



AEROSPACE RECOMMENDED PRACTICE

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Specification Guide for Power Drive Units (PDUs)

RATIONALE

There is a need to create a document that provides a guide for specifying recommended requirements for power drive units (PDUs) because they cover a wide range of types and complexity and often include the integration of numerous components. This document meets this need.

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1. SCOPE

This Recommended Practice provides a guide for specifying general design, performance, and test requirements for power drive units (PDUs) for flight controls and other applications.

1.1 Purpose

This document is intended to be used as a guide for the preparation of a detail specification for a PDU.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AMS2419	Plating, Cadmium-Titanium
AMS4931	Titanium Alloy Bars, Forgings, and Rings, 6Al - 4V Extra Low Interstitial (ELI), Duplex Annealed, Fracture Toughness
AMS-A-21180	Aluminum Alloy Castings, High Strength
AMS-A-22771	Aluminum Alloy Forgings, Heat Treated
AMS-STD-2175	Castings, Classification and Inspection of
AMS-C-8837	Coating, Cadmium (Vacuum Deposited)
AMS-C-26074	Electroless Nickel Coatings
AMS-F-7190	Forging, Steel, for Aircraft Aerospace Equipment and Special Ordnance Applications
AMS-QQ-C-320	Chromium Plating (Electrodeposited)
ARP490	Electrohydraulic Servovalves
ARP719	Gas Motor
ARP926	Fault/Failure Analysis Procedure
ARP1383	Aerospace - Impulse Testing of Hydraulic Components
ARP1625	Cold Gas Systems, Missile or Projectile Design, Installation, Tests and Requirements for
ARP4386	Terminology and Definitions for Aerospace Fluid Power, Actuation, and Control Technologies
ARP4493	Aerospace - Direct Drive Servovalves
ARP4752	Aerospace - Design and Installation of Commercial Transport Aircraft Hydraulic Systems

ARP4761	Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment
ARP4925	Aerospace Design and Installation of Commercial Transport Helicopter Hydraulic Systems
ARP4946	Aerospace - Valves, Check, Hydraulic, Aircraft and Missile
ARP5311	Aerospace - Interface Definition for Mechanical Actuation Subsystems
ARP5724	Aerospace - Testing of Electromechanical Actuators, General Guidelines for
AS567	Safety Cable, Safety Wire, Key Washers, and Cotter Pins for Propulsion Systems, General Practices for Use of
AS1241	Fire Resistant Phosphate Ester Hydraulic Fluid for Aircraft
AS4059	Aerospace Fluid Power - Contamination Classification for Hydraulic Fluids
AS4536	Safety Cable Kit Procurement Specification and Requirement for Use
AS4941	Aerospace - General Requirements for Commercial Aircraft Hydraulic Components
AS5440	Hydraulic Systems, Military Aircraft, Design and Installation, Requirements for
AS5643	IEEE-1394b, Interface Requirements for Military and Aerospace Vehicle Applications
AS6038	Bearings, Ball, Bellcrank, Antifriction, Airframe
AS6039	Bearings, Ball, Rod End, Double Row, Self-Aligning
AS7949	Bearings, Ball, Airframe, Antifriction, General Standard for
AS7997	Motors, Aircraft Hydraulic, Constant Displacement, General Specification for
AS8775	Hydraulic System Components, Aircraft and Missiles, General Specification for
AS8914	Bearing, Roller, Self-Aligning, Airframe, Antifriction
AS8943	Bearing, Sleeve, Plain and Flanged, Self-Lubricating, -65 to +250 °F
AS8976	Bearings, Plain, Self-Aligning, All Metal, General Specification for
AS39901	Bearings, Roller, Needle, Airframe, Antifriction, Inch
AS40401	Solenoid, Electrical, General Specification for

2.1.2 ASD-STAN Publications

Available from ASD-STAN Secretariat, Rue Montoyer, 10/5, B-1000 Brussels, Belgium, Tel: +32 2 775 81 26, www.asd-stan.org.

prEN 2997	Aerospace series - Connectors, electrical, circular, coupled by threaded ring, fire-resistant or non fire-resistant, operating temperatures - 65 °C to 175 °C continuous, 200 °C continuous, 260 °C peak
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2.1.3 ASME Publications

Available from ASME, P.O. Box 2900, 22 Law Drive, Fairfield, NJ 07007-2900, Tel: 800-843-2763 (U.S./Canada), 001-800-843-2763 (Mexico), 973-882-1170 (outside North America), www.asme.org.

ASME Y14.100 Engineering Drawing Practices

2.1.4 ANSI PUBLICATIONS

Copies of these documents are available online at <http://webstore.ansi.org/>.

ANSI/AGMA 2000-A88 Gear Classification and Inspection Handbook - Tolerances and Measuring Methods for Unassembled Spur and Helical Gears (Including Metric Equivalents)

2.1.5 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM D910 Standard Specification for Aviation Gasolines

ASTM E1417 Standard Practice for Liquid Penetrant Testing

ASTM E1444 Standard Practice for Magnetic Particle Testing Examination

2.1.6 Battelle Memorial Institute Publications

Available from Battelle Memorial Institute, 505 King Avenue, Columbus, OH 43201, Tel: 614-424-6424, www.mmpds.org.

MMPDS Metallic Material Properties Development and Standardization

2.1.7 EASA Publications

Available from European Aviation Safety Agency, Ottoplatz, 1, D-50679 Cologne, Germany, Tel: +49 221 8999 000, www.easa.europa.eu.

CS-23 Certification Specifications for Normal, Utility, Aerobatic and Commuter Aeroplanes

CS-25 Certification Specifications for large Aeroplanes

2.1.8 FAA Publications

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov.

14 CFR Part 23 Airworthiness Standards: Normal Category Airplanes

14 CFR Part 25 Airworthiness Standards: Transport Category Airplanes

2.1.9 ISO Publications

Copies of these documents are available online at <http://webstore.ansi.org/>.

ISO 2434	Compressed Non-Breathing Air for Use in Aircraft
ISO 4406	Hydraulic Fluid Power - Fluids - Method for Coding the Level of Contamination by Solid Particles
ISO 9206	Aerospace - Fixed Displacement Hydraulic Motors - General Specifications
ISO 10012	Equipment, Quality Assurance Requirements for Measuring

2.1.10 NAS Publications

Available from Aerospace Industries Association, 1000 Wilson Boulevard, Suite 1700, Arlington, VA 22209-3928, Tel: 703-358-1000, www.aia-aerospace.org.

NASM15981	Fasteners, Externally Threaded, Self-Locking, Design and Usage Limitation for
NASM20995	Wire, Safety or Lock
NASM24665	Pin, Cotter (Split)
NASM33540	Safety Wiring and Cotter Pinning, General Practices for

2.1.11 RTCA Publications

Available from RTCA, Inc., 1150 18th Street, NW, Suite 910, Washington, DC 20036, Tel: 202-833-9339, www.rtca.org.

RTCA/DO-160	Environmental Conditions and Test Procedures for Airborne Equipment
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2.1.12 U.S. Government Publications

Copies of these documents are available online at <https://quicksearch.dla.mil>.

A-A-55598	Bearings, Roller, Cylindrical, Single Row of Rollers, Two Roller Retaining Ribs on Inner Ring, One Roller Retaining Rib on Outer Ring, One Direction Locating
A-A-55599	Bearings, Roller, Cylindrical, Single Row of Rollers, One Roller Retaining Rib on Inner Ring, Two Roller Retaining Ribs on Outer Ring, One Direction Locating
A-A-55600	Bearings, Roller, Cylindrical, Single Row of Rollers, Two Roller Retaining Ribs on Inner Ring, Two Roller Retaining Ribs on Outer Ring, Two Direction Locating
A-A-55601	Bearings, Roller, Cylindrical, Single Row of Rollers, Cylindrical Inner Ring, Two Roller Retaining Ribs on Outer Ring, Non-Locating
A-A-55602	Bearings, Roller, Cylindrical, Single Row of Rollers, Two Roller Retaining Ribs on Inner Ring, Cylindrical Outer Ring, Non-Locating
JSSG-2006	Aircraft Structures
MIL-A-8625	Anodic Coatings for Aluminum and Aluminum Alloys
MIL-DTL-38999	Connectors, Electrical, Circular, Miniature, High Density, Quick Disconnect (Bayonet, Threaded, and Breech Coupling), Environment Resistant, Removable Crimp and Hermetic Solder Contacts, General Specification For

MIL-HDBK-454	General Guidelines for Electronic Equipment
MIL-HDBK-470	Maintainability Program Requirements for Systems and Equipment
MIL-HDBK-831	Preparation of Test Reports
MIL-HDBK-838	Lubrication of Military Equipment
MIL-HDBK-1587	Materials and Process Requirements for Air Force Weapons Systems
MIL-I-8500	Interchangeability and Replaceability of Component Parts for Aerospace Vehicles
MIL-PRF-83282	Hydraulic Fluid, Fire Resistant
MIL-PRF-87257	Hydraulic Fluid, Fire Resistant; Low Temperature, Synthetic Hydrocarbon Base, Aircraft and Missile
MIL-STD-129	Military Marking for Shipment and Storage
MIL-STD-130	Identification Marking of U.S. Military Property
MIL-STD-461	Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems , Equipment
MIL-STD-464	Electromagnetic Enviromenta Effects Requirements For Systems
MIL-STD-704	Aircraft Electrical Power Characteristics
MIL-STD-785	Reliability Program for Systems and Equipment, Development and Production
MIL-STD-810	Environmental Test Methods
MIL-STD-882	System Safety Program Requirements
MIL-STD-889	Dissimilar Metals
MIL-STD-1472	Human Engineering
MIL-STD-1553	Digital Time Division Command/Response Multiplex Data Bus
MIL-STD-31000	Technical Data Packages

2.2 Definitions

Refer to ARP4386 for the generic terms that are called up in this document.

POWER DRIVE UNIT (PDU): An assembly of components which converts a regulated supply of available power to controlled shaft power for the purpose of operating a linear or rotary mechanical actuator.

NOTES:

1. A PDU may be provided with a power source which is electrical, hydraulic (including fueldraulic), or pneumatic.
2. A PDU assembly normally includes all components and subassemblies required to manage the supplied input power, control the motion of the output mechanical shaft(s), and to interface to applicable system controls.
3. PDU configurations vary considerably from application to application.

4. A PDU may include few or many of the following components or features:

- a. Motor: The power converter, which may be electrical, hydraulic, or pneumatic.
- b. Motor power controls: For example, electrical power switching circuits for electric drives, or hydraulic or pneumatic valves for hydraulic or pneumatic drives.
- c. Gear reduction: Various configurations and types.
- d. Brake and associated equipment: Holding or dynamic stopping.
- e. Torque limiting devices: For example, torque brake, slip clutch, etc.
- f. Backup power provisions.
- g. Limit switches and/or position sensors to control output travel.
- h. Electrical, electronic, or other controls which transmit position, velocity, or other commands to the PDU motor drive controls.
- i. Mechanical travel limit stops to limit the rotary output motion in the event of control failure and overtravel of electrical travel authority.
- k. Manual drive to allow for manual operation on the ground without electric, hydraulic, or pneumatic power required.
- l. No-back system: For example, no-back device to keep from backdriving manual drive during normal operation, etc.
- m. Output shaft with provisions for interfacing with driven system actuators.
- n. Interfaces: Mounting provisions for interfacing with aircraft structure; provisions for interfacing with input power source, i.e., electrical, hydraulic, or pneumatic connections; provisions for interfacing with control electronics or mechanical input devices, e.g., electrical wires, mechanical cables.

3. REQUIREMENTS

3.1 Interface Definition

A PDU will typically interface with other aircraft equipment and subsystems for power input, control, power output, built-in test equipment (BITE), and maintenance support equipment. All interfaces should be described within the detailed specification or on the specification control drawing (SCD). Interfaces to the aircraft structure and systems should be in accordance with ARP5311.

Typical power interface requirements for the three classifications of PDUs are listed below.

3.1.1 Hydraulic Power Interface

The PDU should be designed to integrate into hydraulic systems as defined in ARP4752, ARP4925, or AS5440, as applicable. The design, development, and qualification of the hydraulic elements should be in accordance with AS8775 or AS4941 and other applicable standards.

If fuel is the power transmission fluid in the case of fueldraulic systems, then their specific related standards should apply.

3.1.1.1 Hydraulic Fluid Specifications

Applicable hydraulic fluid specification(s) should be stated. Typical aircraft hydraulic specifications such as AS1241, MIL-PRF-87257, and MIL-PRF-83282 may be utilized. The PDU specification should require all materials used in the PDU to be compatible with the selected hydraulic fluid.

If fuel is the power transmission fluid in the case of fueldraulic systems, then ASTM D910 should apply.

3.1.1.2 Hydraulic Fluid Cleanliness

The maximum contamination level of the fluid supplied to the PDU is dependent on the application. The specification should define the cleanliness requirements of the hydraulic fluid that will be supplying the PDU. If the cleanliness level of the supplied hydraulic fluid is not sufficient for the specific application, then additional filtration should be provided as part of the PDU installation. AS4059 and ISO 4406 are the appropriate references for defining hydraulic cleanliness levels.

If fuel is the power transmission fluid in the case of fuelhydraulic systems, then their specific related standards should apply.

3.1.1.3 System Pressure and Flow Characteristics

Fluid system pressure characteristics supplied to the PDU should be specified, including both high and return working pressures, and flow versus pressure characteristics for both supply and return over a range of operating temperatures. The fluid pressure at the defined interfaces should be based on a full system assessment and include line losses and other sources of pressure drop.

Transient pressure conditions such as pump ripple, switching transients, system pressure spikes, and pressure drop should be included where applicable. AS5440, ARP4752, or other applicable specifications may be cited.

3.1.1.4 Fluid Temperature

The range of fluid temperature supplied to the PDU should be specified. If the temperature variation of the hydraulic fluid needs to be considered (for example, the fluid temperature in the PDU increasing from a low ambient temperature to the hydraulic system operating temperature), this should be specified.

3.1.1.5 Hydraulic System Interface Requirements

Adequate information to allow the PDU designer to configure the hydraulic interconnections with the aircraft system should be provided. An interface drawing should be included with the specification control drawing. A description of the hydraulic system that supplies the PDU in schematic form should also be included.

3.1.2 Electrical Power Interface

3.1.2.1 Electrical Power Characteristics

The PDU should meet all performance requirements when supplied with electrical power having the characteristics and limits defined in MIL-STD-704, RTCA/DO-160, or another applicable specification. The power specified may be either AC or DC. The voltage operating range should be specified. If desired, the maximum allowable power consumption may be specified in watts. The maximum current may be specified in amperes and should consider the limiting operating temperature conditions. The available voltage at the defined interfaces should be based on a full system assessment and include line losses and other sources of voltage drop. Transient voltage conditions such as switching transients and system voltage spikes should be included where applicable.

Additional electrical supply power requirements specific to the application should be specified including acceptable harmonic distortion, acceptable power interruption characteristics, acceptability to absorb regenerative energy from the PDU, etc.

3.1.2.2 System Temperature Range

The ambient operating temperature range of the PDU should be specified.

3.1.2.3 Interconnecting Wiring

In some cases, the interconnecting wiring is specified. Usually the selection of interconnecting connector(s) to the aircraft system is specified, such as MIL-DTL-38999, prEN 2997, etc. Connector type, size, and general location may be included on the specification control drawing.