



AEROSPACE RECOMMENDED PRACTICE

ARP5311™

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Superseding ARP5311

Aerospace-Interface Definition for Mechanical Actuation Subsystems

RATIONALE

ARP5311 has been reaffirmed to comply with the SAE Five-Year Review policy.

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1. SCOPE:

This SAE Aerospace Recommended Practice (ARP) defines all the relevant issues that affect the generation of an Interface Control Document for Mechanical Actuation Sub-Systems. It is intended to provide to all parties involved with the generation of Mechanical Actuation Sub-Systems, a definition of documentation, drawings, reports and design parameters required to assure a successful development of mechanical actuation sub-systems for Aerospace-Military and Commercial applications.

1.1 Purpose:

This ARP is intended as a guide, in the preparation of interface requirements, for Mechanical Actuation Subsystems used in Aerospace-Military and Commercial applications. This document focuses on mechanical actuation subsystems to position control surfaces, weapon systems, cargo bay doors and other similar mechanisms, in response to manual or automatic power control system inputs. Detail requirements necessary to completely define the mechanical subsystem interfaces, whether in a Procurement Specification and/or a separate Interface Document, are the responsibility of the procuring agency.

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, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AS1241	Fire Resistant Phosphate Ester Hydraulic Fluid For Aircraft
ARP1383	Impulse Testing of Hydraulic Actuators, Valves, Pressure Containers and Similar Fluid System Components
AIR4922	Primary Flight Control Systems Hydraulic Actuation System Interface Definition
ARP4058	Actuators: Mechanical, Geared Rotary, General Specification For
AS4059	Aerospace - Cleanliness Classification for Hydraulic Fluids
ARP4255	Electrical Actuation Systems for Aerospace and Other Applications
ARP4386	Terminology and Definitions for Aerospace Fluid Power Actuation, and Control Technologies
ARP4761	Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment, SAE, 1996-12
ARP4895	Aerospace - Flight Control Actuator Displacement - Method for Collection Of Duty Cycle Data
SAE J2333	Ship Systems and Equipment-Hydraulic Systems-Filter Selection Parameters

2.1.2 U.S. Government Publications: Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-DTL-38999	Connector, Electrical, Circular Miniature, High Density, Quick Disconnect (Bayonet, Threaded and Beach Coupling), Environment Resistant, Removable Crimp and Hermetic Solder Contacts, General Specification for
MIL-H-5606	Hydraulic Fluid, Petroleum Base, Aircraft, Missile and Ordinance (Inactive for new design)
MIL-HDBK-454	General Requirements for Electronics Equipment - 28 Apr 95
MIL-HDBK-5400	Electronic Equipment, Aerospace, General Specification for
MIL-PRF-83282	Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Aircraft, Metric, NATO Code No. H-537
MIL-PRF-87257	Hydraulic Fluid, Fire Resistant, Low Temperature, Synthetic Hydrocarbon Base, Aircraft and Missile
MIL-STD-464	Department of Defense Interface Standard for Electromagnetic Environmental Effects Requirements for Systems
MIL-STD-704	Electric Power, Aircraft, Characteristics and Utilization of
MIL-STD-810	Test Method Standard for Engineering Considerations and Laboratory Tests
MIL-STD-889	Dissimilar Metals

2.2 Related Documents: The following publications are provided for information purposes only and are not a required part of this SAE Aerospace Technical Report.

RTCA DO-160	Environmental Conditions and Test Procedures for Airborne Equipment
FAR/JAR 25.1309	Equipment, Systems and Installations

2.3 Definitions:

The mechanical actuation subsystem consists of a Power Drive Unit (PDU) such as pneumatic, hydro-mechanical or electro-mechanical PDU, power transmission shafts, and mechanical actuators (either linear or rotary). The PDU receives its input power from either a pneumatic, electric or hydraulic system. Input control signals are analog, digital, optical or mechanical (cables and linkages). The PDU mechanical output provides the input power to the mechanical actuators. The mechanical actuators' output move control surfaces, weapon systems, cargo bay doors and other similar mechanisms. Definitions shown reflect ARP4386.

3. TECHNICAL REQUIREMENTS:

3.1 Required Interfaces:

The mechanical actuation subsystem interfaces are shown in Figure 1.

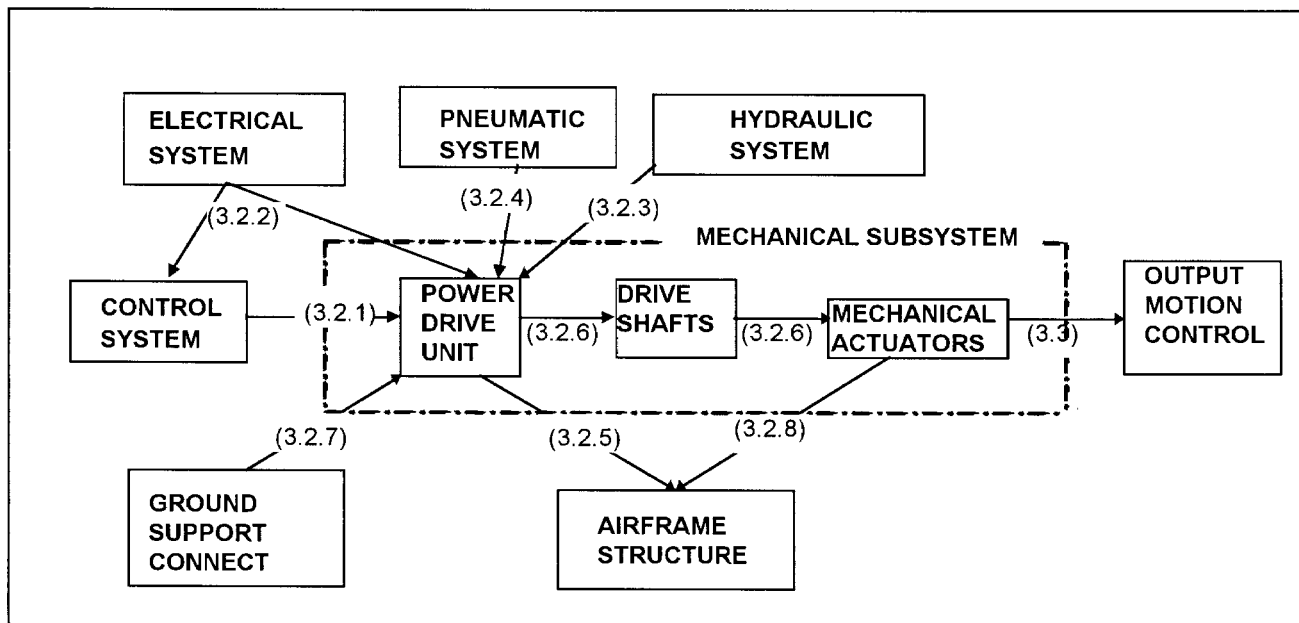


FIGURE 1 - Mechanical Subsystem Interfaces

3.2 Interface Definitions:

The power drive unit normally interfaces with the following:

- Control System
- Electrical, Pneumatic And/Or Hydraulic System
- Drive Shafting
- Airframe Structure

If required, a secondary input drive may also interface with the power drive unit for use on the ground during maintenance and/or checkout.

- 3.2.1 Control Signal Interface: Control signal devices necessary for loop closure and control signals interface shall be defined. All signals, mechanical, electrical (analog and/or digital), or optical, but excluding input power, that are input to or output from the Power Drive Unit, shall be defined.

Definition of this interface shall include, but not be limited to:

- Number and types of interfaces
- Functionality of interfaces (command, status, BIT)
- Description of the protocol at each level (electrical characteristics, syntax, format) such as described by applicable specifications
- Interface schematics

- 3.2.1.1 Analog: The analog control signal interface with the main aircraft flight control computer may be via position sensors such as RVDTs or LVDTs speed sensors such as tachometers, and current sensors.

For RVDTs and LVDTs the following characteristics shall be specified:

- a. Excitation voltage and frequency
- b. Input power
- c. Input and output impedance
- d. Load resistance and inductive reactance
- e. Stroke (degrees or inches)
- f. Null voltage and full stroke output
- g. Output error band
- h. Temperature range, operating and non-operating
- i. Phasing and phase shift

For multi-channel units, tracking channel to channel and cross channel coupling shall also be specified.

- 3.2.1.2 Digital: The digital communication serial data link (such as 1553) and number of transmitters and receivers with the main aircraft flight control computer shall be specified. Functionality (command, status, BIT) and format of the information flow shall also be specified.
- 3.2.1.3 Optical: Interfaces such as optical connectors, optical transducers and optical transfer devices shall be defined in the ICD or the procurement specification.
- 3.2.2 Electrical Power Interface: The electrical input power, AC and/or DC, to the Power Drive Unit shall be defined. The input power definition can be specified as MIL-STD-704 or a similar specification that has been developed for the industry or for a particular vehicle.

A definition of normal, transient and emergency operation shall be provided. This definition shall include normal operation (for the majority of the time), abnormal or transient operation (for a short time), and emergency operation (if applicable). The maximum electrical power available shall also be defined. The physical electrical interface; connection information, size and location shall be defined. The type and location of electrical interface components, such as mating connectors and bonding straps, shall be defined in the interface control drawing as part of the ICD.

- 3.2.2.1 Input Power Normal Operation: The electrical input power, AC and/or DC supplied to operate the system without performance degradation shall be specified as a voltage range per a specification (such as MIL-STD-704 or similar industry or one developed for the specific aircraft). Normally, the actuation subsystem shall be required to perform within specification during the period of momentary (milliseconds) power interruptions. Allowable maximum power consumption and inrush current shall also be specified. The source and impedance characteristics shall be specified. Available power and power quality for ground operation shall also be specified.

- 3.2.2.2 Emergency Operation: Operation following an emergency (loss of primary power) shall be specified and in terms similar to that in 3.2.2.1.
- 3.2.2.3 Regenerated Power: In some electric Power Drive Units, significant aiding loads during portions of system operation will drive the motor into a generating mode. This generated power shall be recognized and its method of disposal specified. The pros and cons of whether to put the power back into the aircraft electrical system, local storage, or dissipate it in a load shall be considered. Electrical distribution systems will have a strong influence on the type of choice (i.e., do not want to raise the voltage) and may be dictated by aircraft systems requirements.
- 3.2.2.4 Grounding and Shielding: The grounding of the actuation subsystem shall be designed to prevent ground loops, and common returns for signal and power circuits, provide effective shielding for signal circuits, minimize electromagnetic interference and protect personnel from electrical hazards. Electrical bonding of electrical and electronic components shall be done in accordance with MIL-STD-464. Bonds between dissimilar materials where an electrolyte may be present shall be protected from corrosion as identified in MIL-STD-889. Each electrical or electronic assembly other than sensors shall have a ground return isolated from the power return lead or connector pin.

The procuring agency shall have the final authority for defining primary and secondary power grounding, interconnecting wire shielding, and shield, component, and safety grounds; normally the actuation subsystem grounding scheme will be defined in the interface control document to ensure compatibility with the aircraft grounding.

The electrical interface control drawing shall define the grounding straps to be provided as part of the line replaceable mechanical actuation components. Mounting of the Power Drive Unit case shall satisfy the electrical bonding requirements of MIL-STD-464.

- 3.2.2.5 Interface Wiring/Connectors: Unless otherwise specified by the procuring agency or as noted in the specification, internal wiring shall meet the requirements of MIL-HDBK-454, and electrical connectors shall meet the requirements of MIL-HDBK-5400. Connectors shall be chosen per MIL-DTL-38999, Series III. Power leads shall be separated from signal leads to avoid interference. If connectors are used as portions of pressure chambers, hydraulic design parameters of the pressure chambers shall be applied to the connectors as well.
- 3.2.3 Hydraulic Power Interface: The hydraulic fluid type (applicable specification) and fluid temperature range shall be defined. Hydraulic system inlet (supply) and outlet (return) pressures to the Power Drive Unit shall be specified as a function of hydraulic flow as well as supply and return transients. The physical hydraulic interface; connection information, size and location shall be defined.
- 3.2.3.1 Fluid Type: The procuring agency shall specify the fluid type. Typical hydraulic fluids are: MIL-H-5606, MIL-PRF-83282 and MIL-PRF-87257 for military aircraft, and AS1241 Phosphate Ester for commercial aircraft.

- 3.2.3.2 Fluid Temperature: The procuring activity shall define the hydraulic system Type (I, II or III) that the mechanical system will interface with. The fluid temperature ranges and required performance in the ranges shall be specified. For example:

TABLE 1

Fluid Temperature	Performance
-65 °F to -40 °F	Limited Operation
-40 °F to +20 °F	Partial Performance
+20 °F to +275 °F	Full Performance

- 3.2.3.3 Fluid Contamination: The maximum fluid contamination level shall be defined per AS4059. The equipment shall perform as required, at the specified contamination level, with hydraulic fluid filtered through a filter element. Filter selection shall be made to ensure reliable operation of all system components. SAE J2333 shall be used as a guide in filter selection.

3.2.3.4 System Pressure:

- 3.2.3.4.1 Operating Pressure: The normal operating system pressure, at the Power Drive Unit inlet (supply) and outlet (return) available for full performance operation, shall be specified as a function of hydraulic flow rate.
- 3.2.3.4.2 Proof Pressure: The proof pressure that the Power Drive Unit will be required to withstand without evidence of leakage, permanent set, or performance degradation when subjected to defined environments and loads shall be specified. The proof pressure is defined as 1.5 times the normal supply pressure.
- 3.2.3.4.3 Static Burst Pressure: The burst pressure that the Power Drive Unit will be required to withstand without rupture (failure) shall be specified. The static burst pressure is normally defined as 2.5 times the normal supply.
- 3.2.3.4.4 Supply and Return Pressure Variations: The Power Drive Unit shall exhibit no instability, other than appropriate changes in velocity under dynamic conditions, as a result of variations in the hydraulic system supply and return pressure as defined in the specification.

The maximum allowable rate of flow change by the Power Drive Unit shall be defined to control the magnitude of the pressure transients, which the Power Drive Unit can create.