



# **Metallic Materials Properties Development and Standardization (MMPDS)**

## **MMPDS-05**

**April 2010**

**Scientific Source:**

Metallic Materials design data acceptable to Government procuring or certification agencies.

***A joint effort of government, industrial, educational, and international aerospace organizations.***

**MMPDS-05**

Copyright 2010 Federal Aviation Administration and licensed exclusively to Battelle Memorial Institute for distribution. All rights reserved. Unauthorized duplication or distribution may violate the Copyright Laws of the United States and of other jurisdictions.

*Except as expressly provided below, the copyrighted work contained herein may not be copied, modified, adapted, translated, included in derivative works or transferred to a third party. The information may be subject to export control laws and regulations of the United States. The user represents and warrants that the information will not be exported, transferred, sublicensed, copied, shared, disclosed, or used in any way except in compliance with all applicable export control laws and regulations of the United States.*

*The owner of this copy of the Handbook is hereby granted a limited license to make copies of no more than 10 individual pages of the Handbook (but specifically not including multiple sections or volumes) from this copy at a time for the sole purpose of attaching as reference and supporting information to a document authored by the owner.*

*The user of this Handbook assumes the responsibility for the selection of material properties from it to meet their requirements. The information contained herein is provided as-is without warranty. There are no warranties of any kind, either express or implied, including but not limited to the implied warranties of merchantability and fitness for a particular purpose.*

## ***FOREWORD***

The Metallic Materials Properties Development and Standardization (MMPDS) Handbook, is an accepted source for metallic material and fastener system allowables for the Federal Aviation Administration (FAA), all Departments and Agencies of the Department of Defense (DoD), and the National Aeronautics and Space Administration (NASA). Per guidance provided by FAA Advisory Circular (AC) 25.613-1 and FAA policy memorandum PS-AIR100-2006-MMPDS, the A and B values contained in the MMPDS have been determined to satisfy the regulatory requirements defined in Title 14 of the Code of Federal Regulations (CFR) 27.613(d), 29.613(d), 25.613(b) and 23.613(b).

MMPDS-05 is the replacement to MMPDS-04/MMPDS-04 Change Notice 1 and prior editions as well as the replacement for all editions of MIL-HDBK-5, Metallic Materials and Elements for Aerospace Vehicle Structures Handbook that was maintained by the U.S. Air Force. The last edition, MIL-HDBK-5J, was classified as noncurrent in the Spring of 2004.

This document contains design information on the strength properties of metallic materials and elements for aircraft and aerospace vehicle structures. All information and data contained in this Handbook has been reviewed and approved in a standardized development process. The development and ongoing maintenance process involves certifying agencies, including the FAA, DoD, and NASA, and major material suppliers and material users worldwide. The data and procedures in this Handbook are continuously reviewed, and if needed, are modified or removed for consistency. With advances in materials and fastener systems, and with the review process of existing information, annual updates of the MMPDS are expected. As such, it is recommended that the latest version of the MMPDS be used.

Beneficial comments (recommendations, additions, deletions) and any pertinent data that may be of use in improving this document should be addressed to Secretariat, MMPDS Coordination Activity (614-424-4433 voice or [bcommmps@battelle.org](mailto:bcommmps@battelle.org) email), Battelle, Mechanical Analysis Group, Room 11-1-080, 505 King Avenue, Columbus, OH 43201. You may also contact the Secretariat through the handbook website, [www.mmpds.org](http://www.mmpds.org)

This Handbook has been approved for public release with unlimited distribution.

Preparing activity:  
FAA - William J. Hughes Technical Center

***EXPLANATION OF NUMERICAL CODE***

For chapters containing materials properties, a deci-numeric system is used to identify sections of text, tables, and illustrations. This system is explained in the examples shown below. Variations of this deci-numerical system are also used in Chapters 1, 8, and 9.

Example A 2.4.2.1.1

General material category (in this case, steel) .....		
A logical breakdown of the base material by family characteristics (in this case, intermediate alloy steels); or for element properties .....		
Particular alloy to which all data are pertinent. If zero, section contains comments on the family characteristics .....		
If zero, section contains comments specific to the alloy; if it is an integer, the number identifies a specific temper or condition (heat treatment) .....		
Type of graphical data presented on a given figure (see following description) .....		

Example B 3.2.3.1.X

Aluminum .....		
2000 Series Wrought Alloy .....		
2024 Alloy .....		
T3, T351, T3510, T3511, T4, and T42 Tempers .....		
Specific Property as Follows .....		
Tensile properties (ultimate and yield strength) .....	1	
Compressive yield and shear ultimate strengths .....	2	
Bearing properties (ultimate and yield strength) .....	3	
Modulus of elasticity, shear modulus .....	4	
Elongation, total strain at failure, and reduction of area .....	5	
Stress-strain curves, tangent-modulus curves .....	6	
Creep .....	7	
Fatigue .....	8	
Fatigue-Crack Propagation .....	9	
Fracture Toughness .....	10	

**REGISTERED TRADEMARKS**

<u>Trademark</u>	<u>Registered by</u>	<u>Chemistry</u>	<u>UNS Number</u>
15-5PH®	AK STEEL CORP.	15Cr - 4.6Ni - 0.22Cb - 2.8Cu	J92110
		15Cr - 4.5Ni - 0.30Cb - 3.5Cu	S15500
17-4-PH® <sup>1</sup>	ARMCO INC. CORP.	16Cr - 4.1Ni - 0.28Cb - 3.2Cu	J92200
		16.5Cr - 4.0Ni - 4.0Cu - 0.30Cb	S17400
17-7PH®	ARMCO INC. CORP.	17Cr-7.1Ni-1.1Al	J17700
ACRES® sleeves	CLICK BOND, INC.	NA	NA
AerMet® 100	CRS HOLDINGS INC.	3.1Cr-11.5Ni-13.5Co-1.2Mo (0.21 - 0.25C)	K92580
AM-350™	ALLEGHENY LUDLUM CORP.	16.5Cr - 4.5Ni - 2.9Mo - 0.10N	S35000
AM-355™	ALLEGHENY LUDLUM CORP.	15.5Cr - 4.5Ni - 2.0Mo - 0.10N	S35500
Cherry®	TEXTRON FASTENING SYSTEMS, INC.	NA	NA
Cherrybucks®	TEXTRON FASTENING SYSTEMS, INC.	NA	NA
Custom450®	CRS HOLDINGS INC.	15Cr - 6.5Ni - 0.75Mo - 0.30 (Cb + Ta) - 1.5Cu	S45000
Custom455®	CRS HOLDINGS INC.	12Cr-8.5Ni-2.0Cu-1.1Ti	S45500
Custom465®	CRS HOLDINGS INC.	6Al- 6V - 2SN	none
Ferrium® S53®	Ques Tek Innovations LLC	10Cr-5.5Ni-14Co-2Mo-1W (0.19-0.23C)	S10500
Hastelloy® X	HAYNES INTERNATIONAL, INC.	47.5Ni-22Cr-1.5Co-9.0Mo	N06002
Elektron® 21	MAGNESIUM ELEKTRON	EV31A	Similar to M12310
HAYNES®	HAYNES INTERNATIONAL, INC.	NA	NA
230®	HAYNES INTERNATIONAL, INC.	59Ni-22Cr-2Mo-14W-0.35Al	N06230
Hi-Lok®	HI-SHEAR CORP.	NA	NA
Hi-Shear®	HI-SHEAR CORP.	NA	NA
HR-120®	HAYNES INTERNATIONAL, INC.	35Fe - 24Cr - 37Ni - 0.65Cb - 0.2N	N08120
HSL180™	HITACHI METALS AND SUMITOMO PRECISION PRODUCTS	12.5Cr-1.0Ni-15.5Co-2.0Mo	NA
INCONEL®	HUNTINGTON ALLOYS CORP.	NA	NA
MP159®	SPS TECHNOLOGY	19Cr - 36Co - 25Ni - 7.0Mo - 0.50Cb - 2.9Ti - 0.20Al - 9.0Fe	R30159

<sup>1</sup> Shown in the customary form of 17-4PH in the Handbook.

**MMPDS-05**  
**1 April 2010**

<u>Trademark</u>	<u>Registered by</u>	<u>Chemistry</u>	<u>UNS Number</u>
MP35N®	SPS TECHNOLOGY	20Cr - 35Ni - 35Co - 10Mo	R30035
PH13-8® Mo	ARMCO INC. CORP.	13Cr-8.0Ni-2.2Ni-1.1Al	S13800
PH15-7® Mo	ARMCO INC. CORP.	15Cr - 7.1Ni - 2.5Mo - 1.1Al	S15700
RENE´® 41	TELEDYNE INDUSTRIES INC.	54Ni - 19Cr - 11Co - 9.8Mo - 3.2Ti - 1.5Al - 0.006B	N0704
ToughMet® 3	Brush Wellman Inc.	77Cu-15Ni-8Sn	C72900

**CONTENTS**

<b>Section</b>	<b>Page</b>
<b>Chapter 1</b>	
1.0 General	1-1
1.1 Purpose and Use of Document	1-1
1.1.1 Introduction	1-1
1.1.2 Scope of Handbook	1-1
1.2 Nomenclature	1-3
1.2.1 Symbols and Definitions	1-3
1.2.2 International Systems of Units (SI)	1-3
1.3 Commonly Used Formulas	1-5
1.3.1 General	1-5
1.3.2 Simple Unit Stresses	1-5
1.3.3 Combined Stresses (see Section 1.5.3.5)	1-5
1.3.4 Deflections (Axial)	1-5
1.3.5 Deflections (Bending)	1-5
1.3.6 Deflections (Torsion)	1-6
1.3.7 Biaxial Elastic Deformation	1-6
1.3.8 Basic Column Formula	1-6
1.3.9 Inelastic Stress-Strain Response	1-7
1.4 Basic Principles	1-9
1.4.1 General	1-9
1.4.2 Stress	1-10
1.4.3 Strain	1-10
1.4.4 Tensile Properties	1-10
1.4.5 Compressive Properties	1-13
1.4.6 Shear Properties	1-13
1.4.7 Bearing Properties	1-14
1.4.8 Temperature Effects	1-15
1.4.9 Fatigue Properties	1-16
1.4.10 Metallurgical Instability	1-19
1.4.11 Biaxial Properties	1-19
1.4.12 Fracture Toughness	1-21
1.4.13 Fatigue Crack Growth	1-29
1.5 Types of Failures	1-33
1.5.1 General	1-33
1.5.2 Material Failures	1-33
1.5.3 Instability Failures	1-34
1.6 Columns	1-35
1.6.1 General	1-35
1.6.2 Primary Instability Failures	1-35
1.6.3 Local Instability Failures	1-35
1.6.4 Correction of Column Test Results	1-36
1.7 Thin-Walled and Stiffened Thin-Walled Sections	1-43
1.8 Allowables-Based Flow Stress for Nonlinear Static Analysis	1-45
1.8.1 Introduction	1-45
1.8.2 Procedure	1-45
1.8.3 Reporting Requirements	1-47
References	1-49

**CONTENTS**

<u>Section</u>	<u>Page</u>
<b>Chapter 2</b>	
2.0 Steel .....	2-1
2.1 General .....	2-1
2.1.1 Alloy Index .....	2-1
2.1.2 Material Properties .....	2-2
2.1.3 Environmental Considerations .....	2-7
2.1.4 Obsolete Alloys, Heat Treatments, and Product Forms .....	2-7
2.2 Carbon Steels .....	2-11
2.2.0 Comments on Carbon Steels .....	2-11
2.2.1 AISI 1025 .....	2-12
2.3 Low-Alloy Steels (AISI Grades and Proprietary Grades) .....	2-15
2.3.0 Comments on Low-Alloy Steels (AISI and Proprietary Grades) .....	2-15
2.3.1 Specific Alloys .....	2-19
2.4 Intermediate Alloy Steels .....	2-71
2.4.0 Comments on Intermediate Alloy Steels .....	2-71
2.4.1 5Cr-Mo-V .....	2-71
2.4.2 9Ni-4Co-0.20C .....	2-79
2.4.3 9Ni-4Co-0.30C .....	2-84
2.5 High-Alloy Steels .....	2-95
2.5.0 Comments on High-Alloy Steels .....	2-95
2.5.1 18 Ni Maraging Steels .....	2-97
2.5.2 AF1410 .....	2-107
2.5.3 AerMet 100 .....	2-110
2.5.4 Ferrium S53 .....	2-117
2.6 Precipitation- and Transformation-Hardening Steels (Stainless) .....	2-129
2.6.0 Comments on Precipitation- and Transformation-Hardening Steels (Stainless) .....	2-129
2.6.1 AM-350 .....	2-129
2.6.2 AM-355 .....	2-136
2.6.3 Custom 450 .....	2-142
2.6.4 Custom 455 .....	2-154
2.6.5 Custom 465 .....	2-166
2.6.6 PH13-8Mo .....	2-172
2.6.7 15-5PH .....	2-191
2.6.8 PH15-7Mo .....	2-206
2.6.9 17-4PH .....	2-218
2.6.10 17-7PH .....	2-236
2.6.11 HSL 180 .....	2-243
2.7 Austenitic Stainless Steels .....	2-249
2.7.0 Comments on Austenitic Stainless Steel .....	2-249
2.7.1 AISI 301 and Related 300 Series Stainless Steels .....	2-251
2.8 Element Properties .....	2-271
2.8.1 Beams .....	2-271
2.8.2 Columns .....	2-271
2.8.3 Torsion .....	2-274
References .....	2-281

**CONTENTS**

<b>Section</b>	<b>Page</b>
<b>Chapter 3</b>	
3.0 Aluminum . . . . .	3-1
3.1 General . . . . .	3-1
3.1.1 Aluminum Alloy Index . . . . .	3-1
3.1.2 Material Properties . . . . .	3-2
3.1.3 Manufacturing Considerations . . . . .	3-27
3.1.4 Obsolete Alloys, Tempers, and Product Forms . . . . .	3-32
3.2 2000 Series Wrought Alloys . . . . .	3-35
3.2.1 2013 Alloy . . . . .	3-35
3.2.2 2014 Alloy . . . . .	3-50
3.2.3 2017 Alloy . . . . .	3-89
3.2.4 2024 Alloy . . . . .	3-92
3.2.5 2025 Alloy . . . . .	3-176
3.2.6 2026 Alloy . . . . .	3-178
3.2.7 2027 Alloy . . . . .	3-180
3.2.8 2050 Alloy . . . . .	3-189
3.2.9 2056 Alloy . . . . .	3-195
3.2.10 2090 Alloy . . . . .	3-201
3.2.11 2098 Alloy . . . . .	3-204
3.2.12 2099 Alloy . . . . .	3-213
3.2.13 2124 Alloy . . . . .	3-221
3.2.14 2196 Alloy . . . . .	3-239
3.2.15 2198 Alloy . . . . .	3-243
3.2.16 2219 Alloy . . . . .	3-255
3.2.17 2297 Alloy . . . . .	3-283
3.2.18 2397 Alloy . . . . .	3-292
3.2.19 2424 Alloy . . . . .	3-295
3.2.20 2519 Alloy . . . . .	3-298
3.2.21 2524 Alloy . . . . .	3-301
3.2.22 2618 Alloy . . . . .	3-305
3.3 3000 Series Wrought Alloys . . . . .	3-314
3.4 4000 Series Wrought Alloys . . . . .	3-314
3.5 5000 Series Wrought Alloys . . . . .	3-314
3.5.1 5052 Alloy . . . . .	3-314
3.5.2 5083 Alloy . . . . .	3-328
3.5.3 5086 Alloy . . . . .	3-334
3.5.4 5454 Alloy . . . . .	3-344
3.5.5 5456 Alloy . . . . .	3-349
3.6 6000 Series Wrought Alloys . . . . .	3-355
3.6.1 6013 Alloy . . . . .	3-355
3.6.2 6061 Alloy . . . . .	3-359
3.6.3 6151 Alloy . . . . .	3-387
3.6.4 6156 Alloy . . . . .	3-390
3.7 7000 Series Wrought Alloys . . . . .	3-395
3.7.1 7010 Alloy . . . . .	3-395
3.7.2 7040 Alloy . . . . .	3-403
3.7.3 7049/7149 Alloy . . . . .	3-406
3.7.4 7050 Alloy . . . . .	3-423
3.7.5 7055 Alloy . . . . .	3-473

**CONTENTS**

<b>Section</b>	<b>Page</b>
3.7.6 7056 Alloy .....	3-492
3.7.7 7068 Alloy .....	3-497
3.7.8 7075 Alloy .....	3-504
3.7.9 7085 Alloy .....	3-577
3.7.10 7136 Alloy .....	3-600
3.7.11 7140 Alloy .....	3-604
3.7.12 7150 Alloy .....	3-612
3.7.13 7175 Alloy .....	3-630
3.7.14 7249 Alloy .....	3-645
3.7.15 7349 Alloy .....	3-653
3.7.16 7449 Alloy .....	3-657
3.7.17 7475 Alloy .....	3-673
3.8 200.0 Series Cast Alloys .....	3-703
3.8.1 A201.0 Alloy .....	3-703
3.9 300.0 Series Cast Alloys .....	3-713
3.9.1 354.0 Alloy .....	3-713
3.9.2 355.0 Alloy .....	3-715
3.9.3 C355.0 Alloy .....	3-718
3.9.4 356.0 Alloy .....	3-720
3.9.5 A356.0 Alloy .....	3-723
3.9.6 A357.0/F357.0 Alloy .....	3-727
3.9.7 D357.0/E357.0 Alloy .....	3-731
3.9.8 359.0 Alloy .....	3-735
3.10 Element Properties .....	3-737
3.10.1 Beams .....	3-737
3.10.2 Columns .....	3-738
3.10.3 Torsion .....	3-740
References .....	3-745
 <b>Chapter 4</b>	
4.0 Magnesium Alloys .....	4-1
4.1 General .....	4-1
4.1.1 Alloy Index .....	4-1
4.1.2 Material Properties .....	4-1
4.1.3 Physical Properties .....	4-2
4.1.4 Environmental Considerations .....	4-2
4.1.5 Alloy and Temper Designations .....	4-2
4.1.6 Joining Methods .....	4-5
4.1.7 Obsolete Alloys, Tempers, and Product Forms .....	4-5
4.2 Magnesium-Wrought Alloys .....	4-9
4.2.1 AZ31B .....	4-9
4.2.2 AZ61A .....	4-21
4.2.3 ZK60A .....	4-23
4.3 Magnesium Cast Alloys .....	4-31
4.3.1 AM100A .....	4-31
4.3.2 AZ91C/AZ91E .....	4-33
4.3.3 AZ92A .....	4-37
4.3.4 EV31A .....	4-43
4.3.5 EZ33A .....	4-49

**CONTENTS**

<b>Section</b>	<b>Page</b>
4.3.6 QE22A .....	4-54
4.3.7 ZE41A .....	4-58
4.4 Element Properties .....	4-63
4.4.1 Beams .....	4-63
4.4.2 Columns .....	4-63
4.4.3 Torsion .....	4-66
References .....	4-67
<b>Chapter 5</b>	
5.0 Titanium .....	5-1
5.1 General .....	5-1
5.1.1 Titanium Index .....	5-1
5.1.2 Material Properties .....	5-1
5.1.3 Manufacturing Considerations .....	5-4
5.1.4 Environmental Considerations .....	5-4
5.1.5 Obsolete Alloys, Tempers, and Product Forms .....	5-5
5.2 Unalloyed Titanium .....	5-7
5.2.1 Commercially Pure Titanium .....	5-7
5.3 Alpha and Near-Alpha Titanium Alloys .....	5-17
5.3.1 Ti-5Al-2.5Sn .....	5-17
5.3.2 Ti-8Al-1Mo-1V .....	5-32
5.3.3 Ti-6Al-2Sn-4Zr-2Mo .....	5-48
5.4 Alpha-Beta Titanium Alloys .....	5-56
5.4.1 Ti-6Al-4V .....	5-56
5.4.2 Ti-6Al-6V-2Sn .....	5-121
5.4.3 Ti-4.5Al-3V-2Fe-2Mo .....	5-139
5.5 Beta, Near-Beta, and Metastable-Beta Titanium Alloys .....	5-149
5.5.1 Ti-13V-11Cr-3Al .....	5-149
5.5.2 Ti-15V-3Cr-3Sn-3Al (Ti-15-3) .....	5-166
5.5.3 Ti-10V-2Fe-3Al (Ti-10-2-3) .....	5-170
5.6 Element Properties .....	5-175
5.6.1 Beams .....	5-175
References .....	5-177
<b>Chapter 6</b>	
6.0 Heat-Resistant Alloys .....	6-1
6.1 General .....	6-1
6.1.1 Material Properties .....	6-3
6.1.2 Obsolete Heat Resistant Alloys, Tempers, and Product Forms .....	6-3
6.2 Iron-Chromium-Nickel-Base Alloys .....	6-5
6.2.0 General Comments .....	6-5
6.2.1 A-286 .....	6-5
6.2.2 N-155 .....	6-16
6.3 Nickel-Base Alloys .....	6-21
6.3.0 General Comments .....	6-21
6.3.1 Hastelloy X .....	6-23
6.3.2 Inconel 600 .....	6-29
6.3.3 Inconel 625 .....	6-36

**CONTENTS**

<b>Section</b>	<b>Page</b>
6.3.4 Inconel 706 .....	6-47
6.3.5 Inconel 718 .....	6-53
6.3.6 Inconel X-750 .....	6-90
6.3.7 Rene 41 .....	6-96
6.3.8 Waspaloy .....	6-118
6.3.9 230 .....	6-124
6.3.10 HR-120 .....	6-137
6.4 Cobalt-Base Alloys .....	6-143
6.4.0 General Comments .....	6-143
6.4.1 L-605 (25 alloy) .....	6-144
6.4.2 188 alloy .....	6-167
References .....	6-183
<b>Chapter 7</b>	
7.0 Miscellaneous Alloys and Hybrid Materials .....	7-1
7.1 General .....	7-1
7.1.1 Obsolete Alloys, Tempers, and Product Forms .....	7-1
7.2 Beryllium .....	7-3
7.2.1 Standard Grade Beryllium .....	7-3
7.3 Copper and Copper Alloys .....	7-9
7.3.0 General .....	7-9
7.3.1 Maganese Bronzes .....	7-10
7.3.2 Copper Beryllium .....	7-13
7.3.3 ToughMet 3 .....	7-22
7.4 Multiphase Alloys .....	7-30
7.4.0 General .....	7-30
7.4.1 MP35N Alloy .....	7-31
7.4.2 MP159 Alloy .....	7-37
7.5 Aluminum Alloy Sheet Laminates .....	7-43
7.5.0 General .....	7-43
7.5.1 2024-T3 Aramid Fiber Reinforced Sheet Laminate .....	7-43
7.5.2 7475-T761 Aramid Fiber Reinforced Sheet Laminate .....	7-52
References .....	7-61
<b>Chapter 8</b>	
8.0 Structural Joints .....	8-1
8.1 Mechanically Fastened Joints .....	8-3
8.1.1 Introduction and Fastener Indexes .....	8-3
8.1.2 Solid Rivets .....	8-13
8.1.3 Blind Fasteners .....	8-39
8.1.4 Swaged Collar/Upset-Pin Fasteners .....	8-112
8.1.5 Threaded Fasteners .....	8-127
8.1.6 Special Fasteners .....	8-149
8.2 Metallurgical Joints .....	8-152
8.2.1 Introduction and Definitions .....	8-152
8.2.2 Welded Joints .....	8-152
8.2.3 Brazing .....	8-174
8.3 Bearings, Pulleys, and Wire Rope .....	8-175

**CONTENTS**

<b>Section</b>	<b>Page</b>
References .....	8-177
<b>Chapter 9</b>	
9.0 Index .....	9-1
9.1 General .....	9-7
9.1.1 Introduction .....	9-7
9.1.2 Cross Index Table for Chapter 9 .....	9-7
9.1.3 Applicability .....	9-7
9.1.4 Approval Procedures .....	9-7
9.1.5 Documentation Requirements .....	9-7
9.1.6 Summary .....	9-10
9.1.7 Data Basis .....	9-12
9.1.8 Rounding Procedures .....	9-14
9.2 Material, Specification, Testing, and Data Requirements .....	9-15
9.2.1 Material Requirements .....	9-15
9.2.2 Specification Requirements .....	9-15
9.2.3 Required Test Methods/Procedures .....	9-15
9.2.4 Data Requirements .....	9-29
9.2.5 Experimental Design .....	9-52
9.3 Submission of Data .....	9-63
9.3.1 Recommended Procedures .....	9-63
9.3.2 Computer Software .....	9-63
9.3.3 General Data Formats .....	9-63
9.4 Substantiation of Properties .....	9-73
9.4.1 S-Basis Minimum Properties .....	9-73
9.4.2 Validating Design Properties for Existing Material .....	9-74
9.4.3 Confirmation of Design Properties for Legacy Alloys .....	9-75
9.5 Analysis Procedures for Statistically Computed Minimum Static Properties .....	9-81
9.5.1 Specifying the Population .....	9-81
9.5.2 Regression Analysis .....	9-93
9.5.3 Combinability of Data .....	9-106
9.5.4 Determining the Form of Distribution .....	9-111
9.5.5 Direct Computation Without Regression .....	9-126
9.5.6 Direct Computation by Regression Analysis .....	9-134
9.5.7 Indirect Computation without Regression (Reduced Ratios/Derived Properties) ...	9-136
9.5.8 Indirect Computation using Regression .....	9-139
9.6 Analysis Procedures for Dynamic and Time Dependent Properties .....	9-141
9.6.1 Load and Strain Control Fatigue Data .....	9-141
9.6.2 Fatigue Crack Growth Data .....	9-161
9.6.3 Fracture Toughness Data .....	9-164
9.6.4 Creep and Creep-Rupture Data .....	9-172
9.7 Analysis Procedures for Structural Joint Properties .....	9-179
9.7.1 Mechanically Fastened Joints .....	9-179
9.7.2 Fusion-Welded Joint Data .....	9-199
9.8 Examples of Data Analysis and Data Presentation for Static Properties .....	9-203
9.8.1 Direct Analyses of Mechanical Properties .....	9-203
9.8.2 Indirect Analyses of Mechanical Properties .....	9-216
9.8.3 Tabular Data Presentation .....	9-220

**CONTENTS**

<b>Section</b>	<b>Page</b>
9.8.4 Room Temperature Graphical Mechanical Properties . . . . .	9-226
9.8.5 Elevated Temperature Graphical Mechanical Properties . . . . .	9-247
9.9 Examples of Data for Dynamic and Time Dependent Properties . . . . .	9-267
9.9.1 Fatigue . . . . .	9-267
9.9.2 Fatigue Crack Growth . . . . .	9-285
9.9.3 Fracture Toughness . . . . .	9-291
9.9.4 Creep and Creep Rupture . . . . .	9-292
9.9.5 Mechanically Fastened Joints . . . . .	9-299
9.9.6 Fusion-Welded Joints . . . . .	9-330
9.10 Statistical Tables . . . . .	9-333
9.10.1 One-Sided Tolerance Limit Factors, K, for the Normal Distribution, 0.95 Confidence, and n-1 Degrees of Freedom . . . . .	9-334
9.10.2 0.950 Fractiles of the F Distribution Associated with n <sub>1</sub> and n <sub>2</sub> Degrees of Freedom . . . . .	9-336
9.10.3 0.950 Fractiles of the F Distribution Associated with n <sub>1</sub> and n <sub>2</sub> Degrees of Freedom . . . . .	9-337
9.10.4 0.95 and 0.975 Fractiles of the t Distribution Associated with df Degrees of Freedom . . . . .	9-338
9.10.5 Area Under the Normal Curve from -∞ to the Mean +Z <sub>p</sub> Standard Deviations . . . . .	9-339
9.10.6 One-Sided Tolerance-Limit Factors for the Three-Parameter Weibull Acceptability Test with 95 Percent Confidence . . . . .	9-340
9.10.7 One-Sided Tolerance Factors for the Three-Parameter Weibull Distribution With 95 Percent Confidence . . . . .	9-341
9.10.8 γ-values for Computing Threshold of Three-Parameter Weibull Distribution . . . . .	9-347
9.10.9 Ranks, r, of Observations, n, for an Unknown Distribution Having the Probability and Confidence of T99 and T90 Values . . . . .	9-350
9.10.10 Fractiles of F Distribution Associated with n1(numerator) and n2 (denominator) Degrees of Freedom . . . . .	9-352
References . . . . .	9-355
 <b>Appendices</b>	
A.0 Glossary . . . . .	A-1
A.1 Abbreviations . . . . .	A-1
A.2 Symbols . . . . .	A-5
A.3 Definitions . . . . .	A-6
A.4 Conversion of U.S. Units of Measure Used in MMPDS to SI Units . . . . .	A-17
B.0 Alloy Index . . . . .	B-1
C.0 Specification Index . . . . .	C-1
C.1 Cross Reference of Canceled MIL Specifications . . . . .	C-11
D.0 Testing Standards . . . . .	D-1
E.0 Subject Index . . . . .	E-1

## APPENDIX E

### E.0 Subject Index

- A-Basis, 1-9, 1-45, 9-11, 9-13, 9-30, 9-37, 9-136, 9-225, A-6
- AMS Specifications, 1-9, 9-15, 9-19, 9-30, 9-73, 9-174, C, D
- Anderson-Darling Test
  - k-Sample Test, 9-106
  - Normality, 9-111
  - Pearsonality, 9-114
  - Weibullness, 9-119
- Applicability of Procedures, 9-7
- Approval Procedures, 9-7
- ASTM Standards, 9-12, 9-15, 9-20
  - A 370, 9-17, 9-20
  - B 557, 9-17, 9-20
  - B 117, 2-166
  - B 769, 1-14, 9-20, 9-137
  - B 831, 1-14, 9-20, 9-137
  - C 693, 9-16, 9-21, 9-226
  - C 714, 9-17, 9-21, 9-226
  - D 2766, 9-17, 9-21, 9-226
  - E 8, 1-10, 1-45, 9-16, 9-17, 9-20, 9-44
  - E 9, 1-13, 9-16, 9-20
  - E 21, 9-17
  - E 29, 9-14
  - E 83, 9-16, 9-20, 9-36
  - E 111, 9-16, 9-20, 9-36, 9-225
  - E 132, 9-17, 9-20, 9-225
  - E 139, 1-15, 9-16, 9-27
  - E 143, 9-16, 9-225
  - E 238, 1-14, 3-8, 9-16, 9-20, 9-24
  - E 399, 1-22, 1-23, 9-17, 9-22, 9-29, 9-164
  - E 466, 1-17, 9-17, 9-21
  - E 561, 1-26, 9-17, 9-23, 9-32
  - E 606, 1-17, 9-16, 9-21, 9-38, 9-57, 9-141
  - E 647, 1-29, 9-16, 9-21
  - E 739, 9-52, D-2
  - E 831, 9-16, 9-21, 9-226
  - G 34, 9-16
  - G 47, 9-33
  - G 64, 3-22, D-2
- B-Basis, 1-9, 8-13, 8-39, 9-11, 9-13, 9-30, 9-46, 9-179, A-6
- Backoff Factor, 9-85, 9-115, 9-122, 9-127, A-1, A-6
- Backoff Method
  - for Pearson Distribution, 9-114
  - for Weibull Distribution, 9-121
- Beams, Properties of
  - Aluminum, 3-737
  - Magnesium, 4-63
  - Steel, 2-271
  - Titanium, 5-175
- Bearing Failure, 1-33
- Bearing Properties, ii, 1-14, 3-7, 9-69, 9-76, 9-137, 9-186
- Bearing Data Analysis Procedures, 9-136, 9-139
- Bearing Testing Standards, 9-16
- Bearings, 8-175
- Bending Failure, 1-33, 1-34, 1-35
- Biaxial Properties, 1-19
  - Modulus of Elasticity, 1-20
  - Ultimate Stress, 1-21
  - Yield Stress, 1-20
- Biaxial Stress-Strain Curves, 1-19, 1-20, 2-19, 9-244
- Brittle Fracture, 1-21
  - Analysis, 1-22
- Cast, Definition of, 9-35, A-6
- Censored Data Analysis, 9-119, 9-120, 9-127, 9-133, 9-134, 9-284, 9-341, 9-347
- Clad Aluminum Plate, Design Values for, 9-137
- Coefficient of Thermal Expansion, 9-10, 9-16, 9-20, 9-21, 9-31, 9-36, 9-226, 9-260, A-5
- Columns, 1-35
  - Aluminum, 1-36, 3-738
  - Local Instability, 1-36
  - Magnesium, 1-36, 4-63
  - Primary Instability, 1-35
  - Stable Sections, 1-35
  - Steel, 2-271
  - Test Results, 1-41
  - Yield Stress, 1-36
- Combinability of Data, 9-187
  - Anderson-Darling k-Sample Test, 9-106
  - F Test, 9-108
  - t-Test, 9-109
- Compression Testing, 9-16, D-1
- Compressive Failure, 1-34
- Compressive Properties, 1-13, 9-13, 9-16, 9-18,

**APPENDIX E - Subject Index (continued)**

- 9-19, 9-20, 9-31, 9-35
- Computational Procedures, 9-7, 9-81, 9-203
- Derived Properties, 9-35, 9-136, 9-138, 9-139
- Nonparametric, 9-126, 9-133
- Normal Distribution, 9-111, 9-112
- Pearson Distribution, 9-111, 9-114, 9-131
- Population Specification, 9-81
- Unknown Distribution, 9-133
- Weibull Distribution, 9-111, 9-119, 9-122, 9-132
- Confidence, 9-13, A-7
- Confidence Interval, A-7
- Confidence Interval Estimate, A-7
- Confidence Level, A-7
- Confidence Limit, A-7
- Confirmation of Legacy Alloys, 9-75
- Constant Amplitude Loading, A-7
- Constant Life Fatigue Diagram, A-7
- Coordination Group Activities, 9-10, 9-15
- Crack Growth Rate Calculation, 9-21
- Creep Definition, 1-15, A-7
- Creep/Stress Rupture, 1-15, 9-172, 9-292
  - Data Analysis, 9-59, 9-174, 9-292
  - Data Generation, 9-16, 9-59, 9-172
  - Data Requirements, 9-27, 9-31, 9-41, 9-173
  - Equations, 9-175
  - Example Problems, 9-293
  - Experimental Design, 9-59
  - Presentation of Data, 1-16, 9-293
  - Terminology, 9-172, A-7, A-16
- Cross-Index Table, 9-8
- Cross Reference of Canceled MIL Specifications, C-11
- Data Basis, 9-12
- Data Presentation, 9-203, 9-267
  - Creep-Rupture, 9-293
  - Elevated Temperature Curves, 9-247
  - Fatigue, 9-267, 9-273, 9-280
  - Fatigue Crack Growth, 1-29, 9-285
  - Fracture Toughness, 9-291
  - Fusion-Welded Joints, 9-330
  - Mechanically Fastened Joints, 9-299,
  - Room-Temperature Design Values, 9-220, 9-225
  - R-curve, 1-25
  - Tabular, 9-220
  - Typical (Full-Range) Stress-Strain, 9-238
  - Typical Stress-Strain, 9-226
- Data Requirements, 9-29
  - Creep/Stress Rupture, 9-31, 9-41, 9-59
  - Derived Properties, 9-31, 9-34, 9-35
  - Directly Calculated, 9-31
  - Elastic Properties, 9-31, 9-36
  - Elevated Temperature Properties, 9-31, 9-37
  - Experimental Design, 9-52
  - Fatigue, 9-32, 9-38
  - Fatigue Crack Growth, 9-32, 9-41, 9-52
  - Fracture Toughness, 9-32, 9-41
  - Fusion-Welded Joints, 9-52, 9-60
  - Mechanically Fastened Joints, 9-31, 9-42
  - Mechanical Properties, 9-11, 9-15, 9-29
  - Modulus, 9-31, 9-36
  - New Materials, 9-11, 9-29
  - Physical Properties, 9-31, 9-36
  - Stress-Strain, 9-33, 9-36
- Data Submission Formats, 9-63
  - A- and B-Basis, 9-64
  - Derived Properties, 9-64
  - Fasteners, 9-68
  - Stress-Strain Curves, 9-68
  - Other Properties, 9-69
  - Software, 9-63
- Definition of Terms, A-6
  - Creep/Stress Rupture, 9-172, A-7
  - Fatigue, 9-141, A-9
  - Fracture Toughness, 9-164
  - Heat, Melt and Cast, 9-35, A-9, A-6, A-12
  - Mechanically Fastened Joints, 9-179
  - Mechanical Properties, 9-18
  - Symbols, A-5
- Degrees of Freedom, A-8, 9-101, 9-192, 9-334, 9-336, 9-337, 9-338, 9-352
  - Fastener Analysis, 9-192, 9-195
  - F-test, 9-108
  - Regression, 9-101, 9-103
  - t-test, 9-109
- Density, 9-9, 9-16, 9-20, 9-31, 9-36, 9-226, A-17
- Derived Properties, 1-9, 9-35, 9-64, 9-136
- Design Mechanical Properties, 9-81
  - By Regression, 9-134
  - Determining Form of Distribution, 9-111
  - Determining Population, 9-81
  - Direct Computation, 9-126

**APPENDIX E - Subject Index (continued)**

- Non Parametric, 9-133
- Pearson, 9-114, 9-131
- Weibull, 9- 121, 9-132
- Example Problems, 9-203
- Presentation, 9-220
- Validating, 9-74
- Dimensionally Discrepant Castings, 9-15
- Direct Computation of Allowables, 9-81, 9-126, 9-203
  - Nonparametric Method, 9-133
  - Pearson Distribution, 9-119, 9-131
  - Regression, by, 9-134
  - Weibull Distribution, 9-132
- Distribution, Form of, 9-111
- Documentation Requirements, 9-7
- Elastic Properties, 9-36, 9-225
- Element Properties
  - Aluminum, 3-737
  - Magnesium, 4-63
  - Steel, 2-271
  - Titanium, 5-175
- Elevated Temperature Curves, 1-15, 9-247
  - Data Requirements, 9-37
  - Presentation, 9-247
  - Working Curves, 9-247
- Elongation, 1-12, 9-259
- Environmental Effects, 1-19, 1-21, 1-23
- Examples of Computation Procedures
  - Complex Exposure, 9-263
  - Creep/Stress Rupture, 9-292
  - Design Allowables, 9-203
  - Fatigue, 9-267, 9-273, 9-280
  - Fatigue Crack Growth, 9-285
  - F-Test, 9-108, 9-207
  - Fusion-Welded Joints, 9-330
  - Linear Regression, 9-134
  - Strain-Departure Method, 9-227
  - t-Test, 9-109, 9-207
- F-Distribution Fractiles, 9-336, 9-337
- F-Test, 9-108
- Failure, 1-33
  - General, 1-33
  - Identification code, fastener, 9-70, 9-71
  - Instability, 1-34
  - Local, 1-35
  - Material, 1-33
  - Types, 1-33
- Fastened Joints, 9-299, 9-303
- Fasteners, 8-3, 9-15, 9-27, 9-42, 9-68, 9-179
  - Data Format, 9-68
  - H-Type, 9-186, 9-199
  - S-Type, 9-186, 9-199
  - Sunset Clause, 9-41
- Fatigue, 9-10, 9-21, 9-52, 9-141, 9-267
  - Data Analysis, 9-141, 9-145, 9-158
  - Data Generation, 9-16, 9-21, 9-32, 9-38, 9-52, 9-144, 9-267
  - Data Requirements, 9-16, 9-21, 9-32, 9-136, 9-263, 9-273, 9-280
  - Experimental Design, 9-52
  - Example Problems, 9-267, 9-273, 9-280
  - Life Models, 9-146, 9-149, 9-156, 9-268, 9-274, 9-276, 9-283
  - Load Control, 9-16, 9-32, 9-38, 9-52, 9-141, 9-267, 9-273
  - Outliers, 9-155, 9-276, 9-284
  - Presentation of Data, 1-17, 9-267, 9-280, 9-285
  - Properties, 1-16
  - Runouts, 9-145, 9-159, 9-269, 9-274
  - Strain Control, 9-16, 9-32, 9-38, 9-53, 9-141, 9-269, 9-280
  - Terminology, 9-52
  - Test Planning, 9-52
  - Time Dependent Effects, 9-159
- Fatigue Crack Growth, 1-29, 9-21, 9-52, 9-161, 9-285
  - Crack-Growth Analysis, 1-30, 9-52, 9-141, 9-161
  - Data Analysis, 9-52, 9-141, 9-144, 9-145, 9-162
  - Data Generation, 1-29, 9-32, 9-41, 9-144, 9-162
  - Data Requirements, 9-16, 9-32, 9-41, 9-144
  - Presentation of Data, 1-30, 9-285
- Flow stress, 1-45
- Forgings, Definition of Grain Directions in, 1-23, 9-19, 9-20
- Fracture Toughness, 1-21, 1-22
  - Analysis, 1-22, 9-165, 9-291
  - Apparent Fracture Toughness, 1-25
  - Brittle Fracture, 1-21
  - Crack Resistance, 1-25, 9-166
  - Critical Plane-Strain, 1-22
  - Data Analysis, 9-127, 9-164, 9-291
  - Data Generation, 9-22, 9-29, 9-32, 9-41,

**APPENDIX E - Subject Index (continued)**

- 9-165
- Data Requirements, 9-22, 9-29, 9-32, 9-41
- Definitions, 9-164
- Environmental Effects, 1-23
- Examples, 9-291
- Middle Tension Panels, 1-25, 9-23, 9-41, 9-165, 9-291
- Plane Stress, 1-23, 9-22, 9-32, 9-164, 9-291, A-12
- Plane Strain, 1-22, 9-22, 9-32, 9-164, 9-291, A-12
- Presentation of Data, 9-291
- R-curve, 1-25, 9-166
- Testing Standards, 9-17
- Transitional Stress States, 1-24, 9-22, 9-164
- Full-Range Stress-Strain Curves, 9-68, 9-238
- Fusion-Welded Joints, 9-28, 9-52, 9-199, 9-330
  - Data Analysis, 9-52, 9-200, 9-202
  - Data Generation, 9-52, 9-60
  - Data Requirements, 9-52, 9-60, 9-199
  - Experimental Design, 9-60
  - Presentation of Data, 9-330
  - Test Methods, 9-28
- Goodness-of-Fit Tests, 9-111
  - Anderson-Darling, 9-111
  - Normality, 9-111
  - Pearsonality, 9-114
  - 3 Parameter Weibull Acceptability, 9-112
  - Weibullness, 9-112
- Grain Direction, Treatment of, 9-136
- Grouped Data Analysis, 9-30, 9-111
- Heat, Definition of, 9-35
- Heat Requirements, 9-11, 9-29, 9-31
- Indirect Design Allowables, 9-11, 9-81, 9-136, 9-216
  - Procedure, 9-138
  - Without Regression, 9-136
  - With Regression, 9-139
- Instability, 1-19, 1-34, 1-35
  - Bending, 1-34
  - Combined Loadings, 1-34
  - Compression, 1-34
  - Local, 1-34
  - Torsion, 1-34
- International System of Units, 1-3
- k-Sample Anderson-Darling Test, 9-106
- Larson-Miller Analysis, 9-59, 9-174, 9-177, 9-257, 9-294
- Legacy Alloys, 9-75
- Load Control, 9-16, 9-32, 9-38, 9-52, 9-141, 9-148, 9-267, 9-273
- Location of Test Specimens, 9-18
- Lot Requirements, 9-11
- Material Failures, 1-33
  - Bearing, 1-33
  - Bending, 1-33
  - Combined Stress, 1-33
  - Compression, 1-33
  - Shear, 1-33
  - Stress Concentrations, 1-33
  - Tension, 1-33
- Material Requirements, 9-15
- Material Specifications, 9-15
- Maximum Likelihood Estimation, 9-160
- Mean Stress/Strain Effects, Evaluation of, 9-274
- Mechanical Properties, 9-73
  - Computation of Design Allowables, 9-81
  - Derived Properties, 9-35, 9-136, 9-139
  - Example Problems, 9-203, 9-216
  - Presentation, 9-220
  - Terminology for, 9-18
  - Test Matrix, Derived Property, 9-31, 9-65
- Mechanically Fastened Joints, 8-3, 9-27, 9-179
  - Data Analysis, 9-179, 9-199, 9-202
  - Data Requirements, 9-42, 9-68
  - Definitions, 9-180
  - Example Problems, 9-203, 9-207, 9-299
  - Presentation of Data, 9-299
  - Shear Strength Analysis, 9-185
  - Test Methods, 9-27
  - Yield Load Determination, 9-181
- Melt, Definition of, 9-35
- Metallurgical Instability, 1-19
- Modulus of Elasticity, 1-11, 1-20, 9-16, 9-20, 9-31, 9-36, 9-63, 9-225, 9-259, A-2
- Modulus of Rigidity, 1-13, 9-225, A-2
- NASM 1312, 9-15, 9-16, 9-27, 9-44, 9-68, 9-181, D-2
- Nomenclature, 1-3
- Nonparametric Data Analysis, 9-30, 9-106, 9-126, 9-133, 9-334
- Normal Curve Statistics, 9-111, 9-181, 9-339
- Normality, Assessment of, 9-111
- Orientation, Specimen, 9-23, 9-19, 9-20, 9-137
- Outliers, Treatment of, 9-155, 9-173

**APPENDIX E - Subject Index (continued)**

- Pearson Method, 9-30, 9-126
  - Anderson-Darling, 9-114
  - Backoff, 9-114
  - Procedure, 9-126
  - Probability Plot, 9-115
- Physical Properties, 9-12, 9-20, 9-31, 9-226, 9-260
- Poisson's Ratio, 1-6, 1-10, 9-17, 9-20, 9-32, 9-225, A-6
- Population, 9-60, 9-61, 9-81
- Presentation of Data, 9-203
  - Creep/Stress Rupture, 9-292, 9-295
  - Design Allowables, 9-220
  - Effect of Temperature Curves, 9-247, 9-262
  - Fatigue, 9-267, 9-281, 9-286
  - Fatigue Crack Growth, 9-285
  - Fracture Toughness, 9-291
  - Fusion-Welded Joints, 9-330
  - Mechanically Fastened Joints, 9-299
  - Physical Properties, 9-225, 9-226, 9-260
  - Stress-Strain, 9-226, 9-235, 9-238
- Primary Test Direction, 9-19
- Probability, A-13
- Probability Plots, 9-111
  - Normal, 9-112
  - Pearson, 9-115
  - Weibull, 9-122
- Proportional Limit, A-2
  - Shear, 1-13
  - Stress, 1-12, 9-226
  - Tension and Compression, 1-11, 9-226
- Pulleys, 8-175
- R-curve, 9-166
- Ramberg-Osgood Method, 1-7, 1-45, 9-12, 9-36, 9-226, 9-230, 9-246
  - Extension of, 9-233
- Ranking of Observations, 9-211, 9-350
- Ratioed Values, 1-9
- Ratioing of Mechanical Properties, 9-76, 9-136
- Reduced Ratios, 9-76
  - By Regression, 9-139
  - Without Regression, 9-136
- Reduction in Area, 1-10, 1-13, 9-14, 9-17, 9-18, 9-32, 9-259
- Reduction of Column Test Results, 1-36, 1-41
- Regression, 9-84
  - Combinability, 9-106
  - Direct Computation, 9-134
  - Determining Design Allowables, 9-81
  - Determining Reduced Ratios, 9-139
  - Example Computations, 9-216
  - Least Squares, 9-96, 9-134
  - Linear, 9-96
  - Quadratic, 9-97
  - Tests for Adequacy of, 9-84, 9-100
  - Tests for Equality, 9-93, 9-103
- Rounding, 9-14
- Runouts, Treatment of, 9-57, 9-145, 9-152, 9-159, 9-267, A-13
- S-Basis, 1-9, 9-12, 9-15, 9-29, 9-73, 9-76
- Separately Cast Test Bars, 9-15
- Shear Failure, 1-32
- Shear Properties, 1-9, 1-13, 1-14, 9-13, 9-18, 9-137
- Shear Properties, Fasteners, 9-47, 9-185, 9-187
- Shear Test Procedures, 1-33, 9-11, 9-17, 9-19, 9-20, 9-32, 9-34, 9-35, 9-64
- Shear Test Procedures, Fasteners, 9-27, 9-29, 9-31, 9-432, 9-44, 9-68
- Shear Yield Stress, 9-247
- Significance, A-15
- Skewness, 1-11, 9-75, 9-113, 9-114, 9-119, 9-126, 9-131
- Specific Heat, 9-17, 9-20, 9-32, 9-226, 9-260
- Specification Requirements, 9-15
- Specifying the Population, 9-81
- Specimen Location, 9-18, 9-137
- Standards, Testing, Appendix D
- Statistical Procedures, Handbook Overview, 9-10
- Statistics
  - Symbols, A-5
  - Tables, 9-333
  - Terms/Definitions, A-6
- Strain, 1-10
  - Rate, 1-10
  - Shear, 1-10
- Strain Departure Method, 9-226, 9-227, 9-230, 9-239
- Stress, 1-5
- Stress-Strain Curves, 1-10, 9-12, 9-226
  - Biaxial, 1-19, 9-243
  - Compression Tangent Modulus, 1-13, 9-235, 9-247
  - Data Requirements, 9-34, 9-36, 9-68
  - Example Computation, 9-227, 9-230, 9-235, 9-238

*APPENDIX E - Subject Index (continued)*

- Full-Range, 9-238
- Mathematical Representation, 9-230, 9-240, 9-244
- Minimum, 9-243
- Presentation, 9-226, 9-229
- Ramberg-Osgood, 9-226, 9-230, 9-233
- Strain-Control, 9-280
- Strain-Departure, 9-204, 9-205, 9-218
- Typical, 1-10, 9-36, 9-226
- Stress Rupture, 1-15, 1-16, 9-175, 9-293, A-8
- Submission of Data, 9-63
- Sunset Clause, Fastener, 9-46
- Symbols and Definitions, 1-3, A-5
  - Creep/Stress Rupture, 9-172, A-7
  - Fatigue, 9-141, A-9
  - Fracture Toughness, 9-162
  - General, 1-3, A-5, A-6
  - Mechanically Fastened Joints, 9-179, 9-180
  - Mechanical Properties, 9-18
  - Physical Properties, 9-20, 9-226
  - Statistics, A-5, A-6
- t-Distribution Fractiles, 9-338
- t-Test, 9-109
- Tabular Data Presentation, 9-220
- Tangent Modulus Curves, 9-227, 9-235, 9-247
- Temperature Effects, 1-15, 9-226, 9-247
- Tensile Properties, 1-10
  - Tensile Proportional Limit, 1-11
  - Tensile Ultimate Stress, 1-11
  - Tensile Yield Stress, 1-11
- Terminology
  - Creep Rupture, 1-15, 9-172
  - Fatigue, 1-16, 9-141
  - Mechanical Property, 9-18
- Test Methods, 9-15, 9-16, 9-21
- Test Specimens, 9-15, 9-43
  - Duplication, 9-31, 9-34
  - Location, 9-18
  - Orientation, 9-18, 9-34
  - Primary Test Direction, 9-18
- Testing Procedures, 9-15
  - Bearing, 9-16, 9-20
  - Compression, 9-16, 9-20
  - Creep/Stress Rupture, 9-16, 9-27, 9-41, 9-59
  - Direction, 9-18
  - Dynamic & Time Dependent Properties, 9-38
  - Elastic Properties, 9-16
  - Fatigue, 9-16, 9-21, 9-38, 9-52
  - Fatigue Crack Growth, 9-16, 9-21, 9-41
  - Fusion-Welded Joints, 9-28, 9-52, 9-60
  - Fracture Toughness, 9-16, 9-22
  - Mechanically Fastened Joints, 9-27, 9-43
  - Mechanical Properties, 9-17, 9-18
  - Modulus, 9-20, 9-36
  - Physical Properties, 9-16, 9-20
  - Shear, 9-16, 9-20
  - Short Transverse, 9-19, 9-20
  - Specimen Location, 9-18
  - Stress-Strain, 9-36, 9-226
  - Tension, 9-16, 9-20
  - Testing Standards, 9-16, 9-18
- Tests of Significance, 9-81, 9-106
  - Definitions, A-15
  - F-Test, 9-108
  - t-Test, 9-109
- Test Standards, 9-16, 9-18
- Thermal Conductivity, 9-10, 9-20, 9-226, 9-260
- Thermal Expansion, 9-10, 9-20, 9-226, 9-260
- Thermal Exposure, 9-12, 9-247, 9-261, 9-262
  - Complex, 9-263
  - Simple, 9-262
- Thin Walled Sections, 1-5, 1-43
- Tolerance Bounds, 1-9, 9-81, A-15
  - T<sub>90</sub>, 9-11
  - T<sub>99</sub>, 9-11
- Tolerance Interval, A-16
- Tolerance Level, A-16
- Tolerance Limit Factors, A-3
  - Normal, One-Sided, 9-334
  - Weibull, One-Sided, 9-340, 9-341
- Torsion, Properties
  - Aluminum, 3-740
  - Magnesium, 4-66
  - Steel, 2-274
- Truncation, Lower Tail, 9-111, 9-124, 9-125
- Typical Basis, 9-12
- Ultimate Stress
  - Bearing, 1-14, 1-33
  - Biaxial, 1-21
  - Compression, 1-13
  - Shear, 1-13, 1-14, 1-33
  - Tensile, 1-12, 1-19, 9-239, 9-242
- Ungrouping of Data, 9-30, 9-111
- Units, 1-3, 9-10, 9-18, 9-21, 9-68, 9-73, 9-220, 9-226, A-17
- Validating Properties, 9-74