CRYOGENIC MATERIALS DATA HANDBOOK

VOLUME I
SECTIONS A, B, C

TECHNICAL DOCUMENTARY REPORT
AFML-TDR-64-280
(REVISED 1970)

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CRYOGENIC MATERIALS DATA HANDBOOK

VOLUME I
SECTIONS A, B, C

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MARTIN MARIETTA CORPORATION
COMPILER
M. KNIGHT
AIR FORCE MATERIALS LABORATORY

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FOREWORD

This report is a compilation of several reports that were prepared by the Martin Marietta Corporation, Denver Division, Denver, Colorado, under several Air Force Contracts between 1964 and 1968. These contracts were initiated under Project 7381 "Materials Application", Task 738106 Engineering and Design Data. The contracts were administered under the Air Force Materials Laboratory, with Mr. Marvin Knight acting as Project Engineer.

Mr. Knight also performed the compilation that resulted in this report.

Fred R. Schwartzberg was the Martin Marietta Program Manager, and Richard G. Herzog was Project Engineer. Other Martin Marietta personnel that assisted during the last contract were Samuel H. Osgood, responsible for data acquisition and presentation, and Mrs. Carol Bryant assisted with data acquisition.

This manuscript was released by Mr. Knight, July 1968 for publication as an RTD Technical Report.

This technical report has been reviewed and is approved.

A. OLEVITCH
Chief, Materials Engineering Branch
Materials Support Division
Air Force Materials Laboratory
ABSTRACT

The "Cryogenic Materials Data Handbook" contains mechanical and physical property data and information on 86 metallic and non-metallic materials, organized in eleven sections. The Handbook also contains Material, Property and Cumulative indices and a complete list of references.
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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 progress report in which data represented by the coordinates was issued, as follows: 1 = MIL-TDR-64-280 (Basic Handbook); 3 = Supplement No. 3; 4 = Supplement No. 4; 5 = Supplement No. 5; and 6 = Supplement No. 6.
The revision of the Cryogenic Materials Data Handbook was prepared under Air Force Contract AF33(657)-9161. The original handbook of mechanical and physical properties of metallic and nonmetallic materials at cryogenic temperatures was prepared under the sponsorship of the Air Force Ballistic Missile Division by personnel of the Cryogenic Engineering Laboratories, National Bureau of Standards, Boulder, Colorado. During the performance of this work, the responsibility of 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 for continuing the generation, assimilation, and presentation of data for the Handbook was awarded to the Martin Marietta Corporation, Denver Division, in June 1962. The twelfth, thirteenth, and fourteenth progress reports were issued by Martin Marietta on a semiannual basis.

The revised edition of the handbook, which supersedes all prior reports because of changes in format, materials, properties, and coding was issued in August 1964.

The materials and properties selected for the revised Handbook are listed in the appropriate index. In general, these materials were selected because of their current interest. Many of the included materials are being used in cryogenic aerospace systems; others are being considered for such applications. In several cases, materials not suitable for most cryogenic applications are also included in the Handbook. These data, which are normally more limited in nature, are presented for informational purposes. A review of the properties of these materials will illustrate why they are not considered suitable for cryogenic service.

NOTE: DATA CONTAINED IN THIS HANDBOOK REPRESENT TYPICAL PROPERTIES, NOT DESIGN DATA.

Manuscript for the revised handbook released by the authors, July 1964 for publication as an RTD Technical Documentary Report. 

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The authors have carefully screened all material to select and use only the most reliable data available. In presenting property information, the data have been plotted as accurately as possible. Documentation of condition, form, size, direction, specimen, and similar variables has been included wherever possible. The numbers in parentheses identify the data source reference. Wherever possible, references that are readily available have been used. In many cases, data are contained in both government reports and technical journals and publications. Various sources for specific data are identified in most cases to simplify the user's task of locating original data. Smooth curves are drawn for most materials. However, when insufficient temperature points are available, the data are presented as (1) solid lines in the region of experimental data connected by a dashed line, or (2) a straight line with small open circles at the actual test temperatures.

Unless otherwise noted, properties are the commonly accepted standards. For example, yield strength is considered to be the 0.2 percent offset stress. The gage length for elongation measurement is considered to be 2 inches for sheet material or four times the reduced section diameter for bar stock. Where test conditions are not standardized, details of testing are given.

Elastic stress concentration factor \( K_e \) can be calculated by several techniques. The three principal techniques are as follows:

1) \( \sqrt{a/r} \)
   where: \( a \) = one-half of the distance between the notches,
   \( r \) = radius at the root of the notch;

2) Peterson's method,*

3) Neuber's concept.†


Peterson's technique has been selected for use in the Handbook and all notch data presently have been converted, using Peterson's relationship.

For the convenience of the user, three indices, a Material Index, a Property Index, and a Cumulative Index, are included in the Handbook.

In Supplement No. 3 fracture toughness data for a variety of metals down to -423°F were first included in the Handbook. Since the concept of fracture mechanics is relatively new and not widely understood, a few comments regarding the subject are in order. However, a thorough treatment of fracture mechanics is beyond the scope of this introductory section. There are a number of books dealing with the subject of fracture. The handbook user is particularly referred to Fracture Toughness Testing and Its Applications, ASTM STP 381 and ASME Metals Engineering Design Handbook, 2nd Edition, for further information regarding fracture mechanics.

The fracture mechanics concept is a stress analysis approach to the problem of brittle fracture that involves the amount of strain energy available and released in initiating and maintaining fast fracture.

It is well known that fracture strength follows an inverse square root law, that is $\sigma = f\left(\frac{1}{a}\right)$, where $\sigma = $ stress and $a = $ crack length. The theory of linear elastic fracture mechanics is an extension of Griffith's concept of crack propagation in brittle solids which states that a defect will propagate rapidly if the elastically stored energy of the system equals or exceeds the energy required to form the additional crack surface. The extension of this concept to account for plastic deformation in the formation of two new surfaces was achieved by Orowan and Irwin and are the basis for our current comprehension of fracture mechanics.

During the last half-dozen years, appreciable attention has been focused on sharp crack fracture mechanics. An ASTM Special Committee on Fracture Testing of High Strength Materials was formed in 1959 to evaluate techniques for determining the strength of metals in the presence of sharp defects. As a result of this effort, a number of recommendations for specimen designs, boundary conditions, and testing techniques have been established.
The bulk of the fracture toughness data generated to date deals with room temperature behavior of high-strength materials, such as heat-treated alloy steels and titanium alloys. The quantity of cryogenic data is quite limited. A considerable portion of the data was generated before the techniques for valid testing were established and are of questionable validity.

The problem is particularly acute for the materials of interest for cryogenic service. These are generally the medium strength, tough materials that exhibit a face-centered cubic structure. They are commonly used in thin sections. This combination of high toughness and small section size makes valid testing particularly difficult. The problem in plane stress fracture toughness testing of these thin gage materials has generally been that test specimens have been so narrow that the net fracture stress has been close to or above the yield strength. This gives a value that can be significantly lower than the value under semi-infinite plate width conditions. The major potential problem caused by using such data is that an erroneous relative ranking of materials can occur. The following schematic illustrates this problem.

Plane stress fracture toughness data were obtained by investigations under References 1, 46, and 179. However, these data were primarily for thin center notch specimens where the specimen width was generally 3 to 4 inches. As a result, the net fracture strength to yield strength ratio was sufficiently high to permit excessive plastic deformation or the specimen was of insufficient width to obtain a valid plane stress toughness ($K_c$) level. The data obtained in References 46 and 179 are for machined notches rather than fatigue extended notches. The effect of a notch less sharp.
than a fatigue extended crack in absorbing energy during slow crack extension and the resultant effect on toughness are not clearly understood.

As a result of these circumstances, these data must be considered as "apparent fracture toughness." These data are therefore not included in the handbook. A review of the data shows that in many cases the net fracture/yield strength ratio exceeded a value of 0.8. For some materials, the 0.8 level was exceeded for all temperatures. Although this value of 0.8 is somewhat arbitrarily selected, it is a generally accepted upper boundary for the applicability of through-cracked specimens. Some of the data obtained under References 46 and 179 shows the effect of width on fracture toughness at 70 and -320°F. Evaluation of specimens up to 18 inches in width clearly shows that the 4-in. test specimens used for the bulk of the program were too narrow.

The amount of plane stress data that meet the requirements of low fracture strength, freedom from width effects, and contain fatigue extended cracks is reduced markedly with elimination of the data from References 46 and 179. Data for two alloys from Reference 177 meet the above criteria and are presented in the Handbook.

As thickness increases the fracture (ductile) mode for notched specimens changes from a predominant slant fracture to a square (brittle) fracture. The effects of increasing thickness are to reduce the critical fracture toughness to a lower limiting value, which is known as the plane strain fracture toughness $K_{IC}$. The following schematic illustrates the concept of the effect of thickness on fracture toughness.
Notched round bar data for aluminum alloys have been obtained from several sources. In some cases, the notched cross sectional area (similar to the effect of width for sheet samples) was not sufficient to give a low net fracture strength/yield strength ratios. Under these conditions a conservative value of toughness is obtained. Where such data are plotted, an arrow pointing upward is used to denote "lower bound value."

It is common to also present fracture toughness data in terms of the energy-release rate \( G_c \) or \( G_{ic} \). Graphs have been plotted in terms of \( K_c \) or \( K_{ic} \) only because \( K \) and \( G \) cannot be conveniently plotted on the same graph when temperature is a variable. The reason for this is that the relationship between \( K \) and \( G \) involves the modulus of elasticity (\( E \)), which is temperature dependent. If it is desired to use the plotted data in terms of energy release rate (\( G \)), the following relationships can be used:

\[
G_c = \frac{K^2}{E}
\]

\[
G_{ic} = \frac{(1 - \mu^2)K_{ic}^2}{E}
\]

where

\( \mu \) = Poisson's ratio;

\( E \) = modulus of elasticity.

A review of fracture toughness testing methods is contained in the TESTING METHODS section, Part V.

Also, in Supplement No. 3, a new section entitled, TYPICAL PROPERTIES, was introduced. This section includes graphical presentations of ultimate tensile strength, yield strength, and elongation for 23 material and temper combinations. The materials selected for this section are those of current interest for which sufficient data has been generated to permit typical curves to be constructed. In addition to the property versus temperature presentations for each material, handy bar graphs in the form of both strength and strength/density are presented. The bar graphs summarize the behavior of key materials on a single sheet.
In addition to the usual updating of data on materials already included in the Handbook, this supplement (No. 4) introduces four relatively new materials, namely: the aluminum alloys X2021 and X7007; an austenitic stainless steel designated as 21-6-9; and the titanium alloy Ti6Al-6V-2Sn.

The MATERIALS GUIDE Section is being supplemented by the addition of subsection entitled SOURCES OF CRYOGENIC MATERIALS PROPERTY DATA. This subsection identifies some sources for cryogenic data that are not included in this Handbook. There are brief descriptions of appropriate Data Centers, their locations, normal activities, and the services available. Pertinent cryogenic data reference works are also described in this subsection.

Section I, MISCELLANEOUS NONMETALLICS, is also included in this supplement. The use of nonmetallic materials as seals and gaskets in cryogenic systems is discussed in this section. The discussion is supplemented by a bibliography.

With the release of this supplement (No. 4) the Handbook is divided into two volumes. Volume I will contain Sections A thru C; Volume II, Sections D thru I plus REFERENCES, TESTING BIBLIOGRAPHY, AND MATERIALS GUIDE.

Supplement No. 4 is the final progress report under Air Force Contract F33615-67C-1794. No further effort on maintaining this document will be performed by the Martin Marietta Corporation after the issue date (8-68). A program for maintenance of the Handbook will probably be initiated in the future and for it to be successful the Air Force must maintain a complete file of cryogenic data. Users of the Handbook are urged to send data to the established Data Centers. Refer to Section MG for the addresses and resumes of the activities of the various Data Centers.

NOTE: DATA CONTAINED IN THIS HANDBOOK REPRESENT TYPICAL PROPERTIES, NOT DESIGN DATA.

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NOTCH TENSILE STRENGTH OF 2014 ALUMINUM

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A.3.ab

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NOTCH TENSILE STRENGTH OF 2219 ALUMINUM

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**A.5.e-5**

**NOTE:** TRANSVERSE, T61 SHEET
0.100-IN. (11)
0.063-IN. (43)
0.065-IN. (43)
0.050-IN. (51)
T651 PLATE
1.00-IN. (100)

**NOTCH TENSILE STRENGTH OF 2219 ALUMINUM**

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NOTCH STRENGTH RATIO OF 2219 ALUMINUM
NOTCH TENSILE STRENGTH OF 2219 ALUMINUM
NOTCH STRENGTH RATIO OF 2219 ALUMINUM

A5.e-11

\( K_T \)
- 3.5, 0.100-IN. (11)
- 7.2, 0.063-IN. (43)
- 10.0, 0.040-IN. (140)

\( K_T \)
- 10.0, 0.090-IN. (140)

NOTE: T87 SHEET, TRANSVERSE

TEMPERATURE (°F)

NOTCH/UNNOTCH STRENGTH RATIO

0.40 0.50 0.60 0.70 0.80 0.90 1.00 1.13

-400 -300 -200 -100 0 100
NOTCH TENSILE STRENGTH OF 2219 ALUMINUM
NOTCH STRENGTH RATIO OF 2219 ALUMINUM
NOTCH TENSILE STRENGTH OF 2219 ALUMINUM
NOTCH STRENGTH RATIO OF 2219 ALUMINUM
NOTCH TENSILE STRENGTH OF 2219 ALUMINUM
NOTCH STRENGTH RATIO OF 2219 ALUMINUM
NOTCH TENSILE STRENGTH OF 2219 ALUMINUM

NOTE: PLATE, TRANSVERSE, EXCEPT WHERE NOTED.

\[ K_T = 10.0, 1.00\text{-IN. (140)} \]

\[ K_T = 10.0, 1.00\text{-IN. (140)} \]

\[ K_T = 10.0, 5.00\text{-IN. (140)} \]

\[ K_T = 2.0, 2.00\text{-IN. (117)} \]

\[ K_T = 10.0, 5.00\text{-IN. (140)} \]
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A.5.f-1

FRACTURE TOUGHNESS OF 2219 ALUMINUM

PLANE STRAIN FRACTURE TOUGHNESS, K_{IC} (10^3 PSI/IN.)

TEMPERATURE (°F)

NOTE: TACT, SC SPECIMEN, W = 6 IN., 1 1/2 IN. PLATE (185)

B = 1 IN., 1 IN. PLATE (185)

TRANS. B = 0.6 - 1.2 IN., 1.25 IN. PLATE (189)
A.5.f-2

NOTE: 167. SNS SPECIMEN, FATIGUE EXTENDED
       NOTCH. W = 1 IN., B = 0.5 IN., A = 0.25 IN.,
       1 IN. PLATE (TS).

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FRAC TURE TOUGHNESS OF 2019 ALUMINUM
FRACTURE TOUGHNESS OF 2219 ALUMINUM

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A.5.f-6

FRACTURE TOUGHNESS OF 2219 ALUMINUM

NOTE: TRANSVERSE CN SPECIMEN
FATIGUE EXTENDED NOTCH, W = 16 IN
2A = 3 IN, B = 0.160 IN. (177)
WELD TENSILE STRENGTH OF 2219 ALUMINUM

NOTE: T651, AB-TIG WELDED EXCEPT AS NOTED. AUTO, 2219 ROO. 0.100-IN. SHEET (2), 0.125-IN. SHEET (27), 0.090-IN. SHEET (51).
WELD TENSILE STRENGTH OF 2219 ALUMINUM

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WELD TENSILE STRENGTH OF 2219 ALUMINUM
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STRESS-STRAIN DIAGRAM FOR 2219 ALUMINUM
STRESS-STRAIN DIAGRAM FOR 2219 ALUMINUM
STRESS-STRAIN DIAGRAM FOR 2219 ALUMINUM

(1-65)
STRESS-STRAIN DIAGRAM FOR 2219 ALUMINUM

NOTE: Transverse direction, 0.100-in. sheet (1)
STRESS-STRAIN DIAGRAM FOR 2219 ALUMINUM
A.5.h-5

NOTE: TEST, TRANSVERSE DIRECTION, 0.100-IN. SHEET (1).

STRESS-STRAIN DIAGRAM FOR 2219 ALUMINUM

STRESS (10^3 PSI) vs. STRAIN (INCHES PER INCH)
A.5.1

NOTE: T82 and T81-0.100-in. sheet, T87-0.033-in. sheet II.

TEMPERATURE (°F)

MODULUS (10^6 PSI)

MODULUS OF ELASTICITY OF 2219 ALUMINUM

(17-64)
MODULUS OF ELASTICITY OF 2219 ALUMINUM

TEMPERATURE (°F)

MODULUS (10^6 PSI)
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Stress (MPa)

168
WELD FATIGUE STRENGTH OF 2219 ALUMINUM
FATIGUE STRENGTH OF 2219 ALUMINUM

STRESS (1) 

(155)

FATIGUE LIFE (CYCLES)

10^2

10^3

10^4

10^5

10^6

10^7

A.5.o-3

70 85 95 80 90 85 90

170
WELD FATIGUE STRENGTH OF 2219 ALUMINUM

Note: TSI, AS-TIG WELDED, 1219 FULLER, AXIAL LOAD, N = 1, G = 10^-11, SHEET (1/16).
SHEAR STRENGTH OF 2219 ALUMINUM
LONGITUDINAL AND TRANSVERSE DIRECTION.

SHEAR STRENGTH OF 2219 ALUMINUM
THERMAL EXPANSION OF 2219 ALUMINUM

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TENSILE STRENGTH OF 2618 ALUMINUM
ELONGATION OF 2618 ALUMINUM
REDUCTION OF AREA OF 2618 ALUMINUM
A.6.e

**NOTICE:** TC 0.100\(\text{in.}\), SHEET (103), EXCEPT AS NOTED.

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**NOTCH TENSILE STRENGTH OF 2618 ALUMINUM**

![Graph showing notch tensile strength of 2618 aluminum vs. temperature (°F).](image-url)
NOTCH STRENGTH RATIO OF 2618 ALUMINUM
NOTCH TENSILE STRENGTH OF 2618 ALUMINUM
NOTCH STRENGTH RATIO OF 2618 ALUMINUM

NOTE: T62, 0.100-IN. SHEET (182).
WELD TENSILE STRENGTH OF 2618 ALUMINUM

NOTE: AS-TIG WELDED, AUTO, 4043 FILLER, GRAIN DIRECTION: LONGITUDINAL WELDED TO TRANSVERSE, 0.100-IN. SHEET (103)
YIELD STRENGTH OF 3003 ALUMINUM

(7-65)
A.7.a-1

YIELD STRENGTH OF 3003 ALUMINUM

Temperature (°F)

Stress (10^3 PSI)

H11, 0.750-IN. BAR (100)

Long.
TENSILE STRENGTH OF 3003 ALUMINUM
TENSILE STRENGTH OF 3003 ALUMINUM
ELONGATION OF 3003 ALUMINUM
A.7.c-1

ELONGATION OF 3003 ALUMINUM

TEMPERATURE (°F)

ELONGATION (PERCENT)
REDUCTION OF AREA OF 3003 ALUMINUM

NOTE: (139),

TEMPERATURE (°F)

REDUCTION OF AREA (PERCENT)
REDUCTION OF AREA OF 3003 ALUMINUM
WELD TENSILE STRENGTH OF 3003 ALUMINUM
THERMAL CONDUCTIVITY OF 3003 ALUMINUM
YIELD STRENGTH OF 5052 ALUMINUM

(7-65)

197
TENSILE STRENGTH OF 5052 ALUMINUM
ELONGATION OF 5052 ALUMINUM
NOTCH TENSILE STRENGTH OF 5052 ALUMINUM
NOTCH STRENGTH RATIO OF 5052 ALUMINUM

NOTE: H32, K = 7.2.
WELD TENSILE STRENGTH OF 5052 ALUMINUM

NOTE: HM, AS-TIG WELDED, AUTO, 5356 FILLER.
MODULUS OF ELASTICITY OF 5052 ALUMINUM
THERMAL CONDUCTIVITY OF 5052 ALUMINUM
ELECTRICAL RESISTIVITY OF 5052 ALUMINUM
YIELD STRENGTH OF 5083 ALUMINUM
YIELD STRENGTH OF 5083 ALUMINUM
A.9.a-2

YIELD STRENGTH OF 5083 ALUMINUM

TEMPERATURE (°F)

STRESS (10^3 PSI)
TENSILE STRENGTH OF 5083 ALUMINUM
TENSILE STRENGTH OF 5083 ALUMINUM
TENSILE STRENGTH OF 5083 ALUMINUM
ELONGATION OF 5083 ALUMINUM
ELONGATION OF 5083 ALUMINUM
ELONGATION OF 5083 ALUMINUM
REDUCTION OF AREA OF 5083 ALUMINUM
REDUCTION OF AREA OF 5083 ALUMINUM
REDUCTION OF AREA OF 5083 ALUMINUM
NOTCH TENSILE STRENGTH OF 5083 ALUMINUM
NOTCH STRENGTH RATIO OF 5083 ALUMINUM
NOTCH TENSILE STRENGTH OF 5083 ALUMINUM
NOTCH STRENGTH RATIO OF 5083 ALUMINUM
WELD TENSILE STRENGTH OF 5083 ALUMINUM
IMPACT STRENGTH OF 5083 ALUMINUM
THERMAL CONDUCTIVITY OF 5083 ALUMINUM
YIELD STRENGTH OF 5083 ALUMINUM
Yield Strength of 5086 Aluminum
TENSILE STRENGTH OF 5086 ALUMINUM

(7-66)

231
TENSILE STRENGTH OF 5086 ALUMINUM
A.10.c

ELONGATION OF 5086 ALUMINUM

TEMPERATURE (°F)

ELONGATION (PERCENT)

NOTE: M34.
ELONGATION OF 5086 ALUMINUM
NOTCH TENSILE STRENGTH OF 5086 ALUMINUM

(3-66)

235
NOTCH STRENGTH RATIO OF 5086 ALUMINUM

TEMPERATURE (°F)

NOTCH/UNNOTCH STRENGTH RATIO

-400 -300 -200 -100 0 100

NOTE: Hi4.

T = 7.2, 0.040-IN. SHEET (19)

T = 10.0, 0.075-IN. SHEET (23)

T = 11.0, 0.060-IN. SHEET (70)
WELD TENSILE STRENGTH OF 5086 ALUMINUM
THERMAL CONDUCTIVITY OF 5083 ALUMINUM
YIELD STRENGTH OF 5154 ALUMINUM
TENSILE STRENGTH OF 5154 ALUMINUM

TEMPERATURE (°F)

STRESS (10^3 PSI)
TEMPERATURE (°F)

ELONGATION OF 5154 ALUMINUM
REDUCTION OF AREA OF 5154 ALUMINUM
NOTCH TENSILE STRENGTH OF 5154 ALUMINUM
NOTCH STRENGTH RATIO OF 5154 ALUMINUM
WELD TENSILE STRENGTH OF 5154 ALUMINUM

TEMPERATURE (°F)

STRESS (10^3 PSI)
THERMAL CONDUCTIVITY OF 5154 ALUMINUM
YIELD STRENGTH OF 5456 ALUMINUM

NOTE: M233.
LONITUCINAL EXCEPT WHERE NOTED.
0.100-IN. SHEET (11)
0.500-IN. PLATE (11)
0.063-IN. SHEET (10)
0.050-IN. SHEET (123)
0.052-IN. SHEET (123)
0.750-IN. PLATE (147)
YIELD STRENGTH OF 5456 ALUMINUM
YIELD STRENGTH OF 5456 ALUMINUM
A.12.b

TENSILE STRENGTH OF 5456 ALUMINUM

NOTE: (123)
LONGITUDINAL EXCEPT WHERE NOTED
0.100-IN. SHEET (1)
0.500-IN. PLATE (1)
0.063-IN. SHEET (10)
0.050-IN. SHEET (43)
0.092-IN. SHEET (123)
0.750-IN. PLATE (147)
TENSILE STRENGTH OF 5456 ALUMINUM
TENSILE STRENGTH OF 5456 ALUMINUM
TENSILE STRENGTH OF 5456 ALUMINUM
NOTE: H36A3, LONGITUDINAL, EXCEPT WHERE NOTED.
0.100-IN. SHEET (1)
0.500-IN. PLATE (11)
0.063-IN. SHEET (10)
0.050-IN. SHEET (43)
0.092-IN. SHEET (123)
0.750-IN. PLATE (147)

ELONGATION OF 5456 ALUMINUM
A.12.c-1

NOTE: H343, TRANSVERSE.
0.100-IN. SHEET (1)
0.060-IN. PLATE (1)
0.056-IN. SHEET (10)
0.050-IN. SHEET (43)
0.092-IN. SHEET (123)

ELONGATION OF 5456 ALUMINUM

ELONGATION (PERCENT)

TEMPERATURE (°F)

(6-63)
ELONGATION OF 5456 ALUMINUM
REDUCTION OF AREA OF 5456 ALUMINUM
NOTCH TENSILE STRENGTH OF 5456 ALUMINUM
NOTE: LONGITUDINAL.
H343, 0.100-IN. SHEET (1)
H343, 0.063-IN. SHEET (10)
H343, 0.050-IN. SHEET (43)
O, 1.00-IN. PLATE (100)
H321, 1.00-IN. PLATE (100)

NOTCH STRENGTH RATIO OF 5456 ALUMINUM
NOTCH TENSILE STRENGTH OF 5456 ALUMINUM
NOTCH STRENGTH RATIO OF 5456 ALUMINUM
WELD TENSILE STRENGTH OF 5456 ALUMINUM
WELD TENSILE STRENGTH OF 5456 ALUMINUM
STRESS-STRAIN DIAGRAM FOR 5456 ALUMINUM
IMPACT STRENGTH OF 5456 ALUMINUM
THERMAL EXPANSION OF 5456 ALUMINUM
YIELD STRENGTH OF 6061 ALUMINUM
YIELD STRENGTH OF 6061 ALUMINUM
TENSILE STRENGTH OF 6061 ALUMINUM
TENSILE STRENGTH OF 6061 ALUMINUM
ELONGATION OF 6061 ALUMINUM

A.13.c

TEMPERATURE (°F)

ELONGATION (PERCENT)
A.13.c-1

ELONGATION (PERCENT)

LONG,
TRANS
T6, 0.025-IN. SHEET (11, 43)
0.750-IN. DIA BAR (12)
FORGING (81)
0.750-IN. DIA BAR (12, 30, 31)
TRANS
LONG,
T651, 1.750-IN. PLATE (100)

NOTE: T6, EXCEPT WHERE NOTED.

TEMPERATURE (°F)

ELONGATION OF 6061 ALUMINUM

274
REDUCTION OF AREA OF 6061 ALUMINUM
NOTCH TENSIILE STRENGTH OF 6061 ALUMINUM
A.13.e-1

NOTCH STRENGTH RATIO OF 6061 ALUMINUM

(7-64)

277
NOTCH TENSILE STRENGTH OF 6061 ALUMINUM

(7-64)
NOTCH STRENGTH RATIO OF 6061 ALUMINUM
NOTCH TENSILE STRENGTH OF 6061 ALUMINUM

TRAN

LONG.

K_T = 1.8, T651, 1.250xIN. PLATE (100)
NOTCH STRENGTH RATIO OF 6061 ALUMINUM
WELD TENSILE STRENGTH OF 6061 ALUMINUM

NOTE: T6, AS T113 WELDED, AUTO, 202 Weld Filler.

STRESS (10^3 PSI)

TEMPERATURE (°F)

LONG AND TRANS,
0.002-IN. SHEET (2)

LONG,
0.125-IN. SHEET (3)

LONG,
0.100-IN. SHEET (1)

TRANS
STRESS-STRAIN DIAGRAM FOR 6061 ALUMINUM
STRESS-STRAIN DIAGRAM FOR 6061 ALUMINUM

NOTE: TC, TRANSVERSE DIRECTION, 0.100-IN. SHEET (1)
MODULUS OF ELASTICITY OF 6061 ALUMINUM

IMPACT STRENGTH OF 6061 ALUMINUM
HARDNESS OF 6061 ALUMINUM
SHEAR STRENGTH OF 6061 ALUMINUM
THERMAL EXPANSION OF 6061 ALUMINUM
YIELD STRENGTH OF 7002 ALUMINUM
A.14.b

TENSILE STRENGTH OF 7002 ALUMINUM
ELONGATION OF 7002 ALUMINUM

REDUCTION OF AREA OF 7002 ALUMINUM

NOTE: Ts, 0.750-IN. PLATE (124)
NOTCH TENSILE STRENGTH OF 7002 ALUMINUM
NOTCH STRENGTH RATIO OF 7002 ALUMINUM

NOTE: TRANVERSE, 0.063-IN. SHEET (128)
A.14.a-2

NOTCH TENSILE STRENGTH OF 7002 ALUMINUM

NOTES: 76
NOTCH STRENGTH RATIO OF 7002 ALUMINUM
WELD TENSILE STRENGTH OF 7002 ALUMINUM
YIELD STRENGTH OF 7039 ALUMINUM
YIELD STRENGTH OF 7039 ALUMINUM
TENSILE STRENGTH OF 7039 ALUMINUM

STRESS ($10^3$ PSI)

TEMPERATURE (°F)
TENSILE STRENGTH OF 7039 ALUMINUM
ELONGATION OF 7039 ALUMINUM
ELONGATION OF 7039 ALUMINUM
NOTE: TS, 0.125-IN. SHEET (1) EXCEPT WHERE NOTED.

NOTCH TENSILE STRENGTH OF 7039 ALUMINUM
NOTCH STRENGTH RATIO OF 7039 ALUMINUM
NOTCH TENSILE STRENGTH OF 7039 ALUMINUM
NOTCH STRENGTH RATIO OF 7039 ALUMINUM
NOTCH STRENGTH RATIO OF 7039 ALUMINUM
NOTE: Tested as TIG welded, autogenous, 5183 filler, except where noted. (139)

WELD TENSILE STRENGTH OF 7039 ALUMINUM
NOTE: TS, LONGITUDINAL DIRECTION, 0.023-IN. SHEET (1).

STRESS-STRAIN DIAGRAM FOR 7039 ALUMINUM
STRESS-STRAIN DIAGRAM FOR 7039 ALUMINUM
MODULUS OF ELASTICITY OF 7039 ALUMINUM
IMPACT STRENGTH OF 7039 ALUMINUM
FATIGUE STRENGTH OF 7039 ALUMINUM
NOTCH FATIGUE STRENGTH OF 7039 ALUMINUM

FATIGUE LIFE (CYCLES)

STRESS (10^6 psi)

10^7

10^6

10^5

10^4

10^3

10^2

10^1

10^0

NOTE: FLAT AXIAL LOAD, S.S.A.N. 9/82.
SHEAR STRENGTH OF 7039 ALUMINUM

(17-64)
THERMAL EXPANSION OF 7039 ALUMINUM
THERMAL CONDUCTIVITY OF 7039 ALUMINUM
YIELD STRENGTH OF 7075 ALUMINUM
TENSILE STRENGTH OF 7075 ALUMINUM

NOTE: TS, 0.060-IN. DIA BAR EXCEPT AS SHOWN.
A.16.cd

ELONGATION OF 7075 ALUMINUM

REDUCTION OF AREA OF 7075 ALUMINUM
A.16.e

NOTCH TENSILE STRENGTH OF 7075 ALUMINUM

NOTE: TS, EXCEPT WHERE NOTED.
NOTCH STRENGTH RATIO OF 7075 ALUMINUM
FRACUTRE TOUGHNESS OF 7075 ALUMINUM
Stress-Strain Diagram for 7075 Aluminum

Note: 76, 0.750-in. Dia Bar (2).
MODULUS OF ELASTICITY OF 7075 ALUMINUM

IMPACT STRENGTH OF 7075 ALUMINUM
A.16.k

TEMPERATURE (°F)

HARDNESS OF 7075 ALUMINUM
FATIGUE STRENGTH OF 7075 ALUMINUM

NOTE: 14.2 KSI MINIMUM TENSILE STRESS, \( n = -1 \).

NOTE: 14.2 KSI MINIMUM TENSILE STRESS, \( n = -1 \).
NOTCH FATIGUE STRENGTH OF 7075 ALUMINUM
NOTCH FATIGUE STRENGTH OF 7075 ALUMINUM
THERMAL EXPANSION OF 7075 ALUMINUM
THERMAL CONDUCTIVITY OF 7075 ALUMINUM
YIELD STRENGTH OF 7079 ALUMINUM
TENSILE STRENGTH OF 7079 ALUMINUM
ELONGATION OF 7079 ALUMINUM
REDUCTION OF AREA OF 7079 ALUMINUM
NOTCH TENSILE STRENGTH OF 7079 ALUMINUM

TEMPERATURE (°F)

STRESS (10³ PSI)

343
NOTCH STRENGTH RATIO OF 7079 ALUMINUM
A.17.e-2

NOTE: T6, K = 7.2.
5.0-IN. BILLET (112).

NOTCH TENSILE STRENGTH OF 7079 ALUMINUM
NOTCH STRENGTH RATIO OF 7079 ALUMINUM
A.17.f

NOTE: MBR SPECIMENS, NOTCH DIA = 0.70; SHANK DIA, LOWER BOUND VALUE.

TEMPERATURE (°F)  

FRACUR' TOUGHNESS OF 7079 ALUMINUM

(3-66)
WELD TENSILE STRENGTH OF 7079 ALUMINUM
YIELD STRENGTH OF X7106 ALUMINUM
TENSILE STRENGTH OF X7106 ALUMINUM
Elongation of X7106 Aluminum

TEMPERATURE (°F)

ELONGATION (PERCENT)
NOTCH TENSILE STRENGTH OF X7106 ALUMINUM
NOTCH STRENGTH RATIO OF X7106 ALUMINUM
WELD TENSILE STRENGTH OF X7106 ALUMINUM
MODULUS OF ELASTICITY OF X7106 ALUMINUM
FATIGUE STRENGTH OF X7106 ALUMINUM

NOTE: TA AXIAL LOAD R = 1, C10500, Sheet (150).
FATIGUE STRENGTH OF X7106 ALUMINUM

NOTE: FOR AXIAL LOAD, N = 0.015, 0.032 IN.
SHEET (1/8).
NOTCH FATIGUE STRENGTH OF X7106 ALUMINUM

FATIGUE LIFE (CYCLES)

STRESS (10^6 psi)

358
YIELD STRENGTH OF 7178 ALUMINUM
TENSILE STRENGTH OF 7178 ALUMINUM
ELONGATION OF 7178 ALUMINUM

NOTE: TS.
NOTCH TENSILE STRENGTH OF 7178 ALUMINUM

(7-69)
NOTCH STRENGTH RATIO OF 7178 ALUMINUM

A.19.e-1

NOTE: TS.

K = 7.2, 0.036-IN. SHEET (85)

TRANS

K = 10, 2.00-IN. PLATE (126)

LONG.

K = 21.0, 0.125-IN. SHEET (27)

TEMPERATURE (°F)

NOTCH/UNNOTCH STRENGTH RATIO
FRACTURE TOUGHNESS OF 7178 ALUMINUM

(3-66)

366
WELD TENSILE STRENGTH OF 7178 ALUMINUM
YIELD STRENGTH OF 355 ALUMINUM

NOTE: SAND CAST (17%)
YIELD STRENGTH OF 355 ALUMINUM
TENSILE STRENGTH OF 355 ALUMINUM

NOTE: SAND CAST (196)
TENSILE STRENGTH OF 355 ALUMINUM
ELONGATION OF 355 ALUMINUM

NOTE: SAND CAST (176).

NOTE: PERMANENT MOLD CAST (176).

TEMPERATURE (°F)

ELONGATION (PERCENT)
YIELD STRENGTH OF 356 ALUMINUM
TENSILE STRENGTH OF 356 ALUMINUM
ELONGATION OF 356 ALUMINUM

REDUCTION OF AREA OF 356 ALUMINUM
NOTCH TENSILE STRENGTH OF 356 ALUMINUM

$K_T = 16$, T61, CAST (100)

$K_T = 6.3$, T6, CAST (133)
NOTCH STRENGTH RATIO OF 356 ALUMINUM
STRESS-STRAIN DIAGRAM FOR 356 ALUMINUM
MODULUS OF ELASTICITY OF 356 ALUMINUM

IMPACT STRENGTH OF 356 ALUMINUM
MODULUS OF RIGIDITY OF 356 ALUMINUM
THERMAL EXPANSION OF 356 ALUMINUM
STRENGTH OF TENS-50 ALUMINUM

*T.M.
ROCKETTYFE, DIV OF NORTH AMERICAN AVIATION INC.
ELONGATION OF TENS-50 ALUMINUM

REDUCTION OF AREA OF TENS-50 ALUMINUM
A.22.h

STRESS-STRAIN DIAGRAM FOR TENS-50 ALUMINUM

NOTE: T6, SAND CAST (2).

* T.M. ROCKETDYNE, DIV OF NORTH AMERICAN AVIATION INC.
MODULUS OF ELASTICITY OF TENS-50 ALUMINUM

IMPACT STRENGTH OF TENS-50 ALUMINUM

*T.M. ROCKETEYNE, DIV OF NORTH AMERICAN AVIATION INC.
(7-64) 388
THERMAL EXPANSION OF TENS-50 ALUMINUM
YIELD STRENGTH OF X2021 ALUMINUM

TEMPERATURE (°F)

STRESS (10^3 PSI)

-400 -300 -200 -100 0 100

50 60 70 80 90 100

1.00-IN. PLATE (101)

0.063-IN. SHEET (101)

0.125-IN. SHEET (101)

0.063-IN. SHEET (199)

NOTE: TRI, LONGITUDINAL.
A.23.a-1

YIELD STRENGTH OF X2021 ALUMINUM
TENSILE STRENGTH OF X2021 ALUMINUM
A.23.b-1

TENSILE STRENGTH OF X2021 ALUMINUM

[Graph showing the tensile strength of X2021 aluminum as a function of temperature (°F), with lines for 1.00-in. plate, 0.125-in. sheet, 0.063-in. sheet, and noting that the test is transverse.]
ELONGATION OF X2021 ALUMINUM
NOTCH TENSILE STRENGTH OF X2021 ALUMINUM
NOTCH STRENGTH RATIO OF 7020 ALUMINUM
A.23.e-2

NOTE: T61, TRANSVERSE (101).

STRESS (10^3 PSI)

TEMPERATURE (°F)

K_T = 10, 1.00-IN. PLATE
K_T = 16, 1.00-IN. PLATE
K_T = 16, 0.125-IN. PLATE
K_T = 16, 0.125-IN. PLATE

NOTCH TENSILE STRENGTH OF X2021 ALUMINUM

(16-68)
NOTCH STRENGTH RATIO OF X2021 ALUMINUM
MODULUS OF ELASTICITY OF X2021 ALUMINUM
FATIGUE LIFE (CYCLES)

NOTCH STRENGTH OF X2021 ALUMINUM

NOTE: TENSILE AXIAL LOAD, A = 1 2 3 4
B = 0.1; 0.250 IN. PLATE (1021)
A.24.a

YIELD STRENGTH OF X7007 ALUMINUM

NOTE: T6, LONGITUDINAL (101).
YIELD STRENGTH OF X7007 ALUMINUM
TENSILE STRENGTH OF X7007 ALUMINUM
TENSILE STRENGTH OF X7007 ALUMINUM
ELONGATION OF X7007 ALUMINUM
NOTCH TENSILE STRENGTH OF X7007 ALUMINUM
A.24.e-1

NOTCH STRENGTH RATIO OF X7067 ALUMINUM
NOTCH TENSILE STRENGTH OF X7007 ALUMINUM
NOTCH STRENGTH RATIO OF X7007 ALUMINUM
B - STAINLESS STEEL
B.1.a

YIELD STRENGTH OF 301 STAINLESS STEEL

(7-64)
YIELD STRENGTH OF 301 STAINLESS STEEL
YIELD STRENGTH OF 301 STAINLESS STEEL

FULL HARD (60% COLD REDUCTION), 0.015-IN., SHEET, LONG, (9)

(T-644)
YIELD STRENGTH OF 301 STAINLESS STEEL
YIELD STRENGTH OF 301 STAINLESS STEEL
TENSILE STRENGTH OF 301 STAINLESS STEEL
TENSILE STRENGTH OF 301 STAINLESS STEEL

(7-6a)
TENSILE STRENGTH OF 301 STAINLESS STEEL

NOTE: FULL HARD (5% COLD REDUCTION), 0.125-IN. SHEET, LONGITUDINAL (10).
TENSILE STRENGTH OF 301 STAINLESS STEEL
TENSILE STRENGTH OF 301 STAINLESS STEEL

NOTE: EXTRA-FULL HARD (60% COLD REDUCED) (0).
ELONGATION OF 301 STAINLESS STEEL
B.1.c-1

ELONGATION OF 301 STAINLESS STEEL

NOTE: THREE-QUARTER HARD (40% COLD REDUCTION), LONGITUDINAL.
Note: Extra full hard (60% cold reduction), longitudinal.

Elongation of 301 Stainless Steel
REDUCTION OF AREA OF 301 STAINLESS STEEL
NOTE: LONGITUDINAL EXCEPT WHERE NOTED.

NOTCH TENSILE STRENGTH OF 301 STAINLESS STEEL
NOTCH STRENGTH RATIO OF 301 STAINLESS STEEL

B.1.e-1

70% COLD REDUCTION
$K_T = 7.2, 0.063$-IN.
SHEET (111)

50% COLD REDUCTION
$K_T = 7.2, 0.063$-IN.
SHEET (0)

ANNEALED
$K_T = 4.3, 0.012$-IN.
PLATE (130)

NOTE: LONGITUDINAL EXCEPT WHERE NOTED.
B.1.e-2

NOTE: THREE-QUARTER HARD (40% COLD REDUCTION), $K_T = 7.4$.

STRESS ($10^3$ PSI) vs. TEMPERATURE ($^\circ$F)

NOTCH TENSILE STRENGTH OF 301 STAINLESS STEEL

(7-65)
NOTCH TENSILE STRENGTH OF 301 STAINLESS STEEL

\[ 3.1 \times 10^{-4} \]

\[ K_f = 4.4, \; 0.013-\text{IN. SHEET (9)} \]

\[ K_f = 3.6, \; 0.025-\text{IN. SHEET (9)} \]

\[ K_f = 21.0, \; 0.065-\text{IN. SHEET (111)} \]

\[ K_f = 21.0, \; 0.015-\text{IN. SHEET (10)} \]

\[ \text{NOTE: EXTRA FULL HARD (60% COLD REDUCTION), LONGITUDINAL} \]
NOTE: EXTRA FULL HARD (60% COLD REDUCTION), LONGITUDINAL.

NOTCH STRENGTH RATIO OF 301 STAINLESS STEEL
NOTE: EXTRA FULL HARD (50% COLD REDUCTION), H = 7.1, LONGITUDINAL T

STRESS (10^3 PSI)

TEMPERATURE (°F)

NOTCH TENSILE STRENGTH OF 301 STAINLESS STEEL

(7-63)
NOTCH STRENGTH RATIO OF 301 STAINLESS STEEL
WELD TENSILE STRENGTH OF 301 STAINLESS STEEL
STRESS-STRAIN DIAGRAM FOR 301 STAINLESS STEEL

NOTE: EXTRA FULL HARD, 0.039-1/16, SHEET (2).
STRESS-STRAIN DIAGRAM FOR 301 STAINLESS STEEL

NOTE: 60% COLD REDUCTION, LONGITUDINAL DIRECTION, 0.023-IN. SHEET (1).
STRESS-STRAIN DIAGRAM FOR 301 STAINLESS STEEL

NOTE: 50\% COLD REDUCTION, TRANSVERSE DIRECTION, 0.025-IN. SHEET (1).
MODULUS OF ELASTICITY OF 301 STAINLESS STEEL
B.1.jk

IMPACT STRENGTH OF 301 STAINLESS STEEL

HARDNESS OF 301 STAINLESS STEEL
FATIGUE STRENGTH OF 301 STAINLESS STEEL
NOTCH FATIGUE STRENGTH OF 301 STAINLESS STEEL
THERMAL EXPANSION OF 301 STAINLESS STEEL
POISSON'S RATIO OF 301 STAINLESS STEEL
THERMAL CONDUCTIVITY OF 301 STAINLESS STEEL

CONDUCTIVITY (BTU/FT HR °F)

TEMPERATURE (°F)

ANNEALED, 0.250-IN DIA BAR (69)
B.2.a

NOTE: LONGITUDINAL DIRECTION FOR SHEET MATERIAL.

YIELD STRENGTH OF 302 STAINLESS STEEL

(7-64)

449 Preceding page blank
TENSILE STRENGTH OF 302 STAINLESS STEEL
ELONGATION OF 302 STAINLESS STEEL

REDUCTION OF AREA OF 302 STAINLESS STEEL
STRESS-STRAIN DIAGRAM FOR 302 STAINLESS STEEL

NOTE: COLD REDUCED, 0.750-IN. DIA BAR (J).
MODULUS OF ELASTICITY OF 302 STAINLESS STEEL

IMPACT STRENGTH OF 302 STAINLESS STEEL
MODULUS OF RIGIDITY OF 302 STAINLESS STEEL
THERMAL EXPANSION OF 302 STAINLESS STEEL

(7-64)
STRENGTH OF 303 STAINLESS STEEL.

TEMPERATURE (°F)

STRESS (10^3 Psi)
ELONGATION OF 303 STAINLESS STEEL

REDUCTION OF AREA OF 303 STAINLESS STEEL
STRESS-STRAIN DIAGRAM FOR 303 STAINLESS STEEL

NOTE: ANNEALED, 0.790-1 IN.

CIA BAR (2)
MODULUS OF ELASTICITY OF 303 STAINLESS STEEL

IMPACT STRENGTH OF 303 STAINLESS STEEL

(7-64)
THERMAL EXPANSION OF 303 STAINLESS STEEL
THERMAL CONDUCTIVITY OF 303 STAINLESS STEEL
YIELD STRENGTH OF 304 STAINLESS STEEL
YIELD STRENGTH OF 304 STAINLESS STEEL

(7-64)
B.4.a-2

YIELD STRENGTH OF 304 STAINLESS STEEL

(7-64)

465
B.4.b

NOTE: ANNEALED.

TENSILE STRENGTH OF 304 STAINLESS STEEL

466
TENSILE STRENGTH OF 304 STAINLESS STEEL

(7-64)
B.4.b-2

TENSILE STRENGTH OF 304 STAINLESS STEEL

(7-64)
ELONGATION OF 304 STAINLESS STEEL

NOTE: ANNEALED.
ELONGATION OF 304 STAINLESS STEEL
ELONGATION OF 304 STAINLESS STEEL
REDUCTION OF AREA OF 304 STAINLESS STEEL

NOTE: ANNEALED.
NOTCH TENSILE STRENGTH OF 304 STAINLESS STEEL
B.4.e-1

NOTCH STRENGTH RATIO OF 304 STAINLESS STEEL

NOTE: EXTRA LOW CARBON GRADE, FULL HARD (50% COLD REDUCTION), 0.012-IN. SHEET (10).
B.4.e-2

NOTE: EXTRA LOW CARBON GRADE, NOTCHED
$K_T \leq 3.3, 0.002$-IN, SHEET (11S).

STRESS (10^3 lbf/in^2)

TEMPERATURE (°F)

NOTCH TENSILE STRENGTH OF
304 STAINLESS STEEL

476
NOTCH STRENGTH RATIO OF 304 STAINLESS STEEL

(7-64)

476
B.4.g

WELD TENSILE STRENGTH OF 304 STAINLESS STEEL

EXTRA LOW CARBON GRADE. FULL HARD (50% COLD REDUCTION), AS-TIG WELDED, AUTO, 0.012-IN. SHEET (10)

TEMPERATURE (°F)

STRESS (10^3 PSI)

90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
-220
-230
-240
-250
-260
-270
-280
-290
-300
-310
-320
-330
-340
-350
-360
-370
-380
-390
-400
STRESS-STRAIN DIAGRAM FOR 304 STAINLESS STEEL

NOTE: ANNEALED, LOW CARBON, 0.750-IN. DIA BAR (£).
NOTE: 60% COLD REDUCED, LONGITUDINAL DIRECTION, 0.020-IN. SHEET.

STRESS-STRAIN DIAGRAM FOR 304 STAINLESS STEEL

(1-44) STRESS-STRAIN DIAGRAM FOR 304 STAINLESS STEEL
SHEET 1

STRESS-STRAIN DIAGRAM FOR 304 STAINLESS STEEL

1-69
MODULUS OF ELASTICITY OF 304 STAINLESS STEEL
B.4.i

NOTE: ANNEALED EXCEPT AS NOTED.

- LOW CARBON, SUBSIZE CHARPY V, 0.750-IN. DIA BAR (2)
- CHARPY K, 0.750-IN. DIA BAR (73)
- CHARPY K, 0.500-IN. PLATE (61)
- SUBSIZE CHARPY V (22)
- 10% COLD REDUCED, CHARPY K, 0.500-IN. DIA BAR (75)
- COLD REDUCED (211 KSI UT), CHARPY K, 0.750-IN. DIA BAR (73, 75, 76)

ENERGY ABSORBED (FT-LB)

TEMPERATURE (°F)

IMPACT STRENGTH OF 304 STAINLESS STEEL
HARDNESS OF 304 STAINLESS STEEL

NOTE: 0.750-IN. DIA BAR (12, 31, 32).
STRESS ($10^3$ PSI)

TEMPERATURE (°F)

COMPRESSIVE STRENGTH OF 304 STAINLESS STEEL
FATIGUE STRENGTH OF 304 STAINLESS STEEL
THERMAL EXPANSION OF 304 STAINLESS STEEL
THERMAL CONDUCTIVITY OF 304 STAINLESS STEEL
STRENGTH OF 310 STAINLESS STEEL
YIELD STRENGTH OF 310 STAINLESS STEEL
TENSILE STRENGTH OF 310 STAINLESS STEEL

(7-64)
ELONGATION OF 310 STAINLESS STEEL
ELONGATION OF 310 STAINLESS STEEL
REDUCTION OF AREA OF 310 STAINLESS STEEL
ELONGATION OF 310 STAINLESS STEEL
NOTCH TENSILE STRENGTH OF 310 STAINLESS STEEL

(7-55)
NOTCH STRENGTH RATIO OF 310 STAINLESS STEEL

(7-68)

498
NOTCH TENSILE STRENGTH OF 310 STAINLESS STEEL

NOTE: 75% COLD REDUCTION, 6,000-IN. SHEET.
NOTCH STRENGTH RATIO OF 310 STAINLESS STEEL

NOTE: 75% COLD REDUCTION, 0.062-IN. SHEET.

TEMPERATURE (°F)

NOTCH/UNNOTCH STRENGTH RATIO

B.5.e-3
WELD TENSILE STRENGTH OF 310 STAINLESS STEEL
STRESS-STRAIN DIAGRAM FOR 310 STAINLESS STEEL

NOTE: ANNEALED, 0.750-IN. DIA BAR (2)
STRESS-STRAIN DIAGRAM FOR 310 STAINLESS STEEL
NOTE: 75.5% COLD REDUCTION, TRANSVERSE DIRECTION, 5.00-IN. SHEET (I).
MODULUS OF ELASTICITY OF 310 STAINLESS STEEL

IMPACT STRENGTH OF 310 STAINLESS STEEL
THERMAL EXPANSION OF 310 STAINLESS STEEL

(7-64)
STRENGTH OF 321 STAINLESS STEEL

(7-64)

507
ELONGATION OF 321 STAINLESS STEEL

REDUCTION OF AREA OF 321 STAINLESS STEEL
STRESS-STRAIN DIAGRAM FOR 321 STAINLESS STEEL
STRESS-STRAIN DIAGRAM FOR 321 STAINLESS STEEL
NOTE: ANNEALED, TRANSVERSE DIRECTION, 0.005-IN. SHEET (1).

STRESS-STRAIN DIAGRAM FOR 321 STAINLESS STEEL
MODULUS OF ELASTICITY OF 321 STAINLESS STEEL

IMPACT STRENGTH OF 321 STAINLESS STEEL
NOTCH FATIGUE STRENGTH OF 321 STAINLESS STEEL
THERMAL EXPANSION OF 321 STAINLESS STEEL

EXPANSION $\left( \frac{L_T - L_{68}}{L_{68}} \times 10^5 \right)$

TEMPERATURE ($^\circ$F)

ANNEALED 0.750-IN. DIA BAR (21)
STRENGTH OF 347 STAINLESS STEEL
ELONGATION OF 347 STAINLESS STEEL

REDUCTION OF AREA OF 347 STAINLESS STEEL
NOTCH TENSILE STRENGTH OF 347 STAINLESS STEEL
NOTCH STRENGTH RATIO OF 347 STAINLESS STEEL
WELD TENSILE STRENGTH OF 347 STAINLESS STEEL
STRESS-STRAIN DIAGRAM FOR 347 STAINLESS STEEL
Modulus of Elasticity of 347 Stainless Steel

Impact Strength of 347 Stainless Steel
FATIGUE STRENGTH OF 347 STAINLESS STEEL
NOTCH FATIGUE STRENGTH OF 347 STAINLESS STEEL
NOTCH FATIGUE STRENGTH OF 347 STAINLESS STEEL
THERMAL EXPANSION OF 347 STAINLESS STEEL

(7-64)
THERMAL CONDUCTIVITY OF 347 STAINLESS STEEL
STRENGTH OF
410 STAINLESS STEEL

(7-64)
B.8.cd

**Elongation of 410 Stainless Steel**

**Reduction of Area of 410 Stainless Steel**
STRESS-STRAIN DIAGRAM FOR 410 STAINLESS STEEL
MODULUS OF ELASTICITY OF 410 STAINLESS STEEL

IMPACT STRENGTH OF 410 STAINLESS STEEL
THERMAL EXPANSION OF 410 STAINLESS STEEL
THERMAL CONDUCTIVITY OF 410 STAINLESS STEEL
STRENGTH OF 416 STAINLESS STEEL

QUENCHED AND TEMPERED (1800°F/1 HR. Q); 700°F/4 HR. AC). 0.750-IN. DIA BAR (2)
B.9.cd

ELONGATION OF 416 STAINLESS STEEL

REDUCTION OF AREA OF 416 STAINLESS STEEL
STRESS-STRAIN DIAGRAM FOR 416 STAINLESS STEEL

NOTE: QUENCHED AND TEMPERRED 1400°F/1 HR. OR, 1000°F/4 HR. AIR, 0.700 IN. DIA. BAR (Q).
IMPACT STRENGTH OF 416 STAINLESS STEEL
THERMAL EXPANSION OF 416 STAINLESS STEEL

EXPANSION \( \left( \frac{L_T - L_{68}}{L_{68}} \times 10^5 \right) \)

TEMPERATURE (°F)

QUENCHED AND TEMPERED (1800°F HIP, 850°F 2 HR, AC), 0.750-IN, DIA BAR (21)
IMPACT STRENGTH OF 440C STAINLESS STEEL
B.10.*

THERMAL EXPANSION OF 440C STAINLESS STEEL

(7-64)
YIELD STRENGTH OF A-286 STAINLESS STEEL
YIELD STRENGTH OF A-286 STAINLESS STEEL
B.11.b

TENSILE STRENGTH OF A-286
B.11.b-1

TENSILE STRENGTH OF A-286 STAINLESS STEEL
ELONGATION OF A-286 STAINLESS STEEL
ELONGATION OF A-286 STAINLESS STEEL
REDUCTION OF AREA OF A-286 STAINLESS STEEL
NOTCH TENSILE STRENGTH OF A-286 STAINLESS STEEL
B.11.e-1

NOTCH STRENGTH RATIO OF A-286 STAINLESS STEEL

NOTE: LONGITUDINAL
WELD TENSILE STRENGTH OF A-286 STAINLESS STEEL

NOTE: TRANSVERSE, A-286 FILLER, 0.095-IN. SHEET (118).
STRESS-STRAIN DIAGRAM FOR A-286 STAINLESS STEEL

NOTE: SOLUTION TREATED AND AGED (1800°F/3 HRS. AC; 1350°F 16 HRS. AC), 0.750-IN. DIA. BAR (G).

STRAIN (INCHES PER INCH)

STRESS (10^3 PSI)
MODULUS OF ELASTICITY OF A-286 STAINLESS STEEL

IMPACT STRENGTH OF A-236 STAINLESS STEEL
FATIGUE STRENGTH OF A-286 STAINLESS STEEL

(1-44)
WELD FATIGUE STRENGTH OF A-286 STAINLESS STEEL

NOTE: SOLUTION TREATED, AS-TIG WELDED,
HASTELLOY W FILLER, AXIAL LOAD,
R = -1, 0.125-IN. SHEET (1/2)
FATIGUE STRENGTH OF A-286 STAINLESS STEEL
B.11.t

THERMAL EXPANSION OF A-286 STAINLESS STEEL
YIELD STRENGTH OF 17-4 PH STAINLESS STEEL
TENSILE STRENGTH OF 17-4 PH STAINLESS STEEL
ELONGATION OF 17-4 PH STAINLESS STEEL

REDUCTION OF AREA OF 17-4 PH STAINLESS STEEL
STRESS-STRAIN DIAGRAM FOR 17-4 PH STAINLESS STEEL
(7-64)
564
MODULUS OF ELASTICITY OF 17-4 PH STAINLESS STEEL

IMPACT STRENGTH OF 17-4 PH STAINLESS STEEL
MODULUS OF RIGIDITY OF 17-4 PH STAINLESS STEEL
THERMAL EXPANSION OF 17-4 PH STAINLESS STEEL
YIELD STRENGTH OF 17-7 PH STAINLESS STEEL
TENSILE STRENGTH OF 17-7 PH STAINLESS STEEL
ELONGATION OF 17-7 PH STAINLESS STEEL

REDUCTION OF AREA OF 17-7 PH STAINLESS STEEL
STRESS-STRAIN DIAGRAM FOR 17-7 PH STAINLESS STEEL
MODULUS OF ELASTICITY OF 17-7 PH STAINLESS STEEL

IMPACT STRENGTH OF 17-7 PH STAINLESS STEEL
MODULUS OF RIGIDITY OF 17-7 PH STAINLESS STEEL
FATIGUE STRENGTH OF 17-7 PH STAINLESS STEEL
NOTCH FATIGUE STRENGTH OF 17-7 PH STAINLESS STEEL
THERMAL EXPANSION OF 17-7PH STAINLESS STEEL

(7-64)
STRENGTH OF AM 350 STAINLESS STEEL

(3-56)
ELONGATION OF AM 350 STAINLESS STEEL
REDUCTION OF AREA OF AM 350 STAINLESS STEEL
B.14.e

NOTCH TENSILE STRENGTH OF AM 350 STAINLESS STEEL

SUB-ZERO COOLED AND TEMPERED (BCT), \( K_I = 6.3 \) (132)
NOTCH STRENGTH RATIO OF AM 350 STAINLESS STEEL
IMPACT STRENGTH OF AM 350 STAINLESS STEEL
YIELD STRENGTH OF AM-355 STAINLESS STEEL

(7-64)
B.15.b

TENSILE STRENGTH OF AM-355 STAINLESS STEEL

(7-64)

586
ELONGATION OF AM-355 STAINLESS STEEL
NOTCH TENSILE STRENGTH OF AM-355 STAINLESS STEEL
NOTCH STRENGTH RATIO OF AM-355 STAINLESS STEEL
WELD TENSILE STRENGTH OF AM-355 STAINLESS STEEL
B.15.i

MODULUS OF ELASTICITY OF AM-355 STAINLESS STEEL

(1-64)
YIELD STRENGTH OF 21-6-9 STAINLESS STEEL
TENSILE STRENGTH OF 21-6-9 STAINLESS STEEL
ELONGATION OF 21-6-9 STAINLESS STEEL

4.75-IN. PLATE ANNEALED (143)
REDUCTION OF AREA OF 21-6-9 STAINLESS STEEL
IMPACT STRENGTH OF 21-6-9 STAINLESS STEEL
YIELD STRENGTH OF COMMERCIALLY PURE TITANIUM

TEMPERATURE (°F)

STRESS (10^3 PSI)

-100
-200
-300
-400
0
100
200
300
400

(1) Grades: Annealed, 0.025-in., 200-psi Yield Strength and Annealed, 0.010-in., 100-psi Yield Strength.

(11) Grades: Annealed, 0.025-in., 200-psi Yield Strength and Annealed, 0.010-in., 100-psi Yield Strength.

(2) Grades: Annealed, 0.025-in., 200-psi Yield Strength and Annealed, 0.010-in., 100-psi Yield Strength.

(12) Grades: Annealed, 0.025-in., 200-psi Yield Strength and Annealed, 0.010-in., 100-psi Yield Strength.

C.1.0
C.1.b

TENSILE STRENGTH OF COMMERCIALY PURE TITANIUM

(6-66)
C.1.c

ELONGATION OF COMMERCIALLLY PURE TITANIUM
REDUCTION OF AREA OF COMMERCIALY PURE TITANIUM
NOTCH TENSILE STRENGTH OF COMMERCIALLY PURE TITANIUM
NOTCH STRENGTH RATIO OF COMMERCIAL PURE TITANIUM
WELD TENSILE STRENGTH OF COMMERCIAL PURE TITANIUM
MODULUS OF ELASTICITY OF COMMERCIALLY PURE TITANIUM
IMPACT STRENGTH OF COMMERCIALLY PURE TITANIUM

C.1.i

ENERGY ABSORBED (FT-LB)

TEMPERATURE (°F)

45,000 PSI YIELD STRENGTH GRADE, ANNEALED, CHARPY-V, 0.800-IN. PLATE (1)

LONG

TRANS

(7-65)
POISSON'S RATIO OF COMMERCIAL PURE TITANIUM
THERMAL CONDUCTIVITY OF PURE TITANIUM
YIELD STRENGTH OF 5Al-2.5 Sn TITANIUM
NOTE: EXTRA-LOW INTERSTITIAL, ANNEALED.

YIELD STRENGTH OF 5Al-2.5Sn TITANIUM
YIELD STRENGTH OF 5Al-2.5 Sn TITANIUM

NOTE: NORMAL INTERSTITIAL, ANNEALED
C.2.a-3

YIELD STRENGTH OF 5Al-2.5 Sn TITANIUM
TENSILE STRENGTH OF 5Al-2.5 Sn TITANIUM
TENSILE STRENGTH OF 5Al-2.5 Sn TITANIUM
TENSILE STRENGTH OF 5Al-2.5 Sn TITANIUM
C.2.b-3

TENSILE STRENGTH OF 5AI-2.5 Sn TITANIUM

NOTE: NORMAL INTERSTITIAL, ANNEALED.
ELONGATION OF 5Al-2.5 Sn TITANIUM
C.2.c-1

ELONGATION OF 5AI-2.5 Sn TITANIUM
NOTE: NORMAL INTERSTITIAL, ANNEALED.

REDUCTION OF AREA OF 5AI-2.5 Sn TITANIUM
C.2.e

NOTCH TENSILE STRENGTH OF 5AI-2.5 Sn TITANIUM

NOTE: EXTRA-LOW INTERSTITIAL, ANNEALED.
NOTCH STRENGTH RATIO OF 5Al-2.5 Sn TITANIUM
NOTCH TENSILE STRENGTH OF 5AI-2.5 Sn TITANIUM
NOTCH STRENGTH RATIO OF 5Al-2.5 Sn TITANIUM
NOTCH TENSILE STRENGTH OF 5Al-2.5 Sn TITANIUM
C.2.e-5

NOTCH STRENGTH RATIO OF 5Al-2.5 Sn TITANIUM
NOTCH TENSILE STRENGTH OF SA1-2.5 Sn TITANIUM
NOTCH STRENGTH RATIO OF 5Al-2.5 Sn TITANIUM
FRACTURE TOUGHNESS OF 5Al-2.5Sn TITANIUM
FRACTURE TOUGHNESS OF 5Al-2.5Sn TITANIUM
FRACTURE TOUGHNESS OF 5A1-2.55n TITANIUM
FRACTURE TOUGHNESS OF 5Al-2.5Sn TITANIUM

NOTE: EXTRA-LOW INTERSTITIAL, Annealed, Transverse.
ENB SPECIMEN, FATIGUE EXTENDED NOTCH, W = 0.5 IN, B = 0.25 IN, A = 0.10 IN, 0.50 IN PLATE, F = LOWER BOUND VALUE (186).

3
635
NOTE: EXTRA LOW INTERSTITIAL, ANNEALED
3C SPECIMEN, W = 1.5 IN., B = 0.187 IN.
(125°F)

FRACTURE TOUGHNESS OF 5Al-3n TITANIUM

C.2.f-4

TEMPERATURE, (°F)

PLANE STRAIN FRACTURE TOUGHNESS, $K_{IC}$ (10^3 PSI/IN.)
C.2.f-5

FRACTURE TOUGHNESS OF 5Al-2.5Sn TITANIUM

NOTE: EXTRA-LOW INTERSTITIAL, ANNEALED,
LONGITUDINAL, CN SPECIMEN, FATIGUE
EXTENDED NOTCH, W = 16 IN., 2A = 3 IN.,
B = 0.016 IN. (177)
WELD TENSILE STRENGTH OF 5Al-2.5 S1 TITANIUM

NOTE: EXTRA-LOW INTERSTITIAL, ANNEALED, AS TIG-WELDED, AUTO, NO FILLER.
WELD TENSILE STRENGTH OF 5AI-2.5 Sn TITANIUM
STRESS-STRAIN DIAGRAM FOR 5Al-2.5 Sn TITANIUM
STRESS-STRAIN DIAGRAM FOR 5Al-2.5Sn TITANIUM
C.2.h-2

STRESS-STRAIN DIAGRAM FOR 5Al-2.5Si TITANIUM

NOTE: LATHA-LOW INTERSTITIAL, ANNEALED, TRANSVERSE, DIRECTION 9.100-IN. SHEET (1)
MODULUS OF ELASTICITY OF 5Al-2.5 Sn TITANIUM

IMPACT STRENGTH OF 5Al-2.5 Sn TITANIUM
IMPACT STRENGTH OF 5Al -2.5 Sn TITANIUM
HARDNESS OF 5AI-2.5 Sn TITANIUM
FATIGUE STRENGTH OF 5Al-2.5 Sn TITANIUM

NOTE: LOW INTERSTITIAL, ANNEX A-0
TR 431, LTS, AXIAL LOAD, R = 0.1, 2,350 MPa, SHEET Ti-6Al-4V
WELD FATIGUE STRENGTH OF 5AI-2.5 Sn TITANIUM
THERMAL EXPANSION OF 5AI-2.5 Sn TITANIUM
THERMAL CONDUCTIVITY OF 5Al-2.5 Sn TITANIUM
YIELD STRENGTH OF 9Al-1Mo-1V TITANIUM

NOTE: SINGLE ANNEALED
YIELD STRENGTH OF 8AI-1Mo-1V TITANIUM

[Graph showing stress vs. temperature for 8AI-1Mo-1V titanium, with annotation 'DIPLEX ANNEALED, 0.012-IN. SHEET']
TENSILE STRENGTH OF 8AI-1Mo-IV TITANIUM
TENSILE STRENGTH OF 8Al-1Mo-1V TITANIUM
C.3.c

ELONGATION OF 8AI-1Mo-IV TITANIUM

NOTE: SINGLE ANNEALED.
ELONGATION OF 8Al-1Mo-1V TITANIUM
NOTCH TENSILE STRENGTH OF 8Al-1Mo-1V TITANIUM
C.3.e-1

NOTCH STRENGTH RATIO OF 8Al-1Mo-1V TITANIUM
NOTCH TENSILE STRENGTH OF 8Al-1Mo-1V TITANIUM
C.3.e-3

NOTCH STRENGTH RATIO OF 8Al-1Mo-1V TITANIUM

TEMPERATURE (°F)
WELD TENSILE STRENGTH OF 8Al-1Mo-1V TITANIUM
WELD TENSILE STRENGTH OF 8Al-1Mo-1V TITANIUM
MODULUS OF ELASTICITY OF 8Al-1Mo-1V TITANIUM
THERMAL EXPANSION OF 8Al-1Mo-1V TITANIUM

(1-68)
YIELD STRENGTH OF 8A1-2Cb-1Ta TITANIUM
TENSILE STRENGTH OF 8A1-2Cb-1Ta TITANIUM
ELONGATION OF 8Al-2Cb-1Ta TITANIUM
NOTCH TENSILE STRENGTH OF 8Al-2Cb-1Ta TITANIUM
NOTCH STRENGTH RATIO OF 8Al-2Cb-1Ta TITANIUM
NOTE: ANNEALED, LONGITUDINAL AND TRANSVERSE, 6.05 IN. SHUT (14).

STRENGTH OF 7AI-12Zr TITANIUM

(1-58)
C.5.c

ELONGATION OF 7Al-12Zr TITANIUM

(1-55)
NOTCH TENSILE STRENGTH OF 7Al-12Zr TITANIUM
NOTCH STRENGTH RATIO OF 7Al-12Zr TITANIUM
TENSILE STRENGTH OF 3A1-2.5V TITANIUM
ELONGATION OF 3A1-2.5V TITANIUM
NOTCH TENSILE STRENGTH OF 3Al-2.5V TITANIUM
NOTCH STRENGTH RATIO OF 3AI-2.5V TITANIUM
C.7.a

YIELD STRENGTH OF 6Al-4V TITANIUM
YIELD STRENGTH OF 6AI-4V TITANIUM
NOTE: NORMAL INTERSTITIAL, ANNEALED

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YIELD STRENGTH OF 6AI-4V TITANIUM
### YIELD STRENGTH OF 6Al-4V TITANIUM

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**NOTE:** NORMAL INTERSTITIAL, AINFELED ANALYSIS, WT%
C.7.a-4

YIELD STRENGTH OF 6Al-4V TITANIUM
YIELD STRENGTH OF 6AI-4V TITANIUM

NOTE: NORMAL INTERSTITIAL SOLUTION TREATED AND AGED.
TENSILE STRENGTH OF 6Al-4V TITANIUM

NOTE: EXTRA-LOW INTERSTITIAL ANNEALED, CHEMICAL ANALYSIS AS SHOWN IN C.7A.
C.7.b-1

TENSILE STRENGTH OF 6AI-4V TITANIUM

NOTE: EXTRA-LOW INTERSTITIAL, ANNEALED.
NOTE: NORMAL INTERSTITIAL ANNEALED, CHEMICAL ANALYSIS AS SHOWN IN C.7.b-2.

TENSILE STRENGTH OF 6Al-4V TITANIUM
TENSILE STRENGTH OF 6AI-4V TITANIUM

TENSILE STRENGTH OF 6Al-4V TITANIUM
C.7.c

NOTE: EXTRA-LOW INTERSTITIAL, ANNEALED.

ELONGATION OF 6Al-4V TITANIUM
Elongation of 6Al-4V Titanium

(Note: Normal interstitial, annealed, chemical analysis as shown in C.7.a-1 and 1.)

Temperature (°F)

Elongation (Percent)
ELONGATION OF 6Al-4V TITANIUM
C.7.c-3

NOTE: NORMAL INTERSTITIAL SOLUTION TREATED AND AGED

TEMPERATURE (°F)

ELONGATION (%) OF 6AI-4V TITANIUM
REDUCTION OF AREA OF 6Al-4V TITANIUM

EXTRA-LOW INTERSTITIAL, ANNEALED, 0.025-IN. DIA BAR (75)

NORMAL INTERSTITIAL, ANNEALED, 0.025-IN. DIA BAR (2)
NOTCH TENSILE STRENGTH OF 6AI-4V TITANIUM
C.7.e-1

NOTCH STRENGTH RATIO OF 6AI-4V TITANIUM

C.7.e-2

**NOTE:** EXTRA-LOW INTERSTITIAL, ANNEALED, CHEMICAL ANALYSIS AS SHOWN IN C.7.A AND A-1.

**NOTCH TENSILE STRENGTH OF 6Al-4V TITANIUM**
NOTCH STRENGTH RATIO OF 6AI-4V TITANIUM
C.7.e-5

NOTCH TENSILE STRENGTH OF 6AI-4V TITANIUM

NOTCH TENSILE STRENGTH OF 6Al-4V TITANIUM
NOTCH STRENGTH RATIO OF 6AI-4V TITANIUM

**C.7.f**

**FRACTURE TOUGHNESS OF 6Al-4V TITANIUM**

(3-64)
WELD TENSILE STRENGTH OF 6A1-4V TITANIUM

NOTE: EXTRA-LOW INTERSTITIAL, AS-1/2 WELDED, AUTO, AND FILLER, 0.032-IN. B.FEET (1).
WELD TENSILE STRENGTH OF 6Al-4V TITANIUM
C.7.h

STRESS-STRAIN DIAGRAM FOR 6AI-4V TITANIUM

NOTE: A-6Al-4V, ALLOY NORMAL INTERSTITIAL, 0.753-IN. DIA EXH (Q).
STRESS-STRAIN DIAGRAM FOR 6AI-4V TITANIUM
C.7.h-3

NOTE: EXTRA-LOW INTERSTITIAL SOLUTION TREATED AND AGED, LONGITUDINAL DIRECTION, 0.004-IN. SHEET IV.

STRESS-STRAIN DIAGRAM FOR 6Al-4V TITANIUM
STRESS-STRAIN DIAGRAM FOR 6AI-4V TITANIUM
MODULUS OF ELASTICITY OF 6AI-4V TITANIUM
IMPACT STRENGTH OF 6Al-4V TITANIUM
IMPACT STRENGTH OF 6Al-4V TITANIUM
IMPACT STRENGTH OF 6A1-4V TITANIUM
HARDNESS OF 6Al-4V TITANIUM

MODULUS OF RIGIDITY OF 6Al-4V TITANIUM
FATIGUE STRENGTH OF 6Al-4V TITANIUM

Fatigue Life Cycles

Stress (10^5 psi)

10^3 10^4 10^5 10^6 10^7

718
NOTCH FATIGUE STRENGTH OF 6AI-4V TITANIUM
NOTCH FATIGUE STRENGTH OF 6A1-4V TITANIUM

STRESS (10^6 psi) vs. FATIGUE LIFE (CYCLES)
FATIGUE STRENGTH OF 6AI-4V TITANIUM
C.7.t

THERMAL EXPANSION OF 6Al-4V TITANIUM

(1-65)
POISSON'S RATIO OF 6AI-4V TITANIUM
THERMAL CONDUCTIVITY OF 6Al-4V TITANIUM
YIELD STRENGTH OF 13V-11Cr-3Al TITANIUM
TENSILE STRENGTH OF 13V-11Cr-3Al TITANIUM
C.8.c

NOTE: SOLUTION TREATED EXCEPT AS NOTED.

0.750-IN. DIA BAR (2)

0.062-IN. SHEET, LONG. (14)

0.040-IN. SHEET (102)

0.025-IN. DIA BAR (76)

SOLUTION TREATED AND AGED, 0.100-IN. SHEET, LONG. (15)

SOLUTION TREATED AND AGED, 0.060-IN. SHEET, LONG. (30)

ELONGATION OF 13V-11Cr-3Al TITANIUM
REDUCTION OF AREA OF 13V-11Cr-3Al TITANIUM
NOTCH TENSILE STRENGTH OF 13V-11Cr-3AI TITANIUM
NOTCH STRENGTH RATIO OF 13V-11Cr-3Al TITANIUM
STRESS-STRAIN DIAGRAM FOR 13V-11Cr-3Al TITANIUM
MODULUS OF ELASTICITY OF 13V-11Cr-3Al TITANIUM
NOTE: SOLUTION TREATED, STANDARD CHARPY V-NOTCH.

IMPACT STRENGTH OF 13V-11Cr-3Al TITANIUM
C.8.k

HARDNESS OF 13V-11Cr-3Al TITANIUM

SOLUTION TREATED AND AGED, 0.060-IN. SHEET, 23 KG LOAD
FATIGUE STRENGTH OF 13V-11Cr-3Al: TITANIUM
SHEAR STRENGTH OF 13V-11Cr-3Al TITANIUM
THERMAL EXPANSION OF 13V-11Cr-3Al TITANIUM
YIELD STRENGTH OF 6AI-6V-2 Sn TITANIUM
YIELD STRENGTH OF 6AI-6V-2 Sn TITANIUM
TENSILE STRENGTH OF 6Al-6V-2 Sn TITANIUM

EXTRA LOW INTERSTITIAL, 1.00-IN. PLATE (197)

NORMAL INTERSTITIAL, 4.00-IN. DIA EAR (197)

NOTE: ANNEALED.
NORMAL INTERSTITIAL, 0.005 IN. DIA BAR (1977)

EXTRA LOW INTERSTITIAL, 1.00 IN. PLATE (1977)

NOTE: SOLUTION TREATED AND AGED.

TENSILE STRENGTH OF 6Al-6V-2Sn TITANIUM
C.9.c

ELONGATION OF 6AI-6V-2 Sn TITANIUM
REDUCTION OF AREA OF 6Al-4V-2Sn TITANIUM

NOTE: ANNEALED.
REDUCTION OF AREA OF 6Al-4V-2 Sn TITANIUM
IMPACT STRENGTH OF 6Al-6V-2Sn TITANIUM

(NOTE: EXTRA LCR INTERSTITIAL, 1.00IN. PLATE)
The eight sections of the two volumes of the handbook contain data on various properties of 88 metallic and nonmetallic materials at cryogenic temperatures. In addition to property data, there is information on tests procedures, other sources of cryogenic data, a treatment of nonmetallic materials used in cryogenic service applications, with a bibliography and a "Materials Selection Guide". The handbook and its supplements were developed under several contracts with the Martin Marietta Corporation.

This revision is just a compilation of their reports performed at the Air Force Materials Laboratory.
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