



AEROSPACE RECOMMENDED PRACTICE	ARP5724™	REV. A
	Issued 2013-10 Revised 2025-07	
	Superseding ARP5724	
Recommended Test Requirements for Electromechanical Actuators		

RATIONALE

This revision provides additional recommendations and aligns the document with related documents that have been recently issued or revised.

FOREWORD

Electromechanical Actuators (EMAs) may be used in a wide variety of applications, such as utility, secondary flight controls, and primary flight controls, in a wide variety of markets, including manned and unmanned civil and military aircraft, small missile fin, and thrust vector control applications up to high-powered utility and flight controls. EMAs may also have either a rotary or a linear output, be servo controlled, or use simple open loop point-to-point or other control topologies. As such, this document covers a wide range of potential applications; the application of any given test requirement is determined by the application and the user.

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1. SCOPE

This Aerospace Recommended Practice (ARP) provides recommended requirements for the testing of electromechanical actuators (EMAs). General test considerations are also provided. While many EMA configurations include motor control electronics, the specific tests required for the electronic hardware, software, or firmware are outside the scope of this document.

1.1 Purpose

The purpose of this document is to facilitate the generation of test requirements, plans, and procedures for EMAs. It covers unit integration, acceptance, and qualification tests. It attempts to provide basic guidance on which tests should be considered for various applications. This document also lists tests that are not unique to EMAs but are still applicable to EMAs. In these instances, a discussion of such tests is not contained in this document; as applicable, the reader may reference the appropriate documents as indicated in the text.

The tests and test methodologies discussed in this document, while not necessarily all-inclusive, are also not to be construed as mandatory. They are advisory, with the user bearing the responsibility to ensure that all relevant specification requirements for the user's equipment are met by the test specifications and procedures generated and that they preclude any undesirable over-testing.

NOTE: This document does not address tests and issues of a higher system level, such as the primary flight control surface level where multiple actuators may be integrated.

1.2 Field of Application

This document focuses on EMA for both military and commercial aircraft applications.

NOTE: It should be the user's responsibility to ensure that particular qualification or certification requirements, or applicable specifications, standards, or regulations for the intended application, are satisfied by the EMA design and the tests and test methods that are developed.

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.

ARP1281	Actuators: Aircraft Flight Controls, Power Operated, Hydraulic, General Specification For
ARP4386	Terminology and Definitions for Aerospace Fluid Power, Actuation and Control Technologies
ARP7490	Recommended Guidelines for the Specifications of Motor Control Electronics for Electrically Powered Actuators

2.1.2 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 D149 Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies

2.1.3 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

2.1.4 U.S. Government Publications

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

MIL-STD-704 Aircraft Electric Power Characteristics

MIL-STD-810 Environmental Engineering Considerations and Laboratory Tests

2.2 Related Publications

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

2.2.1 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.

AIR4543 Aerospace Hydraulics and Actuation Lessons Learned

AIR6127 Managing Higher Voltages in Aerospace Electrical Systems

ARP4058 General Specification Guide for Mechanical Geared Rotary Actuators

ARP4255 Electrical Actuation Systems for Aerospace and Other Applications

ARP4754 Guidelines for Development of Civil Aircraft and Systems

ARP4761 Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment

ARP5007 Development Process - Aerospace Fly-by-Wire Actuation System

ARP5311 Aerospace-Interface Definition for Mechanical Actuation Subsystems

ARP5754 Electromechanical Actuators Specification Guide

ARP5812 Actuators, Linear Mechanical, General Specification Guide

2.3 Definitions

The primary source for terminology and definitions used herein is ARP4386.

LOAD: This is the force applied to the output of a linear actuator or the torque applied to the output of a rotary actuator.

NOTE: Since EMAs may have either linear or rotary outputs, the term load is used throughout this document to represent either force or torque as relevant to the application.

MOTOR CONTROL ELECTRONICS: This is the electronics required to power and control electric servo motors.

NOTE: Other terms are sometimes used to describe motor control electronics, including:

- Actuator Control Electronics (ACE)
- Electronic Actuator Control Unit (EACU)
- Electronic Unit (EU), Motor Control Unit (MCU)
- Motor Power Drive (MPD)
- Power Control Electronics (PCE)
- Power Drive Electronics (PDE)
- Power Drive Unit (PDU)
- Remote Electronic Unit (REU)

For this document, these terms may be considered equivalent.

UNIT INTEGRATION TESTS: These are tests that are designed to subject the EMA to a series of tests to verify that the EMA and subsystem function per its design requirements.

NOTE 1: These tests may be limited to functional verification at a relatively higher level or could include lower-level performance verification.

NOTE 2: These tests generally precede formal qualification tests and are not counted as a part of the formal qualification.

NOTE 3: These tests are performed following a specific test procedure, typically referred to as the integration test procedure (ITP).

NOTE 4: These tests are typically performed once on each design; they may be repeated if determined to be needed based on changes to the hardware or the requirements during the test program.

SYSTEM INTEGRATION TESTS: These tests include control system integration and aircraft system integration.

NOTE 1: Control system integration tests are usually performed by the equipment manufacturer and include all tests required to verify the EMA and the MCE perform properly as a control actuation subsystem.

NOTE 2: Aircraft system integration tests are usually performed by the aircraft manufacturer and include all tests required to verify the control actuation subsystem performs properly with the rest of the aircraft structure, flight control system, power generation system, etc.

NOTE 3: Specifics of system integration tests are outside the scope of this document.

NOTE 4: These tests are typically performed once on each design; they may be repeated if determined to be needed based on changes to the hardware or the requirements during the test program.

2.4 Abbreviations

ACE	Actuator Control Electronics
ATP	Acceptance Test Procedure
BIT	Built-In Test
CE	Control Electronics
DWV	Dielectric Withstanding Voltage
EMA	Electromechanical Actuator
EMU	Electromechanical Unit
ESS	Environmental Stress Screening
FTP	Functional Test Procedure
HASS	Highly Accelerated Stress Screening
HALT	Highly Accelerated Life Test
ITP	Integration Test Procedure
MCE	Motor Control Electronics
PDE	Power Drive Electronics
REU	Remote Electronic Unit
UUT	Unit Under Test
VTC	Validated Test Controller

3. GENERAL

An EMA makes an electromechanical power transformation between the electrical domain (motor winding wires) and the mechanical domain at the EMA output (shaft or rod), which is attached to the driven load.

Depending on the type of motor, an EMA may require Motor Control Electronics (MCE), which can be either integrated into the EMA physical unit or remote.

An EMA generally comprises power management functions (e.g., clutch or brake), safety functions (e.g., soft end-stop or torque limiter), and sensors, which serve the control or monitoring functions.

The tests and the issues documented in this ARP are not necessarily all-inclusive.

To test an EMA, a test setup is required. It is typically comprised of a test controller, a test console including a data acquisition system, and a loading actuator (see Figures 1, 2, and 3).

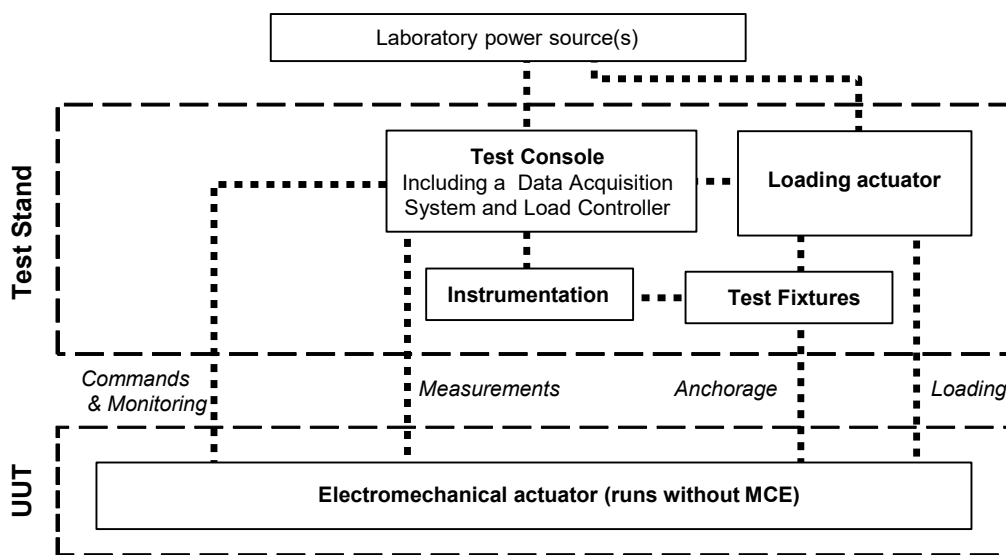


Figure 1 - Example of EMA and test stand diagram for an EMA running without MCE

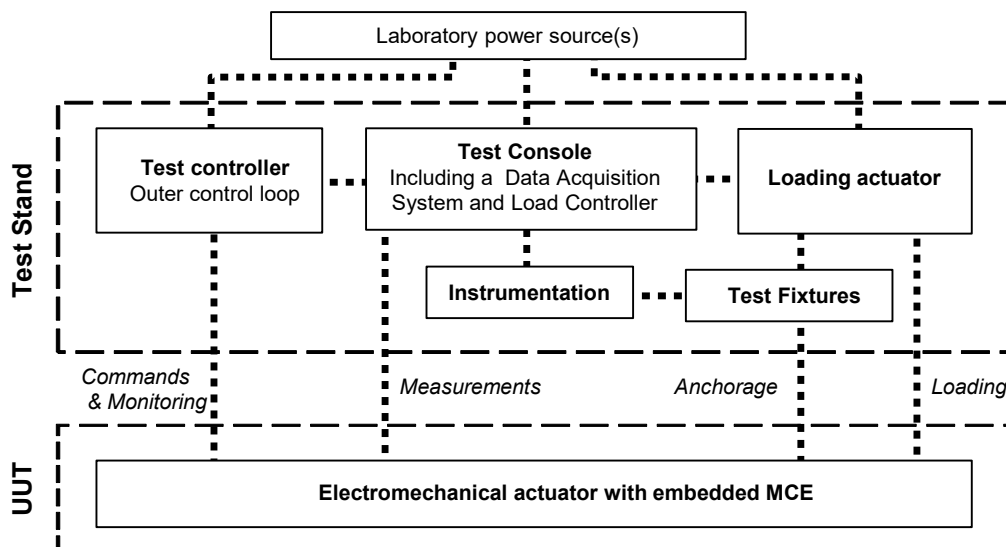


Figure 2 - Example of EMA and test stand diagram for an EMA running with embedded MCE

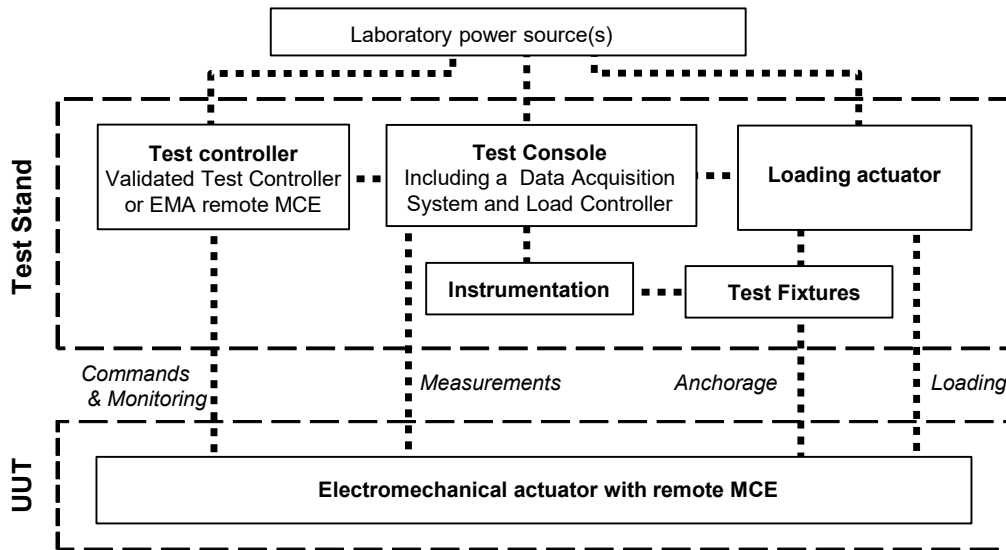


Figure 3 - Example of EMA and test stand Diagram for an EMA running with a remote MCE

In the discussion of the tests and test methodologies contained in this document, the numerical definition or specification of the test parameters to be imposed or measured is not included. These definitions or specifications should be developed to conform to the requirements of the applicable EMA technical specification document, considering the usual influencing factors such as instrumentation accuracy, test temperature, etc.

4. TEST CONSIDERATIONS

4.1 System Considerations

The performance of many EMA configurations is heavily dependent upon the associated electronics when it exists - both the motor control electronics for the electric motor, as well as the associated control loop closures. Some applications employ either brush DC motors or AC induction motors and therefore may not include electronics. For applications where power drive electronics and loop closure electronics are required, the EMA by definition includes the motor control electronics (MCE), whether mounted locally on the actuator itself or at a remote location (refer to ARP4386 and ARP7490).

This document is intended to discuss issues related to testing of the EMA and includes issues related to the MCE. While this document is not intended to discuss issues related to the test controller, it is to be recognized that the planning and execution of several, if not most, tests on an EMA needs to be undertaken with full consideration of the impact that the test controller used to test the EMA will have on the EMA under test.

For example, the EMA has performance capability dependent upon the motor capability, the capability of the MCE and the supply voltage, power control algorithms built into the MCE, and all loop closures around the MCE, the motor, and the EMA. Similarly, the failure transient performance of the EMA is dependent upon the performance of any mode-select devices within the EMA, the electrical energization/de-energization of electrically actuated mode-select devices and the motor, and the control algorithms that govern various EMA functions.

As such, in all those instances where an EMA is subjected to a test that necessitates electronics for its function and the electronics have an impact on the performance of the EMA, the test controller should be either:

- a. The actual electronics to be used with the actuator.
- b. The test electronics that are used to test the EMA, which should be validated separately and independently as being of the required configuration and capability to ensure accurate EMA test results. Such electronics may be termed validated electronics (or validated test controllers).

4.2 Component Considerations

4.2.1 Motor Control Electronics

A critical safety consideration in handling the MCE in a test environment is to ensure that the MCE is discharged before handling the unit. While a typical MCE contains bleed resistors or other devices to ensure the internal charge on capacitors has been depleted, the time over which the discharge occurs can vary and, in the event of failure of the bleed device, may not discharge at all. It is imperative that before handling the MCE, the voltage from source to return be verified to be at a safe level, usually below 30 V.

4.2.2 EMA Mechanical Components

In general, EMAs will not need disassembly as a part of normal testing. In some cases, removal of drain or fill plugs may be required, or the removal of covers to gain access to manual drives or position sensors may be required. For any disassembly that may be required during a test program, the disassembly procedure should carefully consider minimizing effect on performance of the EMA (for example, lubricant loss, potential contamination, and loss in prevailing torque of friction-based locking in bolted joints).

4.2.3 Test Fixture and Setup Considerations

In addition to the usual considerations given to the design of the required test fixtures and setups for conventional servactuators, EMA test fixtures and setups may require additional issues to be addressed, depending upon the planned tests. The following is an illustrative list of such considerations:

- a. Environmental considerations for the required heat transfer for the EMA including the MCE. The considerations or requirements may not be the same for both the actuator and the MCE.
- b. Endurance and duty cycle testing: Need for synchronizing the load system to EMA commands and/or MCE operating parameters.
- c. Duty cycle testing and worst-case requirements for the EMA may or may not be the worst case for the MCE and may require separate tests for each element.
- d. The rate at which an EMA endurance test is conducted may be impacted by the EMA and/or electronics temperatures. Additional cooling may be required if approved by the procuring activity.
- e. Consideration of undertaking an EMA endurance test with validated electronics instead of the MCE intended to be used with the EMA on the aircraft.
- f. Careful consideration should be given to the performance test stress on the actuator and the MCE. Due to motor and MCE losses and the energy required to accelerate/decelerate the motor-gear train inertia, the duration of testing such as stall load and frequency response, among others, may need to be limited to avoid causing thermal damage to the motor or the MCE.
- g. When lower efficiency transmission system components such as Acme screws, worm gears, and no-backs are used, consideration of frictional heating should be made to prevent thermal damage to the mechanical system.
- h. Consideration should be given to side loads, either the need for side-load capability in the test setup or the elimination of side loads from the system, as applicable.
- i. The design of the mechanical test fixture should include consideration of load inertia and mounting structural stiffness to adequately represent the application. In some cases, the effect of actuator internal inertia dominates the effects of load inertia such that the load inertia may be eliminated from the test fixture without adversely affecting the overall system performance. In some applications, it may be difficult to provide fixture inertias low enough for the application. In these cases, careful consideration is to be given to the method of performing the performance tests, particularly frequency response, dynamic stiffness, and servo-loop stability.