Metallic Materials Properties Development and Standardization (MMPDS)

MMPDS-08

Chapter 4 – MAGNESIUM 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.

DoD:
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 acceptable to the Federal Aviation Administration (FAA), the Department of Defense (DoD), and the National Aeronautics and Space Administration (NASA), per the conditions as outlined above. The minutes are copyright protected and are considered approved 30 days after release of meeting minutes, if no objections or corrections have been received by Battelle, or 30 days after a technical change. Approval by the procuring or certificating agency must be obtained for the use of design values for products not contained herein.

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 (614-424-6496 voice or bcommpds@battelle.org email), Battelle, MMPDS, 505 King Avenue, Columbus, OH 43201. You may also contact the Secretariat through the handbook website, 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

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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
17-4-PH® [1]	ARMCO INC. CORP.	15Cr - 4.5Ni - 0.30Cb - 3.5Cu	S15500
		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

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CHAPTER 4

MAGNESIUM ALLOYS

4.1 GENERAL

This chapter contains the engineering properties and characteristics of wrought and cast magnesium alloys used in aircraft and missile applications. Magnesium is a lightweight structural metal that can be strengthened greatly by alloying, and in some cases by heat treatment or cold work or by both.

4.1.1 ALLOY INDEX — The magnesium alloys in this chapter are listed in alphanumeric sequence in each of two parts, the first one being wrought forms of magnesium and the second cast forms. These sections and the alloys covered under each are shown in Table 4.1.

Table 4.1. Magnesium Alloys Index

Section	Designation
4.2	**Magnesium-Wrought Alloys**
4.2.1	AZ31B
4.2.2	AZ61A
4.2.3	ZK60A
4.3	**Magnesium-Cast Alloys**
4.3.1	AM100A
4.3.2	AZ91C/AZ91E
4.3.3	AZ92A
4.3.4	EV31A
4.3.5	EZ33A
4.3.6	QE22A
4.3.7	ZE41A

4.1.2 MATERIAL PROPERTIES

4.1.2.1 *Mechanical Properties* — The mechanical properties are given either as design values or for information purposes. The tensile strength (F_{tu}), tensile yield strength (F_{ty}), elongation (e), and sometimes the compressive yield strength (F_{cy}) are guaranteed by procurement specifications. The properties obtained reflect the location of sample, type of test specimen and method of testing required by the product specification. The remaining design values are "derived" values; that is, sufficient tests have been made to ascertain that if a given material meets the requirements of the product specification, the material will have the compression (F_{cy}), shear (F_{su}) and bearing (F_{bru} and F_{bry}) strengths listed.

4.1.2.1.1 *Tension Testing* — Room temperature tension tests are made according to ASTM E 8. The yield strength (F_{ty}) is obtained by the "offset method" using an offset of 0.2 percent. The speed of testing for room temperature tests has a small effect on the strength and elongation values obtained on most magnesium alloys. The rate of stressing generally specified to the yield strength is less than 100,000 psi per minute and the rate of straining from the yield strength to fracture is less than 0.5 in./in./min. It can be expected that the speed of testing used for room temperature tension tests will approach the maximum permitted.