Metallic Materials Properties Development and Standardization (MMPDS)

MMPDS-08

Chapter 3
ALUMINUM ALLOYS

April 2013

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

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

FOREWORD

The Metallic Materials Properties Development and Standardization (MMPDS) Handbook, is an accepted source for metallic material and fastener system allowables recognized by the Federal Aviation Administration (FAA), all Departments and Agencies of the Department of Defense (DoD), and the National Aeronautics and Space Administration (NASA) within the limitations of the certification requirements of the specific government agency. Some of these limitations are noted below.

Federal Aviation Administration:
Per guidance provided by FAA Advisory Circular (AC) 25.613-1 and FAA policy memorandum PS-AIR100-2006-MMPDS, the 'A' and 'B' basis values published for materials in the MMPDS have been determined by the FAA to satisfy the material strength probability levels required by Title 14 of the Code of Federal Regulations (14 CFR) §§ 27.613(d), § 29.613(d), §25.613(b) and § 23.613(b). These values can be used to demonstrate compliance with the static strength requirements of 14 CFR without further showing. Other data provided (e.g. S-basis properties, fatigue, crack growth, stress-strain curves) in the Handbook might be used for design following FAA ACs and policy. The final determination on their applicability rests with the civil aviation authority responsible for finding compliance for the particular aircraft system on a case-by-case basis.

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Per guidance provided in the Joint Service Specification Guide (JSSG) 2006 and MIL-STD-1530, the "A" and "B" basis design allowables published for materials in the MMPDS have been determined by Department of Defense (DoD) services to satisfy the strength and statistical variability requirements for airframe metallic materials. Other data (e.g. S-basis properties, fatigue, crack growth, stress-strain curves) in the Handbook may be used for design. However, the final determination of the acceptability of data rests with the cognizant design authority responsible for finding compliance for the particular aircraft system.

MMPDS-08 supersedes MMPDS-07 and prior editions of the MMPDS Handbook as well as 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 cancelled by the U.S. Air Force in March 2006.

This document contains design information on the mechanical and physical properties of metallic materials and joints commonly used in aircraft and aerospace vehicle structures. All information contained in this Handbook has been reviewed and approved using a standardized 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 information and procedures in this Handbook are continuously reviewed, and modified or removed as determined to be appropriate. With advances in materials and fastener systems, and with the review process of existing information, periodic updates of the MMPDS should be expected. As such, it is recommended that the latest version of the MMPDS be used.

The allowables contained in the published document, or from approved minutes of the Metallic Materials Properties Development and Standardization (MMPDS) handbook coordination meetings, are

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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

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REGISTERED TRADEMARKS

Trademark	Registered by	Chemistry	UNS Number
15-5PH®	AK STEEL CORP.	15Cr - 4.6Ni - 0.22Cb - 2.8Cu	J92110
		15Cr - 4.5Ni - 0.30Cb - 3.5Cu	S15500
17-4-PH® [1]	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.	6A1- 6V - 2SN	none
Ferrium® S53®	QUES TEK INNOVATIONS LLC	10Cr-5.5Ni-14Co-2Mo-1W (0.19-0.23C)	S10500
Ferrium® M54™	QUES TEK INNOVATIONS LLC	1Cr-10Ni-7Co-2Mo-1.3W (0.28-0.32C)	K91973
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

[1] Shown in the customary form of 17-4PH in the Handbook.

Trademark	Registered by	Chemistry	UNS Number
INCONEL®	HUNTINGTON ALLOYS CORP.	NA	NA
MP159®	SPS TECHNOLOGY	19Cr - 36Co - 25Ni - 7.0Mo - 0.50Cb - 2.9Ti - 0.20Al - 9.0Fe	R30159
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 - 1.1A1	S15700
RENE´ ® 41	TELEDYNE INDUSTRIES INC.	54Ni - 19Cr - 11Co - 9.8Mo - 3.2Ti - 1.5Al - 0.006B	N0704
ToughMet® 3	MATERION BRUSH INC.	77Cu-15Ni-8Sn	C72900

CHAPTER 3 - CONTENTS

CHAPTER 3 - CONTENTS

CHAPTER 3

ALUMINUM

3.1 GENERAL

This chapter contains the engineering properties and related characteristics of wrought and cast aluminum alloys used in aircraft and missile structural applications.

General comments on engineering properties and the considerations relating to alloy selection are presented in this section. Mechanical and physical property data and characteristics pertinent to specific alloy groups or individual alloys are reported in Sections 3.2 through 3.9. Element properties are presented in Section 3.10.

Aluminum is a lightweight, corrosion-resistant structural material that can be strengthened through alloying and, dependent upon composition, further strengthened by heat treatment and/or cold working [Reference 3.1(a)]. Among its advantages for specific applications are low density, high strength-to-weight ratio, good corrosion resistance, ease of fabrication, and diversity of form .

Wrought and cast aluminum and aluminum alloys are identified by a four-digit numerical designation, the first digit indicates the alloy group, as shown in Table 3.1. For structural wrought aluminum alloys the last two digits identify the aluminum alloy. The second digit indicates modifications of the original alloy or impurity limits. For cast aluminum and aluminum alloys the second and third digits identify the aluminum alloy or indicate the minimum aluminum percentage. The last digit, which is to the right of the decimal point, indicates the product form: XXX.0 indicates castings, and XXX.1 and XXX.2 indicate ingot.

3.1.1 ALUMINUM ALLOY INDEX — The layout of this chapter is in accordance with this four-digit number system for both wrought and cast alloys [Reference 3.1(b)]. Table 3.1.1 is the aluminum alloy index that illustrates both the general section layout as well as details of those specific aluminum alloys presently contained in this chapter. The wrought alloys are in Sections 3.2 through 3.7; whereas the cast alloys are in Sections 3.8 and 3.9.

Table 3.1. Basic Designation for Wrought and Cast Aluminum Alloys [Reference 3.1(b)]

Alloy Group	Major Alloying Elements	Alloy Group	Major Alloying Groups
	Wrought Alloys		Cast Alloys
1XXX	99.00 percent minimum aluminum	1XX.0	99.00 percent minimum aluminum
2XXX	Copper	2XX.0	Copper
3XXX	Manganese	3XX.0	Silicon with added copper and/or magnesium
4XXX	Silicon	4XX.0	Silicon
5XXX	Magnesium	5XX.0	Magnesium
6XXX	Magnesium and Silicon	6XX.0	Unused Series
7XXX	Zinc	7XX.0	Zinc
8XXX	Other Elements	8XX.0	Tin
9XXX	Unused Series	9XX.0	Other Elements