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(5) 552 850

Martin Marietta Corp., Denver, Colo.

64-13

(1)

AD No. 438718

DDC FILE COPY

PB 171809-6

(6) CRYOGENIC MATERIALS DATA HANDBOOK.

[redacted] (9) PROGRESS REPORT. no. 14 and 8 ... annual ... rept. no. 3,

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

(16) PROJ[redacted] 7381, (17) TASK [redacted] 738103

MAY 15 1964

[redacted] (15) CONTRACT [redacted] AF33(657)-9161

[redacted]

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

438718

1118 $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 replotting 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

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PROPERTIES

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 pre-ious contract. Numbers 12 and over refer to semiannual progress reports issued by Martin under Air Force Materials Laboratory sponsorship.

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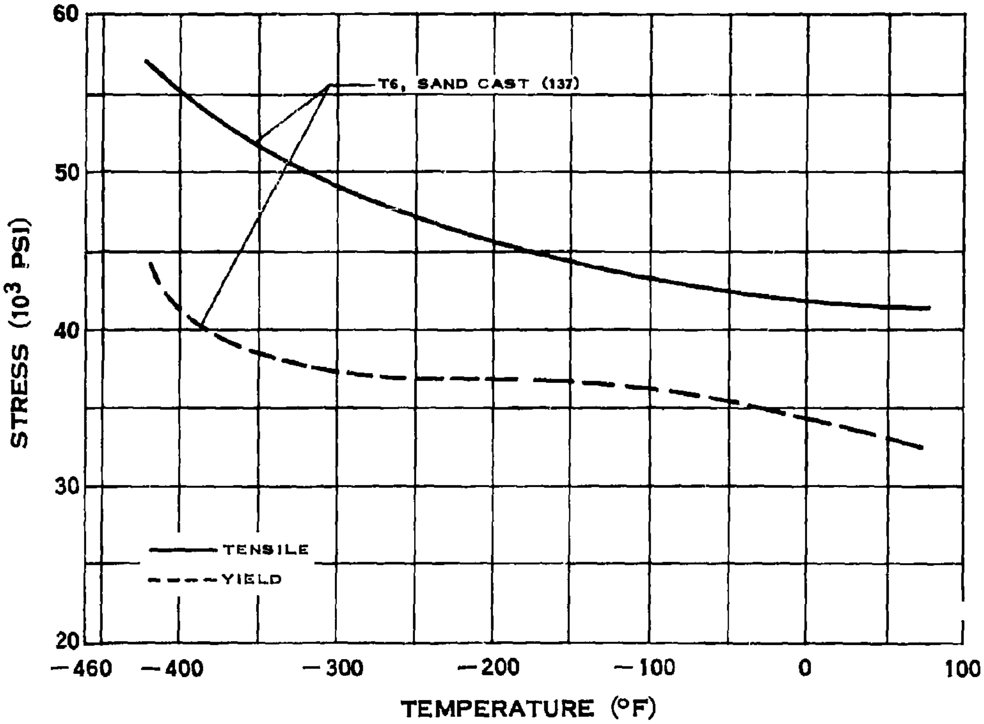
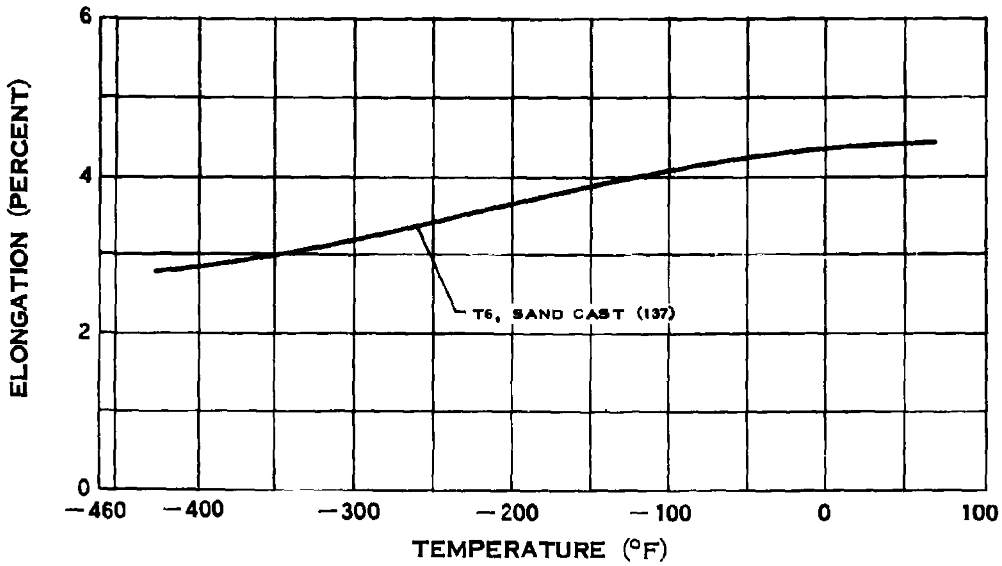
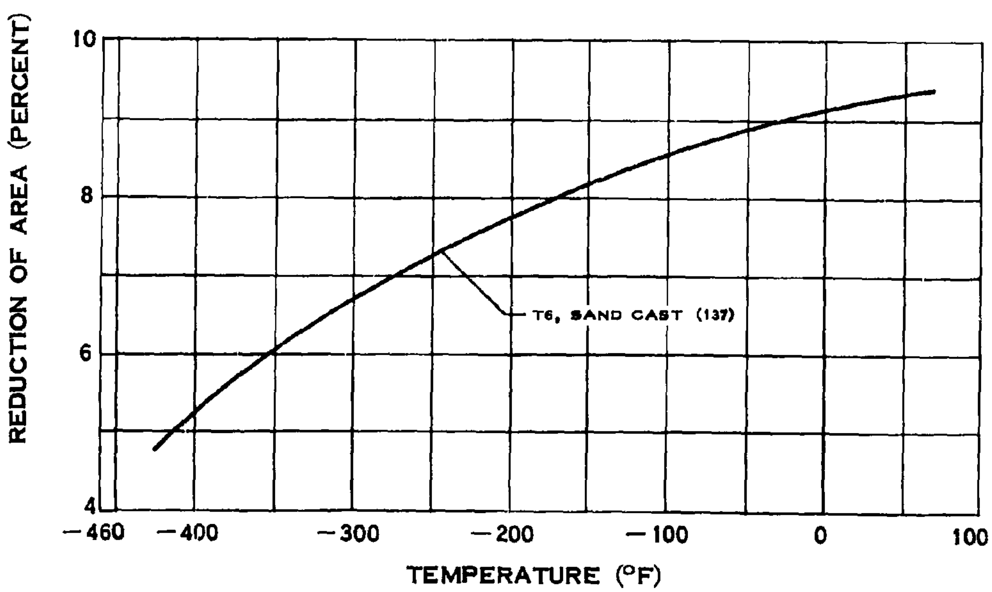


STRENGTH OF TENS-50 ALUMINUM



ELONGATION OF TENS-50 ALUMINUM



REDUCTION OF AREA OF TENS-50 ALUMINUM

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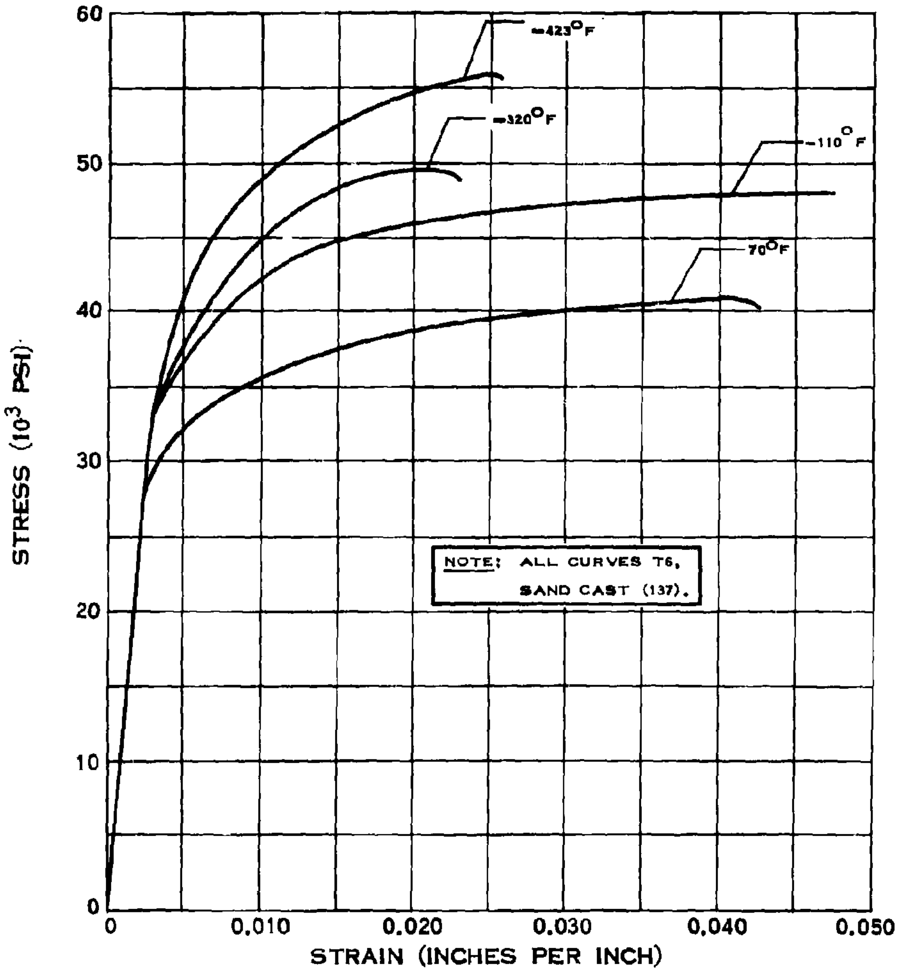
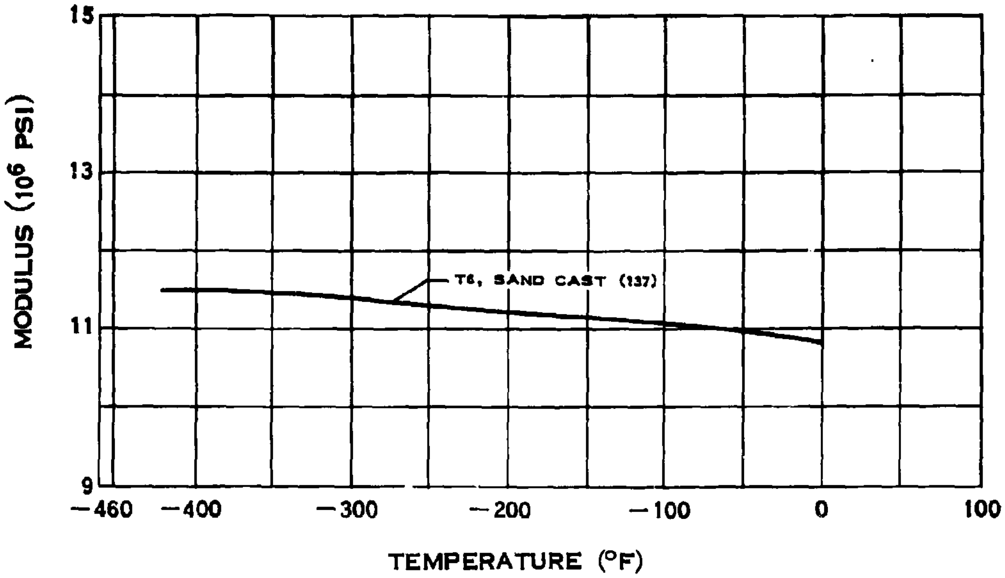
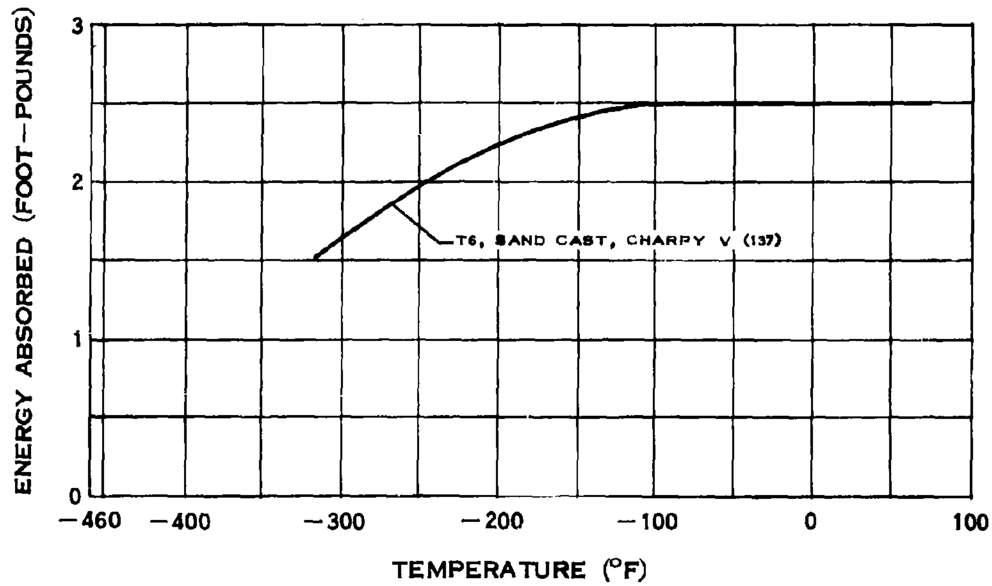


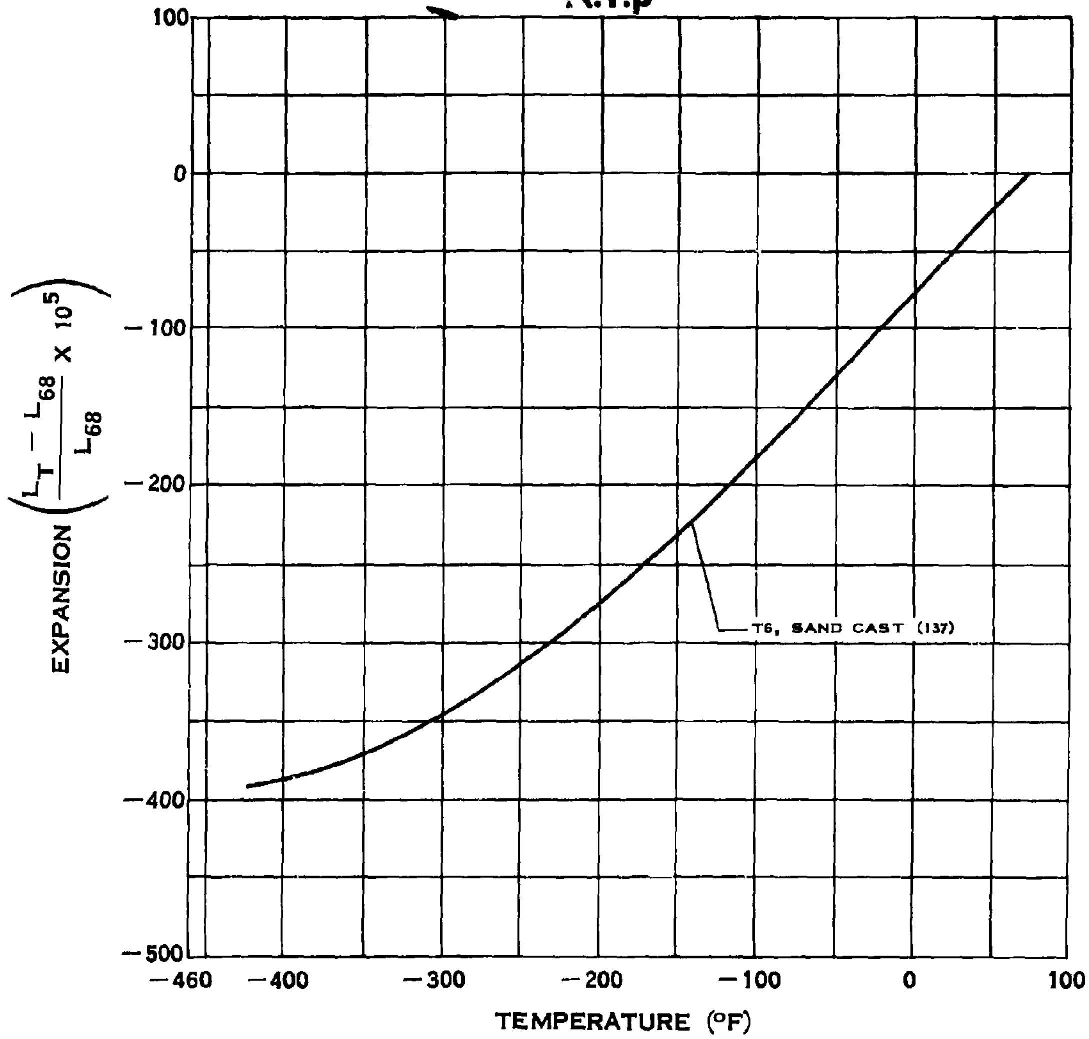
STRESS-STRAIN DIAGRAM FOR TENS-50 ALUMINUM



MODULUS OF ELASTICITY OF TENS-50 ALUMINUM



IMPACT ENERGY OF TENS-50 ALUMINUM



THERMAL EXPANSION OF TENS-50 ALUMINUM

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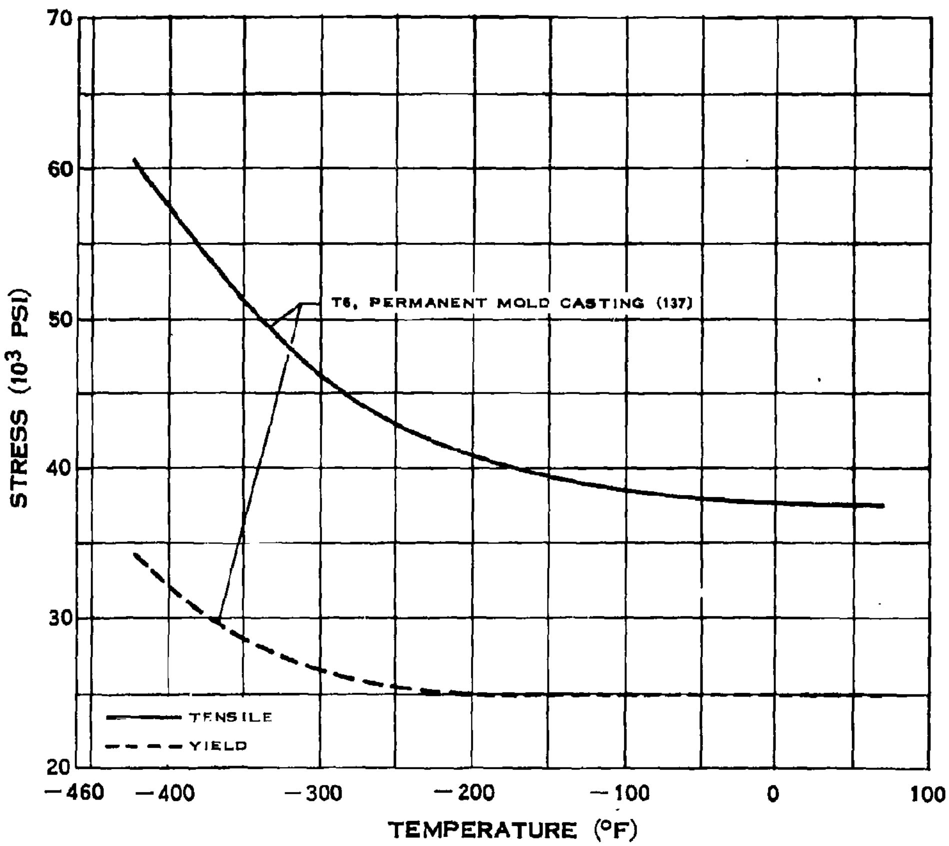

STRENGTH OF 356 ALUMINUM

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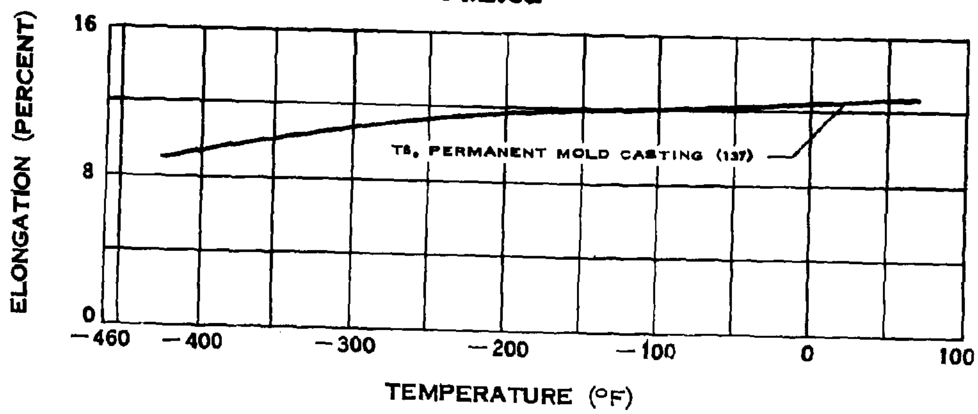

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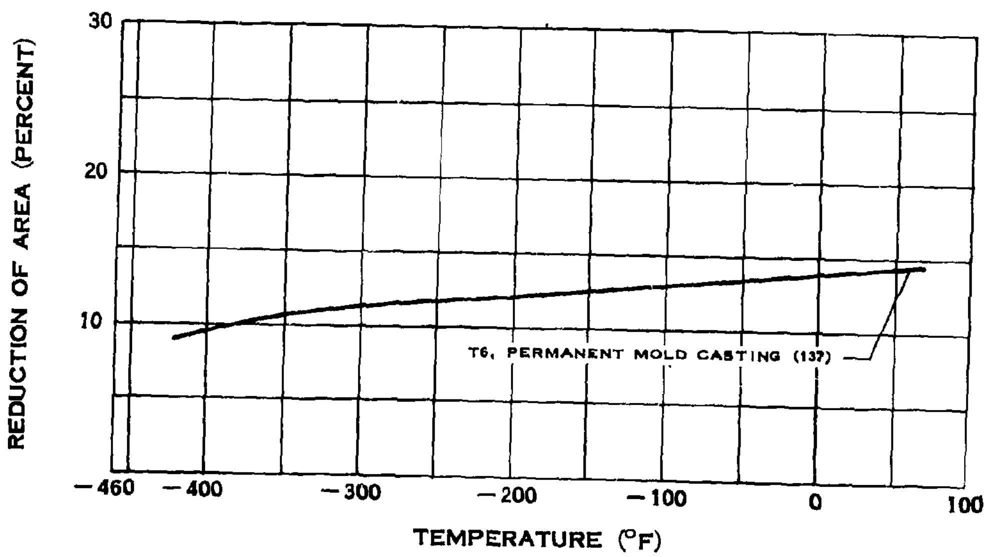

REDUCTION OF AREA OF 356 ALUMINUM

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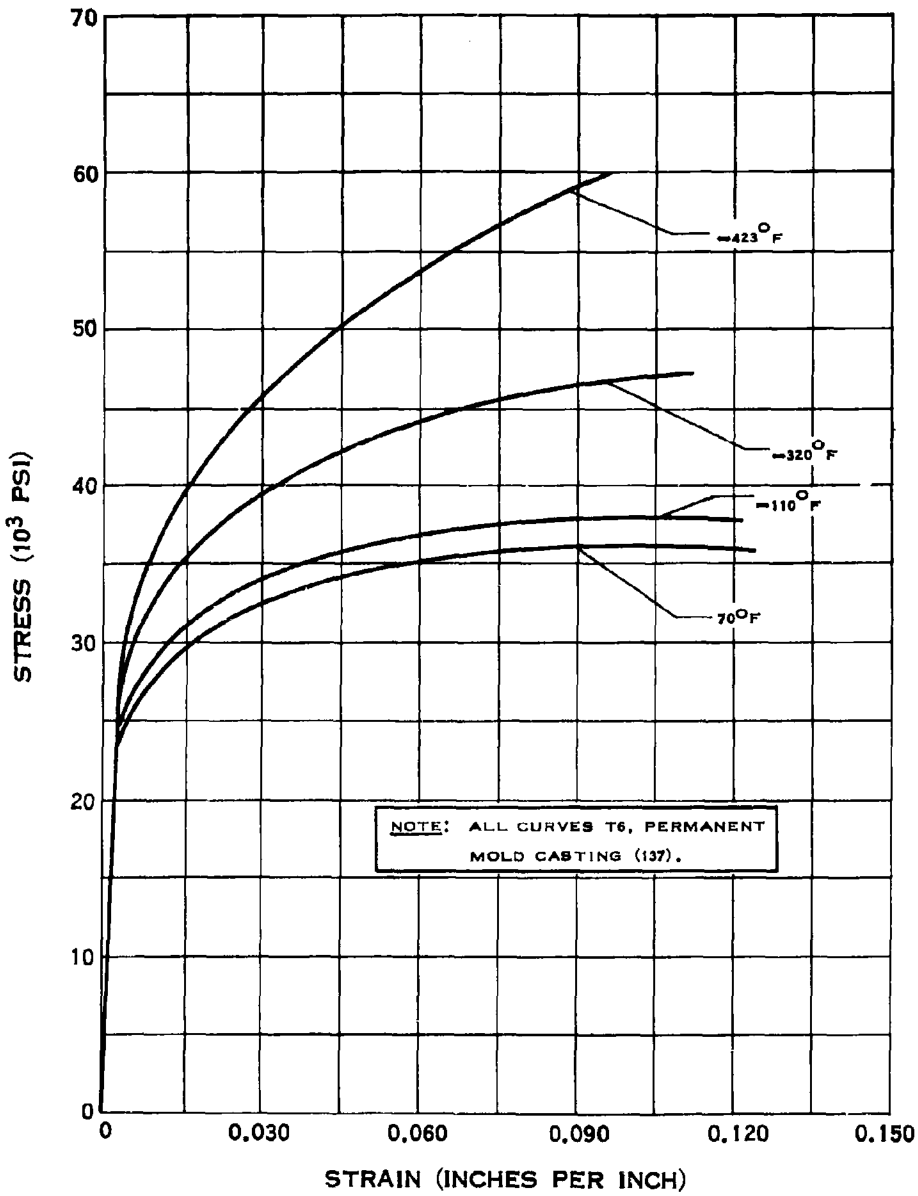

STRESS-STRAIN DIAGRAM FOR 356 ALUMINUM

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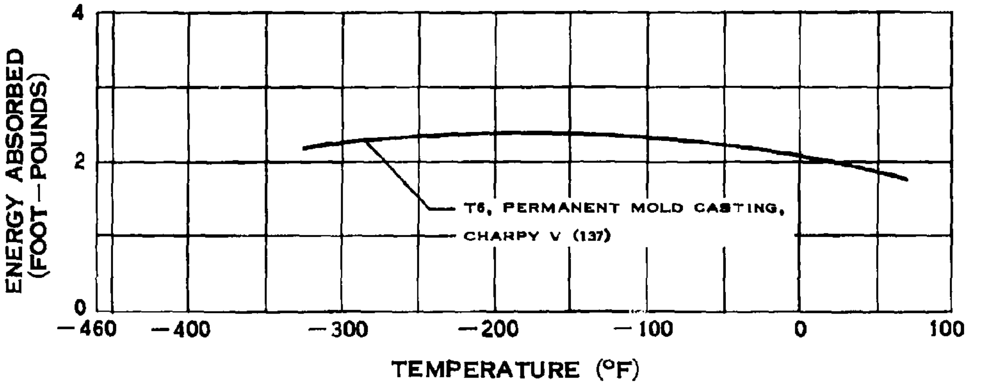
A.2.g



IMPACT ENERGY OF 356 ALUMINUM

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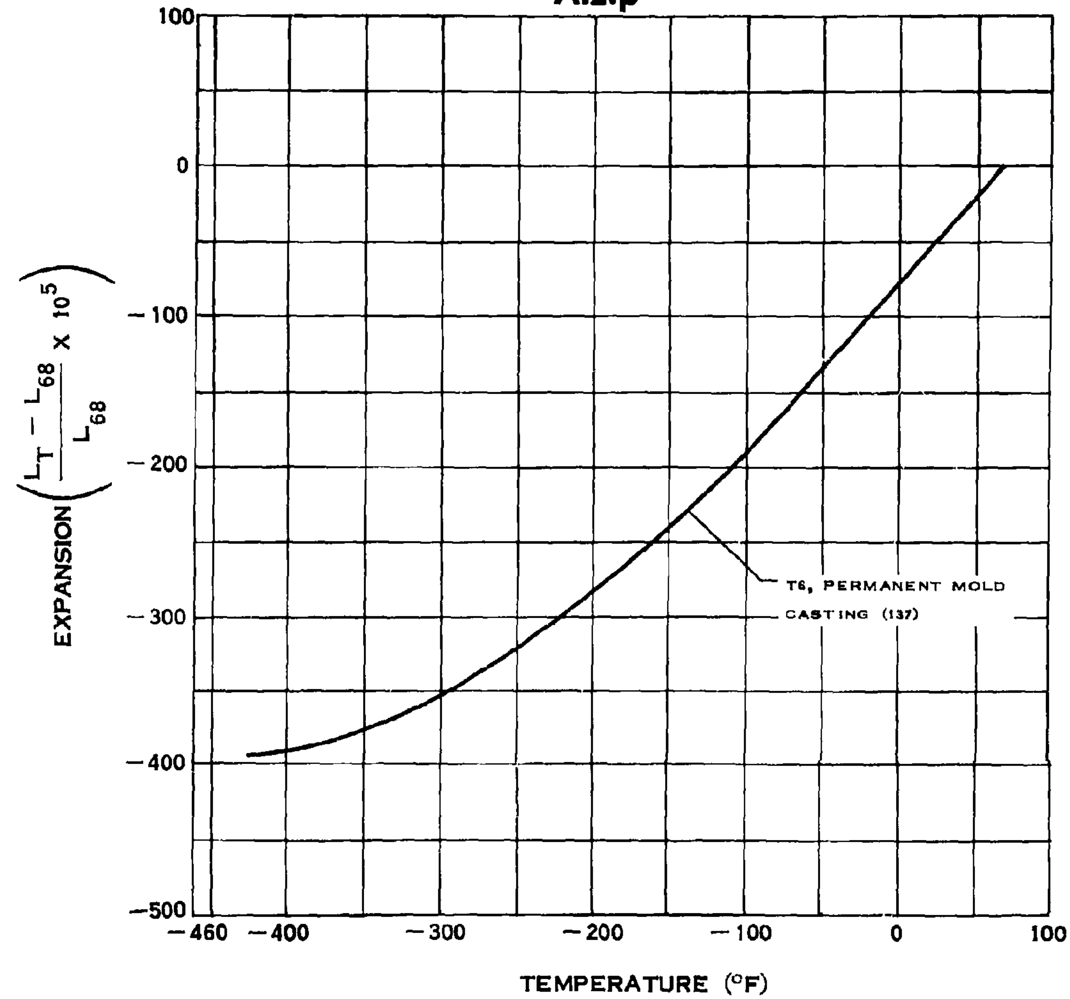
A.2.p



THERMAL EXPANSION OF 356 ALUMINUM

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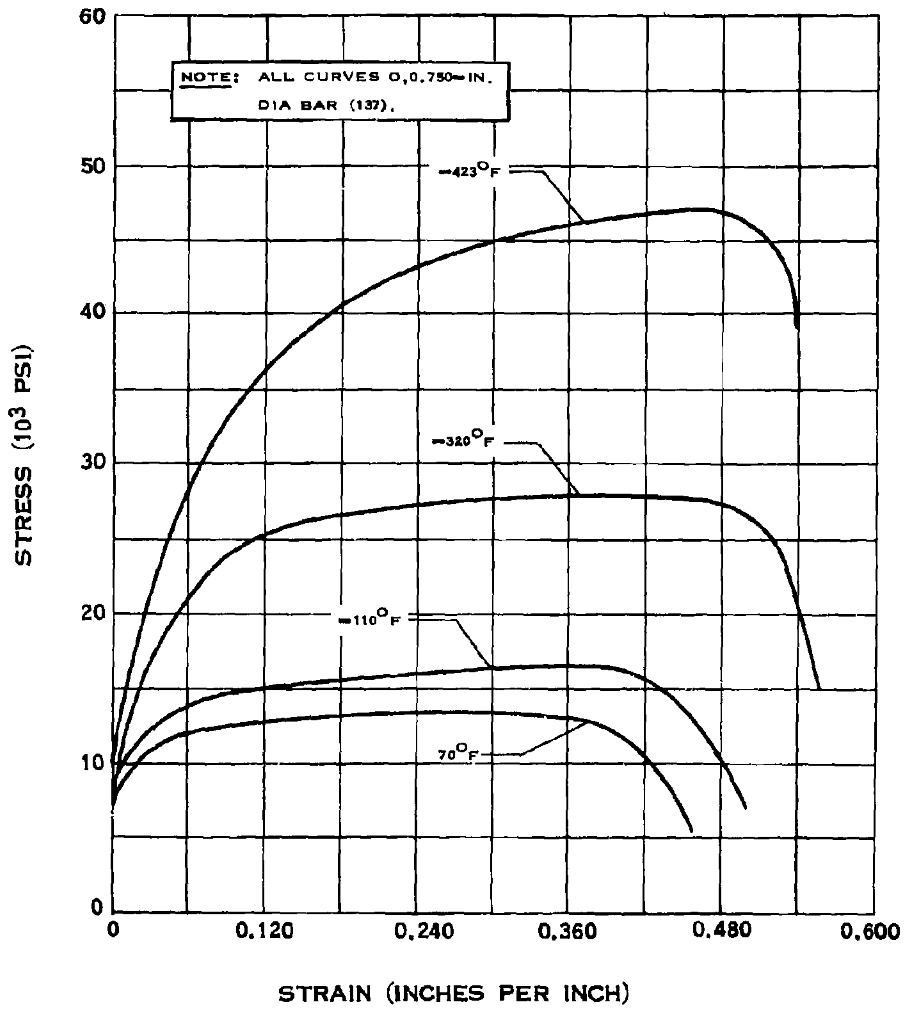

STRESS-STRAIN DIAGRAM FOR 1100 ALUMINUM

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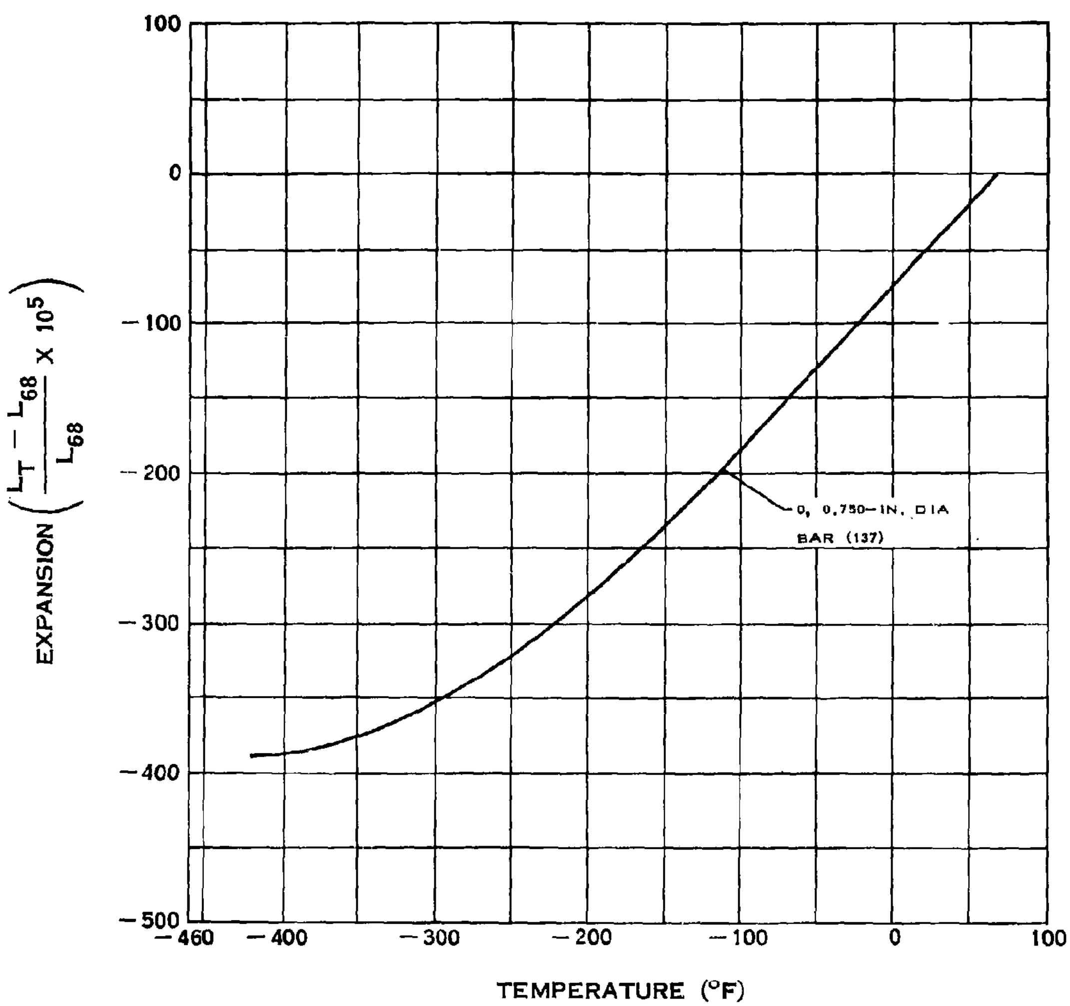

THERMAL EXPANSION OF 1100 ALUMINUM

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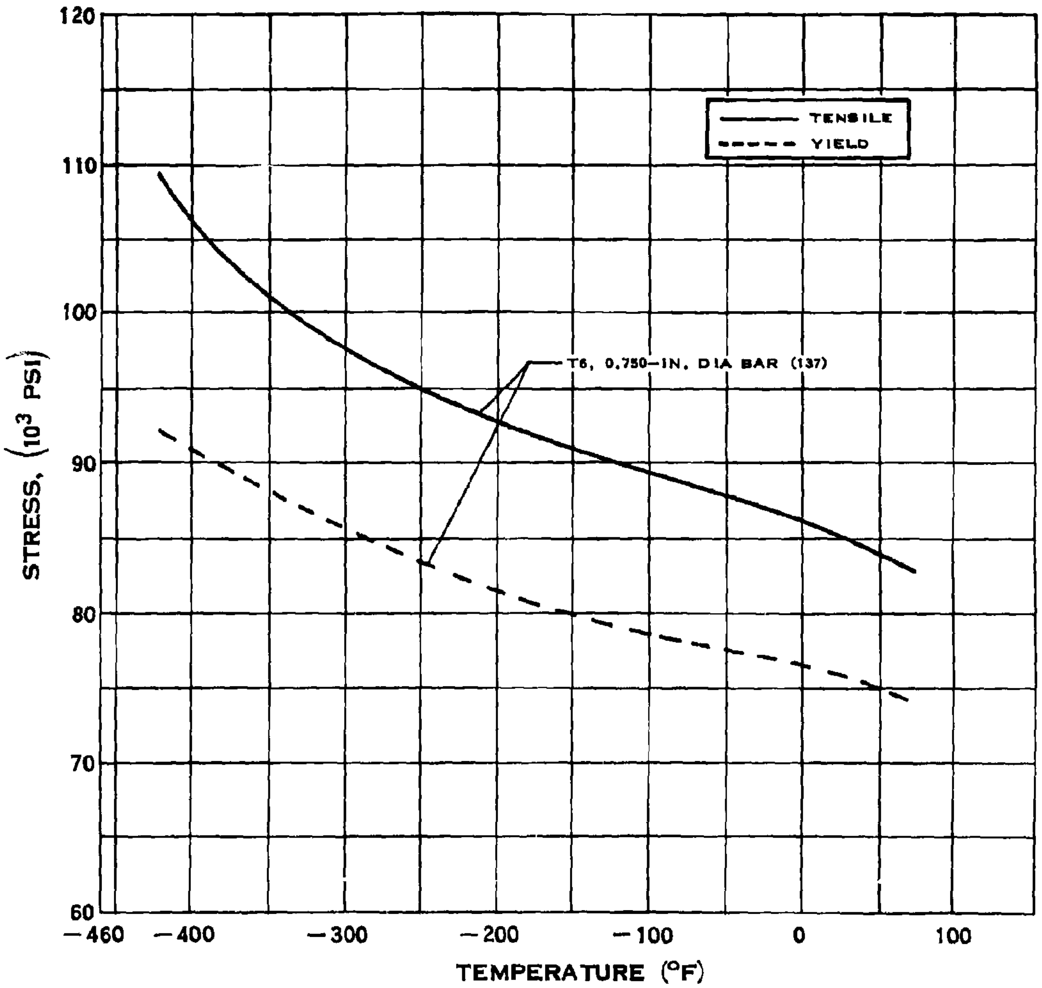
A.4.ab



STRENGTH OF 2020 ALUMINUM

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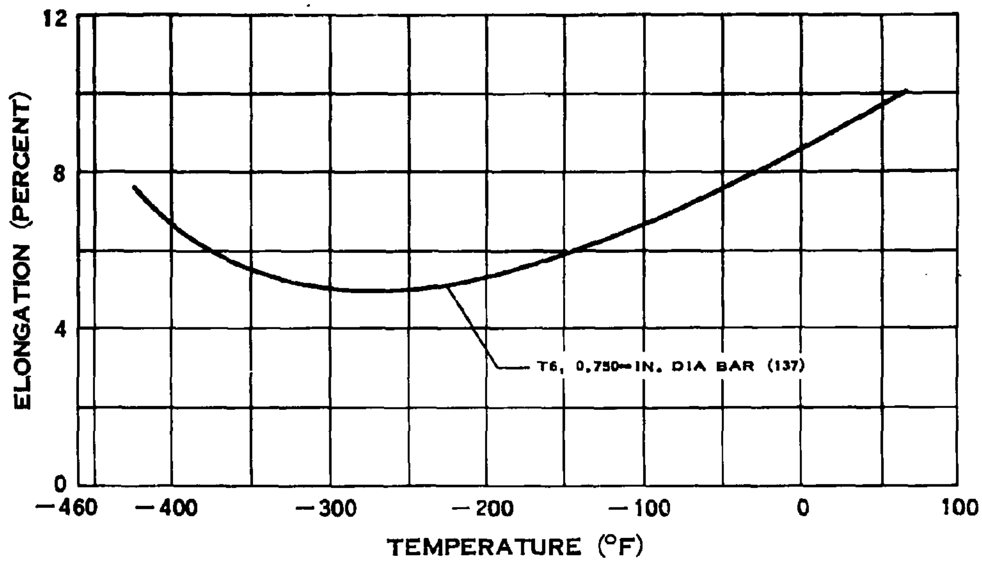
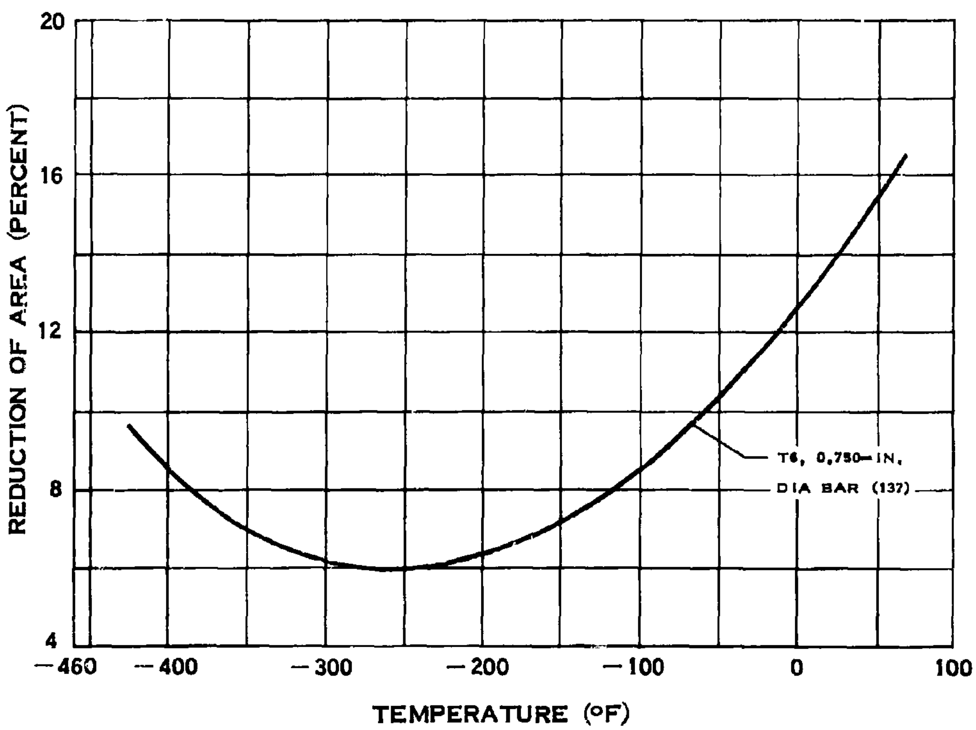
A.4.cd



ELONGATION OF 2020 ALUMINUM



REDUCTION OF AREA OF 2020 ALUMINUM

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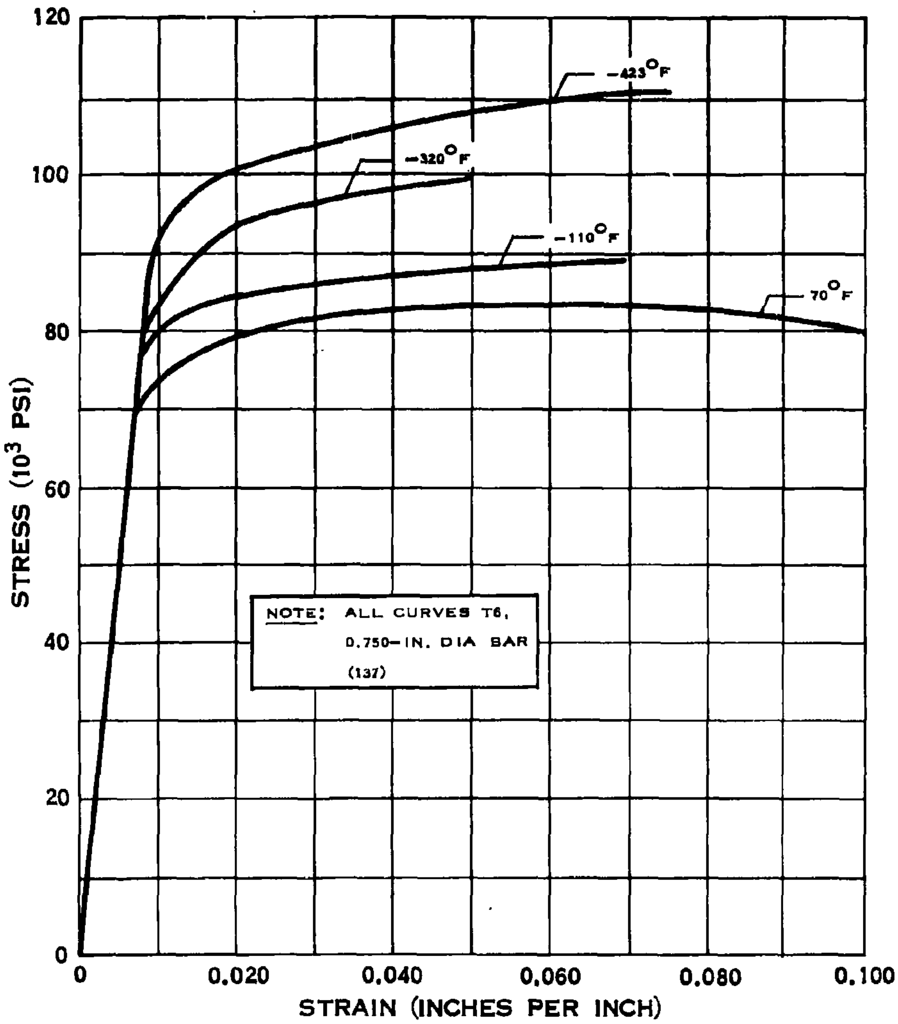
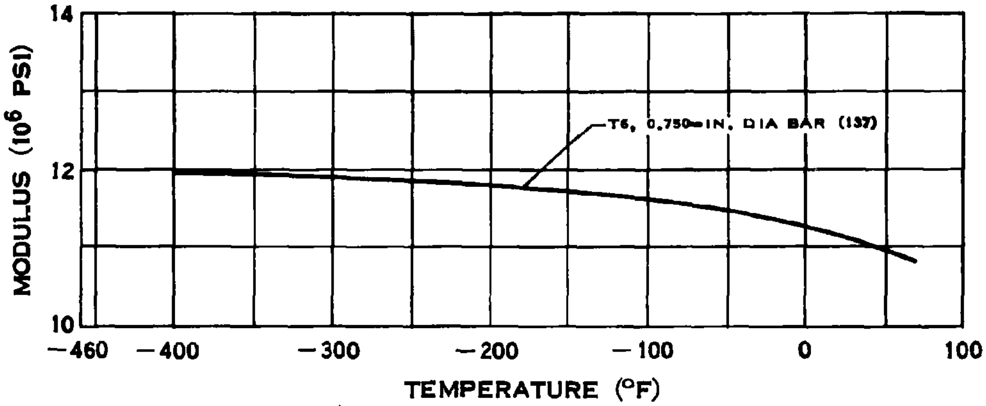
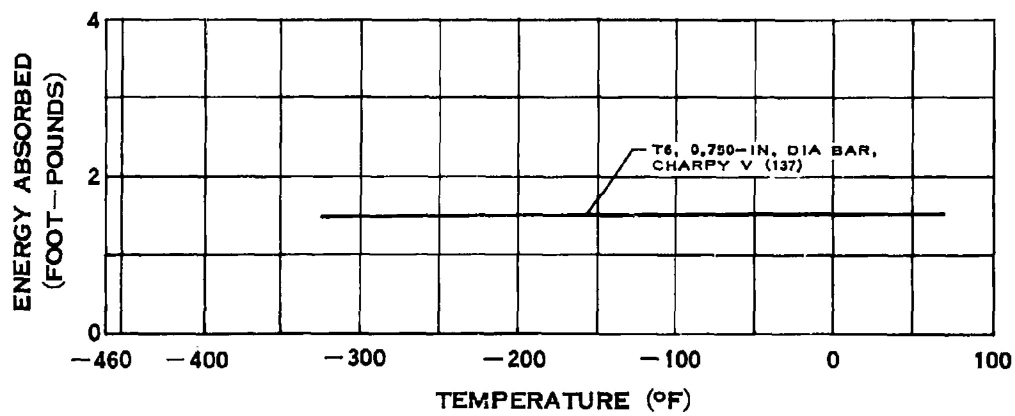


STRESS – STRAIN DIAGRAM FOR 2020 ALUMINUM

A.4.fg



MODULUS OF ELASTICITY OF 2020 ALUMINUM



IMPACT ENERGY OF 2020 ALUMINUM

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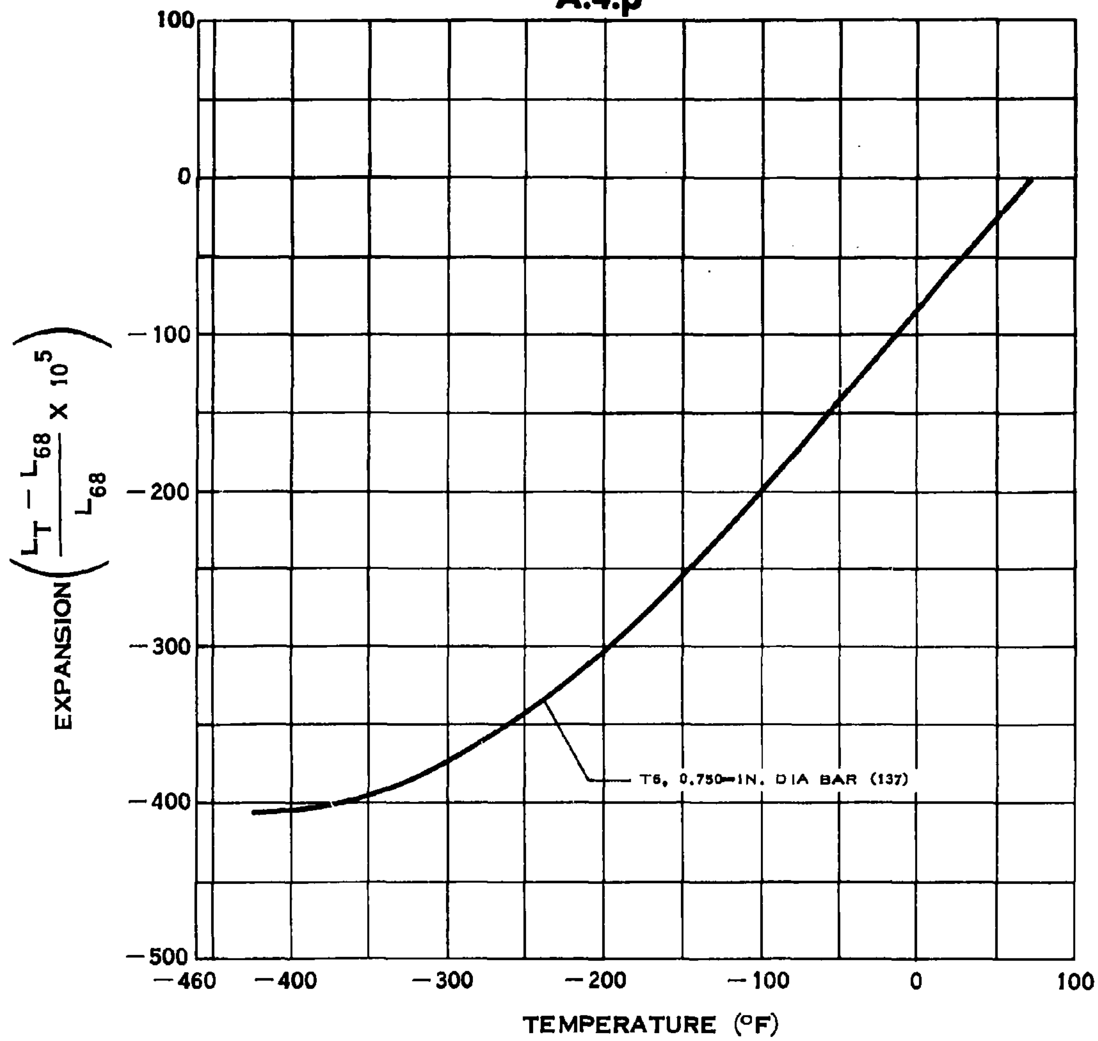

THERMAL EXPANSION OF 2020 ALUMINUM

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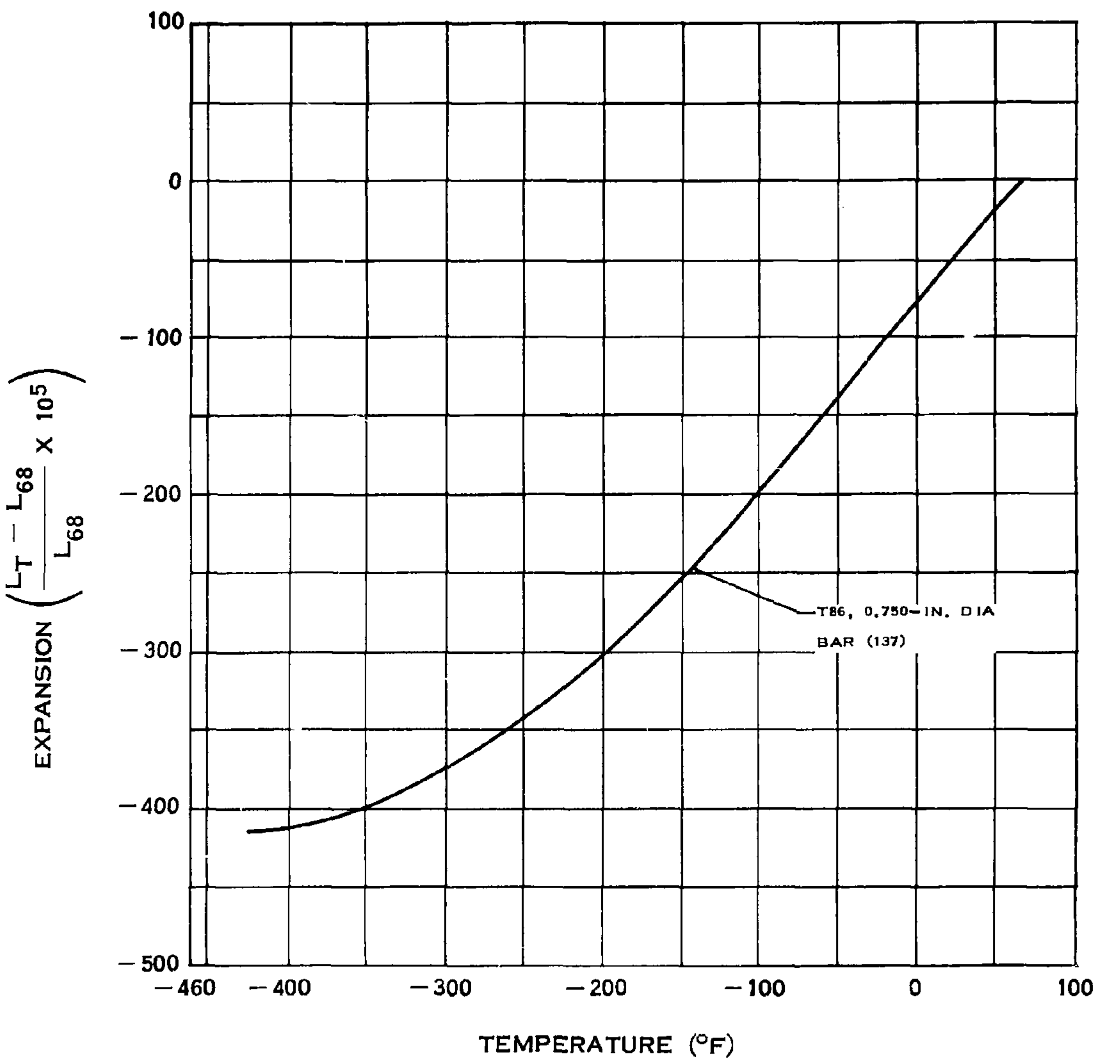
A.5.p



THERMAL EXPANSION OF 2024 ALUMINUM

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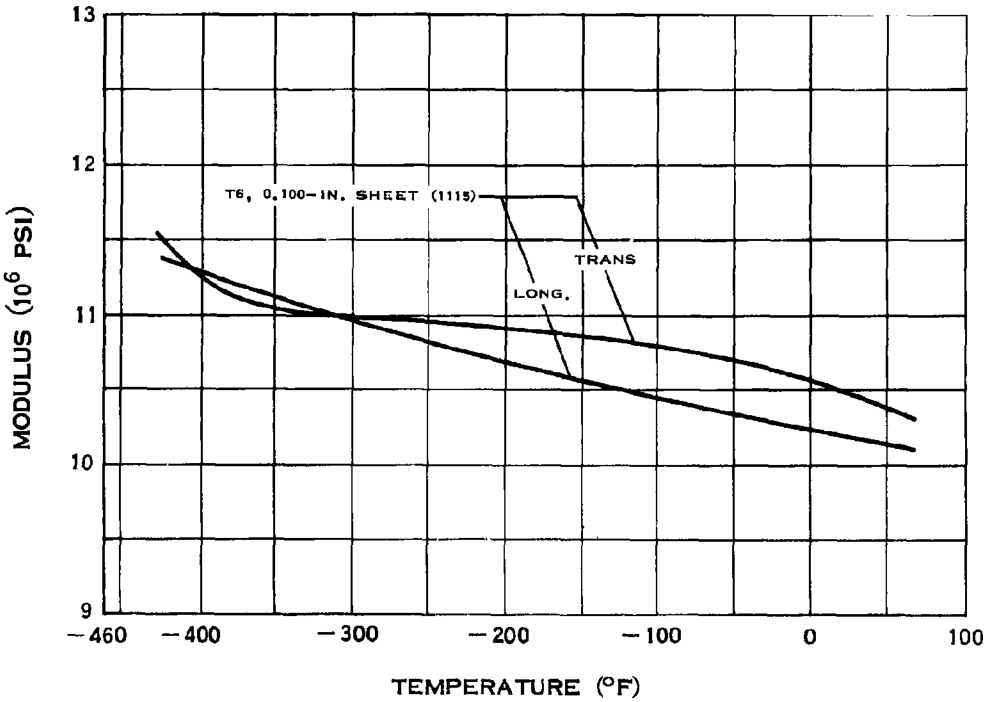
A.6.f



MODULUS OF ELASTICITY OF 6061 ALUMINUM

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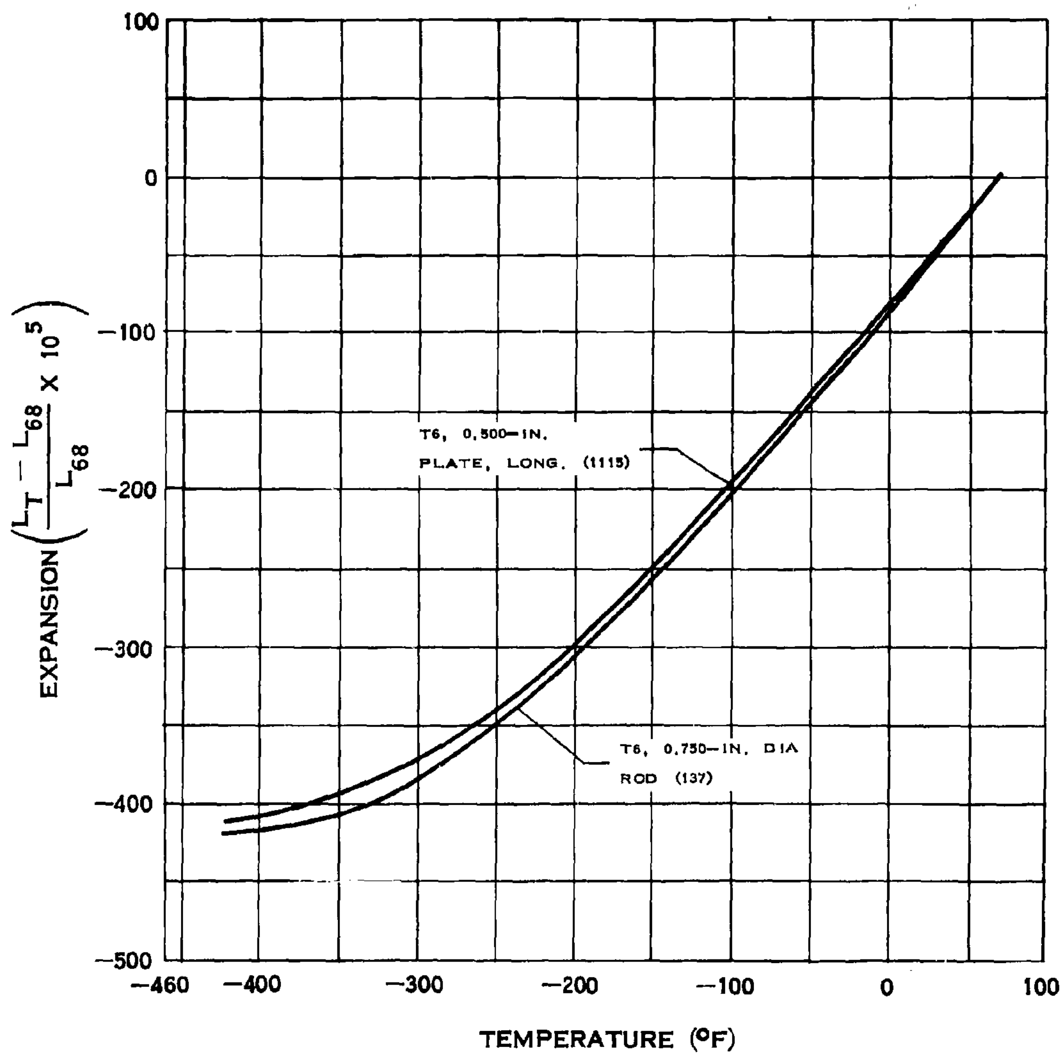

THERMAL EXPANSION OF 6061 ALUMINUM

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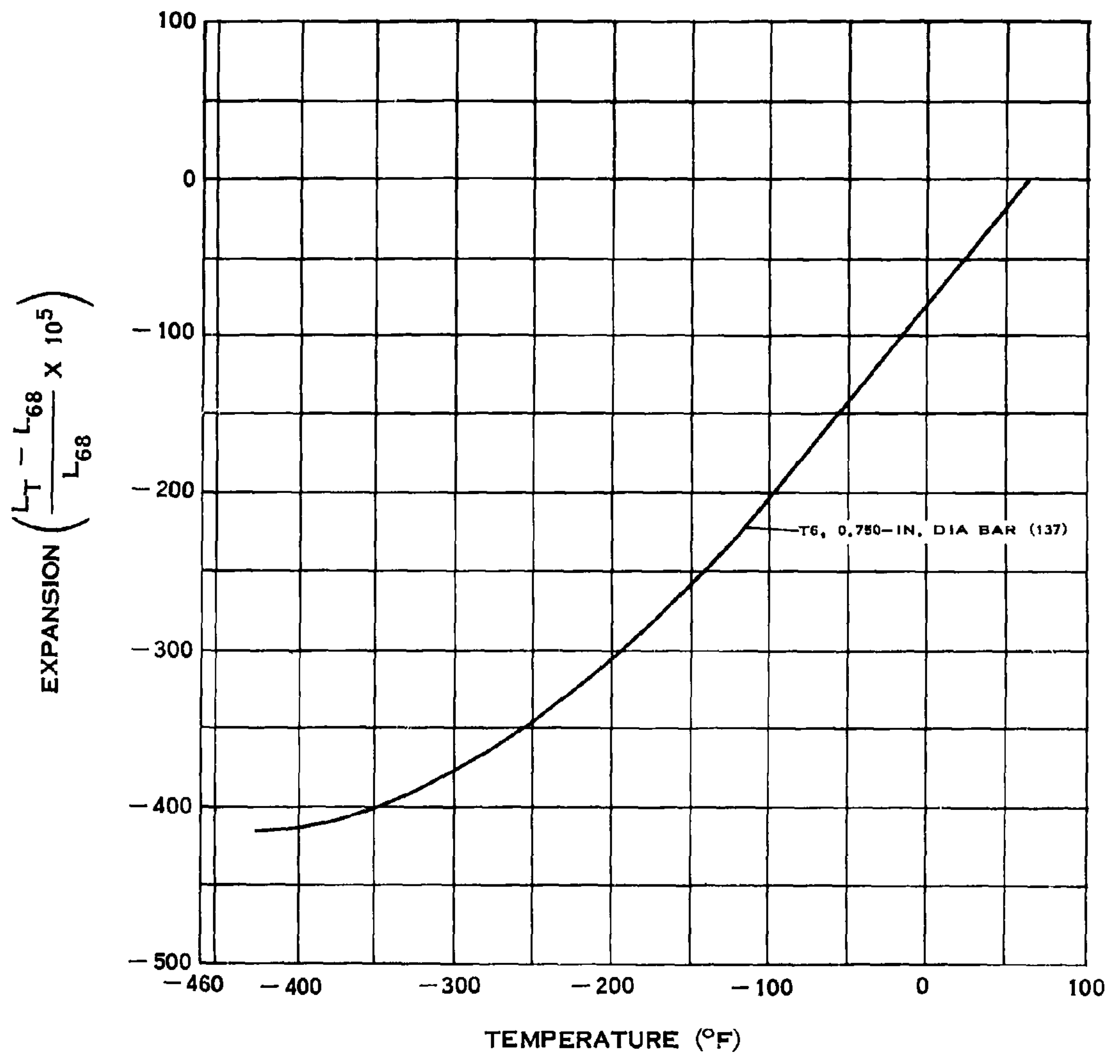
A.7.p



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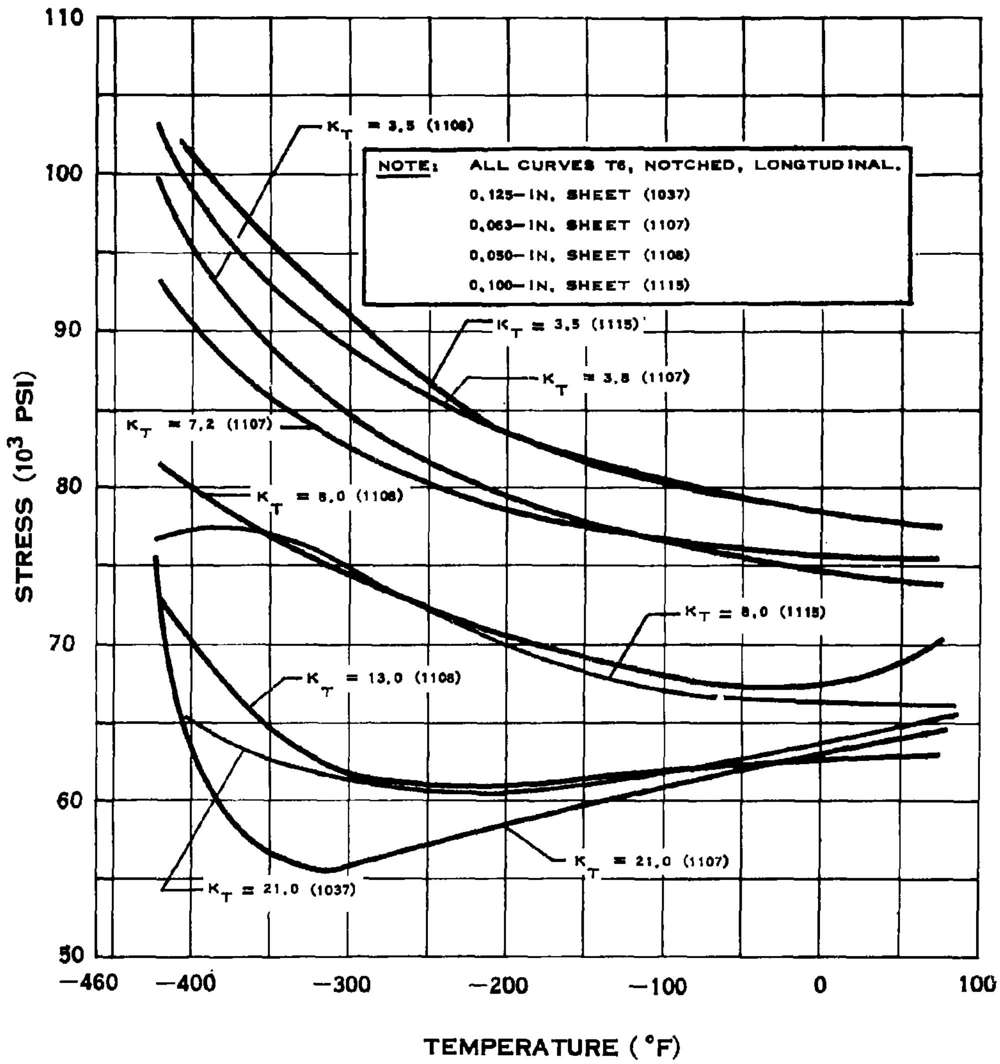

NOTCH TENSILE STRENGTH OF 2014 ALUMINUM

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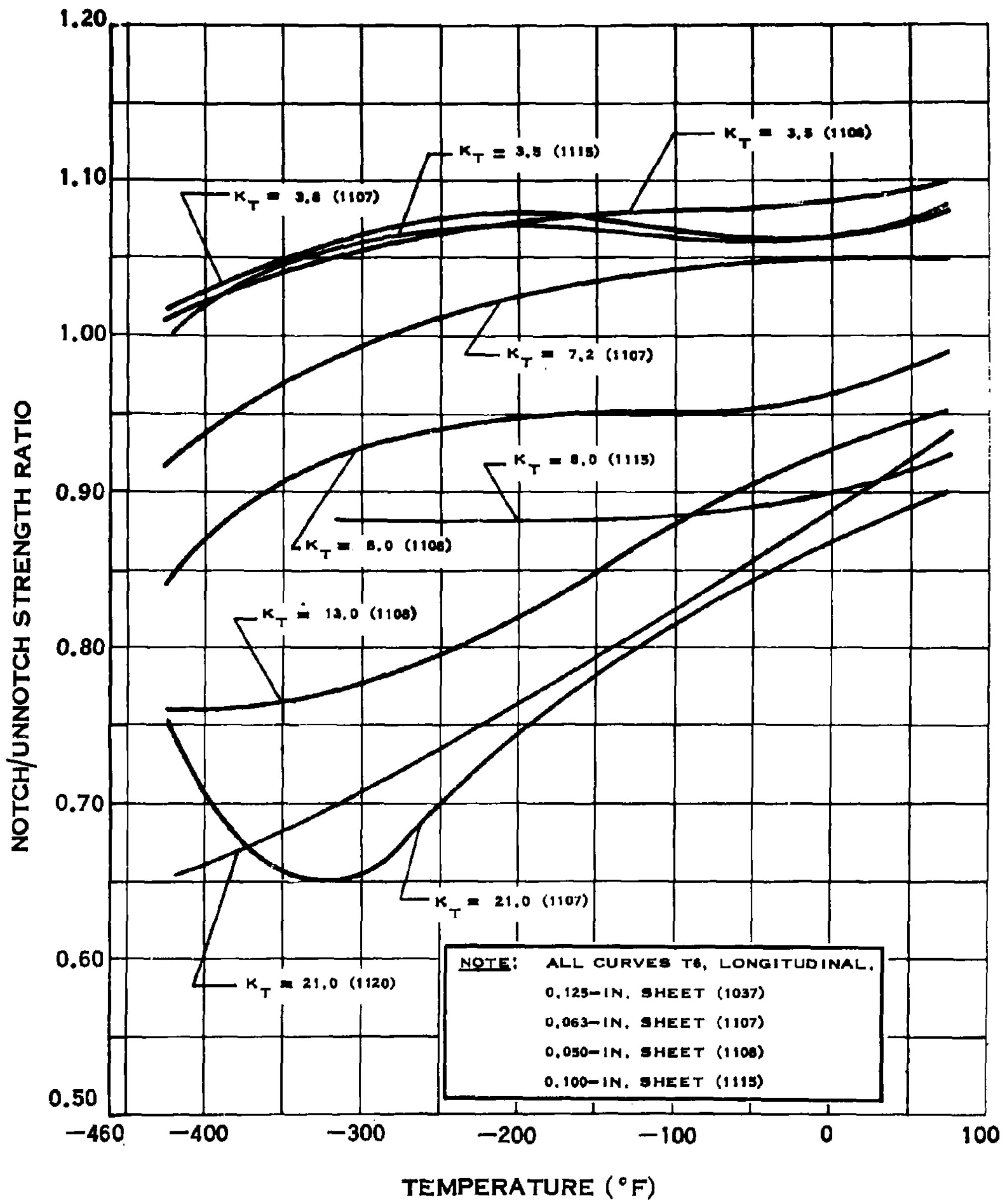
A.8.b-2



NOTCH STRENGTH RATIO OF 2014 ALUMINUM

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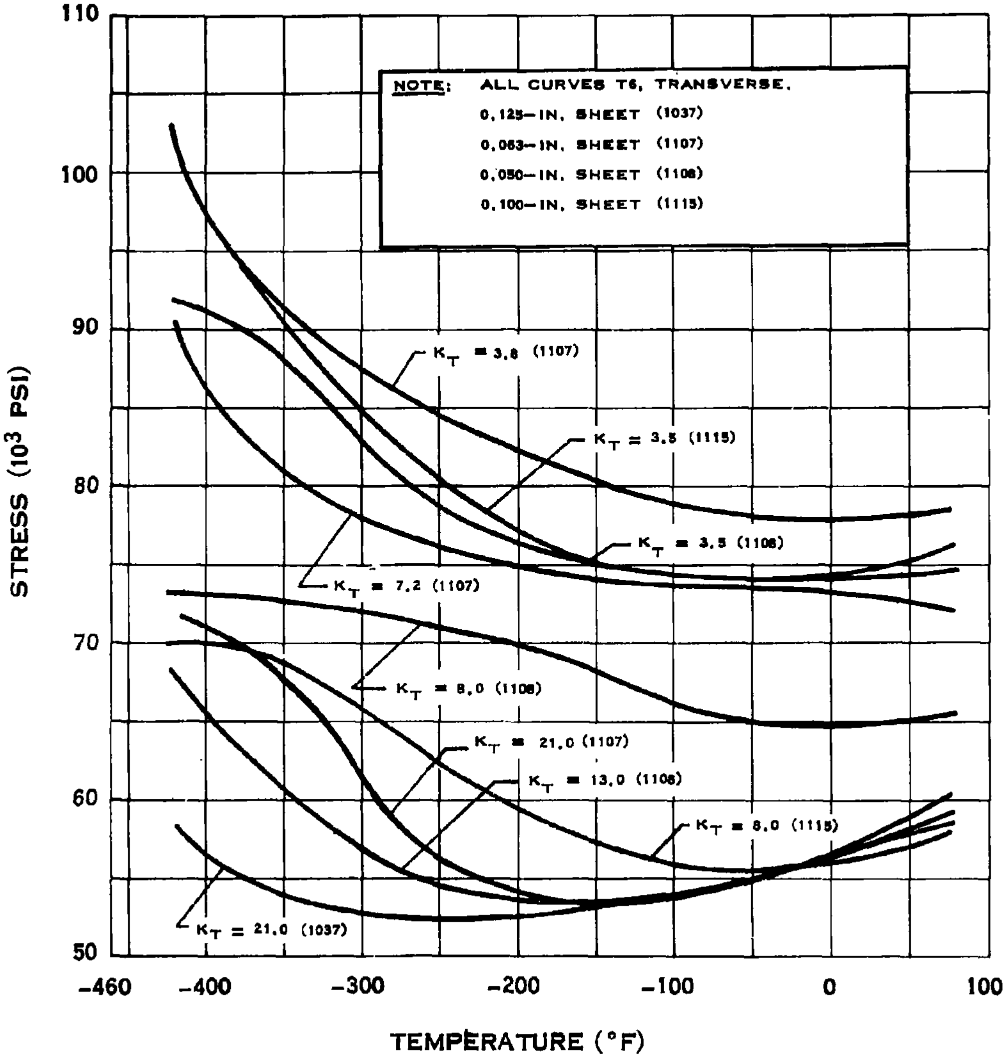
A.8.b-3



NOTCH TENSILE STRENGTH OF 2014 ALUMINUM

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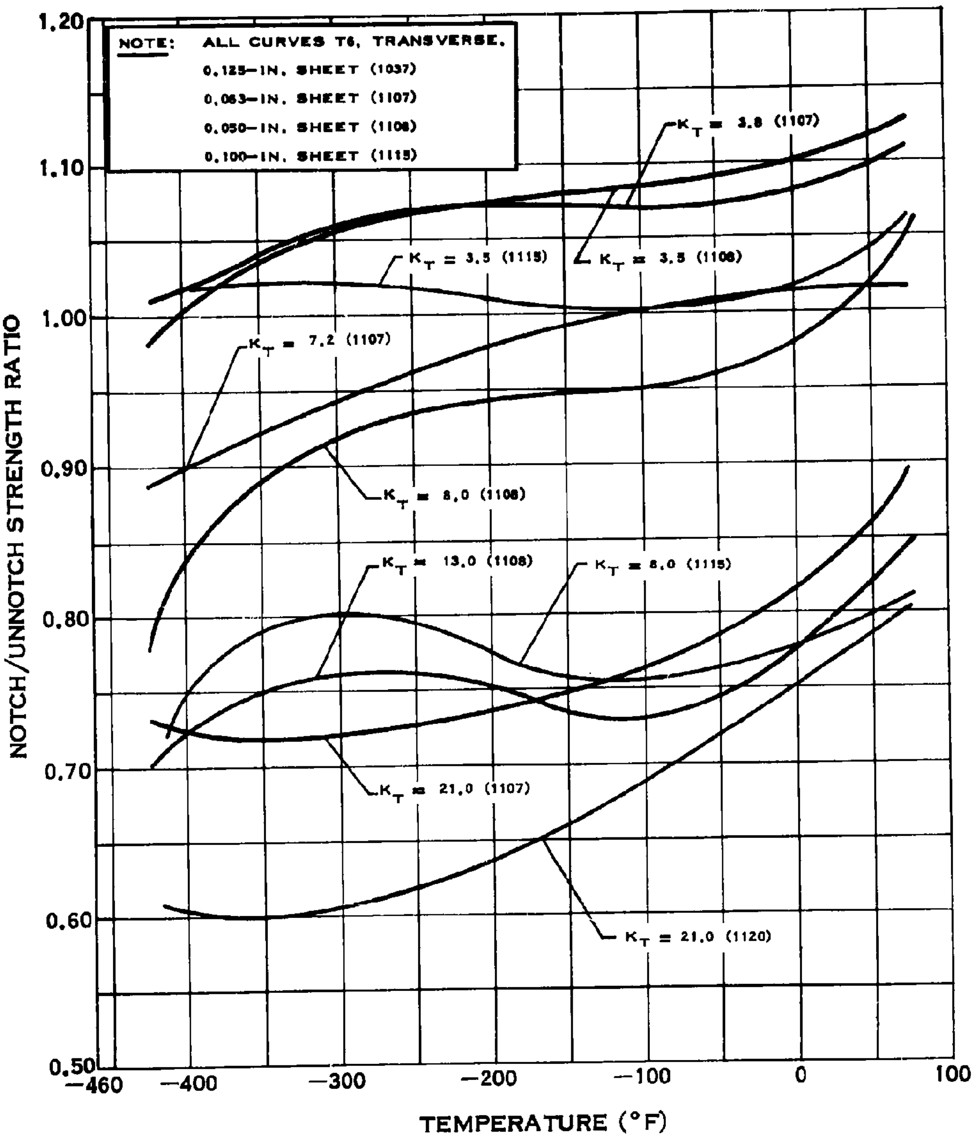
A.8.b-4



NOTCH STRENGTH RATIO OF 2014 ALUMINUM

(7-15-63)

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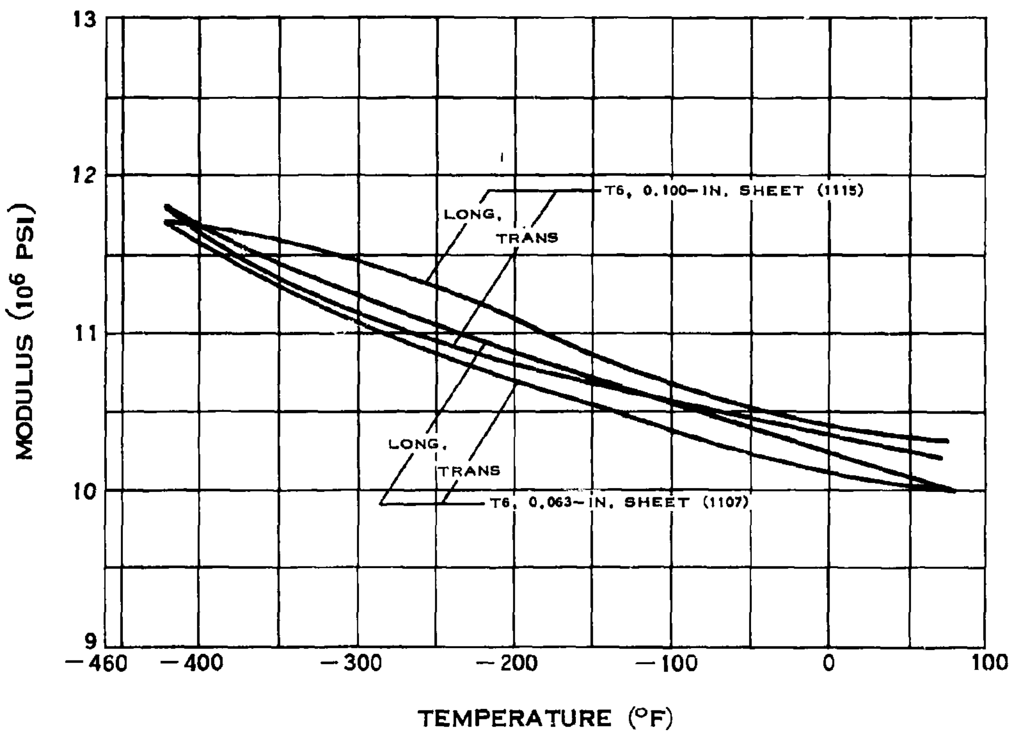
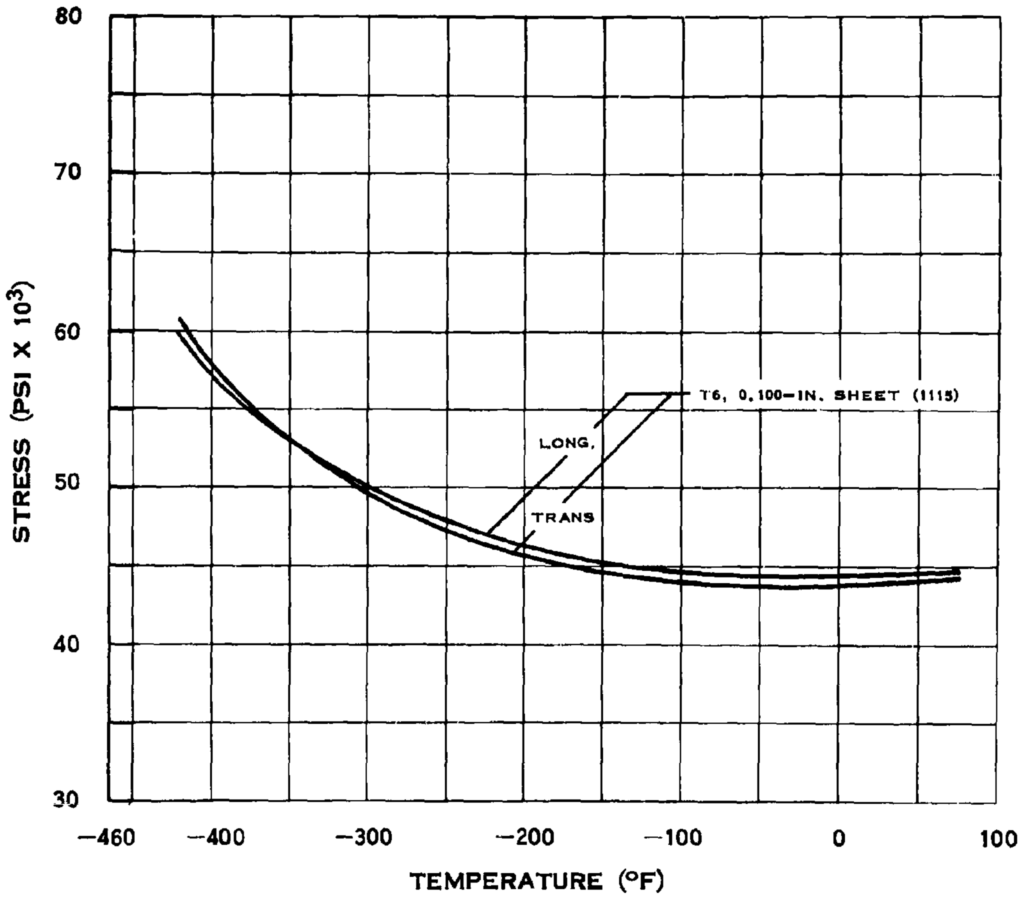


MODULUS OF ELASTICITY OF 2014 ALUMINUM

(1-15-64)

A.8.1



SHEAR STRENGTH OF 2014 ALUMINUM

(7-15-63)

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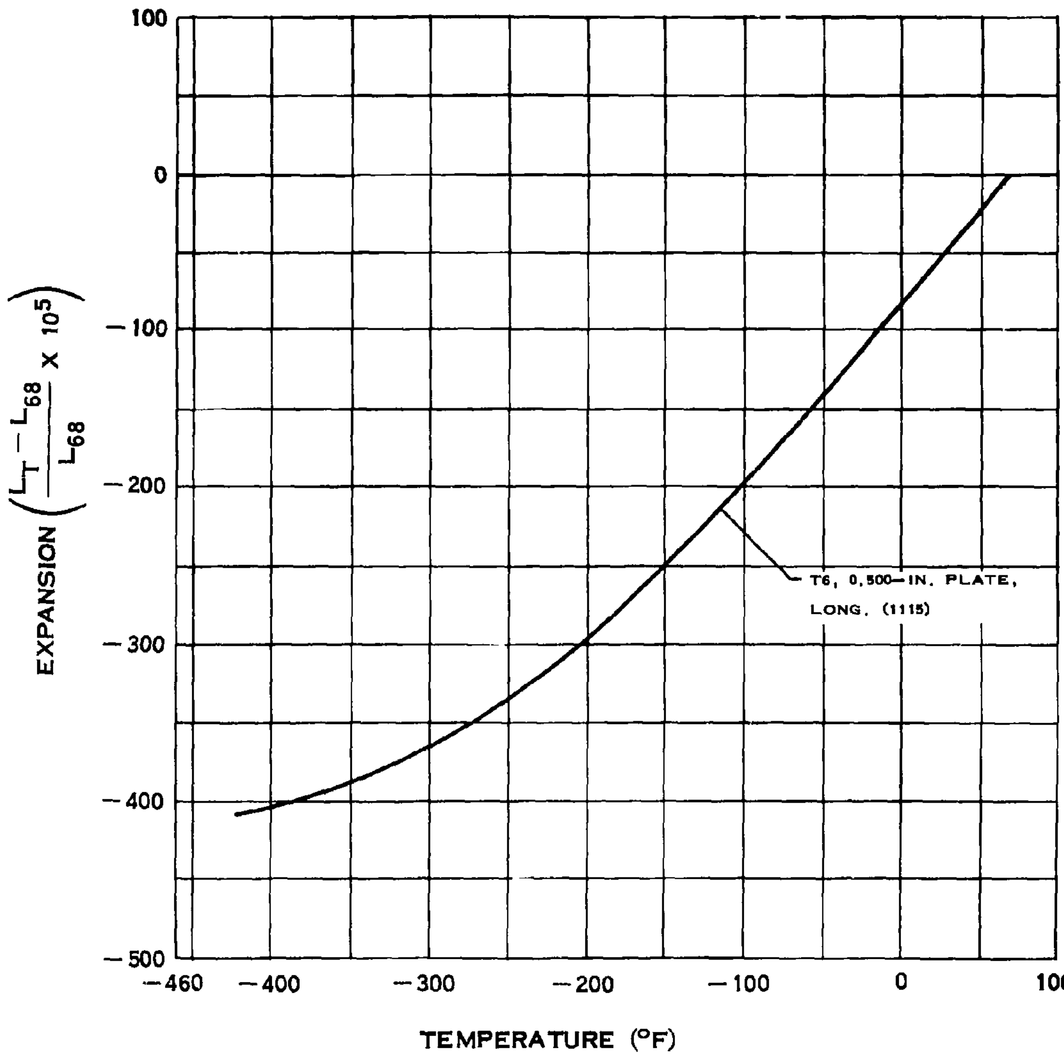

THERMAL EXPANSION OF 2014 ALUMINUM

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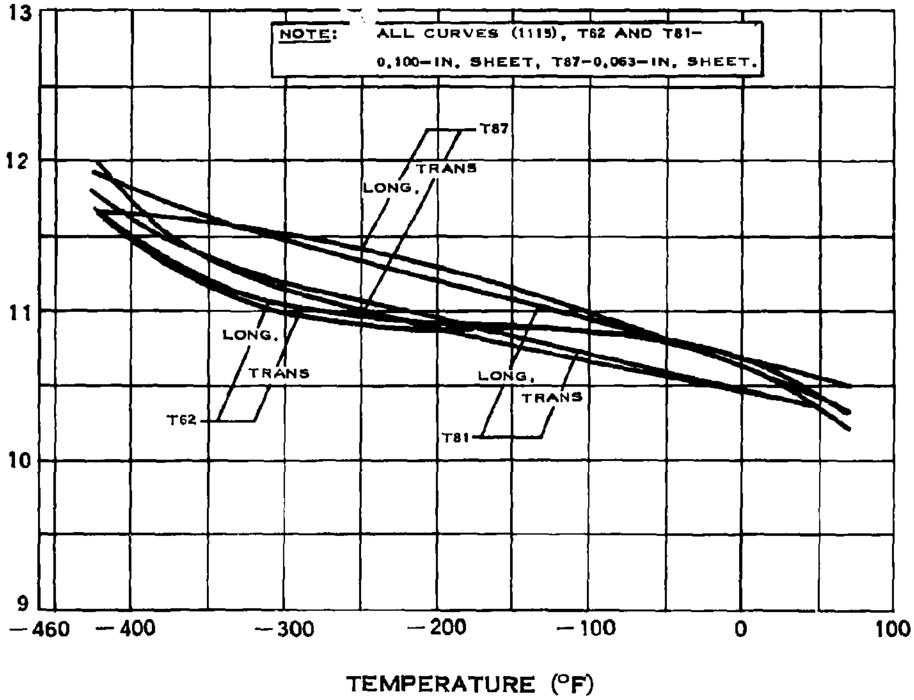
A.9.f



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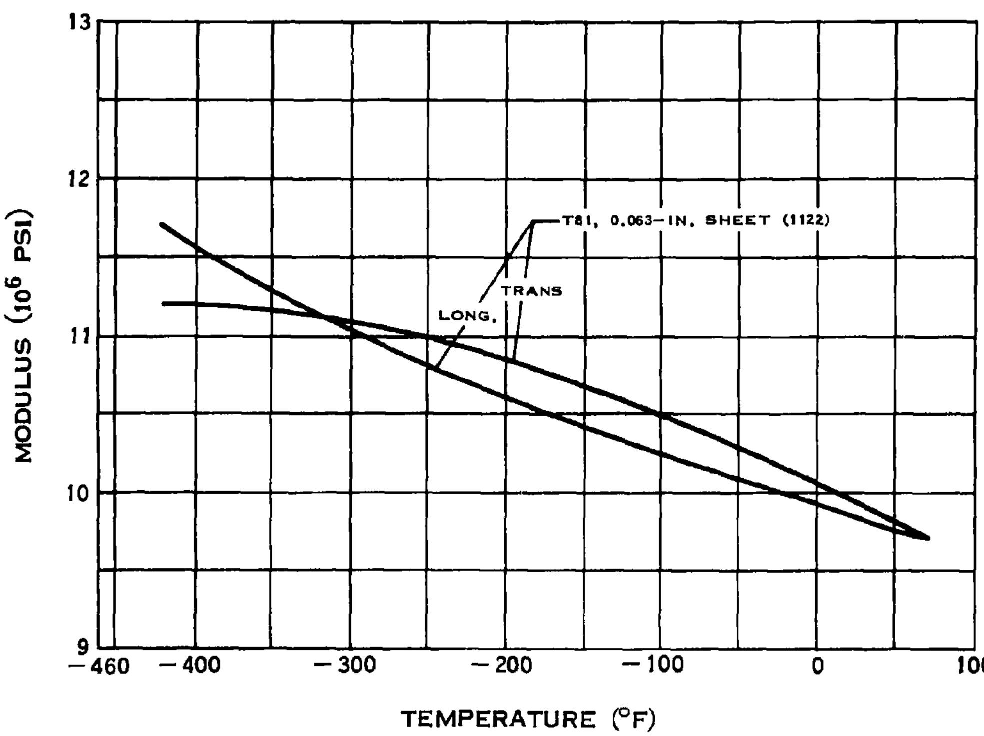

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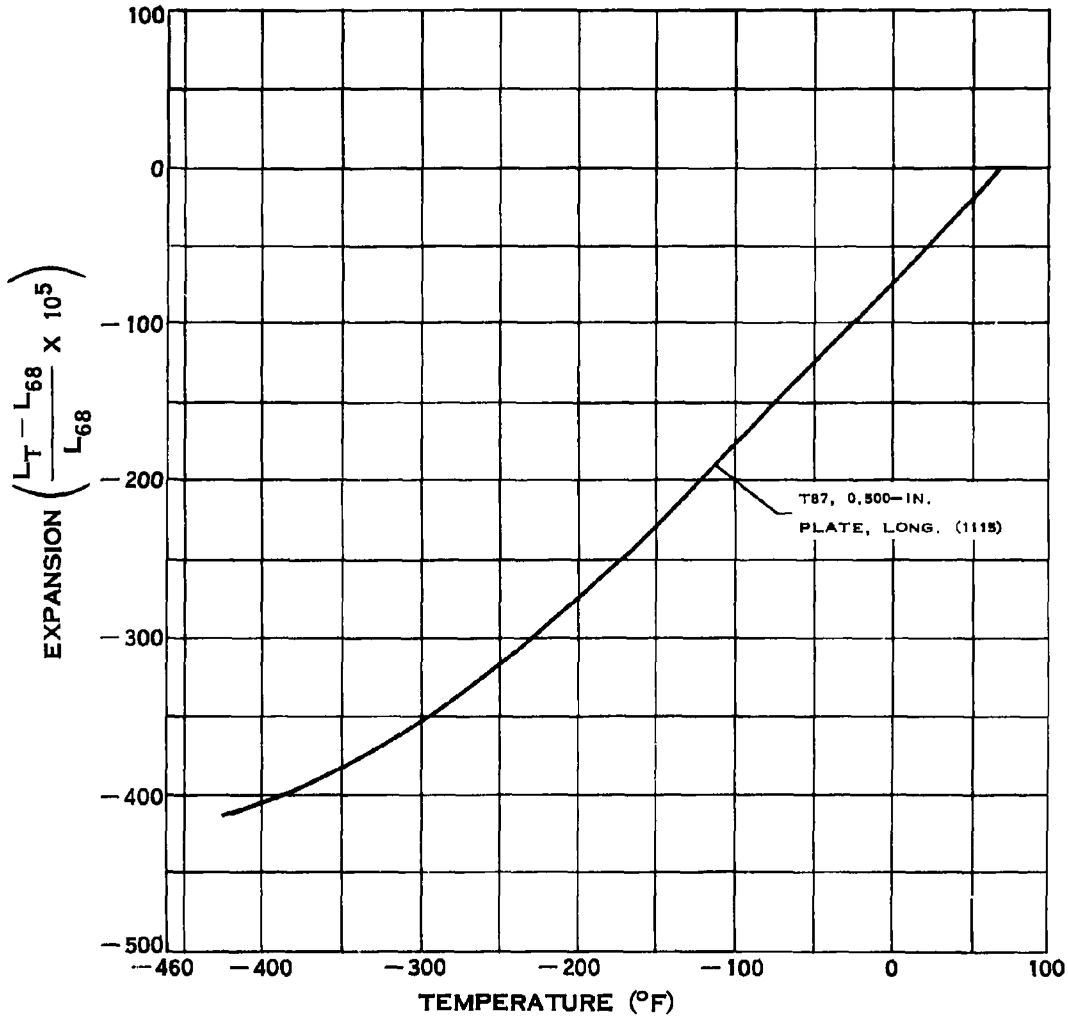
A.9.p



THERMAL EXPANSION OF 2219 ALUMINUM

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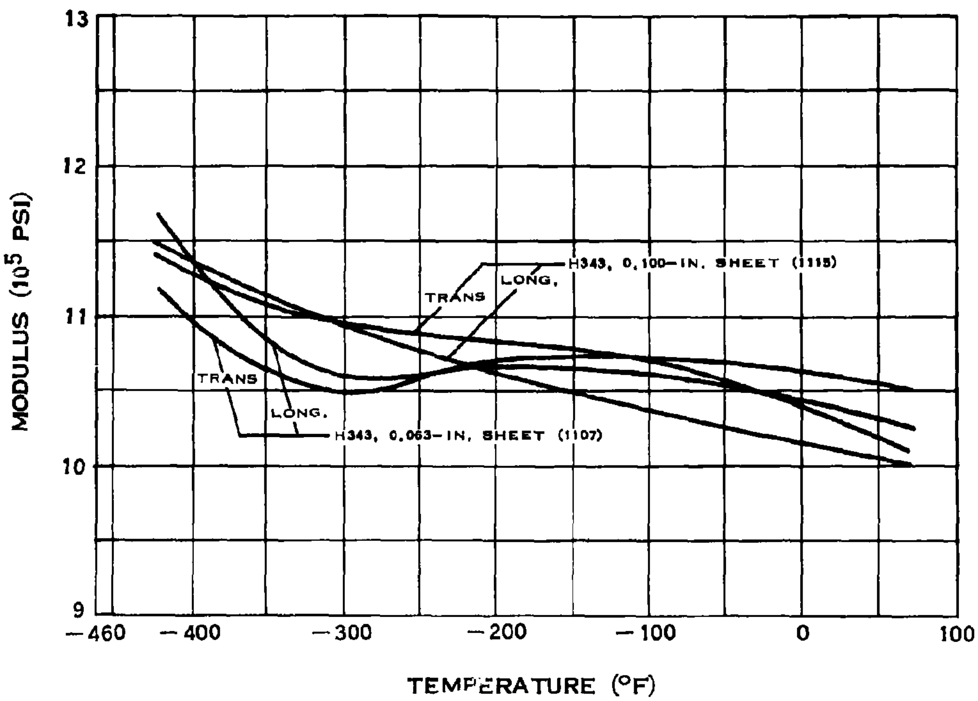
A.11.f



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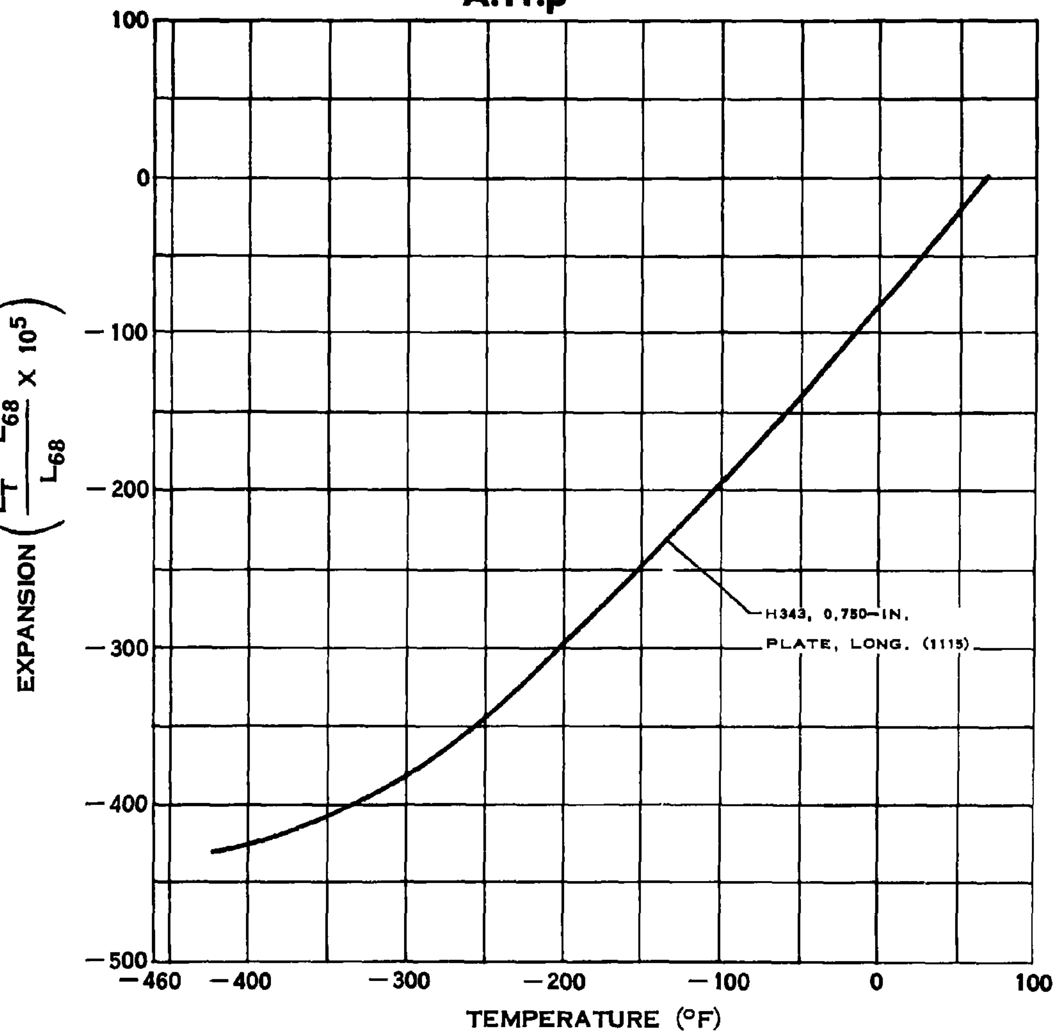

THERMAL EXPANSION OF 5456 ALUMINUM

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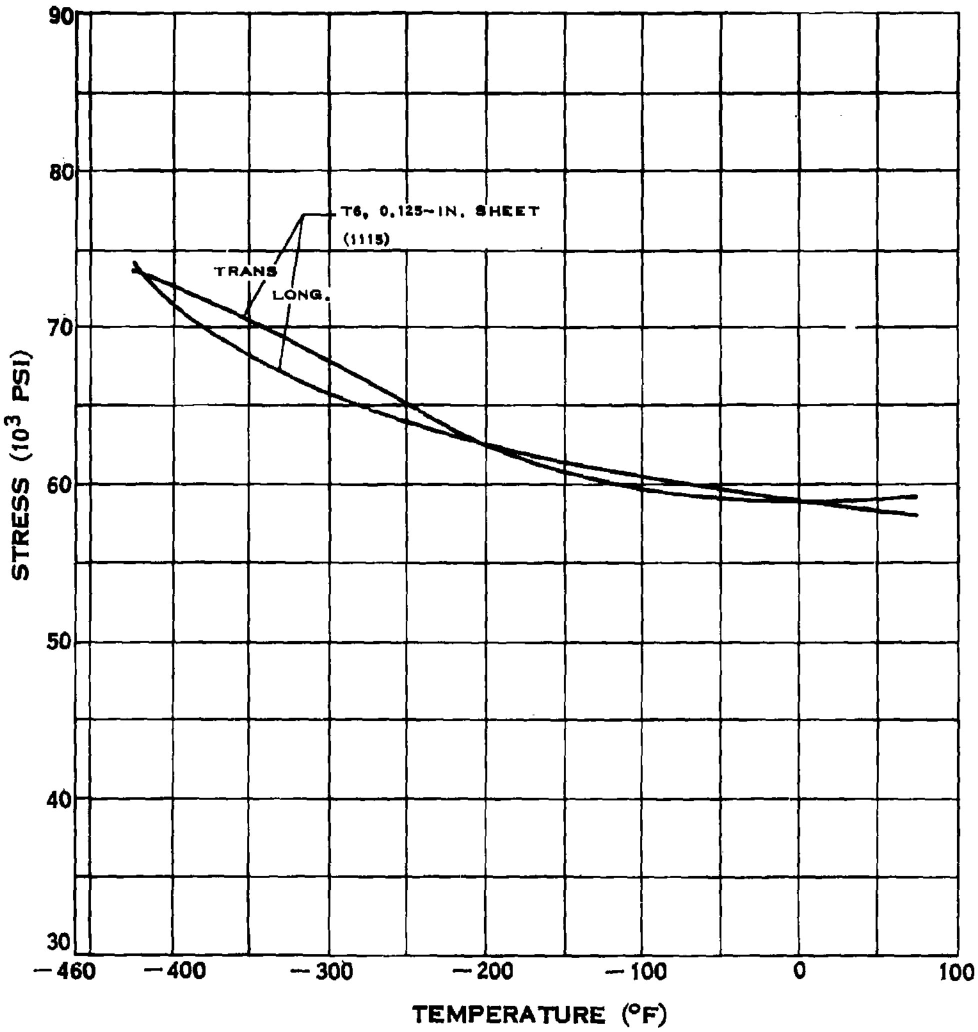
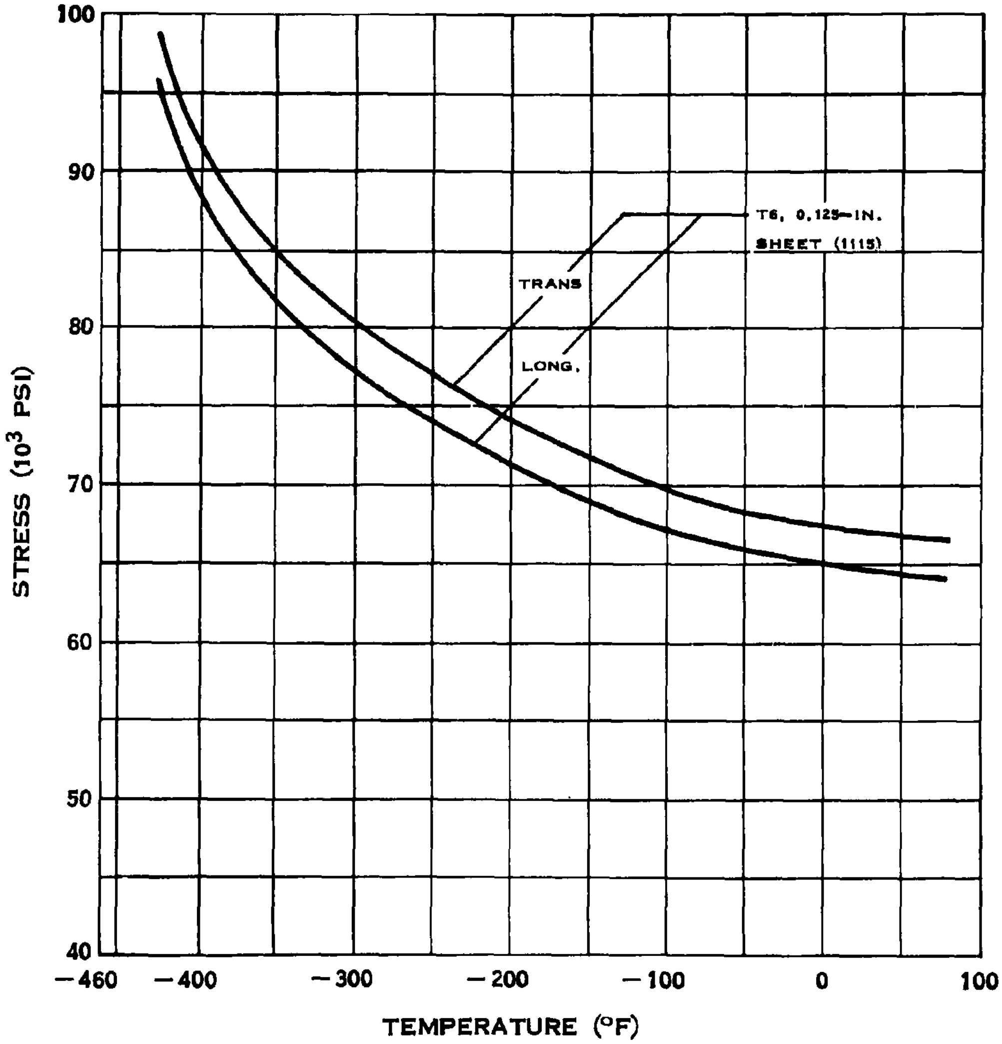
A.12.a



YIELD STRENGTH OF 7039 ALUMINUM

1-15-64

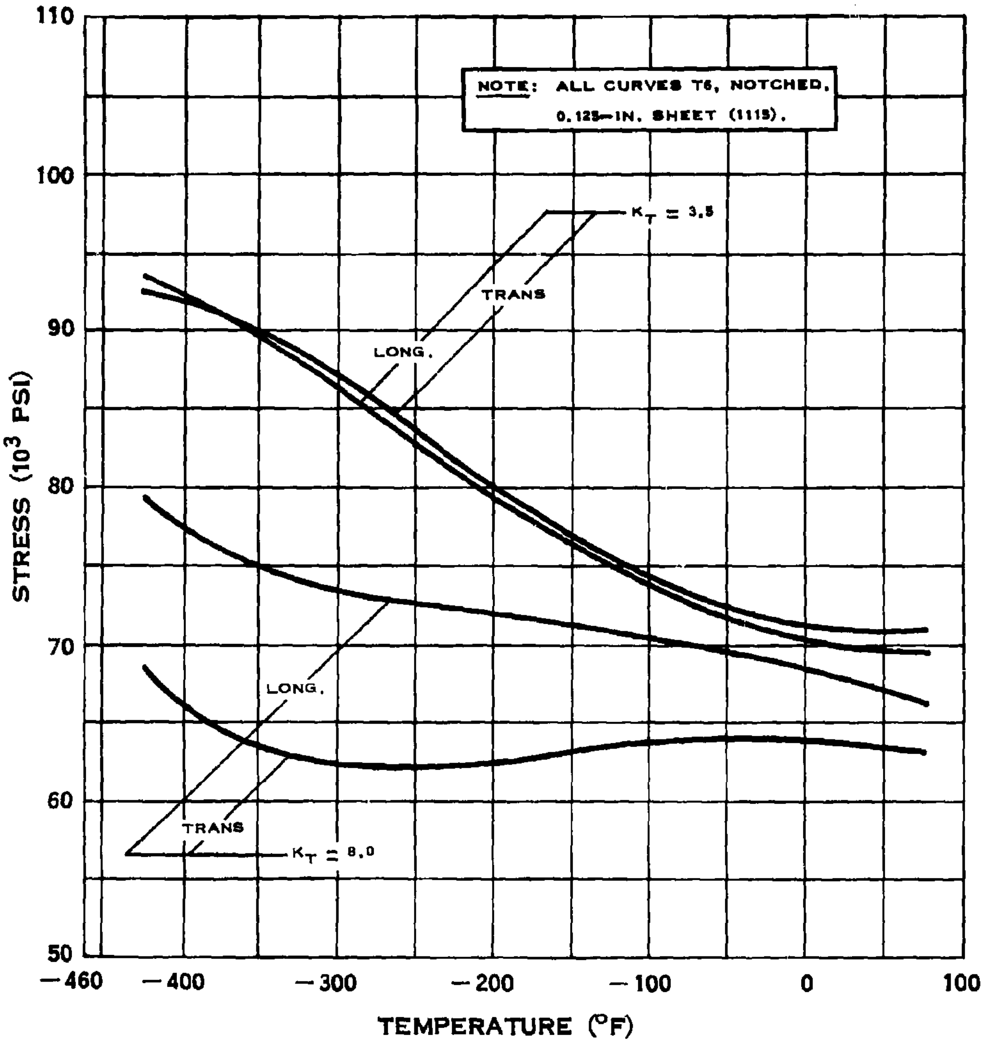
A.12.b



TENSILE STRENGTH OF 7039 ALUMINUM

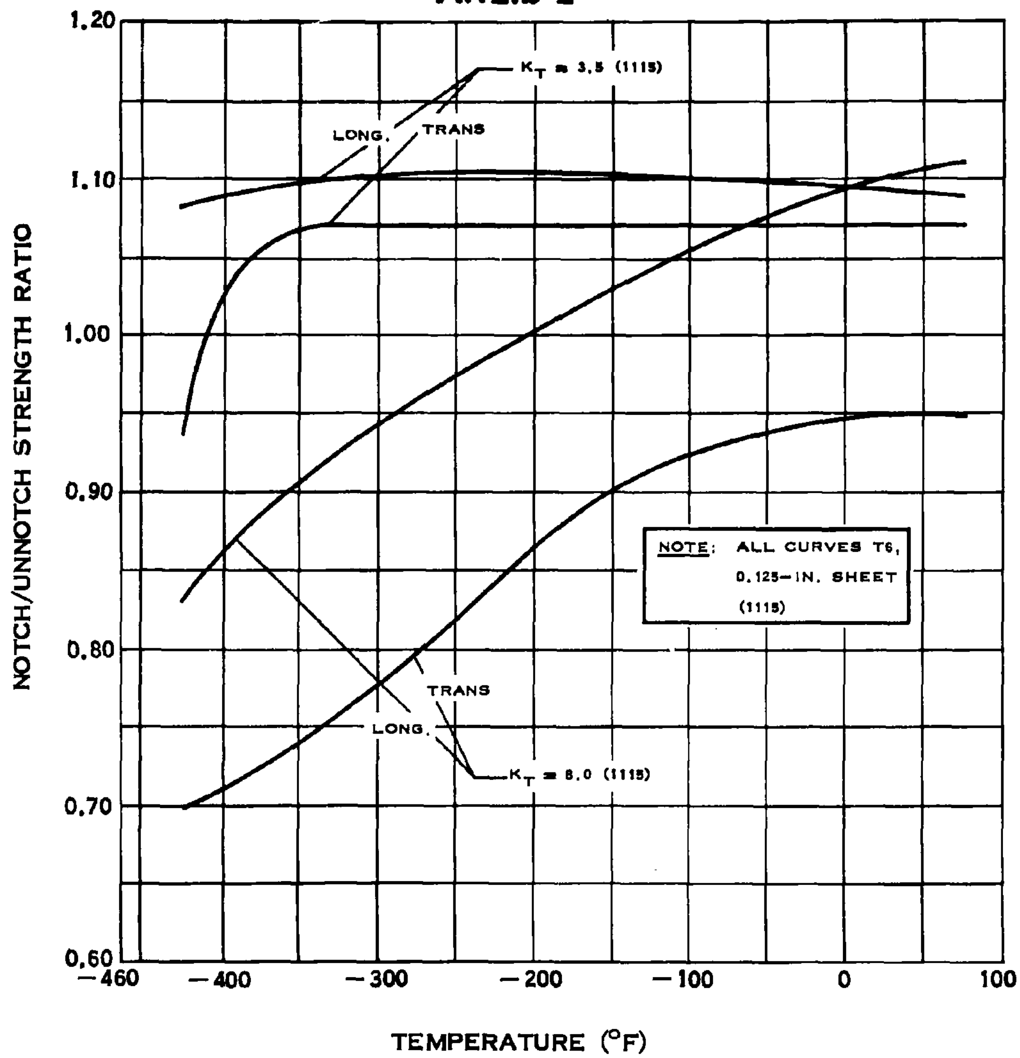
1-15-64

A.12.b-1



NOTCH TENSILE STRENGTH OF 7039 ALUMINUM

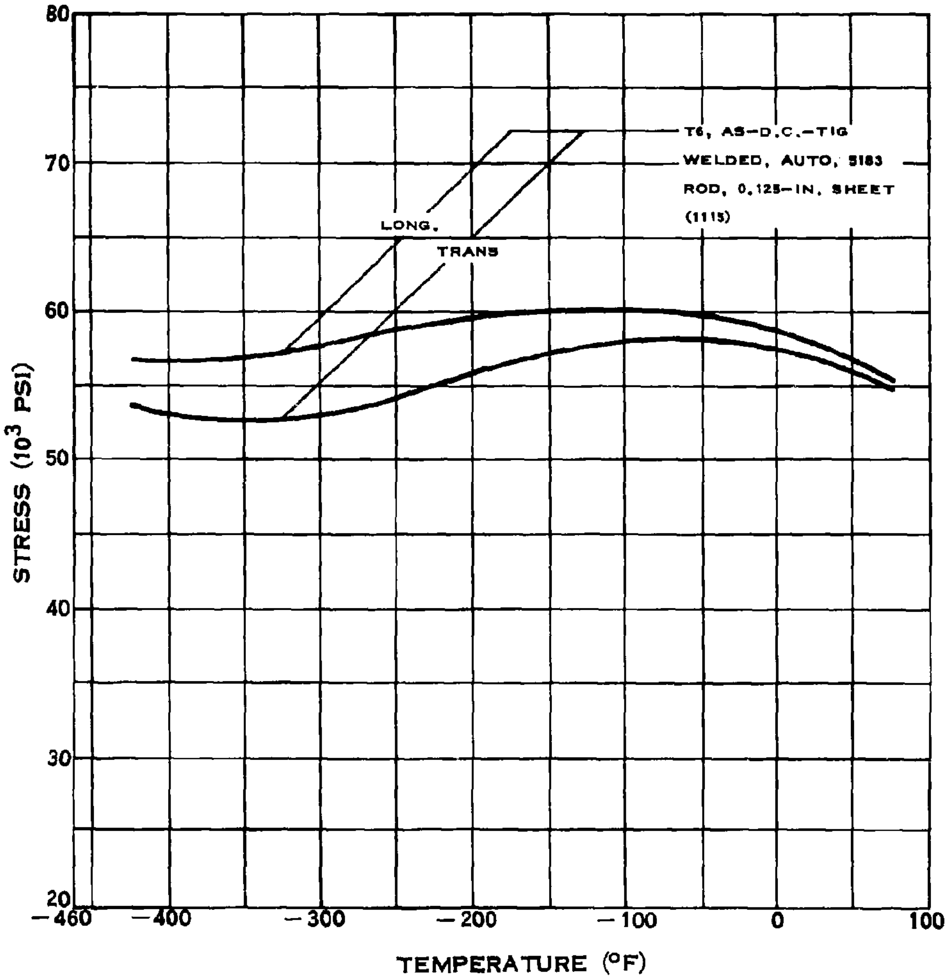
A.12.b-2



NOTCH STRENGTH RATIO OF 7039 ALUMINUM

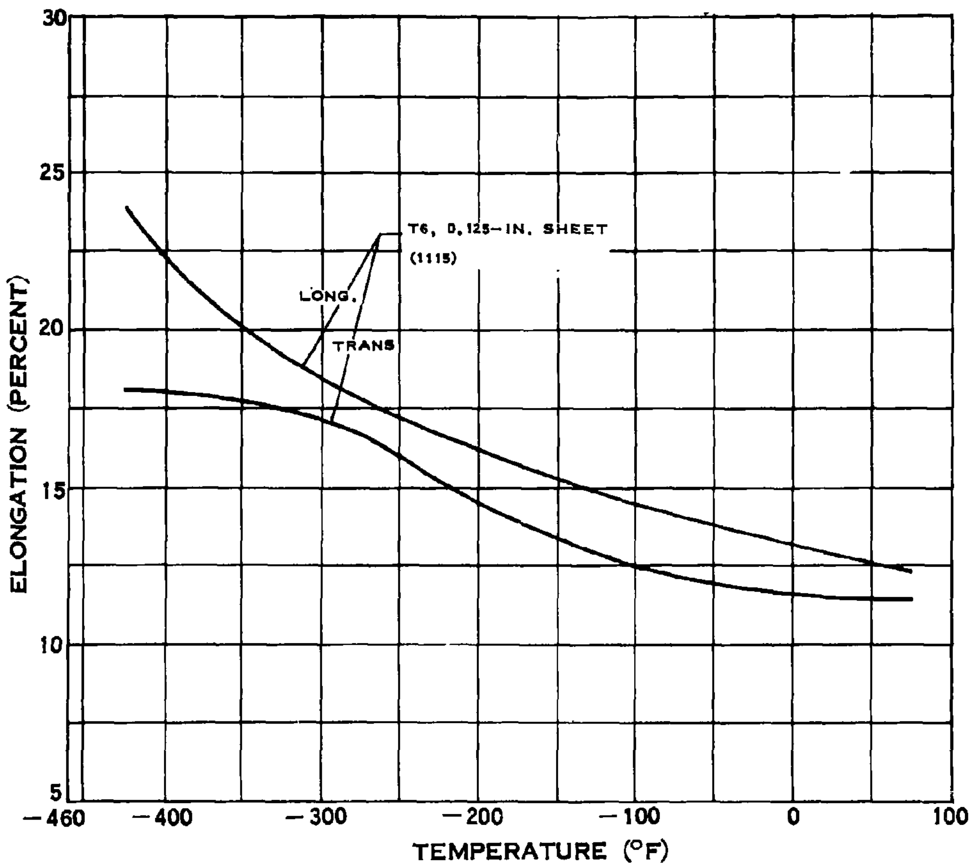
1–15–64

A.12.b-3



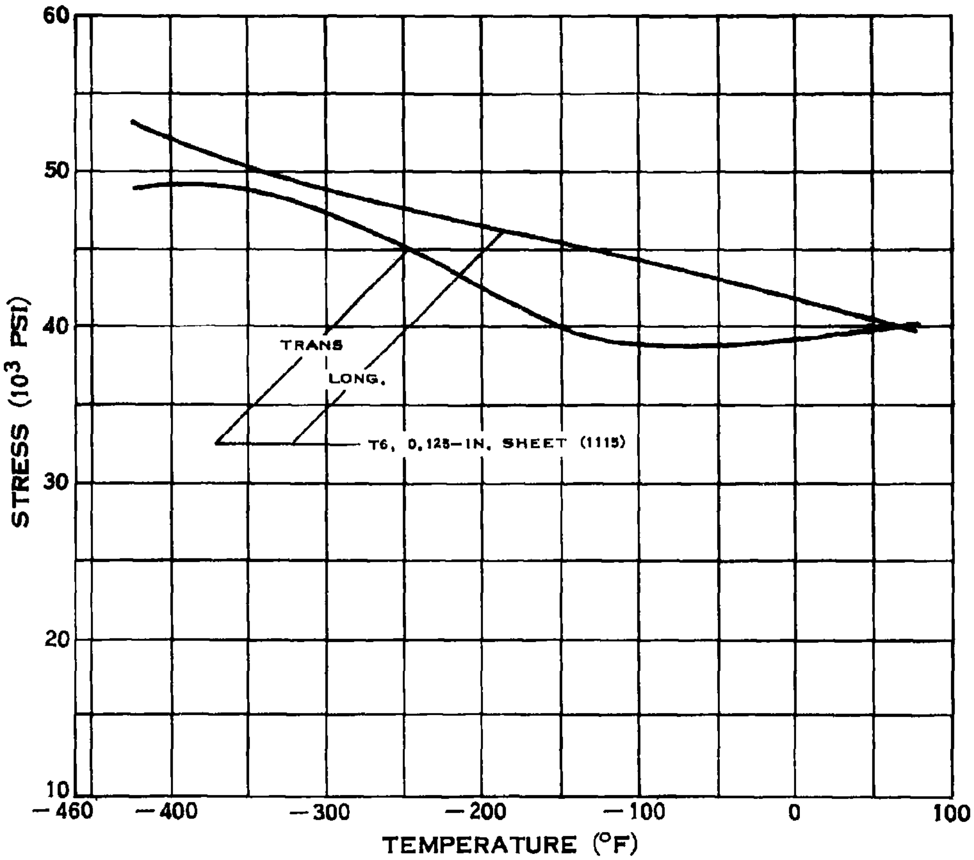
WELD TENSILE STRENGTH OF 7039 ALUMINUM

A.12.c



ELONGATION OF 7039 ALUMINUM

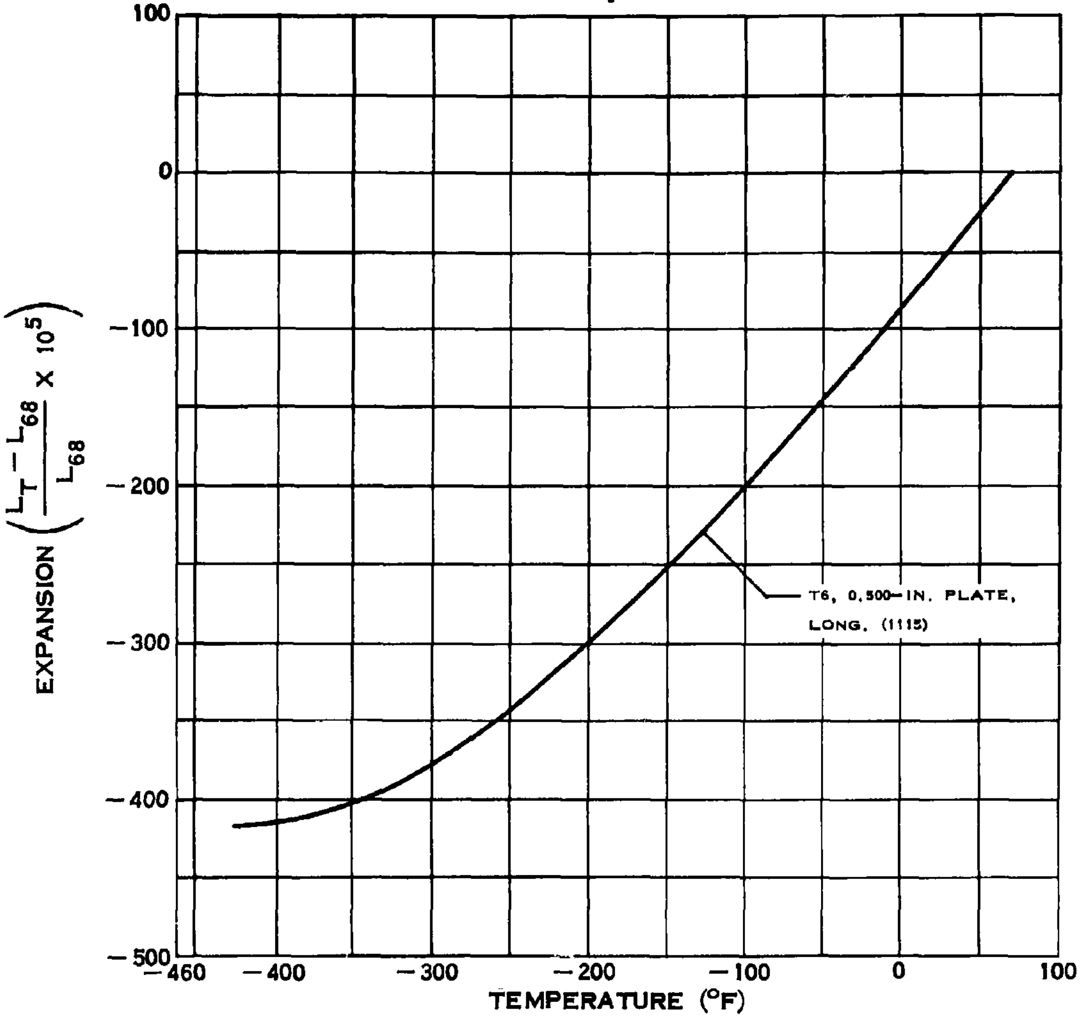
A.12.1



SHEAR STRENGTH OF 7039 ALUMINUM

1-15-64

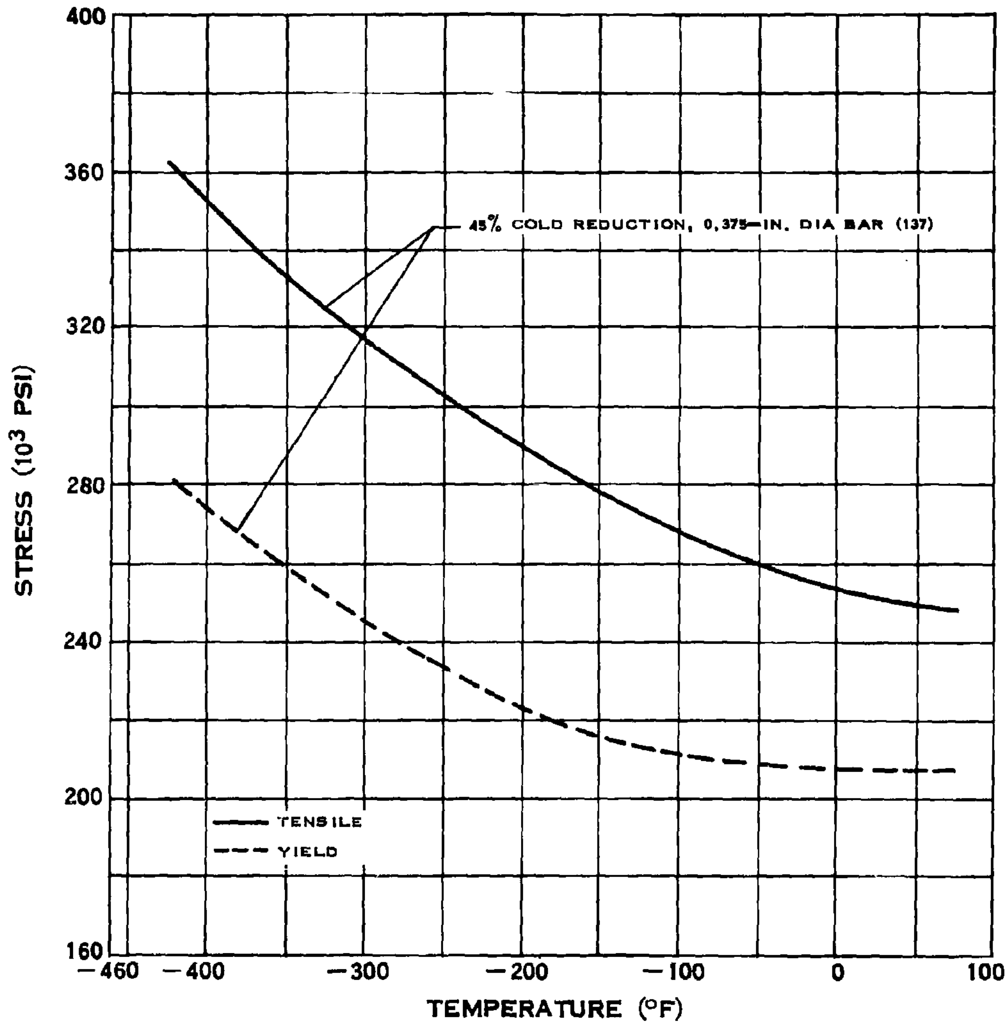
A.12.p



THERMAL EXPANSION OF 7039 ALUMINUM

1-15-64

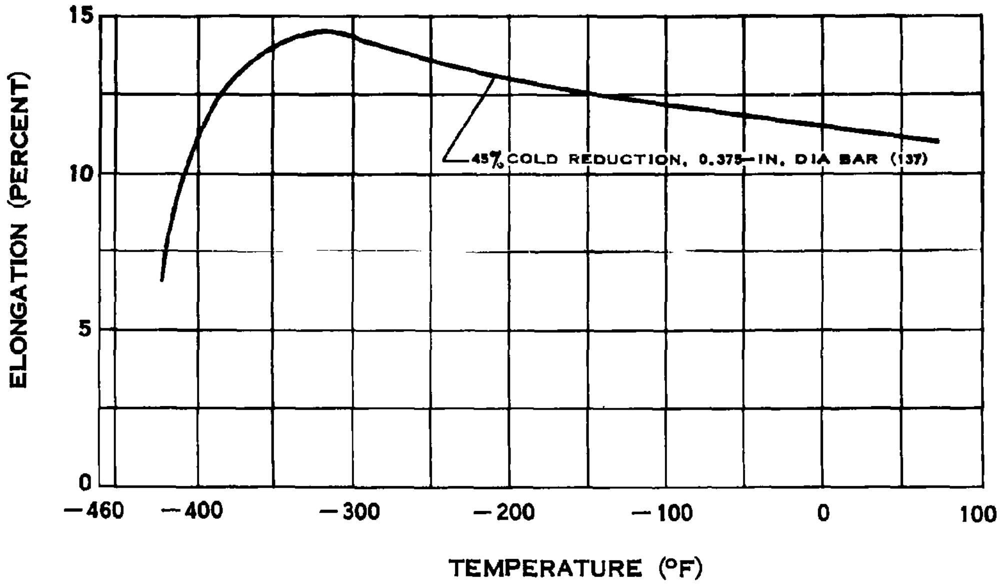
B.1.ab



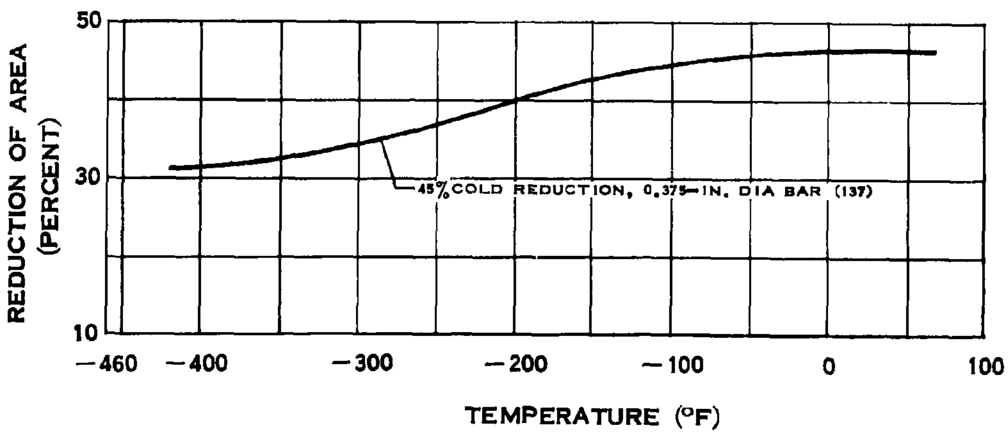
STRENGTH OF ELGILOY

1-15-64

B.1.cd

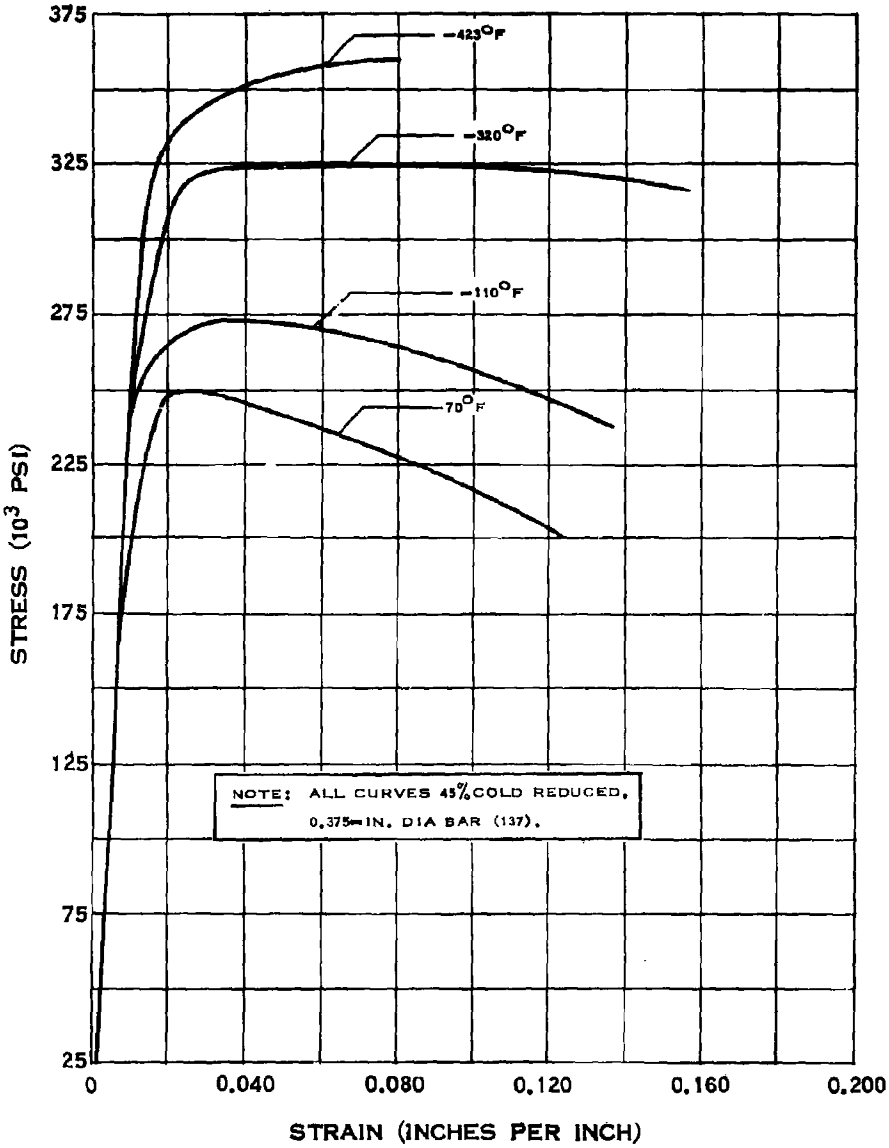


ELONGATION OF ELGILOY



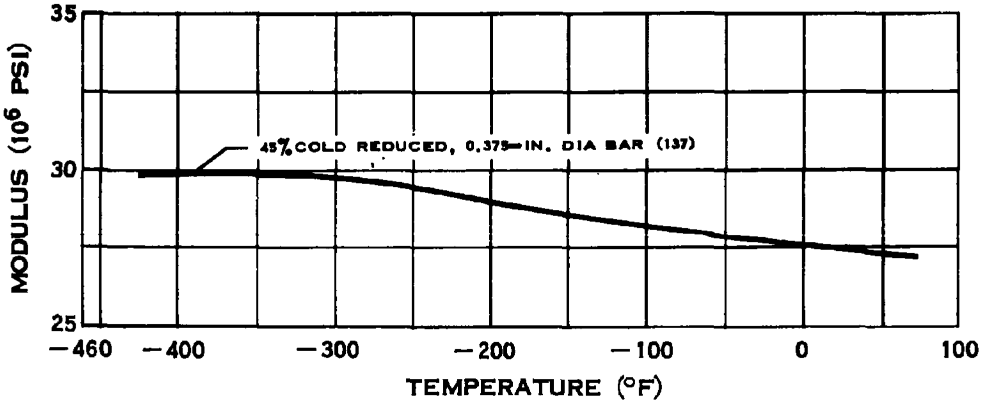
REDUCTION OF AREA OF ELGILOY

B.1.e

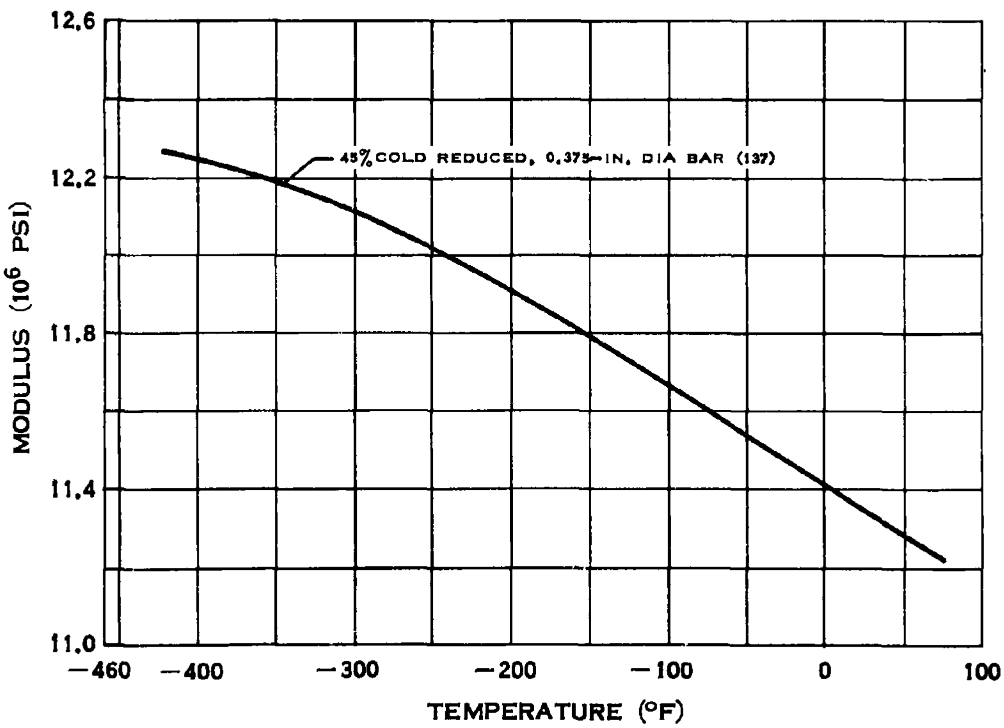


STRESS-STRAIN DIAGRAM FOR ELGILOY

B.1.fm



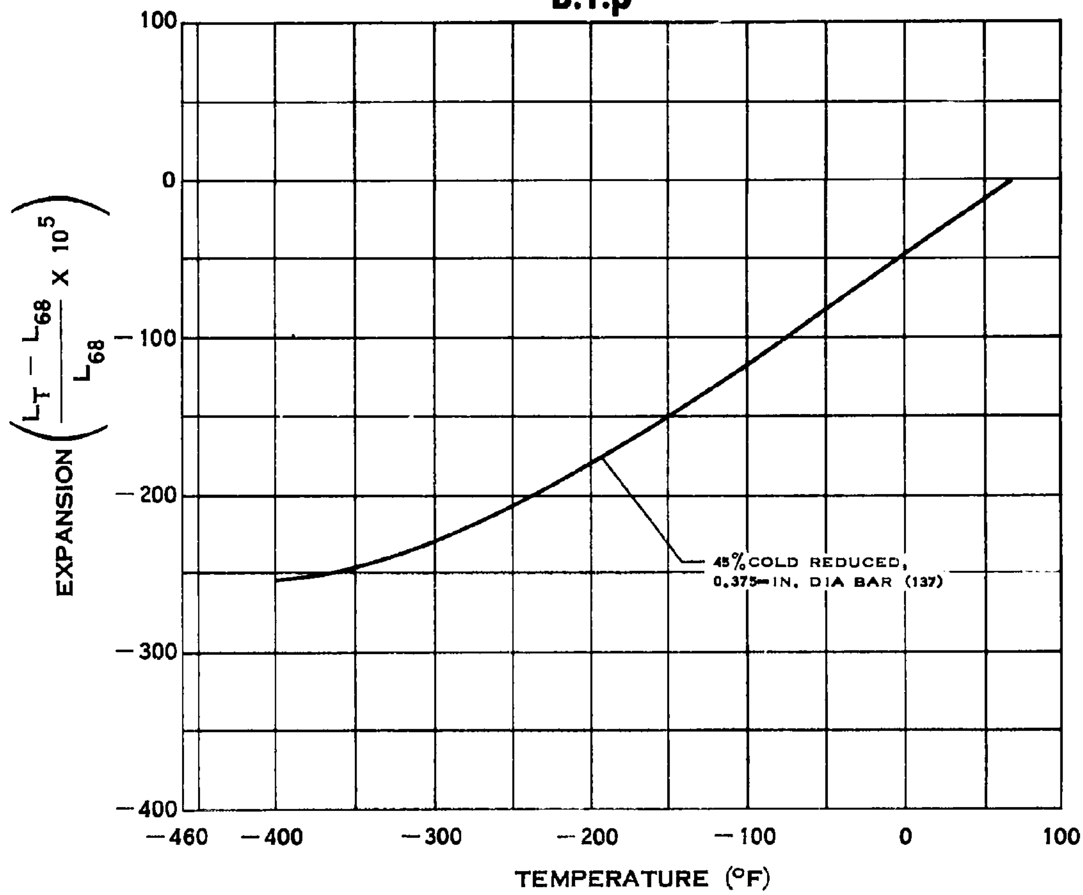
MODULUS OF ELASTICITY OF ELGILOY



MODULUS OF RIGIDITY OF ELGILOY

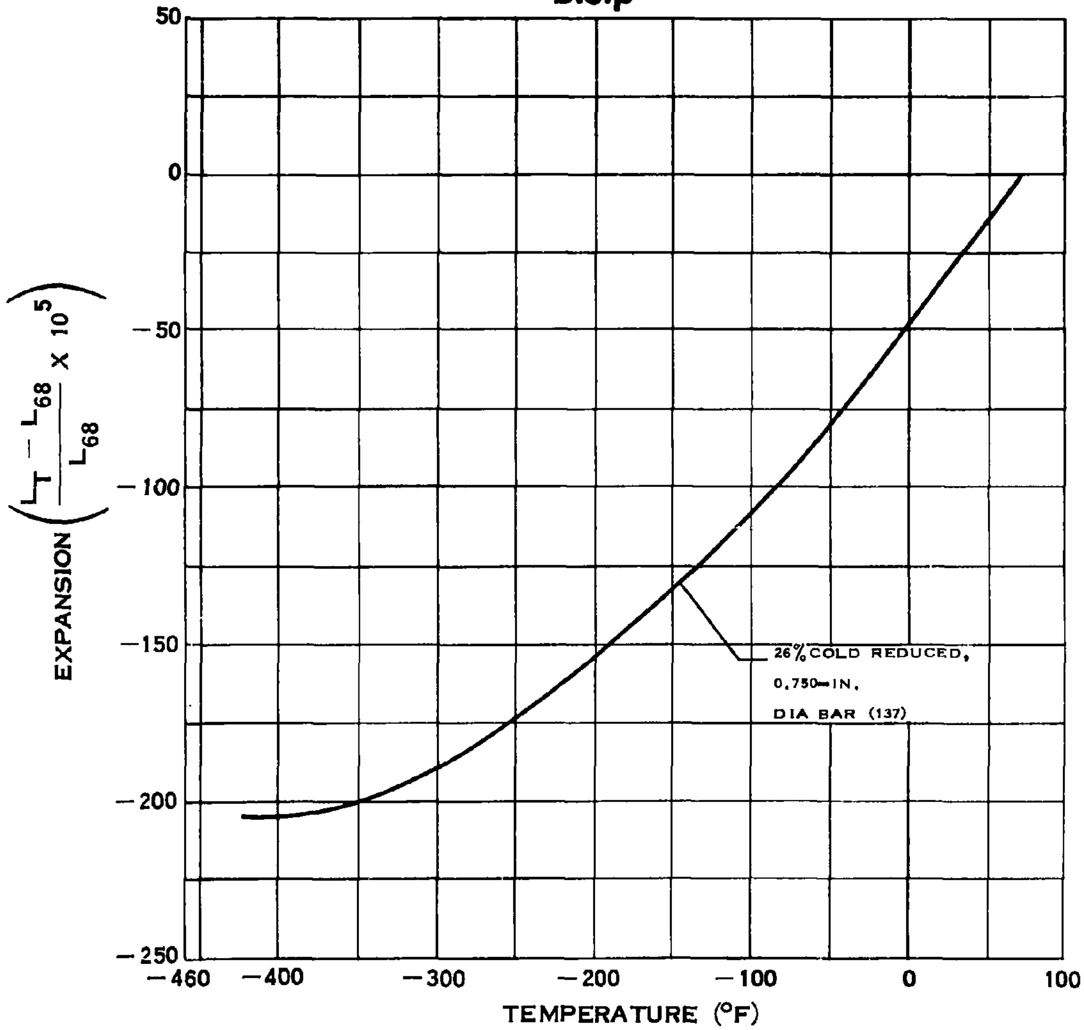
1-15-64

B.1.p



THERMAL EXPANSION OF ELGILOY

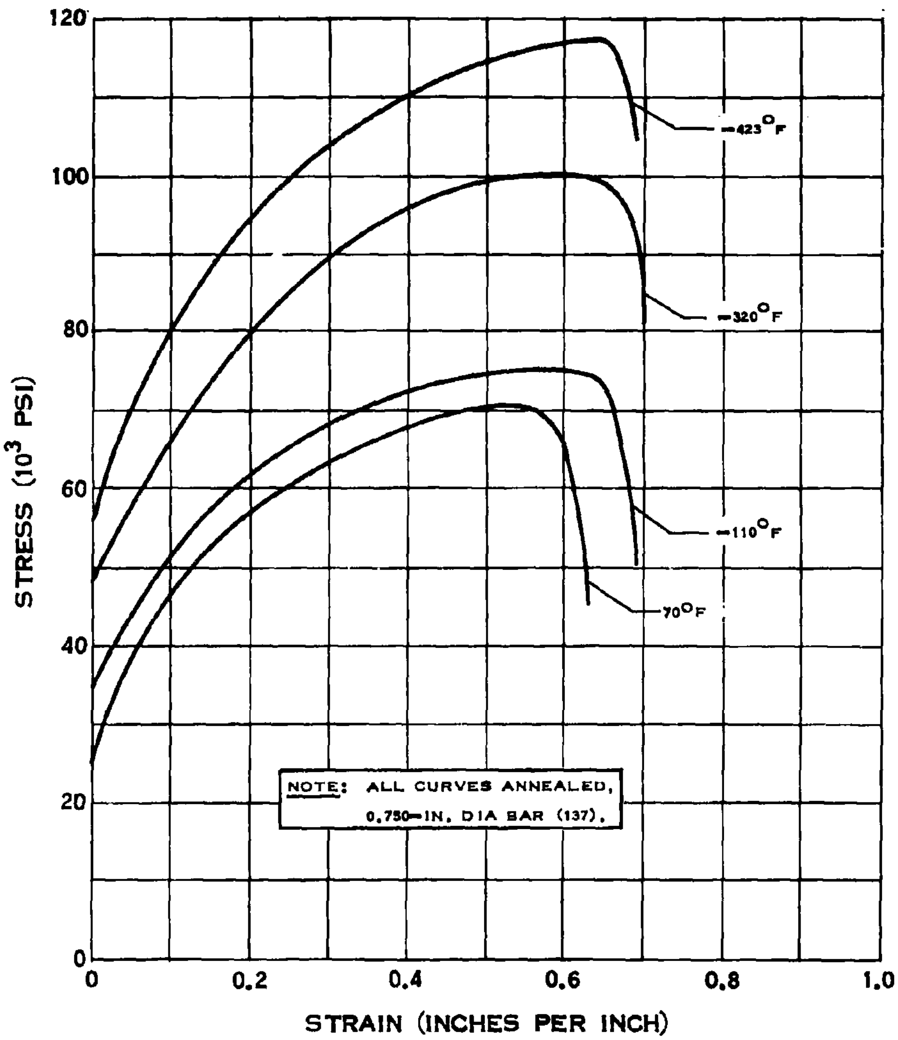
B.3.p



THERMAL EXPANSION OF L-605

1-15-64

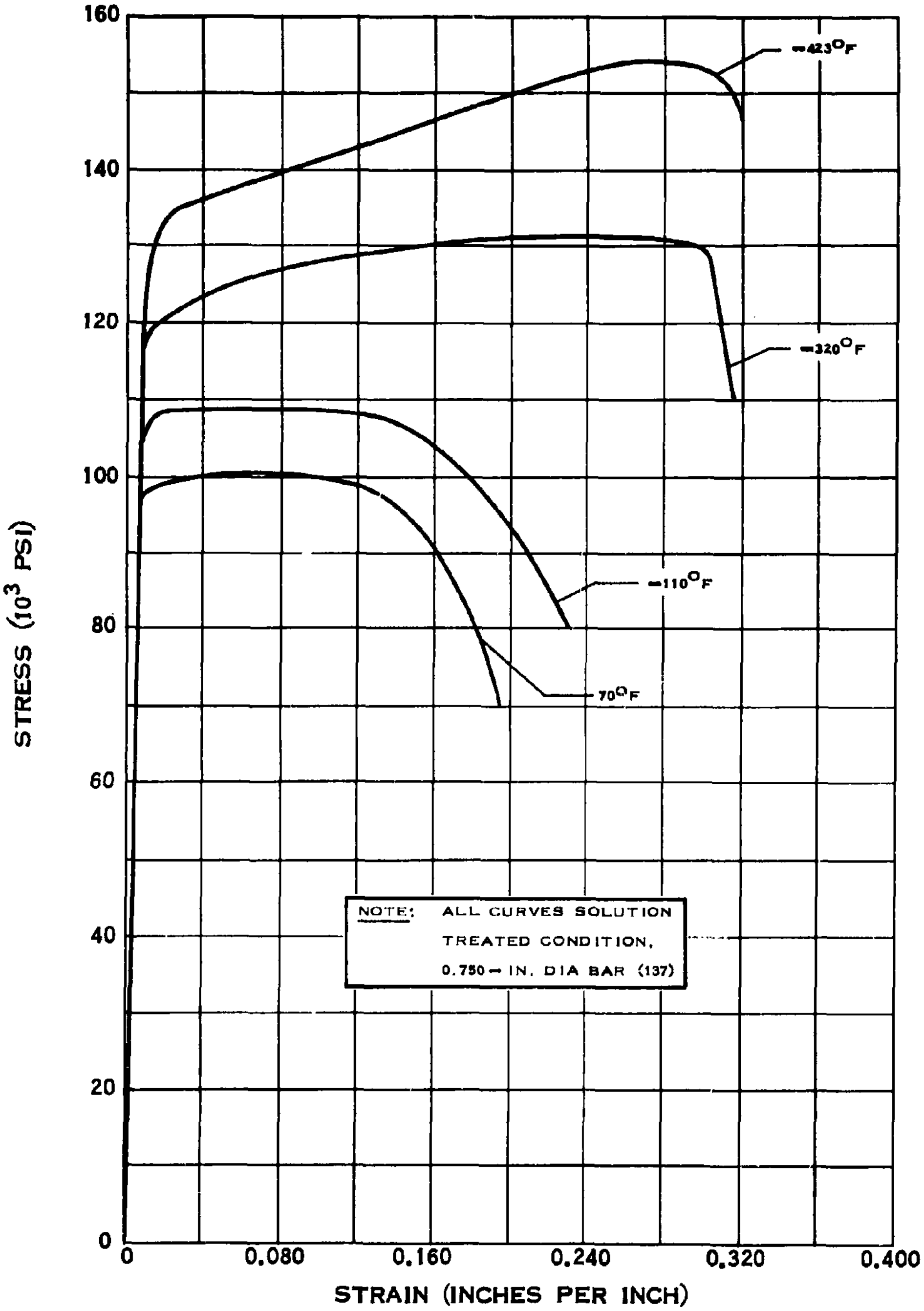
C.1.e



STRESS-STRAIN DIAGRAM FOR BERYLLIUM COPPER

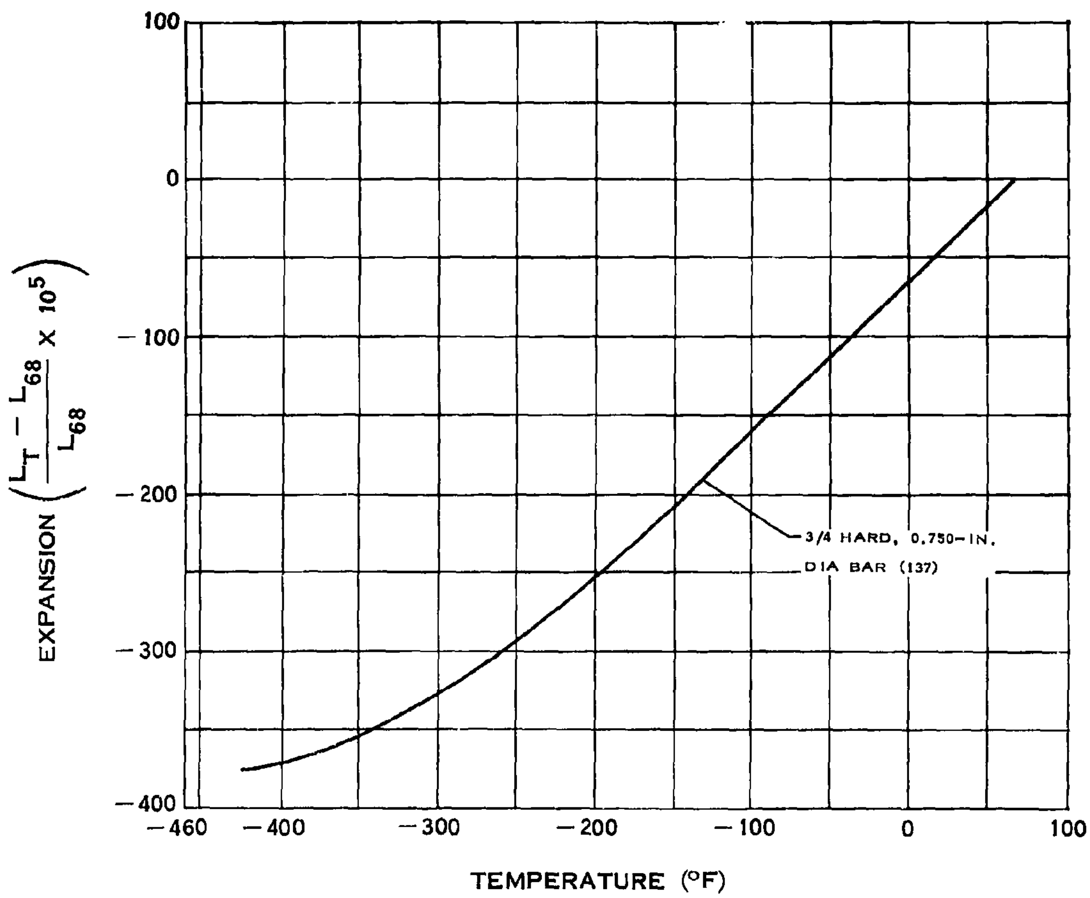
1−15−164

C.1.e-1



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

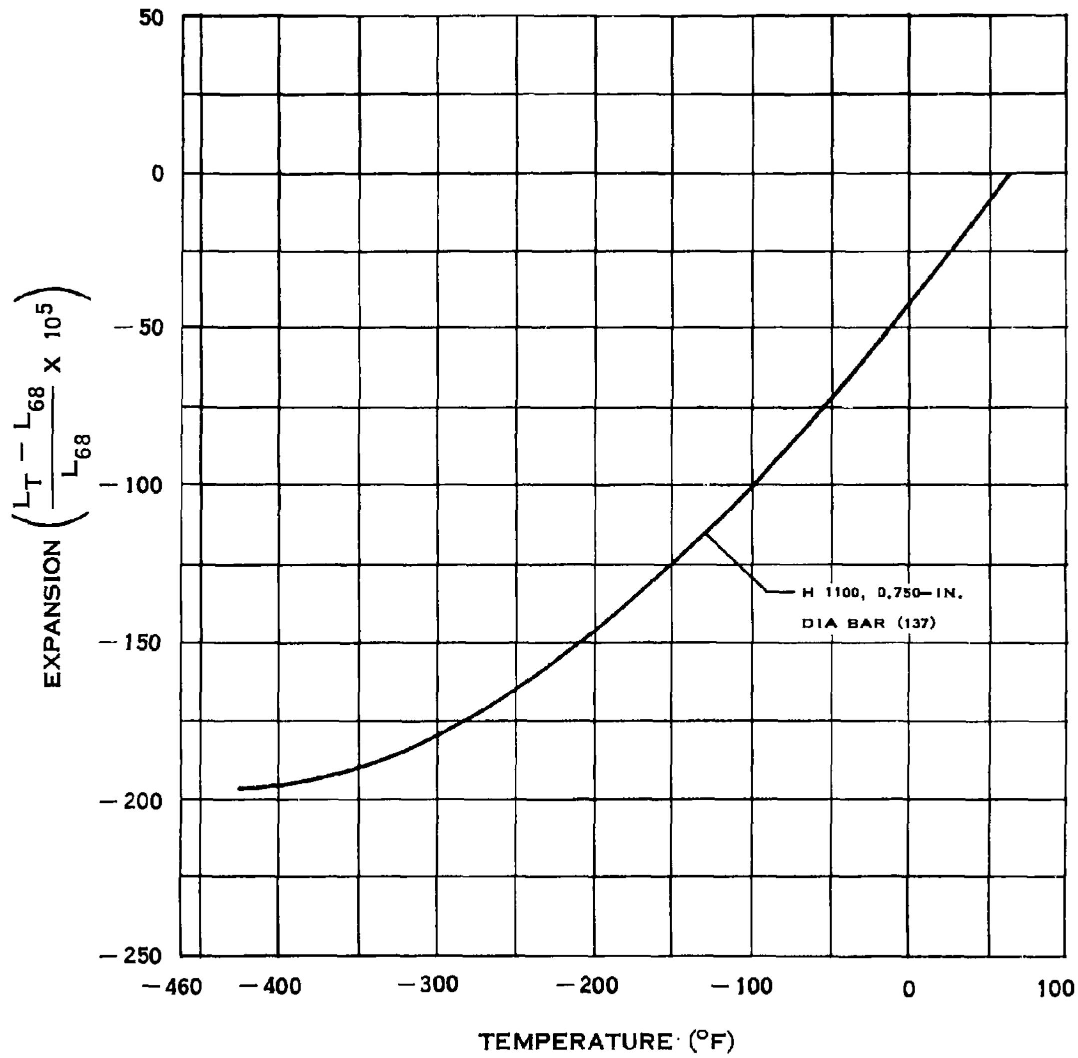
C.2.p



THERMAL EXPANSION OF 70/30 BRASS

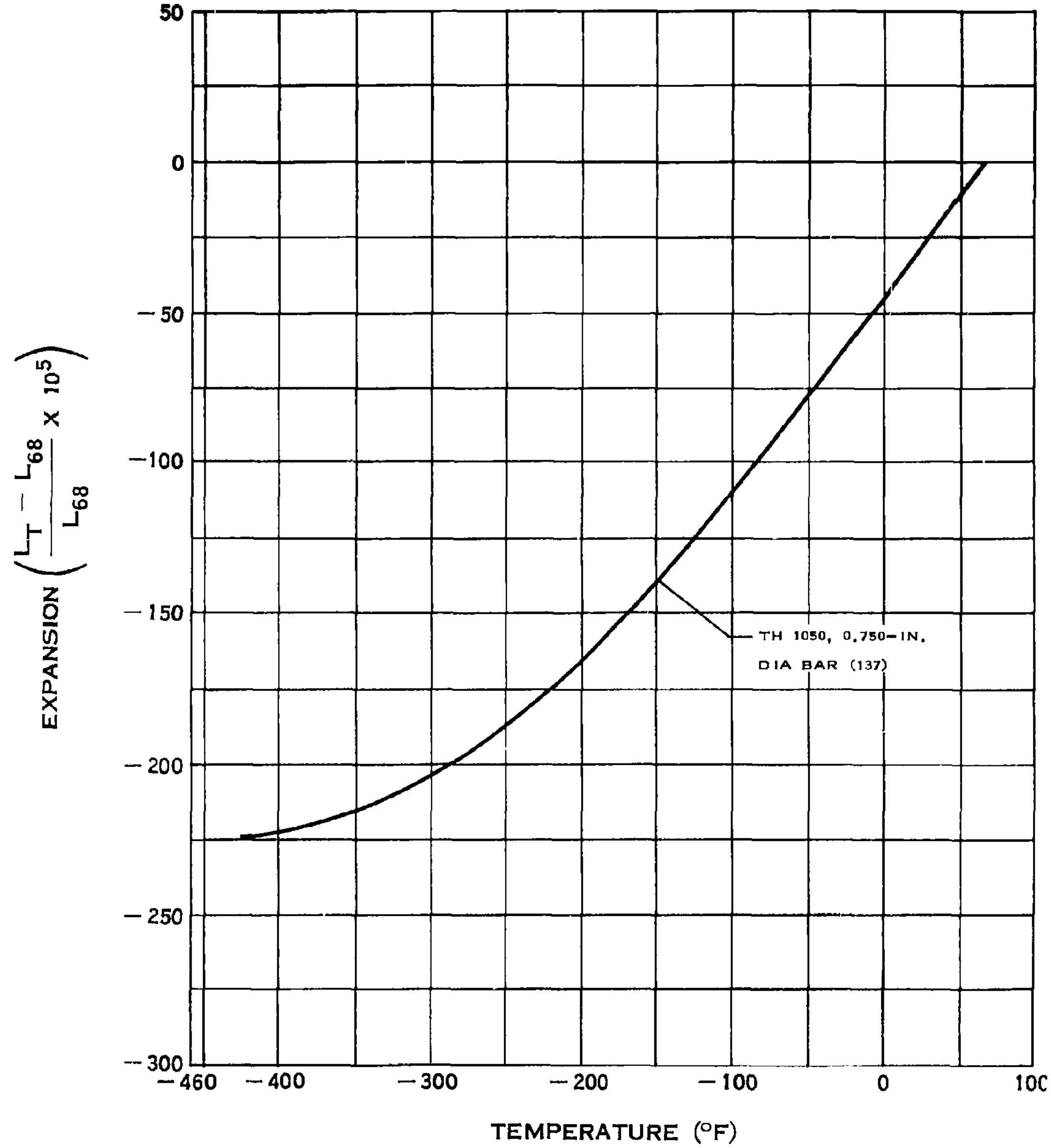
(1-15-64)

D.5.p



THERMAL EXPANSION OF 17-4 PH STAINLESS STEEL

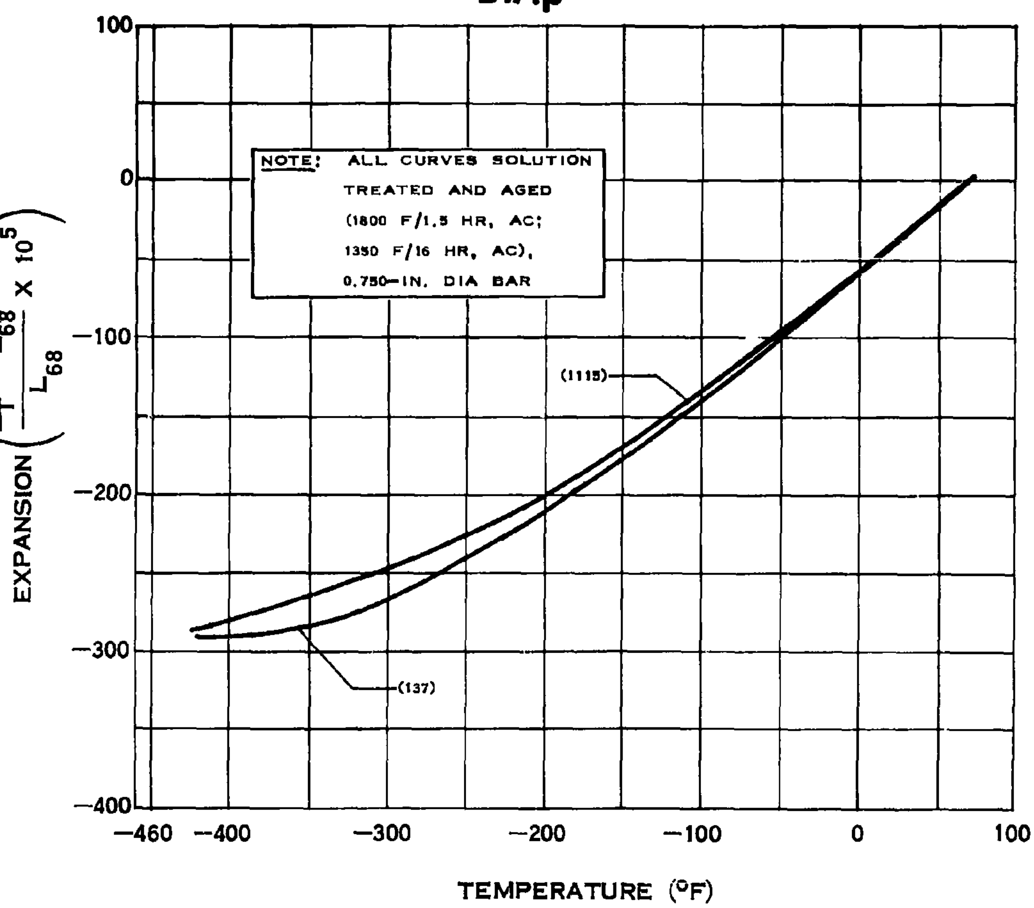
1-15-64



THERMAL EXPANSION OF 17-7PH STAINLESS STEEL

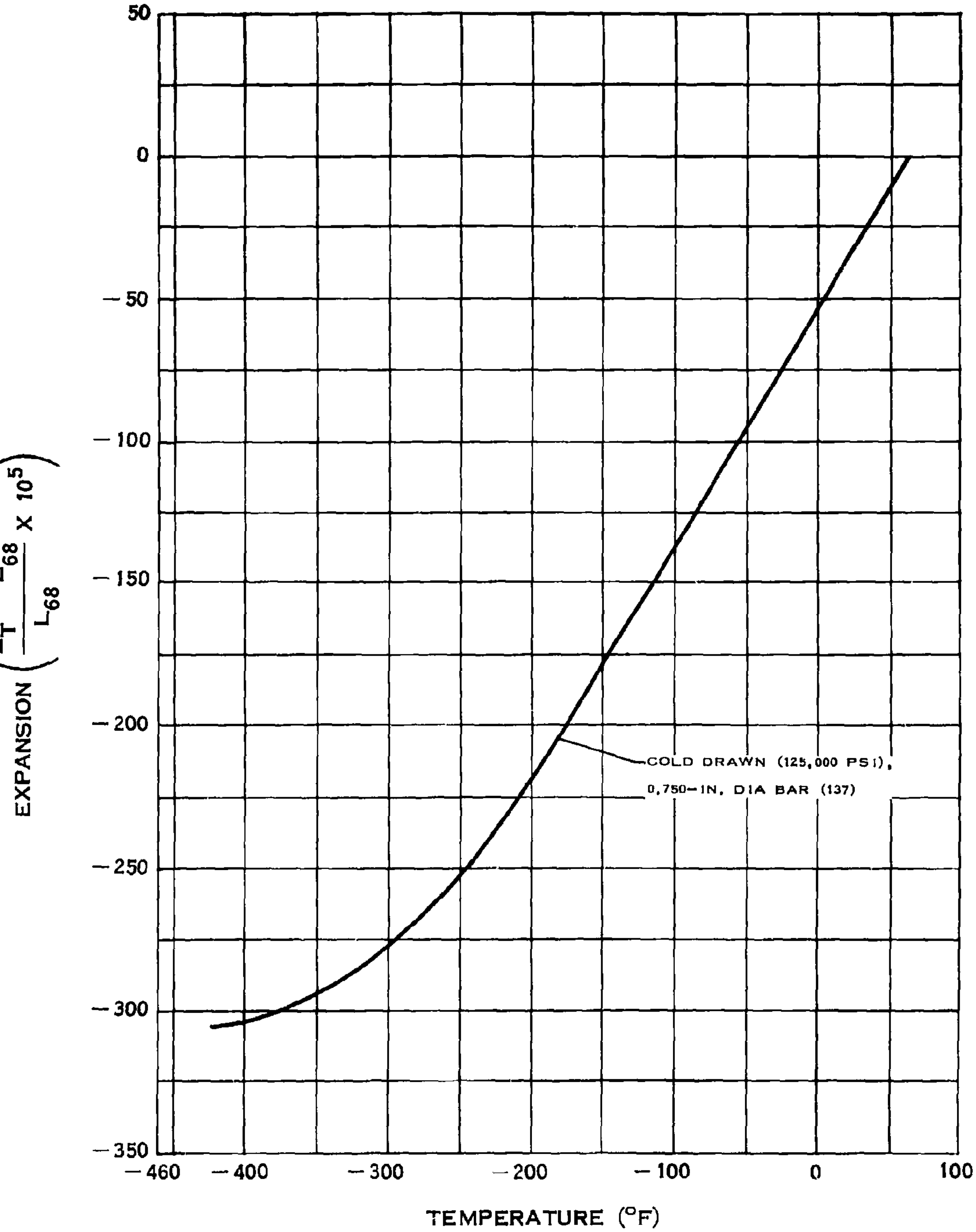
(1-15-64)

D.7.p



THERMAL EXPANSION OF A-286 STAINLESS STEEL

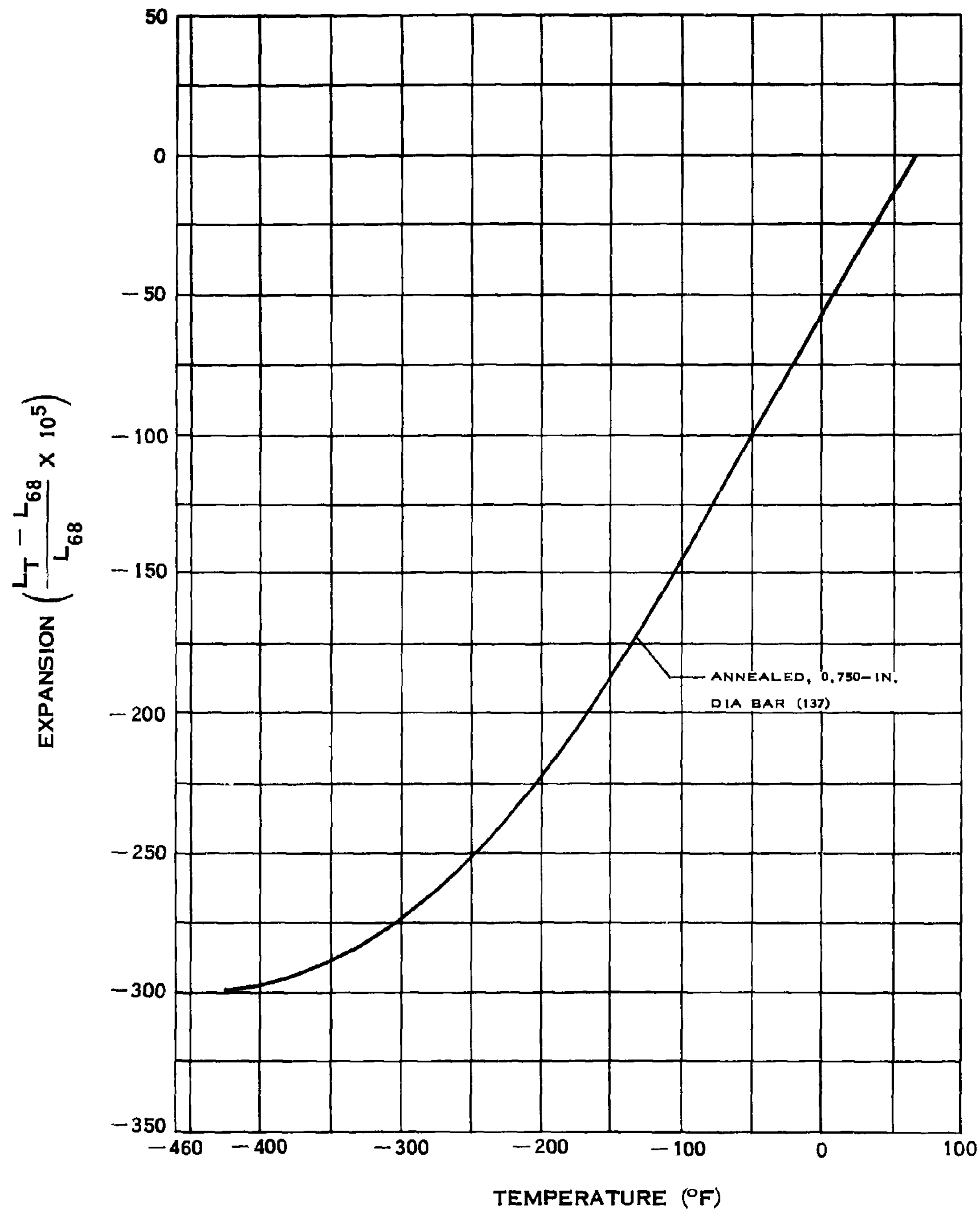
(1-15-64)



THERMAL EXPANSION OF 302 STAINLESS STEEL

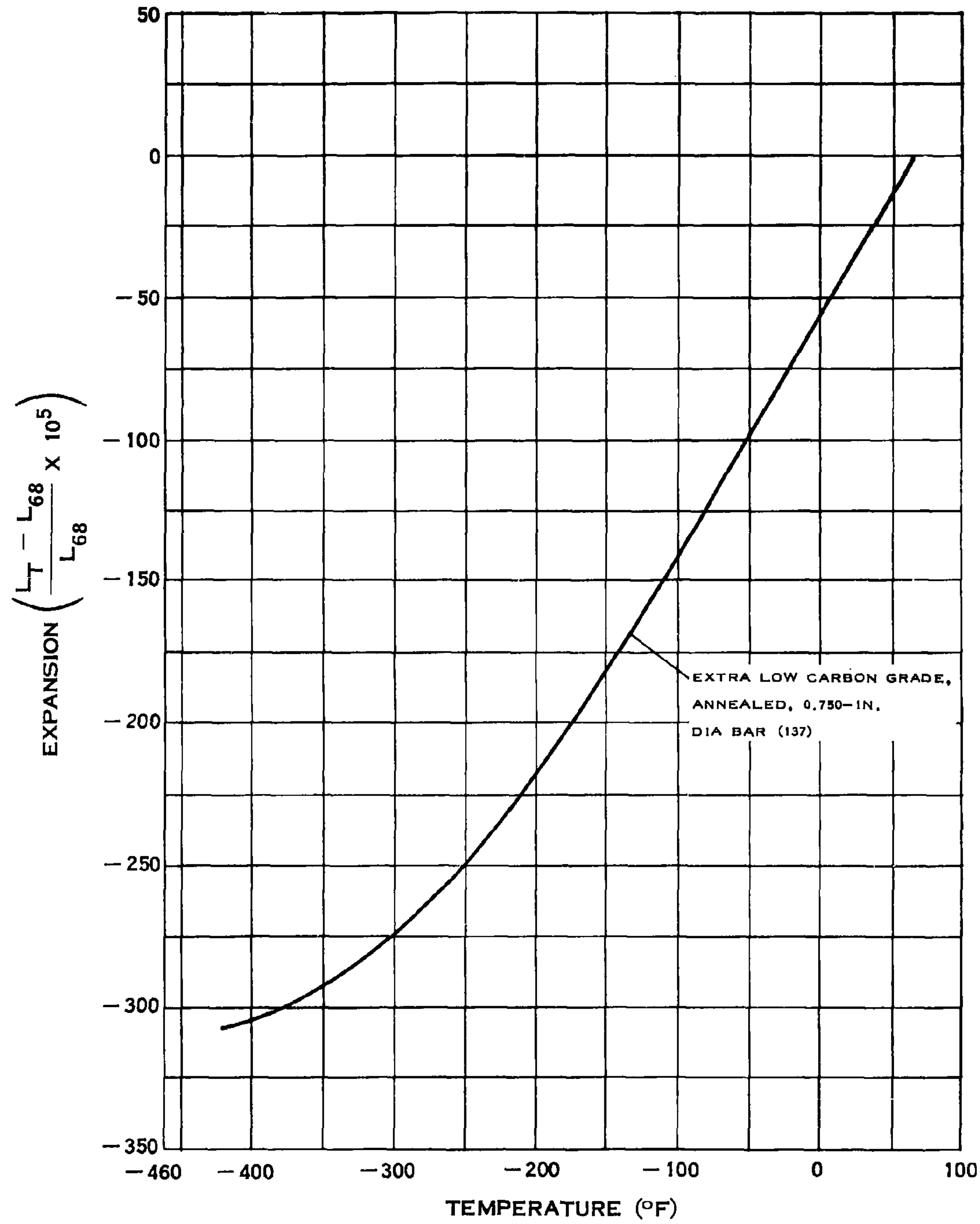
(1-15-64)

D.10.p



1-15-64

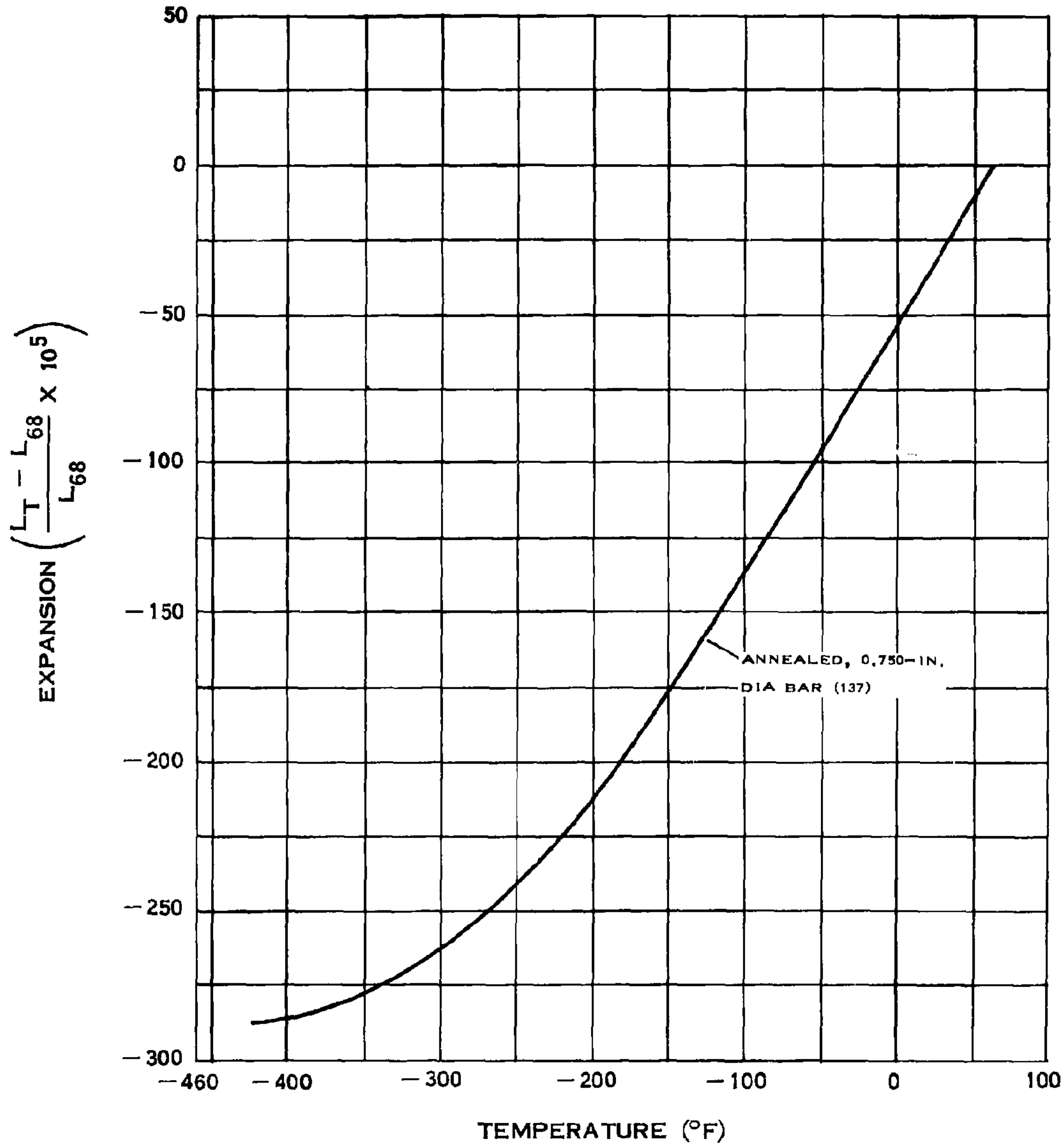
THERMAL EXPANSION OF 303 STAINLESS STEEl



(1-15-64)

THERMAL EXPANSION OF 304 STAINLESS STEEL

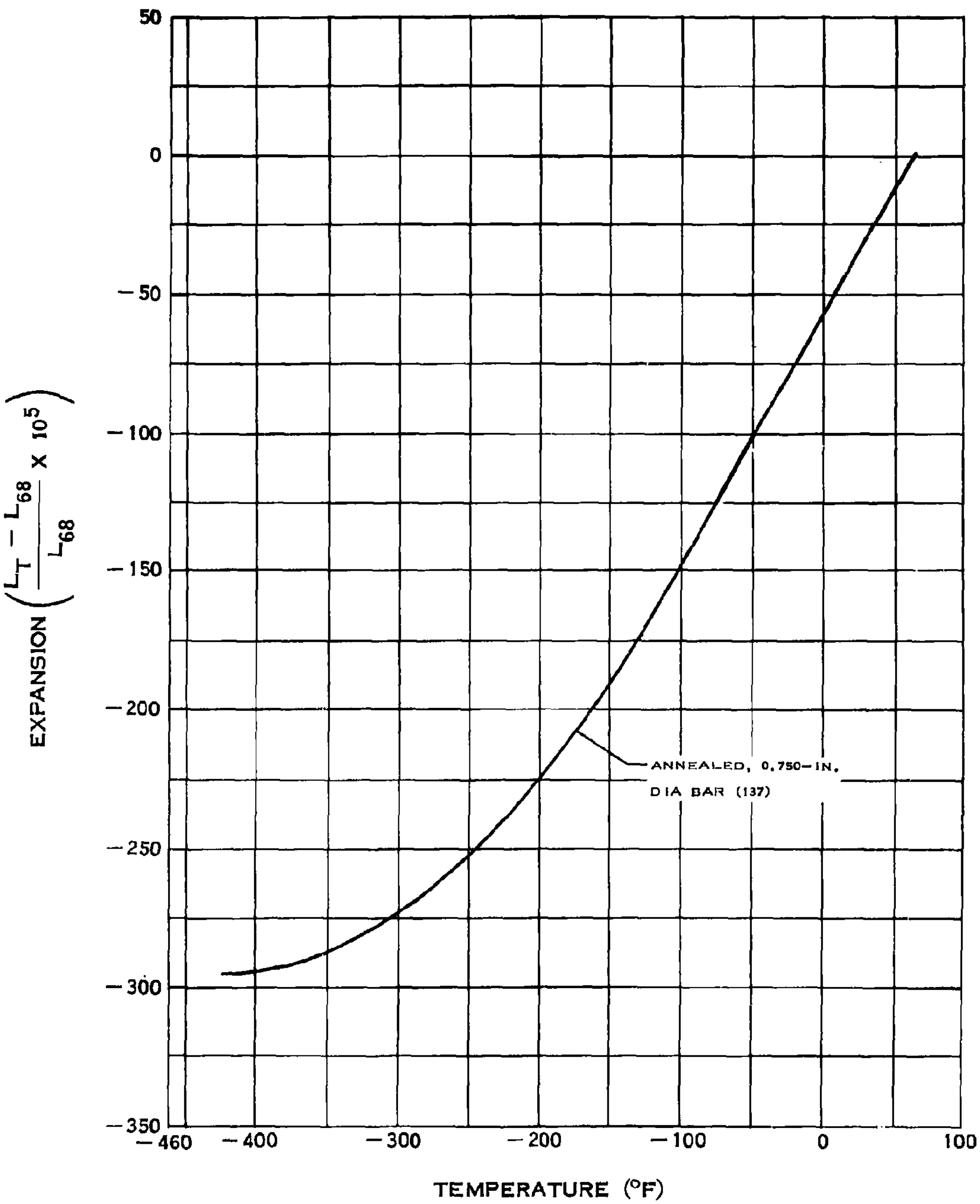
D.12.p



THERMAL EXPANSION OF 310 STAINLESS STEEL

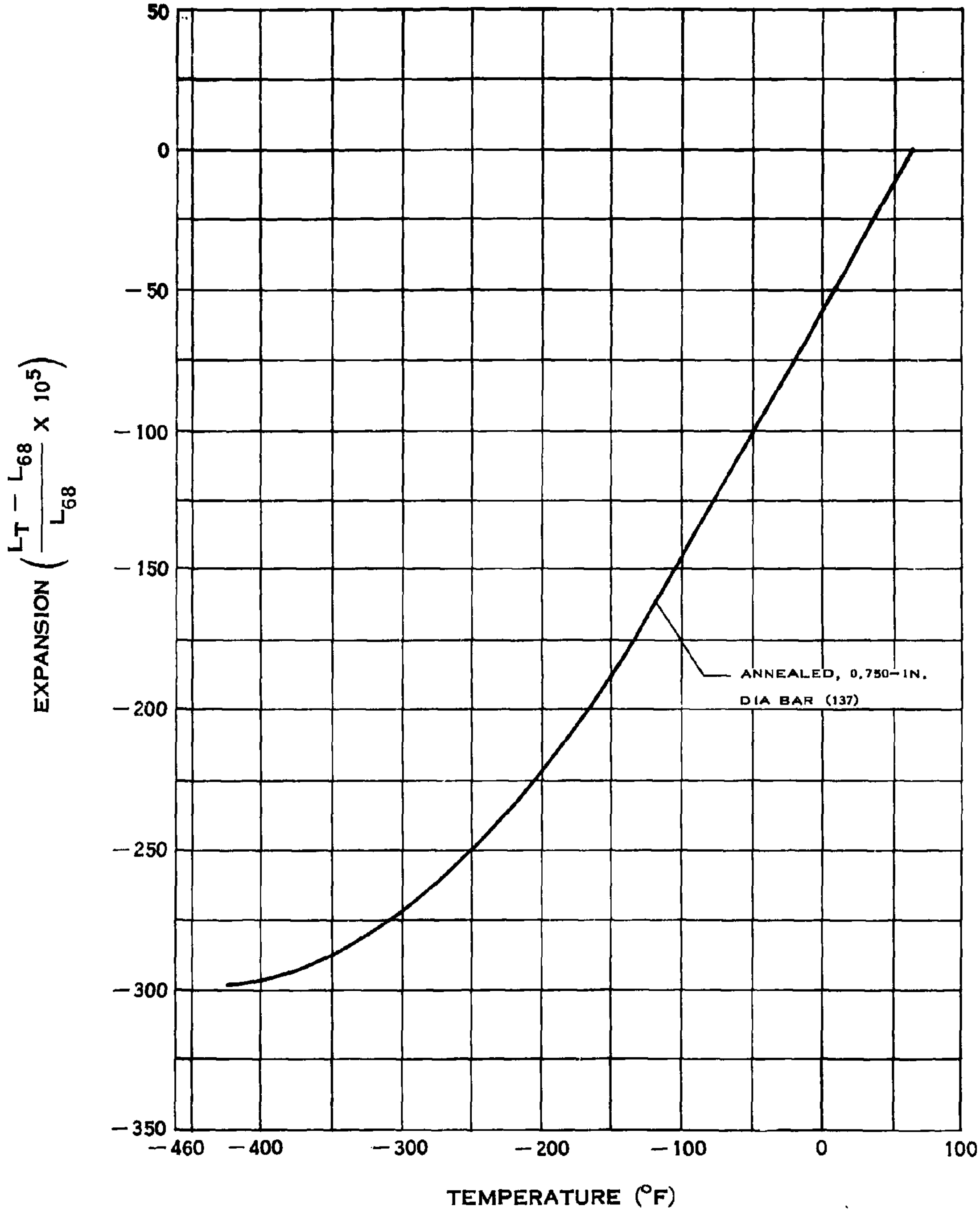
(1-15-64)

D.13.p



THERMAL EXPANSION OF 321 STAINLESS STEEL

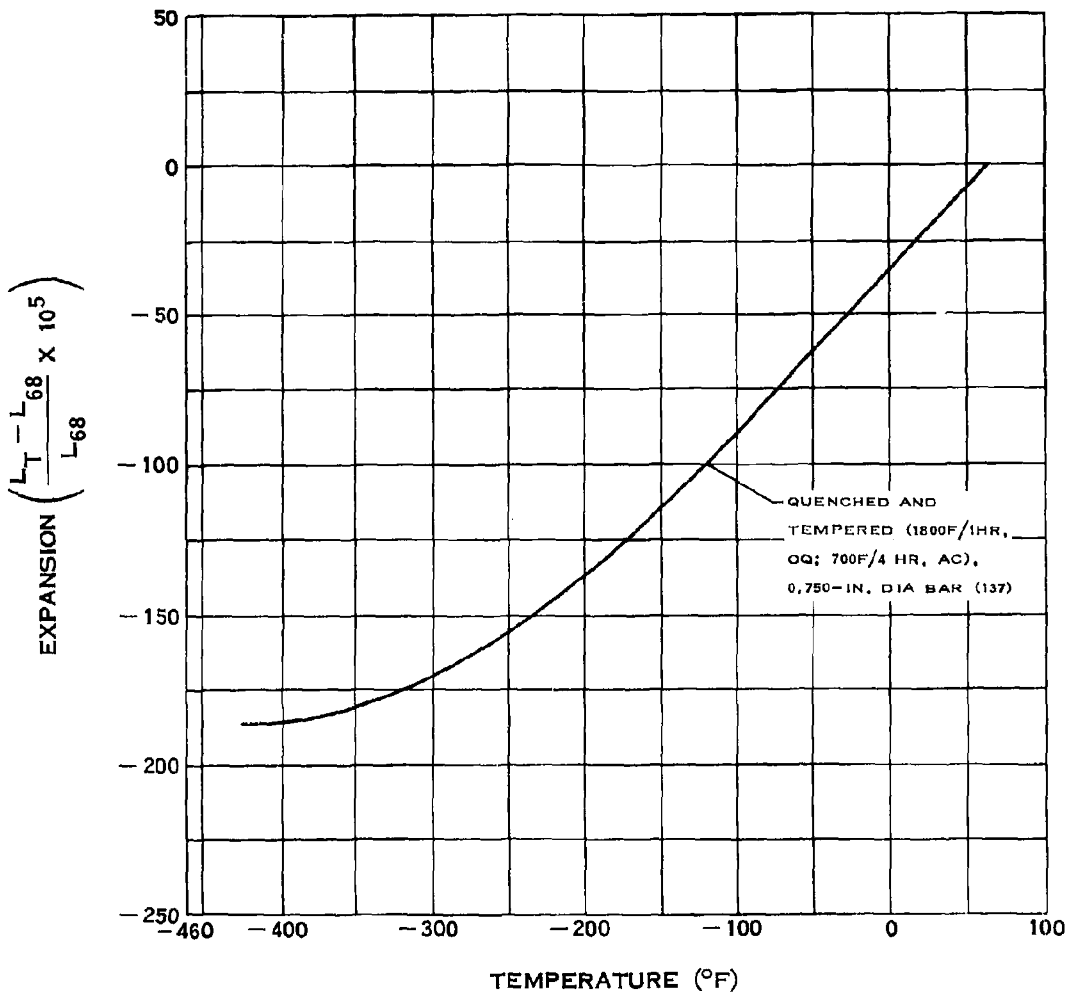
(1-15-64)



THERMAL EXPANSION OF 347 STAINLESS STEEL

1-15-64

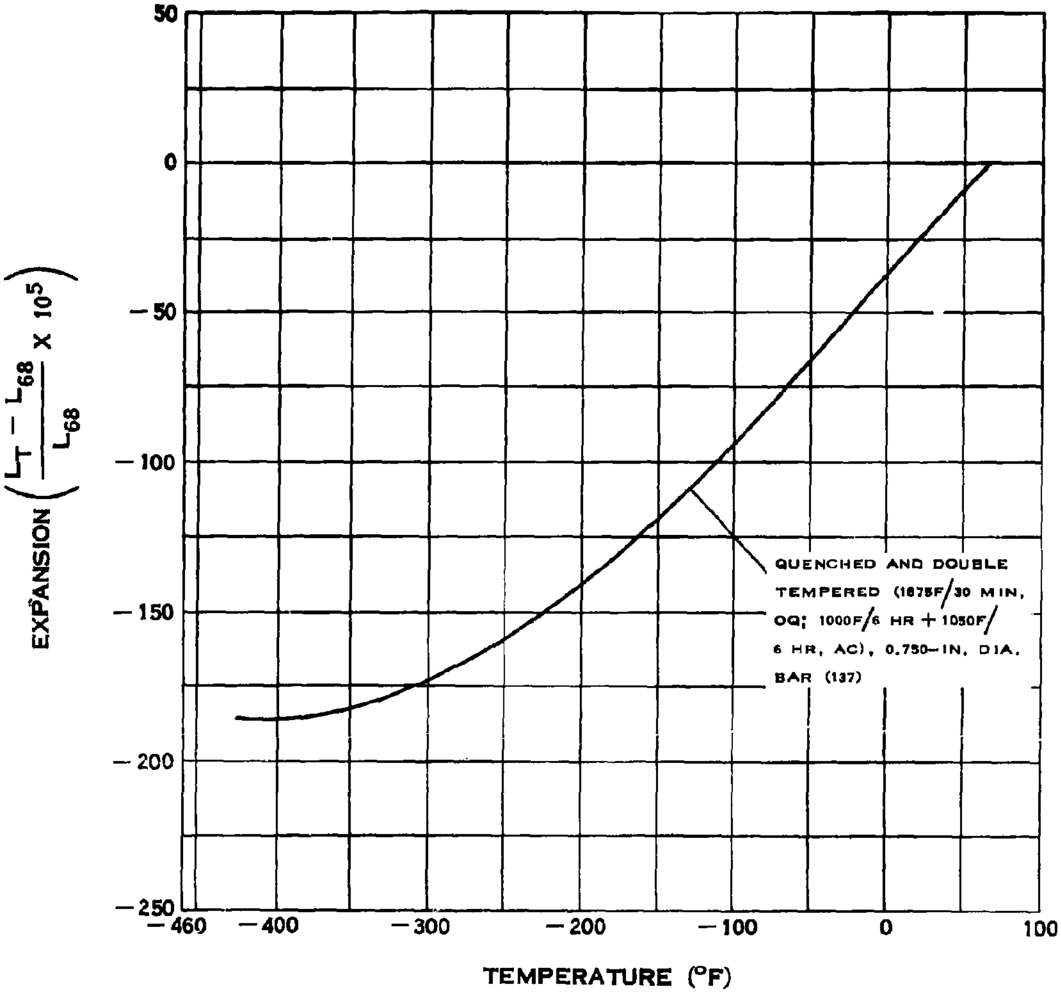
D.16.p



THERMAL EXPANSION OF 416 STAINLESS STEEL

(1-15-64)

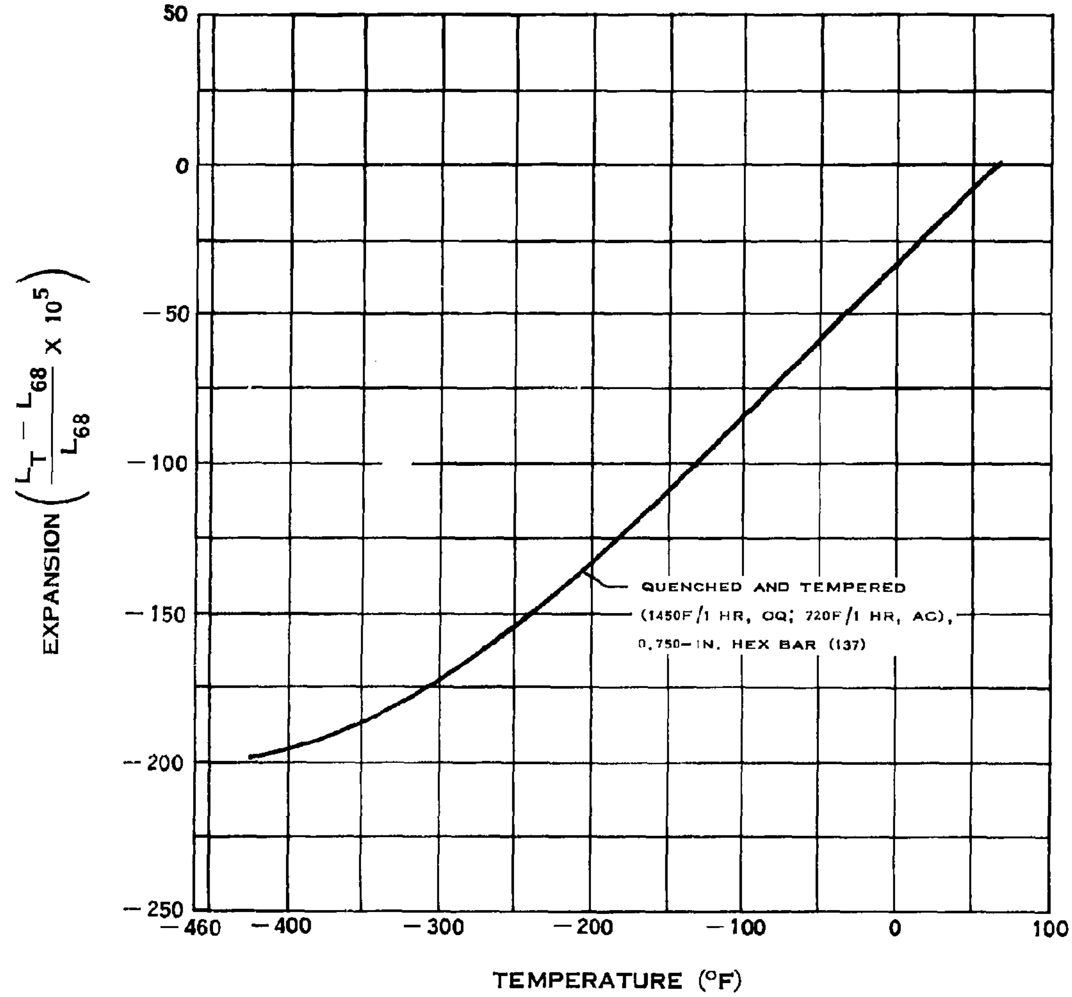
D.17.p



THERMAL EXPANSION OF 440C STAINLESS STEEL

(1-15-64)

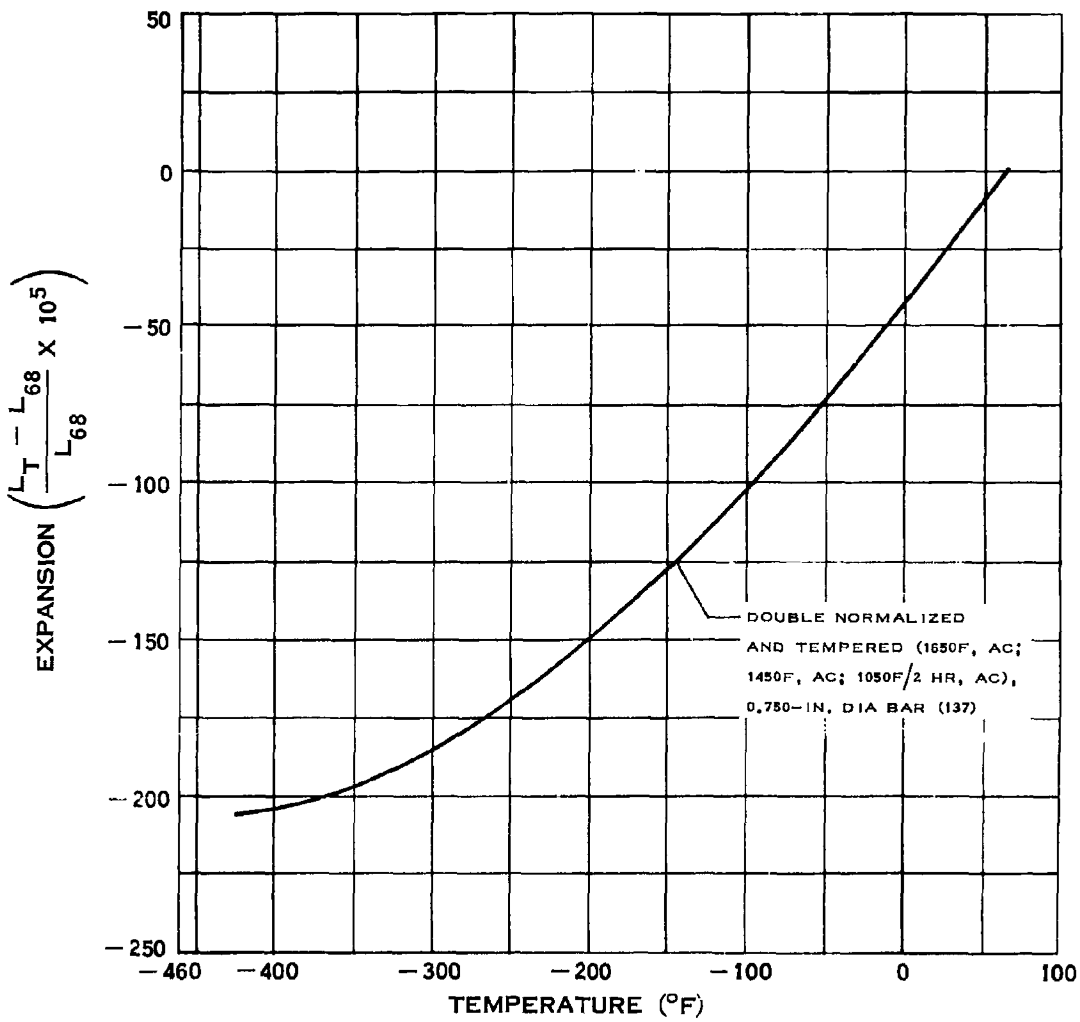
D.18.p



THERMAL EXPANSION OF 1075 STEEL

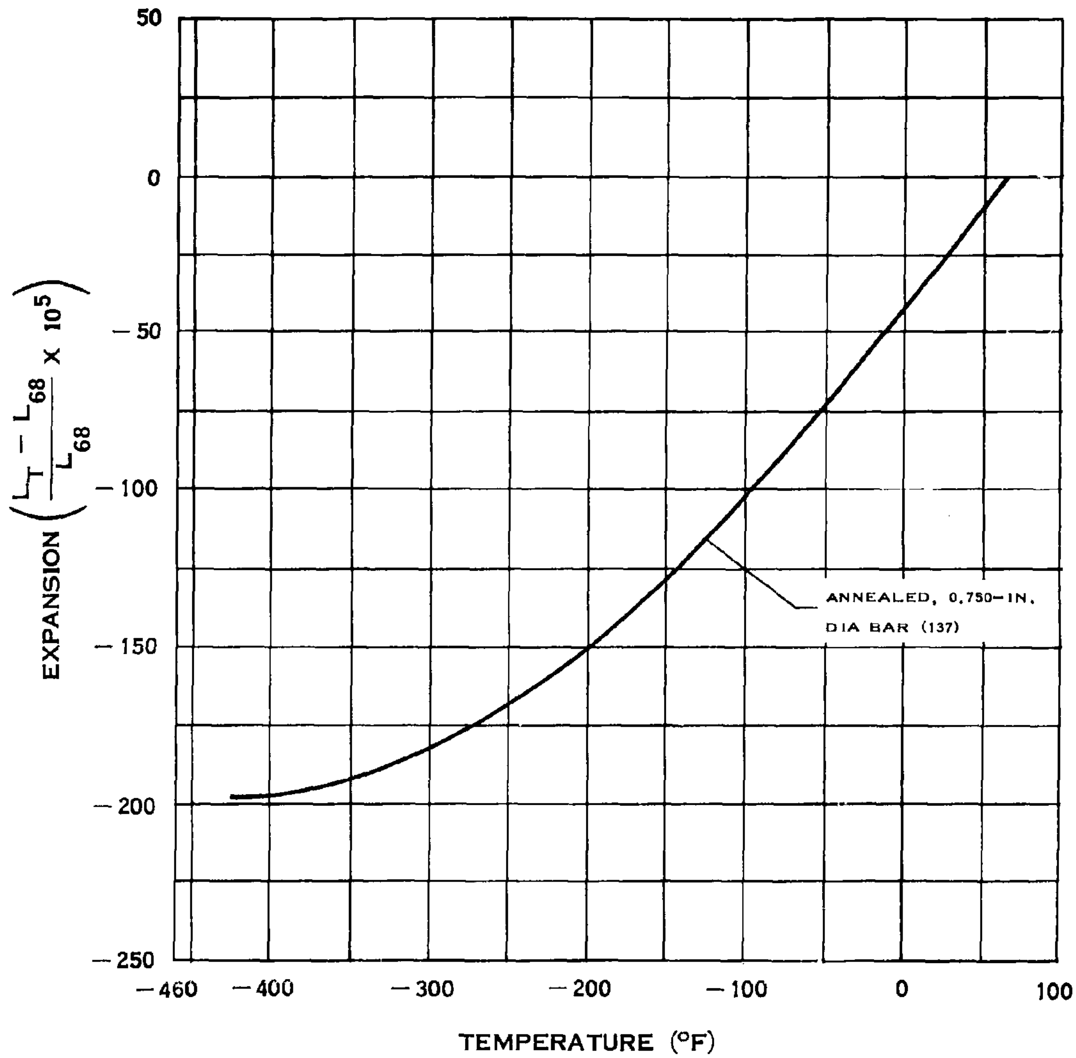
(1-15-64)

D.19.p



THERMAL EXPANSION OF 2800
(9% NICKEL) STEEL

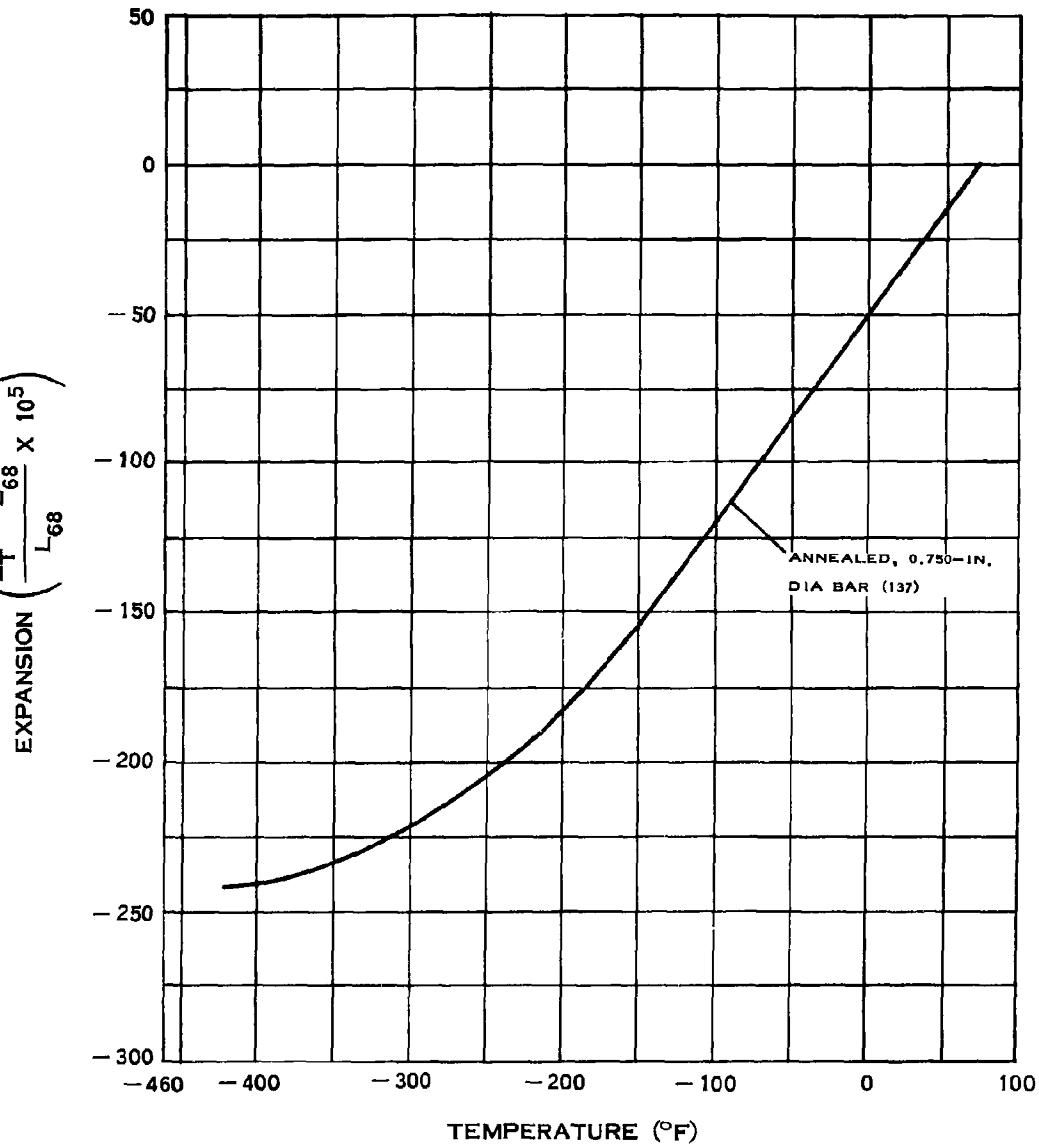
1-15-64



THERMAL EXPANSION OF 4340 STEEL

1-15-64

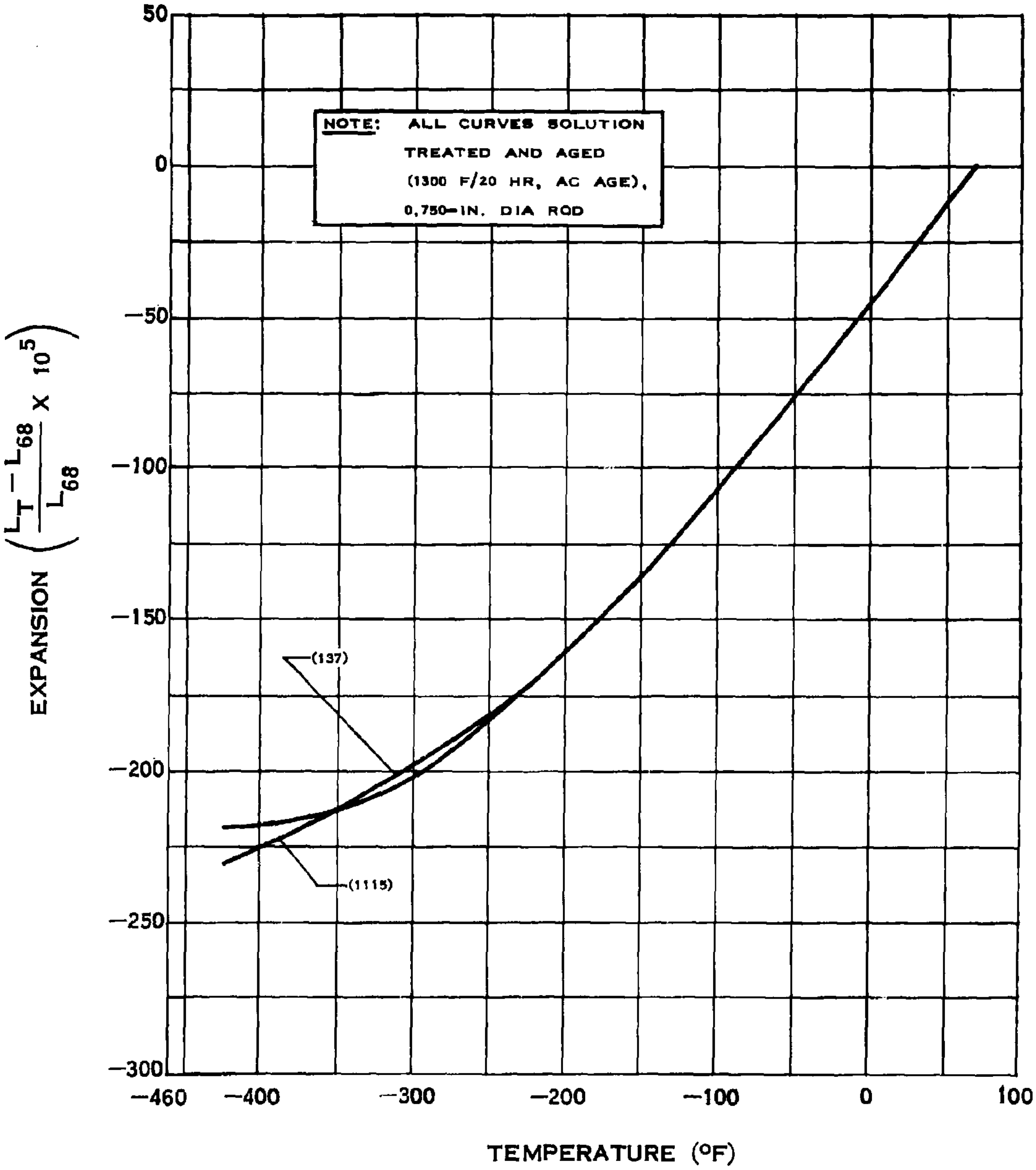
E.1.p



THERMAL EXPANSION OF INCONEL NICKEL

(1-15-64)

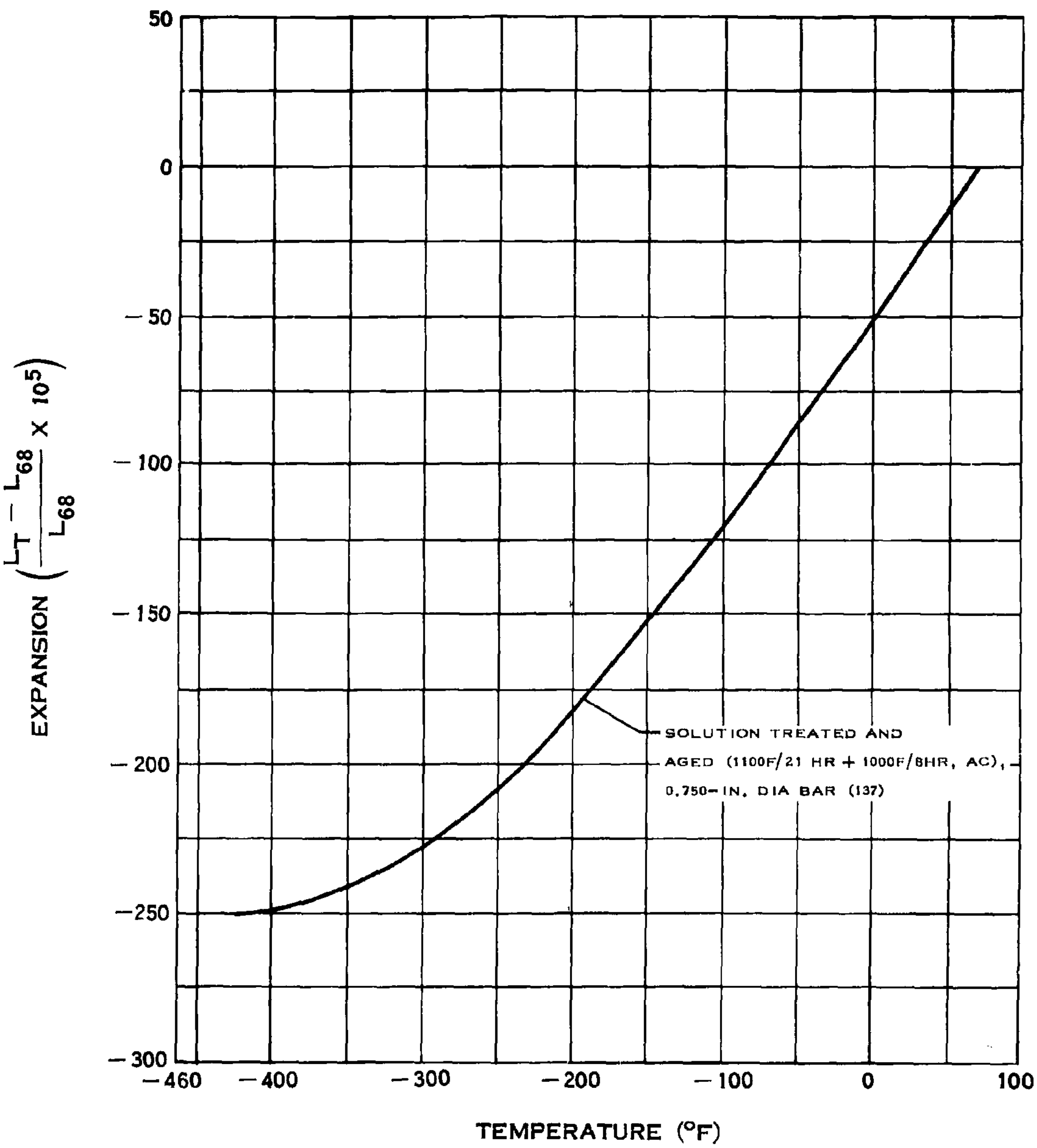
E.2.p



THERMAL EXPANSION OF INCONEL X NICKEL

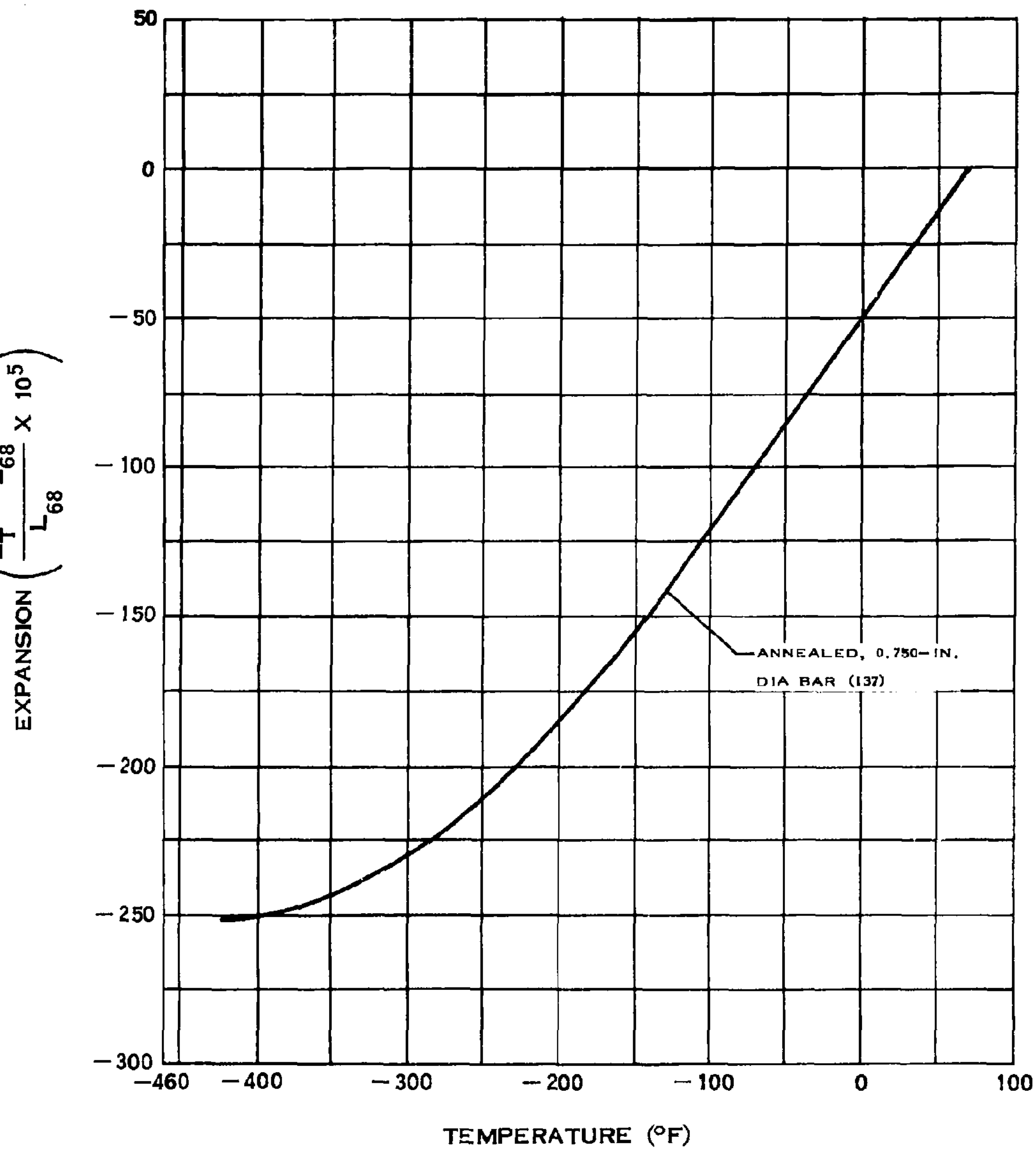
(1-15-64)

E.3.p



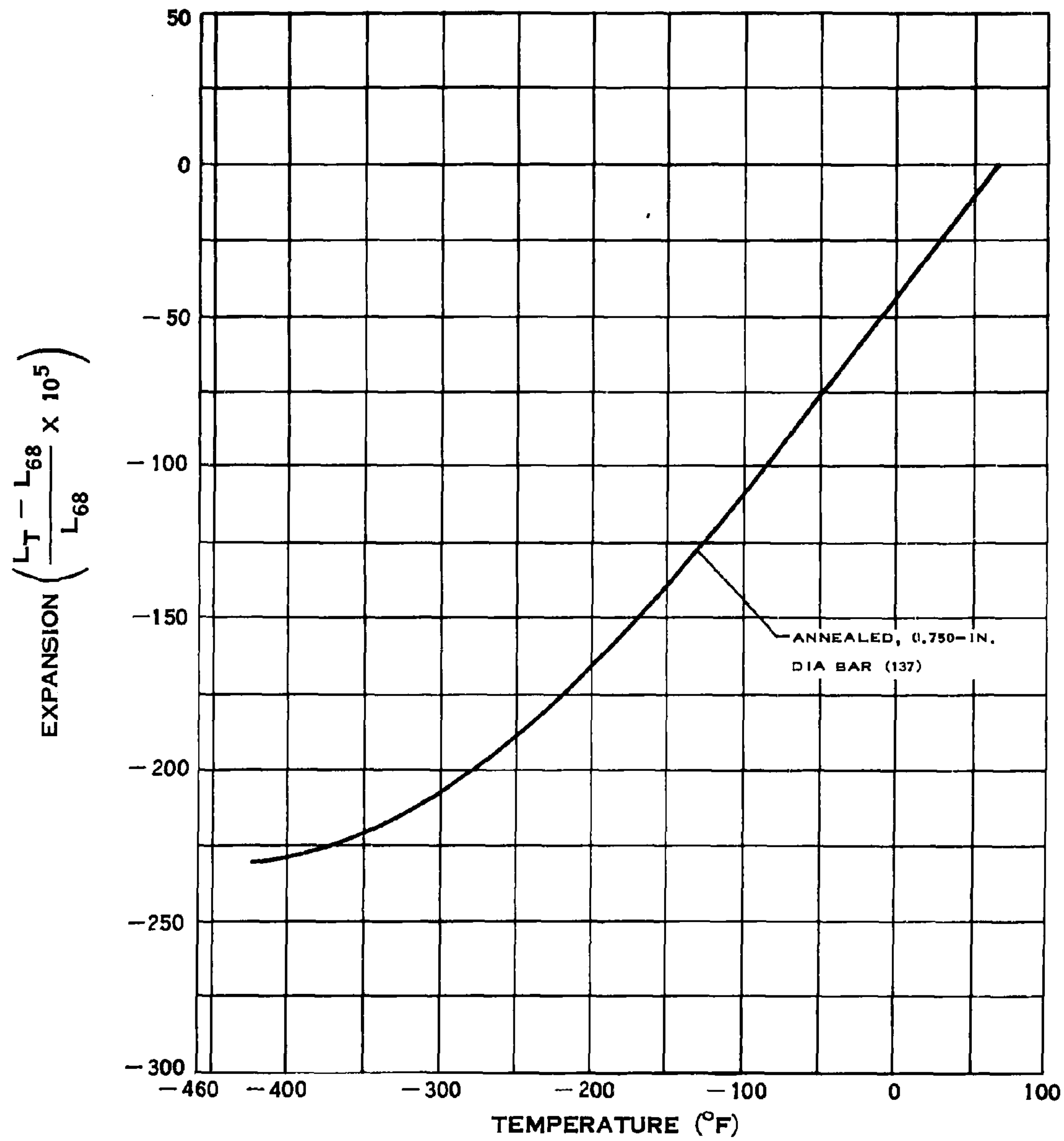
THERMAL EXPANSION OF K MONEL NICKEL

E.4.p



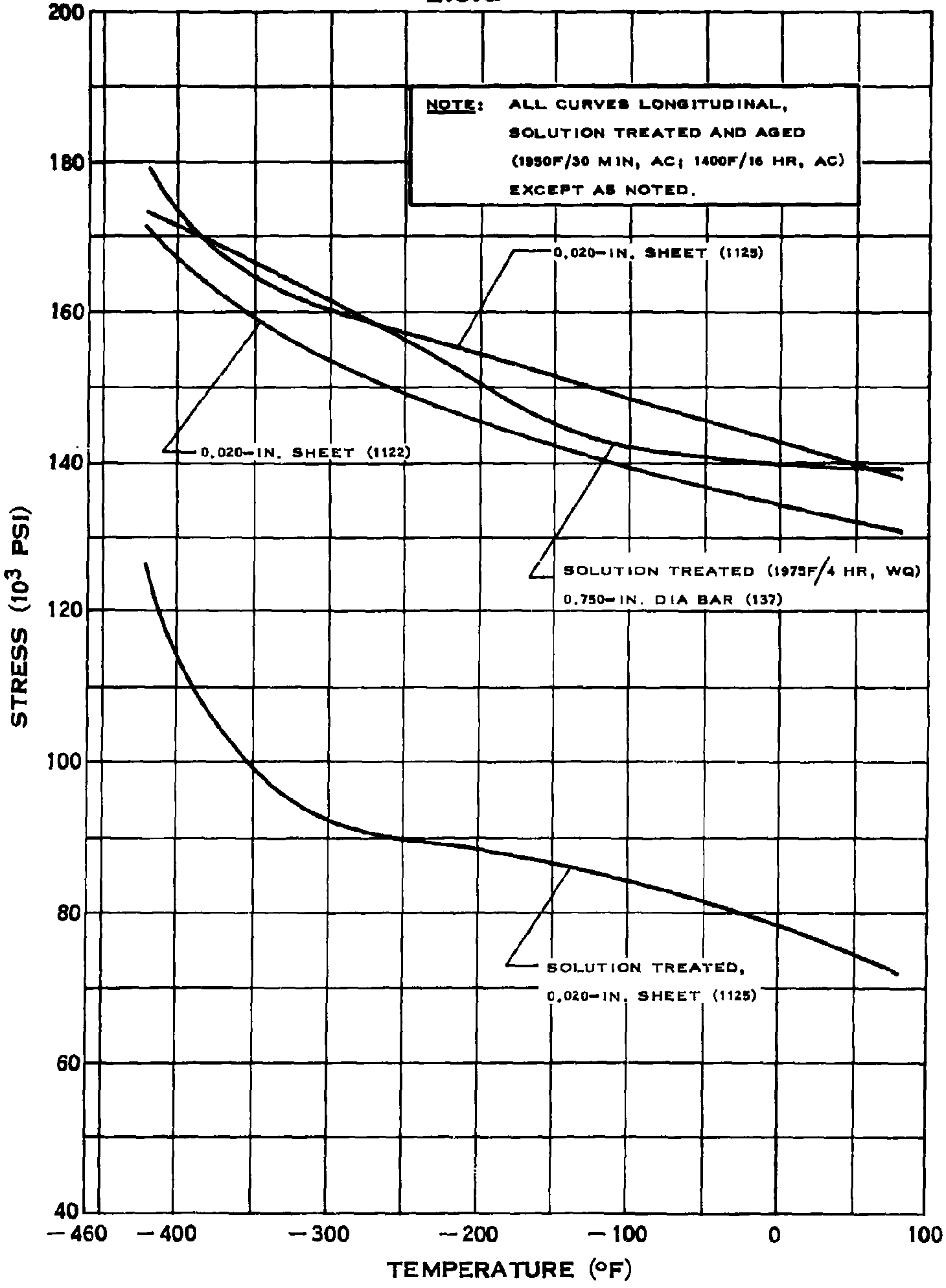
THERMAL EXPANSION OF S MONEL NICKEL

(1-15-64)



THERMAL EXPANSION OF "A" NICKEL

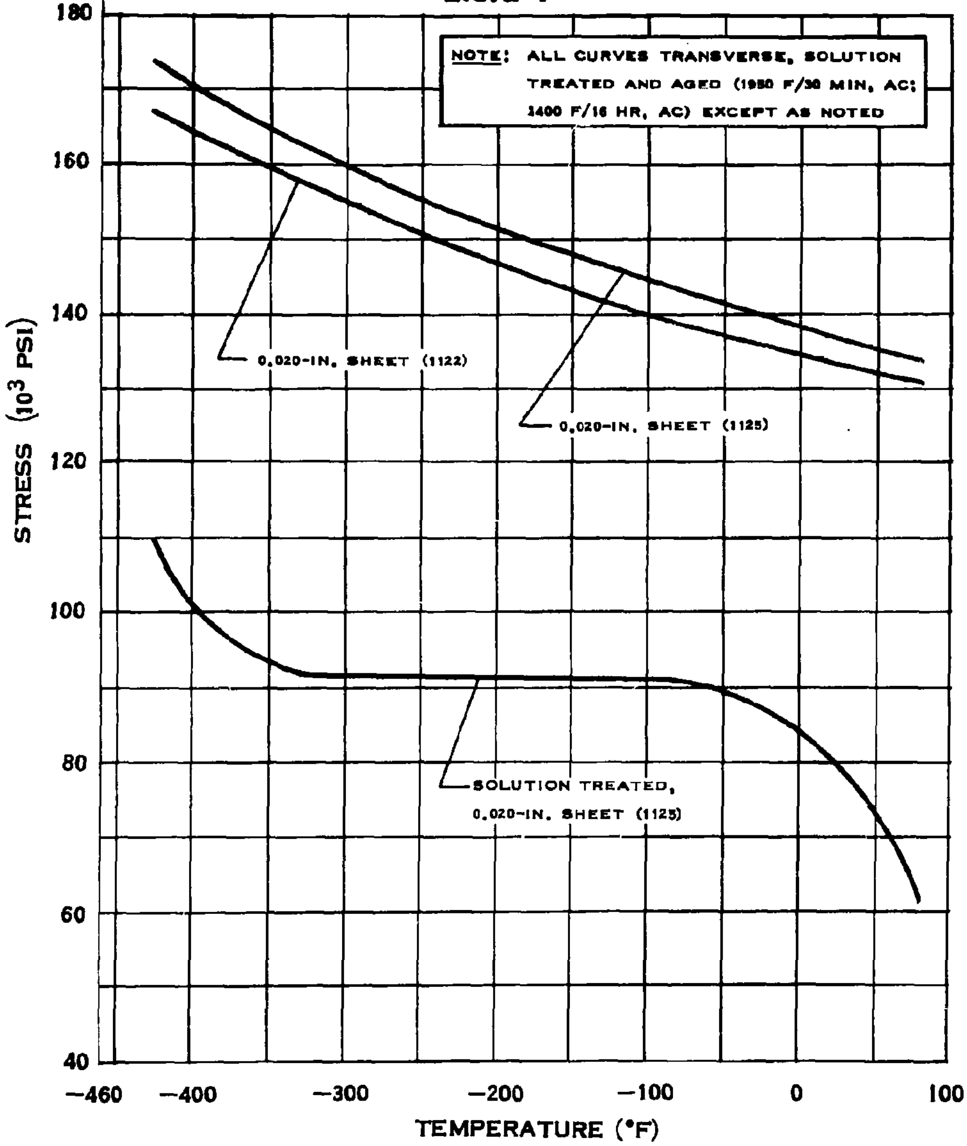
E.6.a



YIELD STRENGTH OF RENE' 41 NICKEL

1-15-64

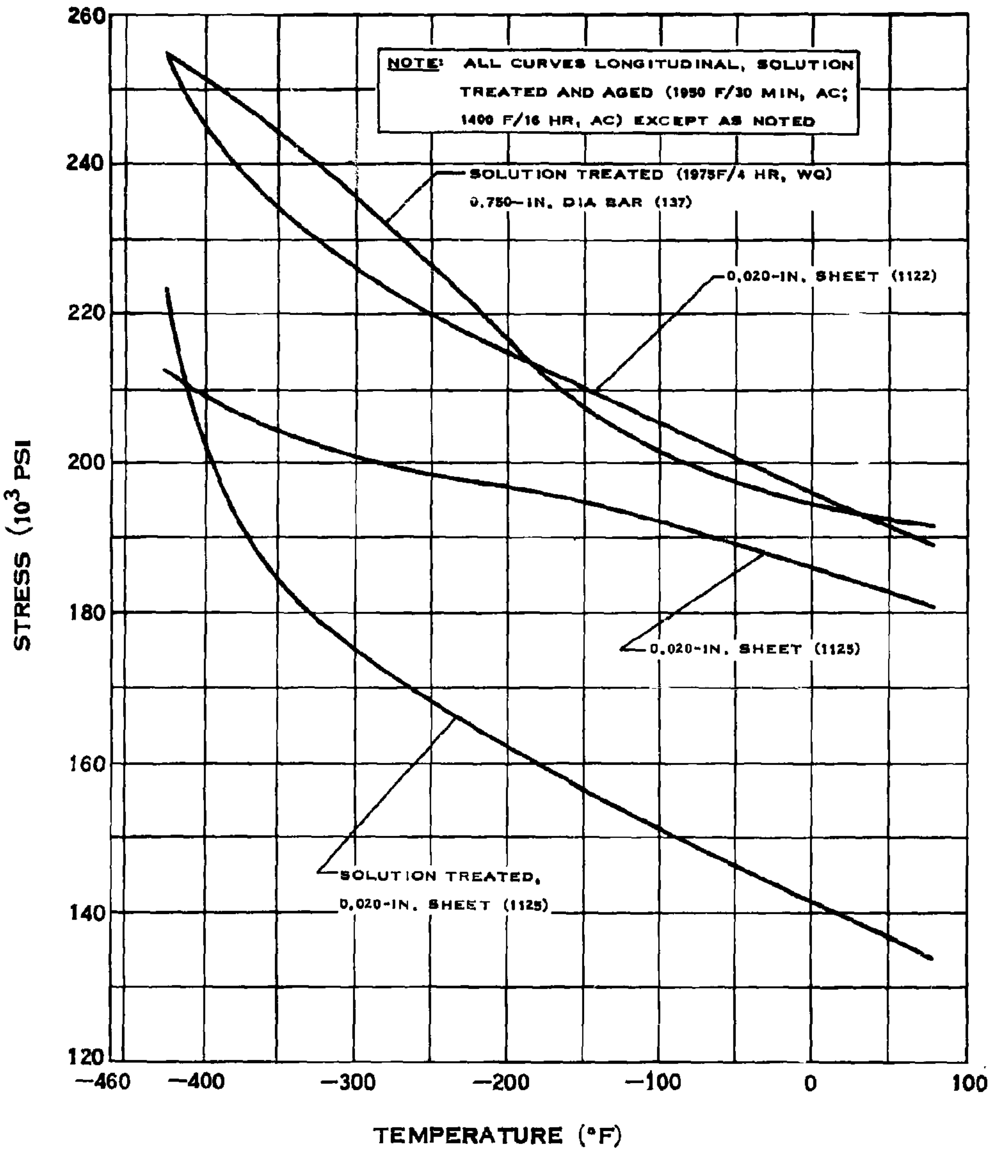
E.6.a-1



YIELD STRENGTH OF RENE' 41 NICKEL

(1–15–64)

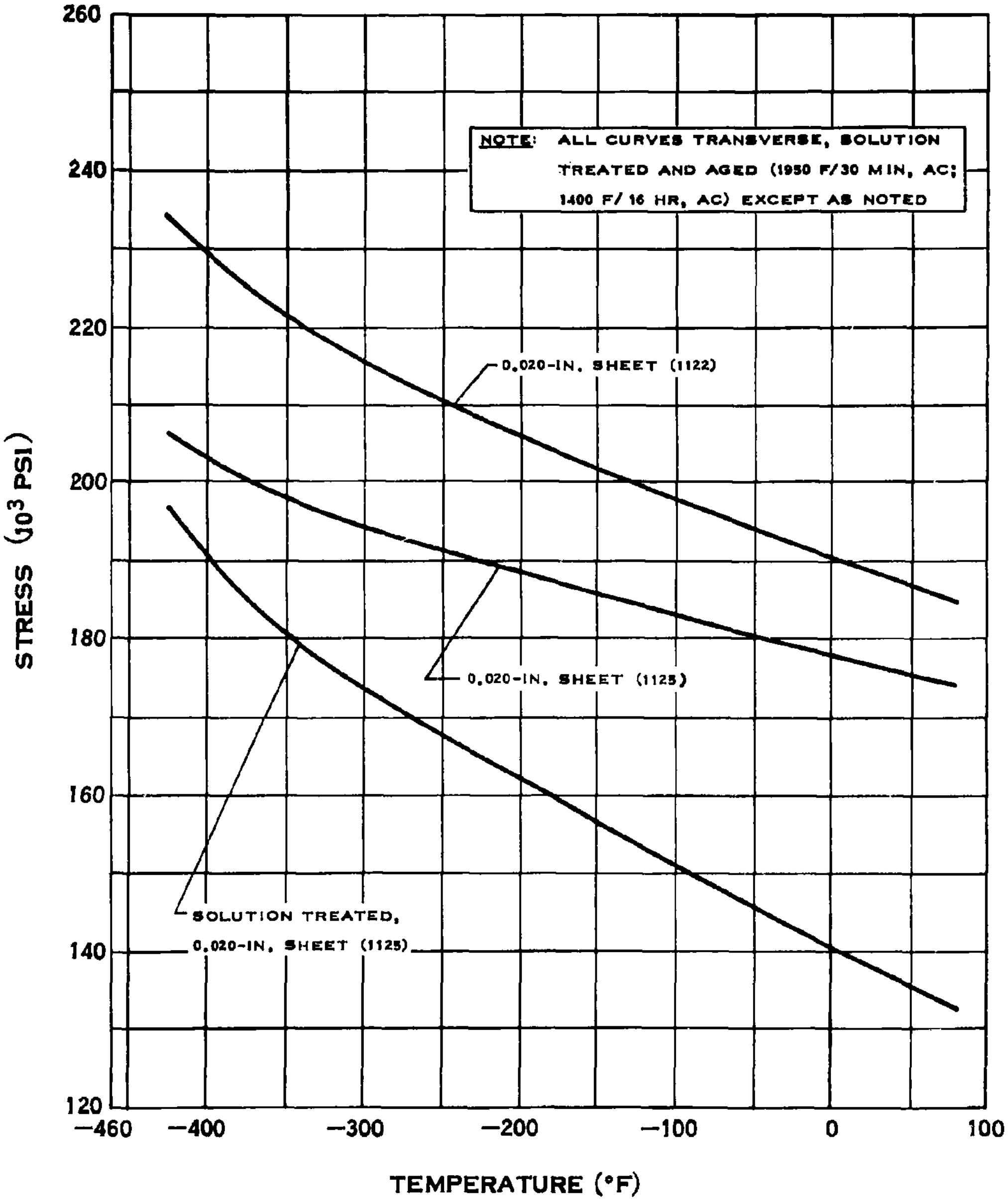
E.6.b



(1-15-64)

TENSILE STRENGTH OF RENE' 41 NICKEL

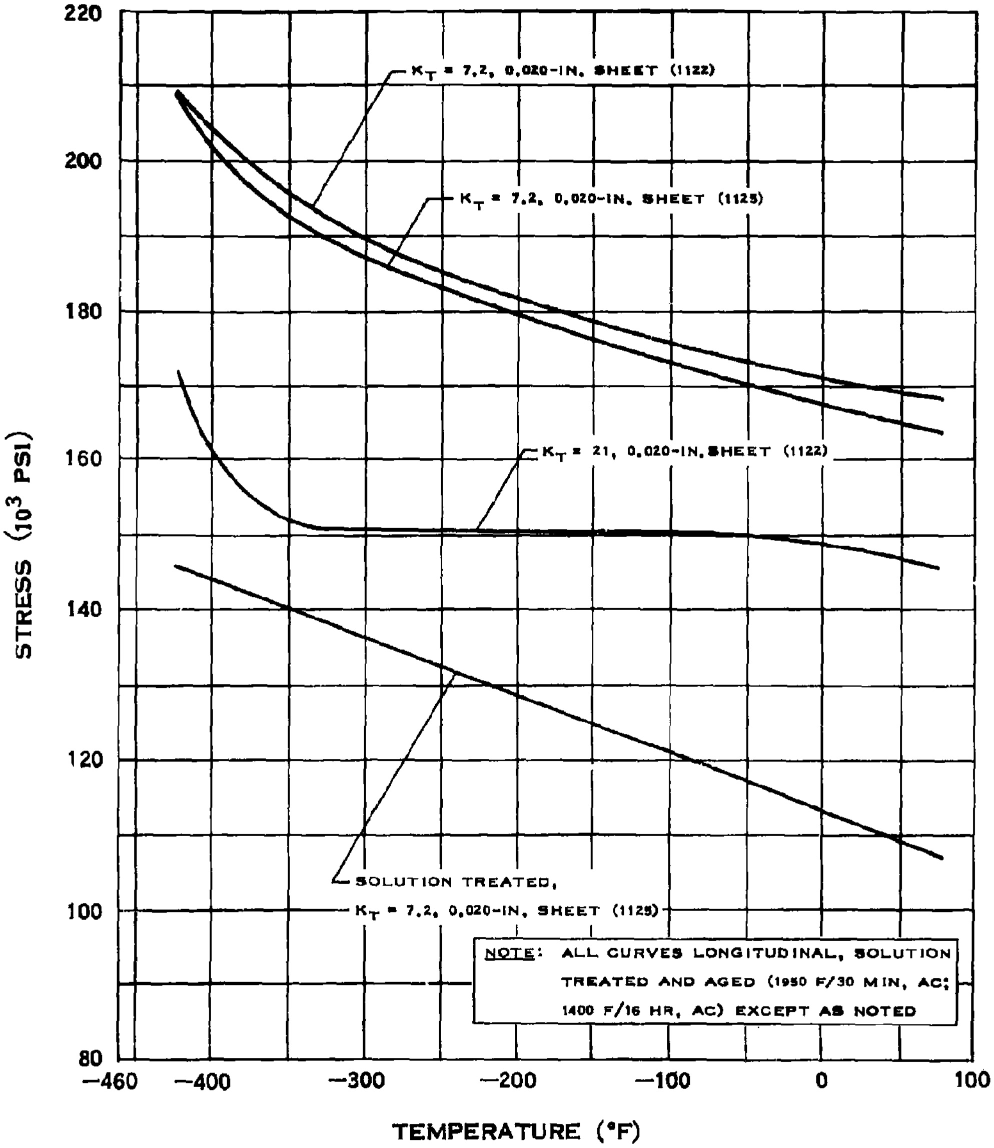
E.6.b-1



TENSILE STRENGTH OF RENE' 41 NICKEL

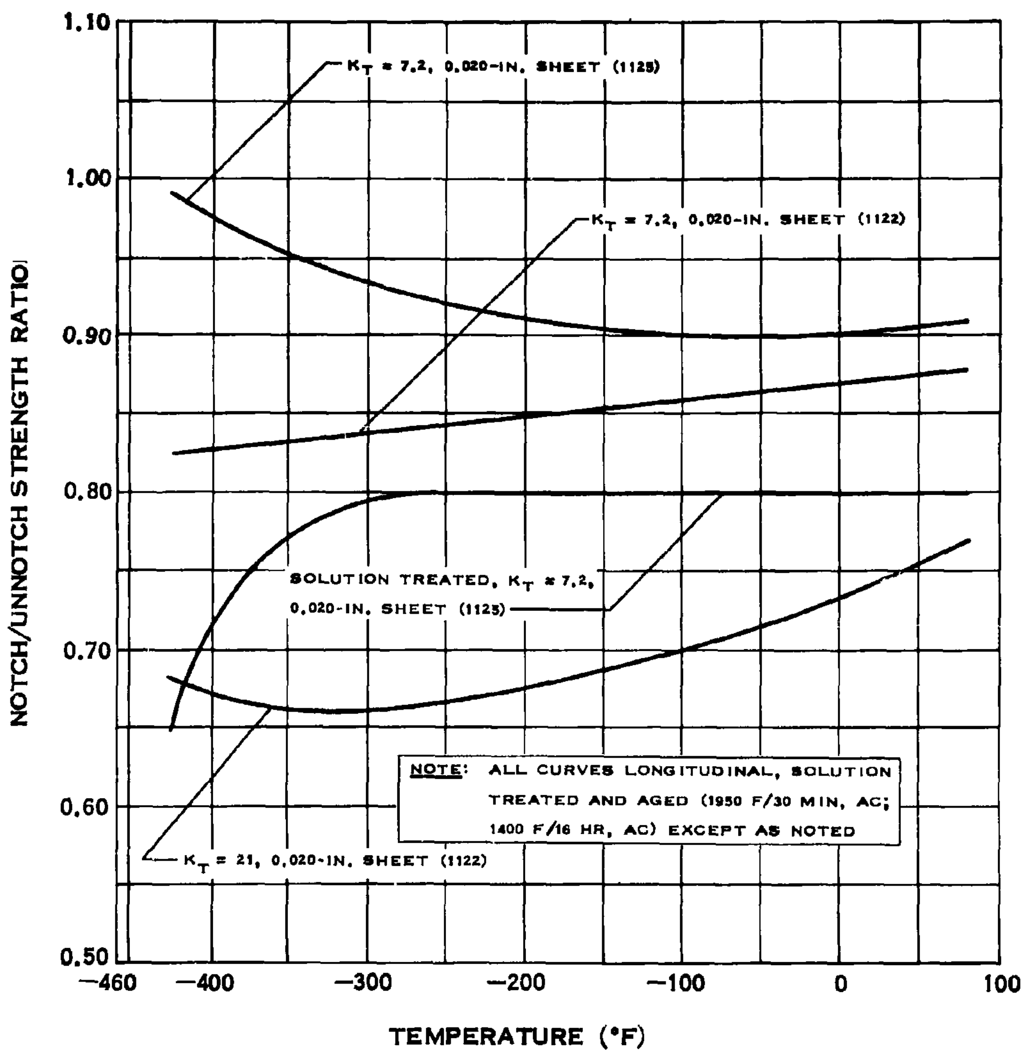
(1-15-64)

E.6.b-2



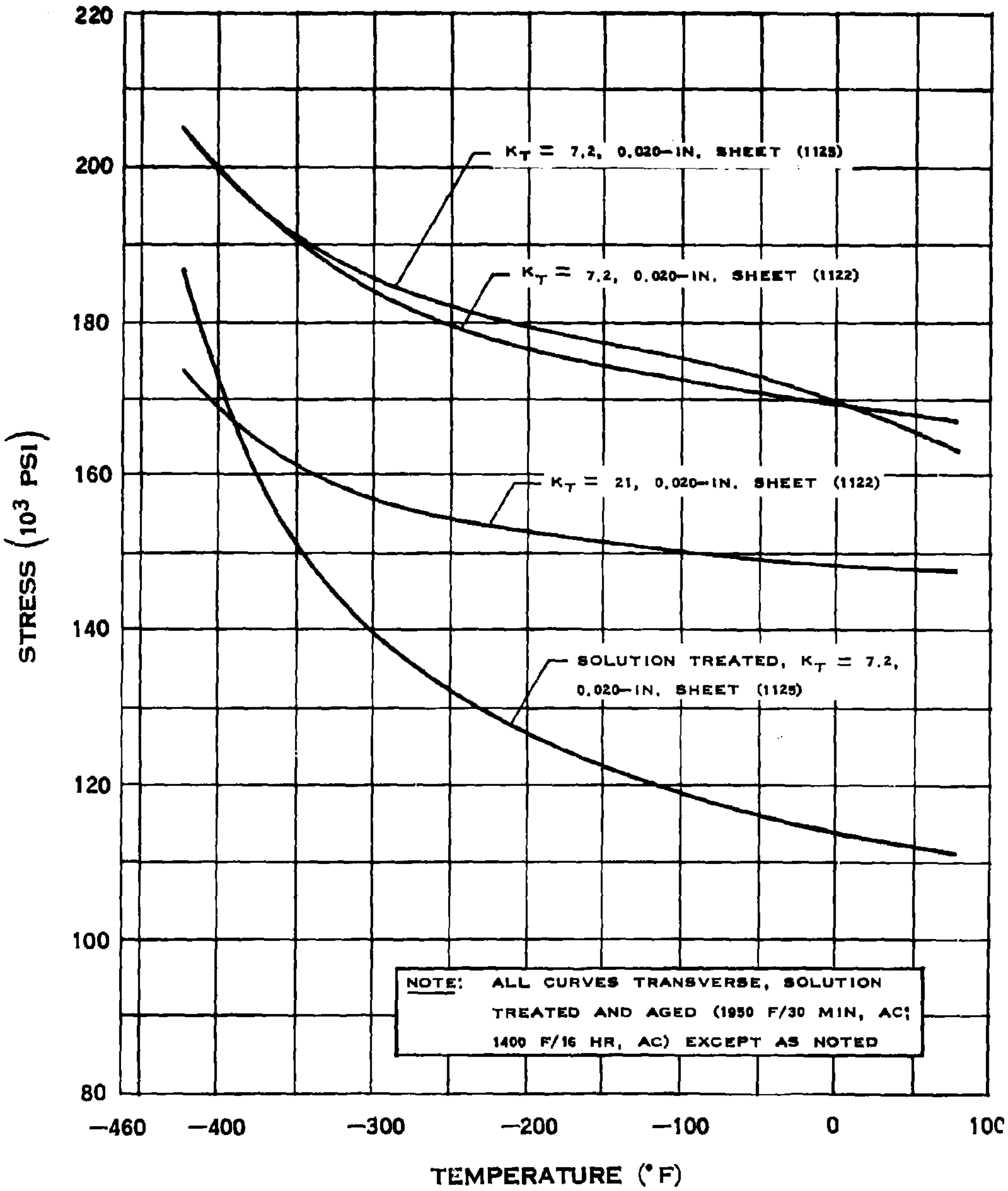
NOTCH TENSILE STRENGTH OF RENE' 41 NICKEL

(1-15-64)



NOTCH STRENGTH RATIO OF RENE' 41 NICKEL

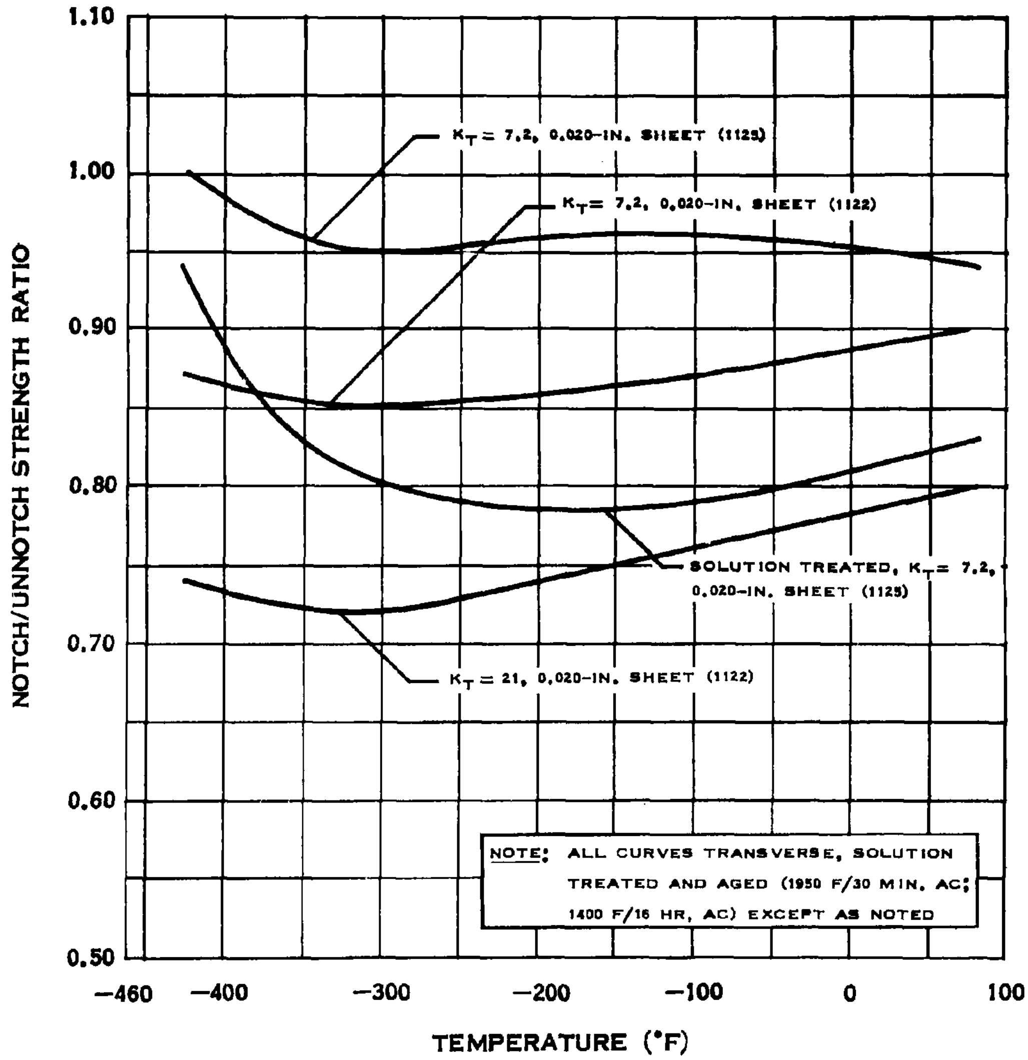
E.6.b-4



NOTCH TENSILE STRENGTH OF RENE' 41 NICKEL

(1–15–64)

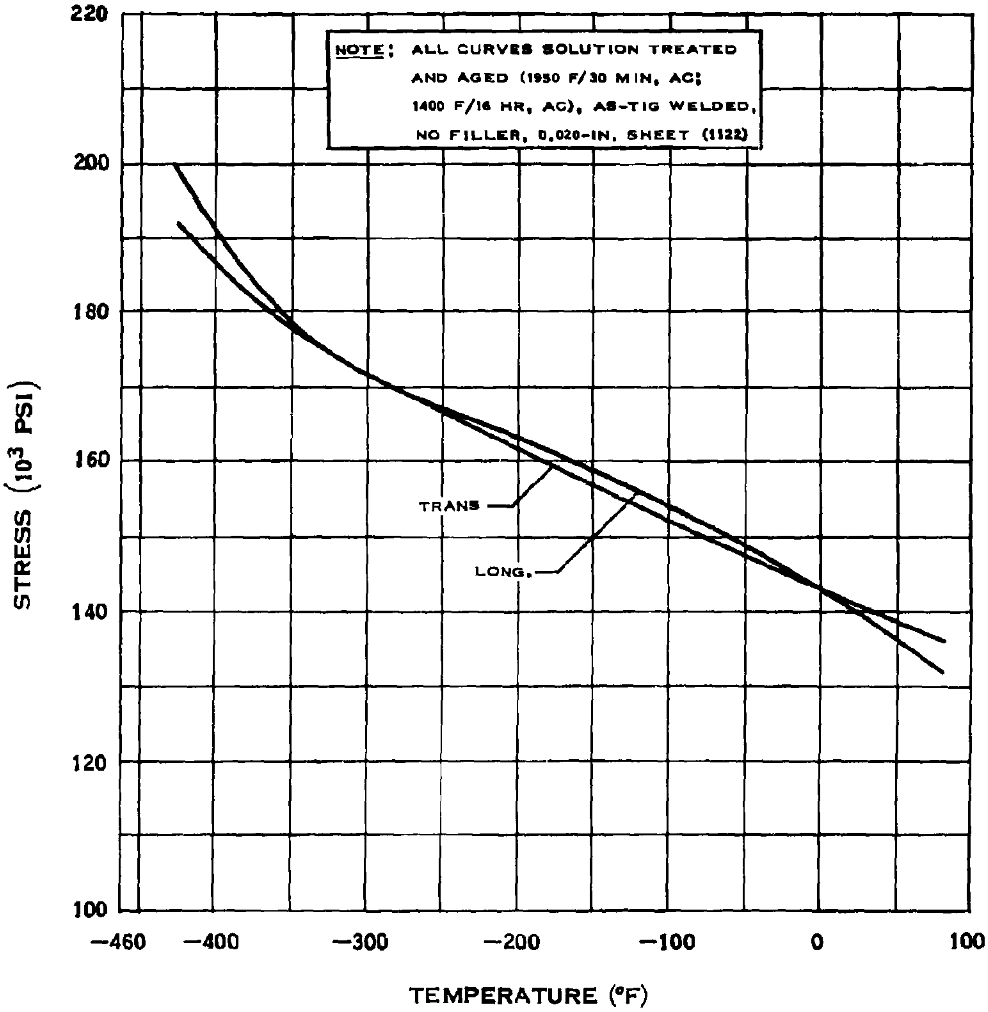
E.6.b-5



NOTCH STRENGTH RATIO OF RENE' 41 NICKEL

(1-15-64)

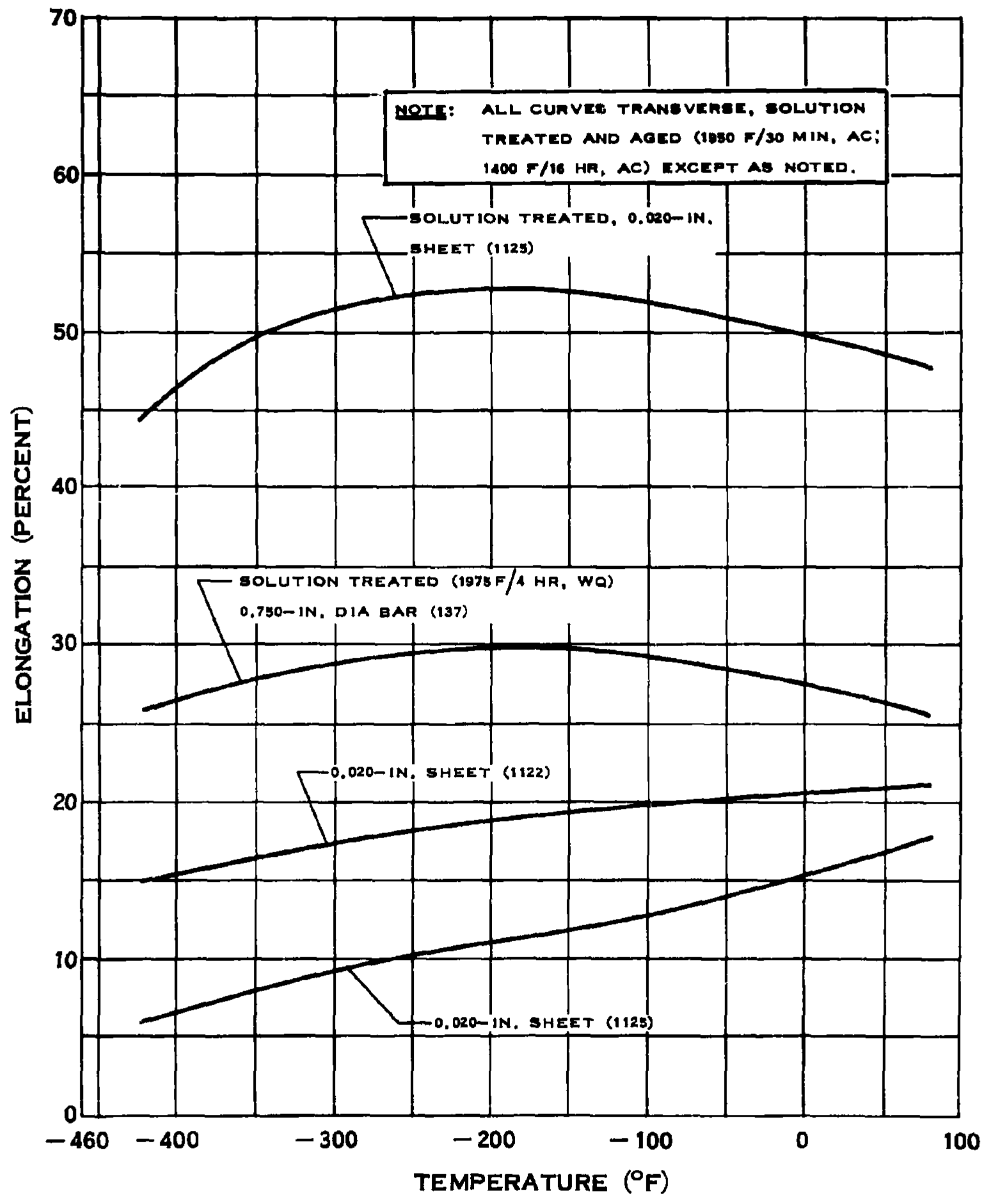
E.6.b-6



WELD TENSILE STRENGTH OF RENE' 41 NICKEL

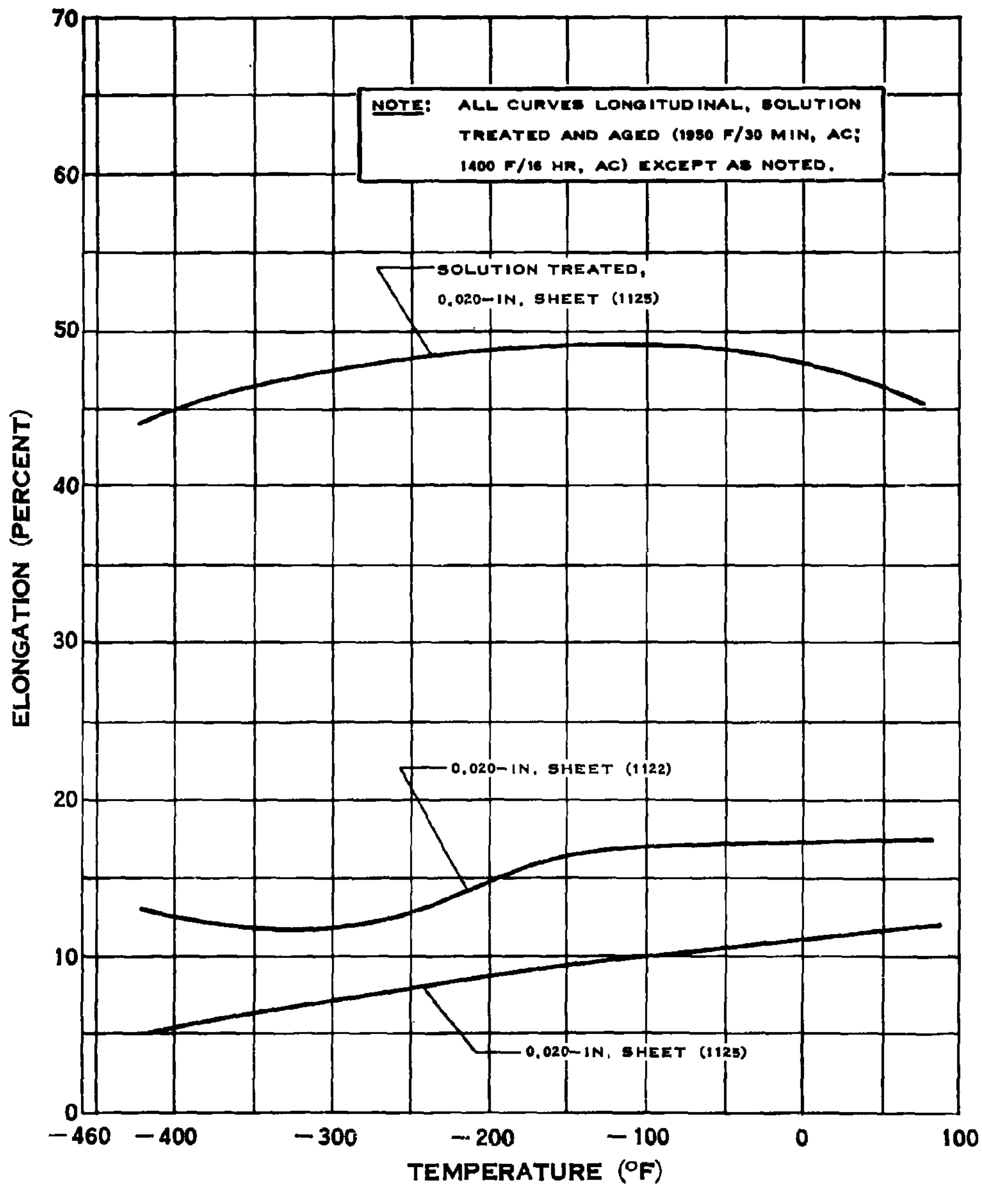
(1−15−64)

E.6.c



ELONGATION OF RENE' 41 NICKEL

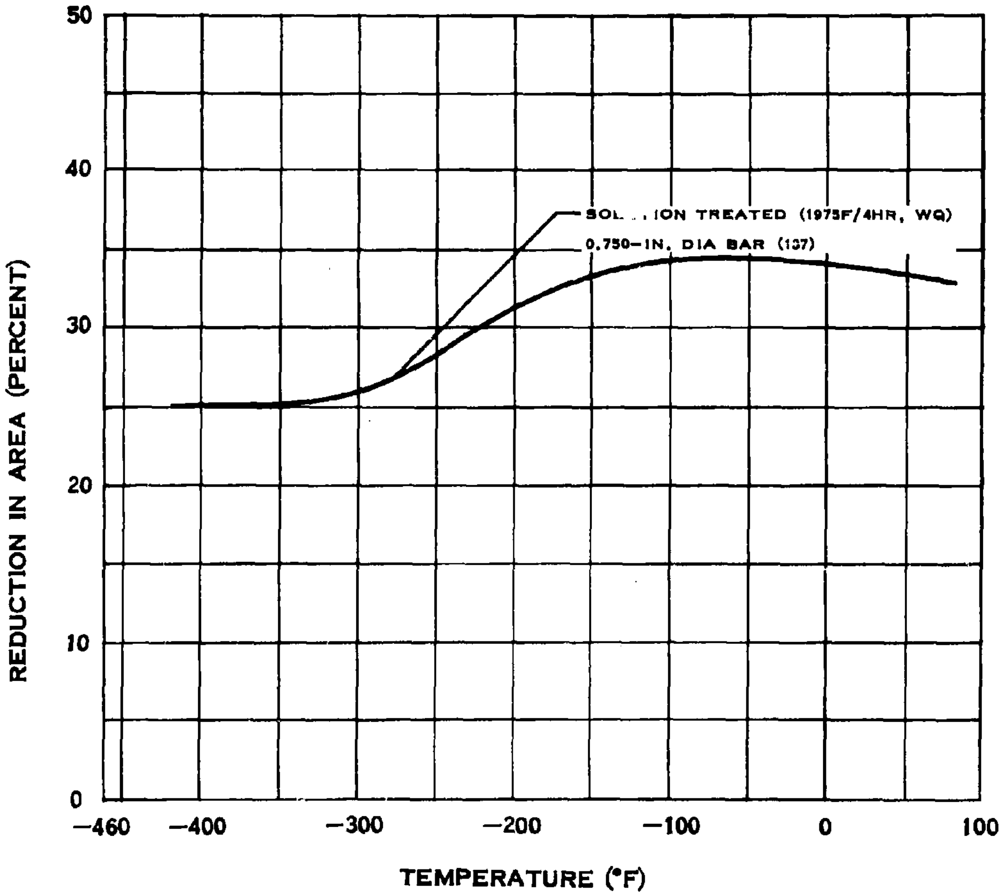
E.6.c-1



ELONGATION OF RENE' 41 NICKEL

1-15-64

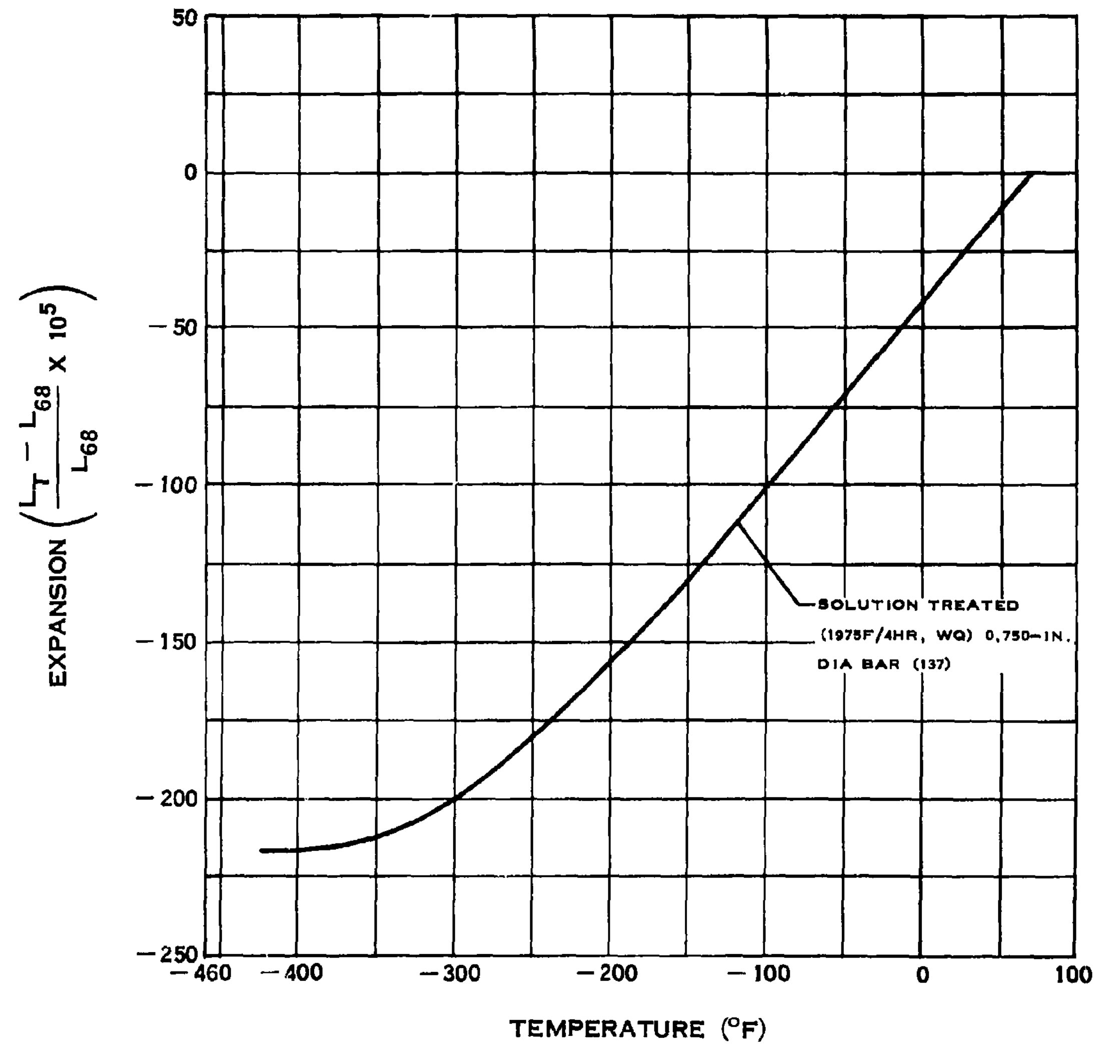
E.6.d



REDUCTION IN AREA OF RENE' 41 NICKEL

(1-15-64)

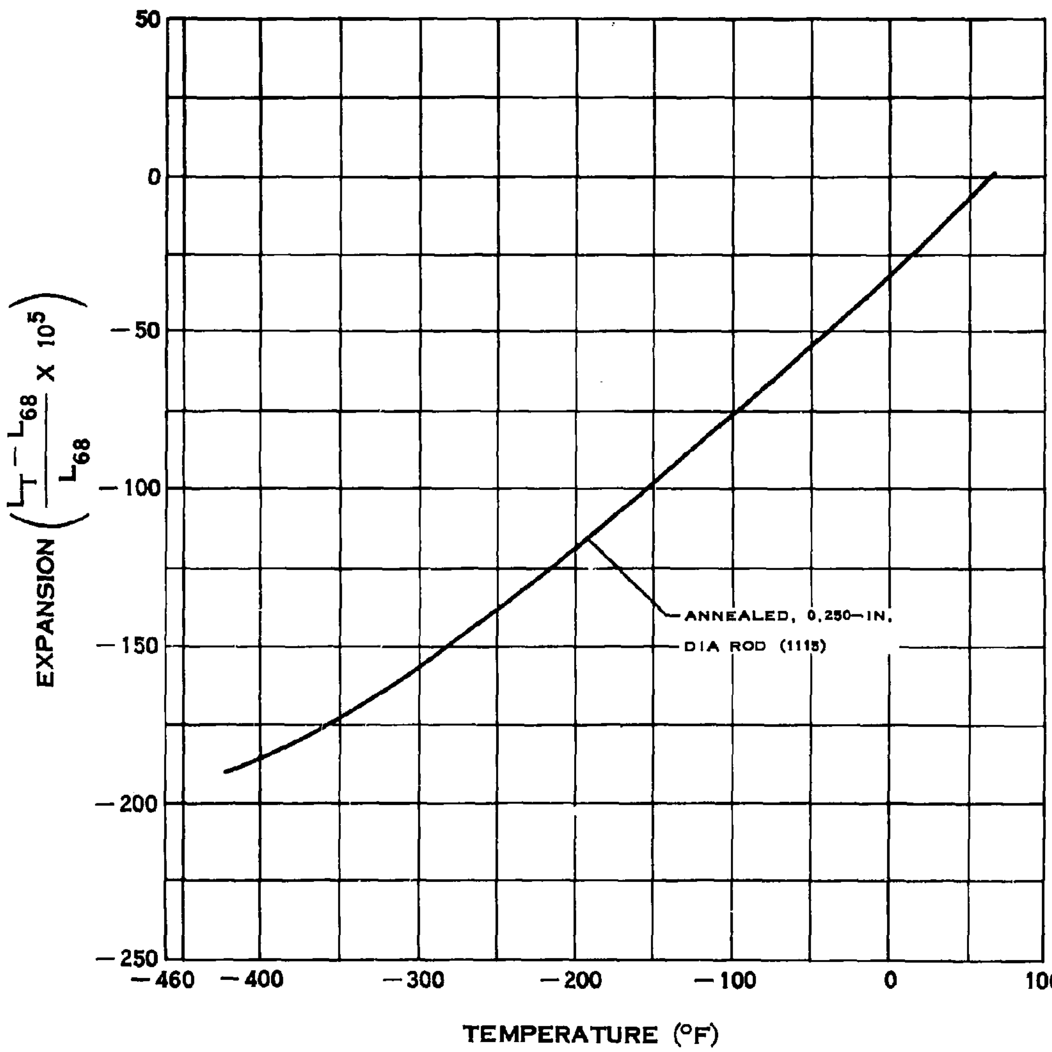
E.6.p



THERMAL EXPANSION OF RENÉ 41 NICKEL

(1-15-64)

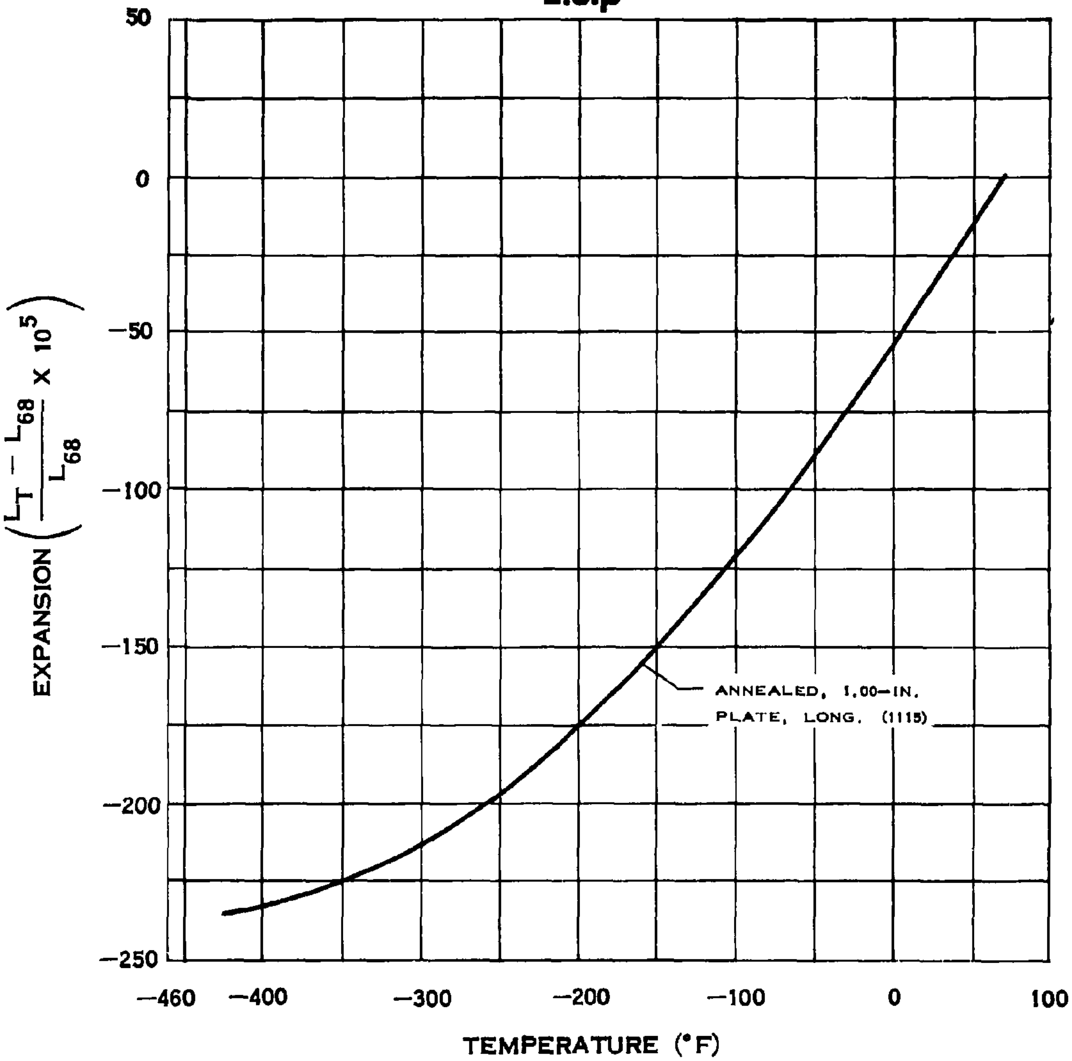
E.7.p



THERMAL EXPANSION OF HASTELLOY B

1-15-64

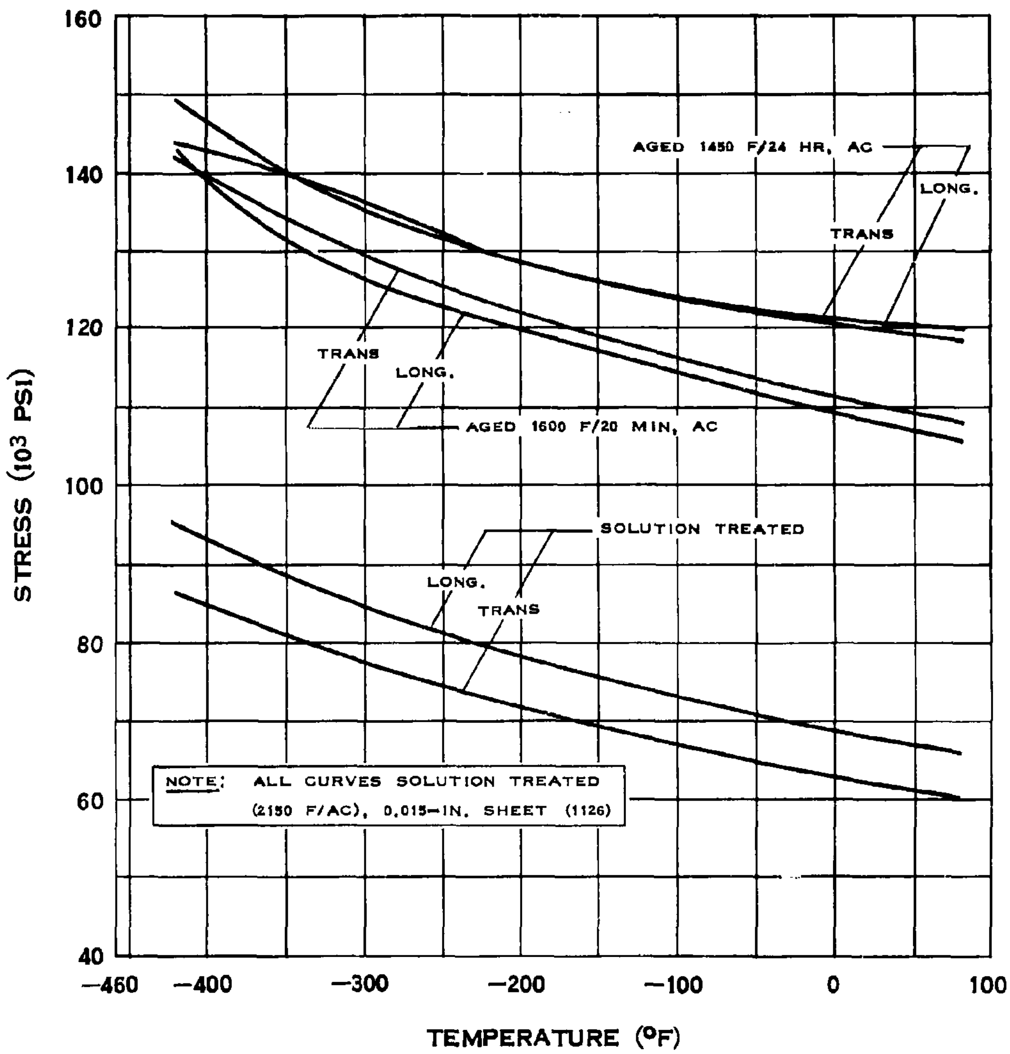
E.8.p



THERMAL EXPANSION OF D-979 NICKEL

(1-15-64)

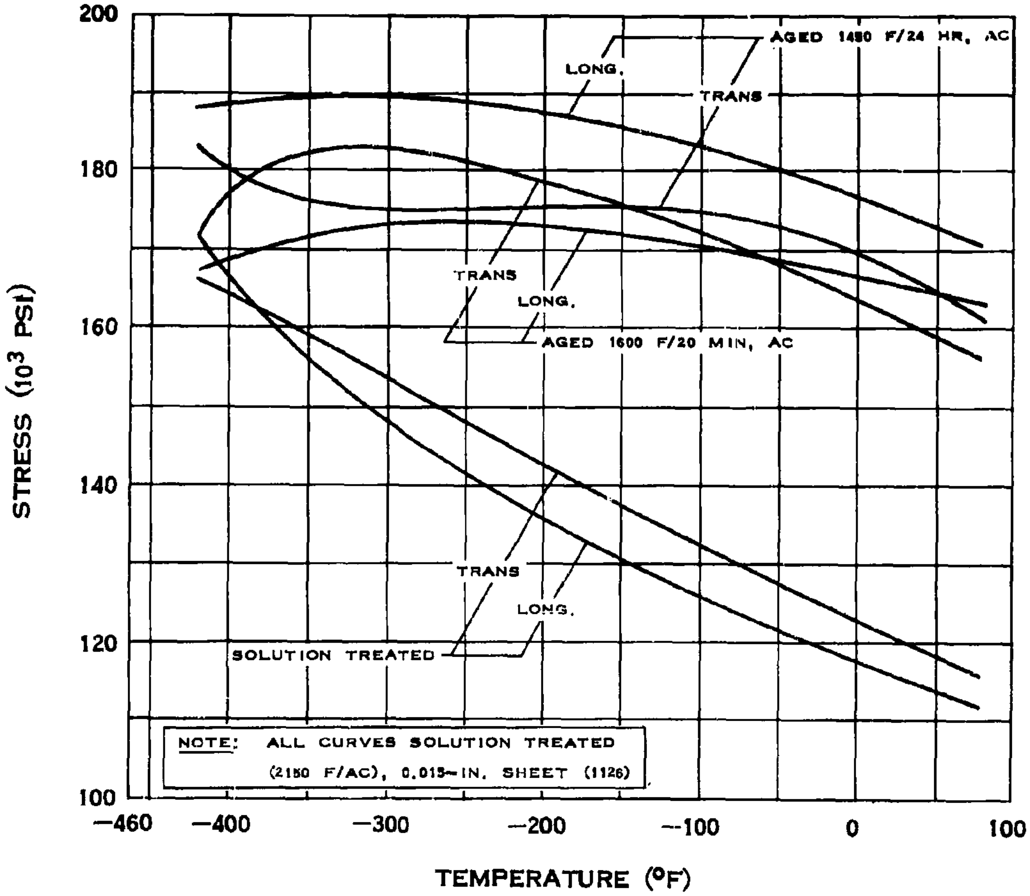
E.9.a



YIELD STRENGTH OF R-235 NICKEL

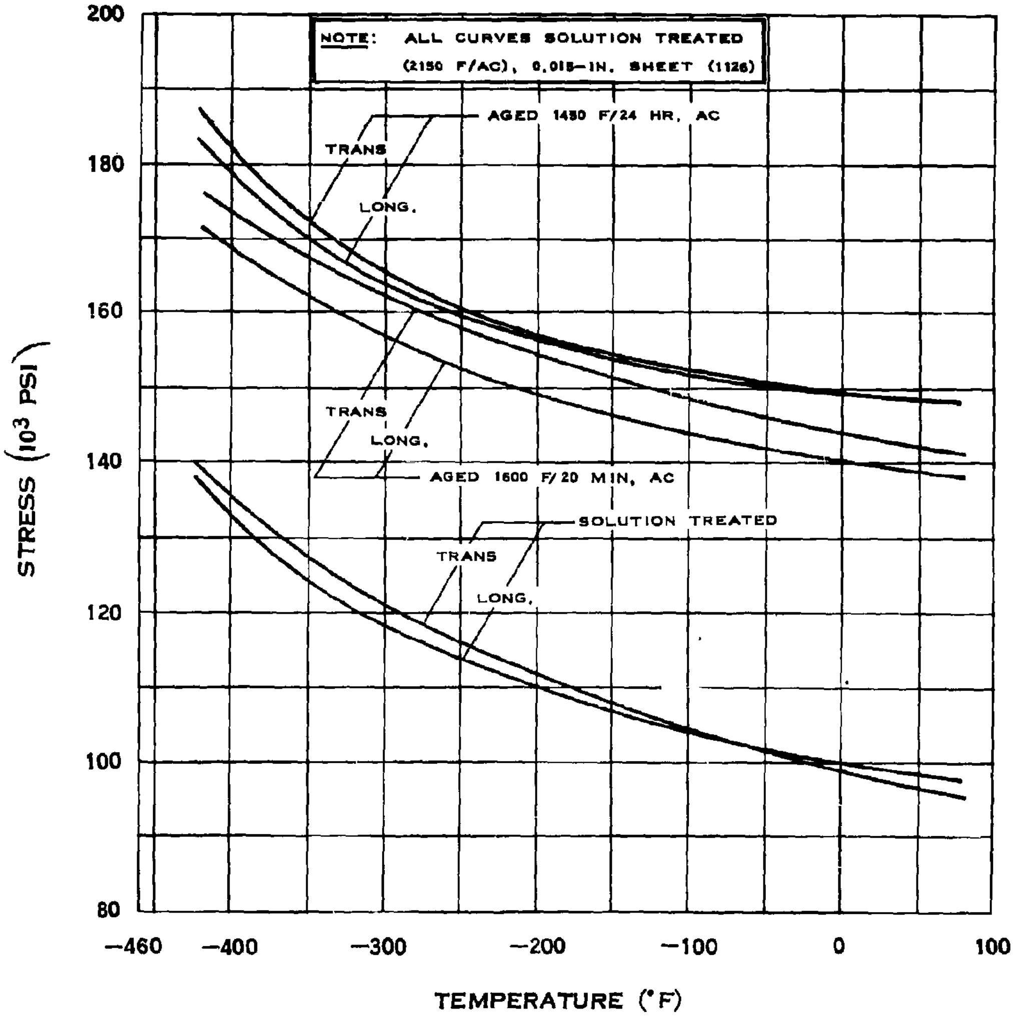
(1-15-64)

E.9.b



TENSILE STRENGTH OF R-235 NICKEL

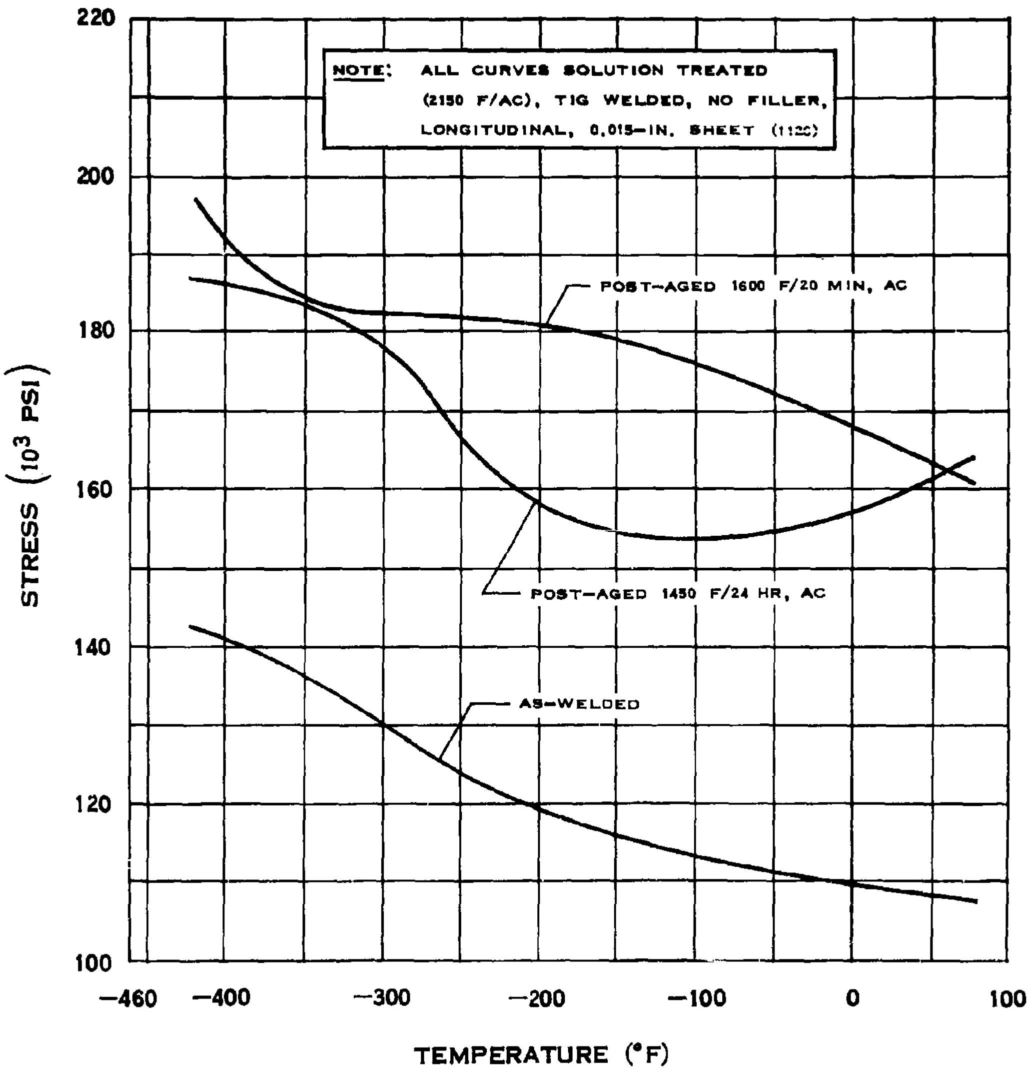
E.9.b-1



NOTCH TENSILE STRENGTH OF R-235 NICKEL

(1-15-64)

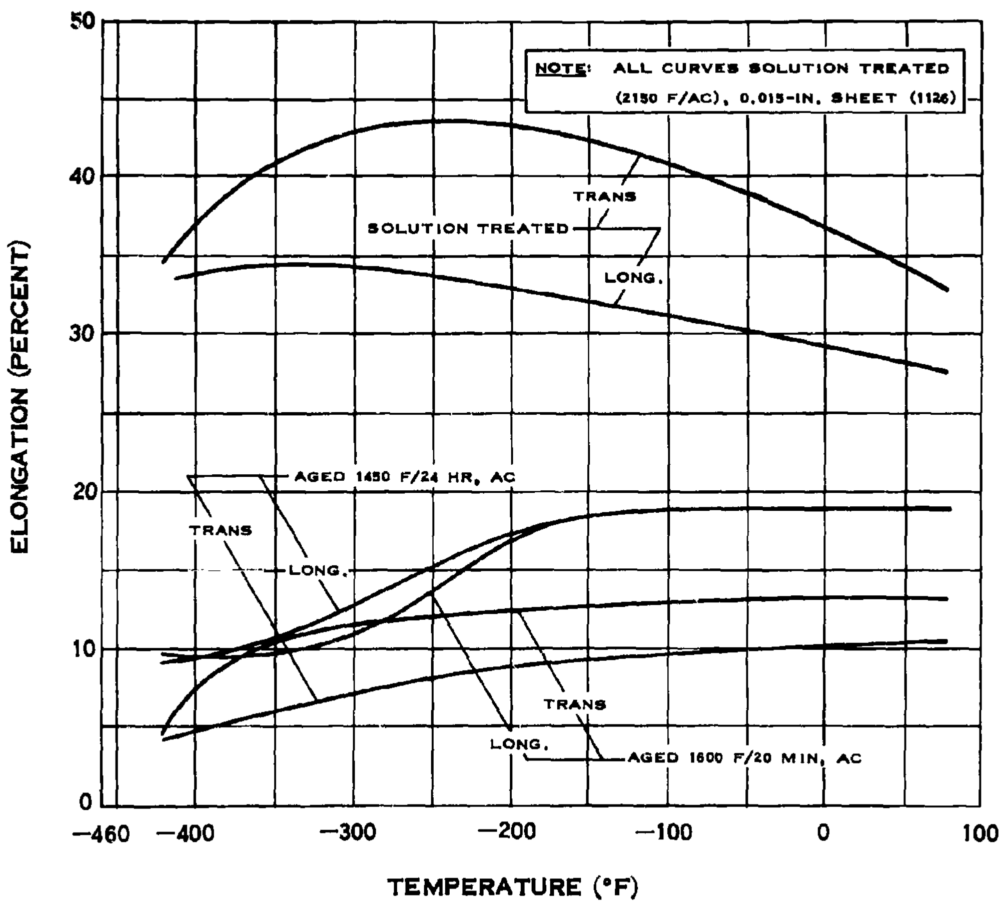
E.9.b-3



WELD TENSILE STRENGTH OF R-235 NICKEL

(1-15-64)

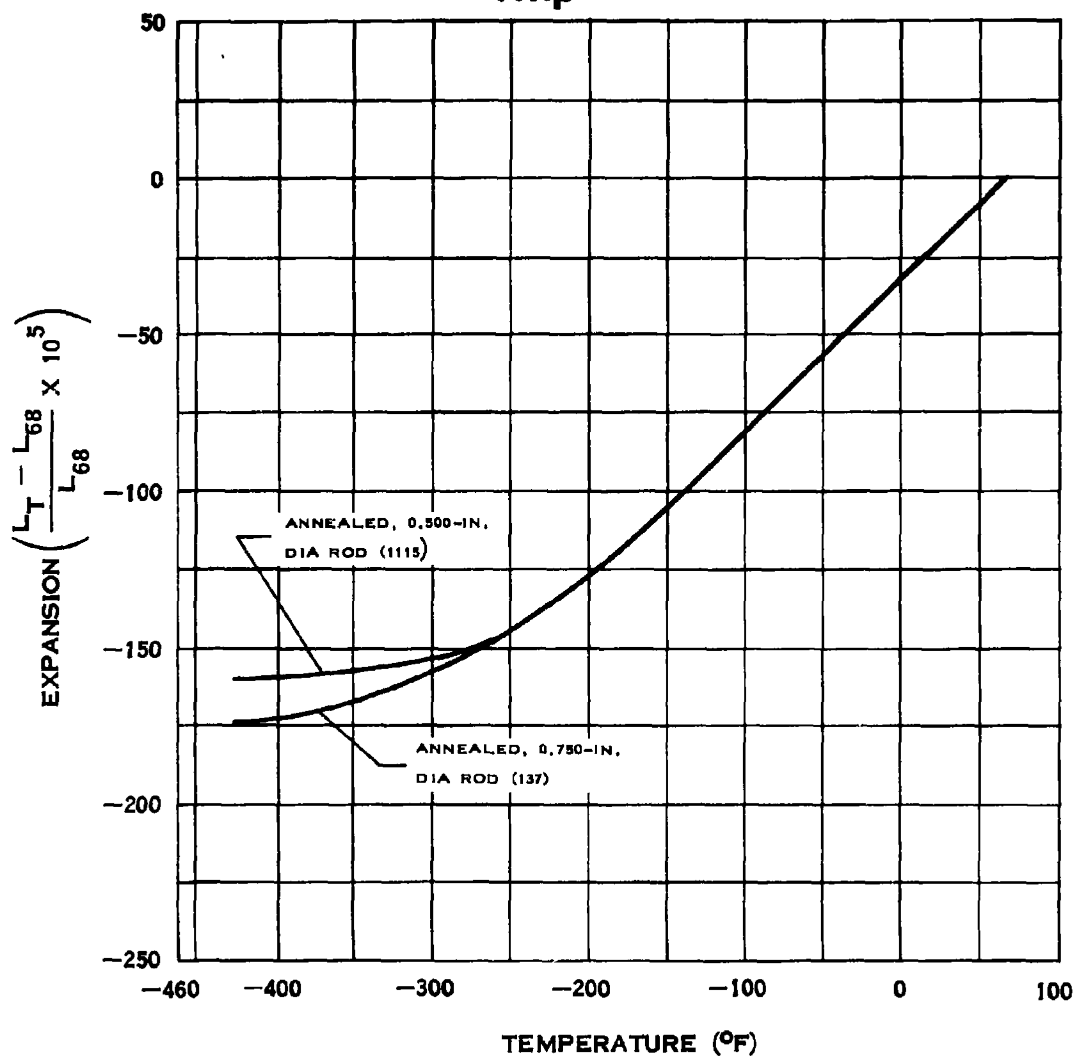
E.9.c



ELONGATION OF R-235 NICKEL

(1-15-64)

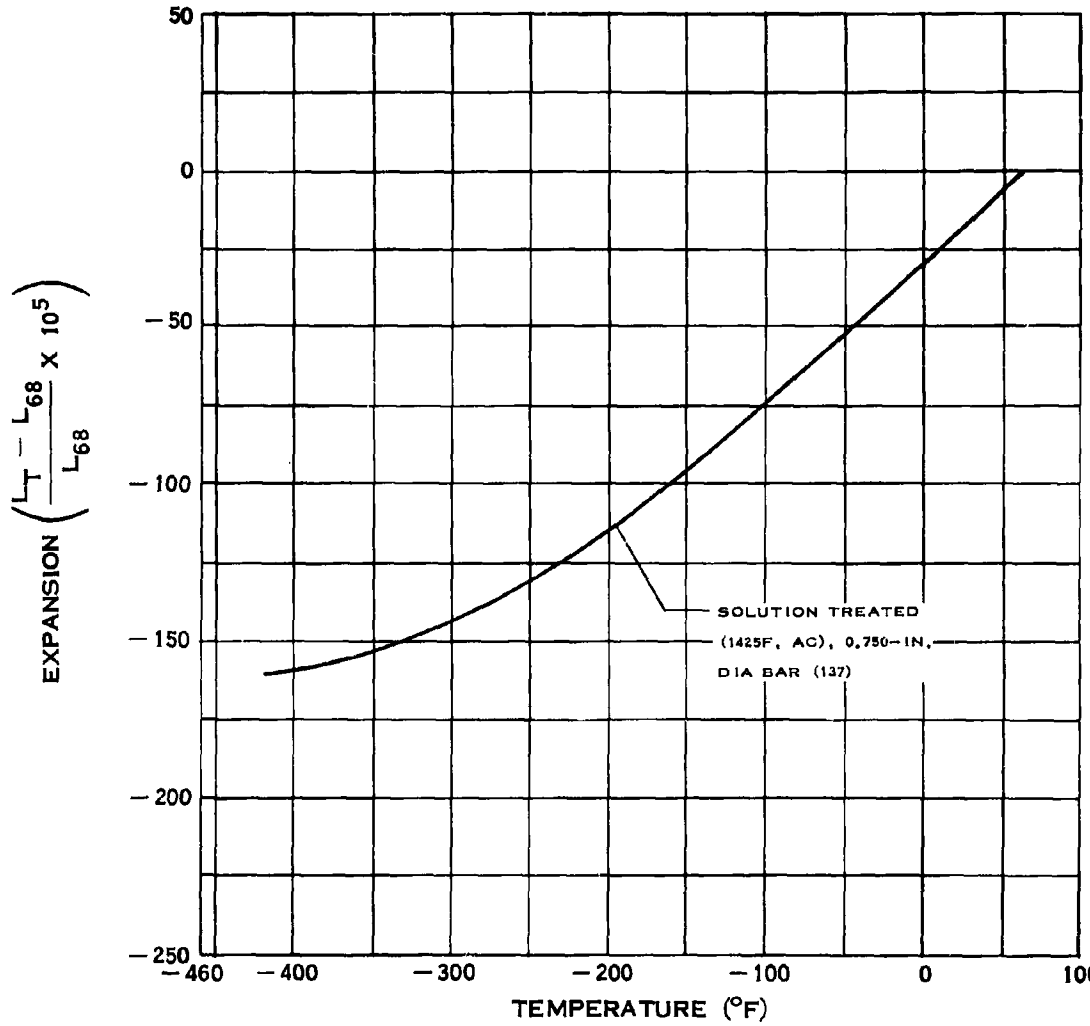
F.1.p



THERMAL EXPANSION OF 5AL-2.5 SN TITANIUM

(1−15−64)

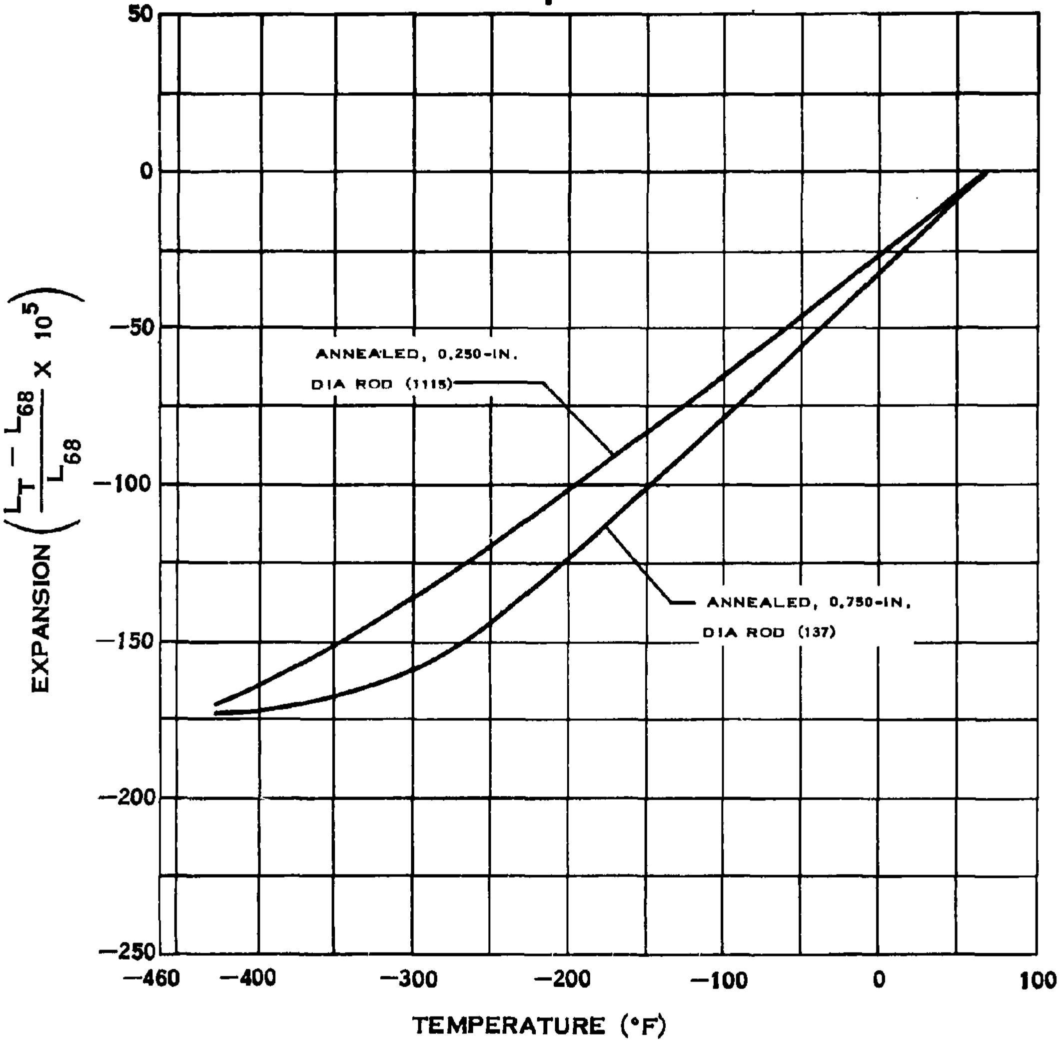
F.2.p



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

1-15-64

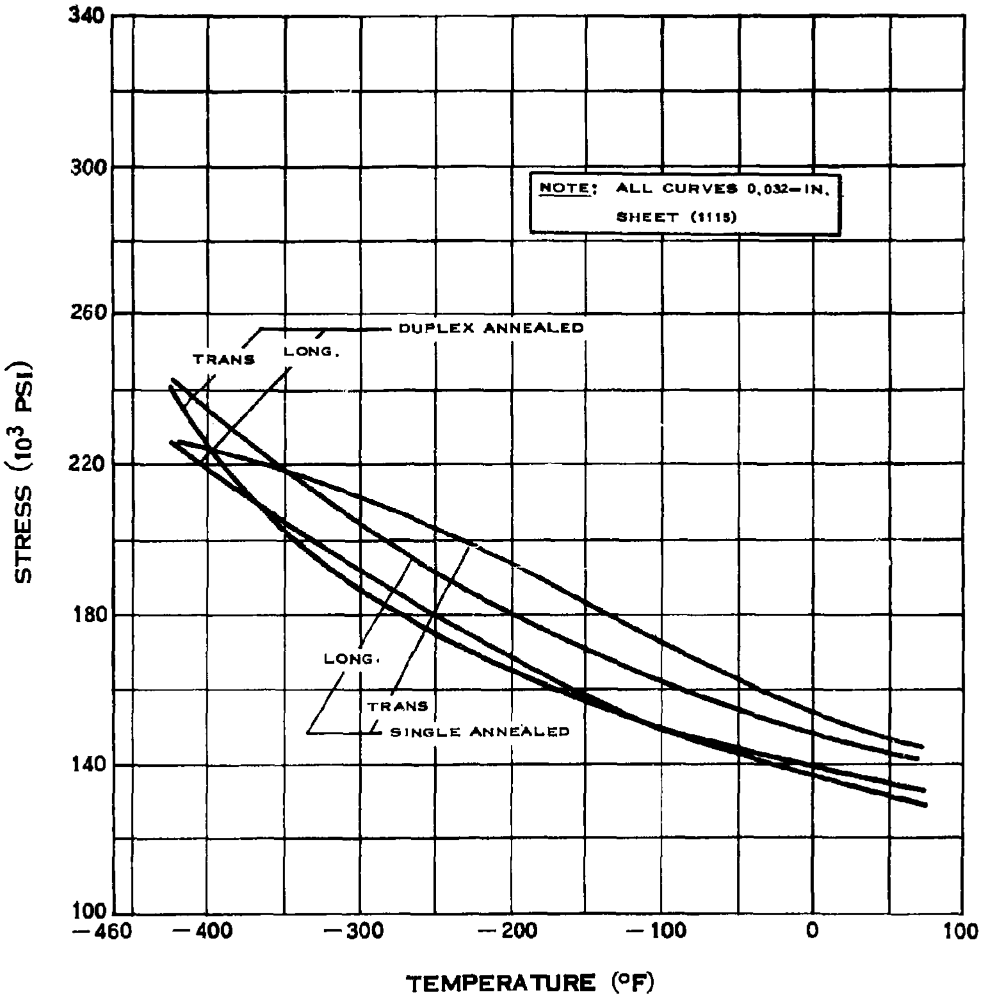
F.3.p



THERMAL EXPANSION OF 6AL-4V TITANIUM

(1–15–64)

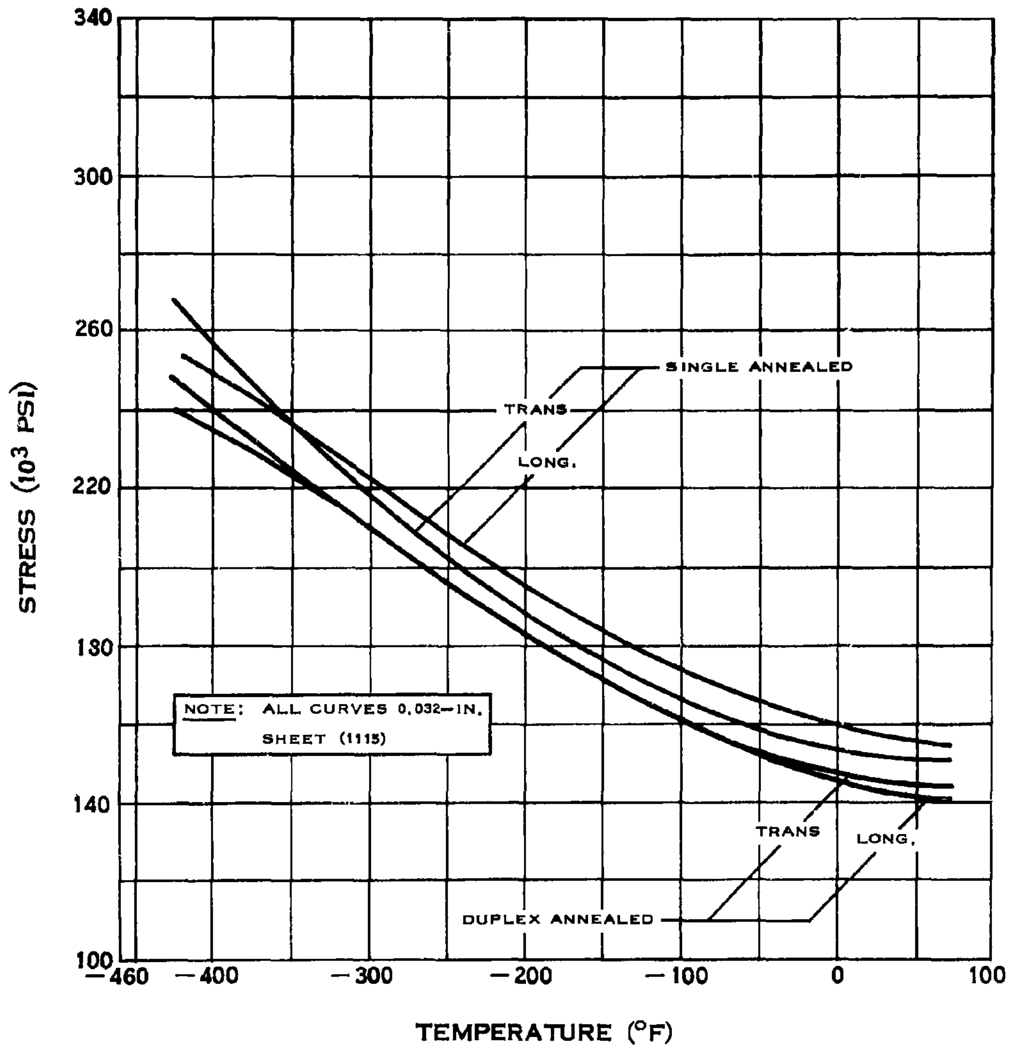
F.4.a



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

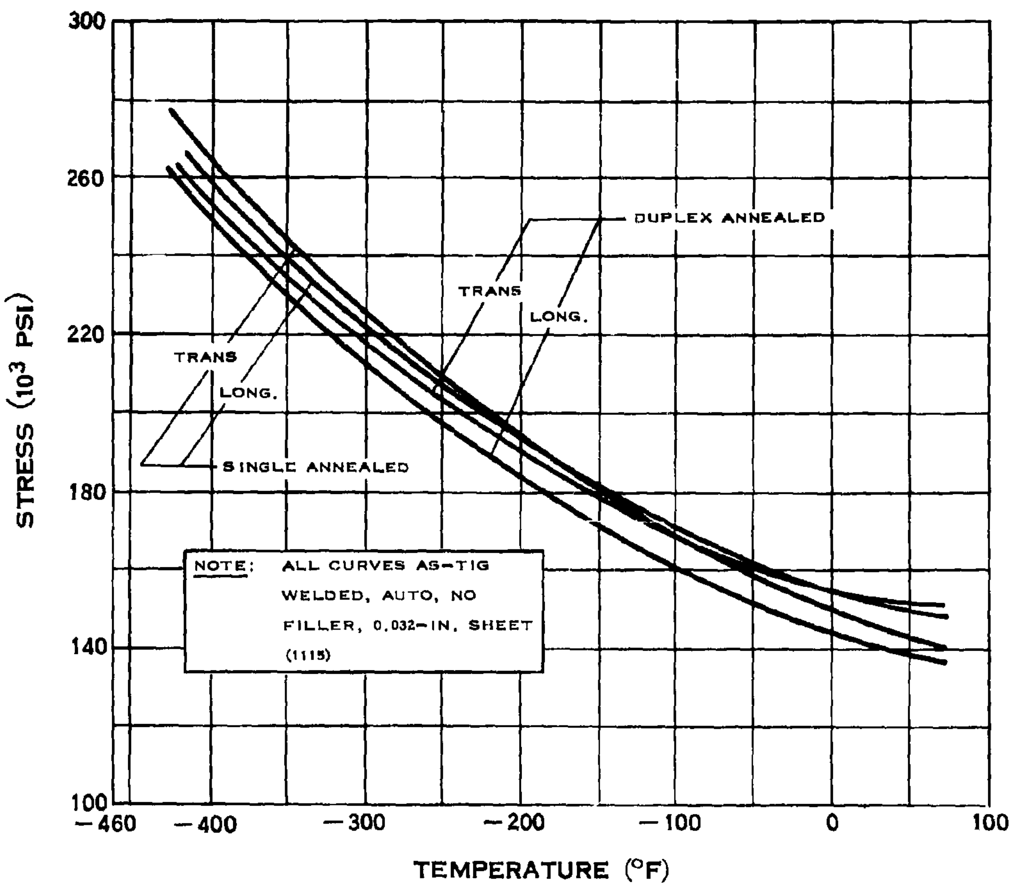
1-15-64

F.4.b



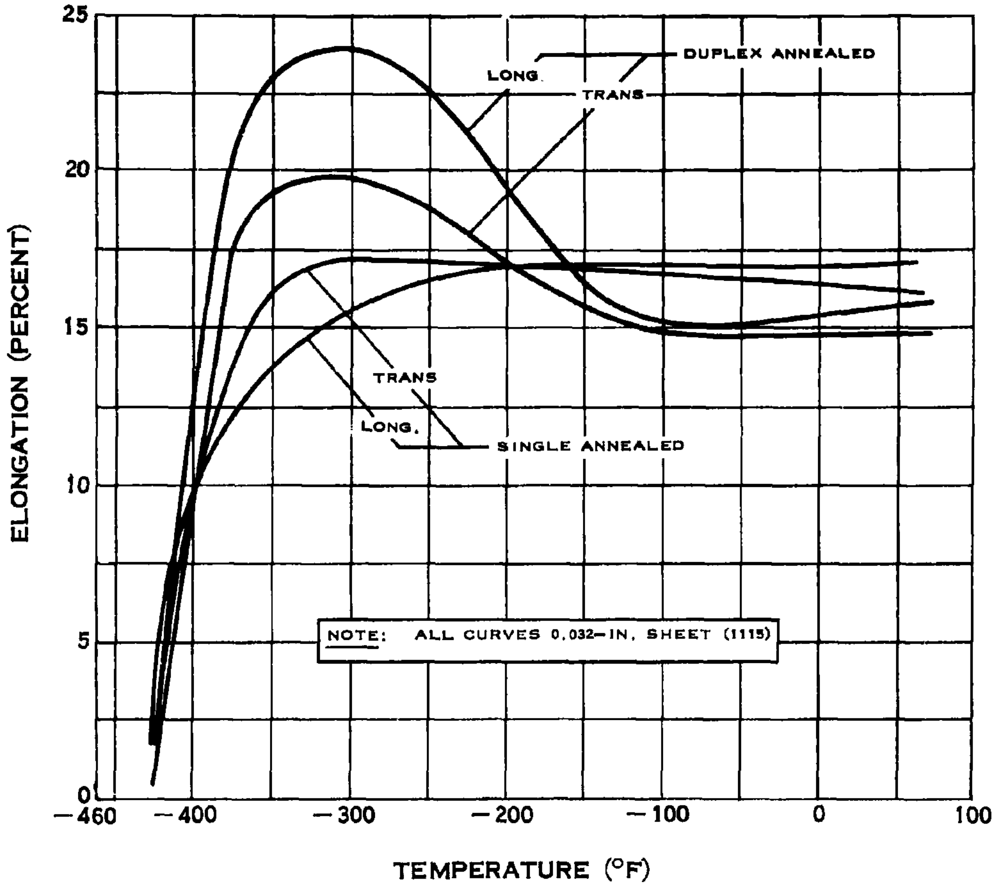
TENSILE STRENGTH OF 8AL-1MO-1V TITANIUM

F.4.b-3



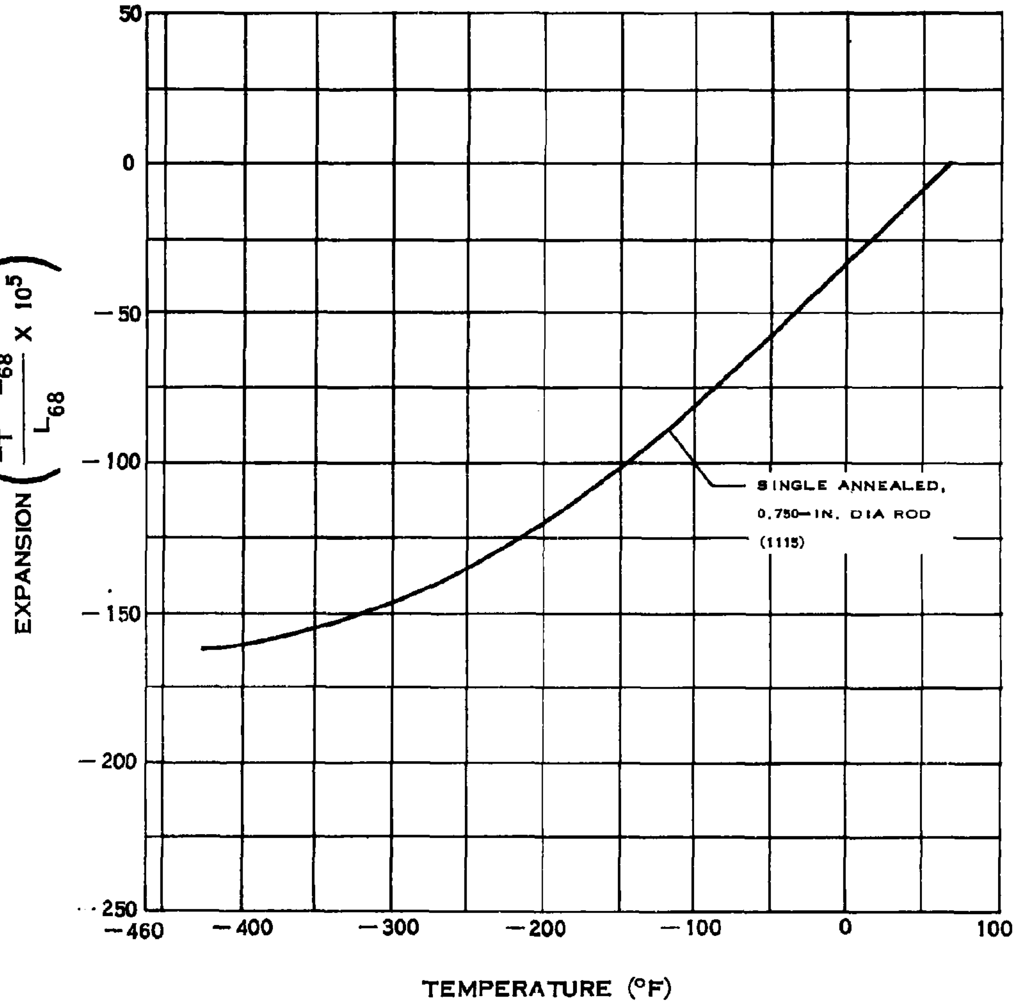
WELD TENSILE STRENGTH OF 8AL-1MO-1V TITANIUM

F.4.c



ELONGATION OF 8AL-1MO-1V TITANIUM

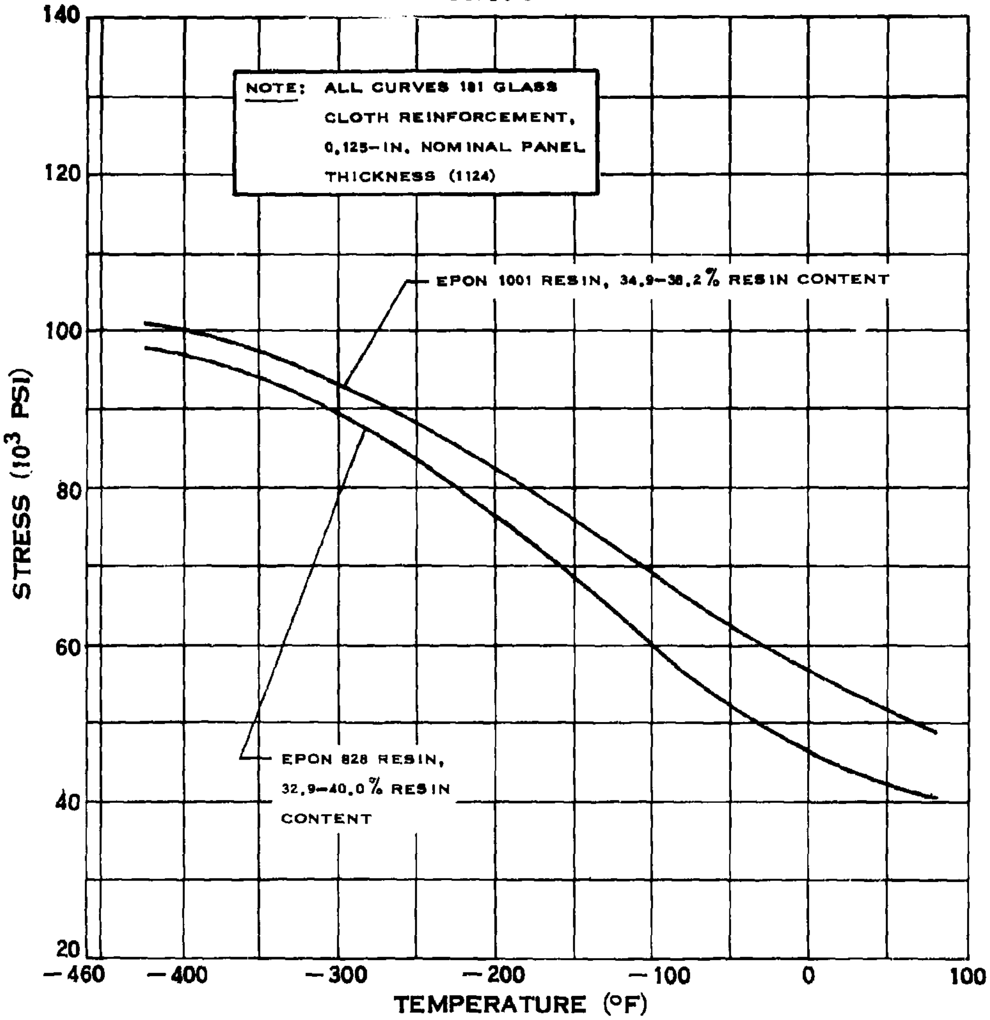
F.4.p



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

1-15-64

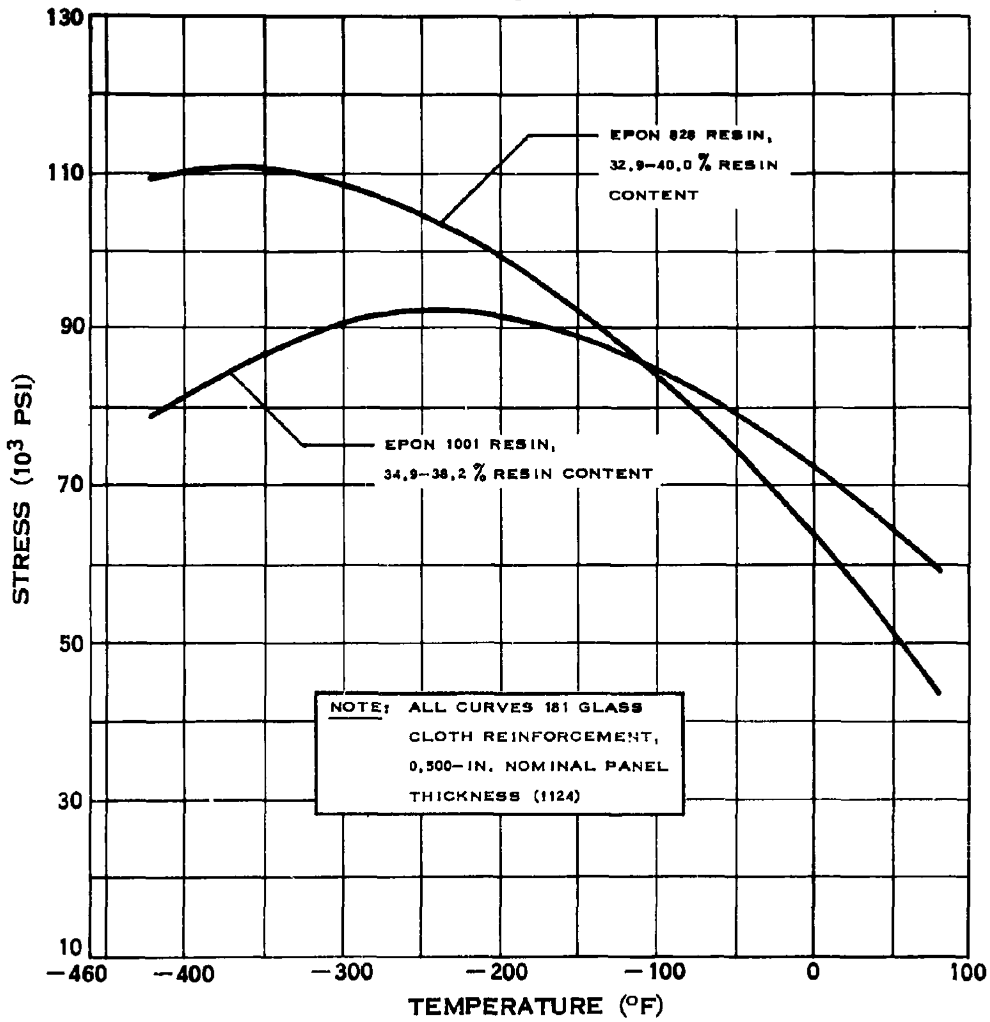
H.6.b



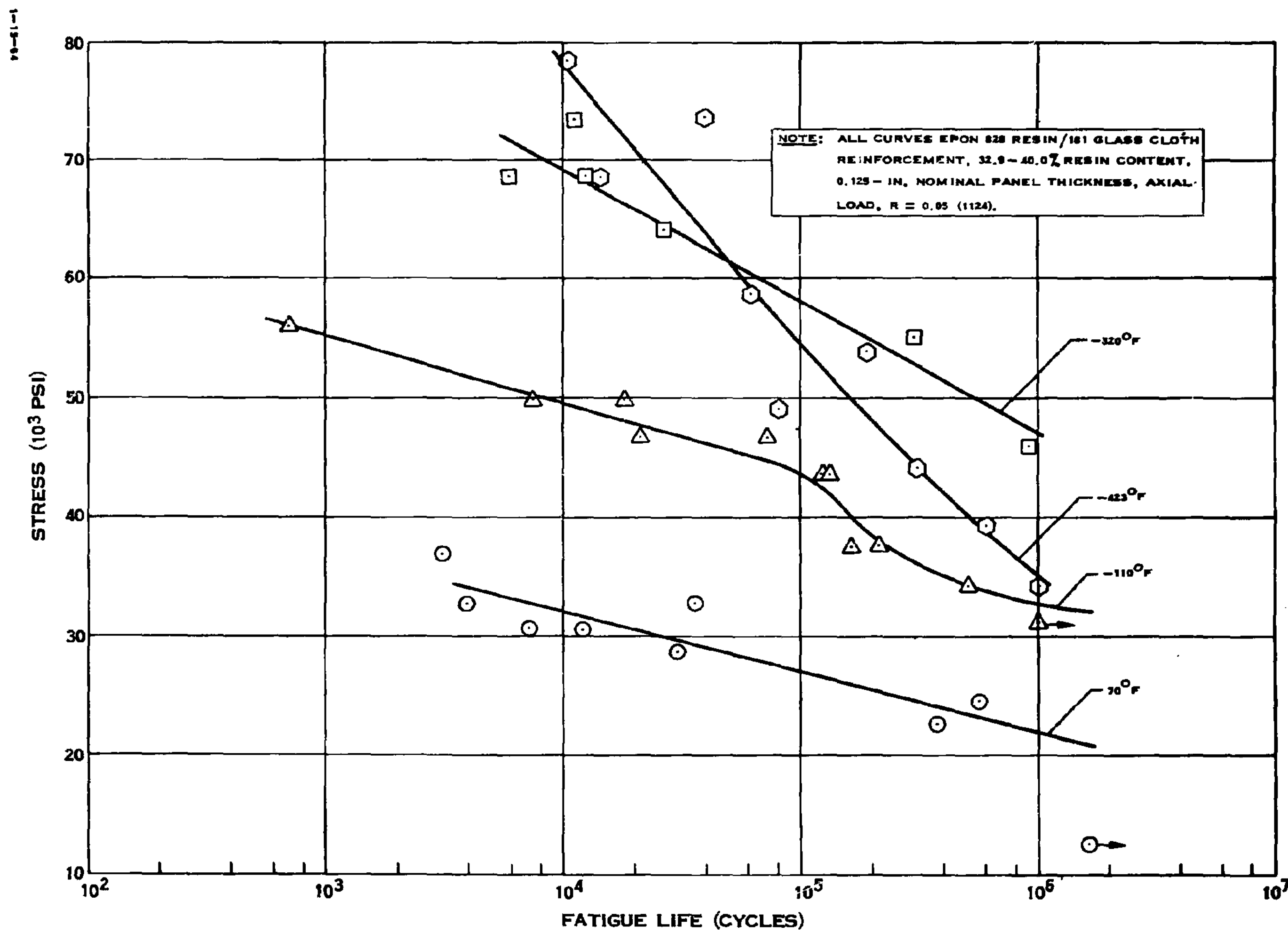
TENSILE STRENGTH OF EPOXY – FIBERGLASS LAMINATE

1–15–64

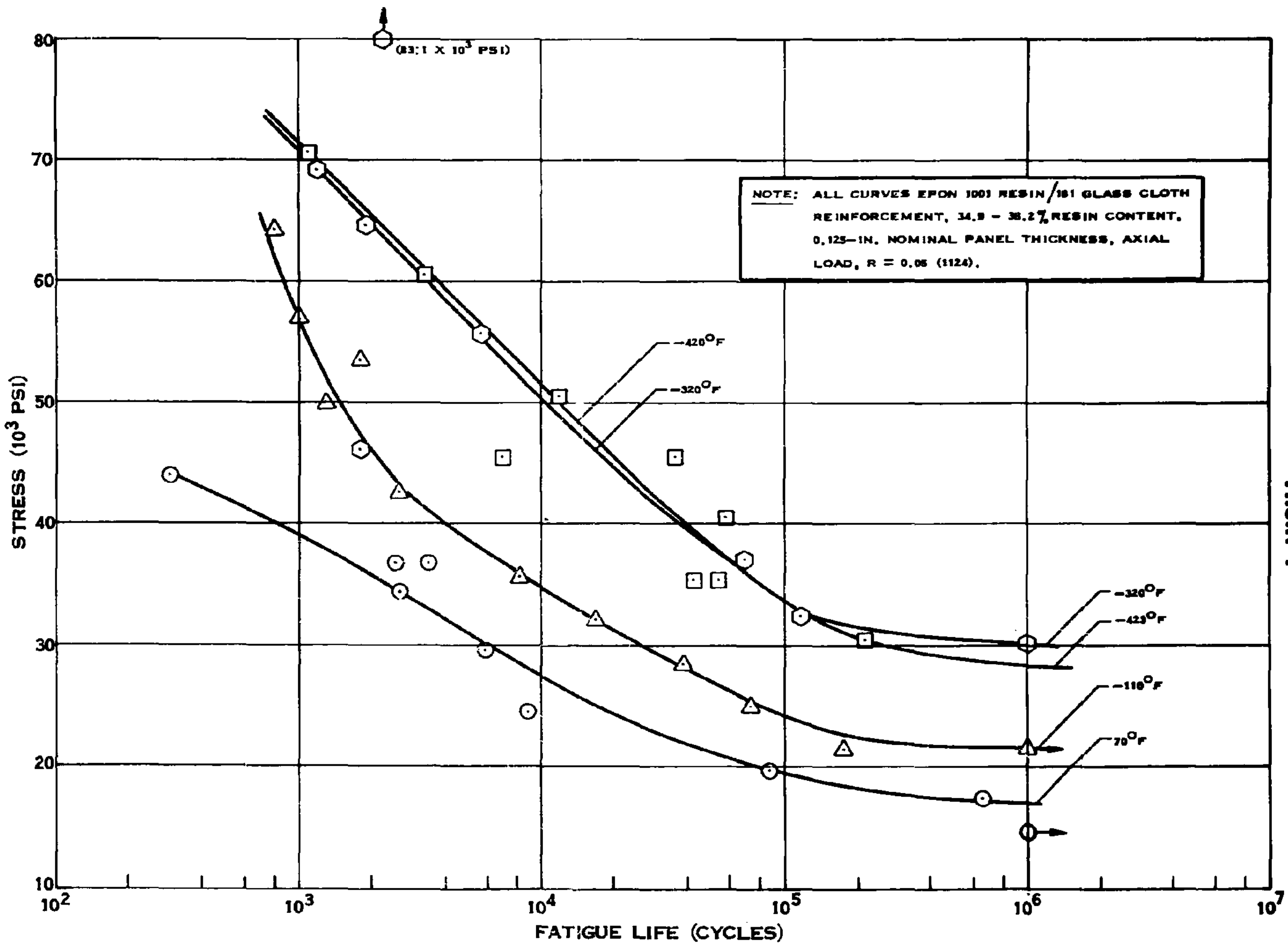
H.6.j



COMPRESSIVE STRENGTH OF EPOXY – FIBERGLASS LAMINATE



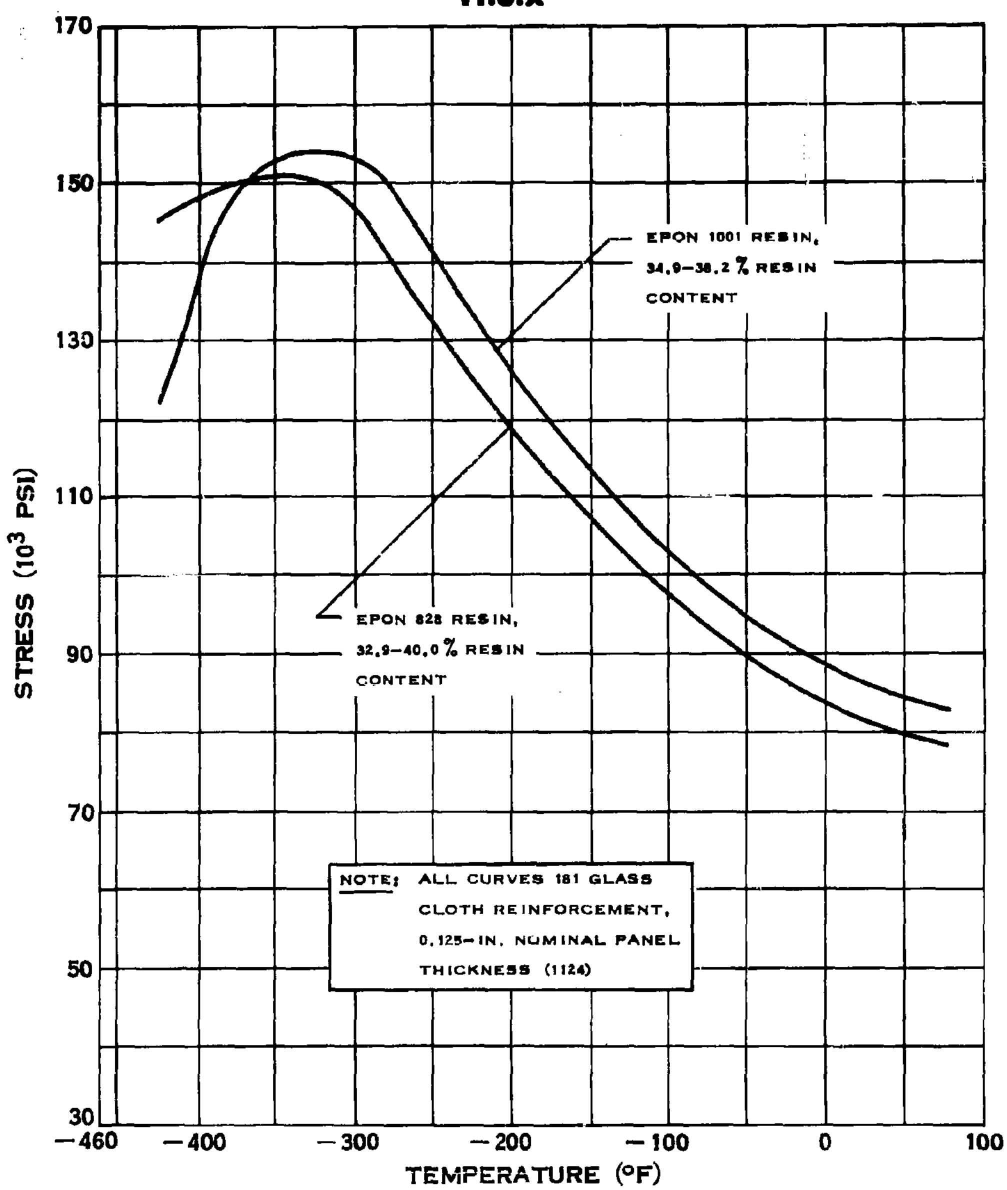
FATIGUE STRENGTH OF EPOXY-FIBERGLAS LAMINATE



FATIGUE STRENGTH OF EPOXY-FIBERGLAS LAMINATE

1-15-64

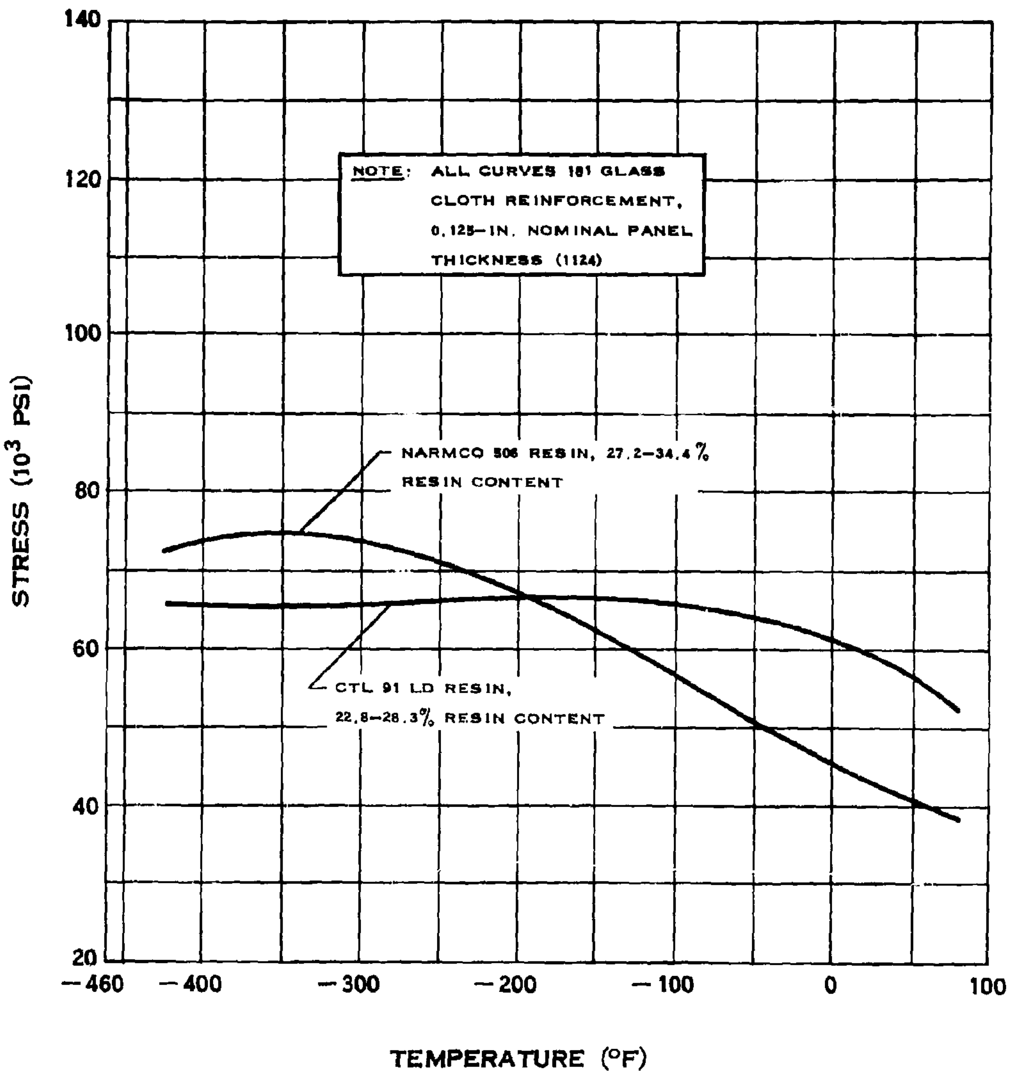
H.6.x



FLEXURAL STRENGTH OF EPOXY – FIBERGLAS LAMINATE

1−15−64

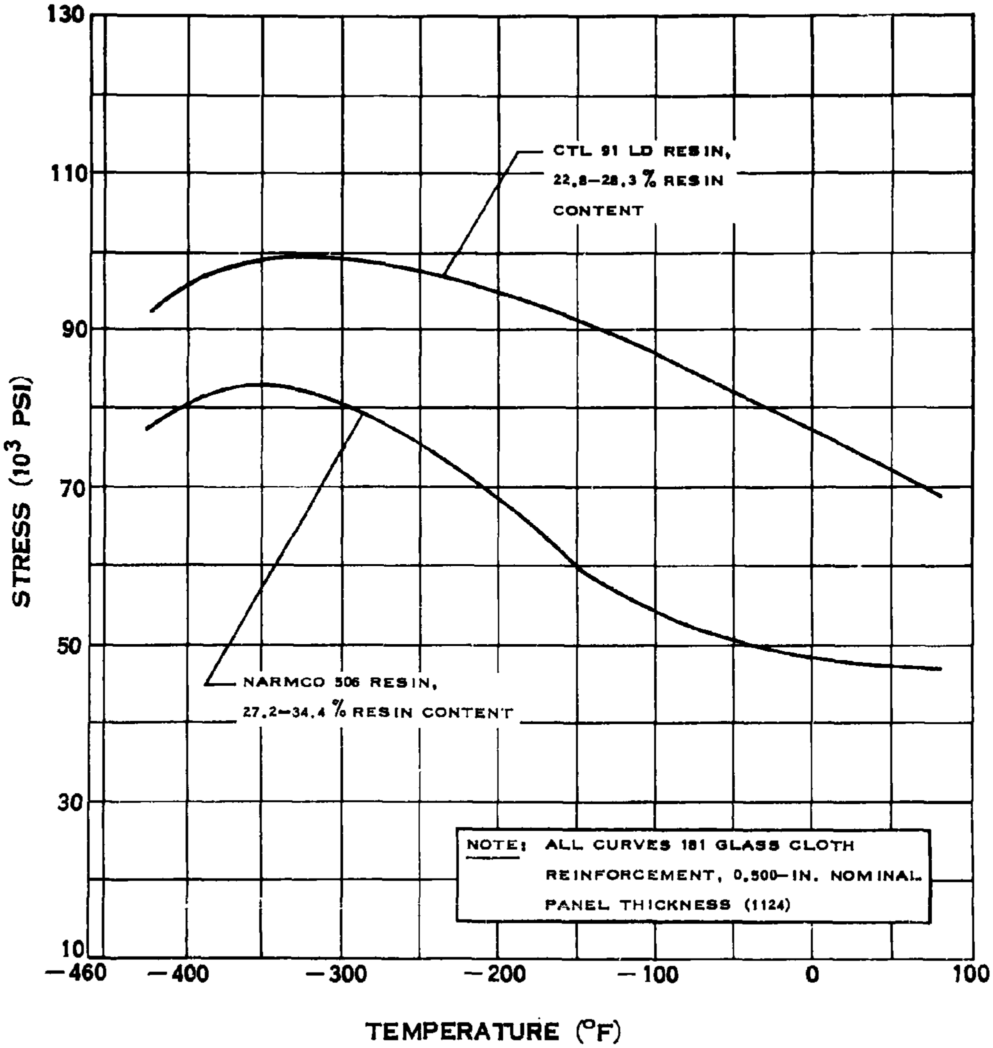
H.7.b



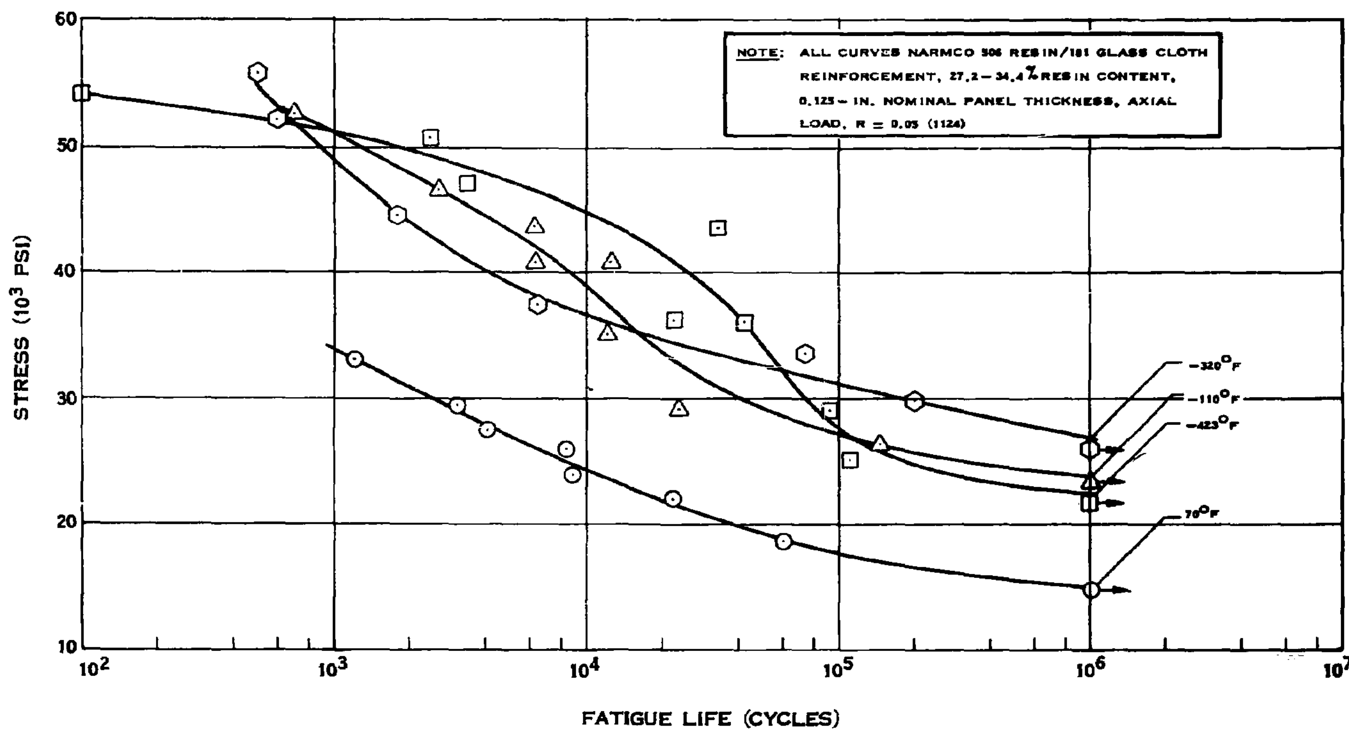
TENSILE STRENGTH OF PHENOLIC – FIBERGLAS LAMINATE

1–15–64

H.7.j

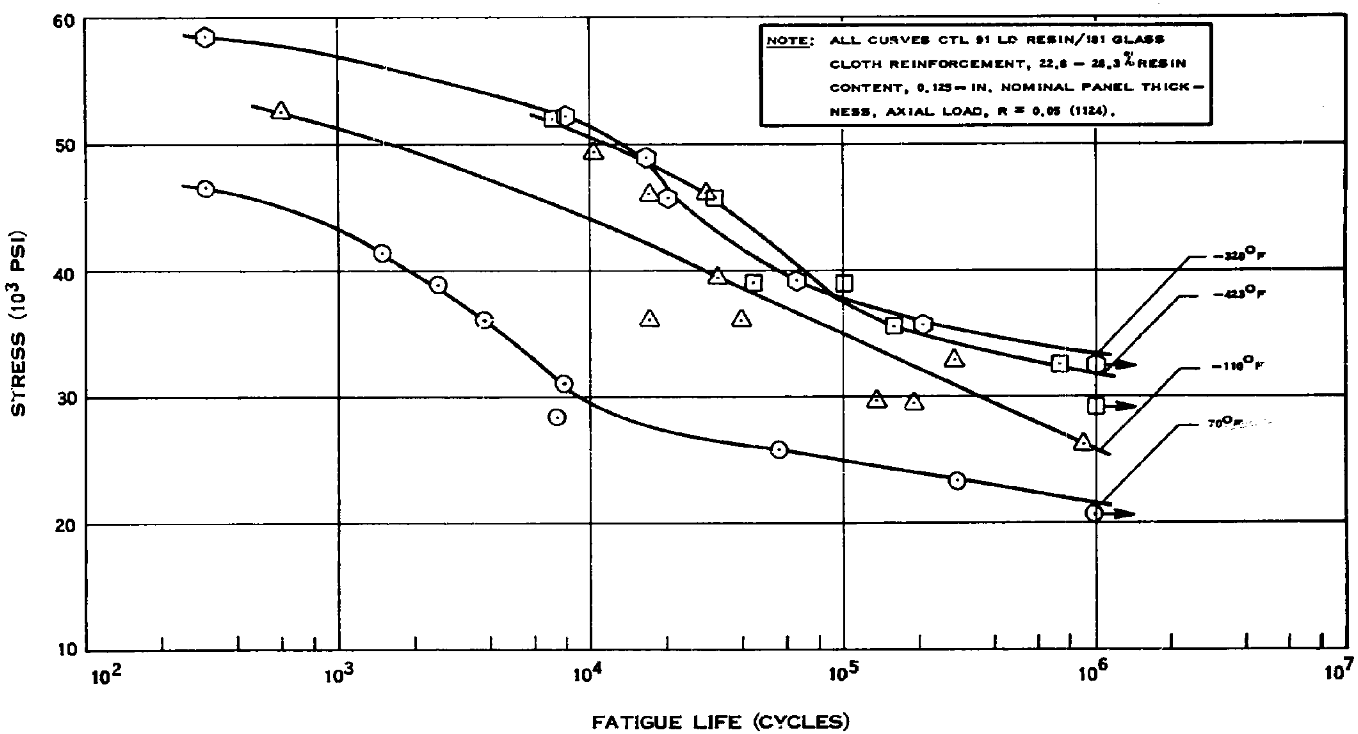


COMPRESSIVE STRENGTH OF PHENOLIC – FIBERGLASS LAMINATE

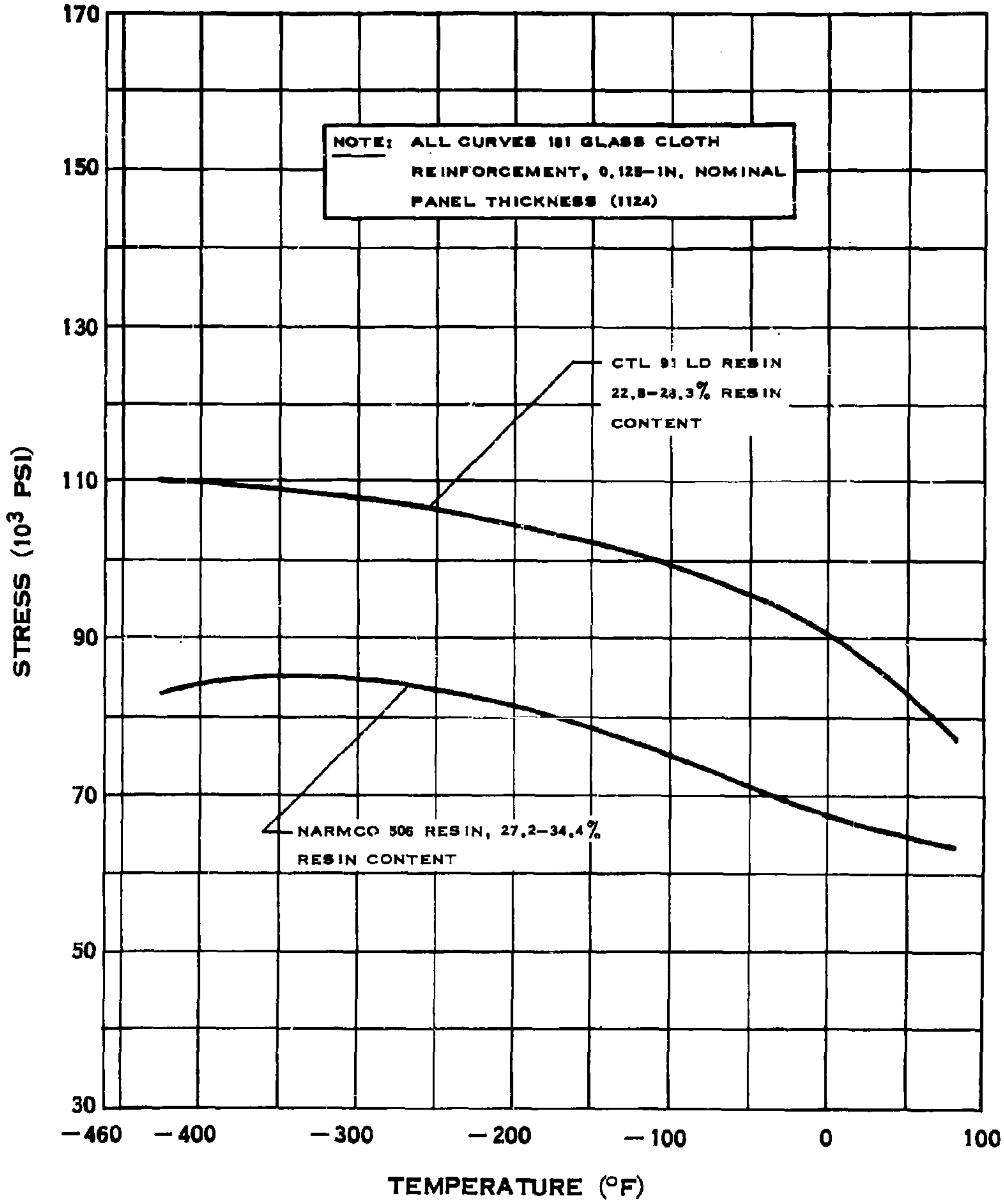


FATIGUE STRENGTH OF PHENOLIC-FIBERGLASS LAMINATE

1-15-64



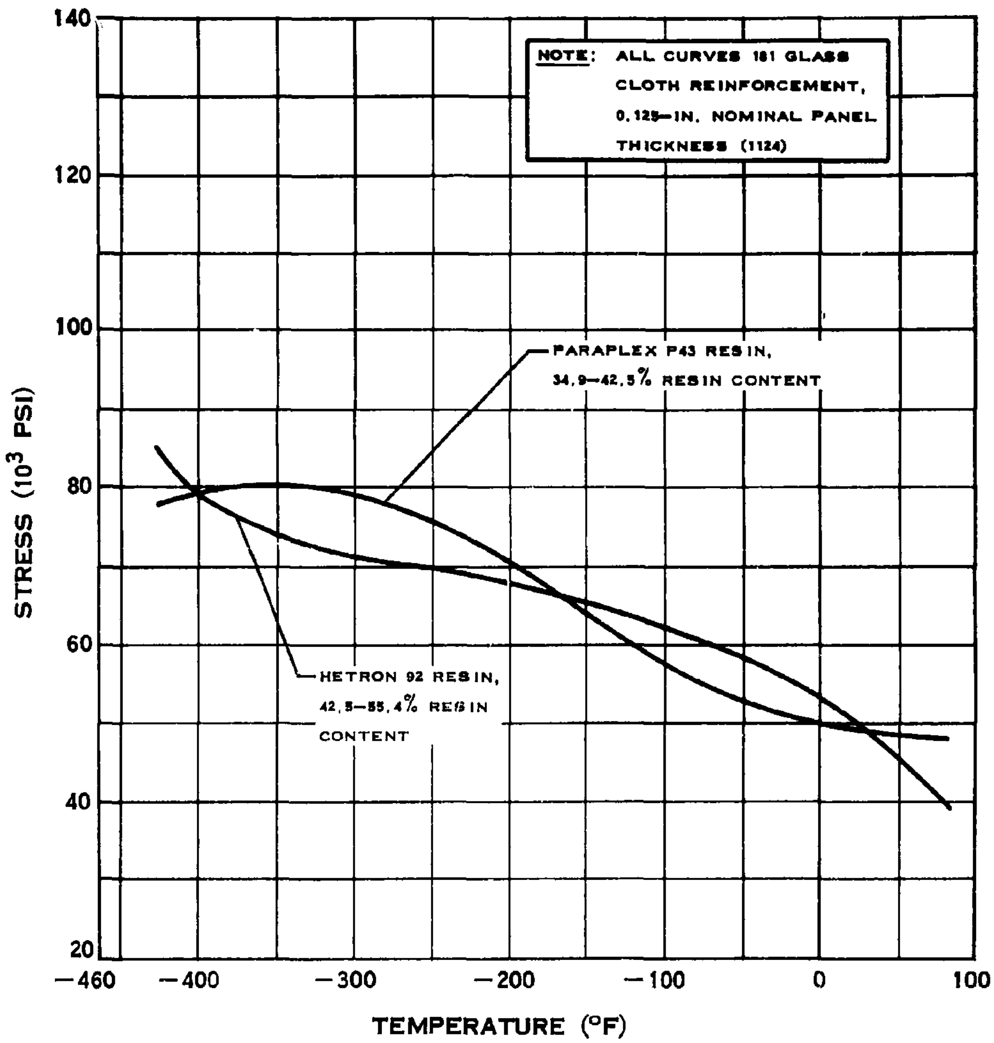
FATIGUE STRENGTH OF PHENOLIC-FIBERGLAS LAMINATE



FLEXURAL STRENGTH OF PHENOLIC – FIBERGLAS LAMINATE

1-15-64

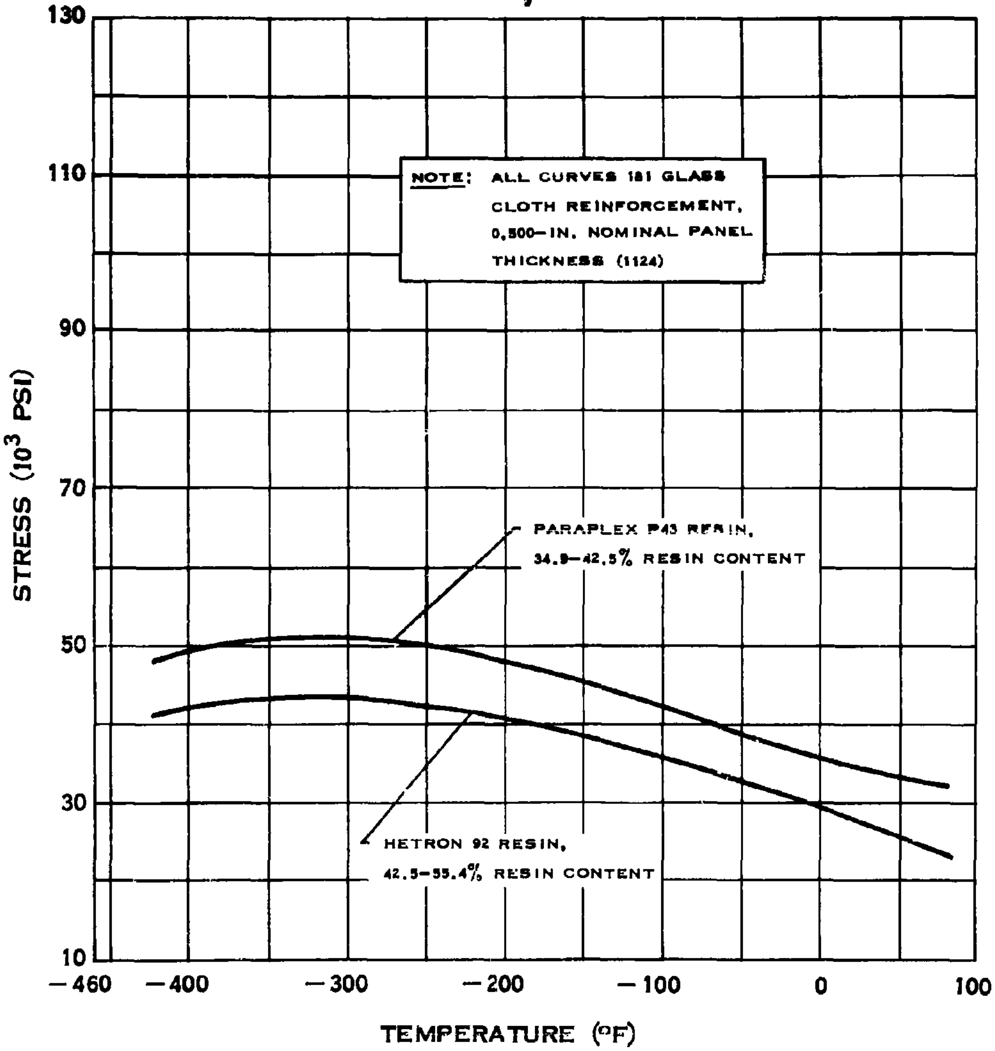
H.8.b



TENSILE STRENGTH OF POLYESTER - FIBERGLAS LAMINATE

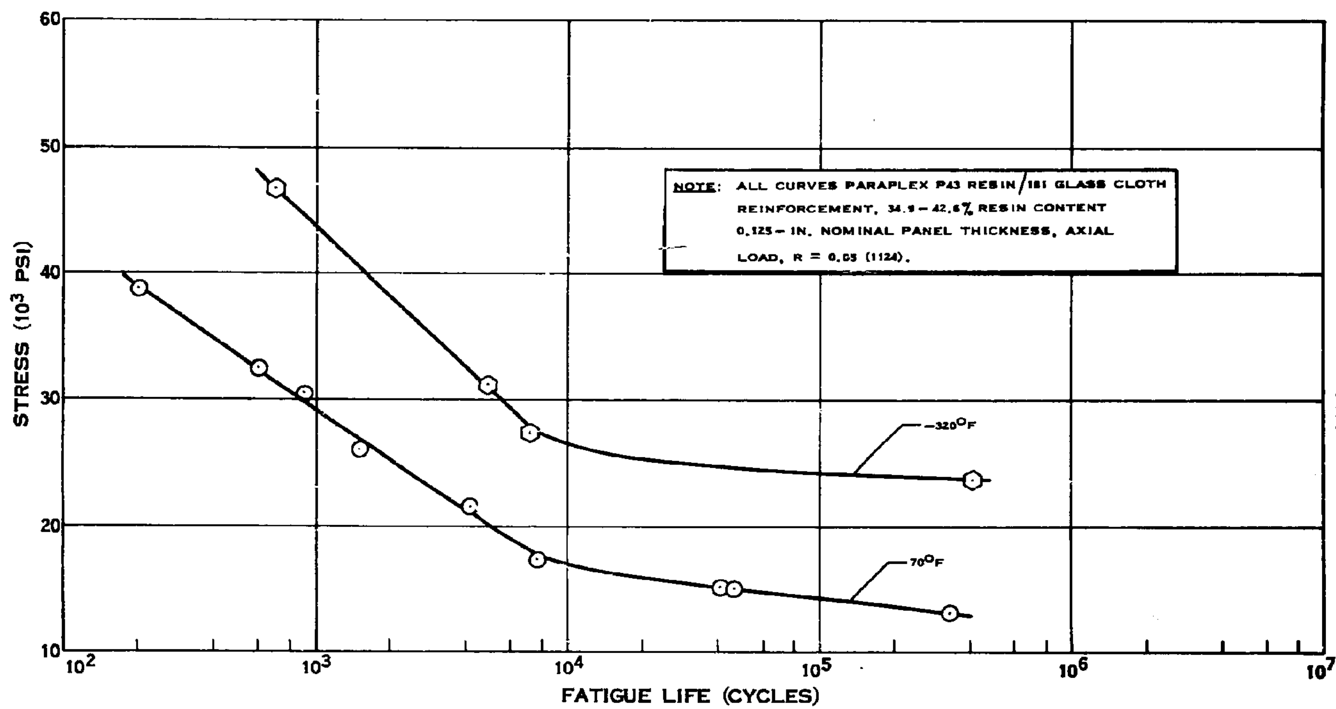
1-15-64

H.8.j



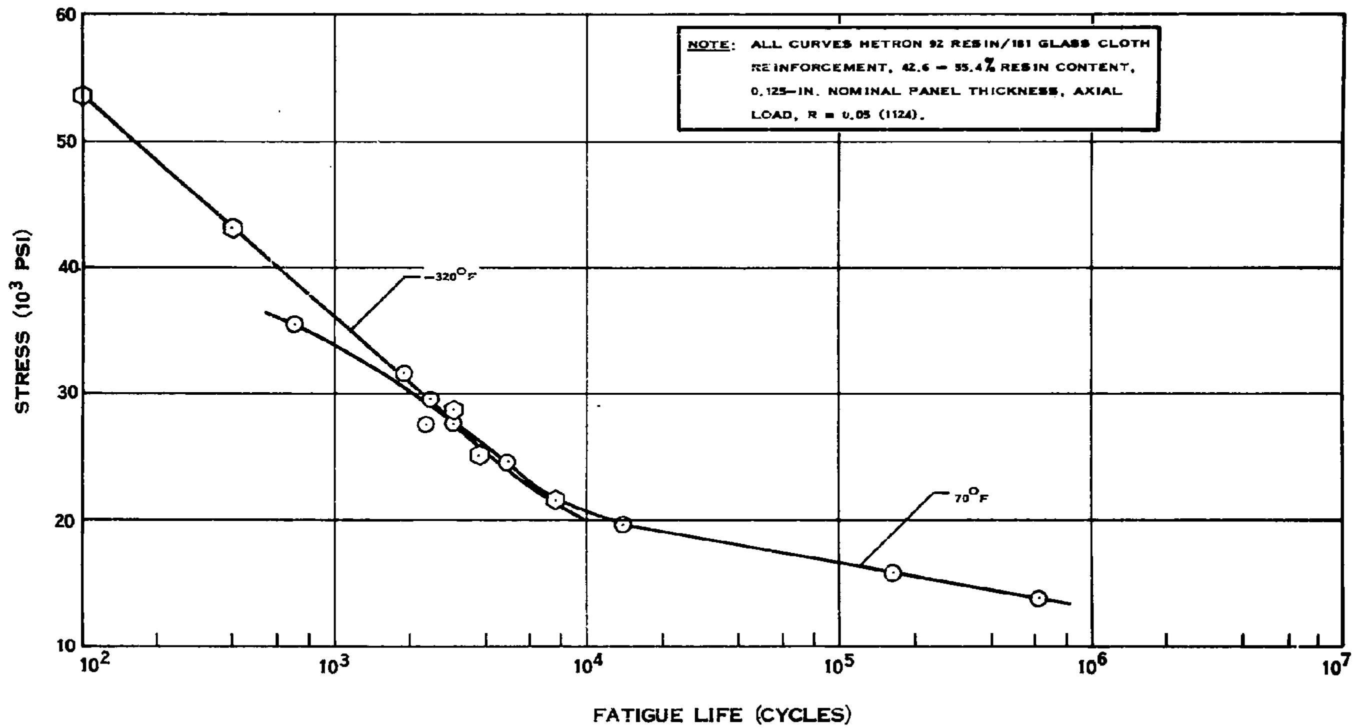
COMPRESSIVE STRENGTH OF POLYESTER - FIBERGLAS LAMINATE

1-15-64



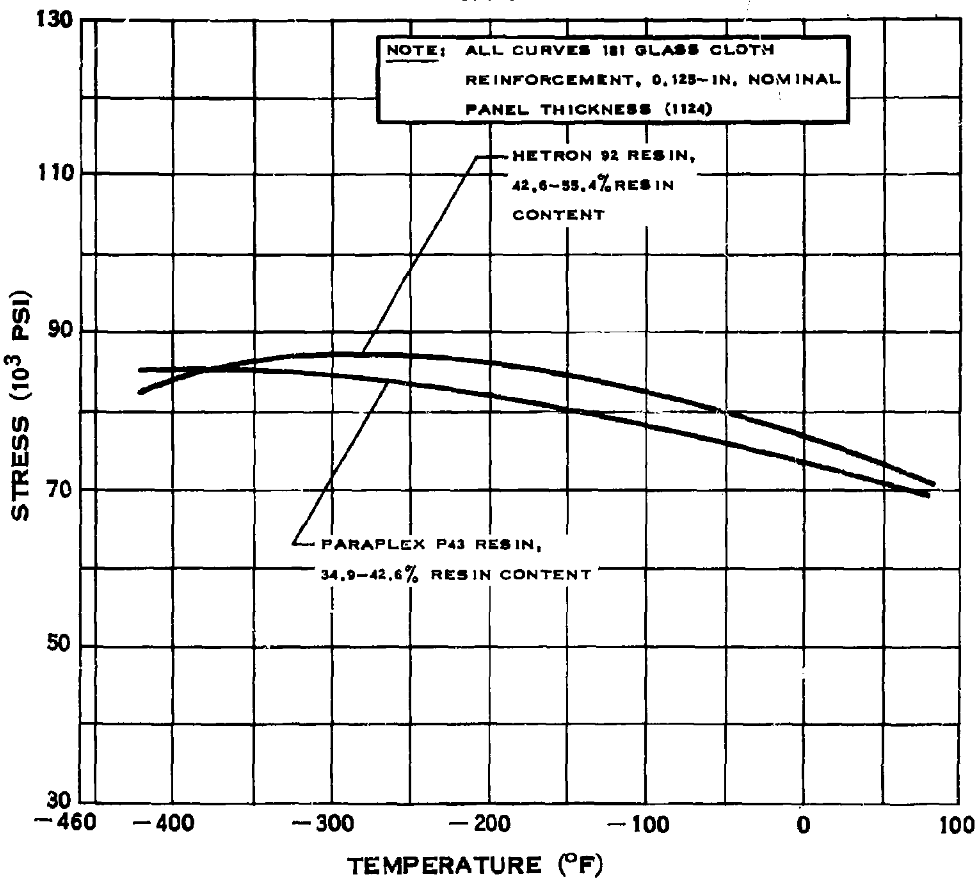
FATIGUE STRENGTH OF POLYESTER-FIBERGLAS LAMINATE

1–15–64



FATIGUE STRENGTH OF POLYESTER-FIBERGLAS LAMINATE

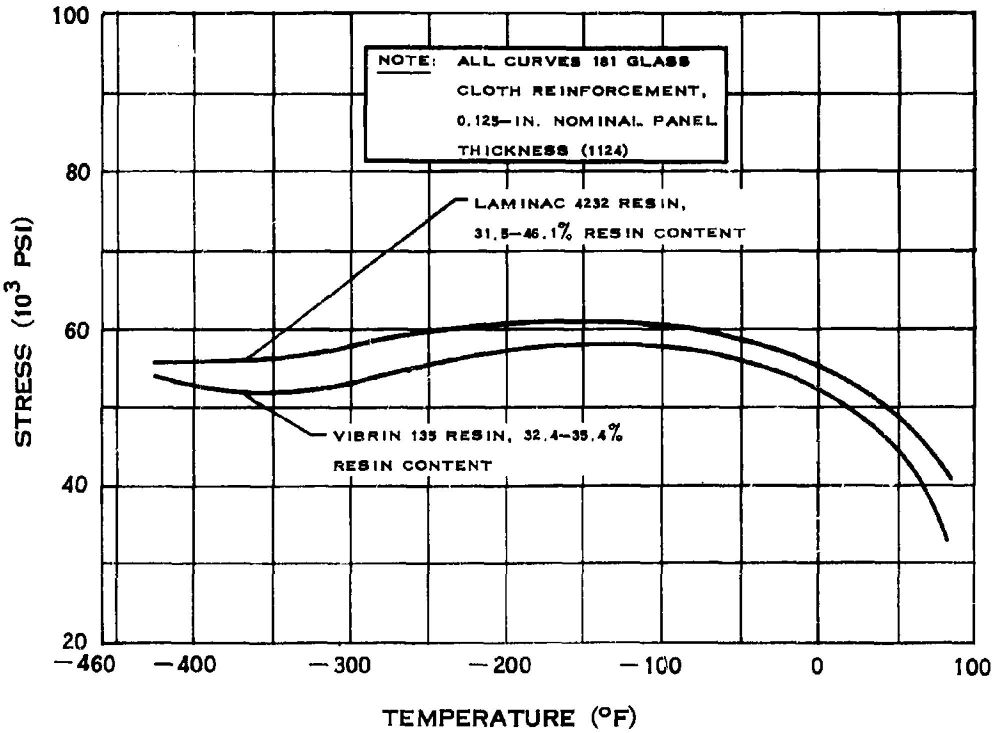
H.8.x



FLEXURAL STRENGTH OF POLYESTER - FIBERGLAS LAMINATE

1-15-64

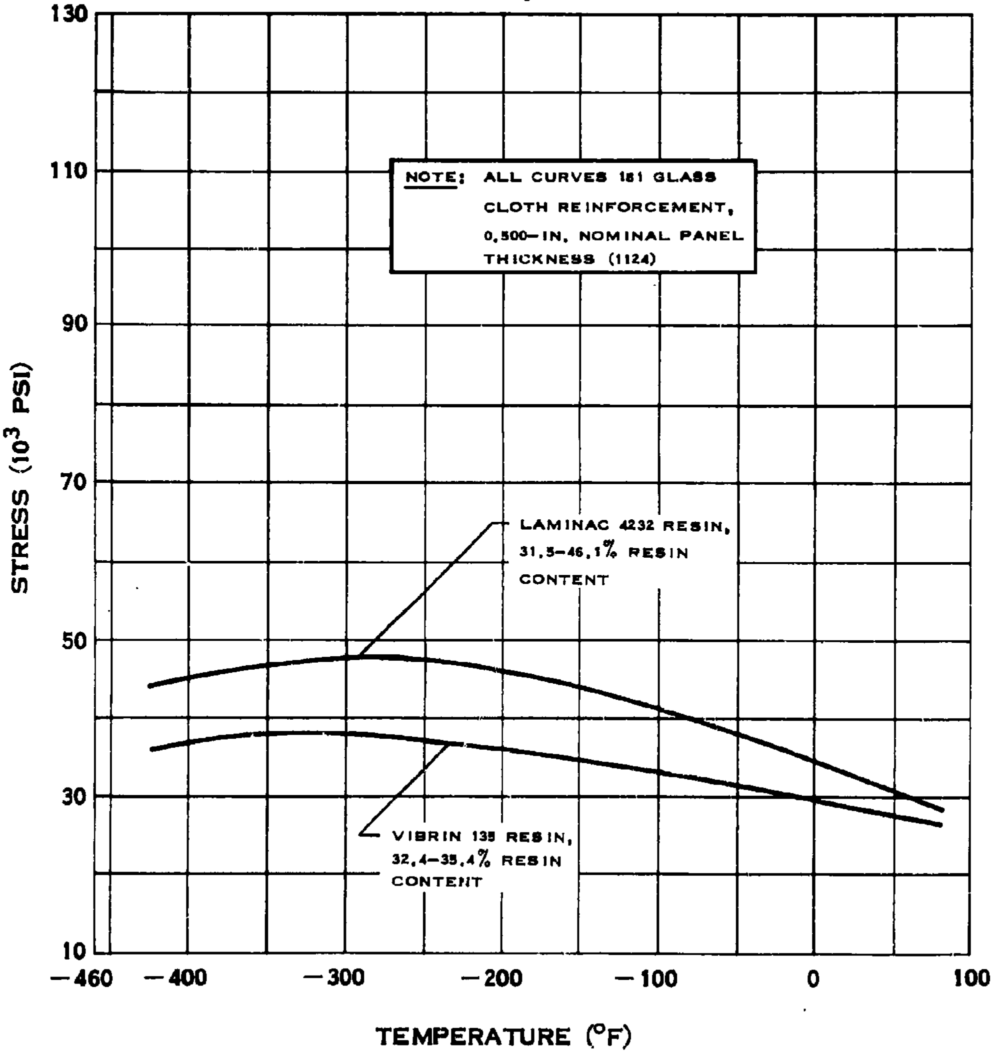
H.9.b



TENSILE STRENGTH OF HIGH TEMPERATURE POLYESTER – FIBERGLAS LAMINATE

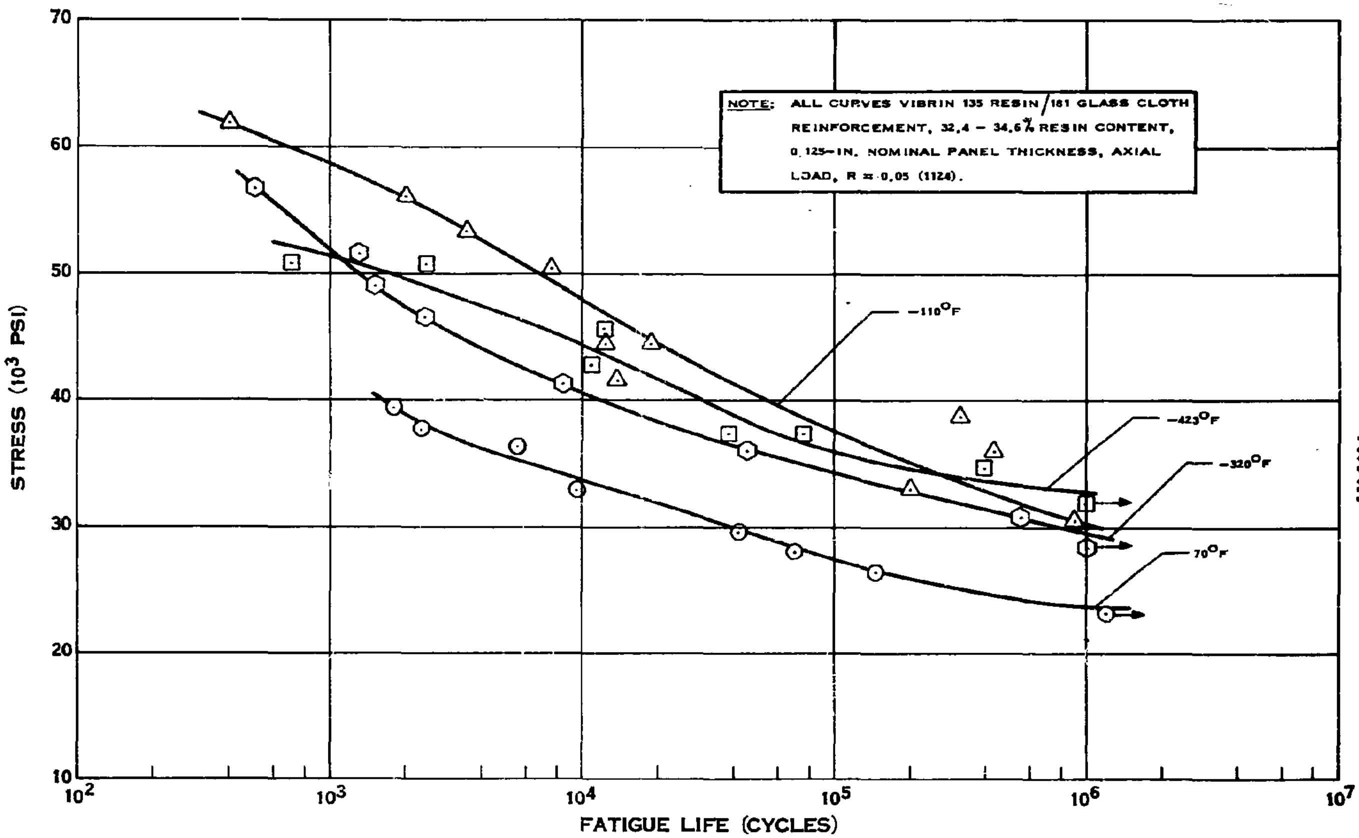
1–15–64

H.9.j



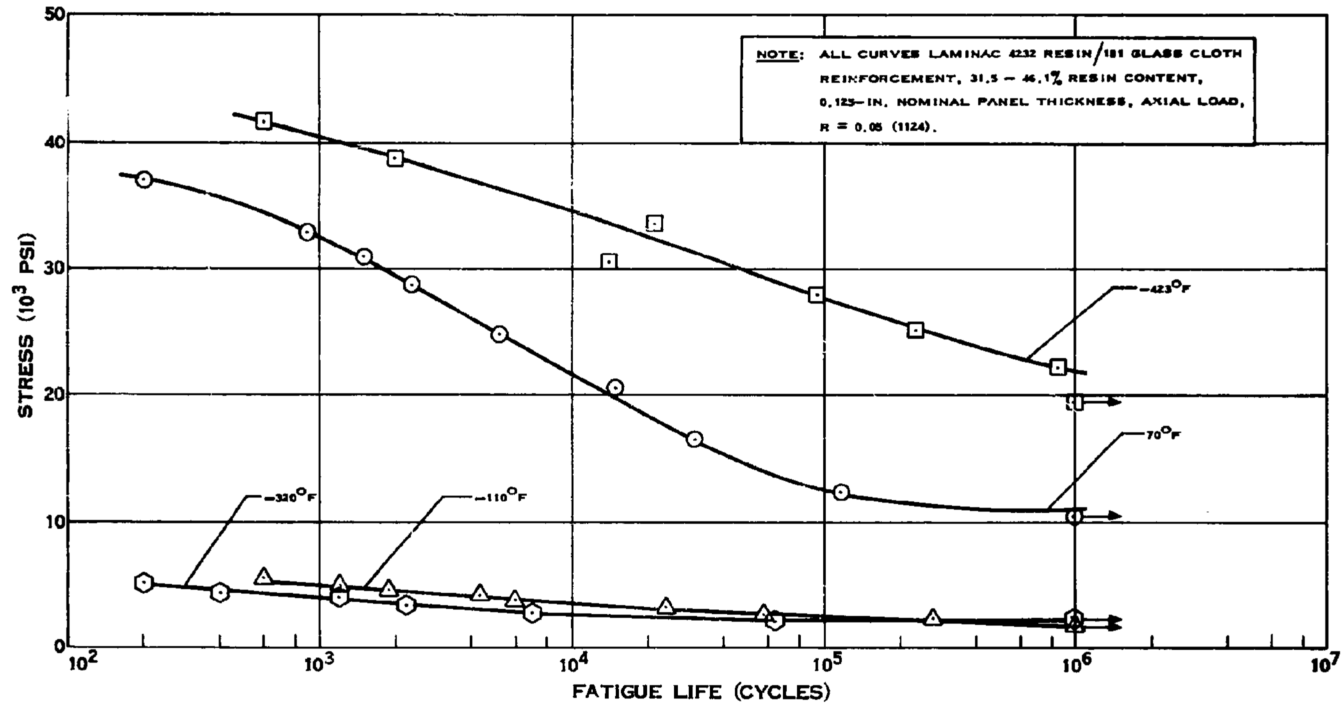
COMPRESSIVE STRENGTH OF HIGH TEMPERATURE POLYESTER - FIBERGLAS LAMINATE

1-15-64

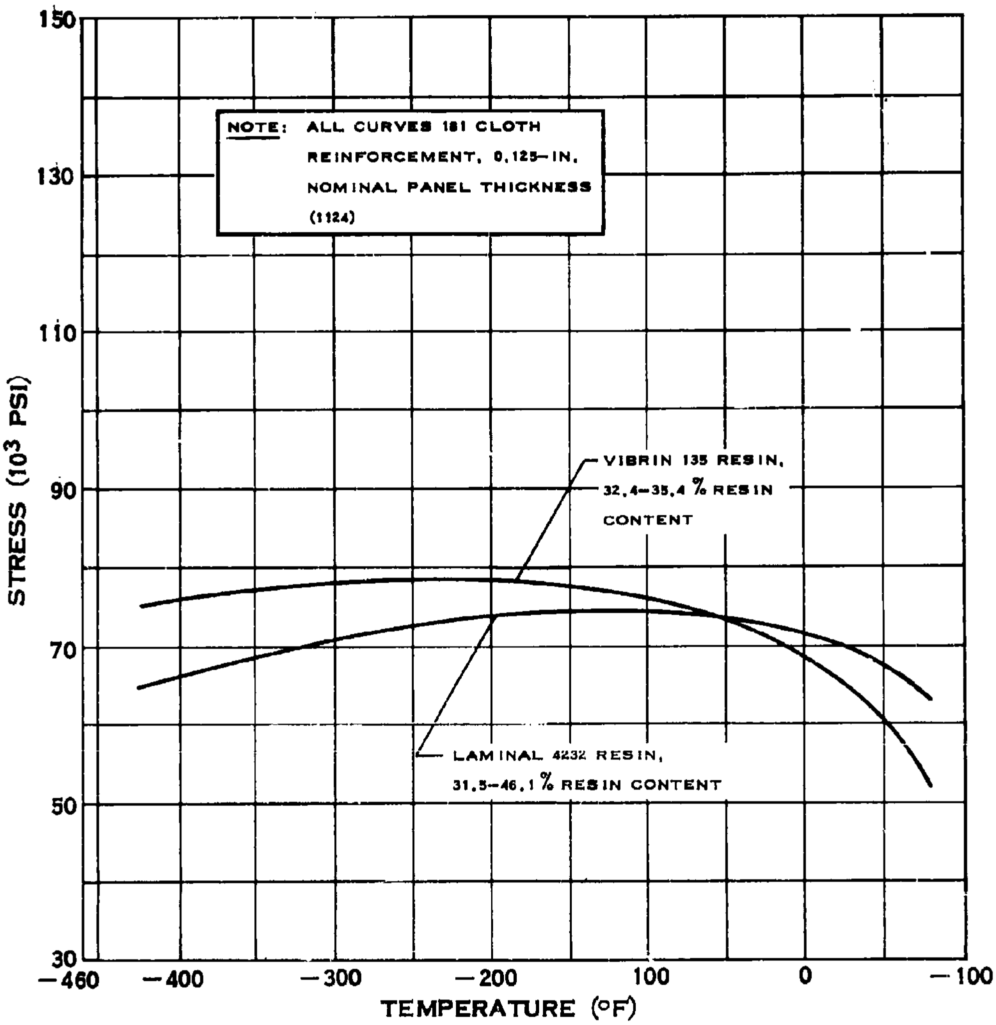


FATIGUE STRENGTH OF HIGH TEMPERATURE POLYESTER-FIBERGLAS LAMINATE

1-15-64

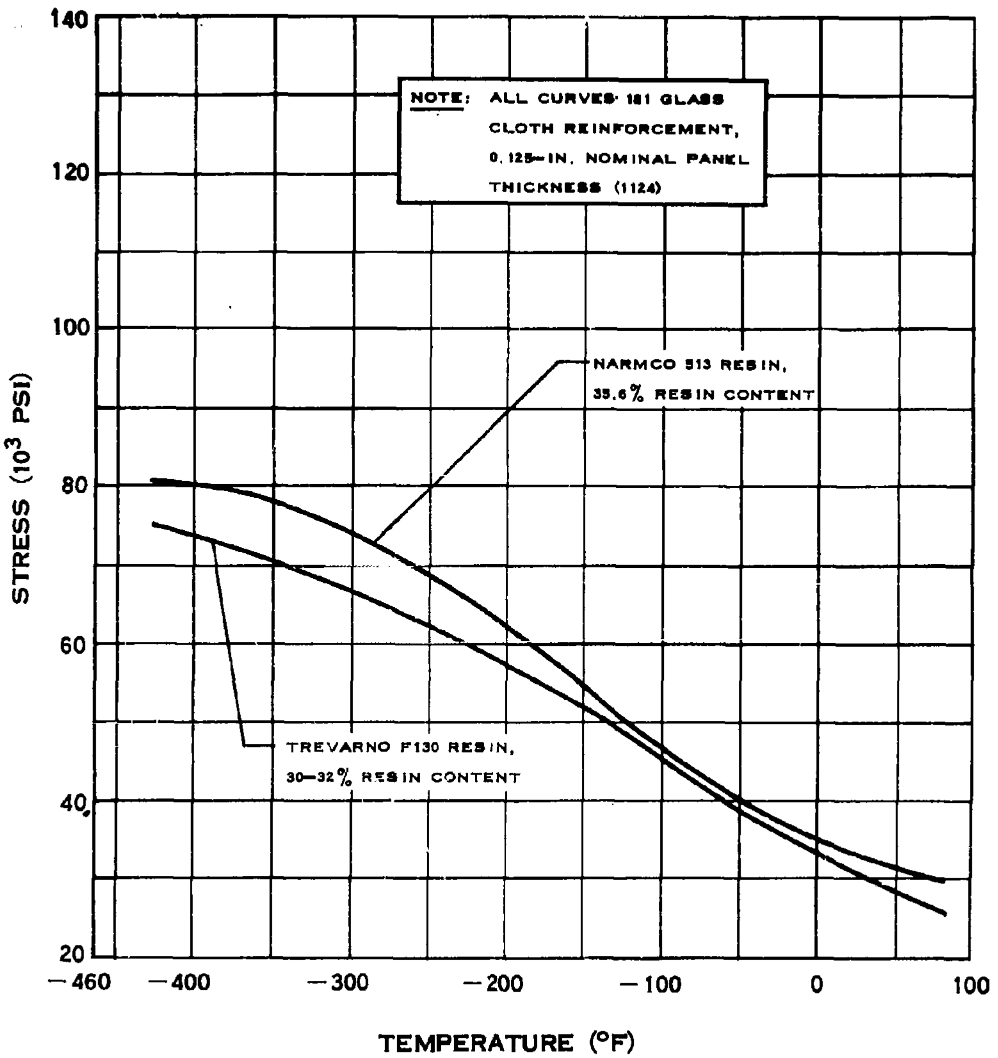


FATIGUE STRENGTH OF HIGH TEMPERATURE POLYESTER-FIBERGLAS LAMINATE



FLEXURAL STRENGTH OF HIGH TEMPERATURE POLYESTER – FIBERGLASS LAMINATE

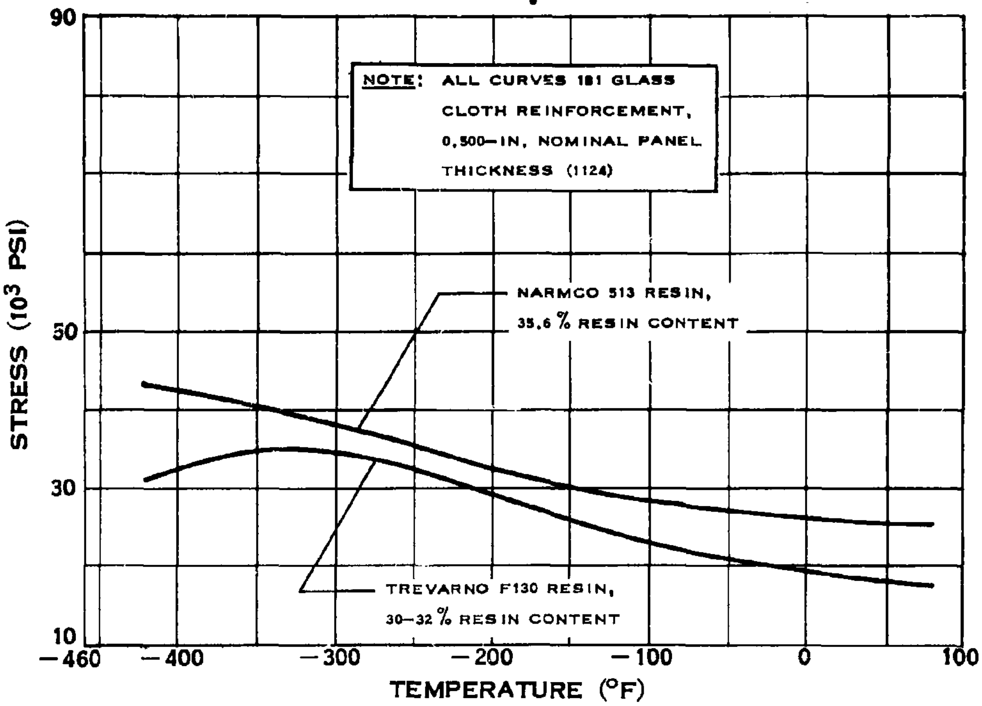
H.10.b



TENSILE STRENGTH OF SILICONE – FIBERGLAS LAMINATE

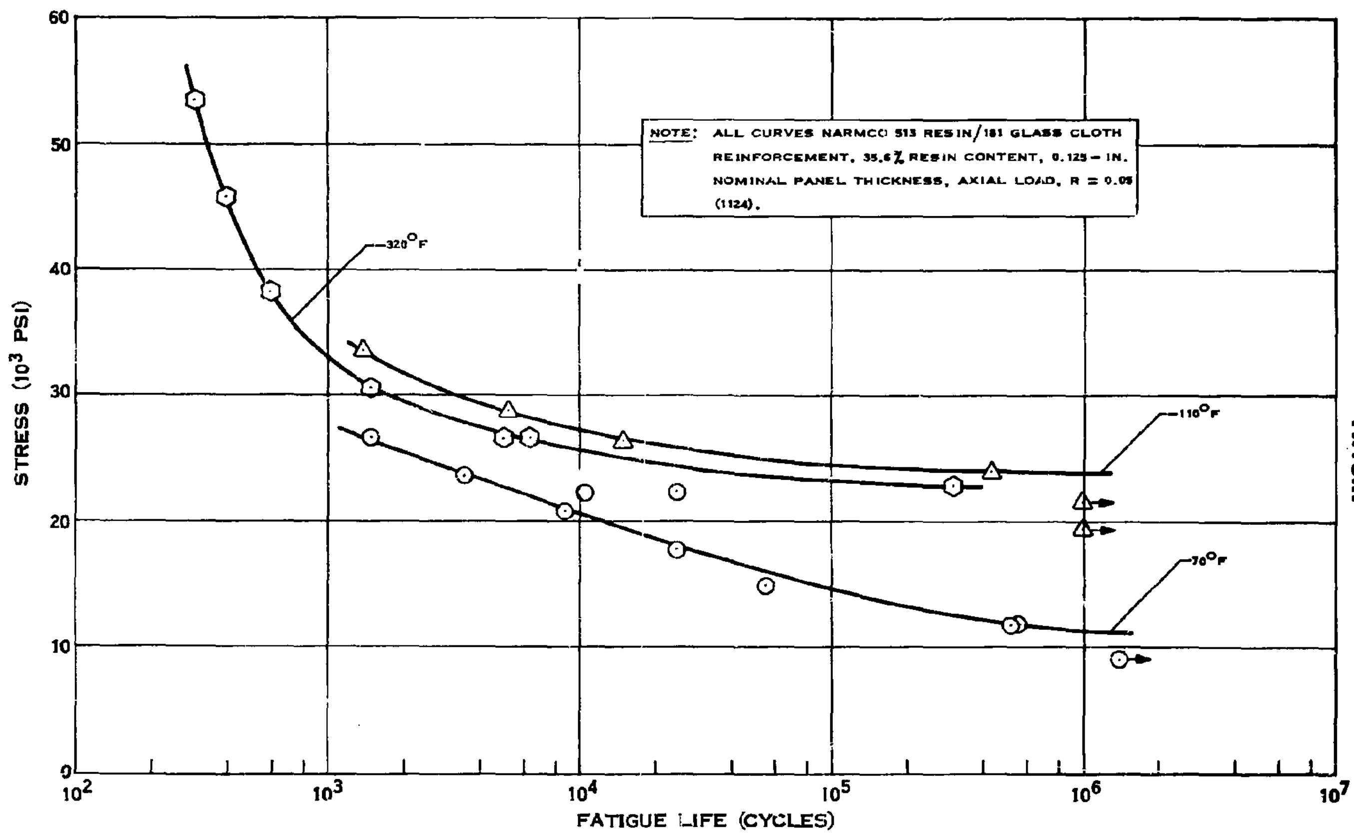
1—15—64

H.10.j



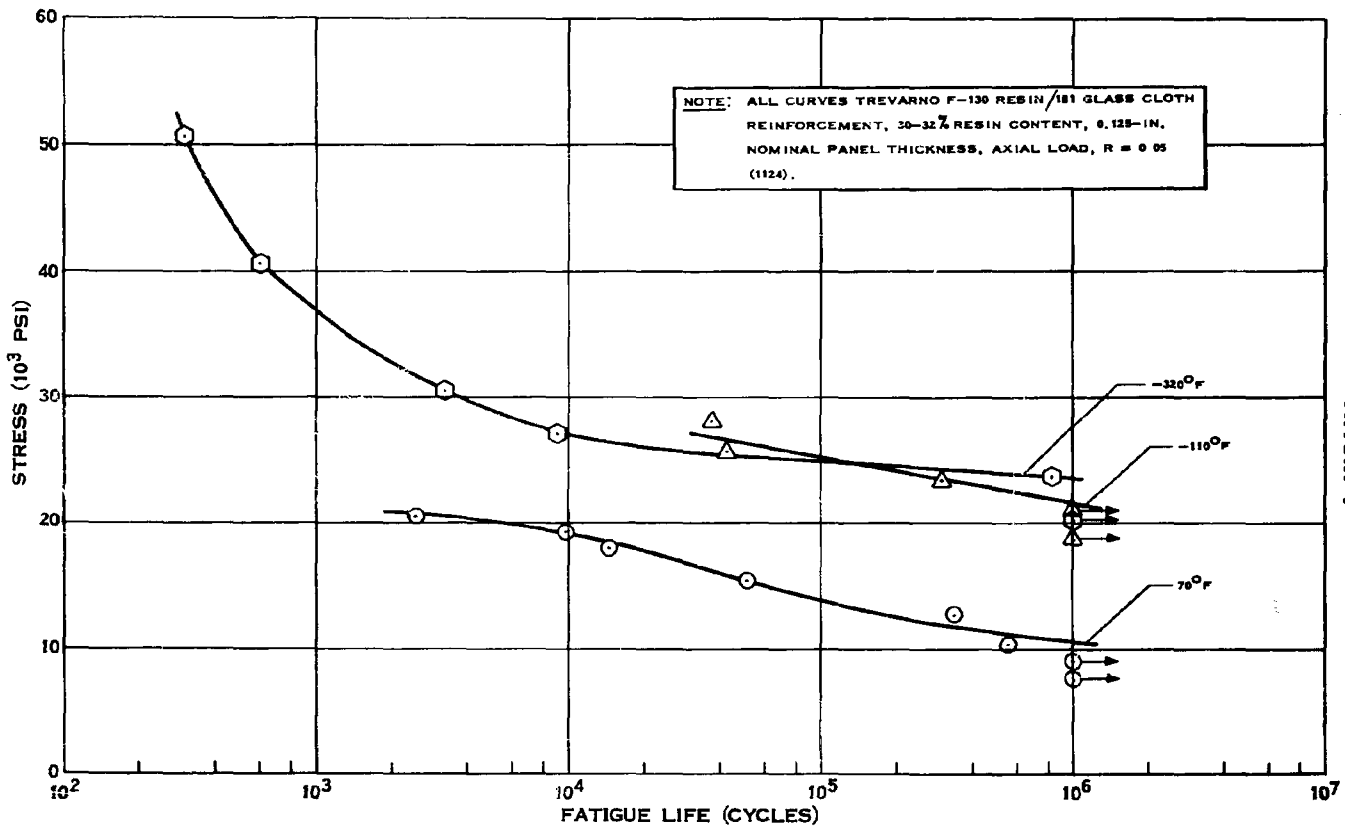
COMPRESSIVE STRENGTH OF SILICONE - FIBERGLASS LAMINATE

1-15-64



FATIGUE STRENGTH OF SILICONE-FIBERGLAS LAMINATE

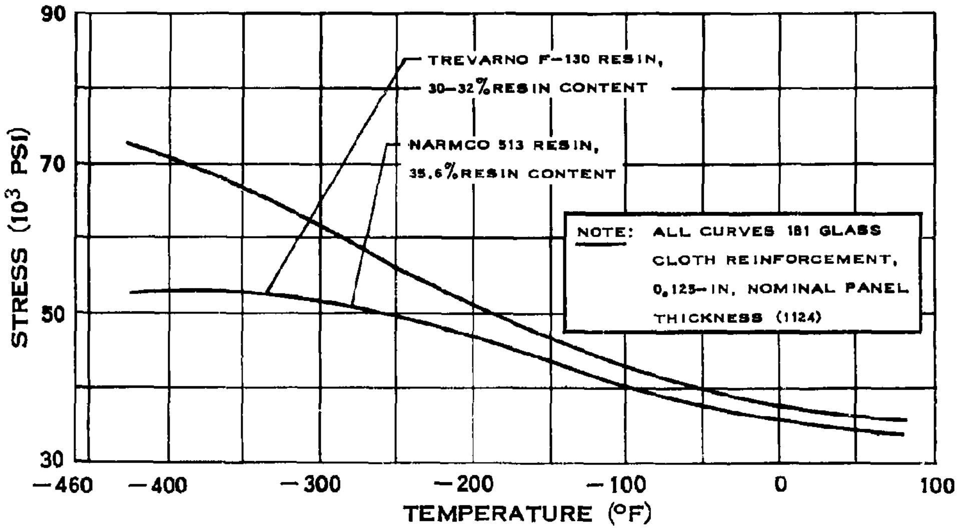
1-15-64



FATIGUE STRENGTH OF SILICONE-FIBERGLAS LAMINATE

1-15-64

H.10.x



FLEXURAL STRENGTH OF SILICONE - FIBERGLAS LAMINATE

1-15-64

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