



Metallic Materials Properties Development and Standardization (MMPDS)

MMPDS-08

Chapter 6 HEAT RESISTANT 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.

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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.

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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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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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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 bcompmpds@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

<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® 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.	6Al- 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.

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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 - 1.1Al	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 6

HEAT-RESISTANT ALLOYS

6.1 GENERAL

Heat-resistant alloys are arbitrarily defined as iron alloys richer in alloy content than the 18 percent chromium, 8 percent nickel types, or as alloys with a base element other than iron and which are intended for elevated-temperature service. These alloys have adequate oxidation resistance for service at elevated temperatures and are normally used without special surface protection. So-called “refractory” alloys that require special surface protection for elevated-temperature service are not included in this chapter.

This chapter contains strength properties and related characteristics of wrought heat-resistant alloy products used in aerospace vehicles. The strength properties are those commonly used in structural design, such as tension, compression, bearing, and shear. The effects of elevated temperature are presented. Factors such as metallurgical considerations influencing the selection of metals are included in comments preceding the specific properties of each alloy or alloy group. Data on creep, stress-rupture, and fatigue strength, as well as crack-growth characteristics, are presented in the applicable alloy section.

There is no standardized numbering system for the alloys in this chapter. For this reason, each alloy is identified by its most widely accepted trade designation.

For convenience in presenting these alloys and their properties, the heat-resistant alloys have been divided into three groups, based on alloy composition. These groups and the alloys for which specifications and properties are included are shown in Table 6.1.

The heat treatments applied to the alloys in this chapter vary considerably from one alloy to another. For uniformity of presentation, the heat-treating terms are defined as follows:

Stress-Relieving — Heating to a suitable temperature, holding long enough to reduce residual stresses, and cooling in air or as prescribed.

Annealing — Heating to a suitable temperature, holding, and cooling at a suitable rate for the purpose of obtaining minimum hardness or strength.

Solution-Treating — Heating to a suitable temperature, holding long enough to allow one or more constituents to enter into solid solution, and cooling rapidly enough to hold the constituents in solution.

Aging, Precipitation-Hardening — Heating to a suitable temperature and holding long enough to obtain hardening by the precipitation of a constituent from the solution-treated condition.

The actual temperatures, holding times, and heating and cooling rates used in these treatments vary from alloy to alloy and are described in the applicable specifications.