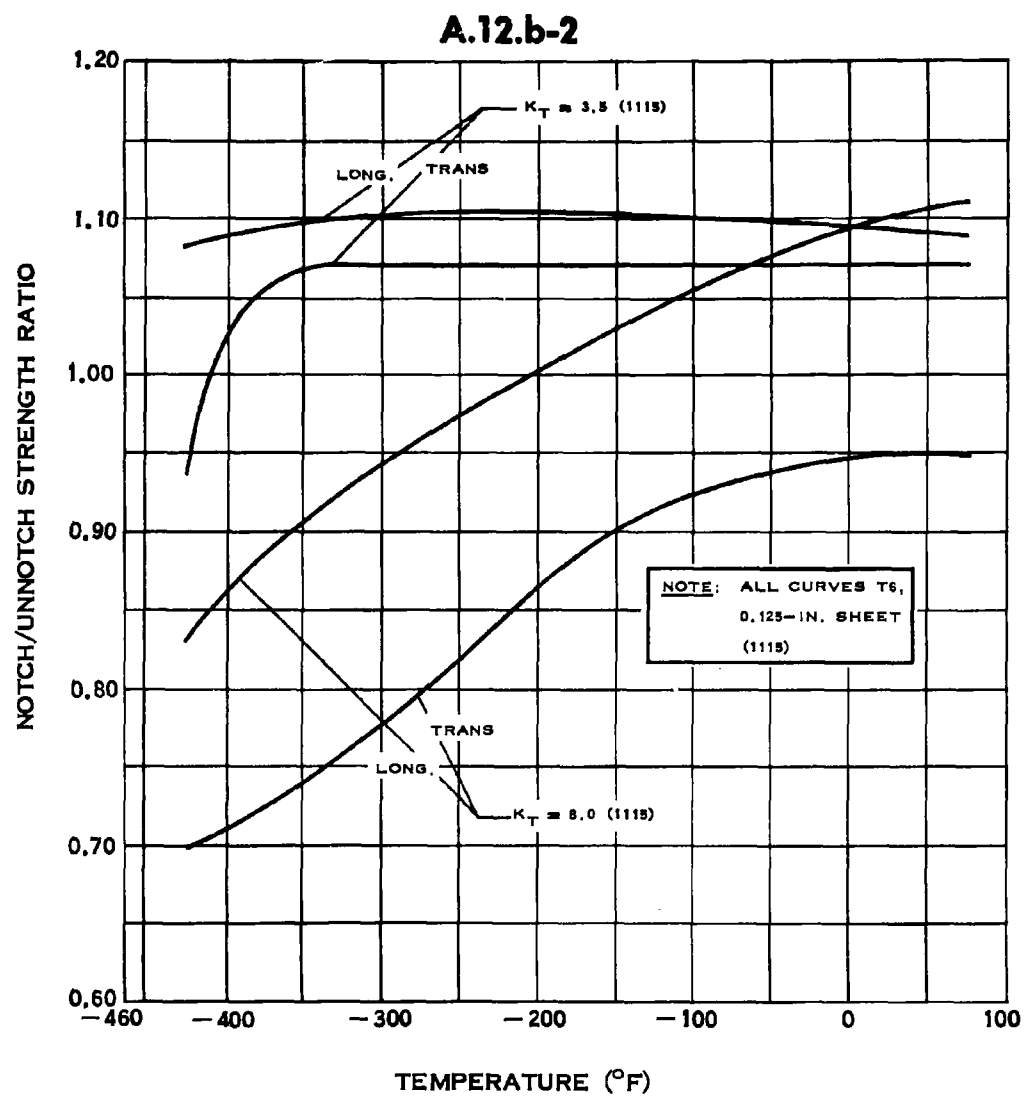


TENSILE STRENGTH OF 7039 ALUMINUM

A.12.b-1

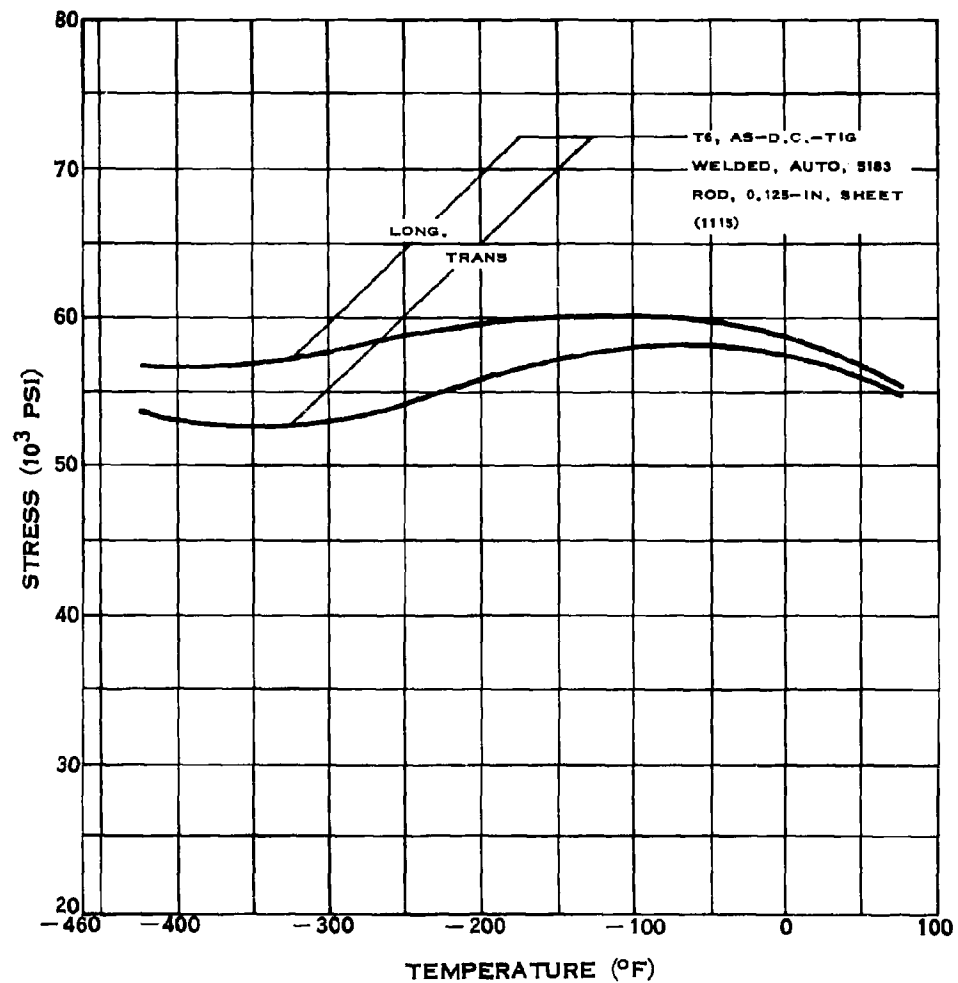


NOTCH TENSILE STRENGTH OF 7039 ALUMINUM



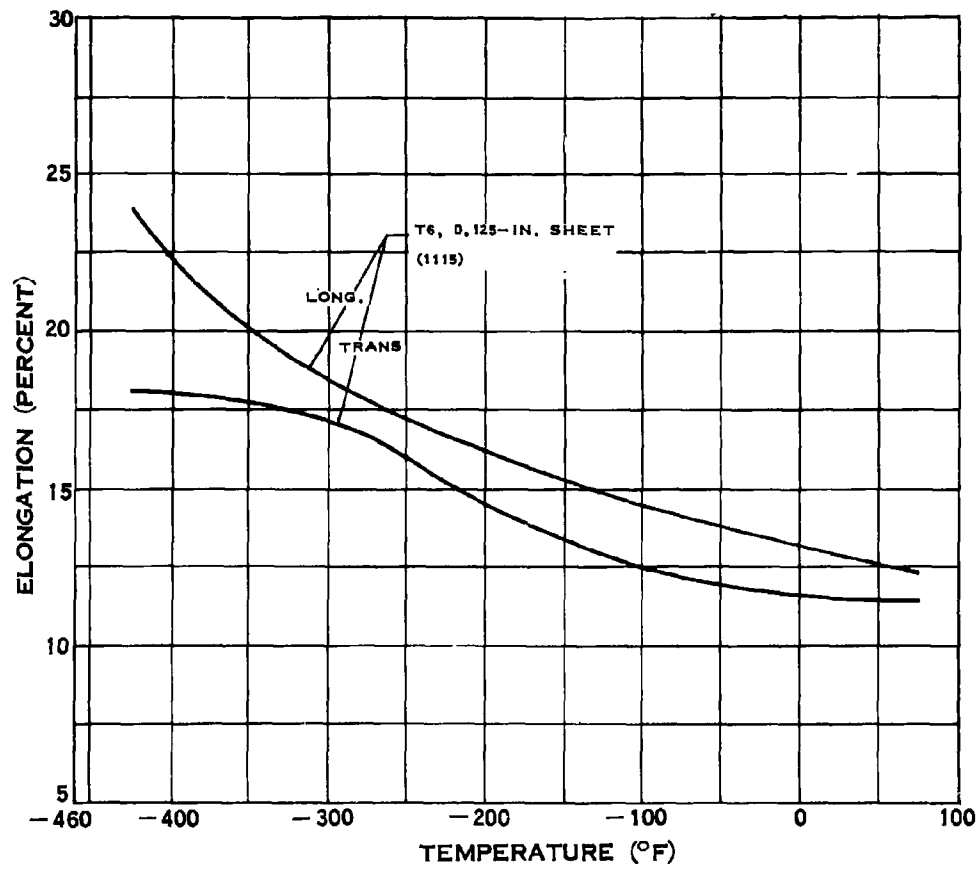
**NOTCH STRENGTH RATIO OF 7039
ALUMINUM**

A.12.b-3



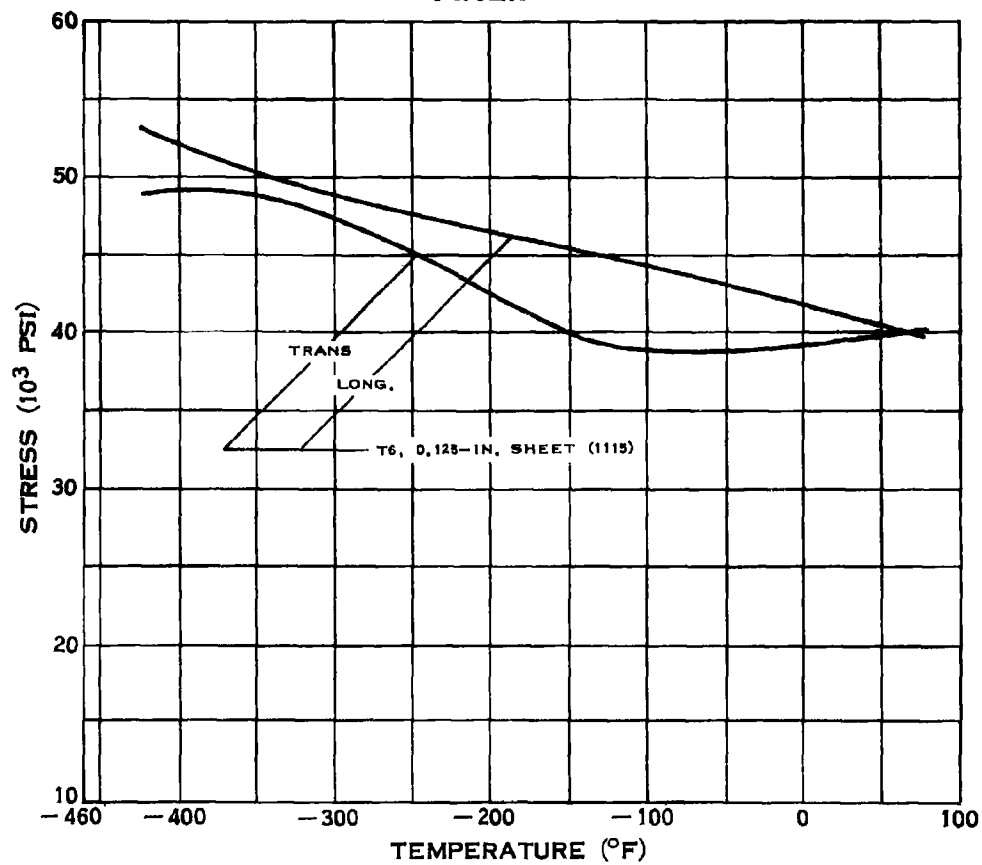
WELD TENSILE STRENGTH OF 7039 ALUMINUM

A.12.c

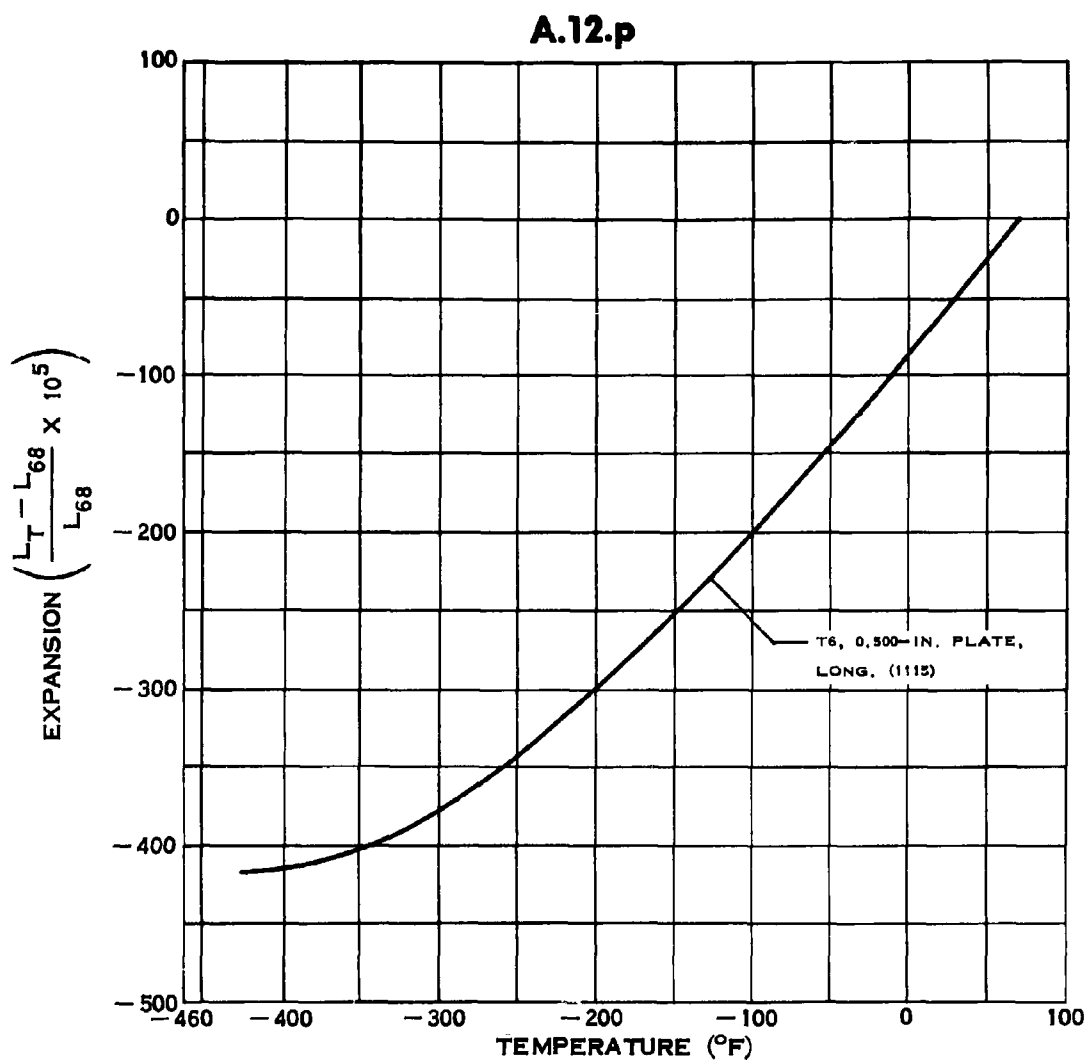


ELONGATION OF 7039 ALUMINUM

A.12.1

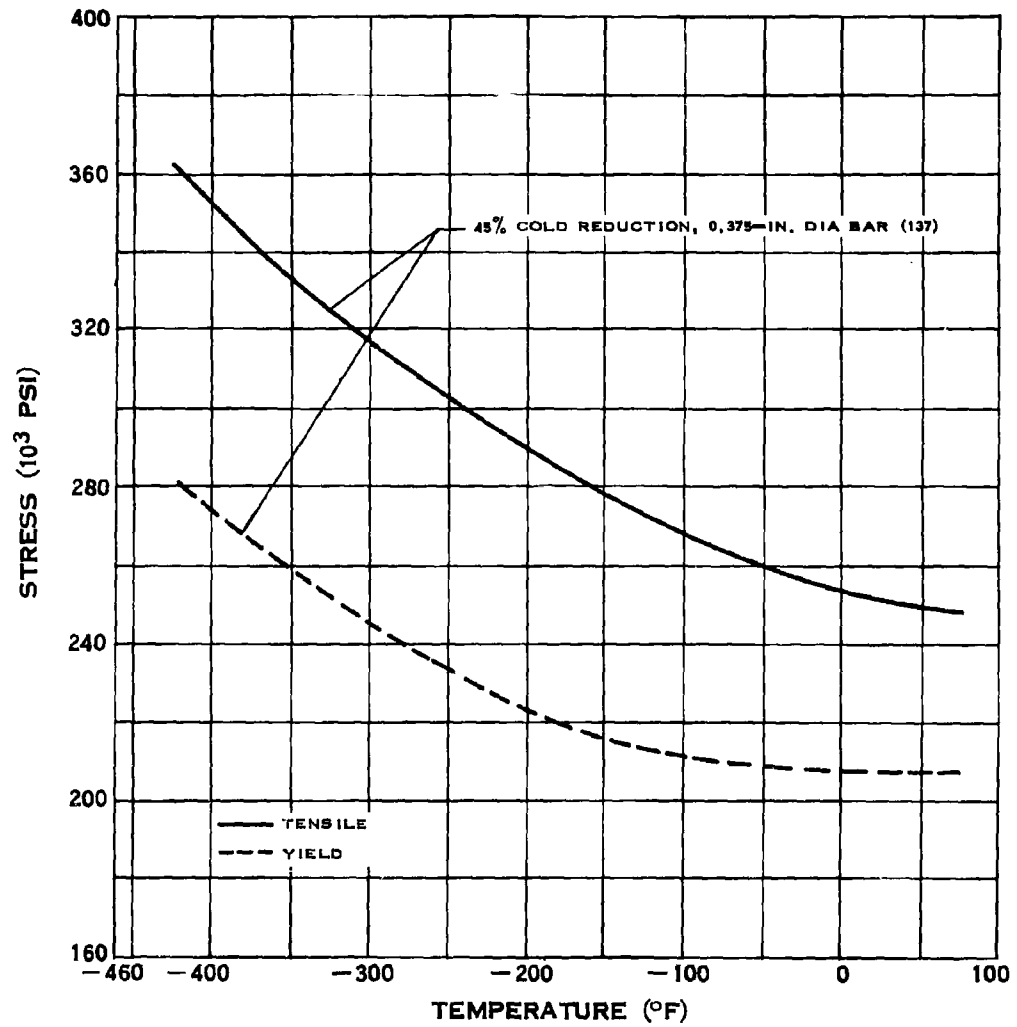


SHEAR STRENGTH OF 7039 ALUMINUM



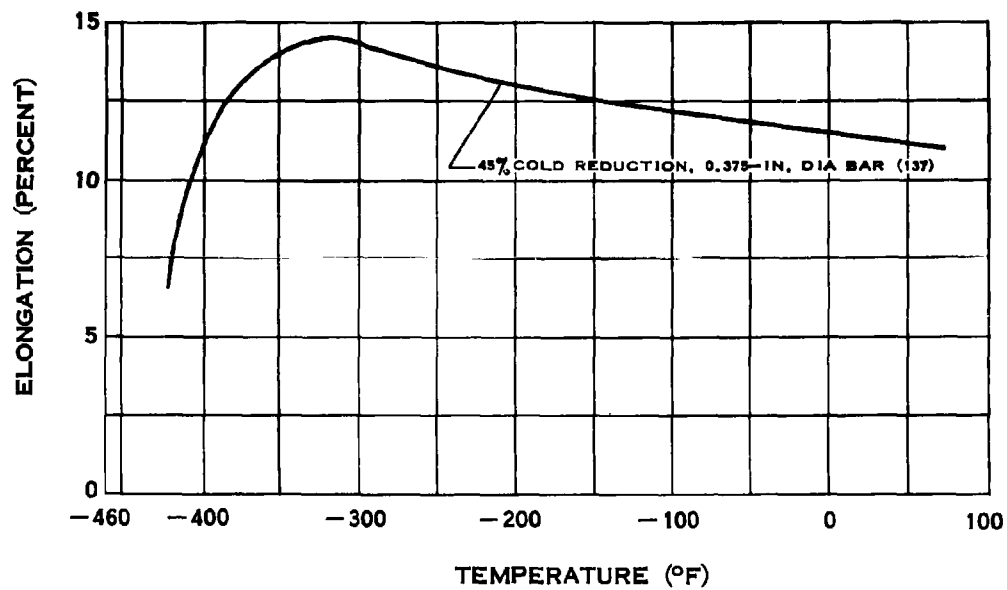
THERMAL EXPANSION OF 7039 ALUMINUM

B.1.ab

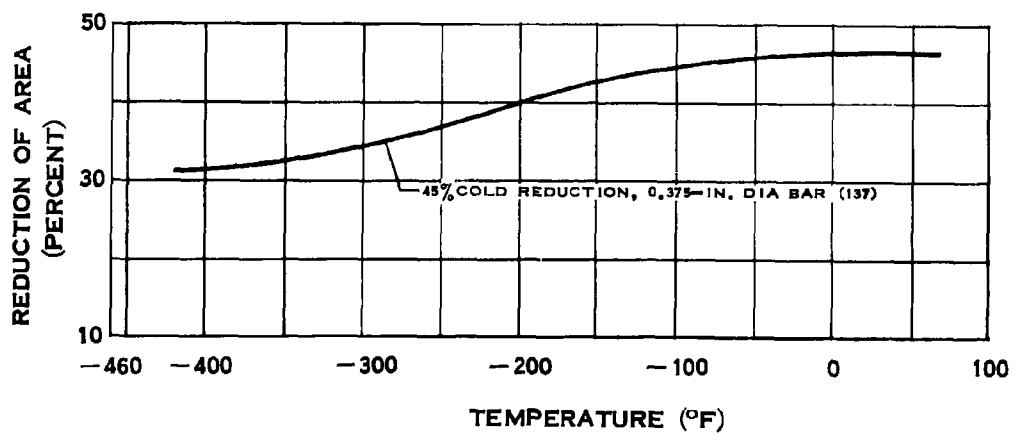


STRENGTH OF ELGILOY

B.1.cd

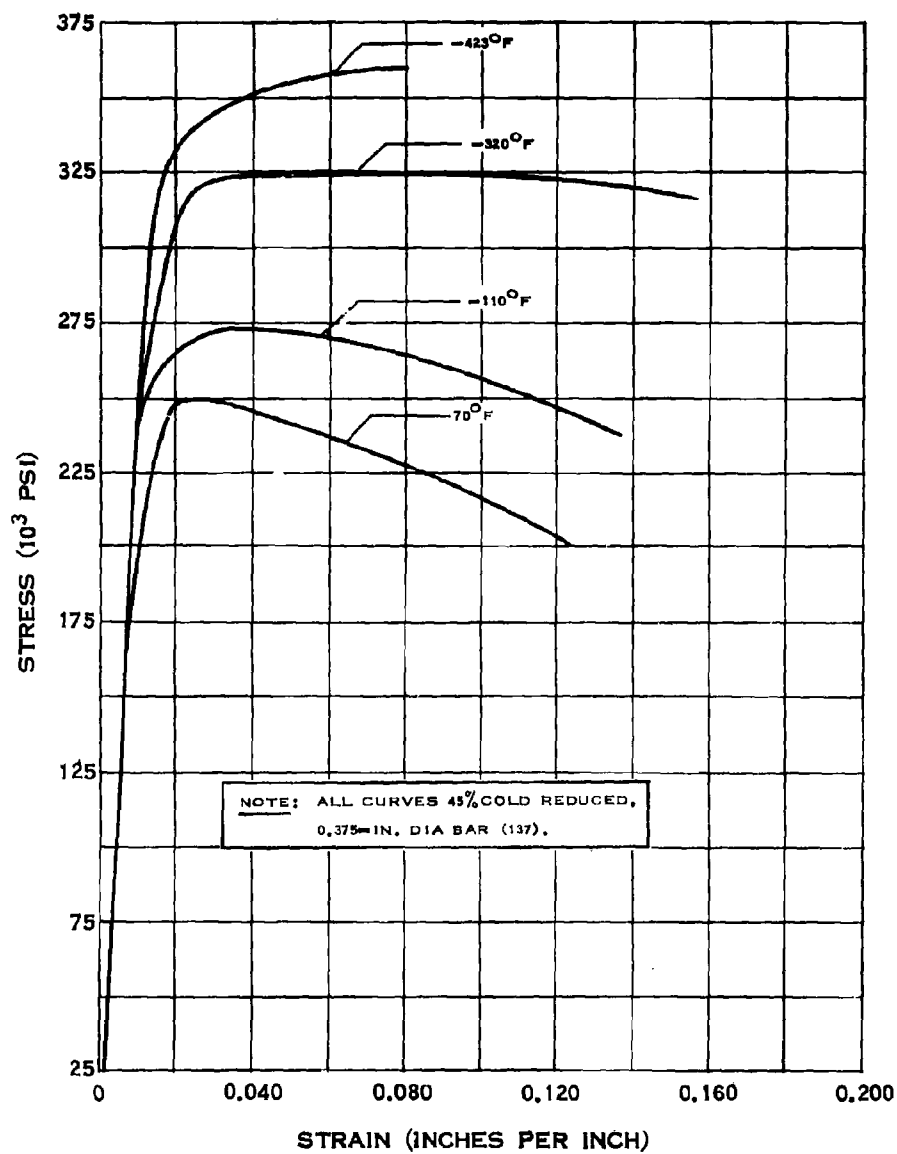


ELONGATION OF ELGILOY



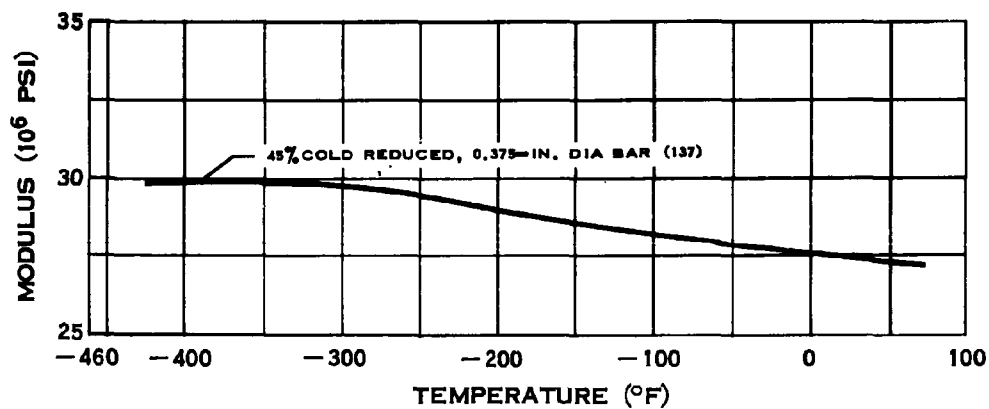
REDUCTION OF AREA OF ELGILOY

B.1.e

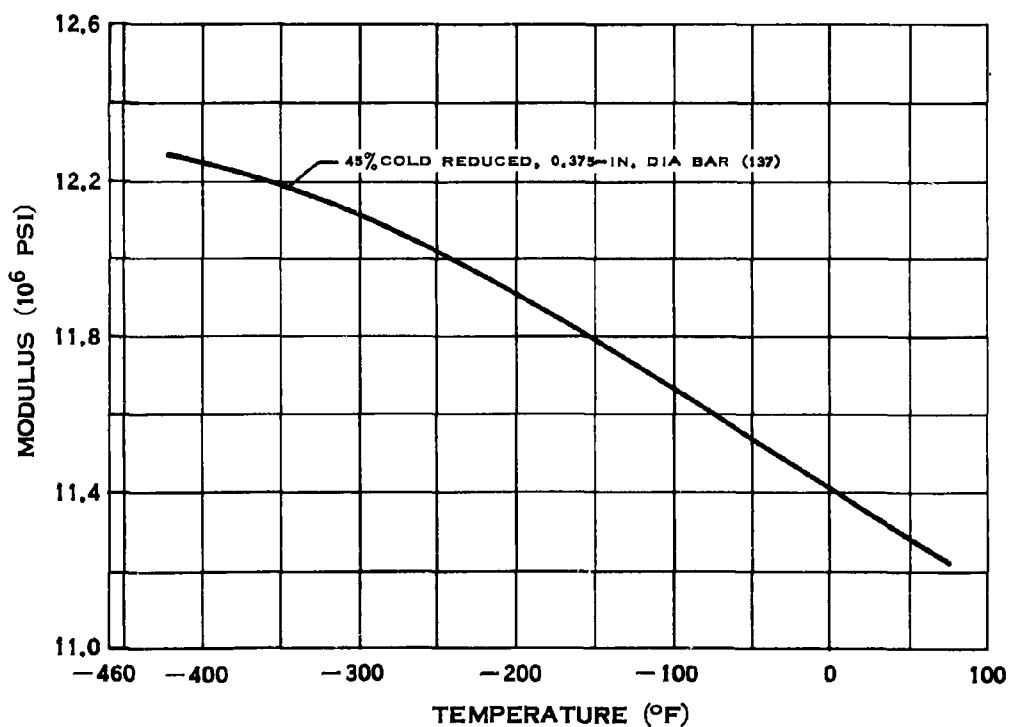


STRESS-STRAIN DIAGRAM FOR ELGILOY

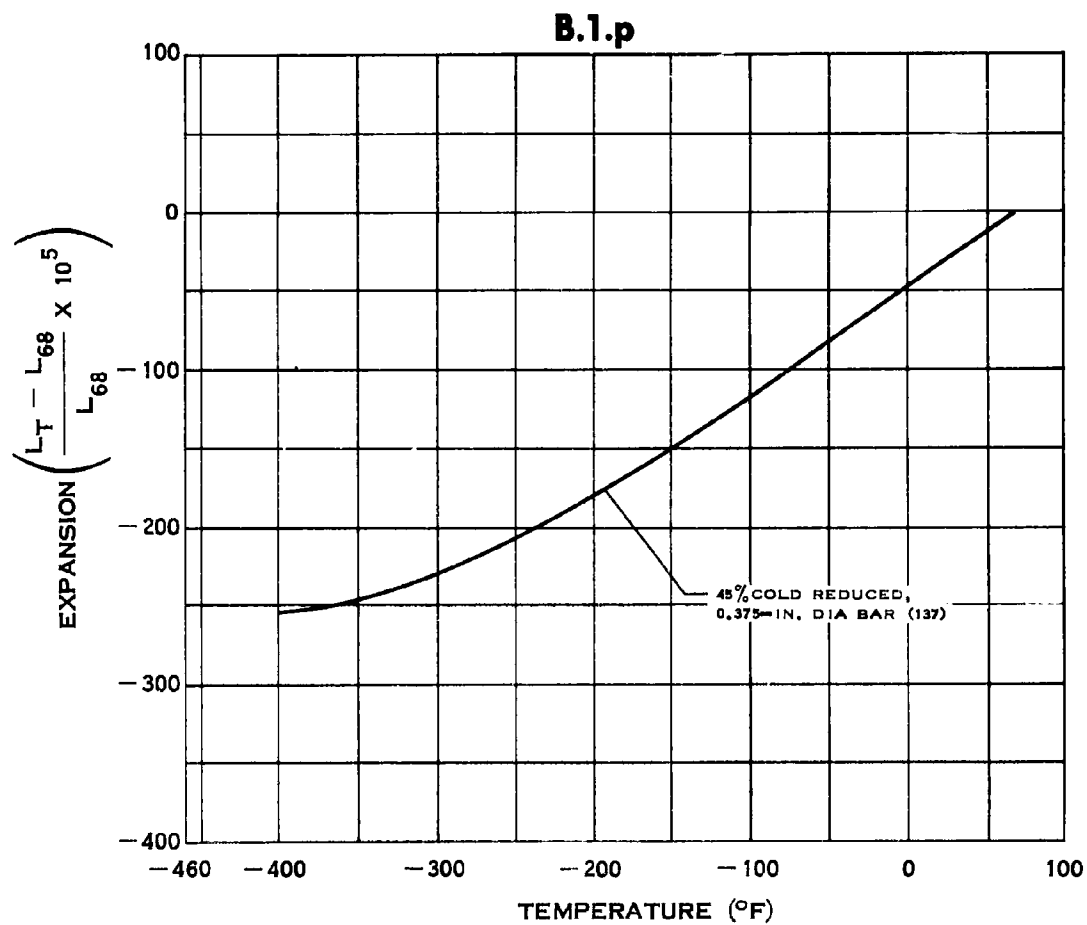
B.1.fm



MODULUS OF ELASTICITY OF ELGILOY

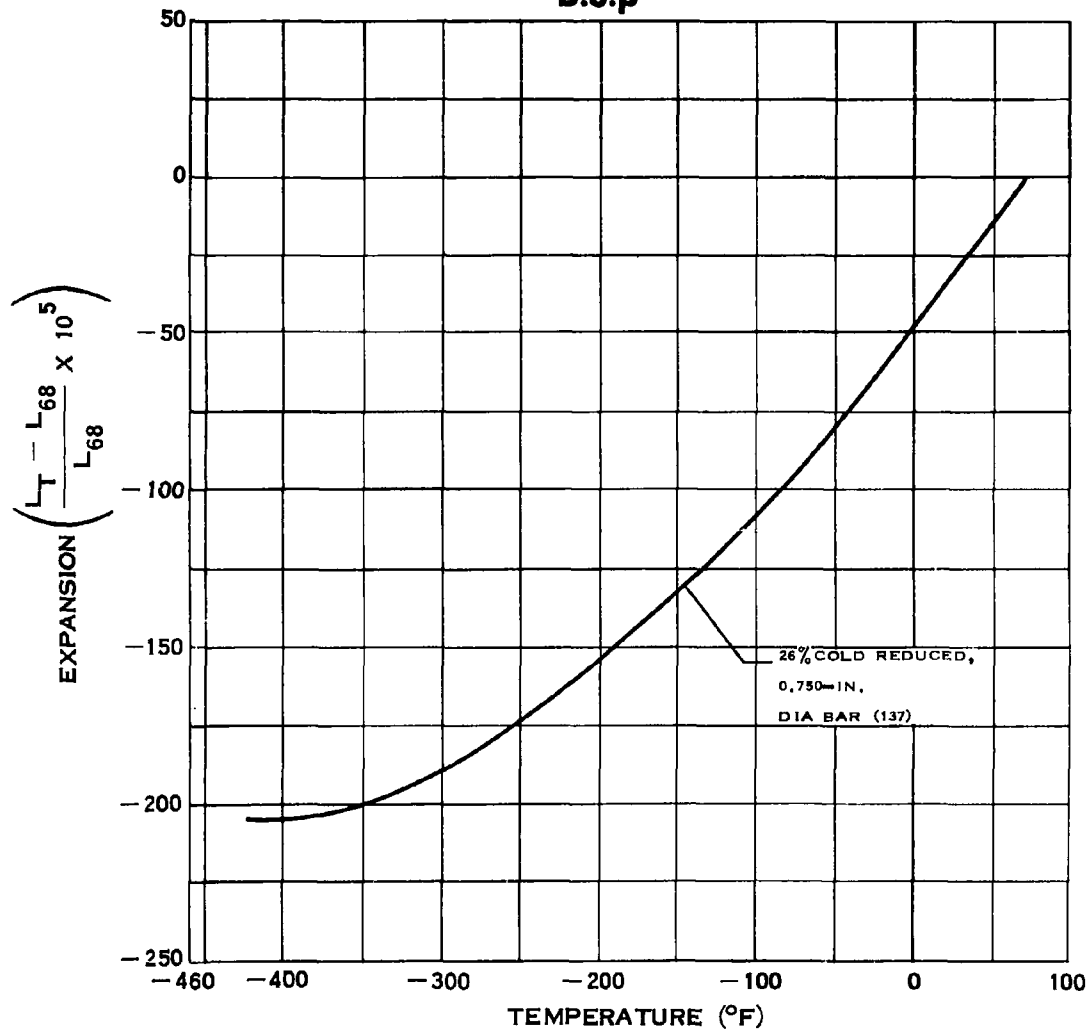


MODULUS OF RIGIDITY OF ELGILOY



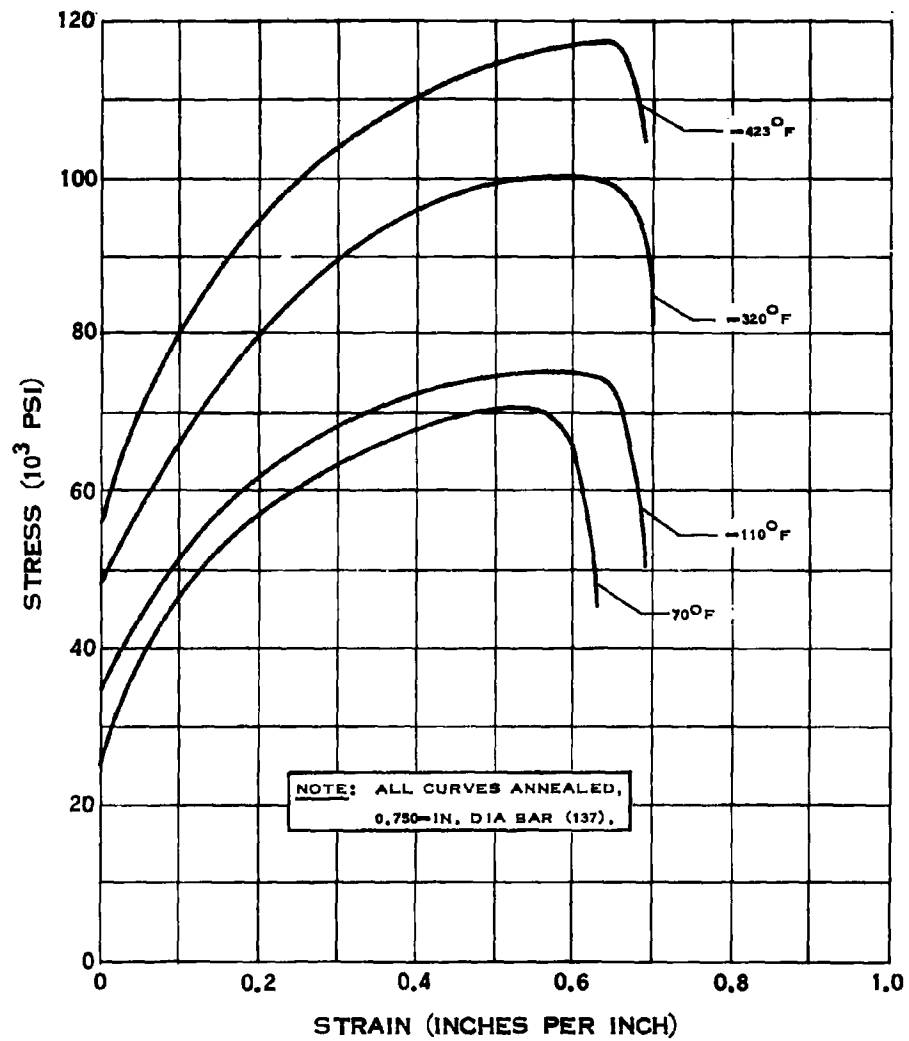
THERMAL EXPANSION OF ELGILOY

B.3.p



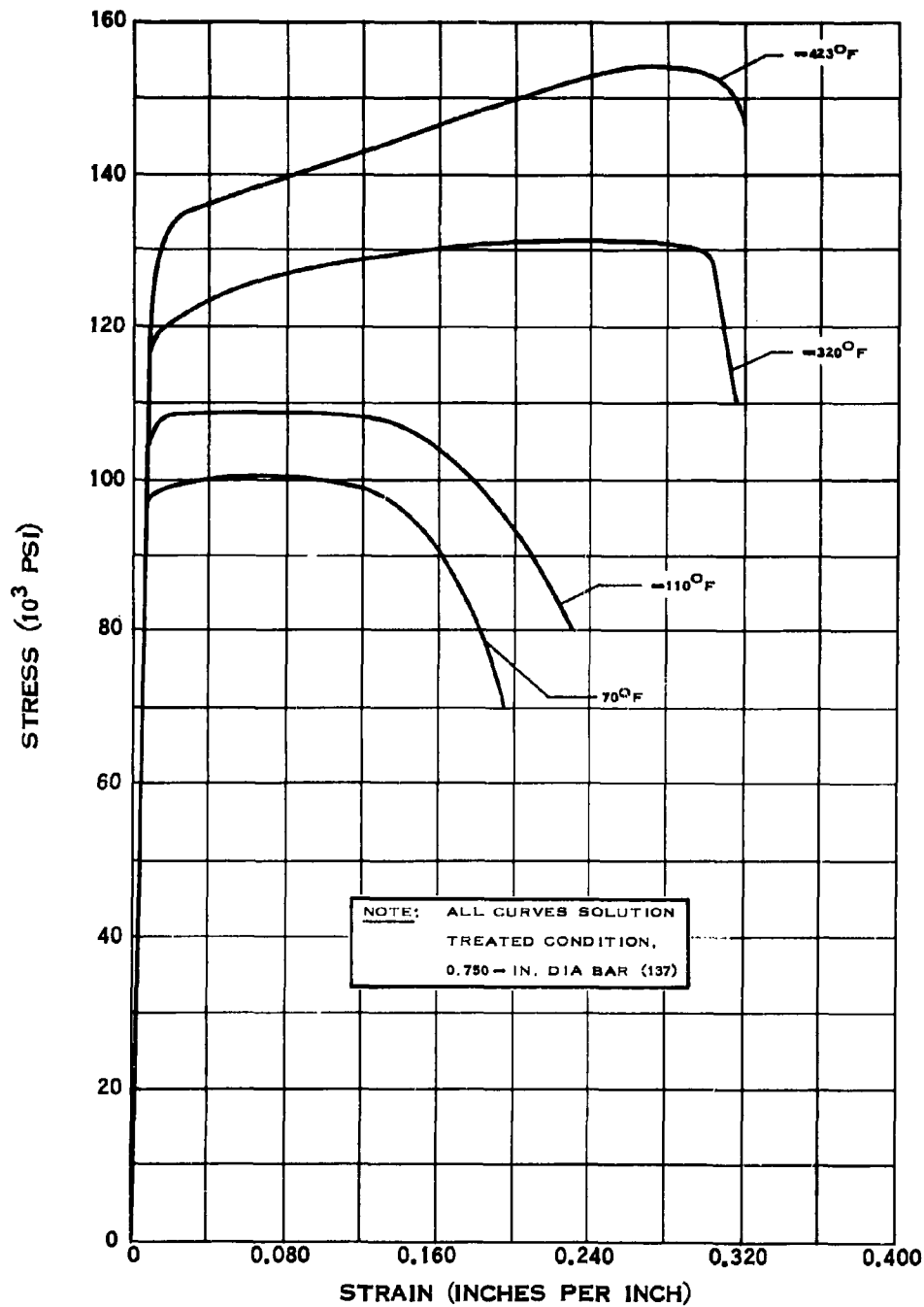
THERMAL EXPANSION OF L-605

C.1.e



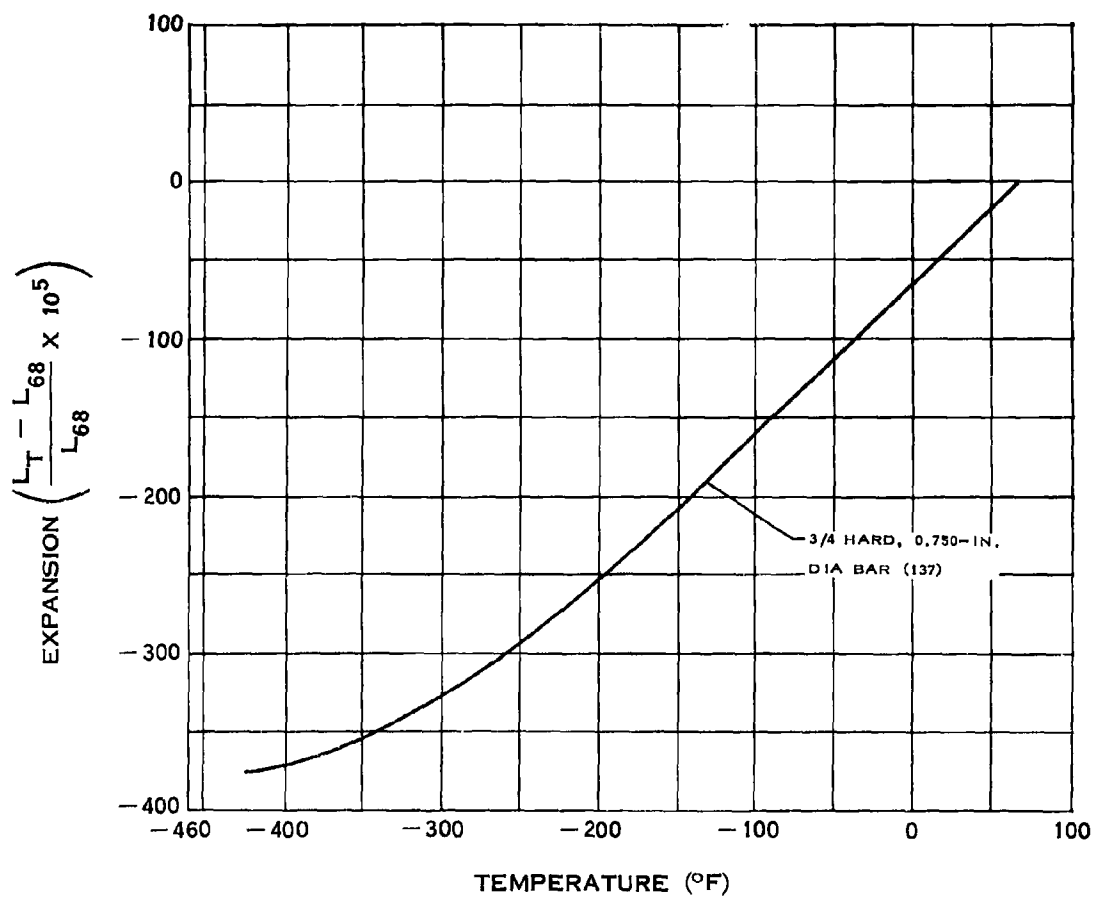
STRESS-STRAIN DIAGRAM FOR BERYLLIUM COPPER

C.1.e-1



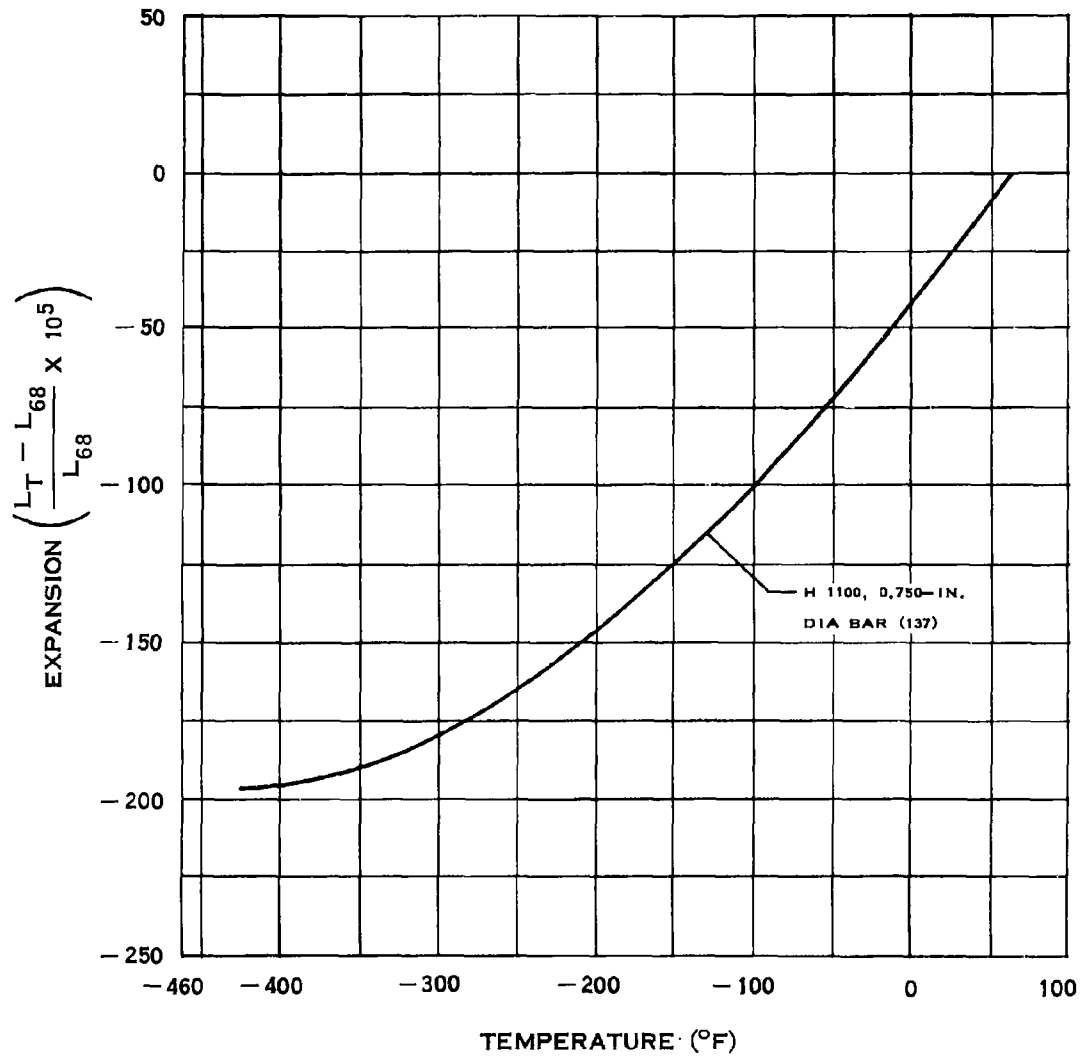
1-15-64 **STRESS-STRAIN DIAGRAM FOR BERYLLIUM COPPER**

C.2.p



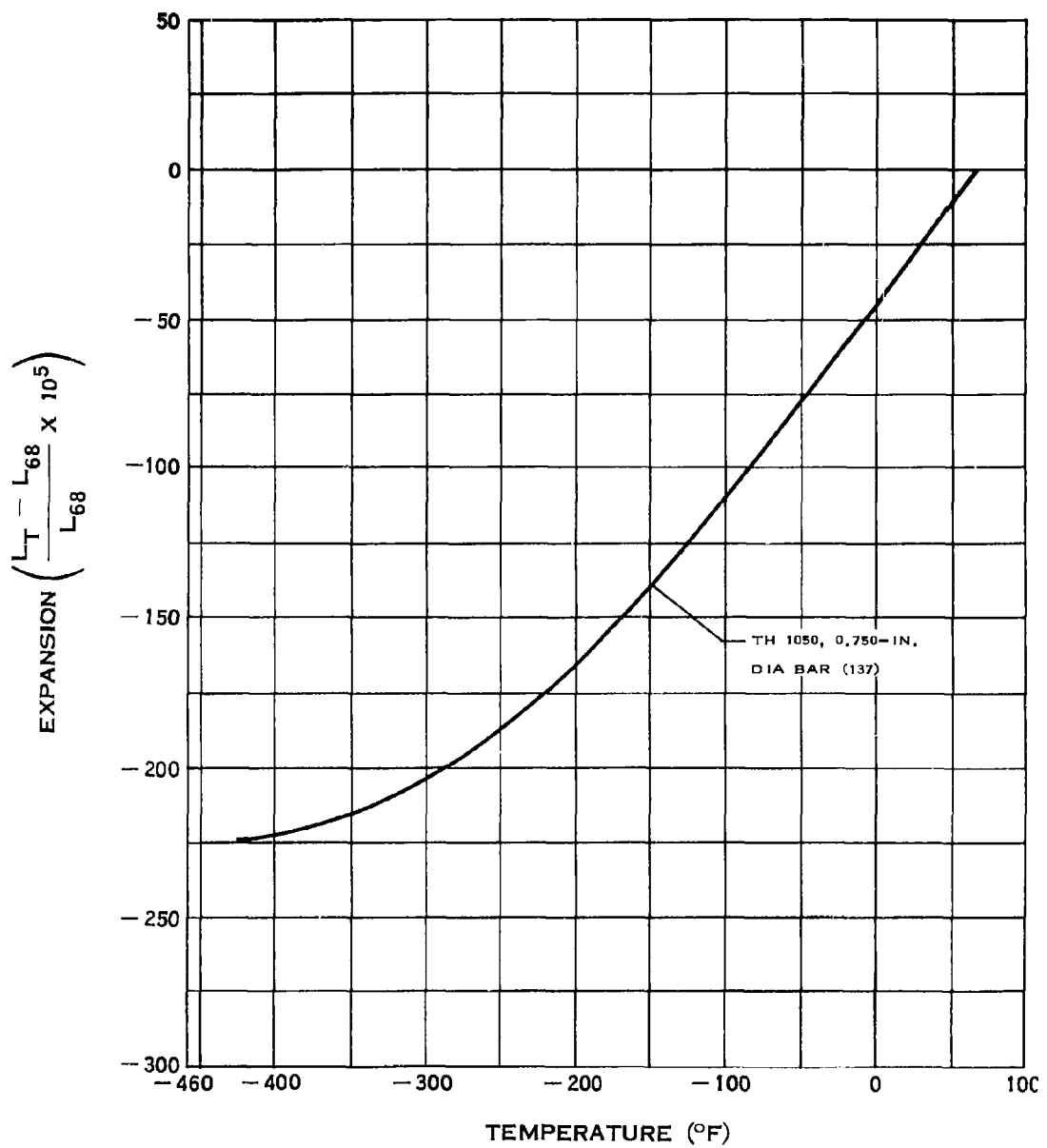
THERMAL EXPANSION OF 70/30 BRASS

D.5.p



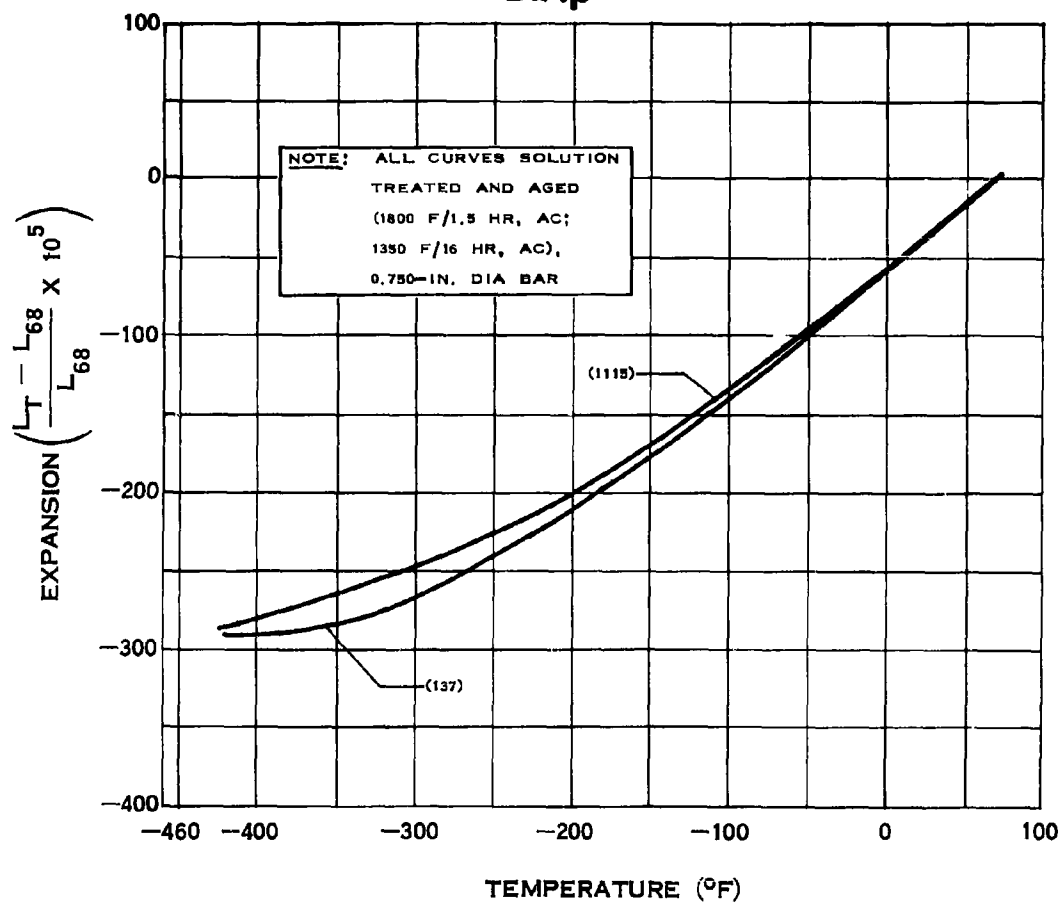
THERMAL EXPANSION OF 17-4 PH STAINLESS STEEL

D.6.p



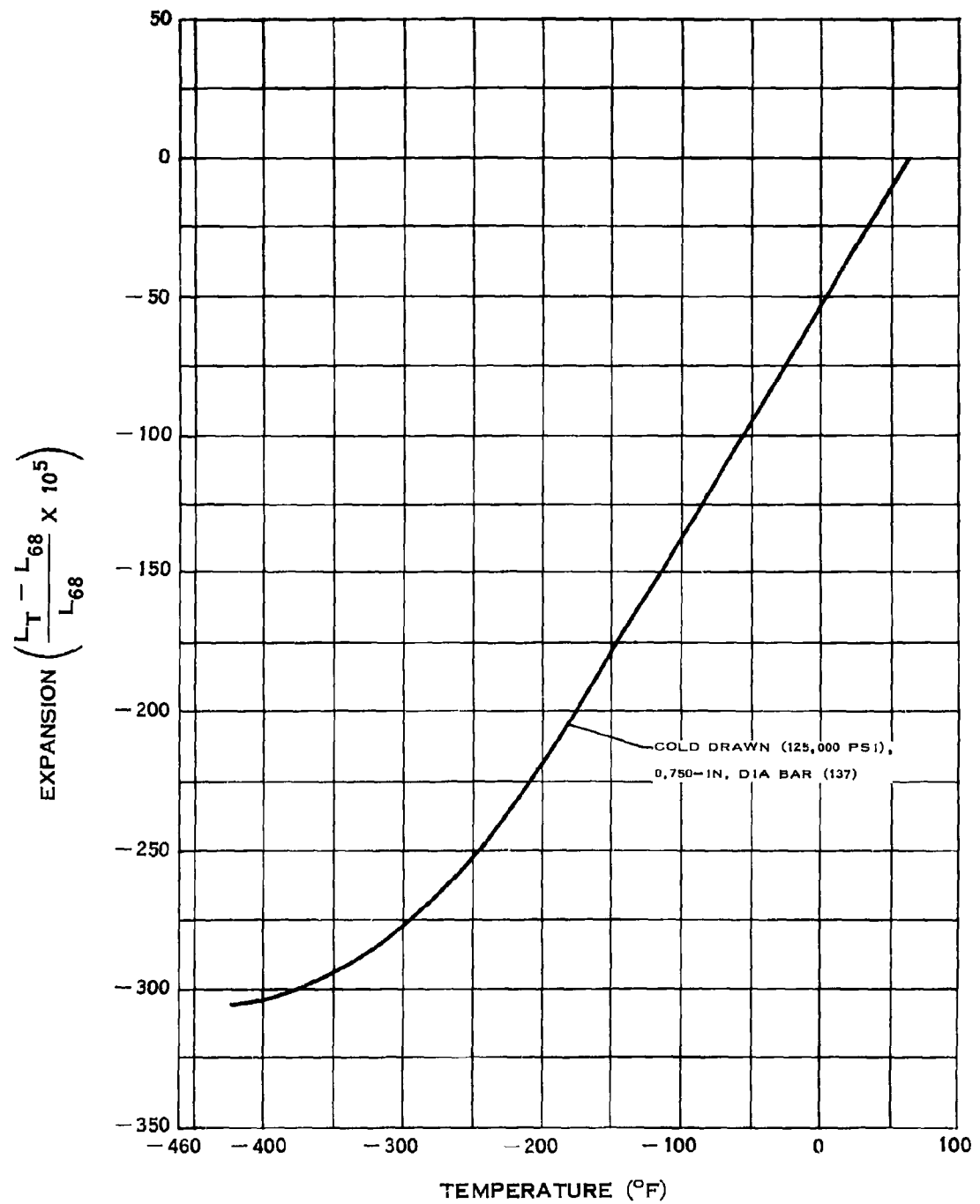
**THERMAL EXPANSION OF 17-7PH
STAINLESS STEEL**

D.7.p



THERMAL EXPANSION OF A-286 STAINLESS STEEL

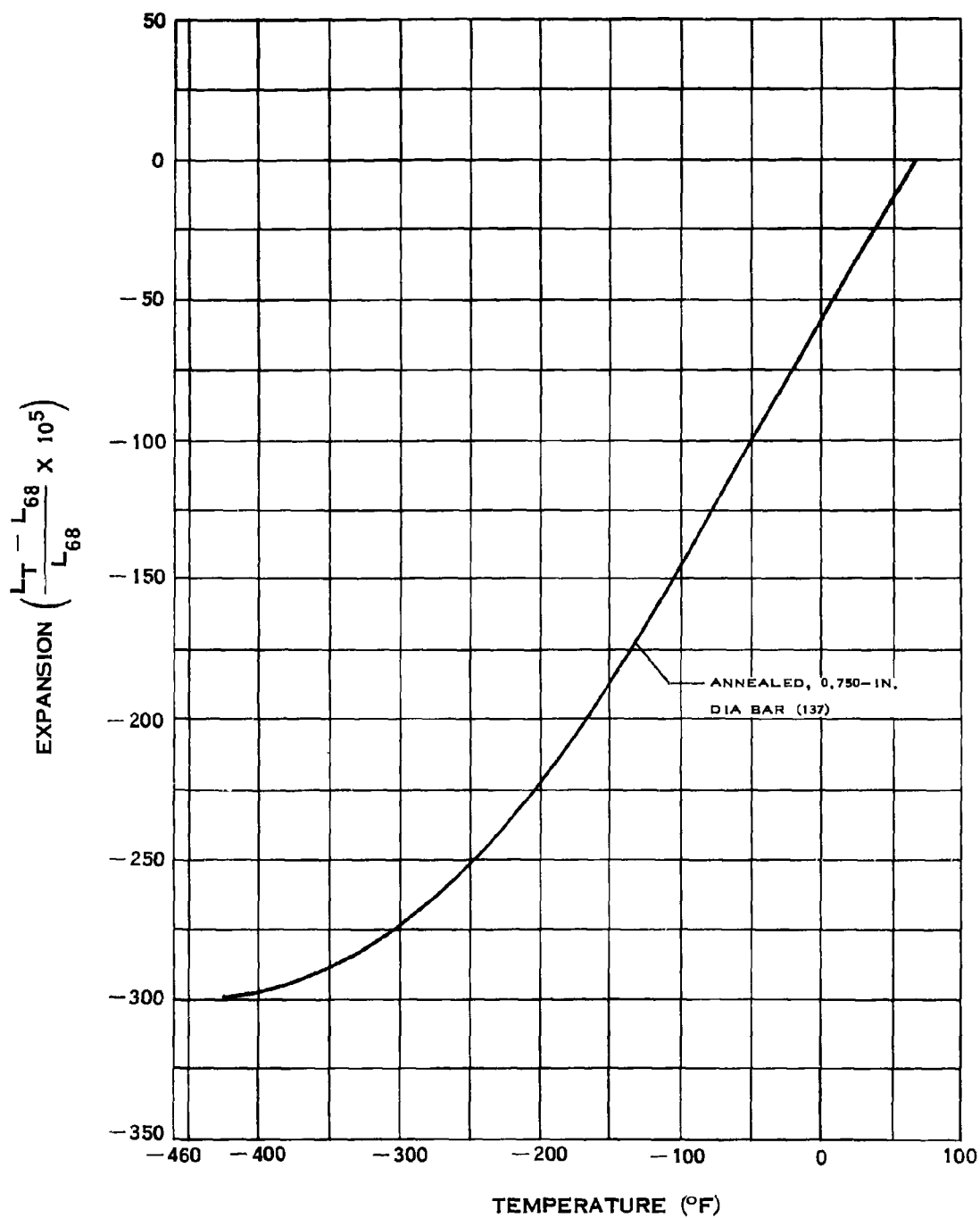
D.9.p



**THERMAL EXPANSION OF 302
STAINLESS STEEL**

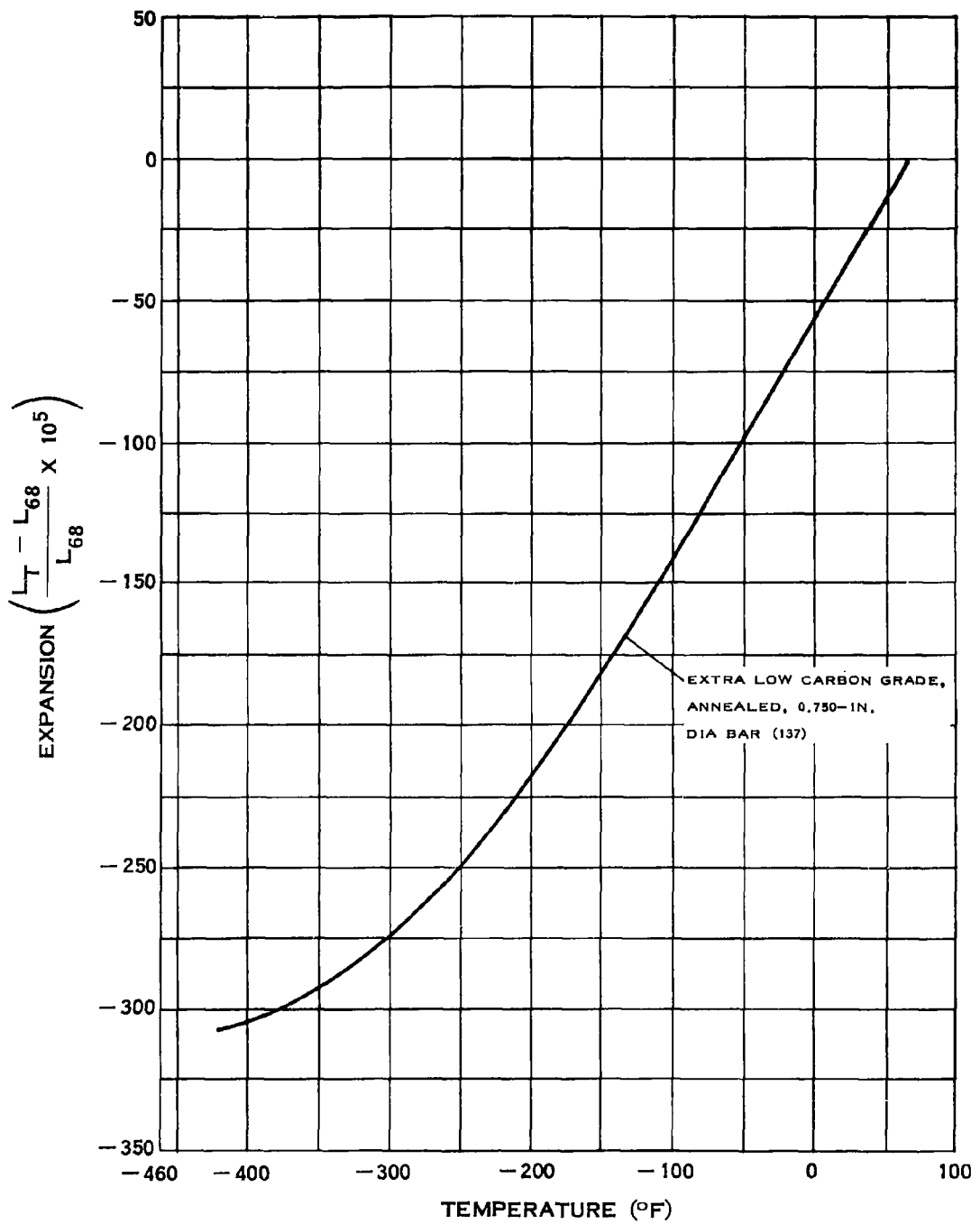
(1-15-64)

D.10.p



**THERMAL EXPANSION OF 303
STAINLESS STEEL**

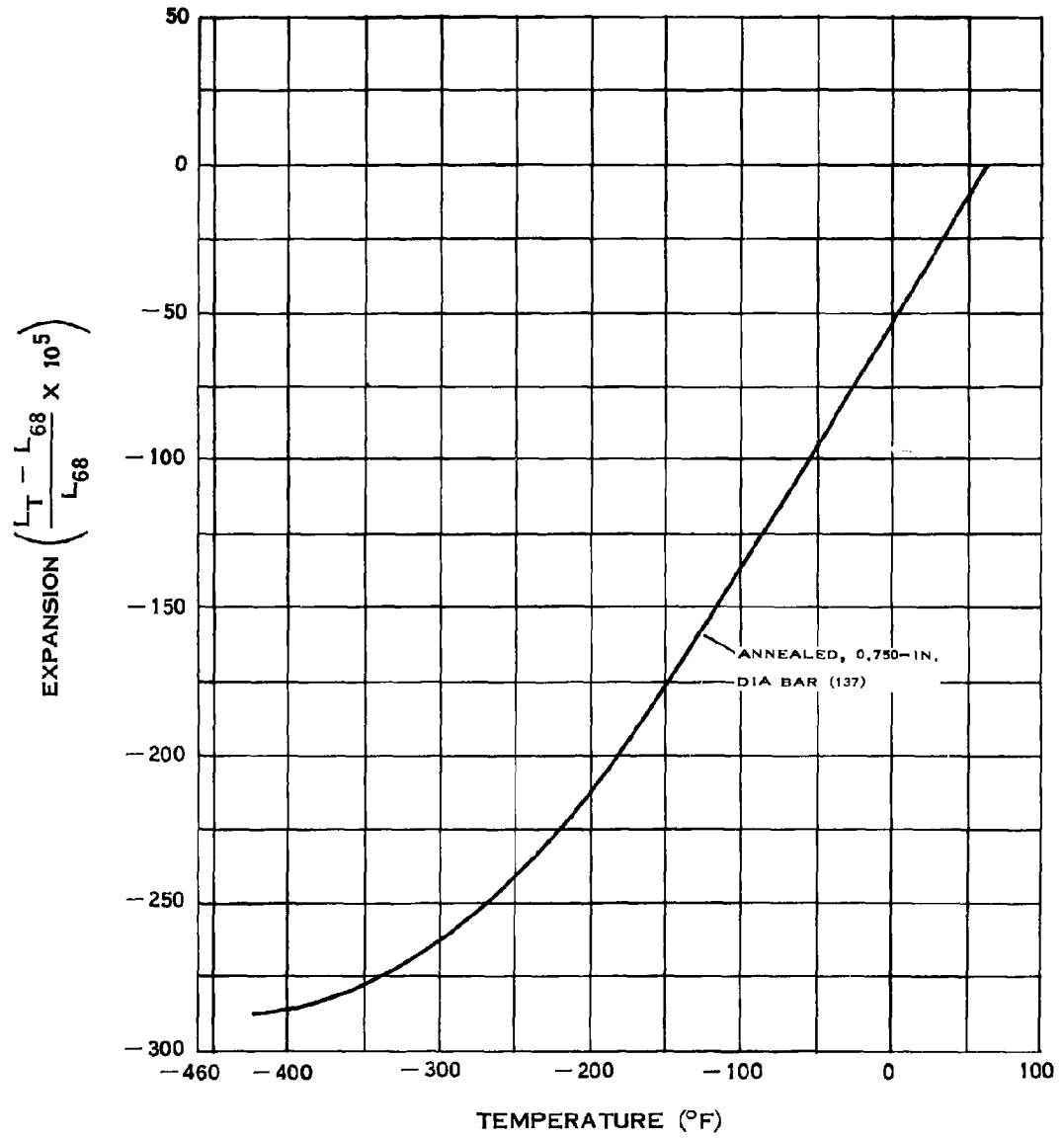
D.11.p



**THERMAL EXPANSION OF 304
STAINLESS STEEL**

(1-15-64)

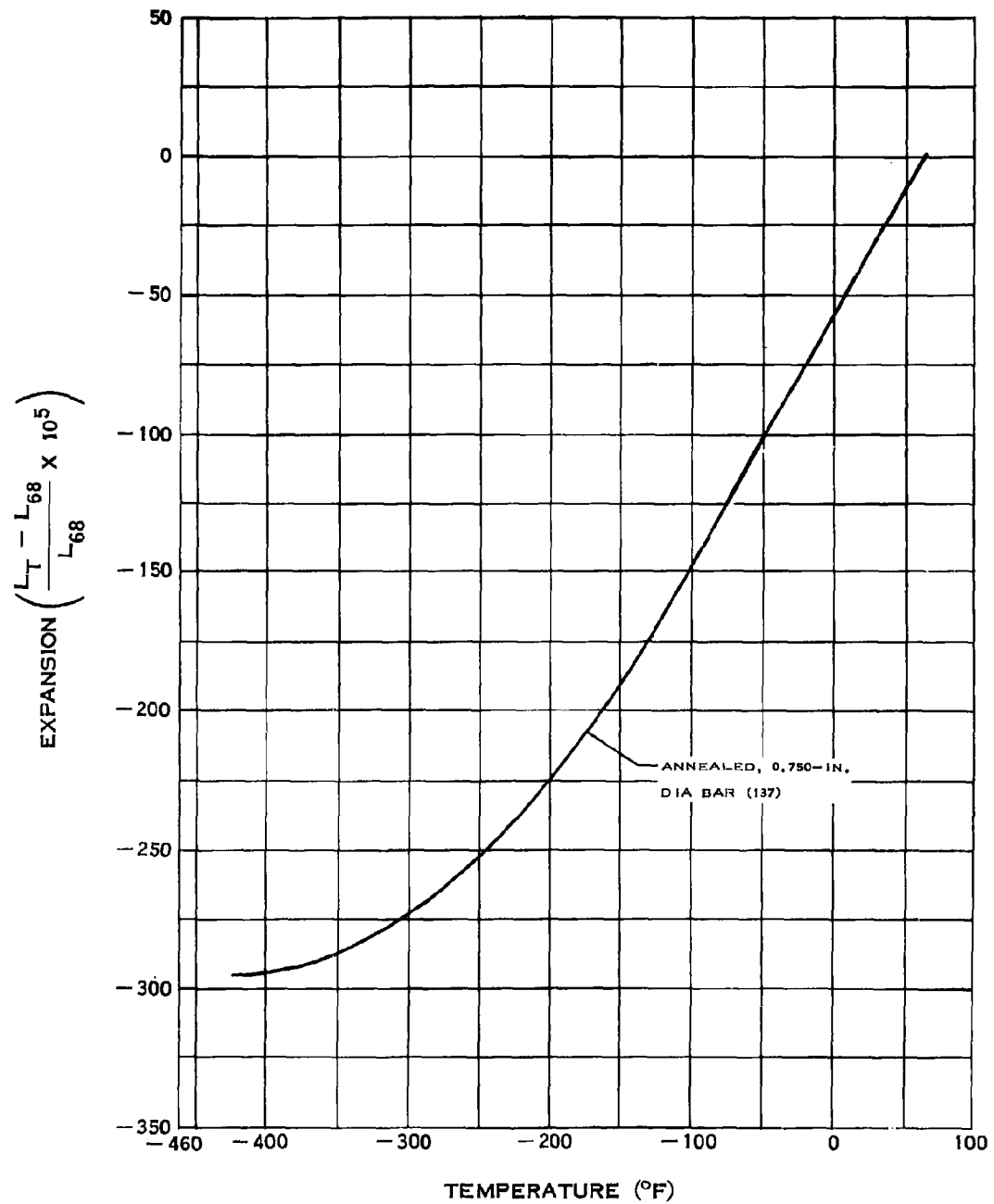
D.12.p



**THERMAL EXPANSION OF 310
STAINLESS STEEL**

(1-15-64)

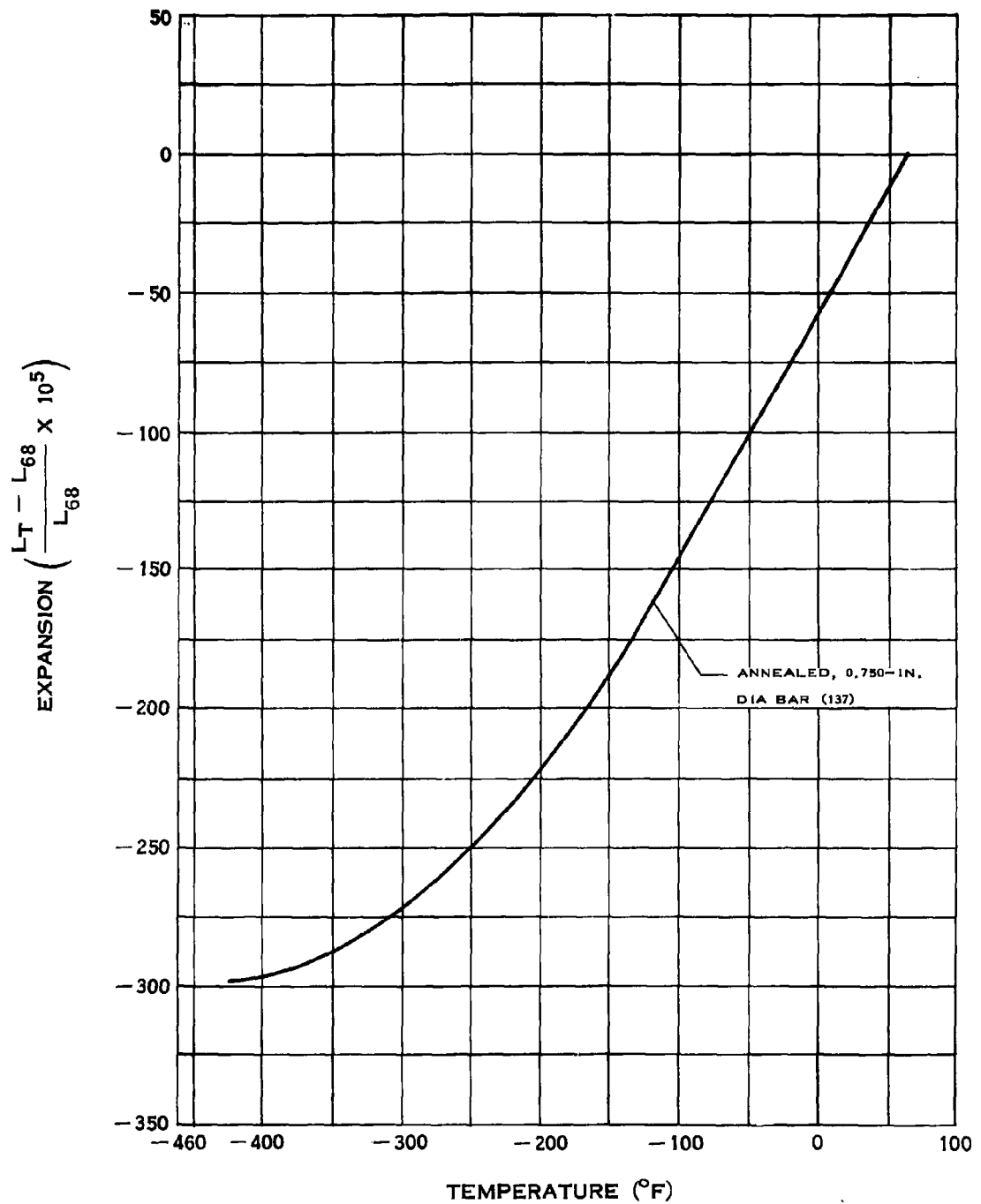
D.13.p



**THERMAL EXPANSION OF 321
STAINLESS STEEL**

(1-15-64)

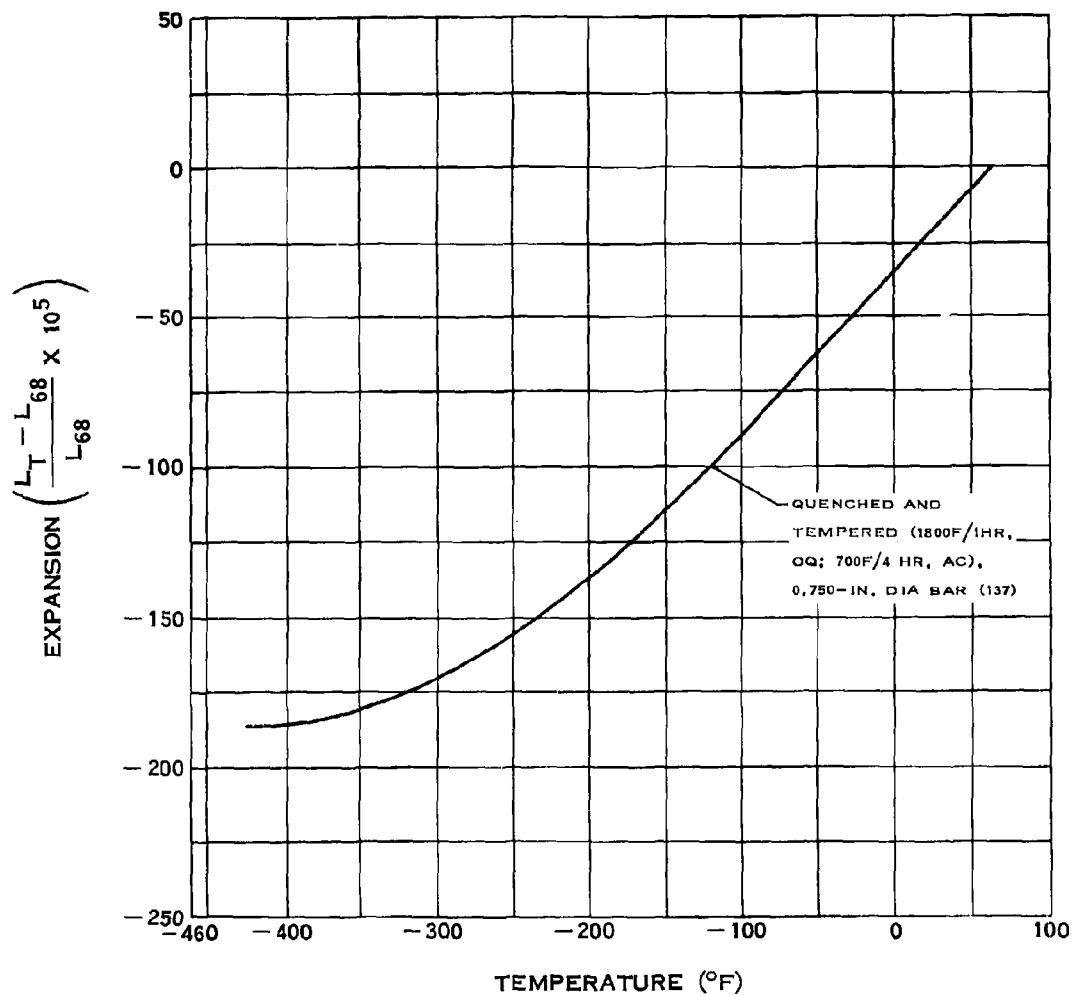
D.14.p



THERMAL EXPANSION OF 347 STAINLESS STEEL

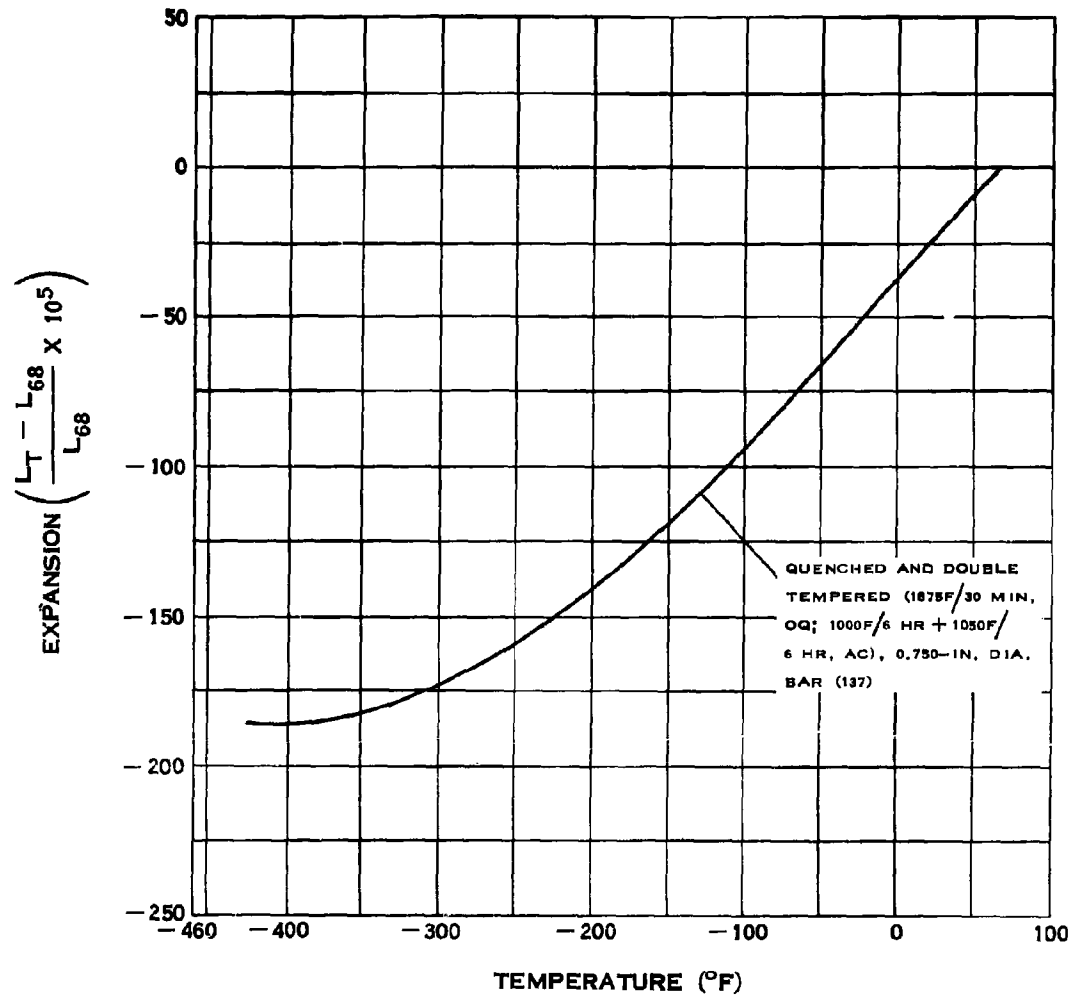
1-15-64

D.16.p



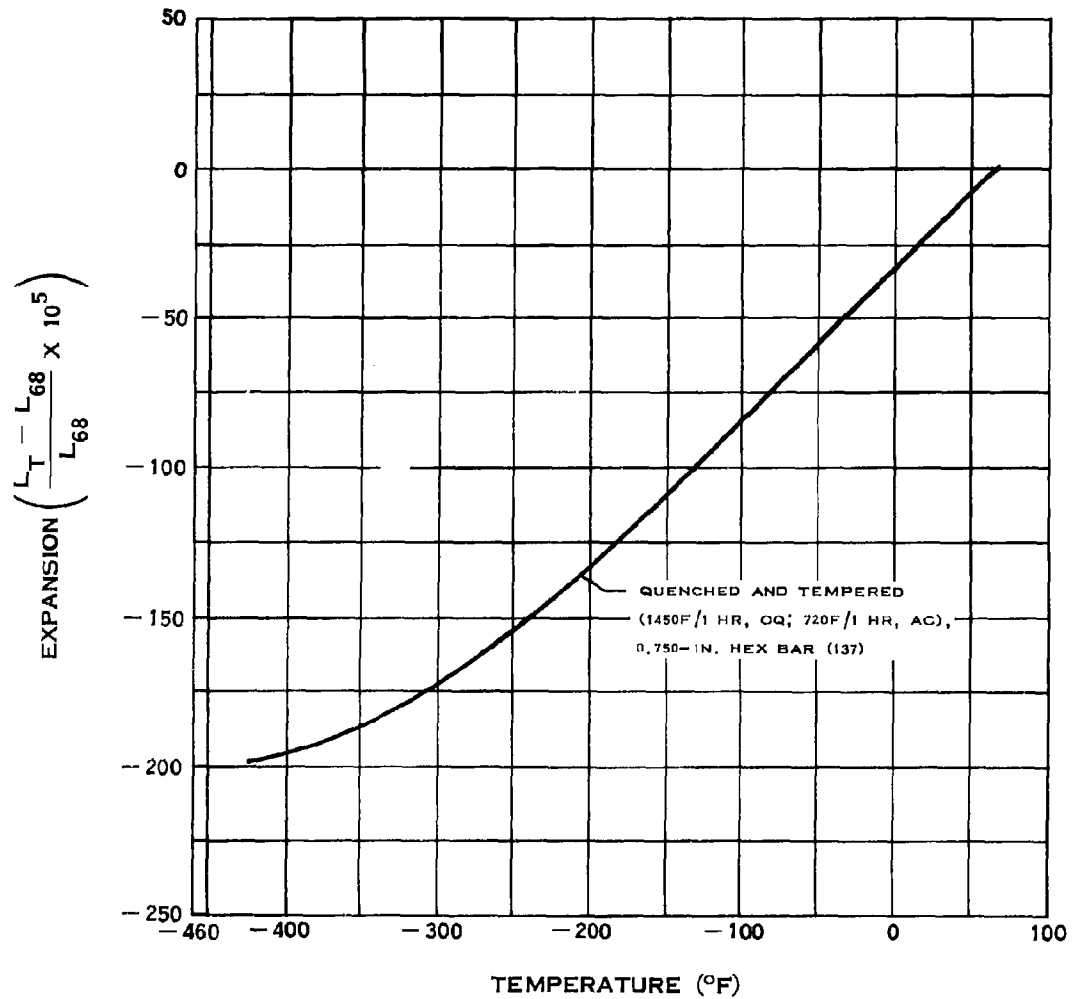
THERMAL EXPANSION OF 416 STAINLESS STEEL

D.17.p



THERMAL EXPANSION OF 440C STAINLESS STEEL

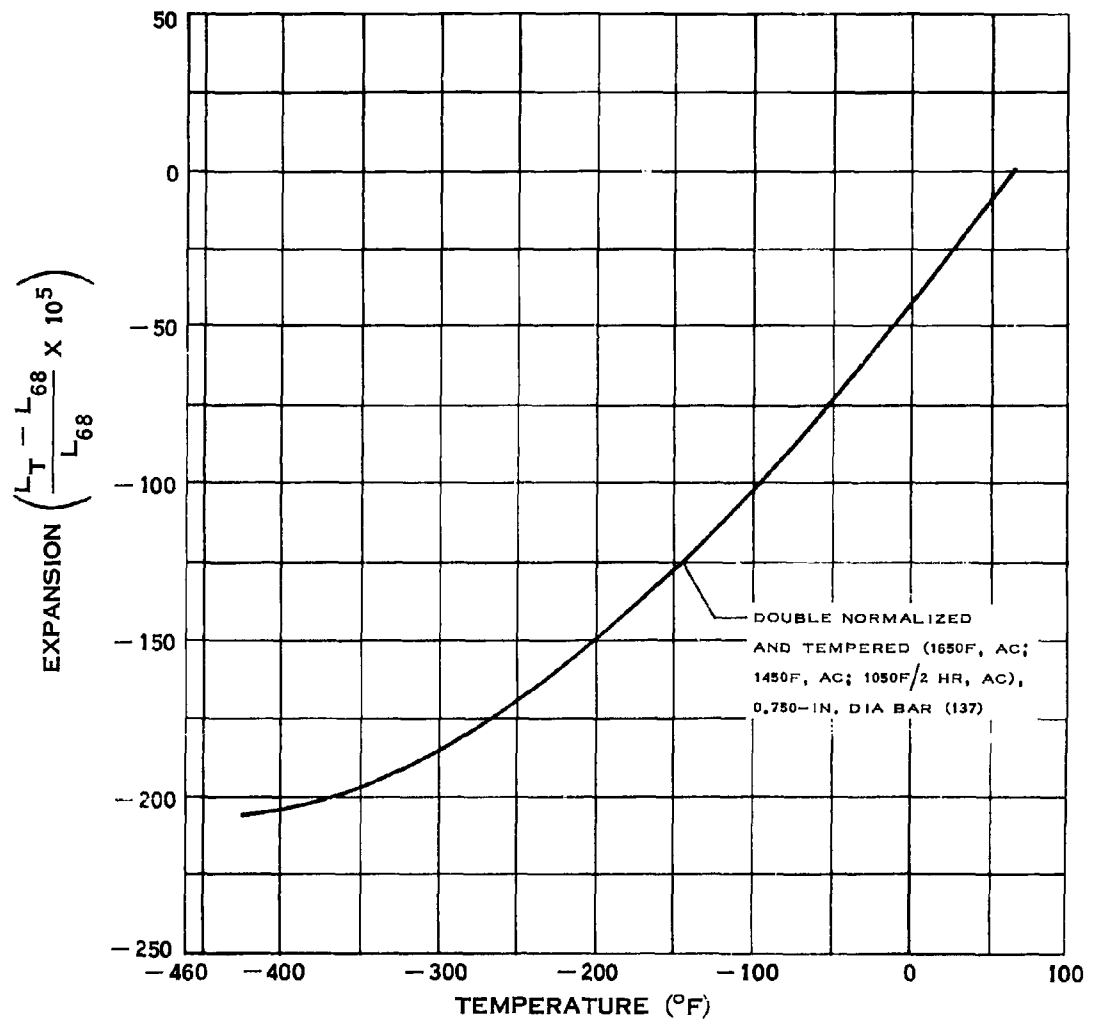
D.18.p



THERMAL EXPANSION OF 1075 STEEL

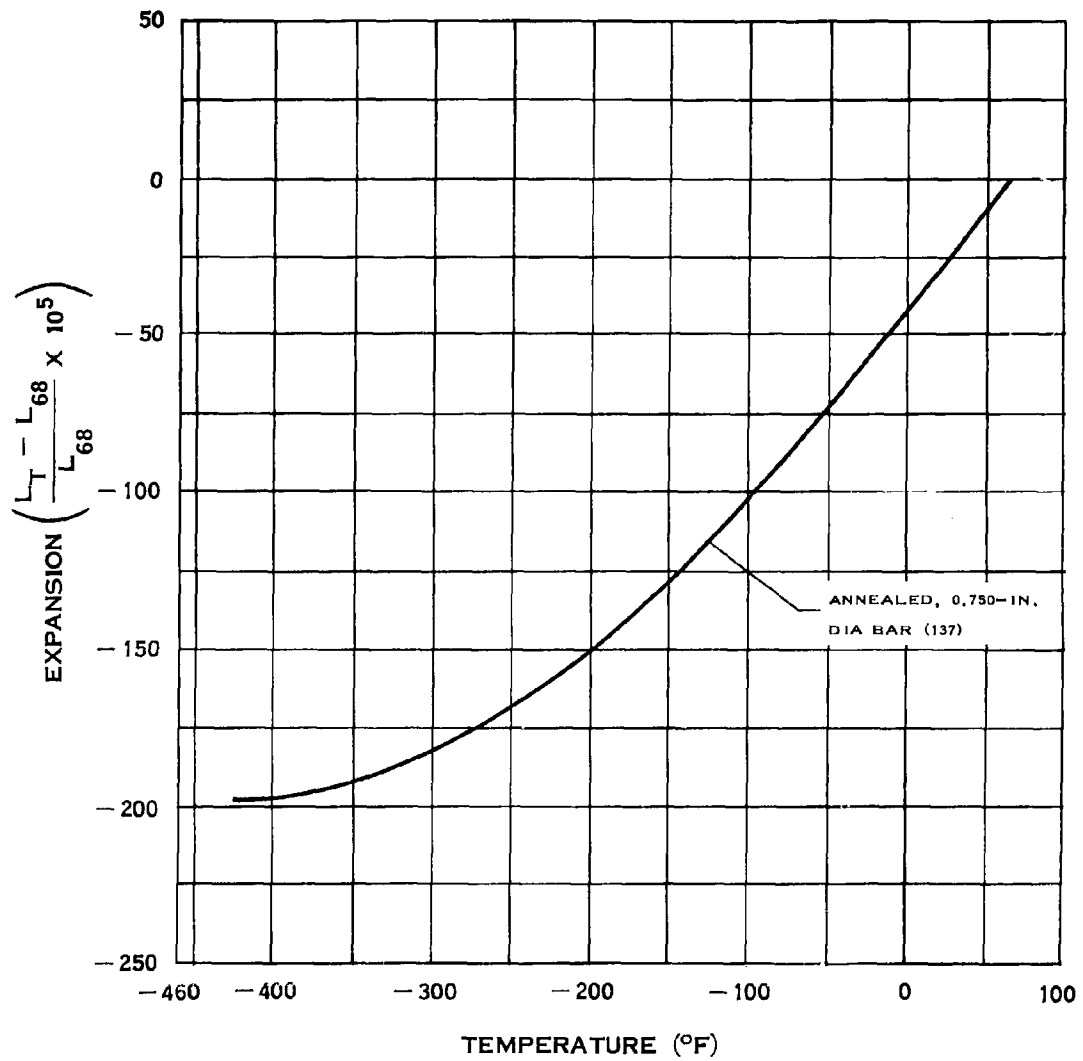
(1-15-64)

D.19.p



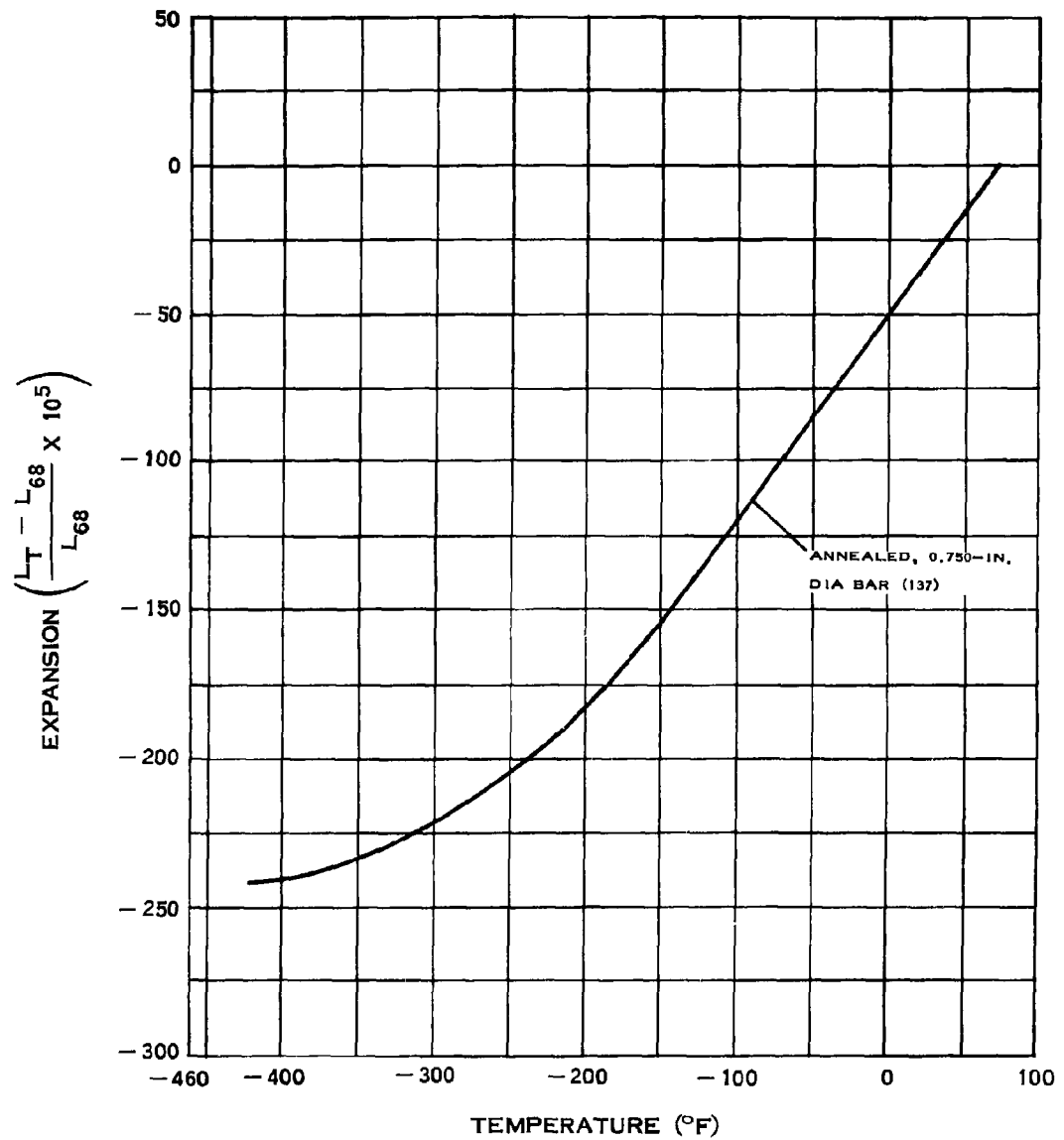
**THERMAL EXPANSION OF 2800
(9% NICKEL) STEEL**

D.20.p



**THERMAL EXPANSION OF 4340
STEEL**

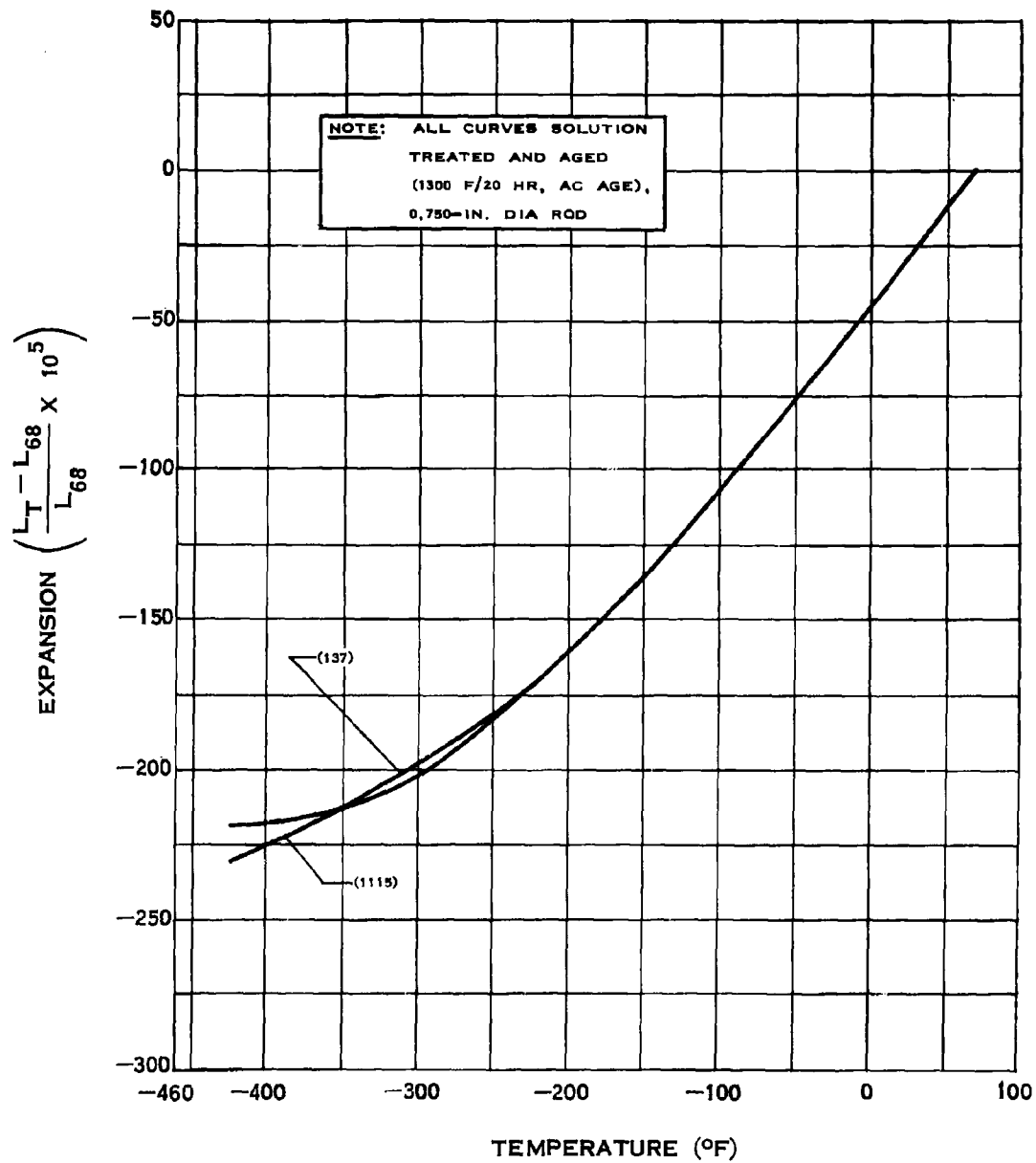
E.1.p



**THERMAL EXPANSION OF
INCONEL NICKEL**

(1-15-64)

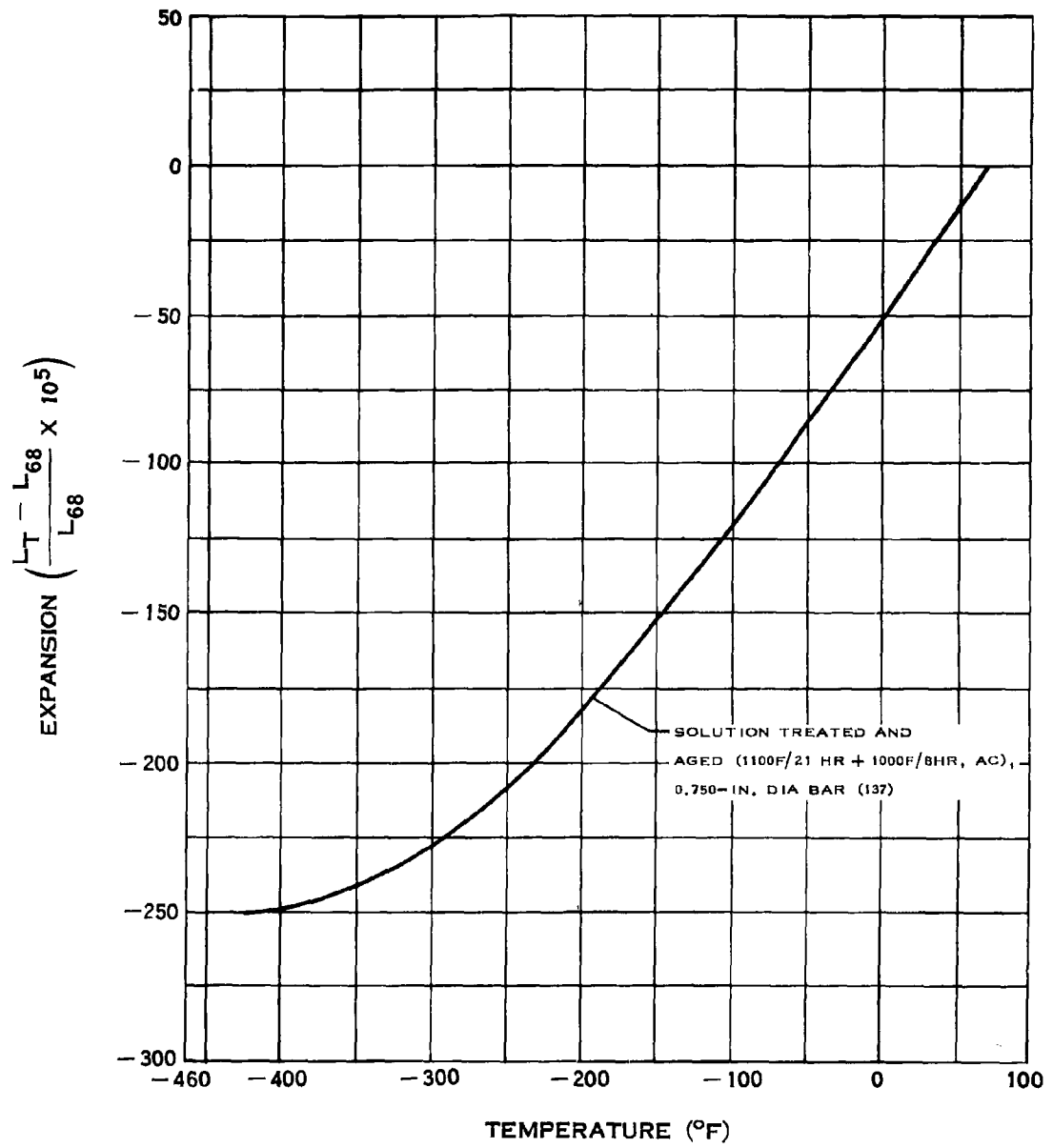
E.2.p



THERMAL EXPANSION OF INCONEL X NICKEL

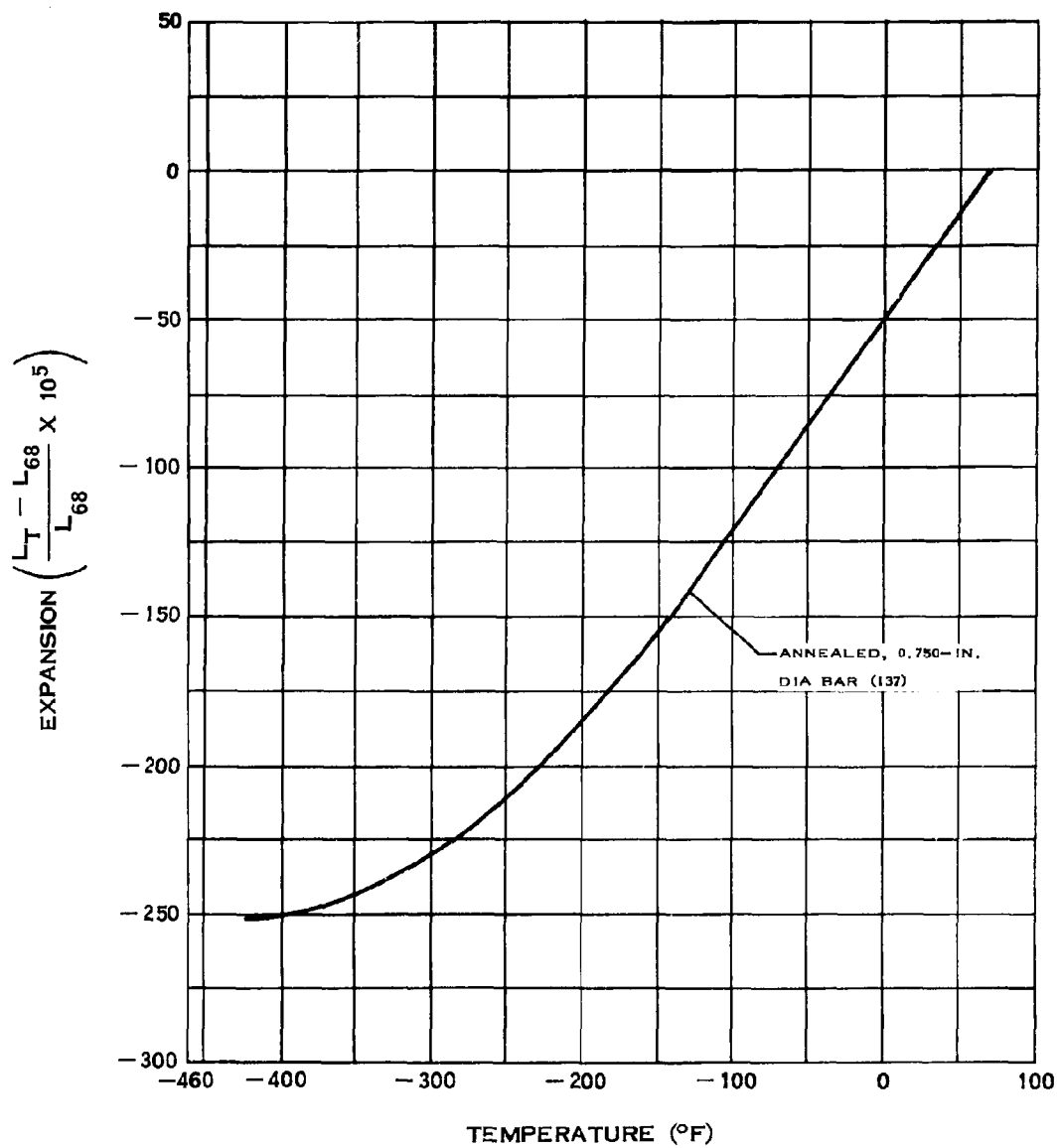
(1-15-64)

E.3.p



THERMAL EXPANSION OF K MONEL NICKEL

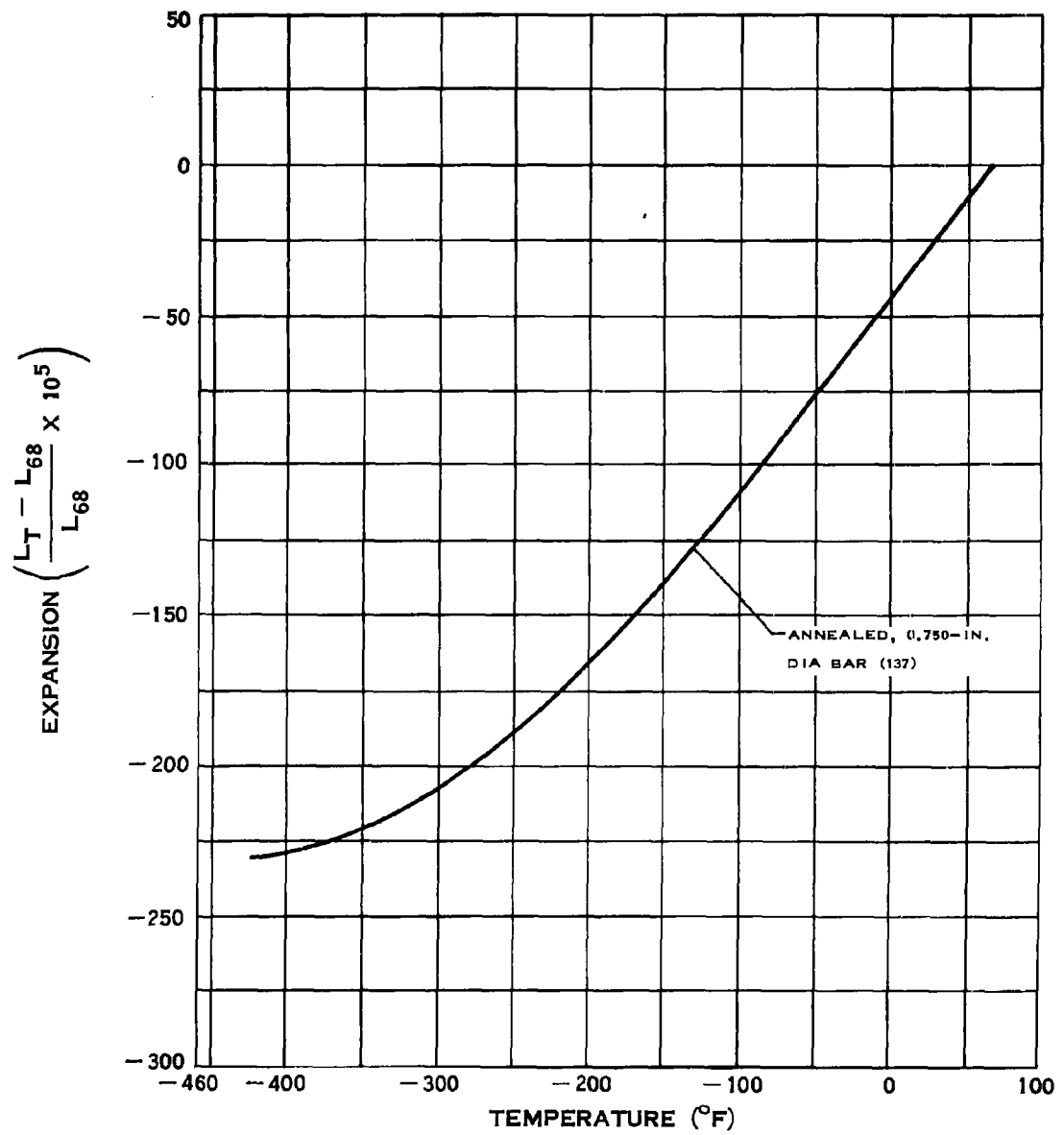
E.4.p



THERMAL EXPANSION OF S MONEL NICKEL

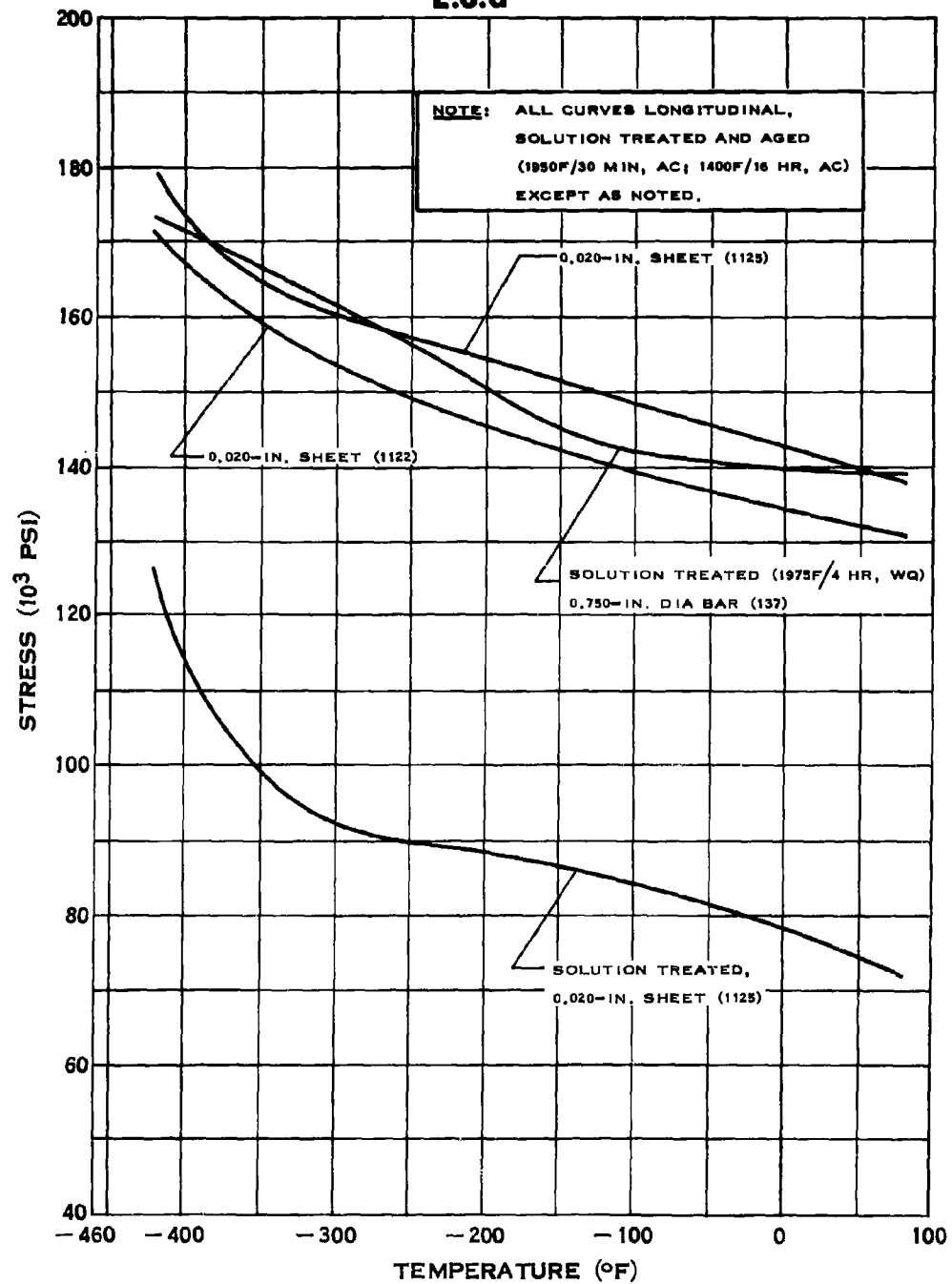
(1-15-64)

E.5.p



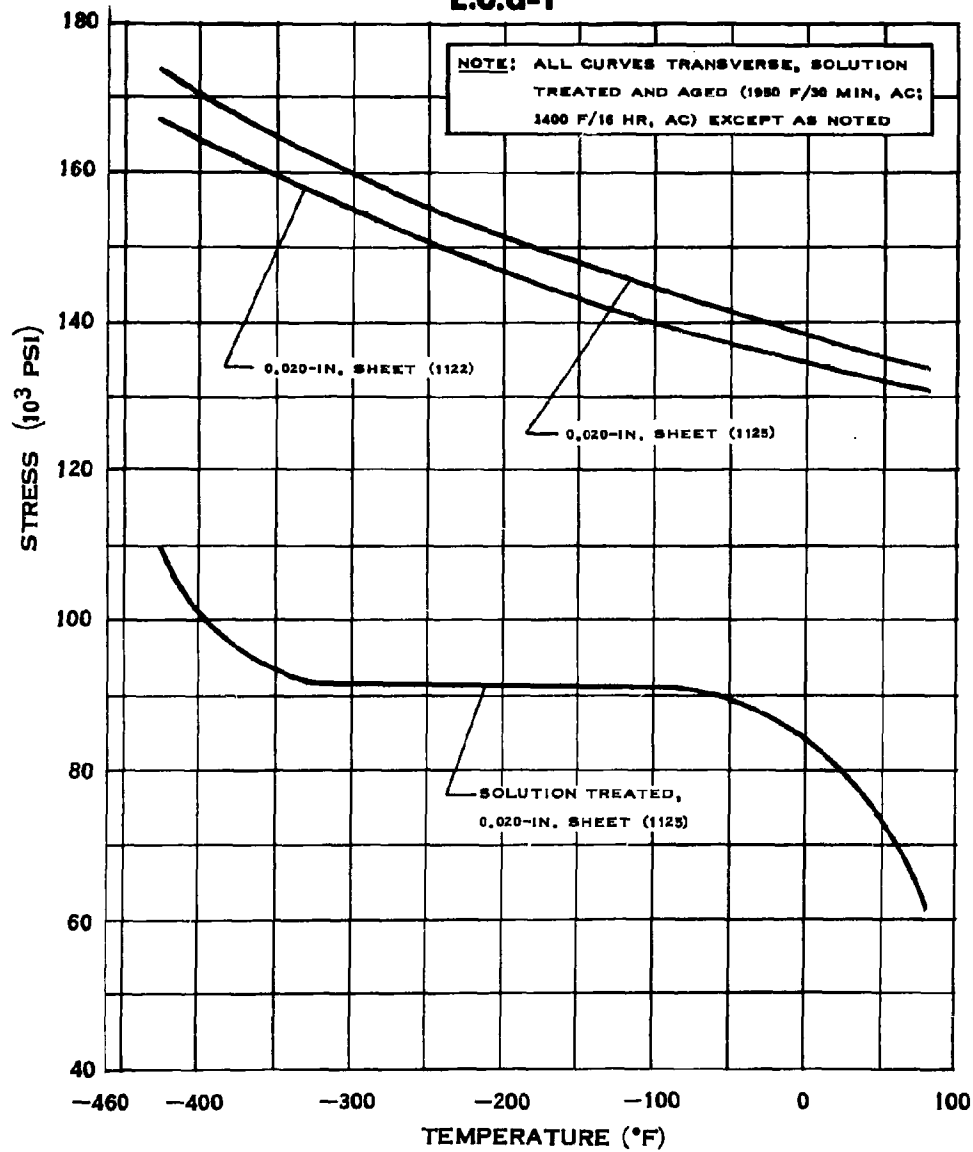
THERMAL EXPANSION OF "A" NICKEL

E.6.a



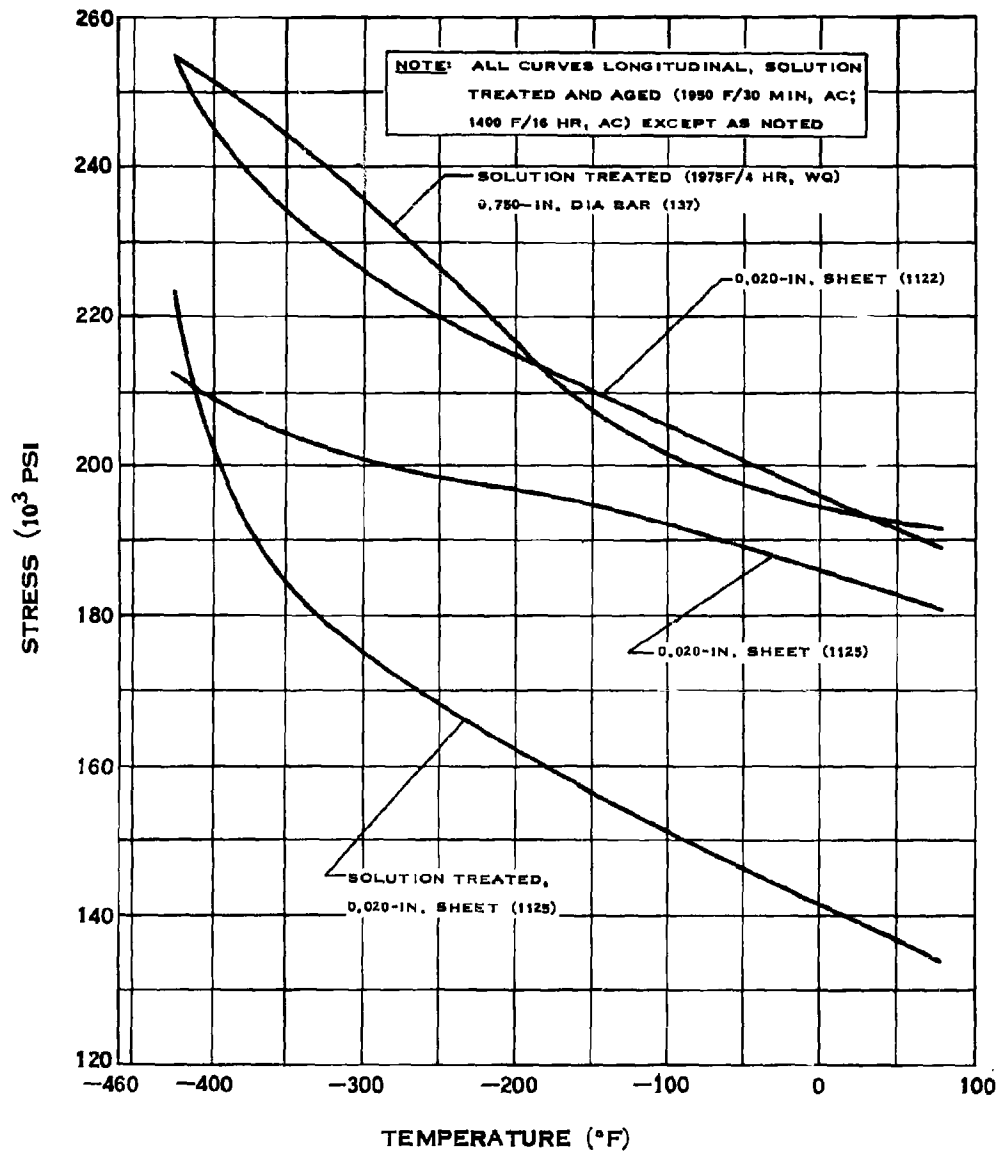
YIELD STRENGTH OF RENE' 41 NICKEL

E.6.a-1



YIELD STRENGTH OF RENE' 41 NICKEL

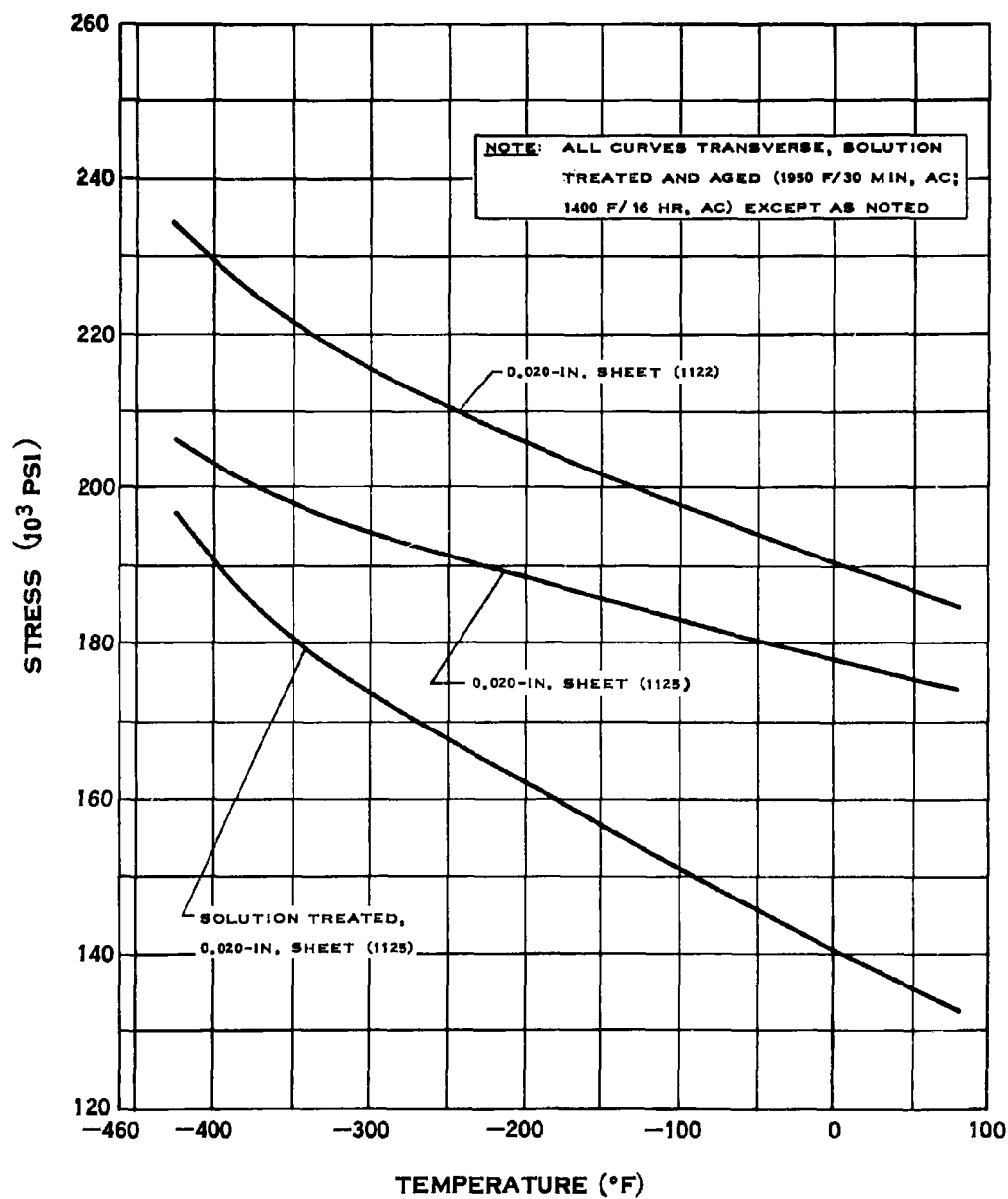
E.6.b



TENSILE STRENGTH OF RENE' 41 NICKEL

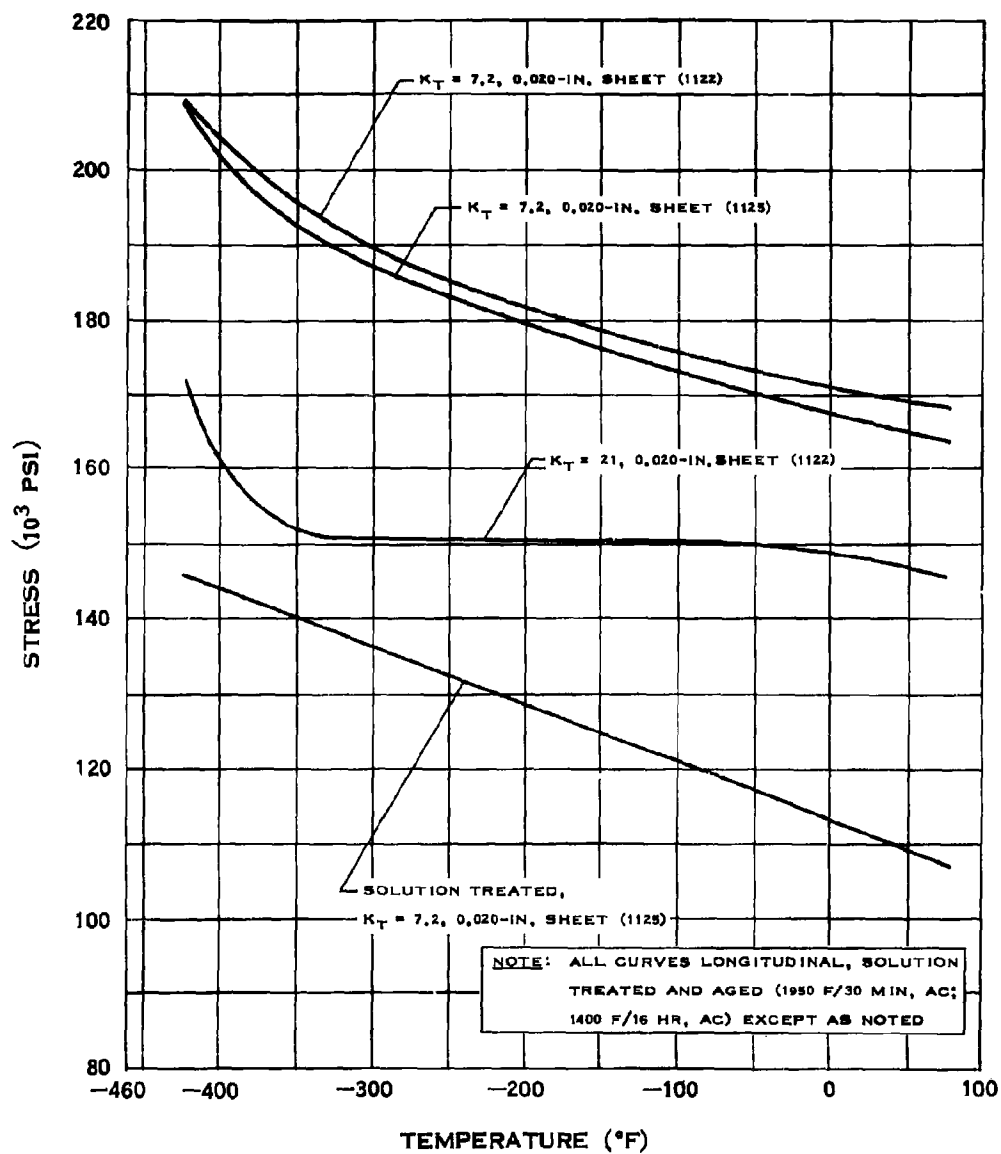
(1-15-64)

E.6.b-1



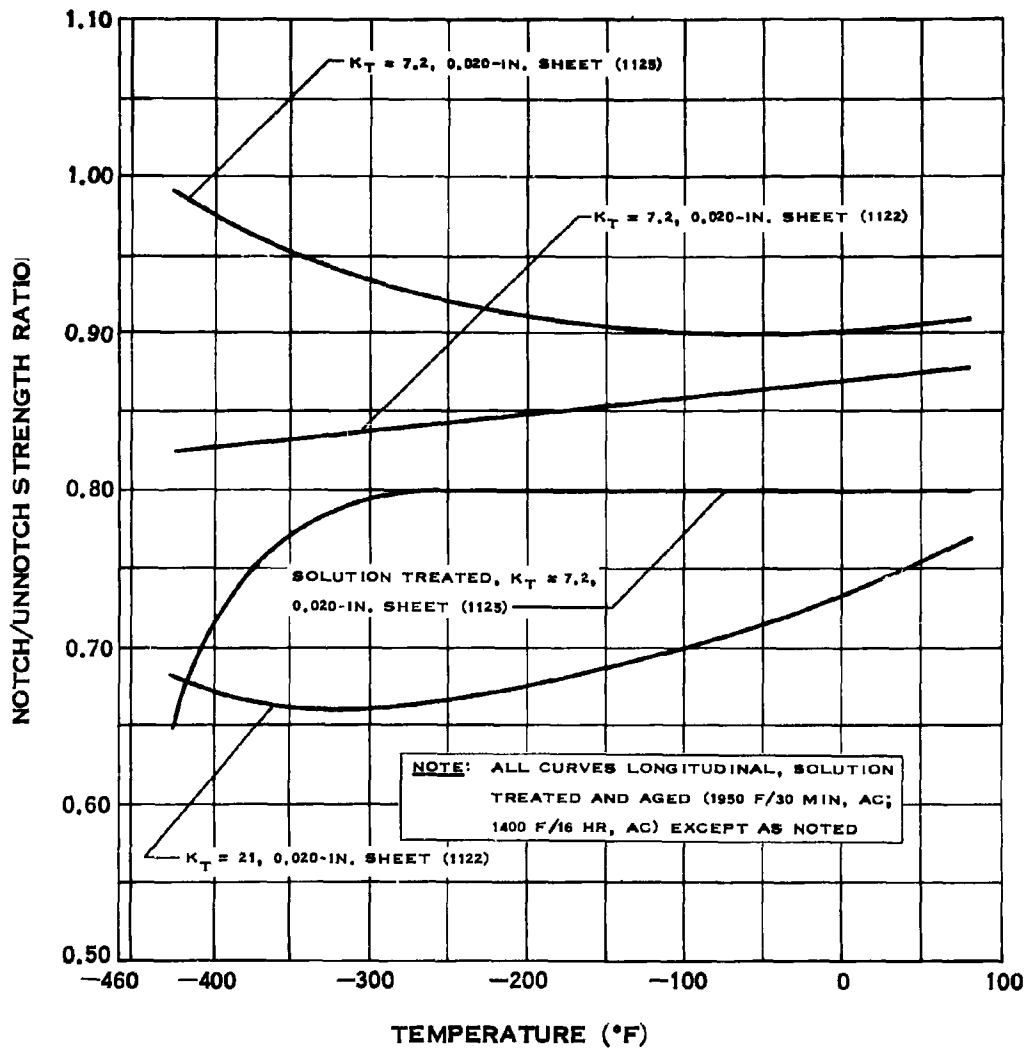
TENSILE STRENGTH OF RENE' 41 NICKEL

E.6.b-2



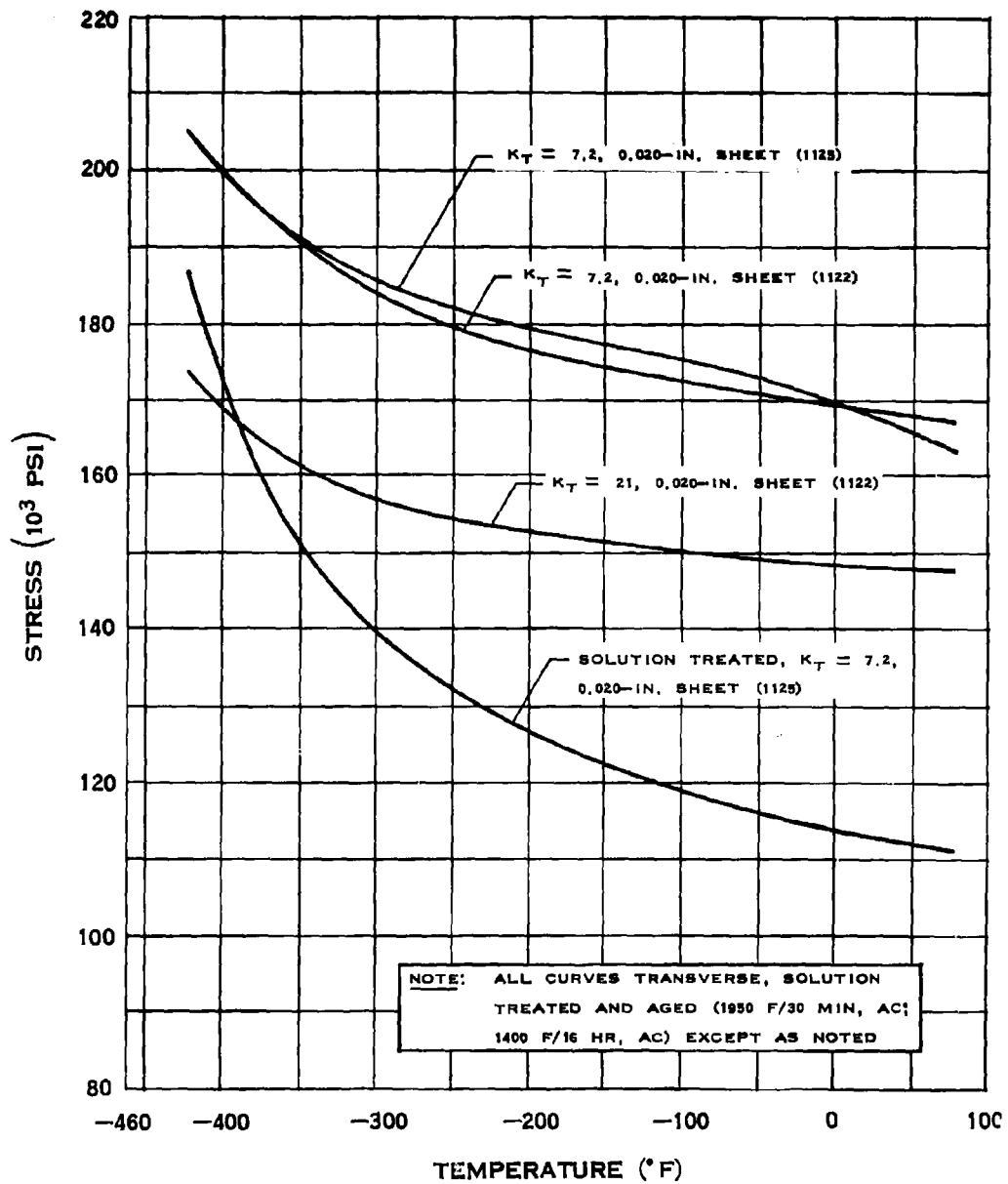
NOTCH TENSILE STRENGTH OF RENE' 41 NICKEL

E.6.b-3



NOTCH STRENGTH RATIO OF RENE' 41 NICKEL

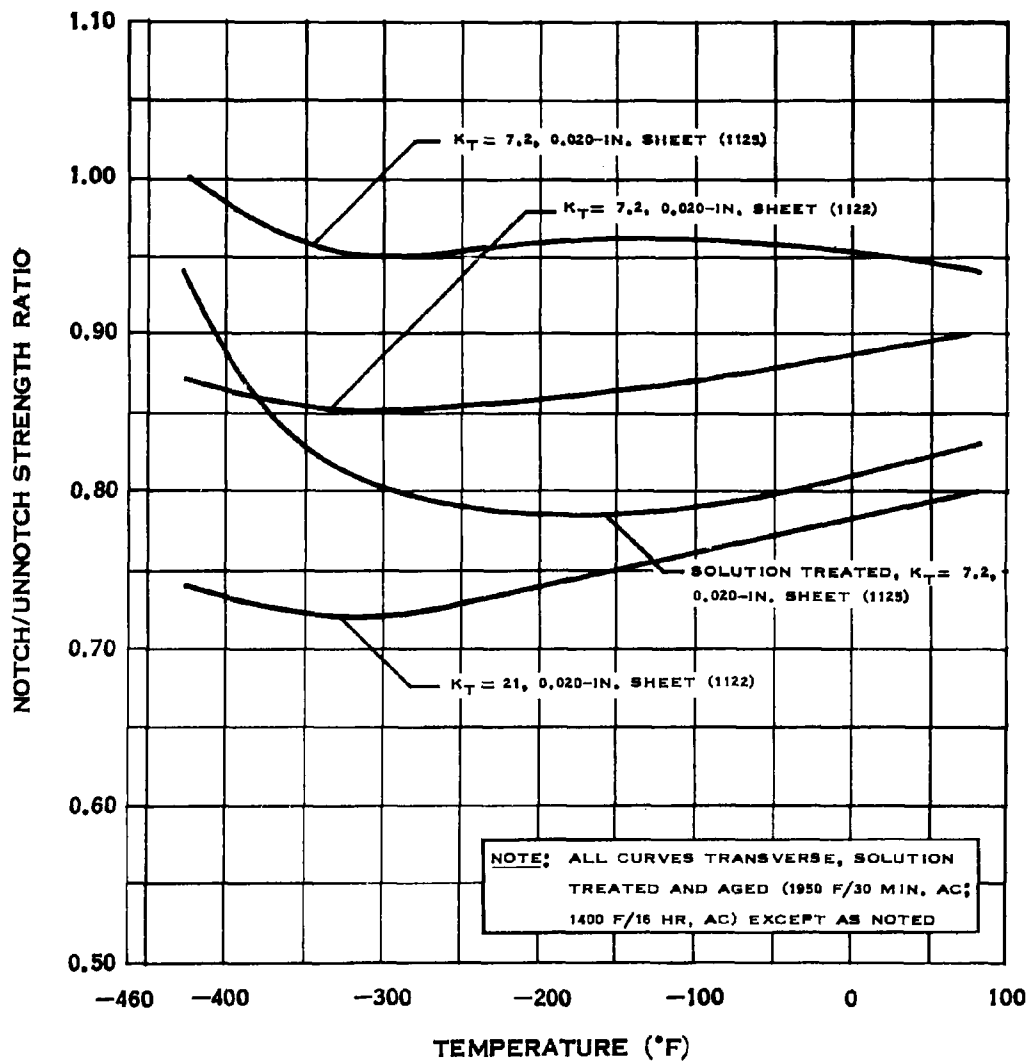
E.6.b-4



NOTCH TENSILE STRENGTH OF RENE' 41 NICKEL

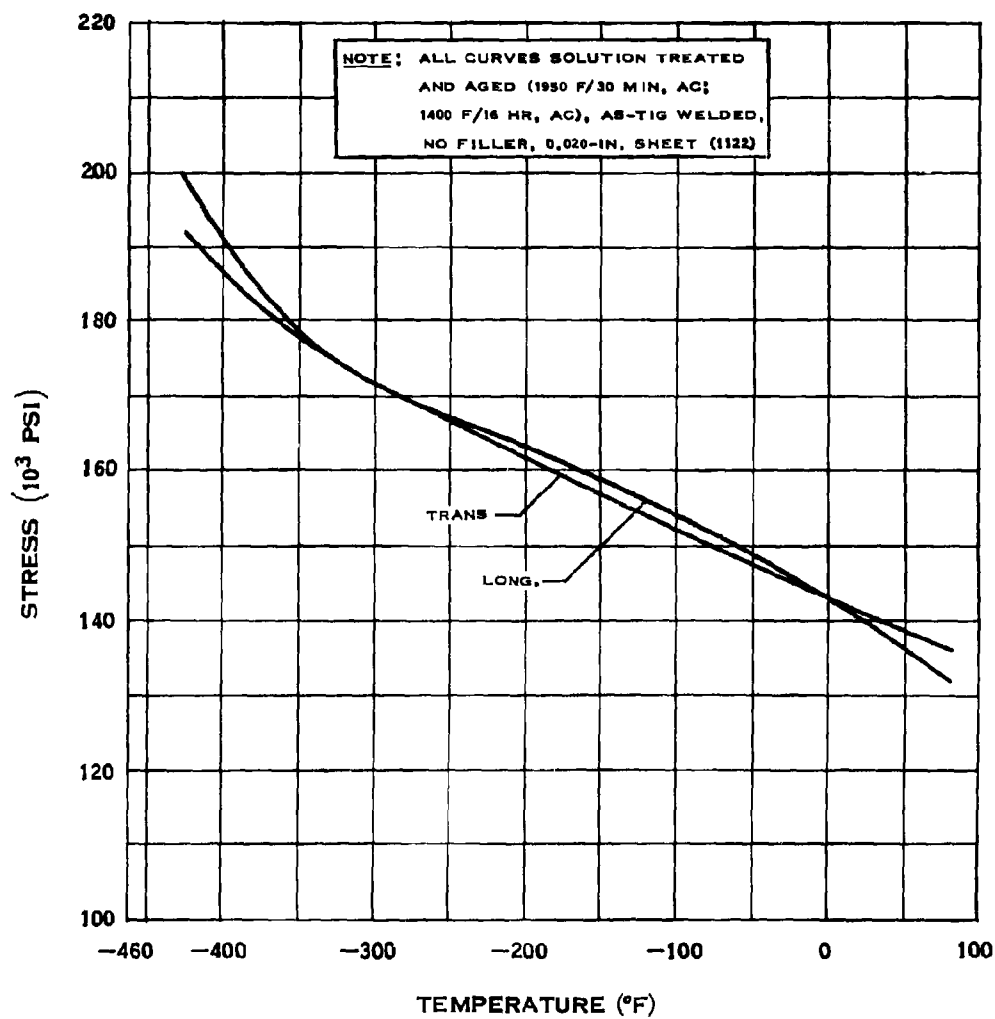
(1-15-64)

E.6.b-5



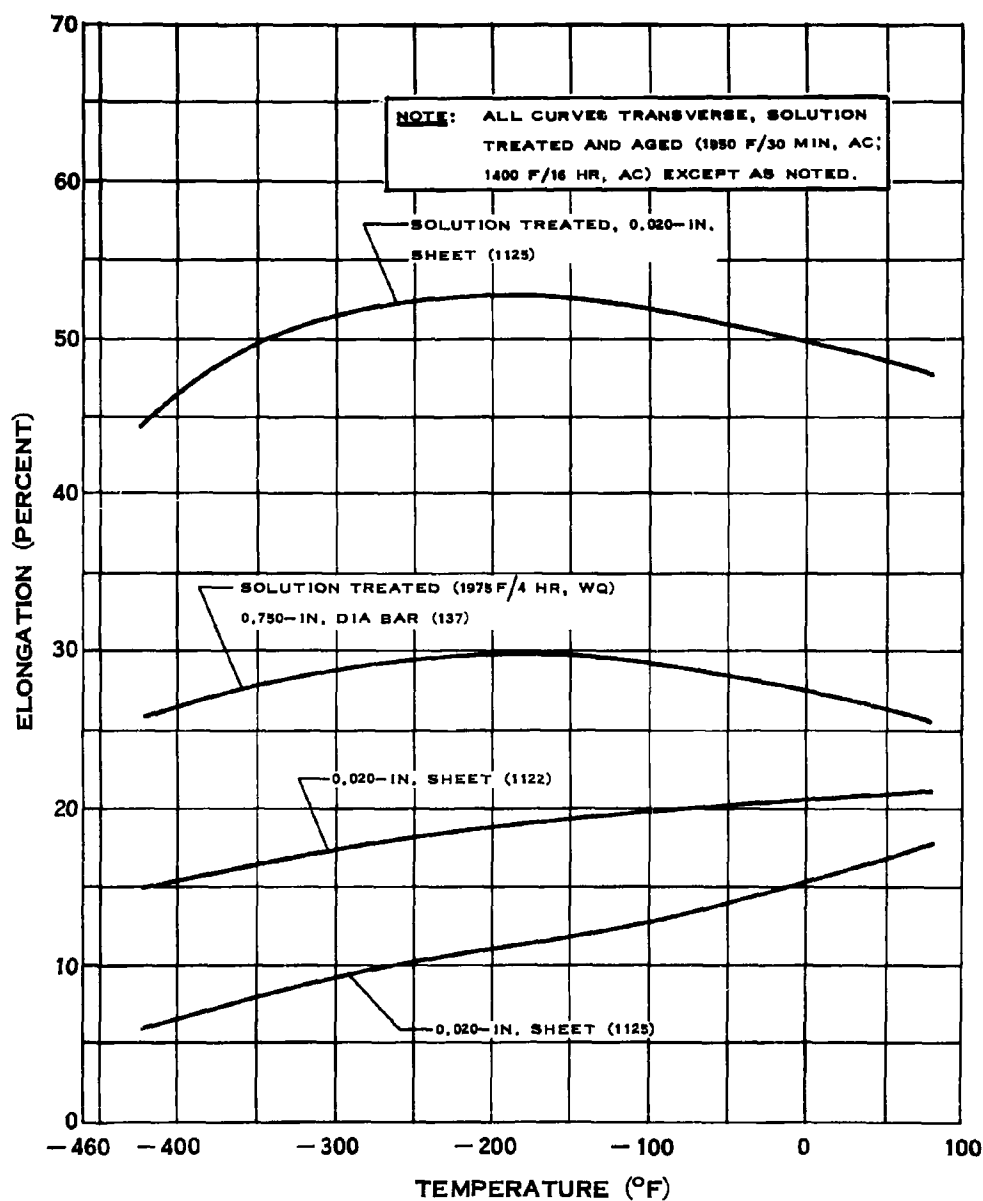
NOTCH STRENGTH RATIO OF RENE' 41 NICKEL

E.6.b-6



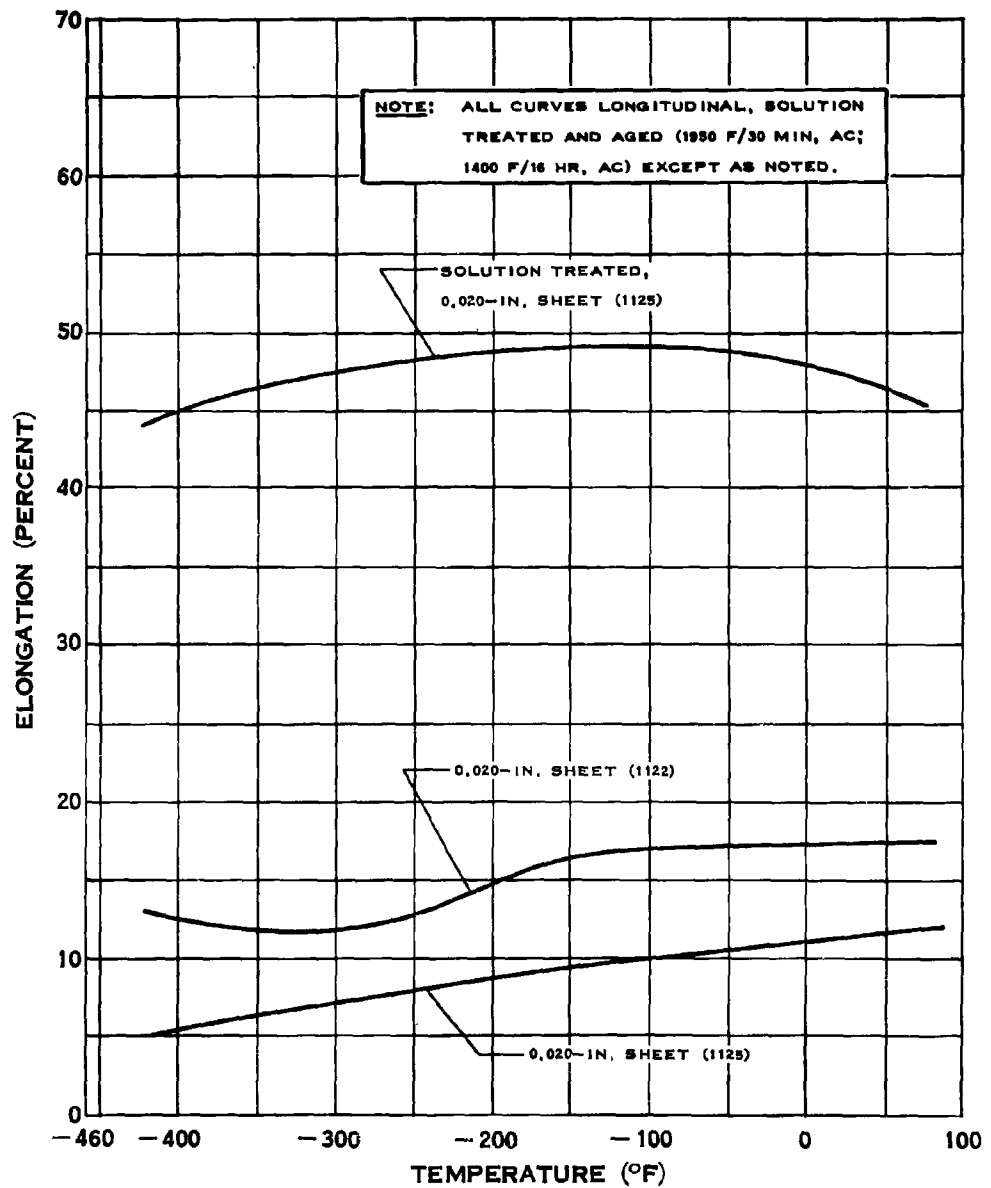
WELD TENSILE STRENGTH OF RENE' 41 NICKEL

E.6.c



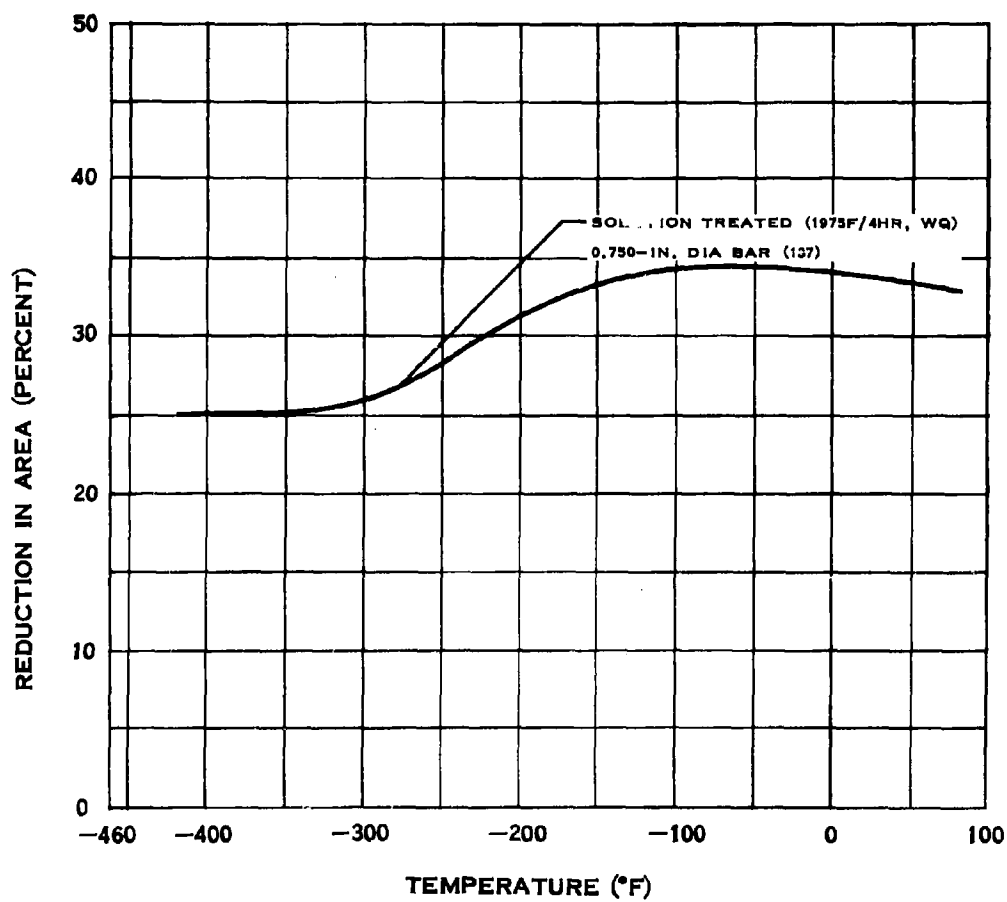
ELONGATION OF RENE' 41 NICKEL

E.6.c-1



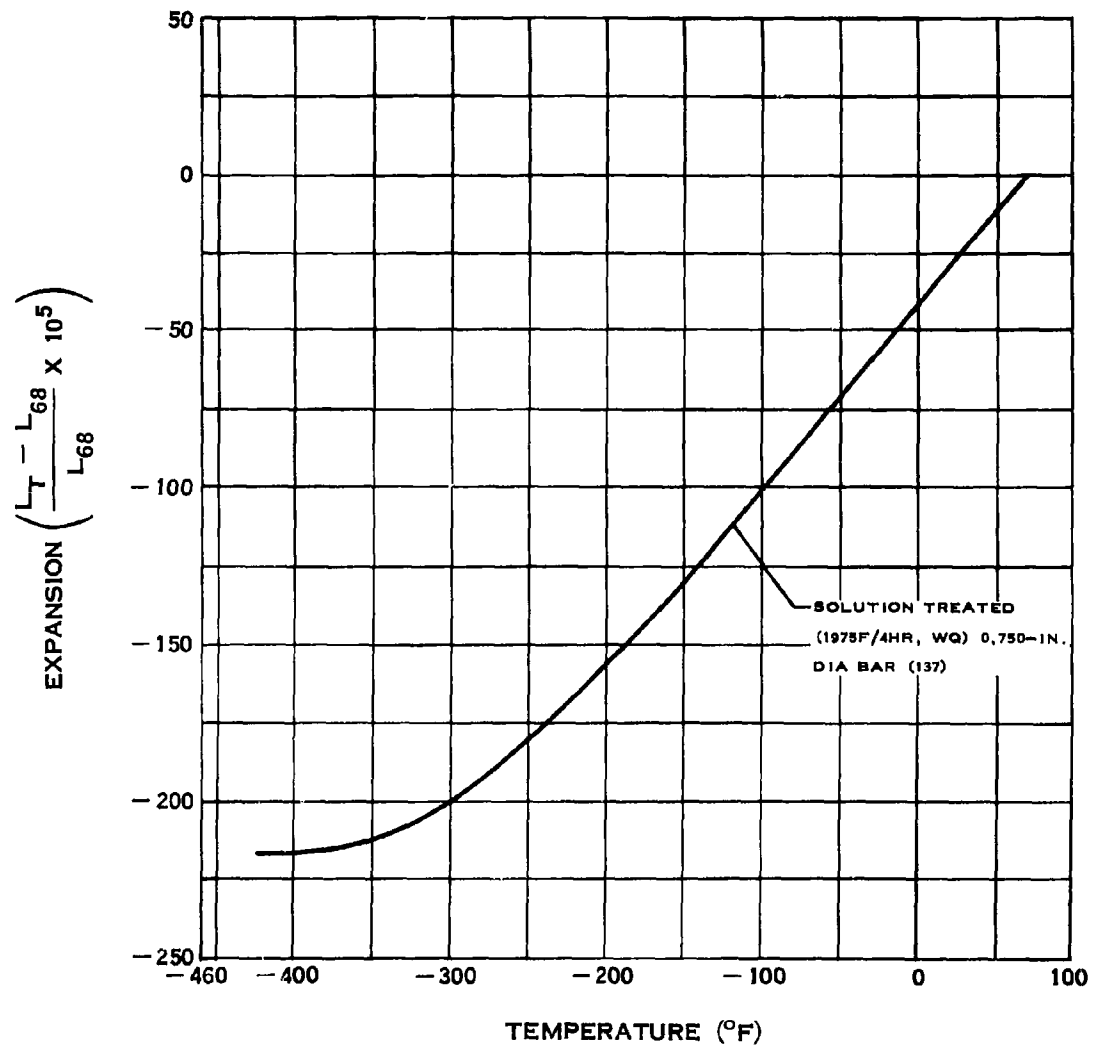
ELONGATION OF RENE' 41 NICKEL

E.6.d



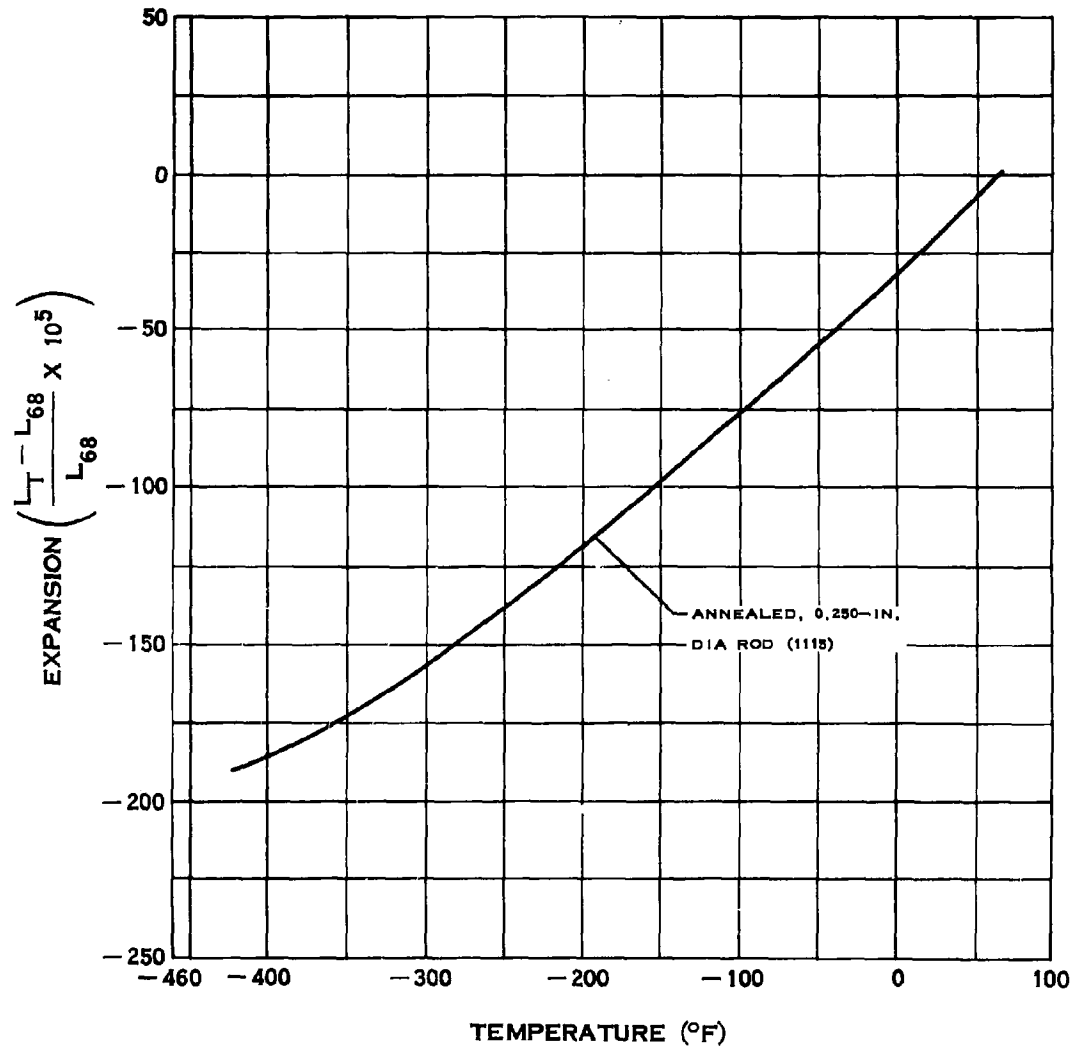
REDUCTION IN AREA OF RENE' 41 NICKEL

E.6.p



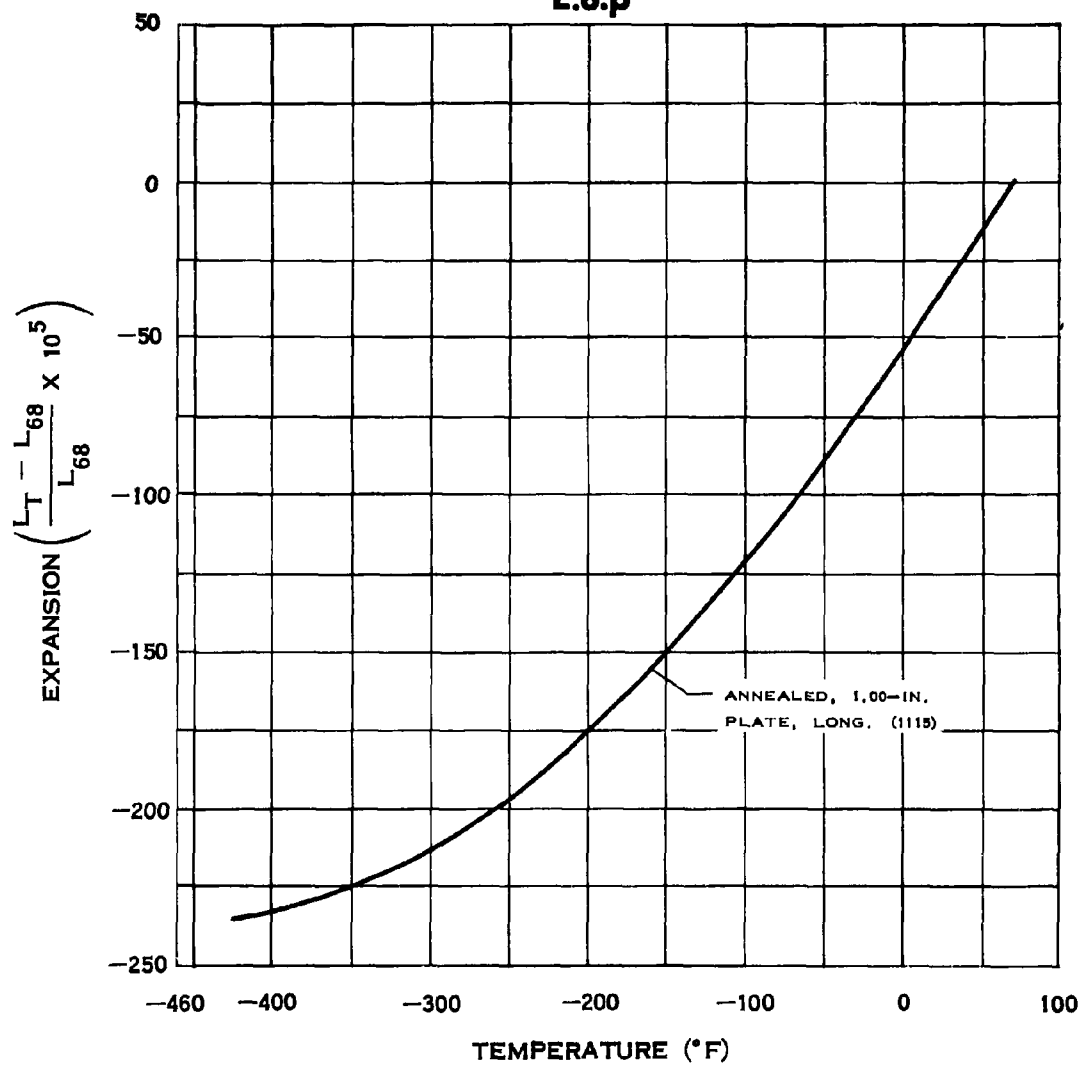
THERMAL EXPANSION OF RENÉ 41 NICKEL

E.7.p



THERMAL EXPANSION OF HASTELLOY B

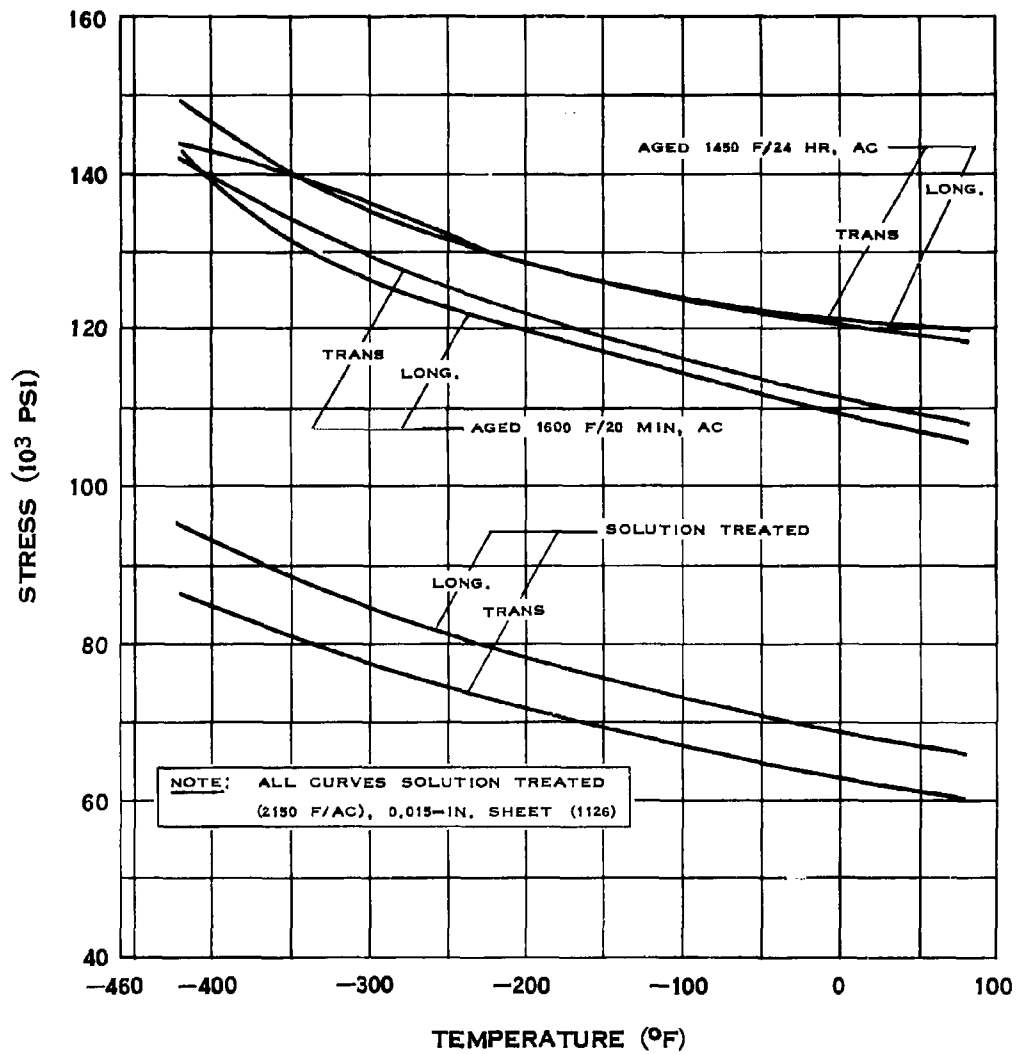
E.8.p



THERMAL EXPANSION OF D-979 NICKEL

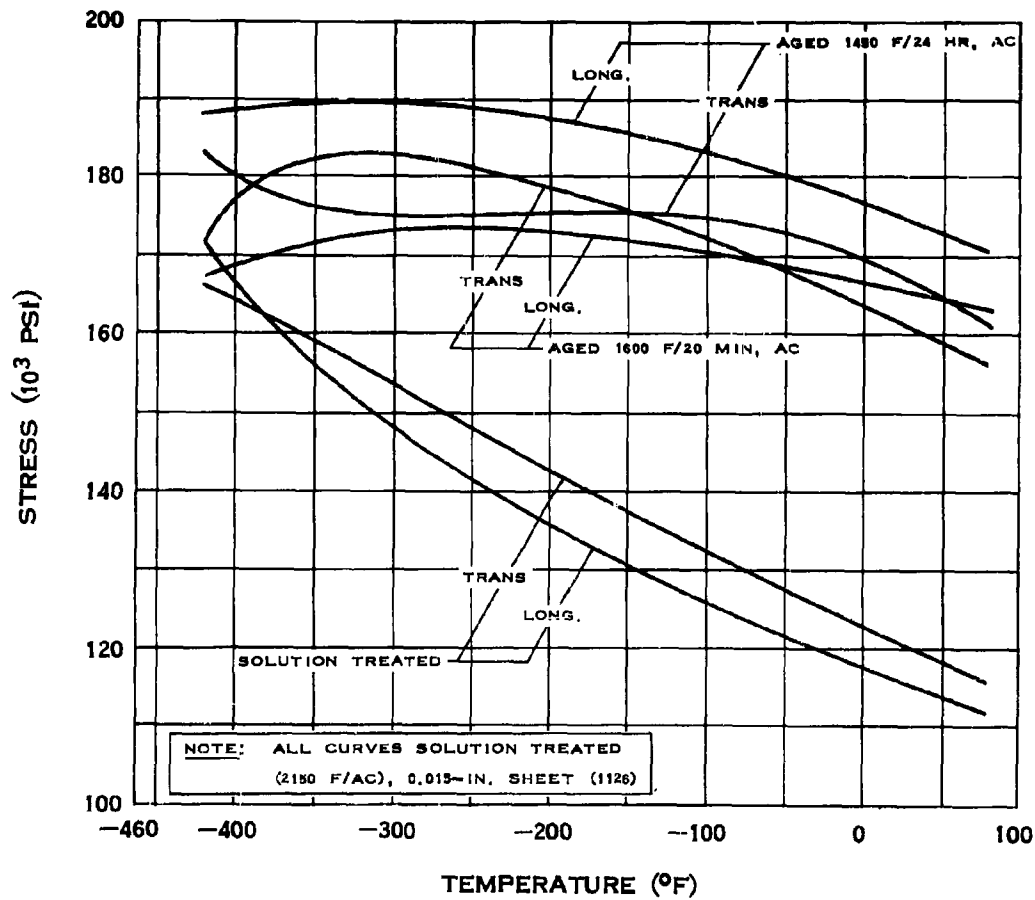
(1-15-54)

E.9.a



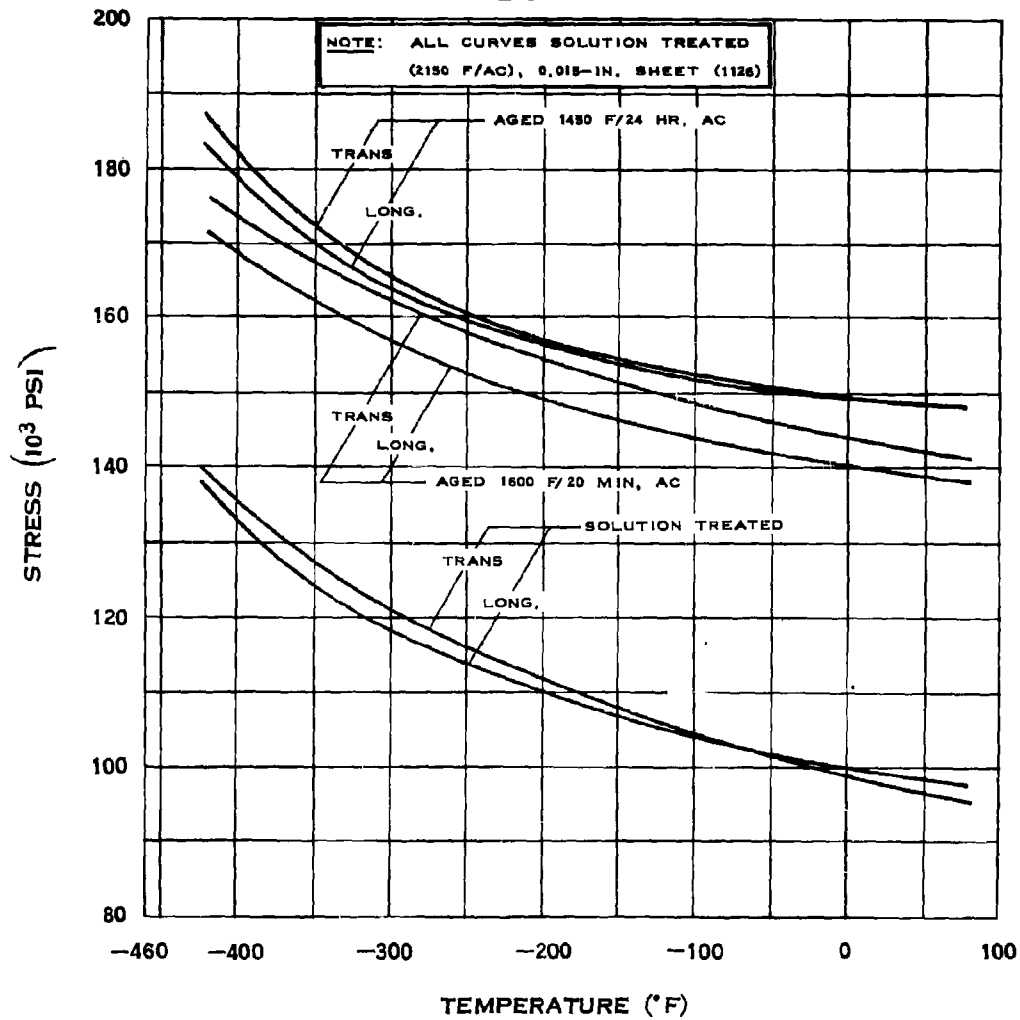
YIELD STRENGTH OF R-235 NICKEL

E.9.b



TENSILE STRENGTH OF R-235 NICKEL

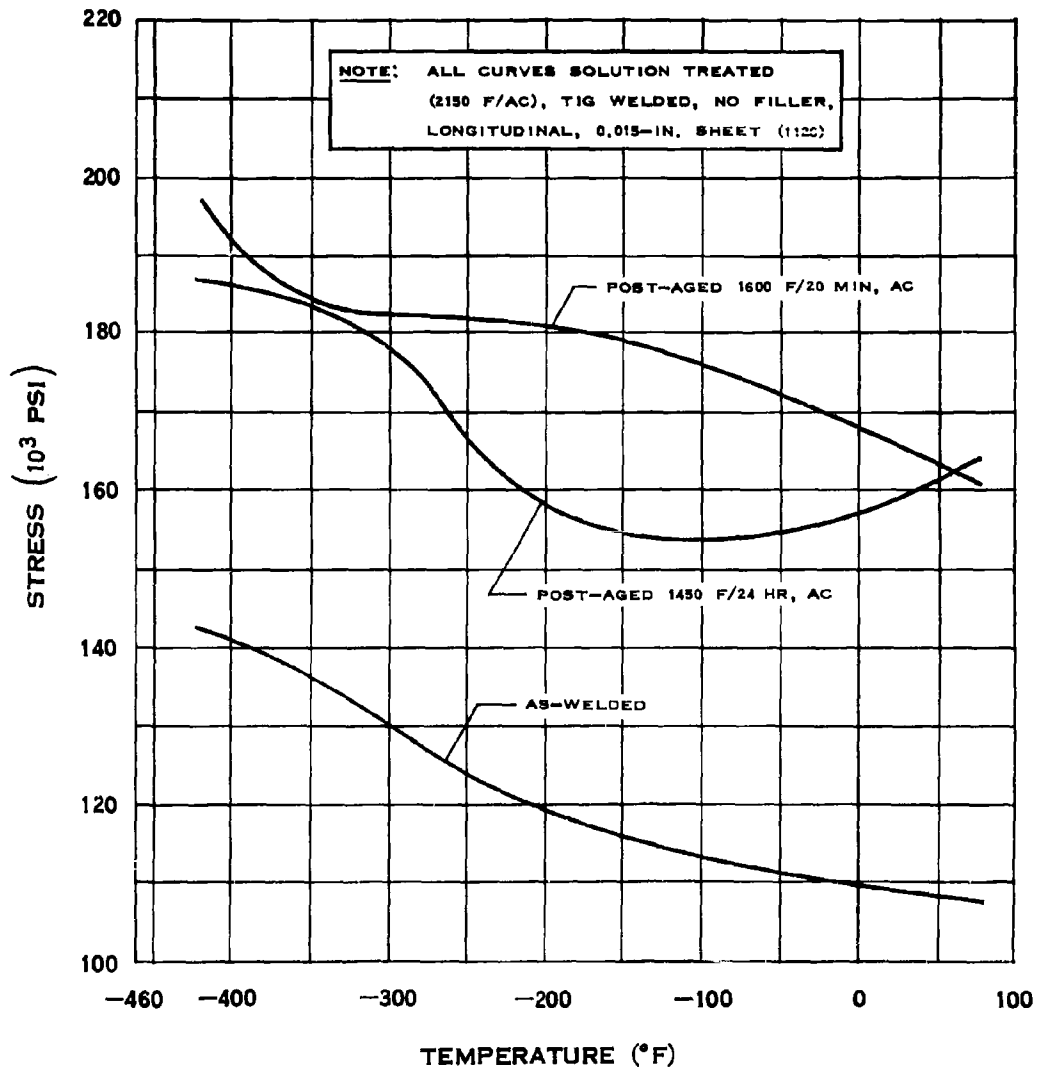
E.9.b-1



NOTCH TENSILE STRENGTH OF R-235 NICKEL

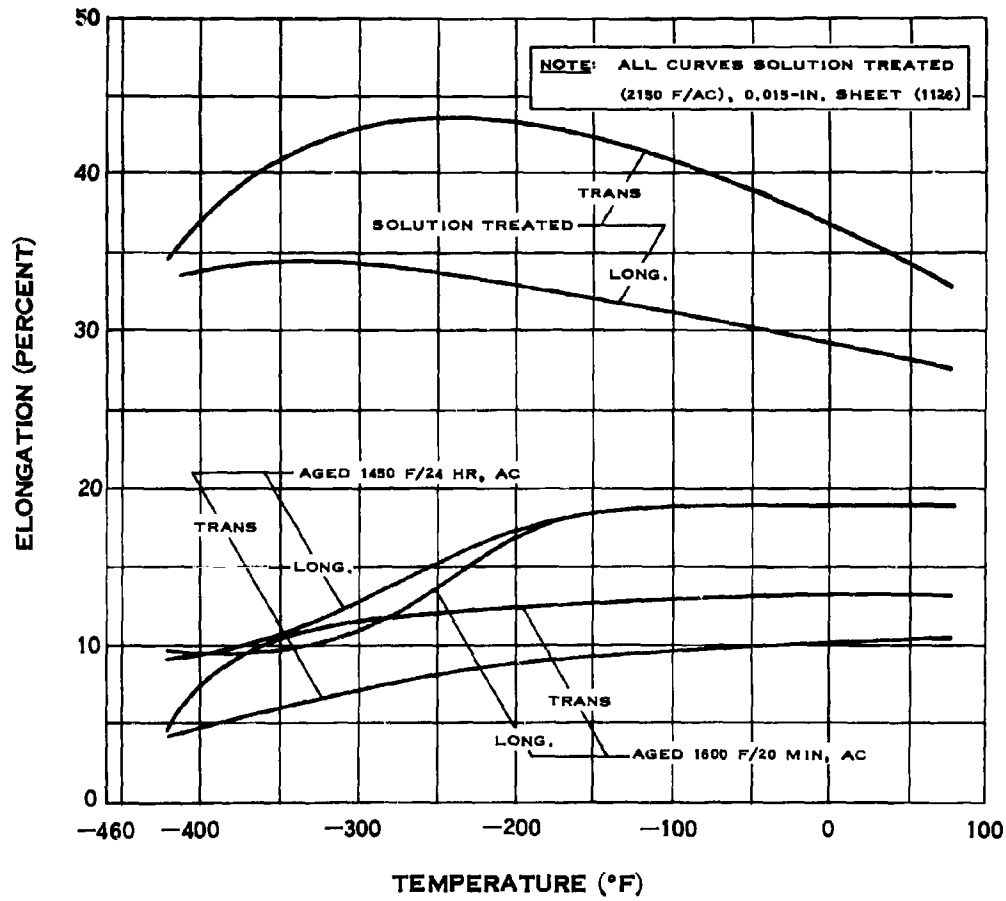
(1-15-64)

E.9.b-3



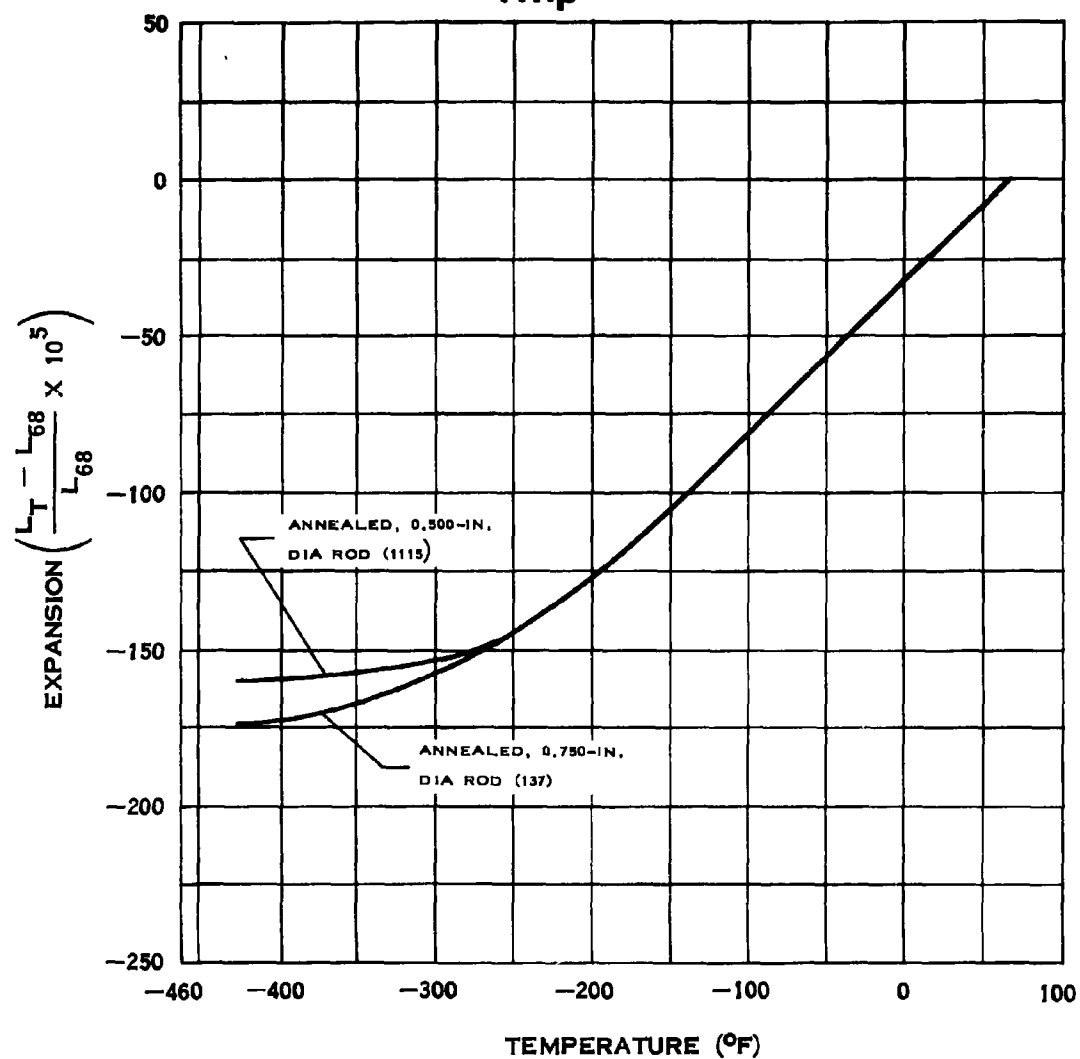
WELD TENSILE STRENGTH OF R-235 NICKEL

E.9.c



ELONGATION OF R-235 NICKEL

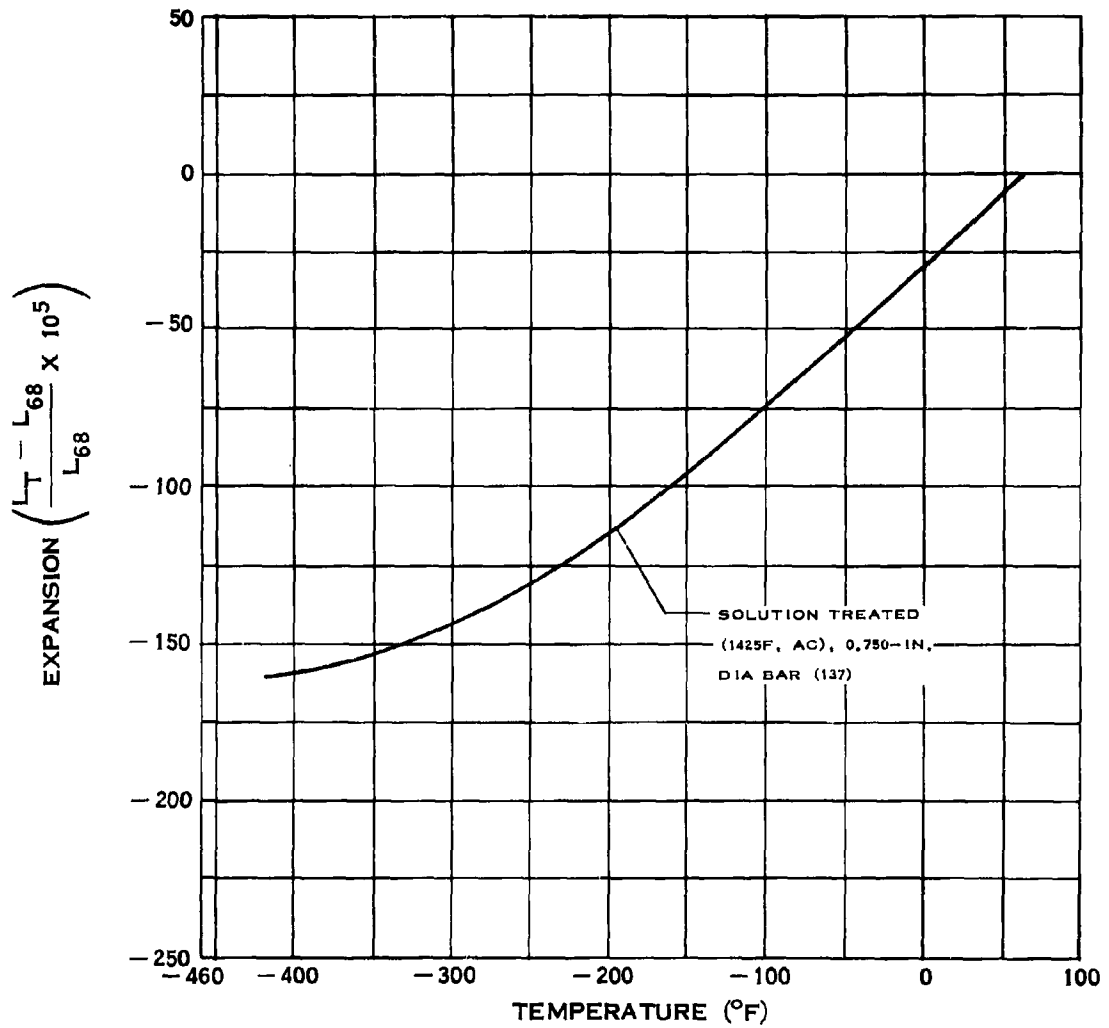
F.1.p



THERMAL EXPANSION OF 5AL-2.5 SN TITANIUM

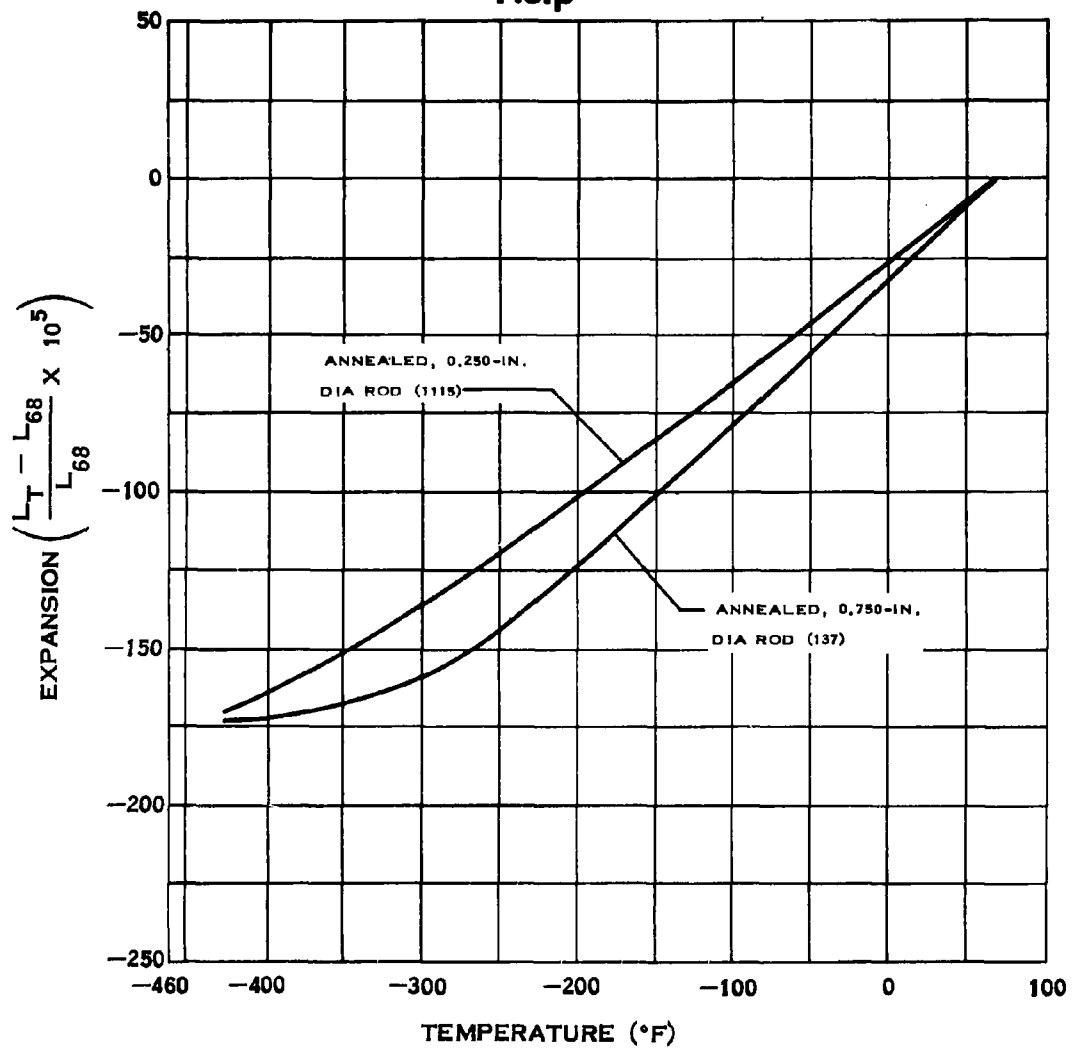
(1-15-64)

F.2.p



THERMAL EXPANSION OF 13V-11CR-3AL TITANIUM

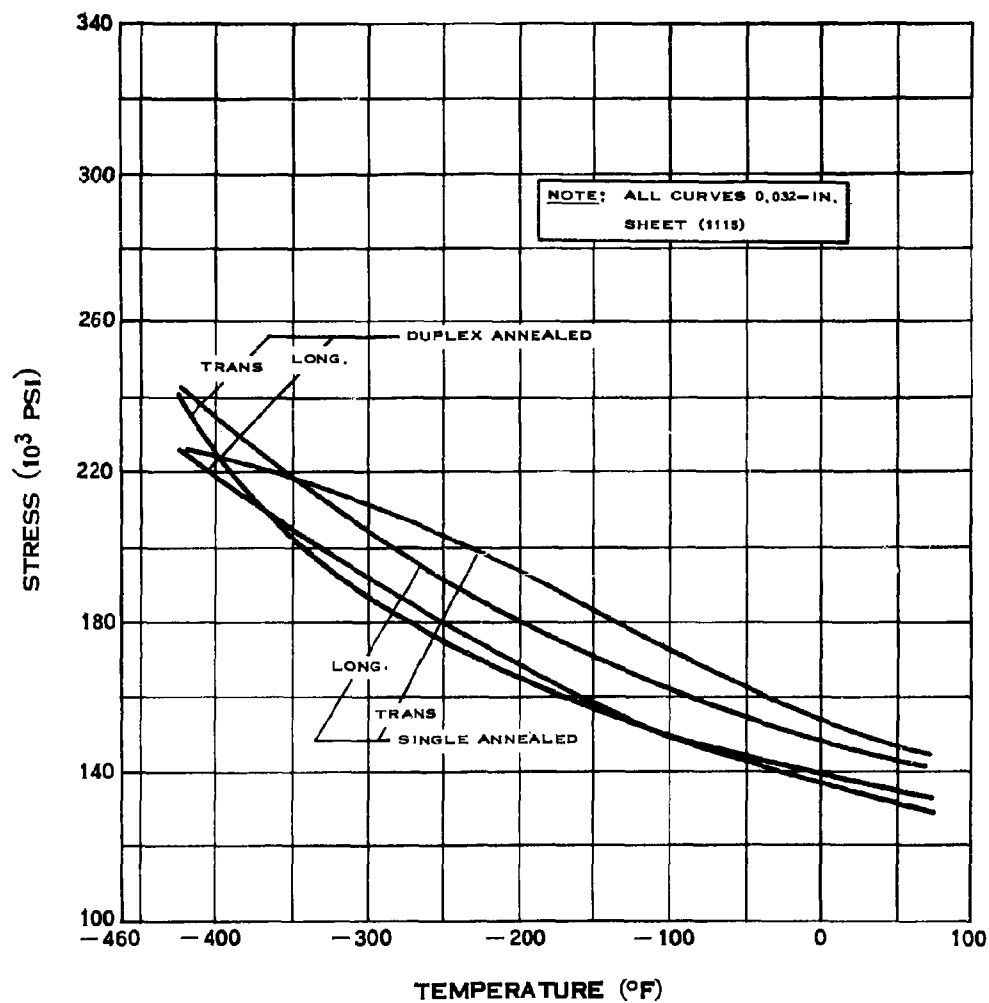
F.3.p



THERMAL EXPANSION OF 6AL-4V TITANIUM

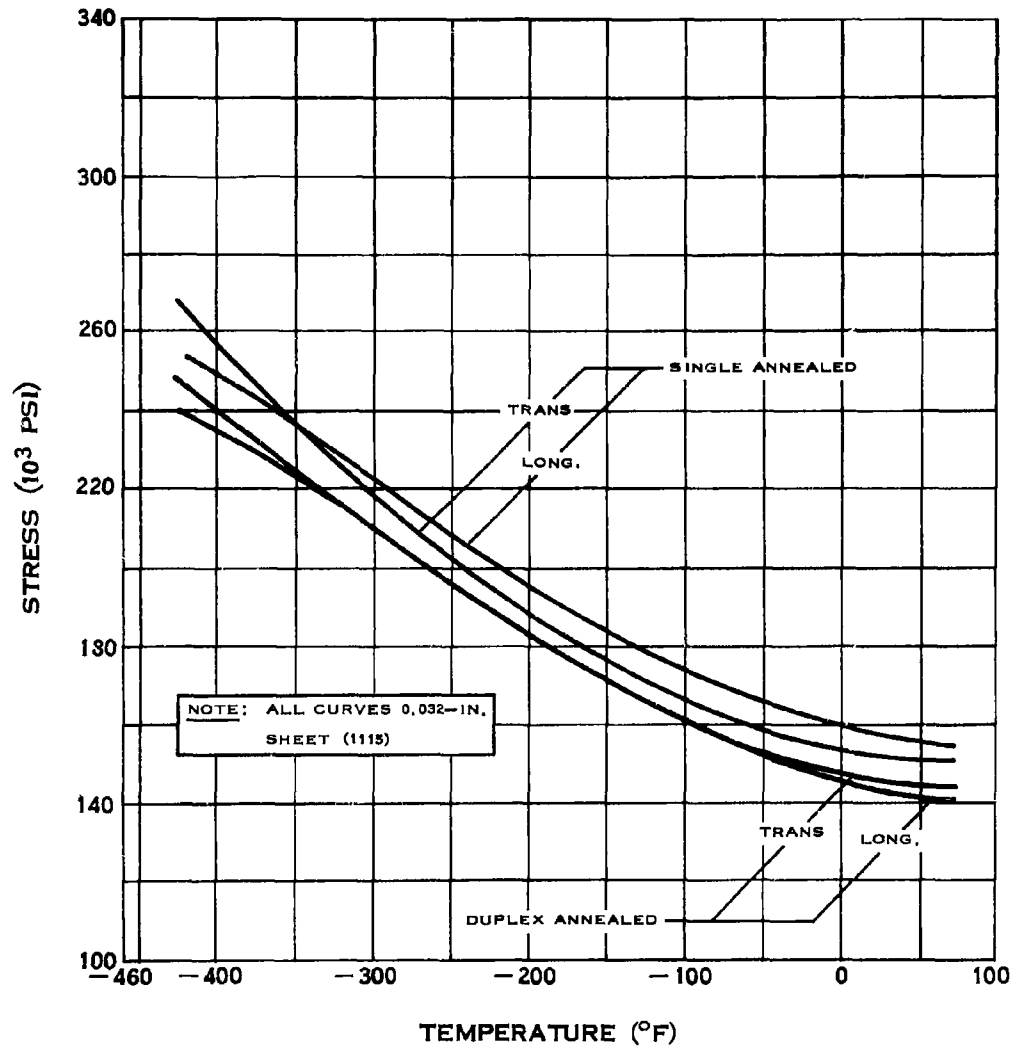
(1-15-64)

F.4.a



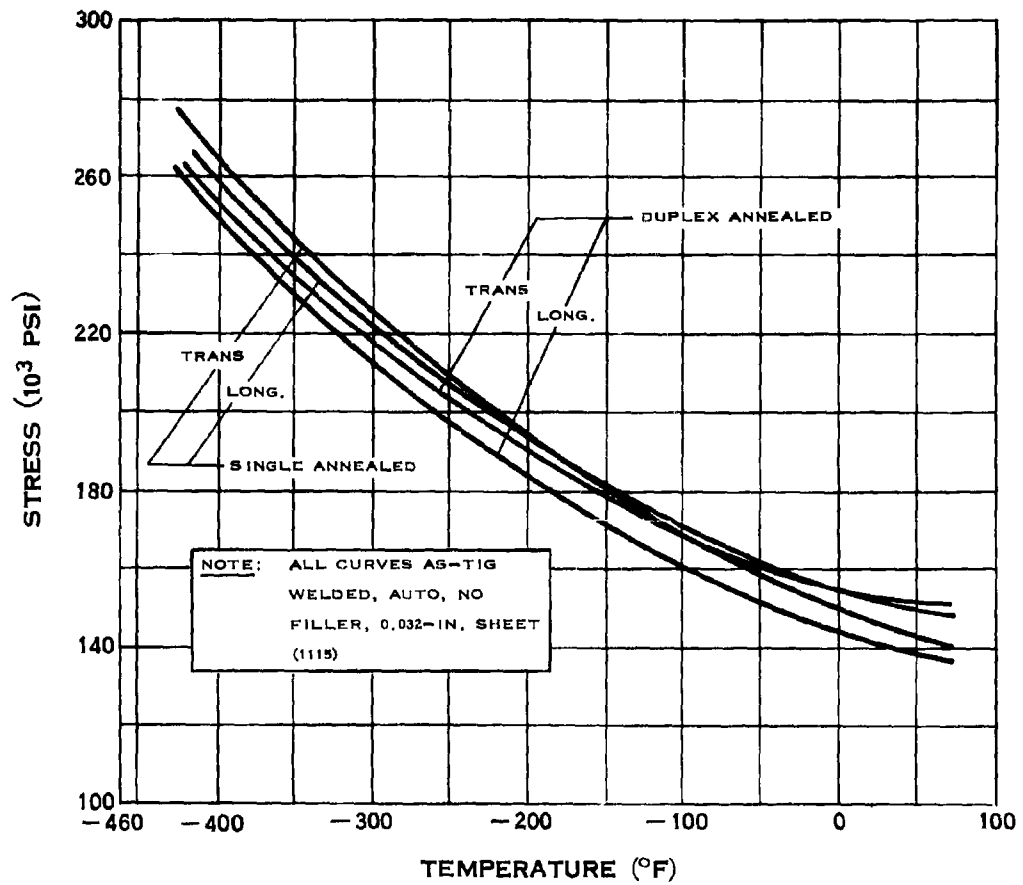
YIELD STRENGTH OF 8AL-1MO-1V TITANIUM

F.4.b



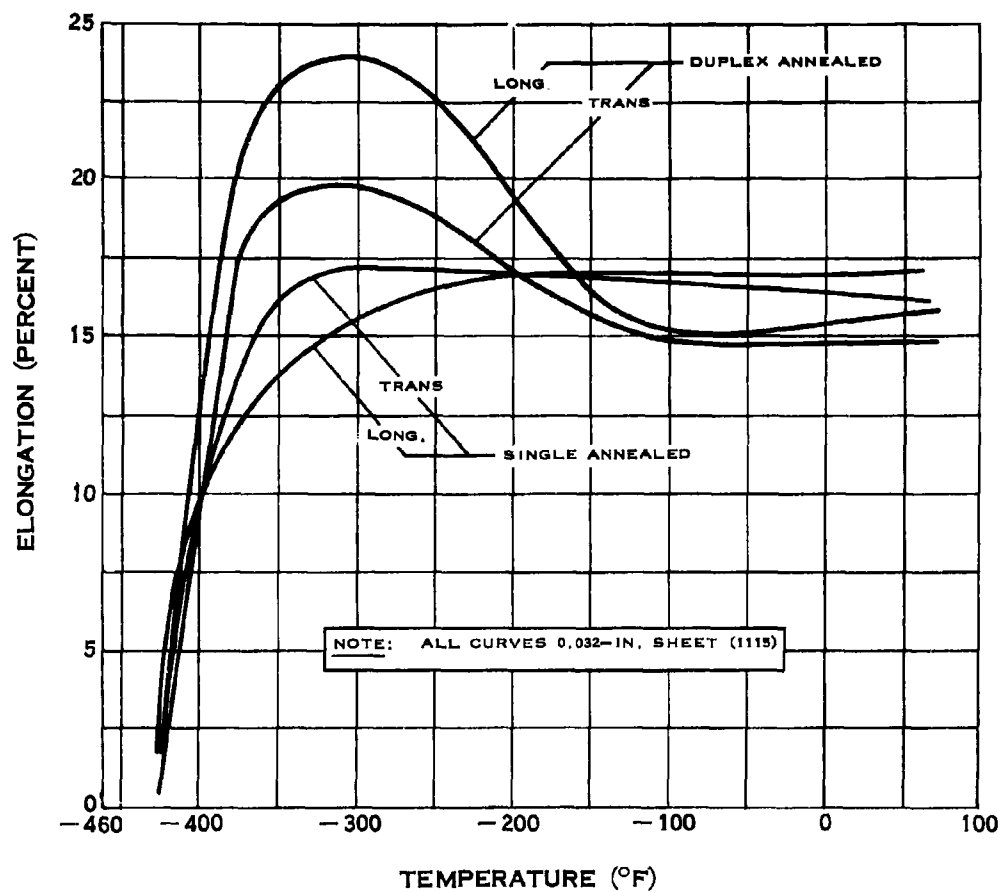
TENSILE STRENGTH OF 8AL-1MO-1V TITANIUM

F.4.b-3



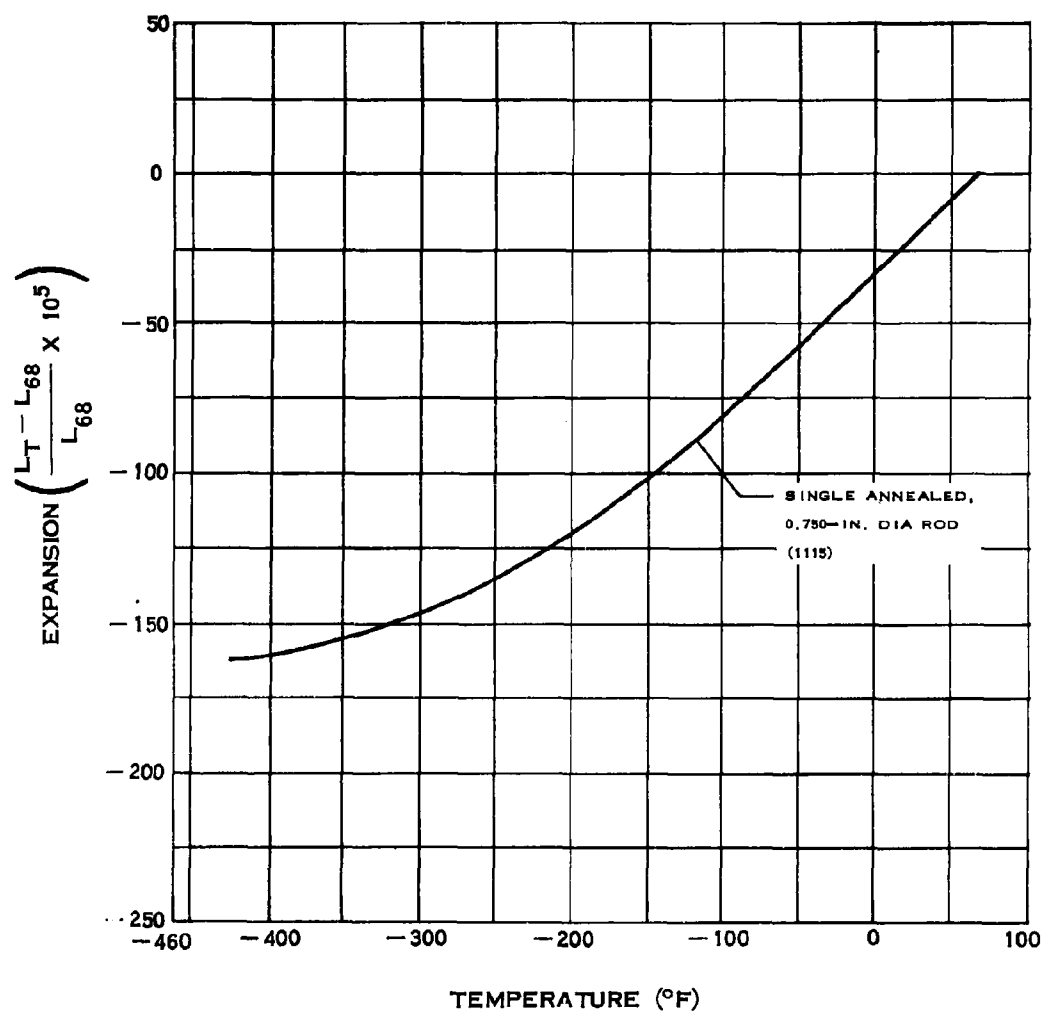
WELD TENSILE STRENGTH OF 8AL-1MO-1V TITANIUM

F.4.c



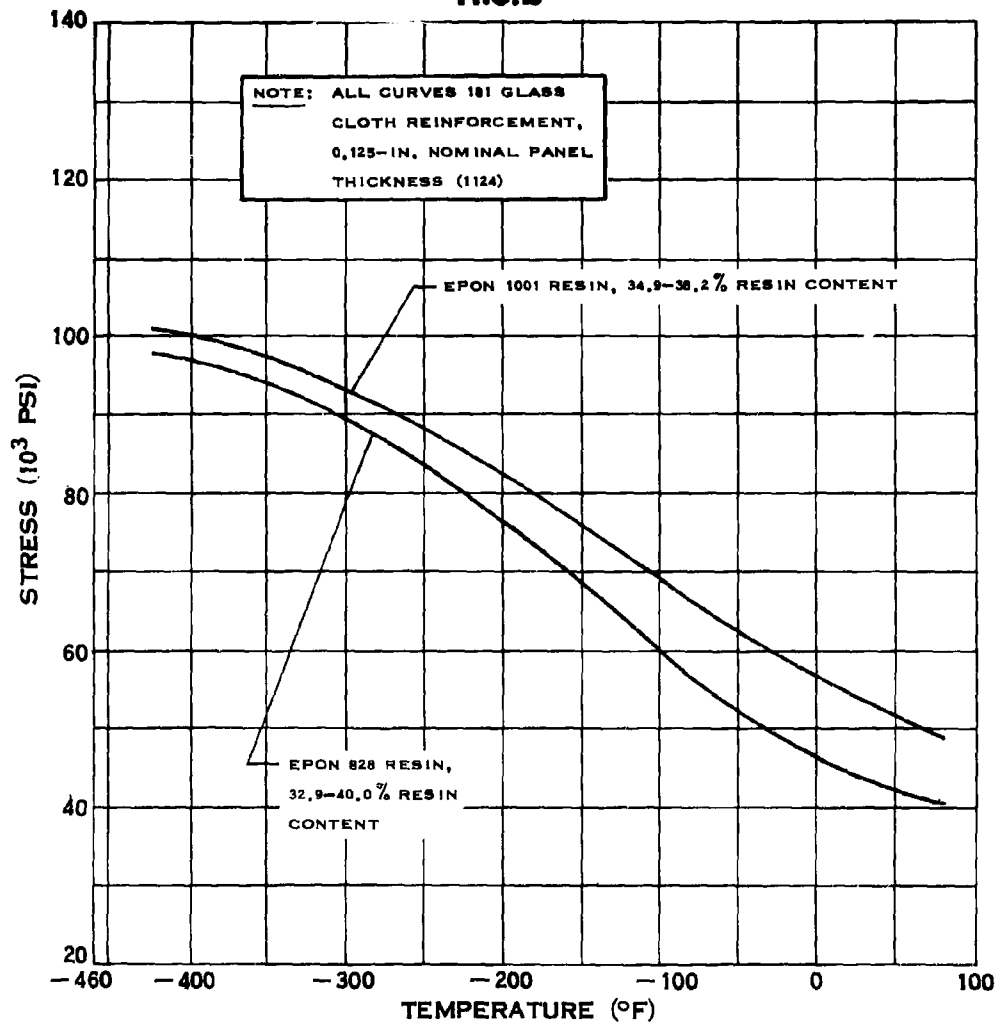
ELONGATION OF 8Al-1Mo-1V TITANIUM

F.4.p



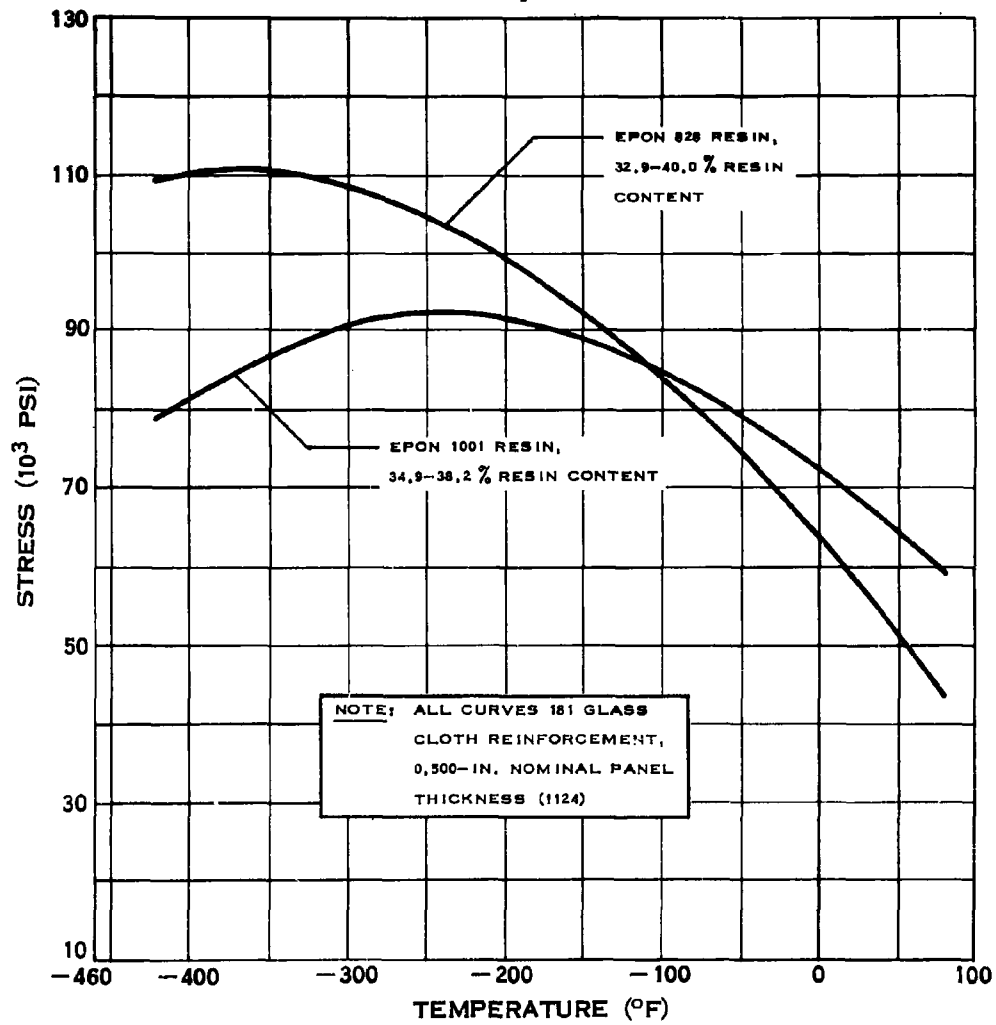
**THERMAL EXPANSION OF 8AL-1MO-1V
TITANIUM**

H.6.b

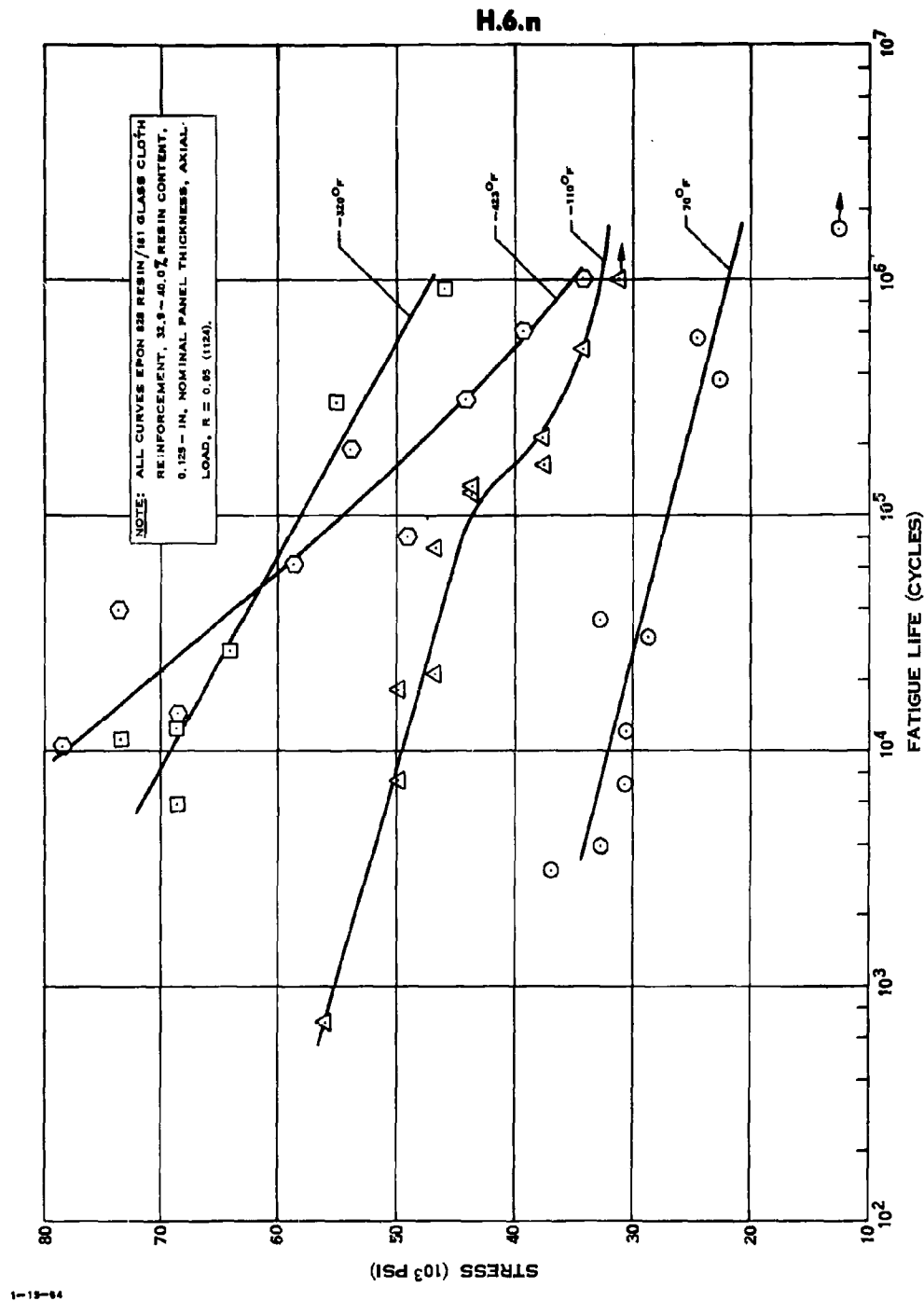


TENSILE STRENGTH OF EPOXY - FIBERGLASS LAMINATE

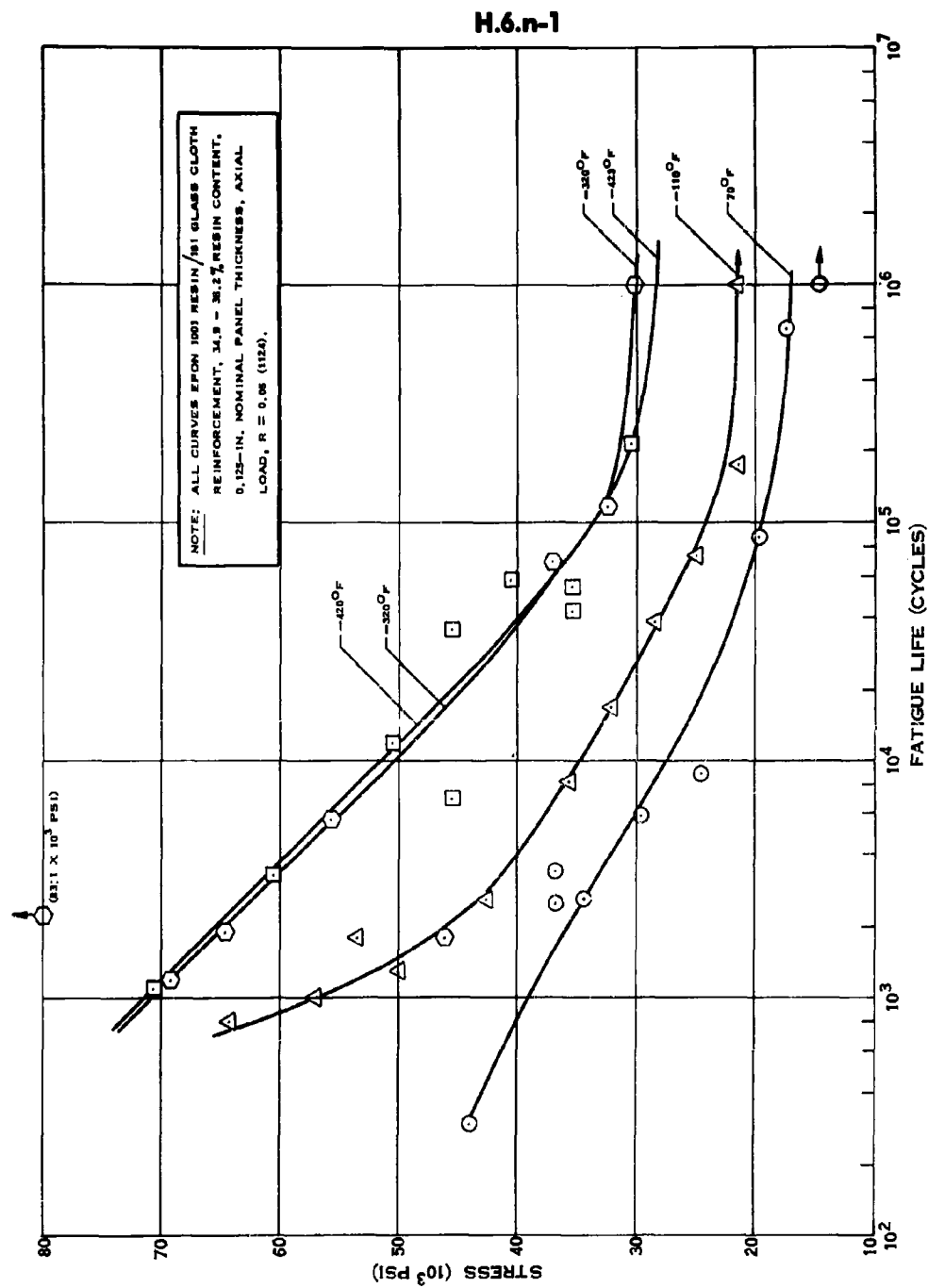
H.6.i



**COMPRESSIVE STRENGTH OF EPOXY -
FIBERGLASS LAMINATE**

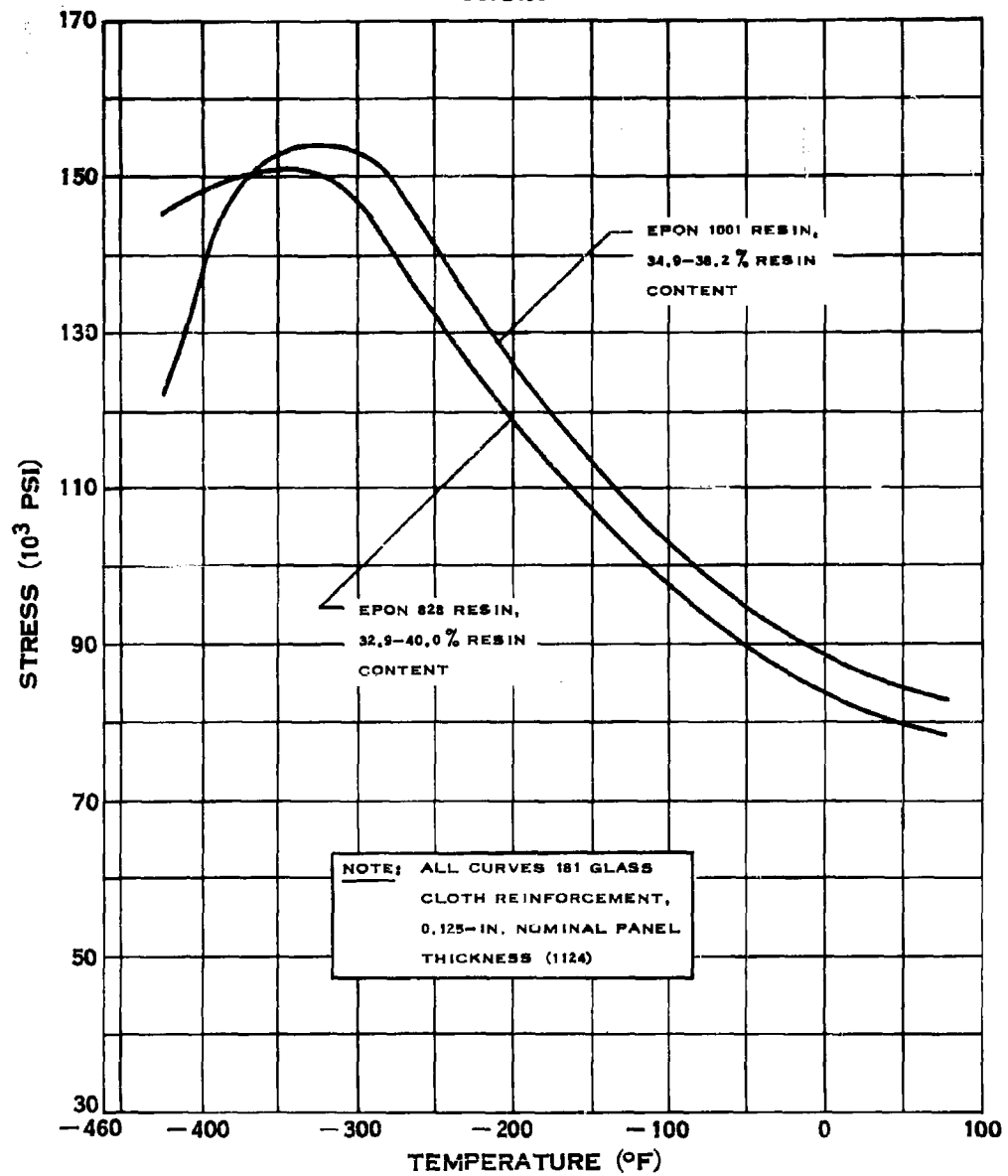


FATIGUE STRENGTH OF EPOXY-FIBERGLAS LAMINATE



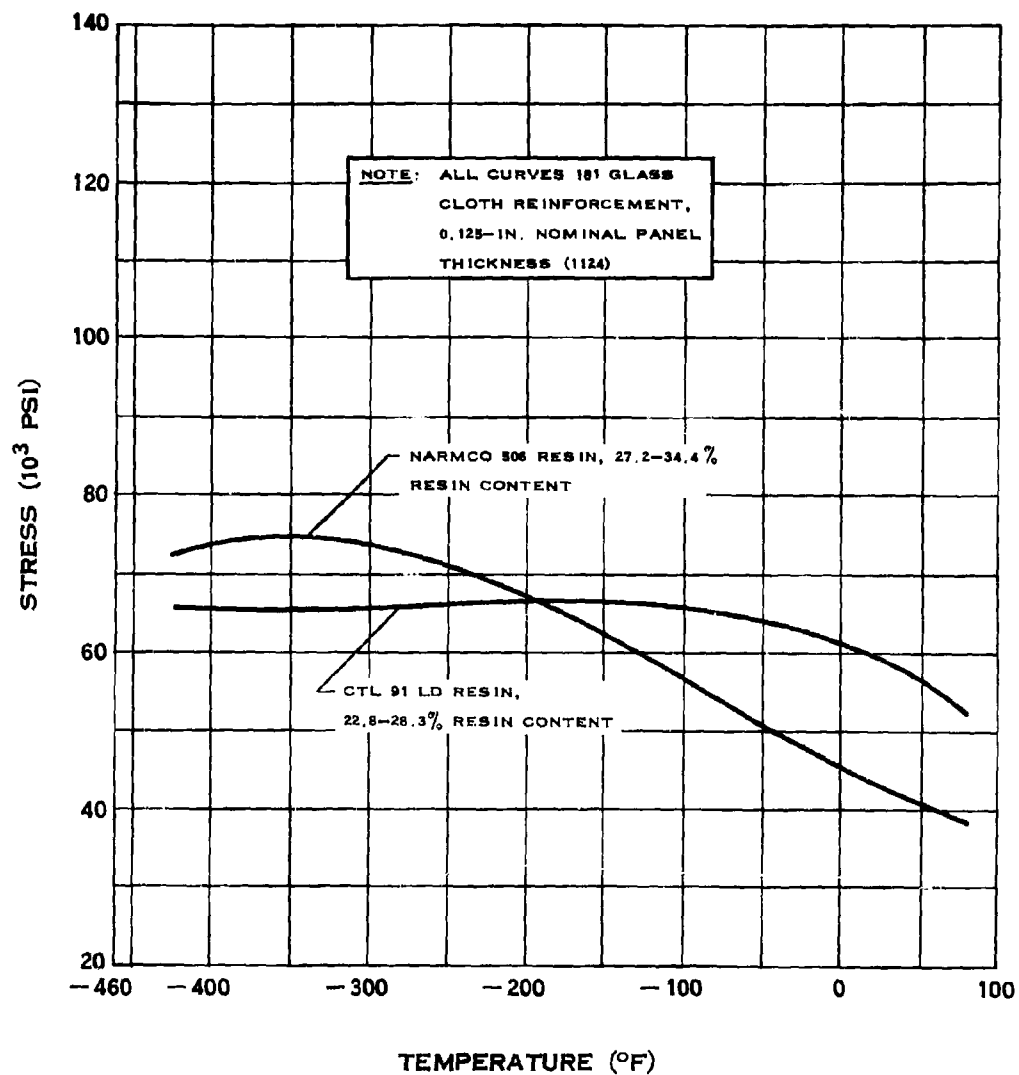
FATIGUE STRENGTH OF EPOXY-FIBERGLAS LAMINATE

H.6.x



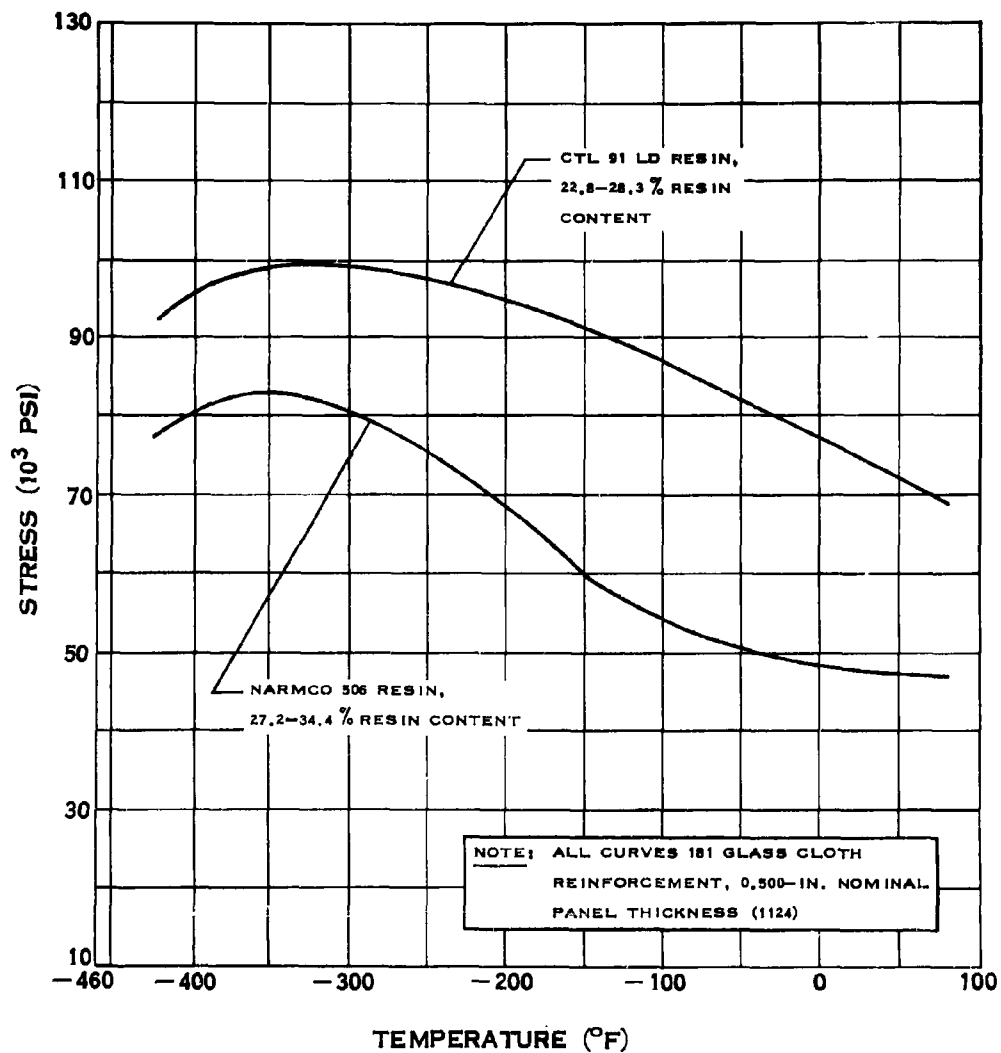
**FLEXURAL STRENGTH OF EPOXY -
FIBERGLAS LAMINATE**

H.7.b

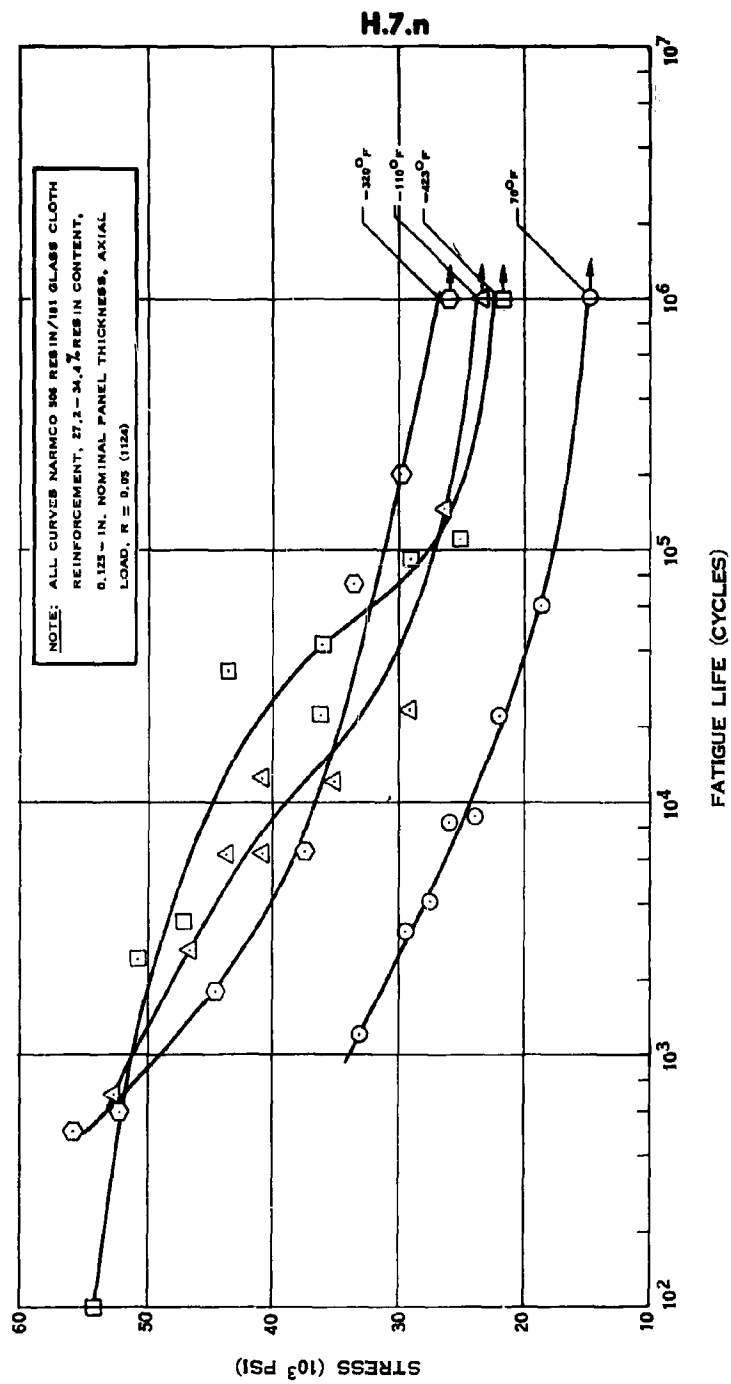


**TENSILE STRENGTH OF PHENOLIC -
FIBERGLAS LAMINATE**

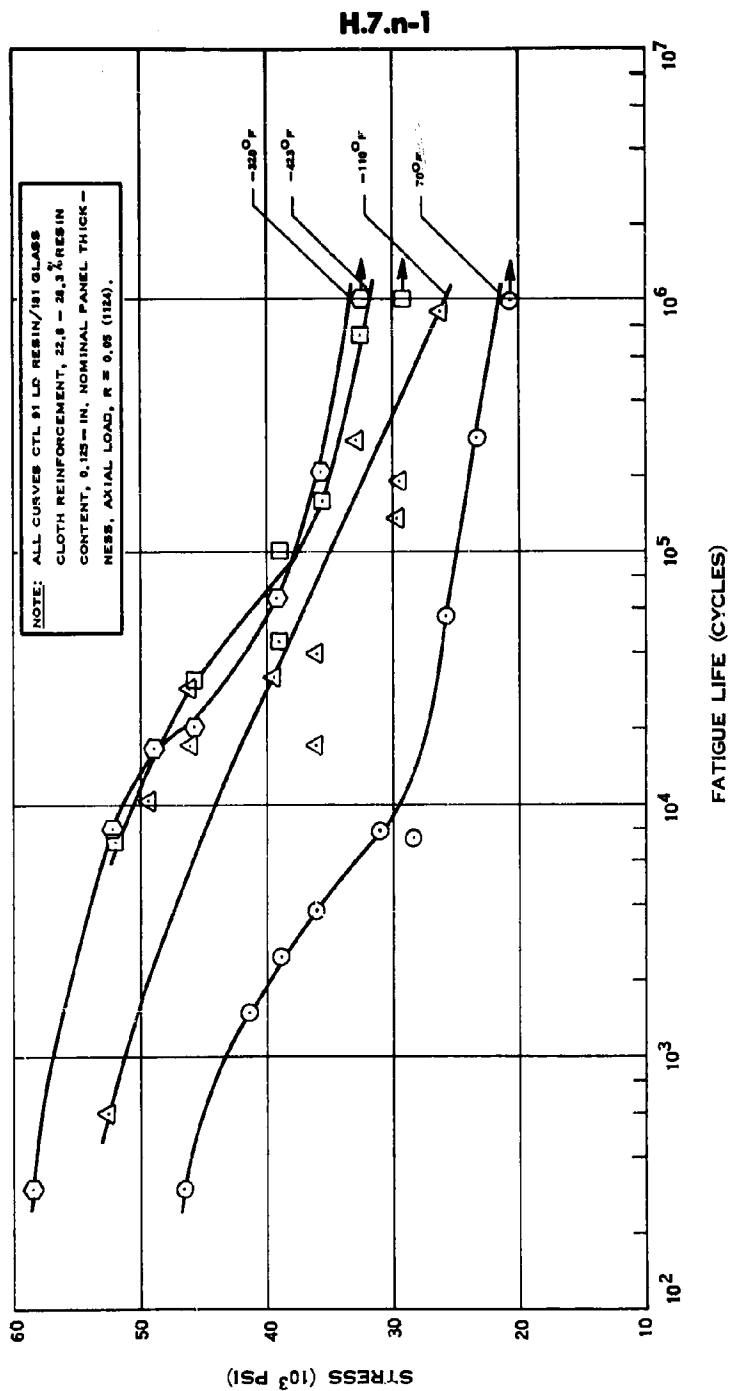
H.7.i



**COMPRESSIVE STRENGTH OF PHENOLIC
- FIBERGLASS LAMINATE**

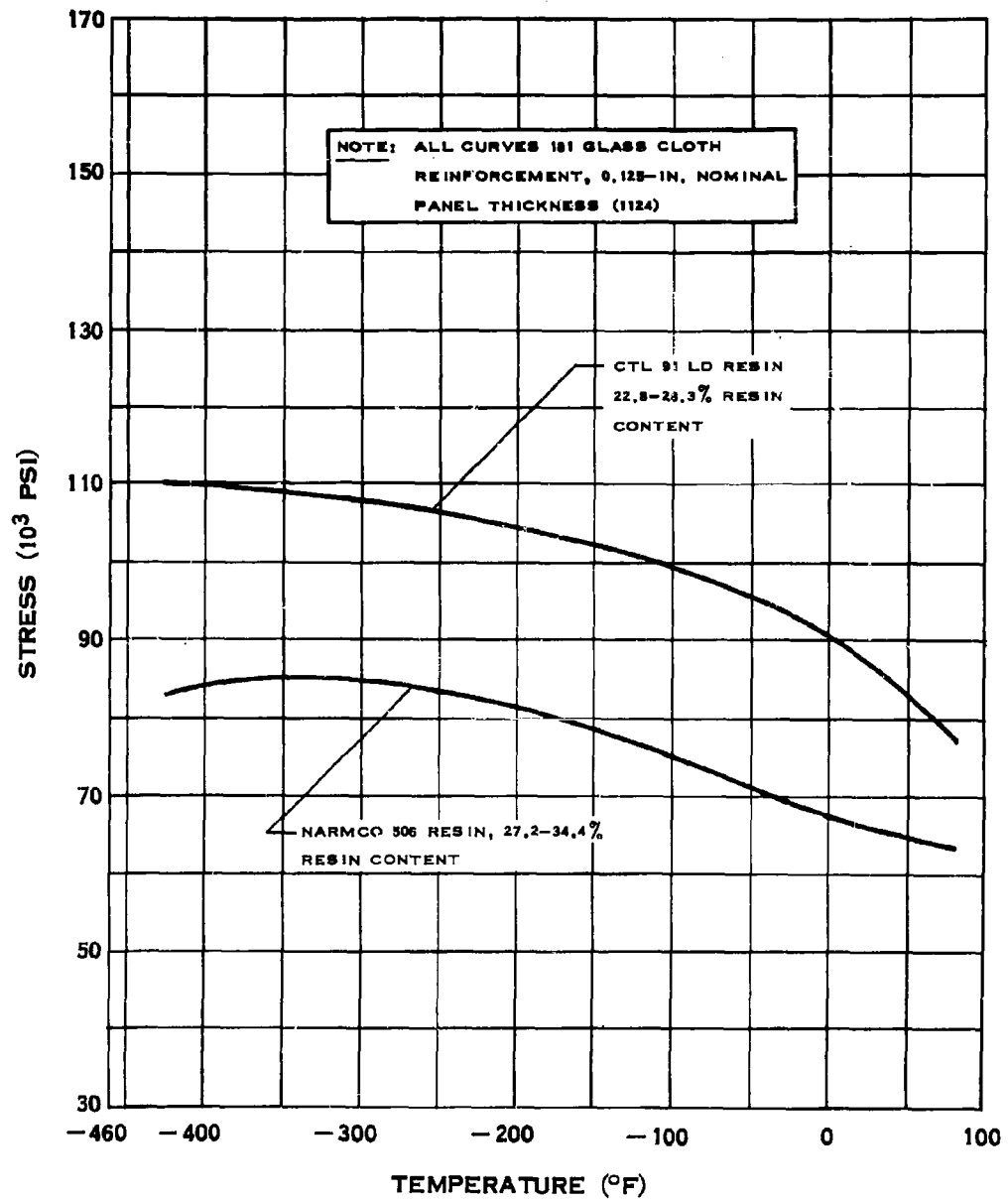


FATIGUE STRENGTH OF PHENOLIC-FIBERGLASS LAMINATE



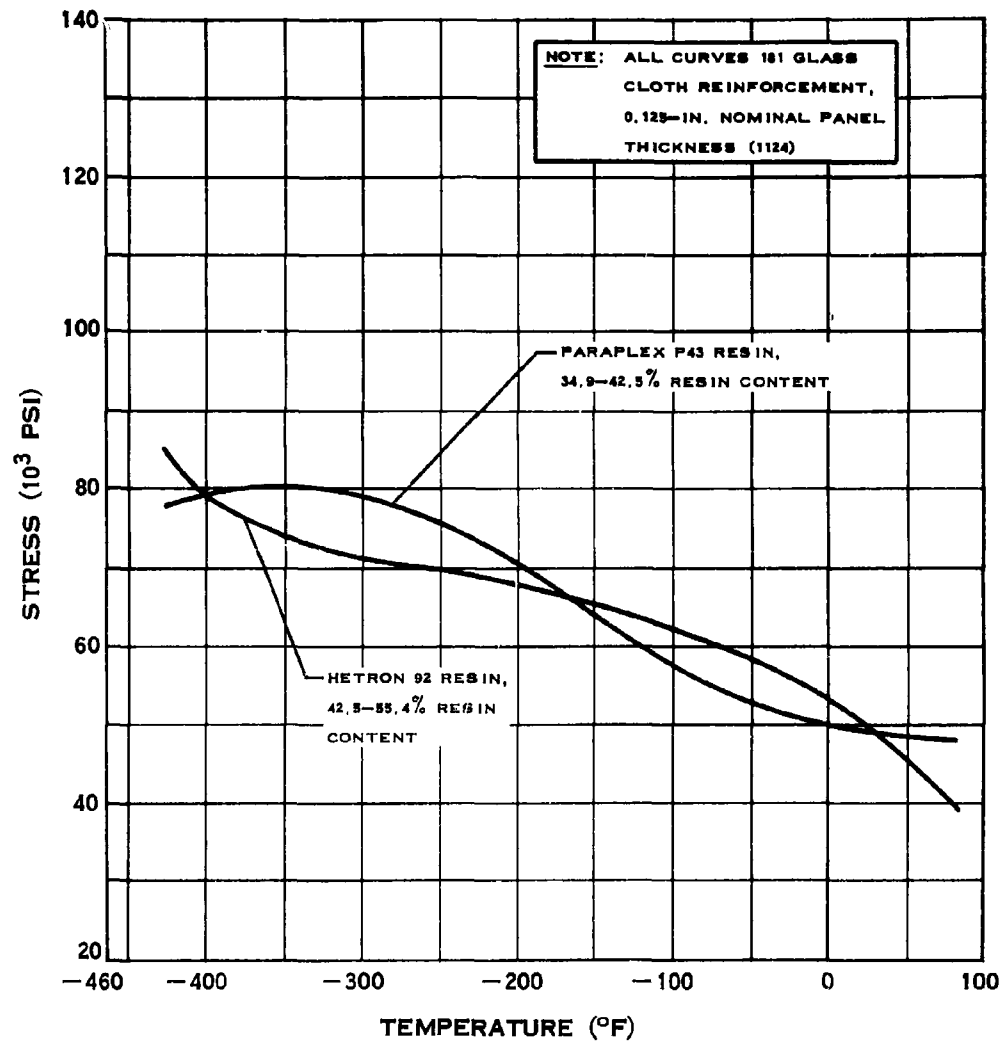
FATIGUE STRENGTH OF PHENOLIC-FIBERGLAS LAMINATE

H.7.x



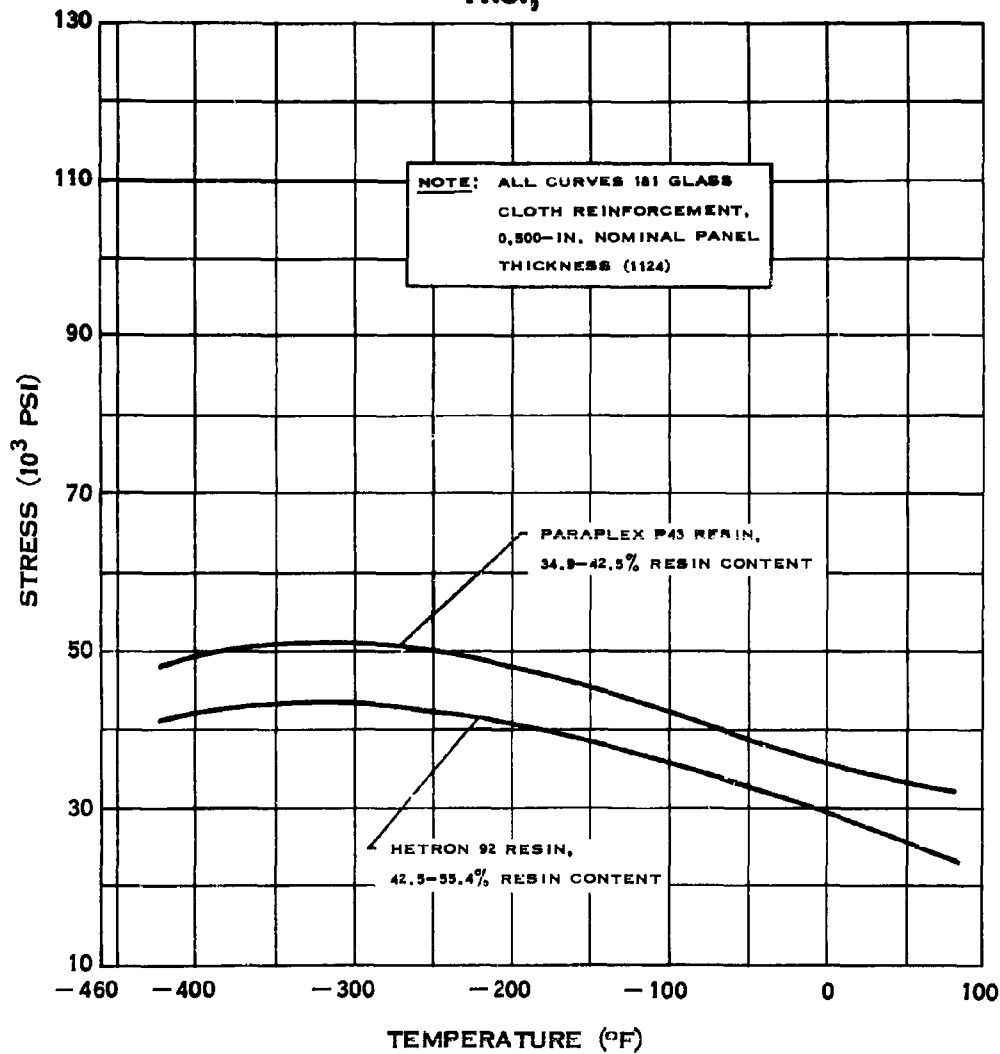
**FLEXURAL STRENGTH OF PHENOLIC -
FIBERGLAS LAMINATE**

H.8.b

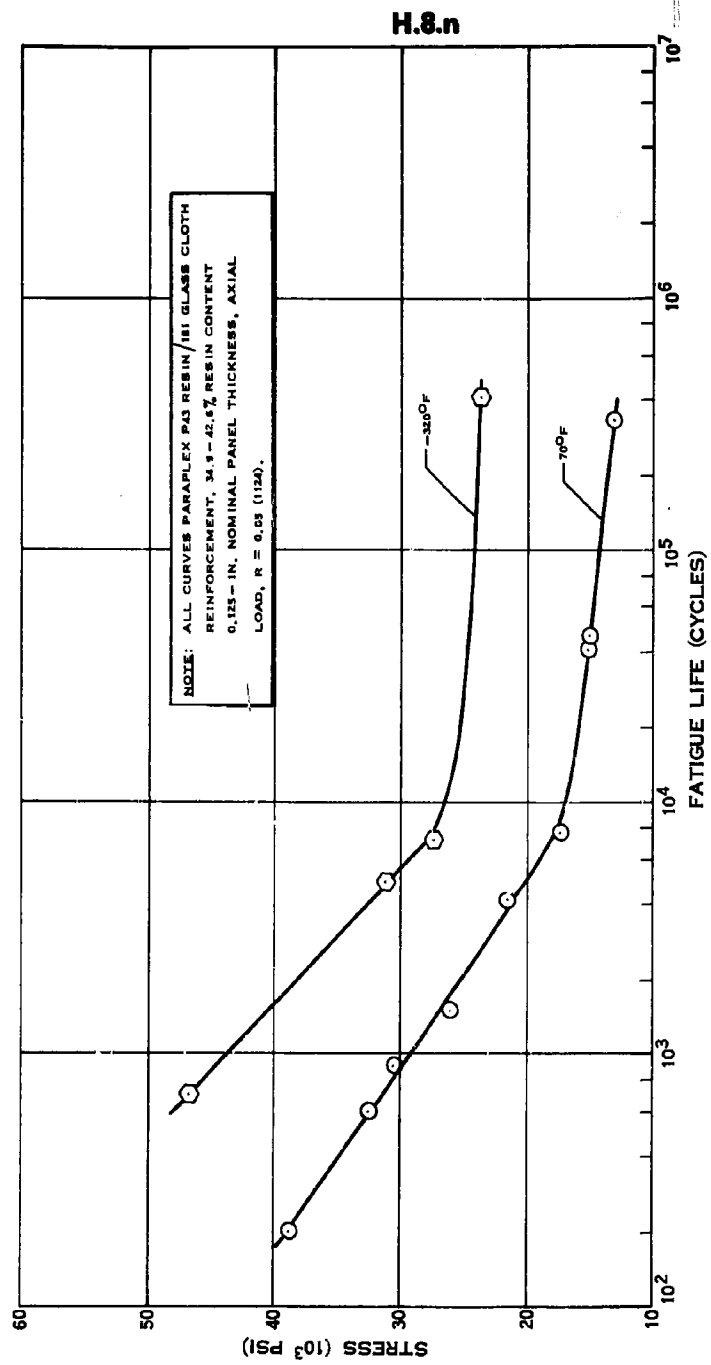


TENSILE STRENGTH OF POLYESTER - FIBERGLAS LAMINATE

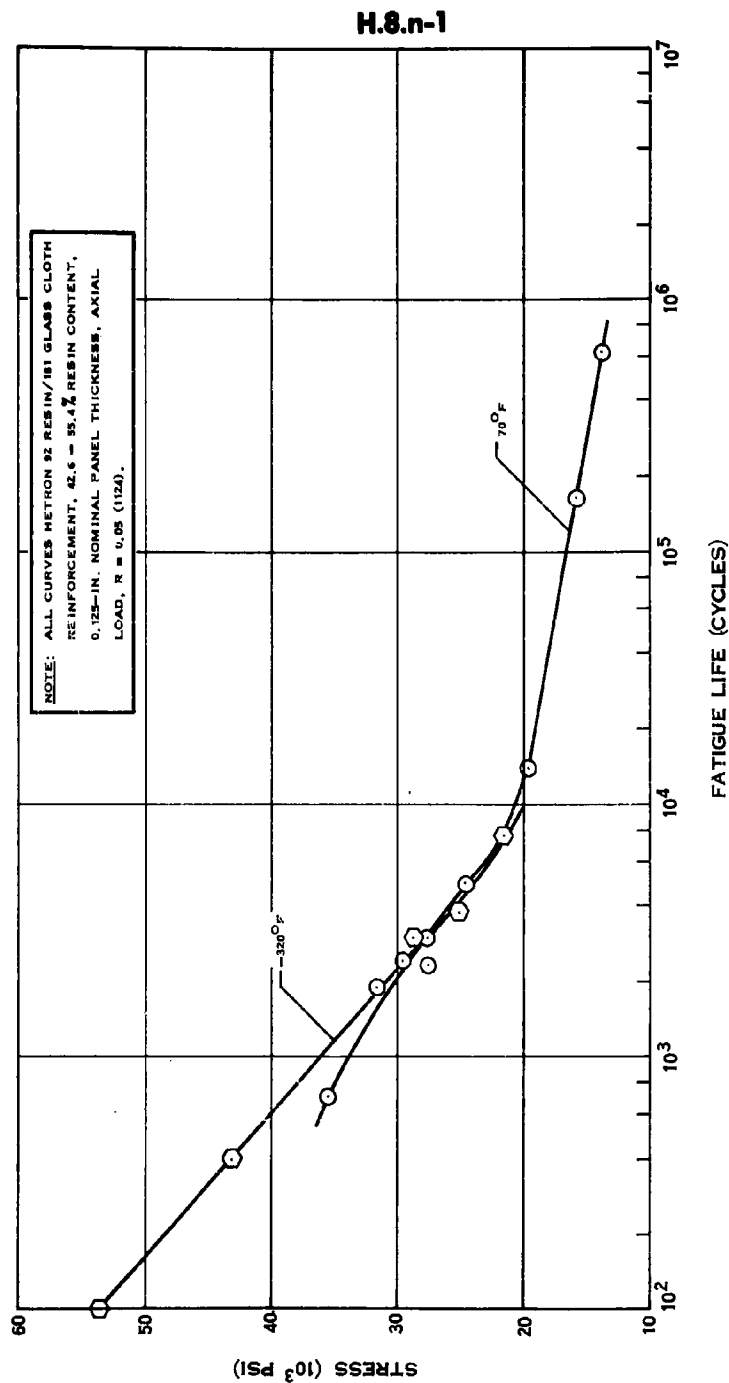
H.8.j



COMPRESSIVE STRENGTH OF POLYESTER - FIBERGLAS LAMINATE

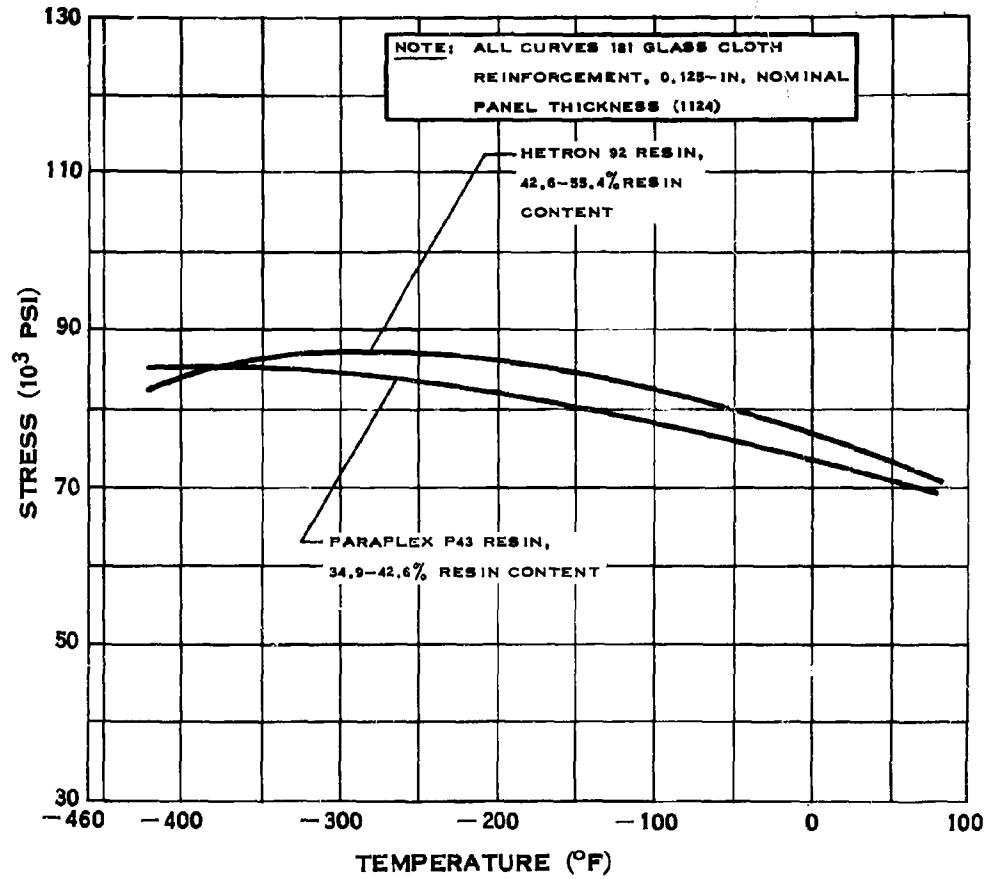


FATIGUE STRENGTH OF POLYESTER-FIBERGLAS LAMINATE



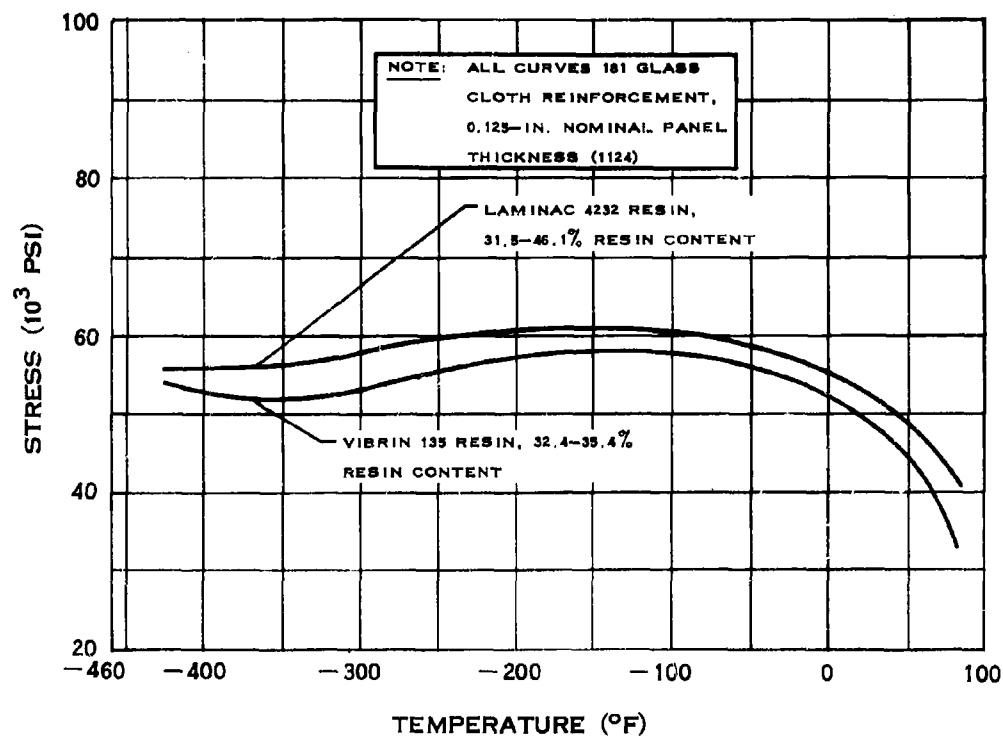
FATIGUE STRENGTH OF POLYESTER-FIBERGLAS LAMINATE

H.8.x



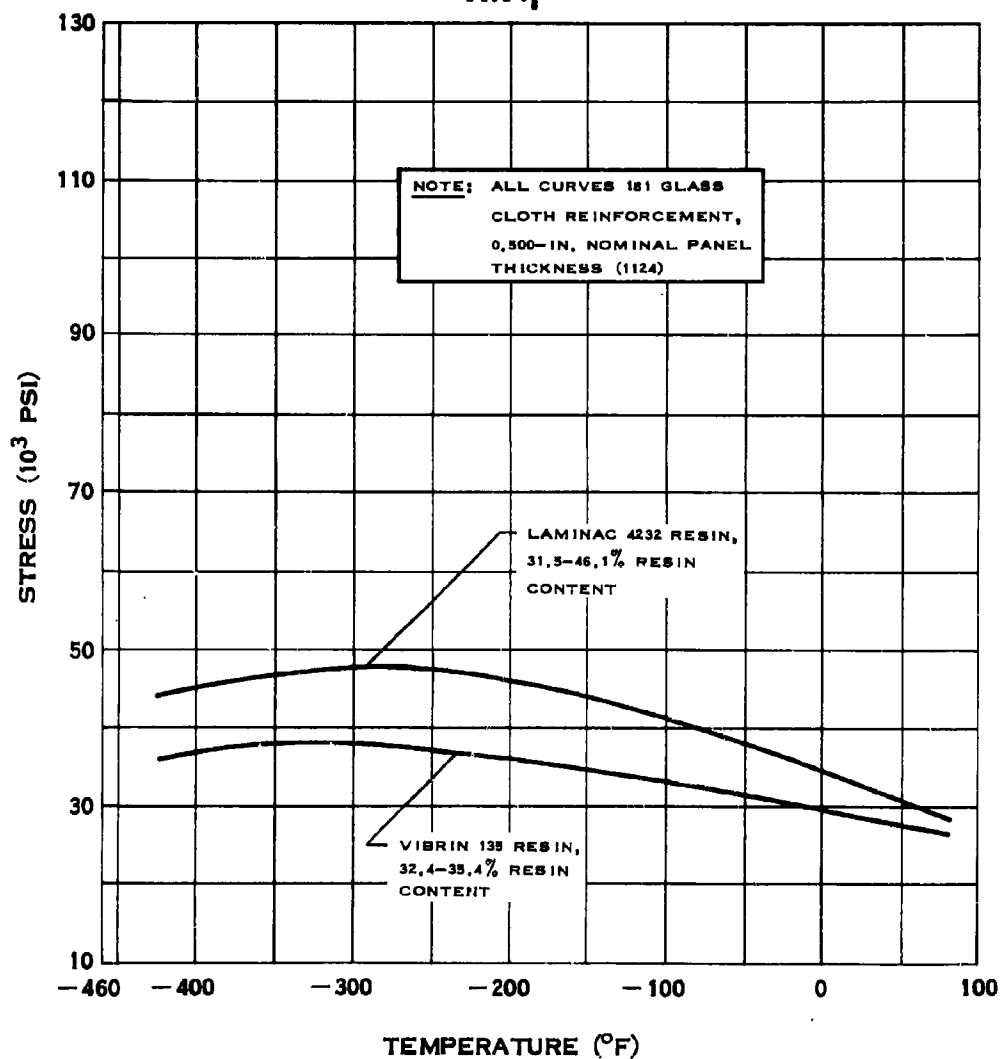
FLEXURAL STRENGTH OF POLYESTER - FIBERGLAS LAMINATE

H.9.b

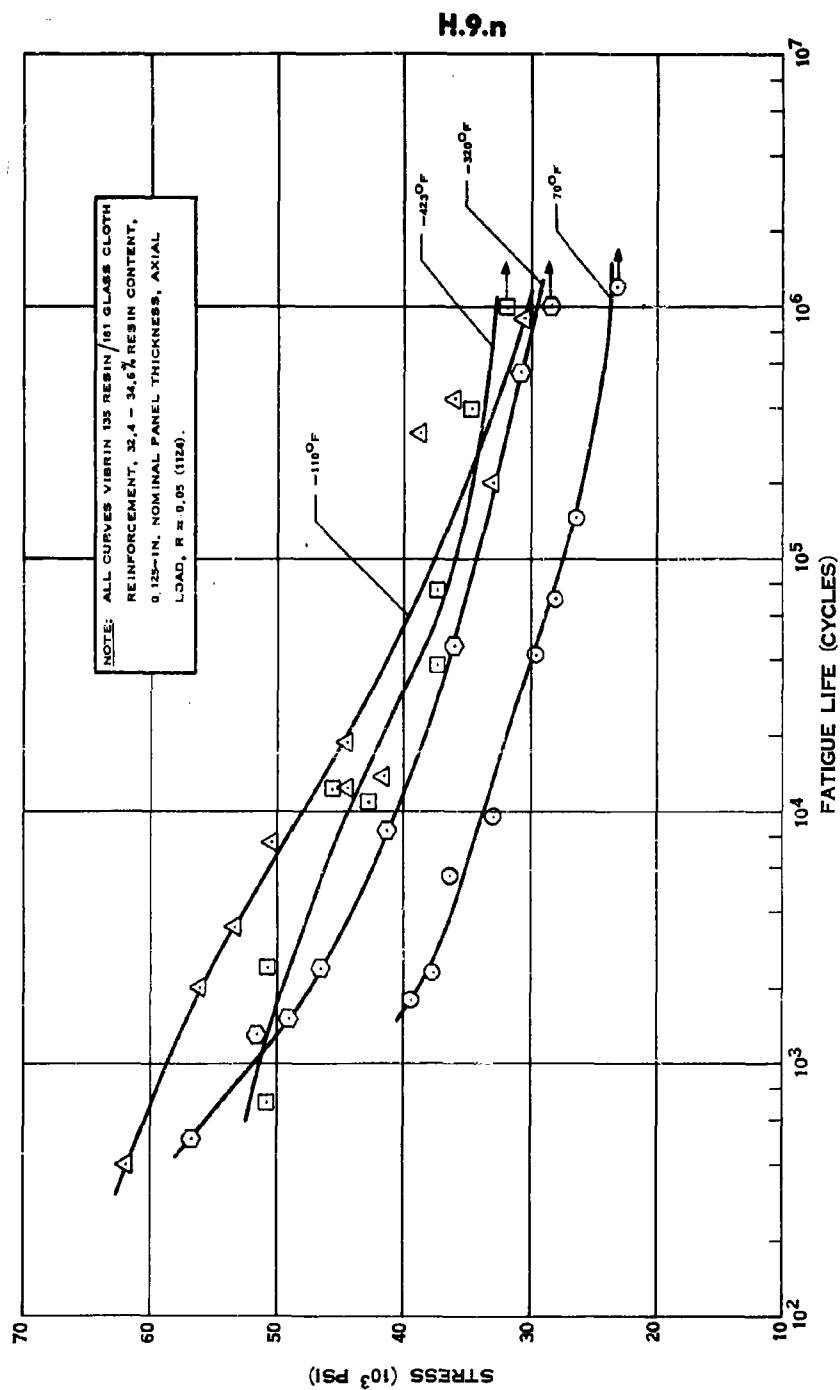


TENSILE STRENGTH OF HIGH TEMPERATURE POLYESTER - FIBERGLAS LAMINATE

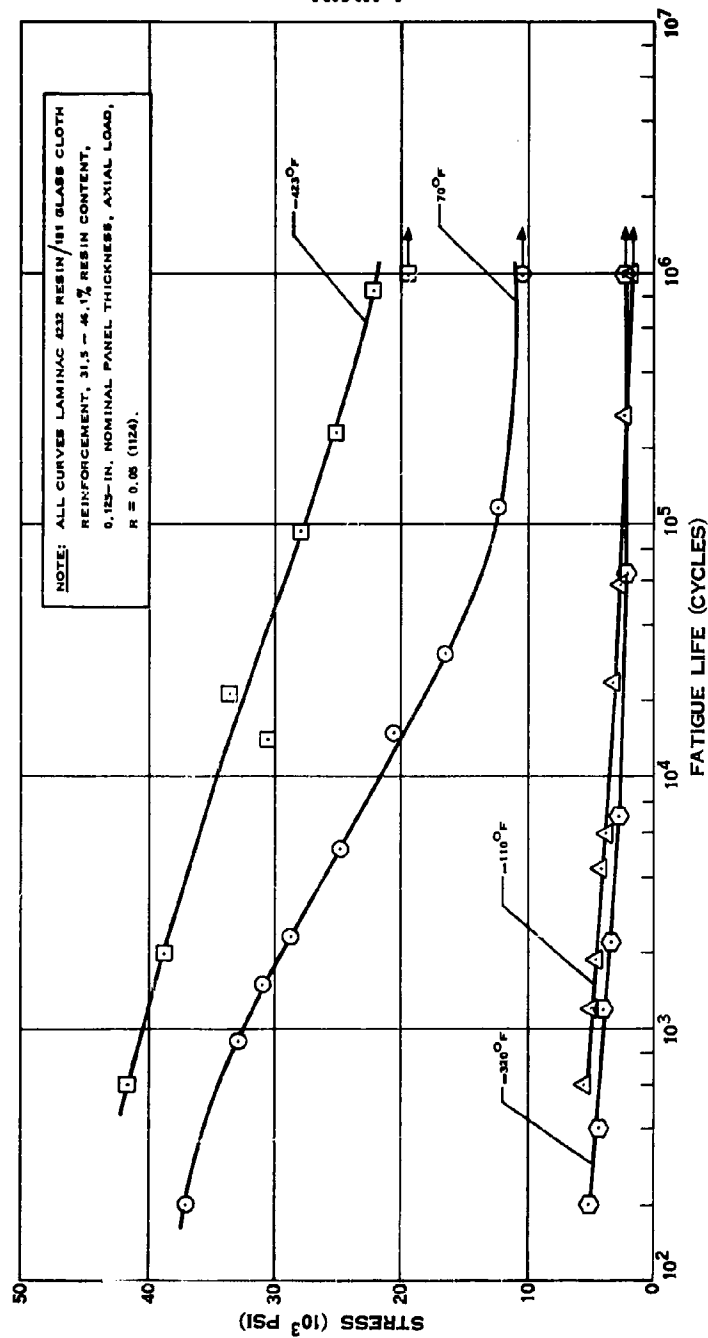
H.9.j



**COMPRESSIVE STRENGTH OF HIGH
TEMPERATURE POLYESTER - FIBERGLAS
LAMINATE**

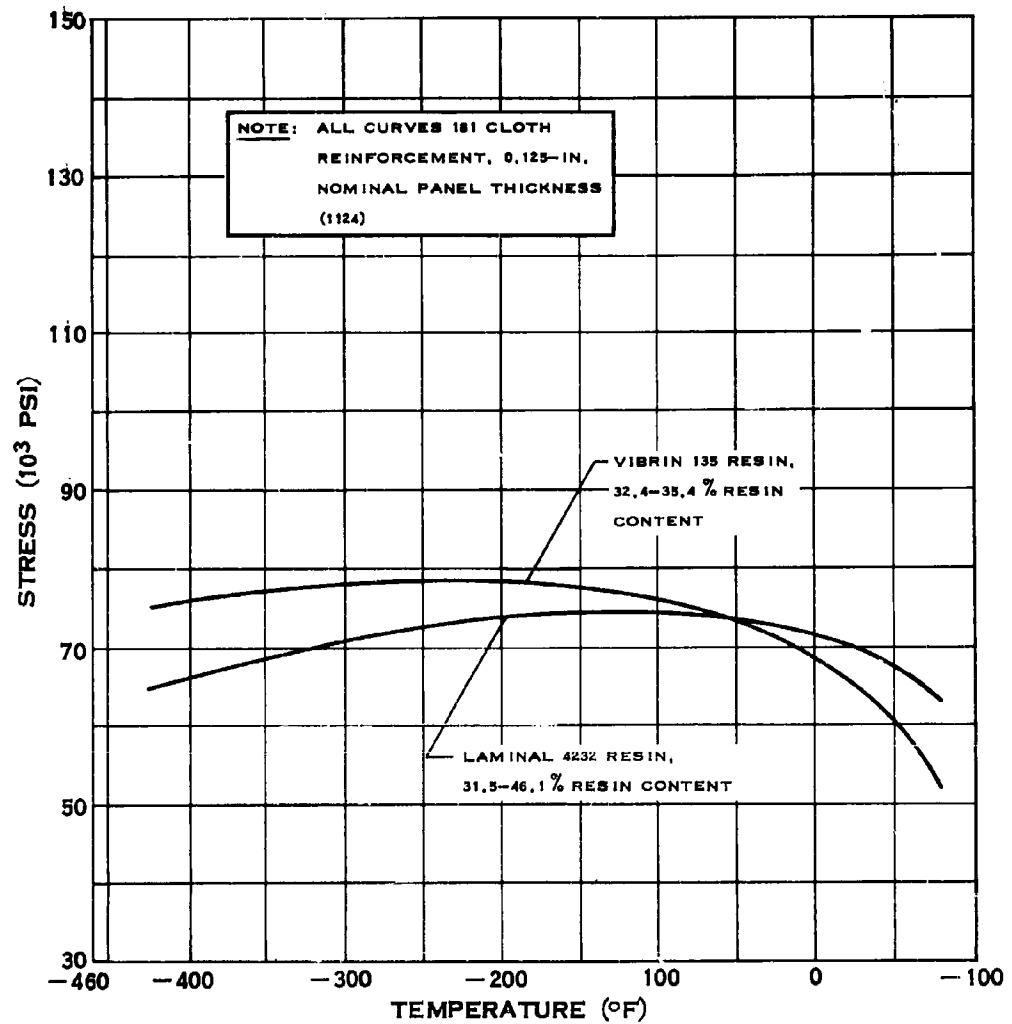


FATIGUE STRENGTH OF HIGH TEMPERATURE POLYESTER-FIBERGLAS LAMINATE



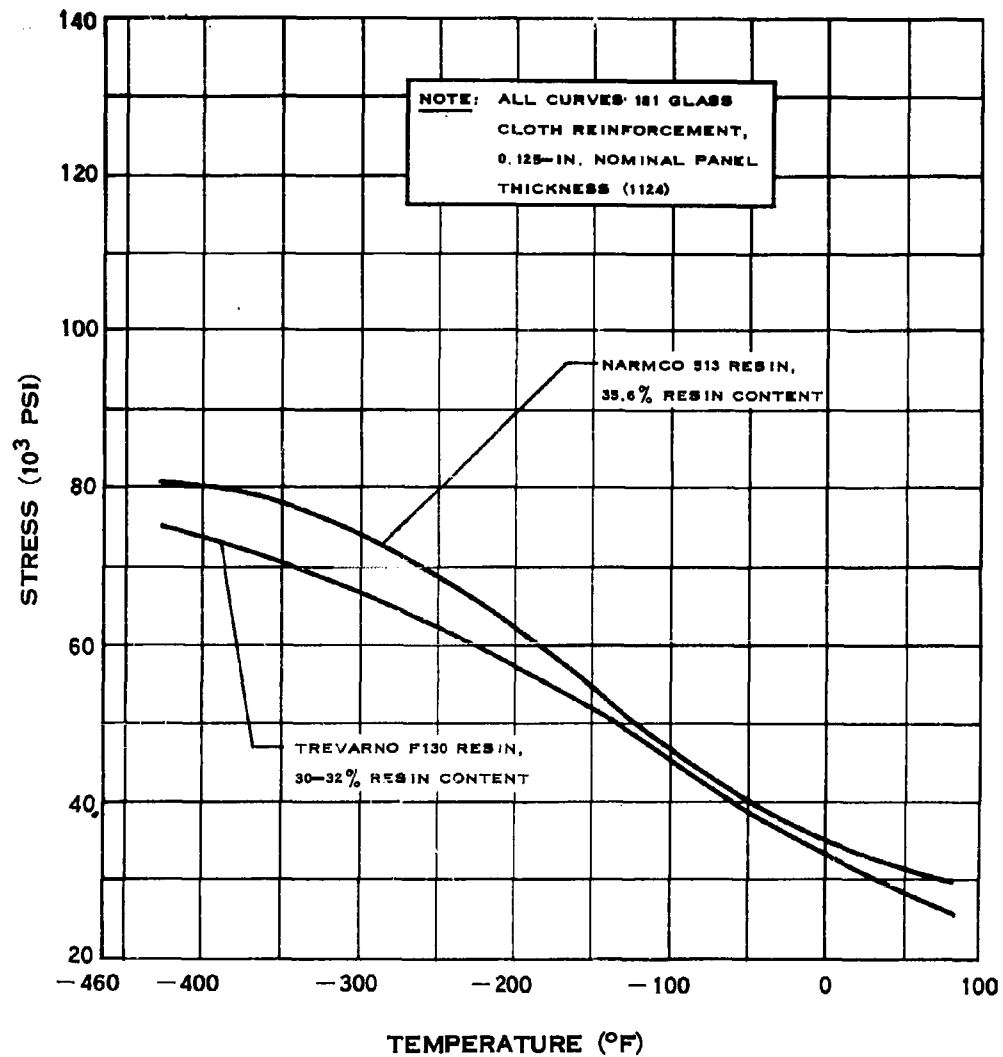
FATIGUE STRENGTH OF HIGH TEMPERATURE POLYESTER-FIBERGLAS LAMINATE

H.9.x



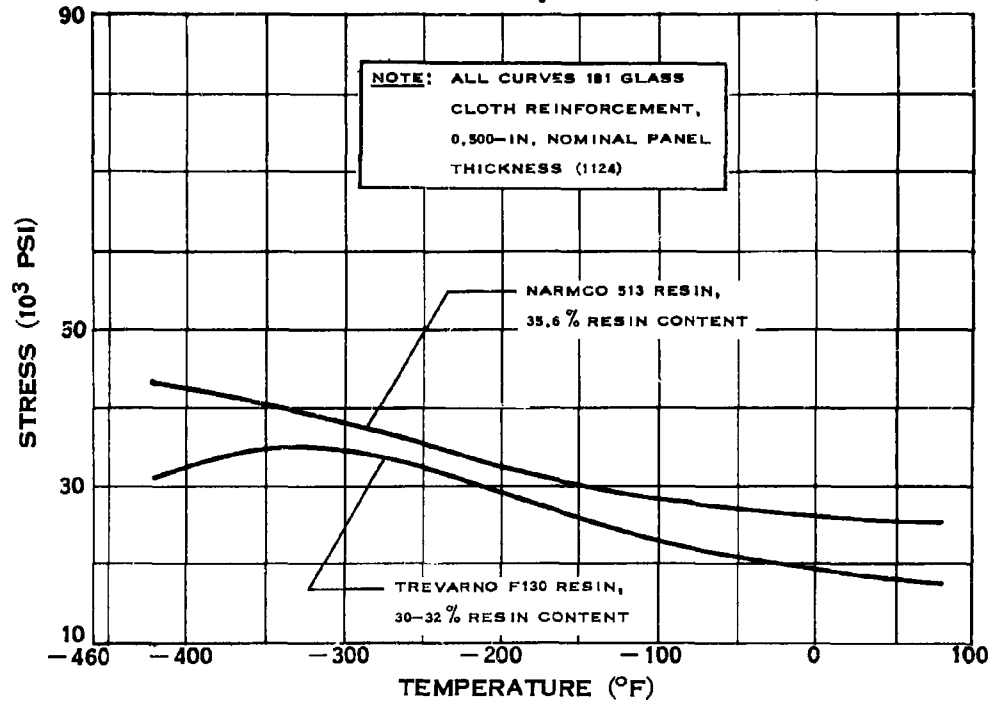
**FLEXURAL STRENGTH OF HIGH
TEMPERATURE POLYESTER - FIBERGLASS
LAMINATE**

H.10.b

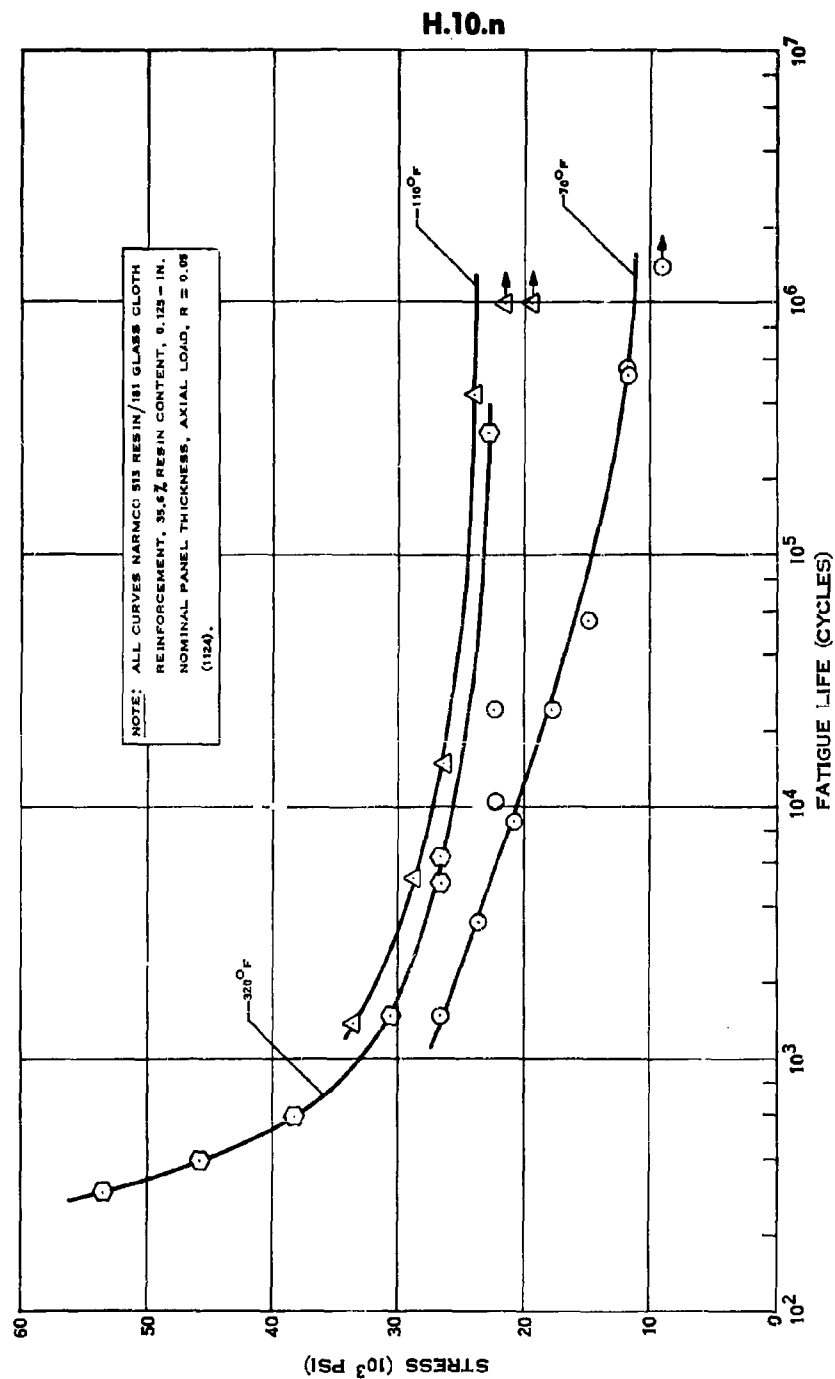


TENSILE STRENGTH OF SILICONE - FIBERGLAS LAMINATE

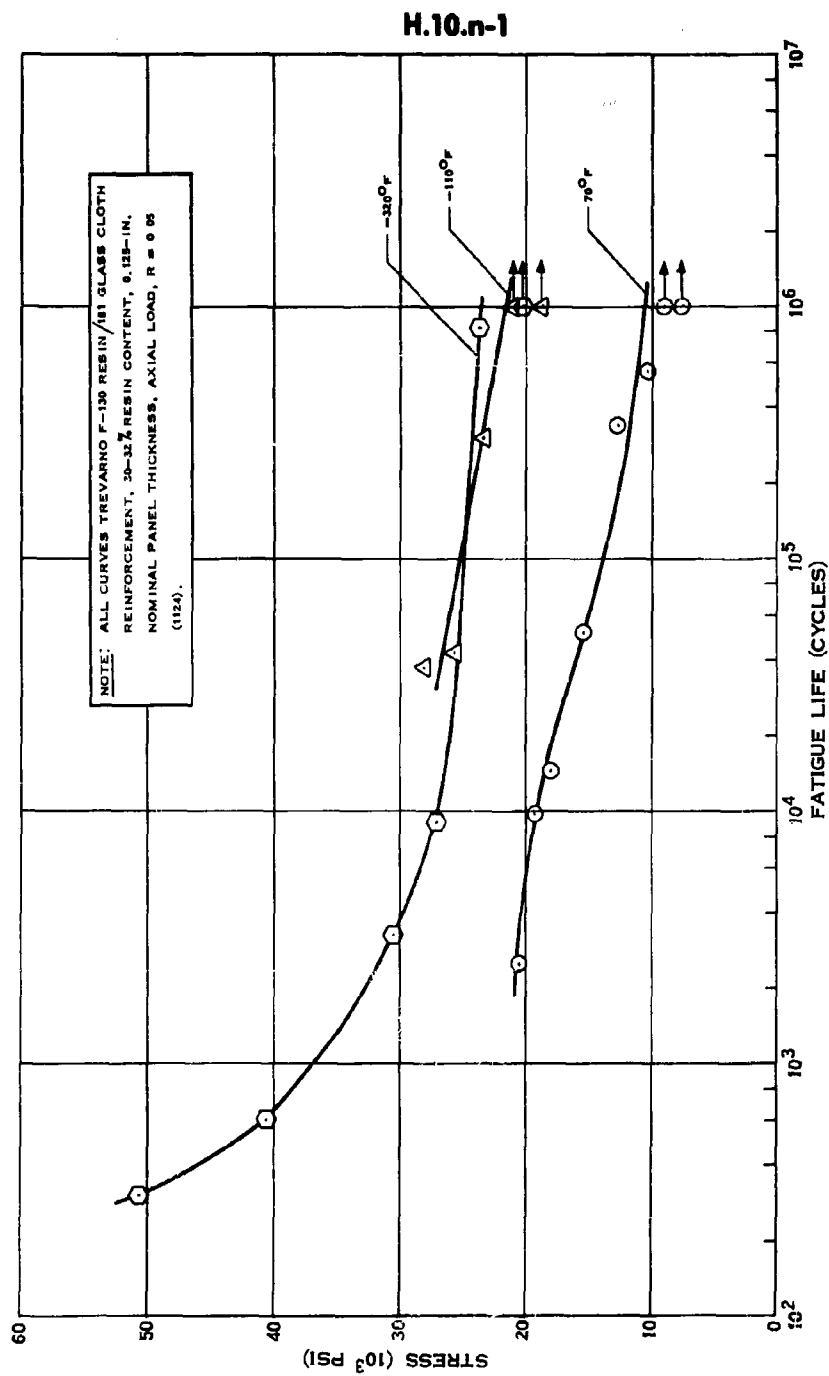
H.10.i



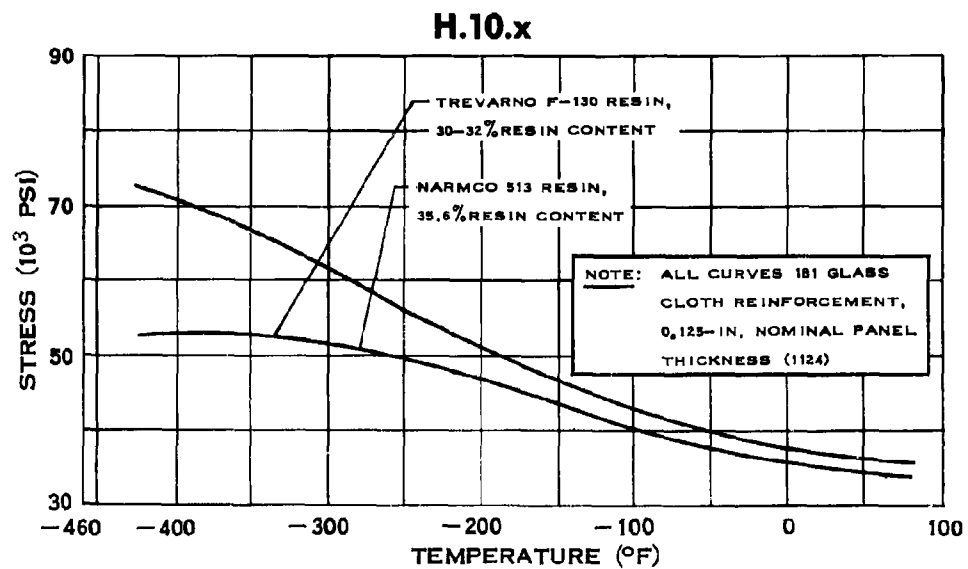
**COMPRESSIVE STRENGTH OF SILICONE -
FIBERGLASS LAMINATE**



FATIGUE STRENGTH OF SILICONE-FIBERGLAS LAMINATE



FATIGUE STRENGTH OF SILICONE-FIBERGLAS LAMINATE



**FLEXURAL STRENGTH OF SILICONE -
FIBERGLAS LAMINATE**

- (1117) W. R. Morgan, Mechanical Properties of 2219-T87 Alloy Plate at Room and Cryogenic Temperatures, George C. Marshall Space Flight Center Report No. IN-P&VE-M-62-9, October 1962.
- (1118) C. E. Cataldo, Weldability Studies of 5456-H343 and 2219-T87 Aluminum Alloy Plates, George C. Marshall Space Flight Center Report No. IN-P&VE-M-62-2, April 1962.
- (1119) J. L. Christian, Mechanical Properties of Aluminum Alloys at Cryogenic Temperatures, Convair/Astronautics Report No. MRG-190, December 1962.
- (1121) R. Markovich and F. R. Schwartzberg, Testing Techniques and Evaluation of Materials for Use at Liquid Hydrogen Temperature, ASTM STP302, 113, 1961.
- (1122) J. L. Christian and A. Hurlich, Physical and Mechanical Properties of Pressure Vessel Materials for Application in Cryogenic Environment, General Dynamics/Astronautics, ASD-TDR-62-258, Part II, April 1963.
- (1123) P. C. Miller, Low-Temperature Mechanical Properties of Several Aluminum Alloys and their Weldments, George C. Marshall Space Flight Center Report No. MTP-S&M-M-61-16, October 1961.
- (1124) N. O. Brink, Determination of the Performance of Plastic Laminates Under Cryogenic Temperatures, Narmco Research and Development, ASD-TDR-62-794, February 1963.
- (1125) J. F. Watson and J. L. Christian, Low-Temperature Properties of K-Monel, Inconel-X, René 41, Haynes 25, and Hastelloy B Sheet Alloys, ASME Paper No. 61-WA-12, 1962.
- (1126) J. L. Christian, Mechanical Properties of High-Strength Sheet Materials at Cryogenic Temperatures, General Dynamics/Astronautics Report ERR-AN-255, 28 November 1962.

UNCLASSIFIED

UNCLASSIFIED