K-01-08

SAE The Engineering Society For Advancing Mobility Land Sea Air and Space®

400 COMMONWEALTH DRIVE, WARRENDALE, PA 15096

AEROSPACE RECOMMENDED PRACTICE

ARP4058

Issued 8-10-88

Submitted for recognition as an American National Standard

ACTUATORS: MECHANICAL, GEARED ROTARY, GENERAL SPECIFICATION FOR

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

1. SCOPE:

This specification establishes general design, performance and test requirements for mechanical geared rotary actuators intended to be used for applications to position control surfaces in response to manual or automatic power control system inputs.

1.1 Purpose: This specification is to be used as a guide in preparing a detail specification for a particular mechanical geared rotary actuator application.

1.2 Definition: Mechanical geared rotary actuators are planetary geared devices typically having a rotary shaft input and rotary outputs. These actuators may be configured to transmit torque and shear loads.

1.3 Interface Definition: This paragraph should describe the actuator's function in the system. It should define all applicable structural, mechanical, and electrical interfaces. A list of associated equipment should be added using part and assembly identifying numbers and who is responsible for them.

2. APPLICABLE DOCUMENTS:

The following documents form a part of this specification to the extent specified herein:

2.1 Specifications:

Federal:

FF-B-185, Bearings, Roller, Cylindrical, and Bearings, Roller, Self & Aligning
QQ-C-320, Chromium Plating (Electrodeposited)
NN-P-530, Plywood, Flat Panel
TT-P-1757, Primer Coating, Zinc Chromate, Low Moisture-Sensitivity

Military:

DOD-D-1000, Drawings, Engineering and Associated Lists
MIL-B-3990, Bearings, Roller, Needle, Airframe, Anti-Friction, Inch
MIL-B-5628, Bearings, Plain, Airframe
MIL-C-6021, Castings, Classification and Inspection of
MIL-B-6038, Bearings, Ball, Bellcrank, Anti-Friction, Airframe
MIL-B-6039, Bearings, Double Row, Ball, Sealed Rod End, Anti-Friction, Self-Aligning
MIL-H-6088, Heat Treatment of Aluminum Alloys
MIL-I-6868, Inspection Process, Liquid Penetrant
MIL-F-7190, Forgings, Steel, for Aircraft/Aerospace Equipment and Special Ordnance Applications
MIL-B-7949, Bearings, Ball, Airframe, Anti-Friction
MIL-I-8500, Interchangeability and Replaceability of Component Parts for Aircraft and Missiles
MIL-A-8625, Anodic Coatings, for Aluminum and Aluminum Alloys
MIL-C-8837, Coating, Cadmium (Vacuum Deposited)
MIL-S-8879, Screw Threads, Controlled Radius Root with Increased Minor Diameter, General Specification for

Military (Continued):

MIL-Q-9858, Quality Program Requirements
MIL-S-13165, Shot Peening of Metal Parts
DOD-P-16232, Phosphate Coating, Heavy, Manganese or Zinc Base (for Ferrous Metals)
MIL-A-21180, Aluminum - Alloy Castings, High Strength
MIL-A-22771, Aluminum Alloy Forgings, Heat Treated
MIL-N-25027, Nut, Self-Locking 250°F, 450°F, and 800°F,(125 KSI FTU, 60 KSI FTU and 30 KSI FTU)
MIL-C-26074, Coatings, Electrolysis Nickel, Requirements for
MIL-B-83050, Bolt-Self Retaining Impedance Type
MIL-F-83142, Forgings, Titanium Alloys, for Aircraft and Aerospace Applications
MIL-A-83444, Airplane Damage Tolerance Requirements

2.2 Standards:

MIL-STD-12, Abbreviations for Use on Drawings, Specifications, Standards and in Technical Documents
MIL-STD-129, Marking for Shipment and Storage
MIL-STD-130, Identification Marking of U.S. Military Property
MIL-STD-453, Inspection, Radiographic
MIL-STD-454, Standard General Requirements for Electronic Equipment
MIL-STD-470, Maintainability Program Requirements (For Systems and Equipment)
MIL-STD-785, Reliability Program for Systems and Equipment, Development and Production
MIL-STD-794, Parts and Equipment, Procedures and Packaging and Packing of
MIL-STD-810, Environmental Test Methods
MIL-STD-831, Test Reports, Preparation of
MIL-STD-838, Lubrication of Military Equipment
MIL-STD-866, Grinding of Chrome Plated Steel and Steel Parts Heat Treated to 180,000 PSI or Over
MIL-STD-882, System Safety Program Requirements
MIL-STD-889, Dissimilar Materials
MIL-STD-970, Standards and Specifications, Order of Precedence for the Selection of
MIL-STD-1472, Human Engineering Design Criteria for Military Systems, Equipment and Facilities
MIL-STD-1537, Electrical Conductivity Test for Measurement of Heat Treatment of Aluminum Alloy, Eddy Current Method
MIL-STD-6866, Inspection, Penetrant Method of
MIL-STD-45662, Calibration System Requirements

MS 15981, Fastener, Externally Threaded, Self-Locking Design and Usage Limitations for
MS 20995, Wire, Safety or Lock
MS 21244, Nut-Castellated, Hexagon, Counter Bored Assembled Washer 450°
MS 24665, Pin, Cotter (Split)
MS 33540, Safety Wiring and Cotter Pinning, General Practices for
MS 33588, Nuts, Self-Locking, Aircraft, Reliability and Maintenance Usage Requirements for

2.3 Publications:

Military Handbooks:

MIL-HDBK-5, Metallic Materials and Elements for Aerospace Vehicle Structures
MIL-HDBK-275, Guide for Selection of Lubricant, Fluids, and Compounds for use in Flight Vehicles and Components

Air Force Systems Command Design Handbook

AFSC DH 1-6, System Safety

SAE Aerospace Recommended Practice:

ARP 926, Fault/Failure Analysis Procedure

SAE Aerospace Material Specification:

AMS 2419, Plating-Cadmium-Titanium

3. REQUIREMENTS:

Requirements are outlined covering the designs of mechanical rotary geared actuators which may be integrated into a detail specification to be prepared by the procuring agency.

3.1 Configurations: The geared rotary actuators may be driven by mechanical shafting or angle gear reduction mechanisms, or both, and may be powered by fluid power, pneumatic or electric motors. In some cases, the complete geared rotary actuator may also incorporate torque limiters, over-travel limiters, speed limiters, asymmetry controllers and detectors, or no back devices depending on the particular system requirements. Electrical transducers to provide position feedback may also be part of a typical geared rotary actuator assembly. Electrical switches may be incorporated to provide indicators for travel limits.

3.2 Characteristics:

3.2.1 The detail specification should specify performance requirements.

3.2.2 The detail specification should specify actuator output travel, velocity, and minimum efficiency and should specify efficiency under aiding and opposing loads at static break-away and dynamically at normal operating speeds.

3.2.3 Specify actuator gear ratio (where applicable).

3.3 Physical Characteristics:

3.3.1 Dimensions: The detail specification should specify the maximum permissible envelope dimensions of the geared rotary actuator and related parts when installed and operated.

3.3.2 Mounting: Mounting provision for the geared rotary actuator should be in accordance with the detail specification. Suitable clearances should be provided between the geared rotary actuator, structure, and other components to preclude binding or jamming due to possible combinations of temperature effects, loads and deflections (including structural deflections).

3.3.3 Moisture Pockets: External housing designs which could result in pockets, wells, traps, etc. into which water or other liquids can drain into or collect should be avoided. If such designs are unavoidable, provisions for draining moisture from these pockets should be incorporated.

3.3.4 Weight: The detail specification should specify the maximum wet weight compatible with specification requirements. Every consideration should be given to achieving a minimum weight in accordance with good design practices, safety and vulnerability.

3.4 Reliability:

3.4.1 Reliability Mean Time Between Failure: The mean time between failure (MTBF) of the actuator should be specified in the detail specification and should conform to the value established for the contractor based on environment, utilization, complexity, and alternate modes of operation of the system. The MTBF should be defined in terms of duty cycles together with the confidence level. The MTBF should be specified for actual test and service operation. Failure is defined as any malfunction causing performance degradation outside the limits defined in the detail specification.

3.4.2 Reliability Analysis: A reliability analysis of the geared rotary actuator using a mathematical reliability model should be performed. The minimum reliability limits and prediction of MTBF should be determined in accordance with MIL-STD-785. The failure mode and effects portion of this analysis should be prepared in accordance with ARP 926.

3.5 Maintainability:

3.5.1 Maintainability Characteristics: Unless otherwise specified in the detail specification, the maintainability requirements should be in accordance with MIL-STD-470. The actuator should be designed such that the planned mission can be accomplished with a minimum expenditure of maintenance manhours, elapsed time, personnel skills, Aerospace Ground Equipment (AGE), and technical data. The specific quantitative maintainability requirements should be specified in terms of:

a. The mean elapsed time required to perform corrective maintenance (MCT) on the actuator while installed.

b. The 90th percentile maximum elapsed time required to perform corrective maintenance (Mmax) on the actuator while installed.

c. The mean elapsed time required to perform preventive maintenance (MPT) on the actuator while installed.

d. The mean maintenance manhours required to perform a maintenance task, including overhaul, in the field and depot maintenance shops.

e. The mean elapsed time required to perform servicing maintenance (MST) on the unit while installed.

3.5.1 (Continued):

f. The mean time between unscheduled removals (MTUR).

g. The mean time between unscheduled maintenance actions (MTBUM).

3.5.2 Maintenance and Repair Cycles: The detail specification should specify the time interval between preventative maintenance tasks for actuator operating hours.

3.5.3 Installation and Accessibility: The geared rotary actuator should be designed, installed and located such that inspection, rigging, repair, lubrication and connection of such test equipment as may be required for field maintenance, can be readily accomplished without removal of the actuator from the installed position. Installation should be implemented without requiring adjustments of the actuator. The design should permit use of standard tools and test equipment. The detail specification should define, as required, the method and accuracy of rigging the input. The actuator may be classified as a line replaceable unit with no inplace maintenance/overhaul.

3.5.4 Lubrication: All components requiring lubrication should be lubricated in accordance with MIL-STD-838. Whenever possible, permanently lubricated components should be provided. Lubricants listed in MIL-HDBK-275 should be used. Any use of special lubricants must be justified and approved for use by the procuring agency. Suitable lubrication fittings are to be supplied when required.

3.5.5 Environmental Conditions: The actuator should not suffer any damage, deterioration or degradation of performance when subjected to any environment or any natural combination of environments within the operational envelope as encountered during worldwide operations, as specified in MIL-STD-810 and in the detail specification. The actuator should meet all the requirements listed in Table I. The detail specification should specify, when applicable, the allowable damage and degraded performance after an extended life period for the actuator.

TABLE I - Environmental Criteria

ENVIRONMENT	APPLICABLE DOCUMENT(S)
Temperature, Ambient	per detail specification
Operating temperature range	per detail specification
Altitude	Per MIL-STD-810
Thermal Shock	per detail specification
Salt Spray	per MIL-STD-810
Sand and Dust	per MIL-STD-810
Mechanical Shock	per MIL-STD-810
Acceleration	per detail specification
Humidity	per detail specification
Fungus	per detail specification
Vibration	per MIL-STD-810

3.6 Structural Characteristics:

3.6.1 Strength: Unless otherwise specified, geared rotary actuators should be designed using the material properties of MIL-HDBK-5.

3.6.2 Damage Tolerance: The structural attachment elements of a geared rotary actuator that are essential to safety should meet the requirements of MIL-A-83444. Actuators should incorporate materials, stress levels, and structural configurations to minimize crack initiation, and to minimize failure due to the propagation of undetected flaws, cracks, or other damage. The detail specification should specify magnitude, direction and type of all externally applied loads. If travel limiters or stops are incorporated, load paths resulting from bottoming should be considered and tested. All possible combinations of loading should be specified, together with the diagram of the operational geometry.

3.6.3 Limit Loads: The detail specification should specify the maximum limit load permitted without permanent deformation of parts.

3.6.4 Output Ultimate Load: The detail specification should specify that the actuator should withstand, with the input restrained, an output load 1.5 times the limit load specified in 3.6.3 without failure for a specified period of time.

3.6.5 Fatigue: The actuator should be designed to withstand all loading requirements for its specified application without fatigue failures during its specified useful life. For applications containing multiple output gearsets, the specification should define the load distribution along the length of the actuator gearsets.

3.6.6 Operating Life:

3.6.6.1 Total Cycles: The detail specification should define an operating spectrum of output rotation and torque versus number of cycles for the actuator, which should be commensurate with its operational use.

3.6.6.2 Toothwear: Consideration should be given to toothwear due to gear tooth location. Certain gear teeth in an actuator may incur more wear than others during the actuator's life. Allowance for toothwear may be specified by stipulating allowable actuator backlash after one life of actuator use.

3.6.6.3 Static Fatigue Cycles: The detail specification should specify the total number of static fatigue cycles the actuator should be subjected to at the most critical output position (for example, retract or extend, if most critical).

3.6.6.4 Bottoming Out Cycles: If stops are incorporated, specify number of bottoming cycles, speed, input side inertia and the load condition at the time stops are hit.

3.6.6.5 Useful Life: The detail specification should specify the useful life of the actuator which should be considered as the time of its delivery from the supplier's facility until its identity is destroyed.

3.6.6.6 Stiffness: The detail specification should specify the minimum rotary actuator stiffness required (in-lb per radian). Stiffness may vary with output position; specify output positions as necessary.

3.6.6.7 Shear Load: The detail specification should specify any shear loads to be carried by the rotary geared actuator structure.

3.6.6.8 Backlash: The detail specification should specify the maximum backlash requirements. Backlash less than 0.5 deg measured at the output is difficult to achieve and adds to cost.

3.7 Design and Construction: The actuator should be designed and constructed to meet the operational requirements in the detail specification.

3.7.1 Sealing: The rotary actuator should be sealed to prevent contamination of lubricant. If condensation can occur inside the actuator, then all internal parts are to be adequately corrosion protected and provision made to prevent entrapping water inside.

3.7.2 Antifriction Bearings: Approved type ball, roller or needle bearings in accordance with MIL-B-6038, MIL-B-6039, and MIL-B-7949, MIL-B-3990 and FF-B-185 should be used except as indicated in the following paragraphs. Sealed bearings are preferable over shielded bearings in an atmospheric environment.

3.7.3 Journal Bearings: Where freeplay and friction are not major considerations, journal or plain bearings in accordance with MIL-B-5628 or tetrafluoroethylene-lined bearings may be used.

3.8 Materials, Processes, Assembling and Parts:

3.8.1 Materials: The materials used in rotary geared actuators should be suitable for the service and purpose intended and should conform to the applicable government specifications when such specifications exist for the type of material being used. Non-specification materials may be used provided it can be demonstrated that their use will result in a superior product. The use of each material in its application should be substantiated. MIL-HDBK-5 should be used as the authority for strength of all actuator metals. Use of materials for critical structural applications should be approved by the procuring agency.

3.8.2 Metals: All metals should be compatible with the lubricants used and with the intended temperature, function or service, and storage conditions to which the components will be exposed. The metals used should possess adequate corrosion resistant characteristics or should be suitably protected to resist corrosion which may result from such conditions as dissimilar metal combinations, moisture, salt spray and high temperature deterioration, as applicable. Contact between dissimilar metals as defined in MIL-STD-889 should be minimized during fabrication, installation or assembly. However, where contact cannot be avoided, measures defined in MIL-STD-889 should be taken to avoid galvanic corrosion.

3.8.3 Metal Characteristics: Use of vacuum melted steels should be encouraged, where cost effective. When ultra-high strength steels are employed, this is mandatory. Heat treatments and fabrication techniques which impart low residual stresses and maintain maximum dimensional stability are desirable.

3.8.4 Castings and Forgings: Castings and forgings should be designed to the criteria of the following listed specifications as applicable. Additional requirements for design not included in the listed specifications must appear on the part drawing.

MIL-C-6021	MIL-A-21180	MIL-F-83142
MIL-F-7190	MIL-A-22771	

3.8.5 Material Quality Control: Sufficient controls over wrought, cast or forged material should be exercised so that aircraft quality is maintained. Non-destructive and destructive tests such as x-ray, penetrant, magnetic particle, tensile tests and chemical analysis must be performed in accordance with the applicable military specifications to ensure good quality. Minimum requirements for inspection are:

Forgings should be penetrant and/or magnetic particle inspected per MIL-STD-6866 and MIL-I-6868 as applicable.

Castings should be x-rayed per MIL-STD-453 and/or magnetic particle inspected and penetrant inspected for MIL-STD-6866 and MIL-I-6868 as applicable.

Wrought product in the form of sheet, bar, tubing or plate should be tested as specified in the applicable material specification.

3.8.6 Conductivity Tests: When aluminum alloy materials are employed, use of conductivity testing for alloy temper inspection is desirable. When specified, measurement should be in accordance with MIL-STD-1537 to the limits referenced in MIL-H-6088.

3.8.7 Shot Peen: Steels heat treated above 220 000 psi (1520 MPa) ultimate levels are to be subsequently saturation shot peened for 200% coverage using MIL-S-13165 shot as the final operation. Specific areas for bearings and bores and gear profiles are exempt as approved by the procuring activity.

3.8.8 Use of Standard Parts: Use of standard parts not specified herein should be selected from established standards and specifications and in the order of precedence specified in MIL-STD-970.

3.8.9 Processes: Unless otherwise specified herein, processes or special tooling used in a rotary actuator should conform to the following:

3.8.10 Metal Coatings: Ferrous alloys heat treated to 200 000 psi ultimate tensile strength and above should utilize protective coatings which minimize or eliminate hydrogen embrittlement. These include, but are not limited to, vacuum deposited cadmium (MIL-C-8837), aluminum titanium cadmium (AMS 2419), or chromium applied in accordance with QQ-C-320.

External surfaces of ferrous alloy parts need not be coated if the chromium content of the alloy is greater than 12%. Anodized coatings should be in accordance with MIL-A-8625, electroless nickel in accordance with MIL-C-26074.

3.8.11 Staking, Peening and Swaging: Each application of staking, peening, and swaging, or any other means of permanent deformation for locking purposes, should be subject to procuring agency approval.

3.8.12 Safetying: Use of safety wire on threaded connections should be avoided if a reasonable alternative is available. Threaded parts should be safety wired when necessary in accordance with MS 33540.

3.8.13 Grinding: Grinding of high strength steel should be in accordance with MIL-STD-866. Low stress grinding is recommended on high strength steels.

3.8.14 Assembling:

3.8.15 Mechanical Joining: Individual parts may be mechanically joined with removable fasteners, or threaded connections, or by other qualified methods for permanent joining.

3.8.15.1 Joining with Removable Fasteners: Unless otherwise specified in the detail specification, all removable fasteners should be selected and used as follows:

(a) Bolts smaller than 1/4 in (6 mm) should not be used to make single bolt connections, or connections essential to the structural performance of the actuator.

(b) Bolt joints should use a positive method of retention such as self-locking nuts, plate nuts or cotter pins. Self-locking nuts should be in accordance with MIL-N-25027 and MS 33588. However, a single fastener joint requires use of a self-retaining fastener with a second locking or retaining method such as MIL-B-83050 bolt, MS 21244 nut and MS 24665 cotter pin.

3.8.15.2 Threaded Joints: All threaded joints should be provided with adequate wrenching and holding provisions for assembly and disassembly of the joint before and after service use. Internal screw threads and external rolled threads should be in accordance with the thread form requirements of MIL-S-8879.

3.8.15.2.1 Retention of Threaded Joints: All threaded joints which carry critical loads should be positively locked in the assembled position so that load reversal at the threads is prevented. The use of jam locknuts is not a positive locking means unless otherwise restrained.

3.8.15.2.2 Retention of Removable Fasteners: Removable fasteners, unless restrained from moving by the attachment of adjoining parts, should incorporate a positive locking means or be safety wired with MS 20995 lockwire. Cotter pins and safety wiring should be installed in accordance with MS 33540. Self-locking externally threaded fasteners may be used within the limitations specified in MS 15981 and MS 24665.

3.8.15.2.3 Use of Retainer Rings: Retainer rings or pins should not be used to retain parts unless the rings are positively confined. They should not allow freeplay which could result in structurally destructive action or fatigue failure of the retained parts. Where used, retainer rings should be commercially available types which can be installed and removed with standard tools. Their use is subject to procuring agency approval.

3.9 Corrosion Protection: In addition to the required metal corrosion protection, all external parts are to be painted with a prime coat and finish coat of epoxy or other approved material as specified by the detail specification. Holes in shafts and gears which are too small or too long to be adequately protected by plating must receive an approved corrosion protection.

3.9.1 Faying Surfaces, Bearing, Bolts, Metal Seal Cases, etc.: At assembly, the mating surfaces, O.D.'s, I.D.'s etc., should be coated with wet primer per TT-P-1757 for corrosion protection.

3.10 Identification and Marking:

3.10.1 Identification: The identification requirements for the actuator should be as specified in MIL-STD-130.

3.10.2 Marking and Serialization: Each actuator should be marked and serialized. Placards should be the engraved or chemically etched type and mechanically secured to the component parts. Adhesive foil placards' use should be approved by the procuring activity and should be overcoated with a suitable clear material not softened by oils, grease or cleaning solvents. Placards and data plates should be located such that they can be read when the component to which they are attached is installed in the application.

3.11 Workmanship:

3.11.1 Quality: The supplier should exercise extreme care in fabricating, assembling, handling, and packing actuator units to assure that the components are clean and free of internal and external contaminants. All parts should be free from pits, rust, scrapes, splits, cracks, burrs, sharp edges, and discontinuities.

3.11.2 Physical Defect Inspection: All magnetic, high-stress parts should be subject to magnetic particle inspection in accordance with MIL-I-6868. All non-magnetic, high-stress parts should be subject to fluorescent penetrant inspection in accordance with MIL-STD-6866. Cracks or other injurious defects disclosed by the inspection should be cause for rejection.

3.11.3 Interchangeability: Parts, components, sub-assemblies, and assemblies having the same part number should meet the requirements of MIL-I-8500 and be interchangeable in form, fit and function with other parts bearing the same part number.

3.12 Safety: The actuator and its components should be designed to provide a maximum of safety to personnel during the course of installation and maintenance. Adequate precautionary warnings and information should be affixed to components when considered necessary for safety or to prevent needless damage. An example is a component with a compressed spring. Special attachment or lift points should be designated when the weight of the actuator requires special handling provisions. Actuators should meet the safety requirements of AFSC DH 1-6 and MIL-STD-454. Applicable paragraphs of MIL-STD-882 should be referred to for guidance.

3.13 Human Performance/Engineering: When applicable, the design should consider and apply the principles, analysis, criteria and philosophies of Human Engineering as defined in MIL-STD-1472. This should include the application, during all phases of the actuator design, of knowledge as to man's unique capabilities and limitations regarding the installation, operation and maintenance of the actuator package. The following general requirements are established to reduce the possibility of human errors during assembly and maintenance of the actuator package:

a. When reversed or rotated mounting of an interfacing component cannot be tolerated, nonsymmetrical mounting arrangements (including keyways or pins) should be used.

b. "Stacked" assemblies should use flanged arrangements which prevent assembly if a part is omitted, or indicator markings which are exposed when the part is missing.

3.14 Ground Support Equipment: The actuator should be designed to be installed, tested, serviced and maintained using standard GSE and hand tools.

3.15 Documentation:

3.15.1 Analysis Requirements: The detail specification should indicate the general analysis approach and analysis procedures that are applicable to all actuator designs for the specific application. As a minimum, the following areas should be considered:

3.15.2 Performance: Substantiation of actuator performance and limits thereof.

3.15.3 Moving Parts Clearance: Demonstration of adequate clearance of all moving parts under all combinations of environments and loads.

3.15.4 Selection of Materials and Minimum Size of Structural Members: Justification should be provided for materials and processes employed and for all operational stress levels anticipated.

3.15.5 Qualification Analysis: When items, components, or complete actuators are qualified on a similarity basis, sufficient data, (that is, test or analytical, or both) should be furnished to the procuring activity to demonstrate that those part(s) can be fully qualified.

3.16 Drawings: Drawings applicable to parts, components, subassemblies and the complete actuator assembly should be in accordance with DOD-D-1000.

4. QUALITY ASSURANCE PROVISIONS:

4.1 General: The quality assurance provisions should be in accordance with the detail specification. The supplier should have a quality system which conforms to the requirements of MIL-Q-9858. Except as otherwise specified, the supplier may utilize his own or any other inspection facilities and services acceptable to the procuring agency. Inspection records of the examination and tests should be kept complete and available to the procuring activity as specified in the contract.

4.2 Test Requirements and Options: Appropriate tesing, as outlined herein, should be conducted during the development and production of actuators to insure proper design and performance, continuing quality and the degree of unit reliability (expected in service).

At the option of the procuring organization, any of the test requirements specified herein may be waived, or modified, owing to design experience or operating considerations. Request for waiver or modification of test requirements should be accompanied by complete detailed information and justification.

4.3 Classification of Tests: The following test programs, for the purpose of demonstrating compliance of actuators with the requirements of this specification, should be classified as follows:

4.3.1 Acceptance Tests: These tests are performed on each actuator to demonstrate baseline performance.

4.3.2 Preproduction Tests: These tests are performed on the initial unit(s) to provide a basis for preliminary design approval to proceed with the production program. The preproduction test specimens should approximate as nearly as practicable the intended production units in design configuration, material, processing and production techniques. An assurance test, in addition to the acceptance tests, should be as specified in the detail specification and should include tests as outlined in 4.7.

4.3.3 Qualification Tests: These tests are performed on production configuration actuators to confirm full compliance with the requirements of the detail specification. Each test specimen should initially and periodically throughout the qualification tests be subjected to the Acceptance Tests per 4.3.1. The number of qualification test units should be specified by the procuring agency.

4.4 Test Procedures:

4.4.1 Acceptance Test: The acceptance test procedure should specify those tests which each actuator should satisfactorily complete as a condition for acceptance. The procedure should insure that each actuator which is accepted meets the basic dimensional and performance requirements. It should describe tests in detail indicating the environmental conditions, specifying the test fixtures, equipment and instrumentation, the format of the individual unit test data sheet or test log, and the measurements and observations which should be recorded. The procedure should be updated when subsequent testing or usage indicates additional or modified tests should be incorporated.

4.4.2 Preproduction Test Procedure: The preproduction or safety test procedure should specify those tests which are necessary to demonstrate that the actuator is satisfactory for limited life usage prior to formal qualification test completion. Cycle testing may be abbreviated to meet expected conditions.

4.4.3 Qualification Test Procedure: The qualification test procedure should specify those tests which are necessary to demonstrate that the actuator is satisfactory for its intended use. As a minimum, the qualification tests should include all the applicable tests specified in 4.8 and its subparagraphs. These tests should demonstrate that adequate margins exist with respect to all critical parameters associated with the intended use of the actuator. Additional tests should be added to the plan whenever it appears that the specified tests do not measure all of the parameters which may be critical in a particular application. The qualification test procedure should prescribe the format for the test log and detail instructions for maintaining the test log. Also, provisions should be included in the test procedure for certification by a representative of the procuring activity at stated periods during testing. The test procedure should establish the procedure to be followed when the test specimens do not meet the individual test requirements.

4.5 Test Conditions:

4.5.1 Environmental Conditions: Unless otherwise specified in the detail specification, the ambient temperature tolerance should be ± 5°F (± 3°C) for test values specified herein. If environmental conditions are not specified or if "room conditions" are specified, the ambient temperature should be 73 ± 18°F (23 ± 10°C).

4.5.2 Test Instruments: The instruments used to measure and record required test parameters should be calibrated in accordance with MIL-STD-45662 and should meet the accuracy requirements of MIL-STD-810. These instruments should be recalibrated as necessary to insure accuracy of test results.

4.5.3 Test Fixtures: The actuators should be mounted in appropriate test fixtures during testing outlined herein. The detail specification should specify the degree to which the fixture will simulate the installation including structural compliance.

4.6 Acceptance Tests:

4.6.1 General: Each actuator should be subjected to this acceptance test and any other tests specified in the detail specification. These tests may be supplemented by individual component tests when required.

4.6.2 Examination of Product: The actuator should be carefully examined to determine conformance with the requirements of this specification and the detail specification for workmanship, marking, conformance to applicable engineering drawings, conformance to applicable specifications and standards, and for any visible defects.

4.6.3 Backlash: With the input locked, measure total backlash with a plus and minus nominal torque at the output as specified in the detail specification. Apply a specified torque sufficient to exceed actuator friction, measure angle, release slowly and measure angle, repeat for each direction of output. Backlash is the difference of the two readings.

4.6.4 No Load Torque: Operate actuator with no output load to check that the parts are not binding. Input torque should not exceed a value as specified in the detail specification.

4.6.5 Operation Under Load: Operate actuator with output loaded. Operate throughout the specified operating range. Measure torque at the input in opposing and aiding directions. Opposing and aiding torque should be within detail specification values. (These measure actuator efficiency.)

4.6.6 Weight: Check and record. Value not to exceed detail specification weight. Suitable allowance for lubricant should be incorporated.

4.6.7 Rejection and Retest: Failure of any actuator to conform to any of the acceptance tests should be cause for rejection of that assembly. Actuator assemblies which have been rejected may be reworked or have parts replaced to correct the defects found in the original test actuators and then resubmitted for acceptance. Replacement parts should be in accordance with released detail design drawings.