

## ***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 (FAA):**

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.

### **Department of Defense (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.

### **National Aeronautics and Space Agency (NASA):**

The “A” and “B” basis design allowables published in the MMPDS handbook have been accepted by the National Aeronautics and Space Agency (NASA) as satisfying the strength requirements for metallic materials used in spacecraft and launch vehicles, as tailored in NASA-STD-6016. Other data (e.g. S-basis properties, fatigue, stress-strain curves) in the Handbook may be used for design. However, the final determination of the acceptability of data rests with the NASA design authority responsible for the particular system.

MMPDS-10 supersedes MMPDS-09 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

**MMPDS-10**  
**1 April 2015**

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 certifying 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 [bcommpps@battelle.org](mailto:bcommpps@battelle.org) email), Battelle, MMPDS, 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<br>(in this case, intermediate alloy steels); or for element properties .....              |  |  |  |
| Particular alloy to which all data are pertinent. If zero, section contains comments<br>on the family characteristics .....                                   |  |  |  |
| If zero, section contains comments specific to the alloy; if it is an integer, the<br>number identifies a specific temper or condition (heat treatment) ..... |  |  |  |
| Type of graphical data presented on a given figure<br>(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            |
| 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            |
| 282®                  | HAYNES INTERNATIONAL, INC.      | 57Ni-20Cr-10Co-8.5Mo-2.1Ti-1.5Al-0.005B        | N07208            |
| 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            |

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

**MMPDS-10**  
**1 April 2015**

| <u>Trademark</u> | <u>Registered by</u>                                 | <u>Chemistry</u>  | <u>UNS Number</u> |
|------------------|--|---|-------------------|
| HSL180™          | HITACHI METALS AND<br>SUMITOMO PRECISION<br>PRODUCTS | 12.5Cr-1.0Ni-15.5Co-2.0Mo                                       | NA                |
| INCONEL®         | HUNTINGTON ALLOYS<br>CORP.                           | NA  | NA                |
| MP159®           | SPS TECHNOLOGY                                       | 19Cr - 36Co - 25Ni - 7.0Mo - 0.50Cb -<br>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<br>INC.                          | 54Ni - 19Cr - 11Co - 9.8Mo - 3.2Ti -<br>1.5Al - 0.006B          | N0704             |
| ToughMet® 3      | MATERION BRUSH INC.                                  | 77Cu-15Ni-8Sn   | C72900            |

## Table of Contents

|  |       |
|--|-------|
| CHAPTER 8 - STRUCTURAL JOINTS . . . . .                        | 8-1   |
| 8.1 MECHANICALLY FASTENED JOINTS . . . . .                     | 8-2   |
| 8.1.1 INTRODUCTION AND FASTENER INDEXES . . . . .              | 8-2   |
| 8.1.1.1 Data Sources . . . . .                                 | 8-12  |
| 8.1.1.2 Fastener Shear Strengths . . . . .                     | 8-12  |
| 8.1.1.3 Edge Distance Requirements . . . . .                   | 8-12  |
| 8.1.2 SOLID RIVETS . . . . .                                   | 8-27  |
| 8.1.2.1 Protruding-Head Solid Rivet Joints. . . . .            | 8-27  |
| 8.1.2.2 Flush-Head Solid Rivet Joints. . . . .                 | 8-27  |
| 8.1.3 BLIND FASTENERS . . . . .                                | 8-38  |
| 8.1.3.1 Protruding-Head Blind Fasteners . . . . .              | 8-38  |
| 8.1.3.2 Flush-Head Blind Fasteners . . . . .                   | 8-38  |
| 8.1.4 SWAGED COLLAR/UPSET-PIN FASTENERS . . . . .              | 8-81  |
| 8.1.4.1 Protruding-Head Swaged Collar Fastener Joints. . . . . | 8-81  |
| 8.1.4.2 Flush-Head Swaged Collar Fastener Joints. . . . .      | 8-82  |
| 8.1.5 THREADED FASTENERS . . . . .                             | 8-92  |
| 8.1.5.1 Protruding-Head Threaded Fastener Joints. . . . .      | 8-92  |
| 8.1.5.2 Flush-Head Threaded Fastener Joints. . . . .           | 8-93  |
| 8.1.6 SPECIAL FASTENERS . . . . .                              | 8-100 |
| 8.1.6.1 Fastener Sleeves . . . . .                             | 8-100 |
| 8.1.6.2 Sleeve Bolts. . . . .                                  | 8-100 |
| 8.2 METALLURGICAL JOINTS . . . . .                             | 8-103 |
| 8.2.1 INTRODUCTION AND DEFINITIONS. . . . .                    | 8-103 |
| 8.2.2 WELDED JOINTS . . . . .                                  | 8-103 |
| 8.2.2.1 Fusion Welding—Arc and Gas . . . . .                   | 8-104 |
| 8.2.2.2 Flash and Pressure Welding . . . . .                   | 8-105 |
| 8.2.2.3 Spot and Seam Welding . . . . .                        | 8-105 |
| 8.3 BEARINGS, PULLEYS, AND WIRE ROPE . . . . .                 | 8-125 |
| REFERENCES . . . . .   | 8-127 |