SPECIFICATION NO. 16ZK056A
CODE IDENT: 81755
DATE: 28 May 1999

CRITICAL ITEM DEVELOPMENT SPECIFICATION

FOR THE

IMPROVED F-16 SINGLE-PLACE CANOPY ACTUATOR

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1. SCOPE

1.1 General. This specification establishes the performance, design, development, and test requirements for the Improved F-16 Single-Place Canopy Actuator.

2. APPLICABLE DOCUMENTS

2.1 Government documents. The following documents of the exact issue shown form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered as superseding requirements.

SPECIFICATIONS

Federal

TT-I-735A Notice 1 5 Nov 1991	Isopropyl Alcohol

Military

MIL-W-5088H 20 Jul 1979	Wiring, Aircraft, Selection and Installation of
MIL-H-5606C(1) 19 Nov 1973	Hydraulic Fluid, Petroleum Base; Aircraft, Missile and Ordnance
MIL-T-5624J 30 Oct 1973	Turbine Fuel, Aviation, Grades JP-4 and JP-5
MIL-E-7080B(3) 29 Apr 1968	Electric Equipment, Aircraft, Selection and Installation of
MIL-S-7742D(1) 2 Sep 1992	Screw Threads, Standard, Optimum Selected Series: General Specification for
MIL-L-7808J Notice 1 26 Feb 1988	Lubricating Oil, Aircraft Turbine Engine, Synthetic Base
MIL-A-8243D(1) 21 Dec 1989	Anti-icing and Deicing-Defrosting Fluids

MIL-I-8500C(1) 3 May 1972	Interchangeability and Replaceability of Component Parts for Aircraft and Missiles
MIL-M-8609B Notice 1 12 Dec 1987	Motors, Direct-Current, 28 Volt System, Aircraft, General Specification for
MIL-S-8805D(3) 11 May 1992	Switches and Switch Assemblies, Sensitive and Push, (Snap Action), General Specification for
MIL-S-8879C(1) 2 Sep 1992	Screw Threads, Controlled Radius Root With Increased Minor Diameter, General Specification for
MIL-C-38736B Notice 1 27 Apr 1993	Cleaning Compound, Solvent Mixtures

STANDARDS

Military

MIL-STD-130D Notice 3 1 Aug 1973	Identification Marking of U.S. Military Property
MIL-STD-461A Notice 3 1 May 1970	Electromagnetic Interference Characteristics, Requirements for Equipment
MIL-STD-462 Notice 2 1 May 1970	Electromagnetic Interference Characteristics, Measurement of
MIL-STD-704A Notice 3 11 Apr 1973	Electrical Power, Aircraft, Characteristics and Utilization of
MIL-STD-810E Notice 2 1 Sep 1993	Environmental Test Methods and Engineering Guidelines
MIL-STD-838C 30 Dec 1983	Lubrication of Military Equipment

MIL-STD-889B Notice 3 17 May 1993	Dissimilar Metals
MIL-STD-965B 22 Jan 1993	Parts Control Program
MIL-STD-1472A 15 May 1970	Human Engineering Design Criteria for Military Systems, Equipment and Facilities
MS20995E Notice 1 30 Jan 1990	Wire, Safety or Lock
MS24665F 18 Jun 1986	Pin, Cotter (Split)
MS33540J Notice 1 15 May 1992	Safety Wiring and Cotter Pinning, General Practices for

OTHER PUBLICATIONS

AFSC DH 1-3 2nd Ed. Rev. 3 1 Jul 1973	Personnel Subsystems
MIL-HDBK 275 1 May 1969	Guide for Selection of Lubricant Fluids and Compounds for Use in Flight Vehicles and Components

2.2 Non-Government documents. The following documents of the latest issue in effect form a part of this specification to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this specification, the contents of this specification shall be considered as superseding requirements.

SPECIFICATIONS

Lockheed Martin

FMS-1011	Procurement Specification for Steel, CR-MO-V-NI, Type D6AC

FPS-1001	Castings - Engineering and Inspection Requirements for
FPS-1029	Heat Treatment, Forging and Process Requirements, Type D6AC Steel
FPS-3001	Contractor's Finish Specifications for F-16 Air Combat Fighter
FPS-3008	Marking of F-16 Parts
NDTS 1101	Penetrant Inspection
NDTS 2101	Magnetic Particle Inspection
16PR711	F-16 Materials Procurement and Processing Specification Applicable Issues
16PP027	Program Parts Selection Lists
16PP224	Subcontractor/Vendor Packaging and Transportation Instructions for Shipments to Lockheed Martin Tactical Aircraft Systems (LMTAS)

Industry

ASA-B5.15	Involute Splines, Serrations, and Inspections

DRAWINGS

Lockheed Martin

16VK056001 Actuator, Canopy - Electromechanical, Rotary, Single Place

3. REQUIREMENTS

3.1 Item definition. The canopy actuator described in this specification and shown in Specification Control Drawing (SCD) 16VK056001 is a rotary electromechanical actuator to be used to latch, unlatch, raise, lower, and maintain at any desired intermediate position the F-16 single-place canopy. The actuator shall operate either electrically by means of an electric motor powered by the aircraft dc electrical system or manually by means of a flexible shaft coupled to the gear train by means of an external fitting in the gear case. The complete actuator assembly shall include an adjustable connecting link as shown in SCD 16VK056001. The actuator and the adjustable connecting link shall be designed in accordance with the requirements of this specification and SCD 16VK056001.

3.1.1 Interface definition. The actuator shall be compatible with existing F-16 systems and equipment and shall meet all requirements while installed in the F-16 aircraft. The actuator shall interface with the aircraft electrical system as defined in Figure 1.

3.2 Characteristics.

3.2.1 Performance. The actuator performance shall be in accordance with the following requirements

3.2.1.1 Operation. The actuator shall operate from the zero to the 100 percent travel position and return, or stop and hold at any intermediate travel position, and then proceed in either direction as desired. Operation shall be smooth in both directions without chatter regardless of aiding or opposing loads. The actuator travel for electrical and manual operation shall be as shown on SCD 16VK056001.

3.2.1.2 Normal operating torque. The actuator, during normal operation in the electrical mode, shall provide output torque as specified in Figure 2. Operating loads for the adjustable connecting link shall be as listed in Table I. Negative link loads represent compression while positive loads represent tension. The angles referenced in Table I are as shown in Figure 3.

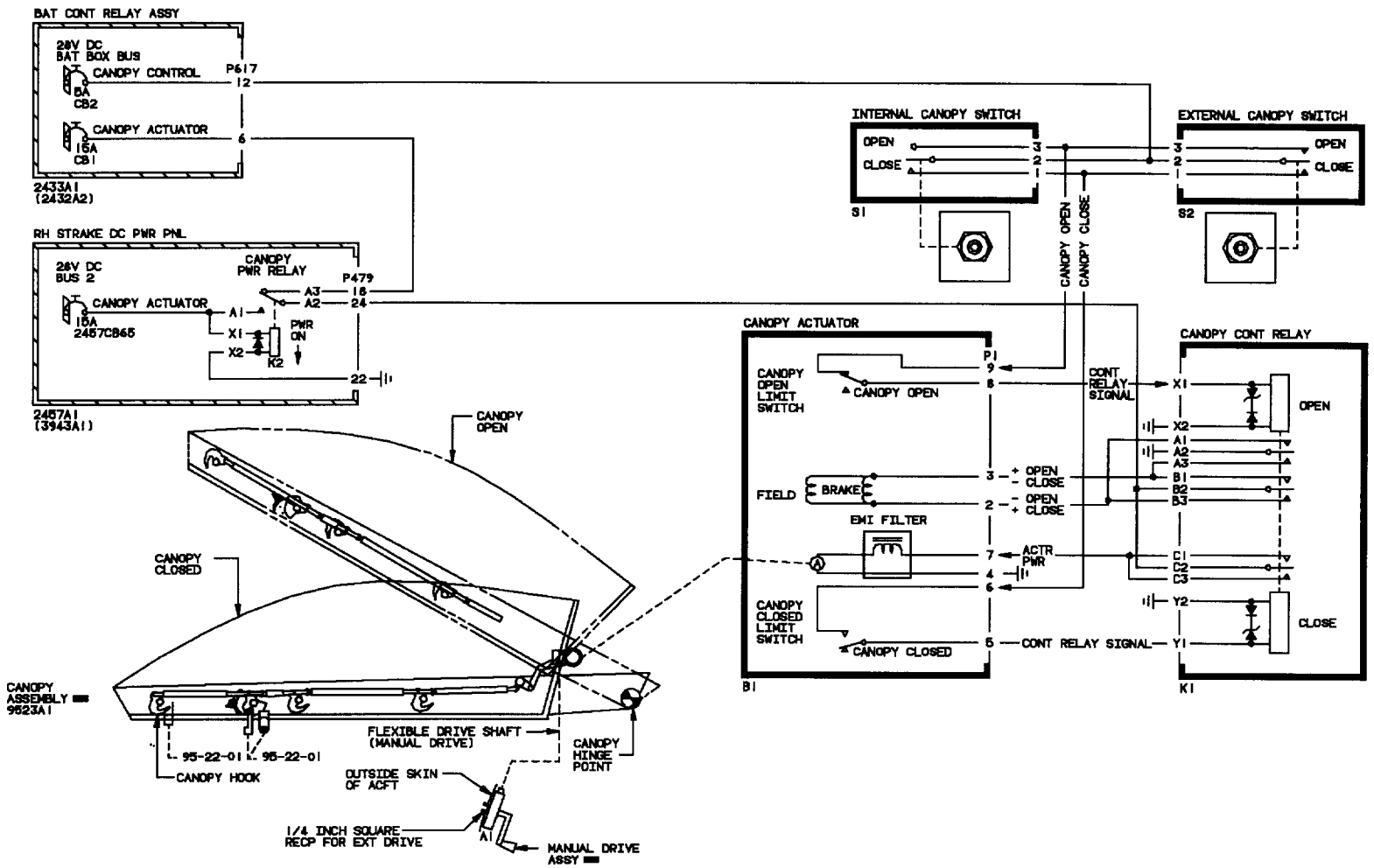


Figure 1. Electrical Interface for Canopy Actuation

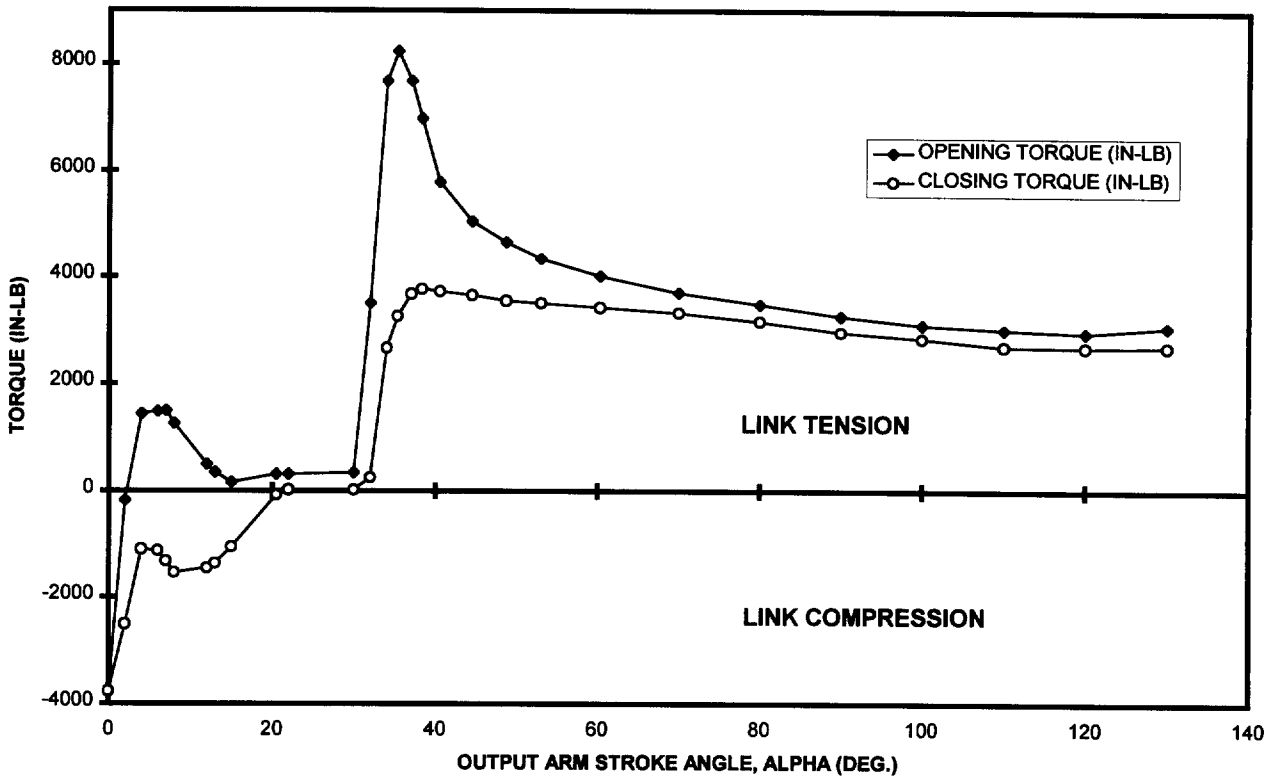
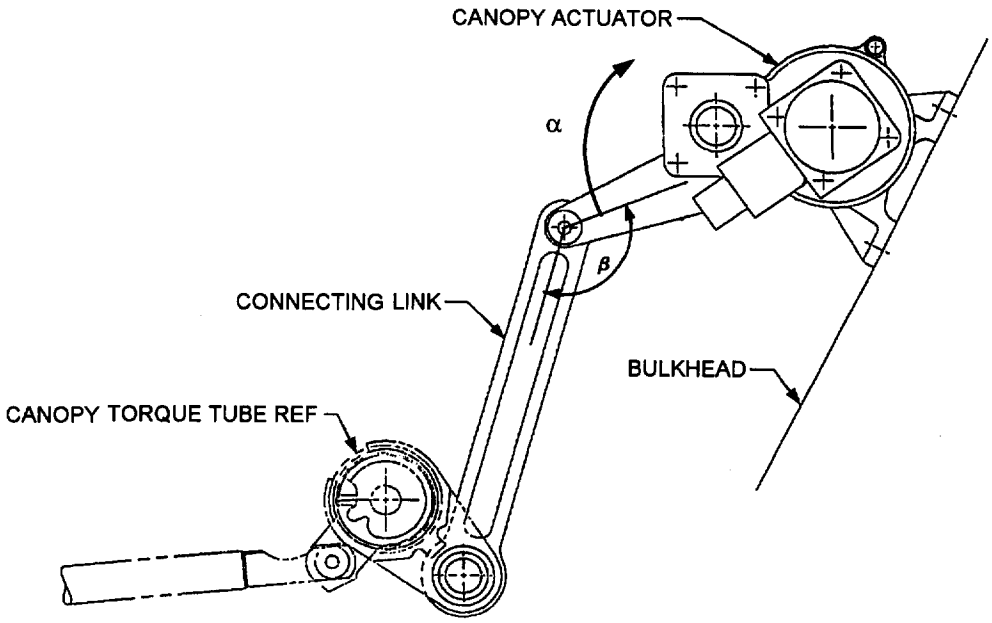


Figure 2. Actuator Stroke versus Operating Torque

TABLE I SOURCE DATA - ACTUATOR STROKE VERSUS OPERATING TORQUE

OUTPUT ARM	LINK	OPENING STROKE		CLOSING STROKE	
α (DEG.)	β (DEG.)	LINK LOAD (LB.)	TORQUE (IN-LB)	LINK LOAD (LB.)	TORQUE (IN-LB)
0.0	127.0	-856	-3,760	-856	-3,760
2.0	124.3	-40	-182	-550	-2,499
4.0	122.0	308	1,437	-236	-1,101
6.0	118.0	305	1,481	-232	-1,127
7.0	116.5	304	1,496	-269	-1,324
8.0	114.7	252	1,259	-308	-1,539
12.0	108.5	95	495	-279	-1,455
13.0	107.4	66	346	-260	-1,365
15.0	104.6	30	160	-198	-1,054
20.5	98.0	57	310	-15	-80
22.0	96.5	57	311	4	21
30.0	90.2	63	344	4	21
32.0	89.3	637	3,503	45	247
34.0	88.1	1,397	7,679	486	2,672
35.3	87.4	1,500	8,250	594	3,264
37.0	85.6	1,401	7,683	671	3,680
38.3	85.3	1,273	6,978	688	3,771
40.5	83.2	1,060	5,789	683	3,730
44.5	80.2	930	5,040	675	3,658
48.7	77.0	868	4,652	663	3,553
53.0	74.5	820	4,346	662	3,509
60.3	69.9	778	4,018	664	3,430
70.0	64.6	746	3,706	670	3.329
80.0	59.9	733	3,488	666	3,169
90.0	55.6	720	3,267	654	2,968
100.0	52.5	712	3,107	654	2,854
110.0	49.6	722	3,024	646	2,706
120.0	47.5	731	2,964	664	2,693
130.0	46.5	771	3,076	678	2,705



(Full-Down Position Shown)

Figure 3. Canopy Actuator Mechanism Geometry

3.2.1.3 Normal operating time. Under all combinations of loading conditions, the time to travel to canopy fully closed shall not be less than four seconds or greater than the times shown below when operating electrically. Under all combinations of loading conditions, the time to travel to canopy fully open, when operating electrically, shall be as follows:

Temperature	Voltage (dc)	Time (seconds)
Ambient	16	≤ 13
Ambient	20	≤ 10
-40°F	16	≤ 15
-40°F	20	≤ 12

3.2.1.4 Electrical duty cycle. The duty cycle for electrical operation shall be one minute on and three minutes off.

3.2.1.5 Irreversibility. The deenergized actuator shall hold its stroke position against limit loads as shown in Figure 4 with no slippage in either direction.

3.2.1.6 Position. The actuator shall operate and hold as specified herein with the actuator oriented in any position.

3.2.1.7 Free play. The free play of the deenergized actuator shall not exceed 0.5 degrees of output arm rotation when loaded with a full reversing 100 inch-pound (in-lb) load. The stiffness shall be at least 229,000 in-lb per radian in the torque range of 1,000 to 2,000 in-lb.

3.2.1.8 Endurance life. The actuator and the adjustable connecting link shall be designed for one service life of the load spectrum shown in Table II with a scatter factor of two based on test.

3.2.1.9 Limit load. The actuator and the adjustable connecting link shall hold against application of the limit loads shown in Figure 4. There shall be no rotation of the output arm or the manual drive. The actuator and link shall meet the performance requirements of this specification following application of the limit loads, and there shall be no distortion or permanent set of actuator or link components after application of the limit loads.

3.2.1.10 Ultimate load. The actuator and the adjustable connecting link shall withstand ultimate loads equal to 1.5 times the limit

loads as shown in Figure 4. Distortion and permanent set are permitted, however, there shall be no structural failure of actuator or link components. Actuator operation is not required during or after application of the ultimate load.

3.2.1.11 Maximum stall torque. The actuator stalling torque shall not exceed 11,000 in-lb.

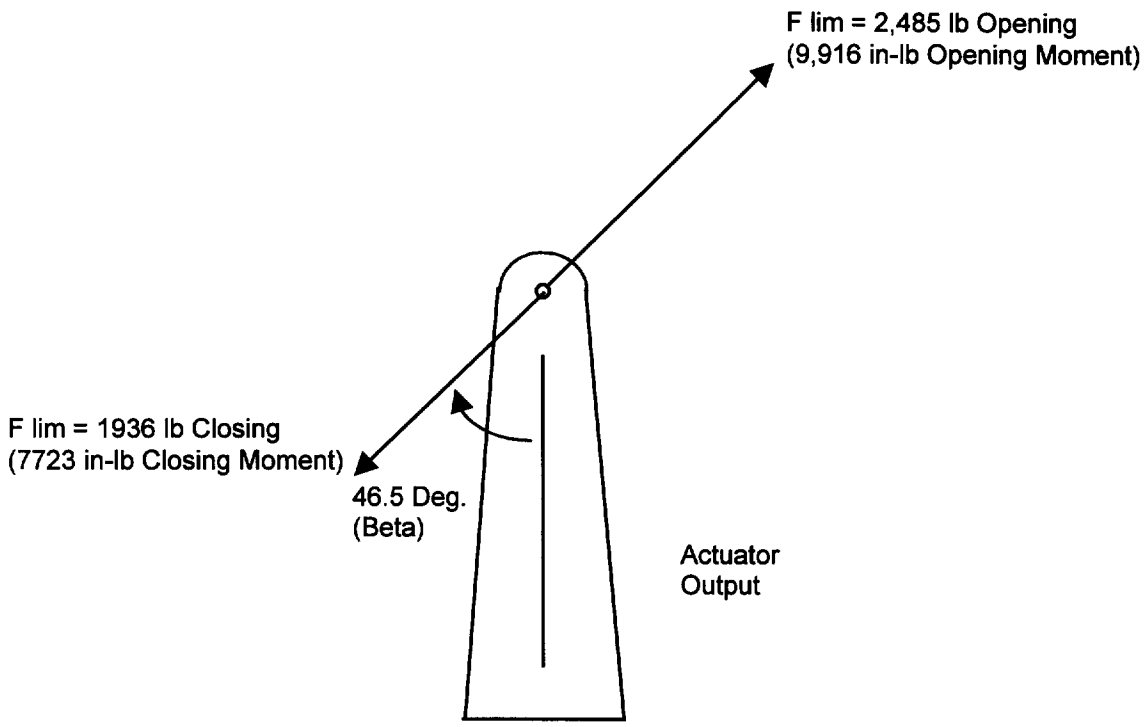


Figure 4. Limit Loads

TABLE II CANOPY ACTUATOR ENDURANCE LIFE SPECTRUM

Layer	Cycles	Temperature	Force Application Sequence
1	17,000	Ambient	Duty Cycle per Figure 2 and Table I
2	300	-40°F	Duty Cycle per Figure 2 and Table I
		Wind Gust/Towing Loads as Shown:	
1	7,179,053	Ambient	from +653.9 lb to +415.9 lb to +653.9 lb
2	1,199,921	Ambient	from +891.9 lb to +177.9 lb to +891.9 lb
3	772,987	Ambient	from +1,128.9 lb to -59.1 lb to +1,128.9 lb
4	18,429	Ambient	from +1,366.9 lb to -297.1 lb to +1,366.9 lb
5	21,500	Ambient	from +1,604.9 lb to -535.1 lb to +1,604.9 lb
6	11,262	Ambient	from +1,891.5 lb to -1,267.3 lb to +1,891.5 lb
7*	9,215	Ambient	from +2,129.5 lb to -1,505.3 lb to +2,129.5 lb
	or 25,250	Ambient	from +1,891.5 lb to -1,267.3 lb to +1,891.5 lb

* Vendor option to perform low cycle/high load or high cycle/low load combination. LMTAS shall be advised to vendor choice prior to testing.

NOTES:

1) Ambient temperature is 73°F ± 18°F.

2) A positive force is a closing load on the actuator arm, tangential to the arc of motion.

3) The above data is for one aircraft life (8,000 hours).

4) Endurance test shall be for two service lives of duty cycle loads, and for the fatigue damage equivalent of two service lives of wind gust/towing loads.

5) Wind gust/towing loads shall be applied in the canopy full open position (β = 46.5°) with the actuator de-energized. The loads applied at β = 46.5° shall be calculated by multiplying the tangential loads in the table above by 1/sin 46.5°.

6) Wind gust/towing loads on the adjustable connecting link shall be calculated by multiplying the above loads by 1/sin 46.5°. A positive load is link tension and a negative load is link compression.

7) Maximum frequency for wind gust/towing load endurance testing is 6 Hz.

3.2.1.12 Manual operation. Provision for manual operation shall be as shown on the specification control drawing. When the manual input is rotated, the electric motor shall not rotate in either direction. Under all combinations of loading conditions, the maximum number of manual input revolutions required to achieve full canopy travel in either direction shall not exceed 135. The manual input operating torque shall not exceed 22 in-lb, and the limit holding torque shall be sufficient to hold against the limit loads of Figure 4. Electrical operation shall not cause the manual input shaft to rotate in either direction. The maximum actuator output torque required during manual operation for the canopy opening stroke is 5,000 in-lb.

3.2.2 Physical characteristics. The geometry, maximum weight, envelope, dimensions, and wiring schematic are as shown on SCD 16VK056001.

3.2.3 Reliability. The actuator shall have a mean-cycle-between-failure (MCBF) of 50,000 cycles when operated within the environmental extremes and load requirements of this specification.

3.2.4 Maintainability. The actuator shall be in accordance with the following maintainability requirements.

3.2.4.1 Scheduled maintenance. The actuator shall require no scheduled maintenance, including maintenance inspections, lubrication, or parts replacement.

3.2.4.2 Reversibility restrictions. The actuator design shall incorporate features that preclude incorrect mechanical or electrical installation.

3.2.5 Environmental conditions. The actuator shall meet the requirements specified herein with the environments as follows and as tested for in Section 4.

3.2.5.1 Pressure. The pressure range will be as follows:

a. Normal

(1) 15.5 to 2.72 psia operating range
(2) 1.0 psi per second varying
(3) 15.5 to 21.0 psia pressure check during maintenance

b. Abnormal

(1) 2.72 to 1.04 psia for 10 minutes at a time
(2) 1.04 to 0.44 psia for 2 minutes at a time
(3) Sudden change from 10.92 to 5.92 psia (explosive decompression in crew station)

3.2.5.2 Temperature. The temperature range will be as follows:

Nonoperating and storage:	-65°F to +203°F
Operating:	-40°F to +160°F
Nonoperating in flight:	-40°F to +131°F

3.2.5.3 Salt fog. The actuator shall withstand in both operating and nonoperating conditions, exposure to salt fog atmosphere.

3.2.5.4 Humidity. The equipment shall withstand the effects of humidities up to 100 percent including conditions wherein condensation takes place in or on the equipment. The equipment shall withstand the above conditions during operation and exposure in a nonoperating condition.

3.2.5.5 Sand and dust. The actuator shall withstand, in both operating and nonoperating conditions, exposure to sand and dust particles as encountered in desert areas.

3.2.5.6 Fungus. The actuator shall withstand, in both operating and nonoperating conditions, exposure to fungus growth as encountered in tropical climates.

3.2.5.7 Acoustical noise. The actuator shall operate in accordance with the requirements of this specification during and after being subjected to acoustical noise with an overall sound pressure level of 127 dB.

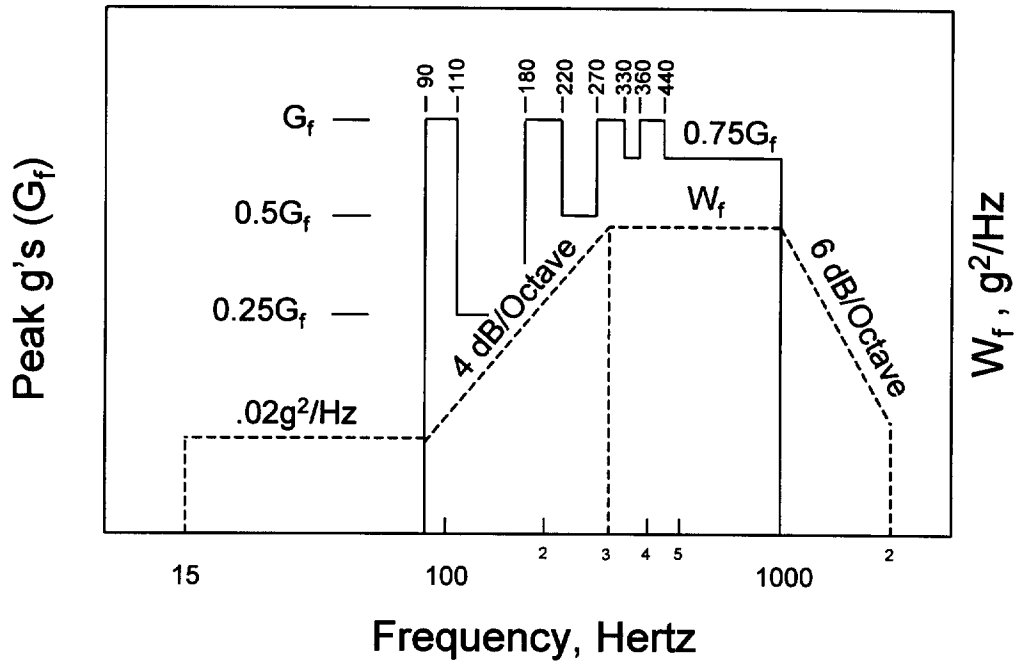
3.2.5.8 Explosive atmosphere (vapor-safe). The actuator shall not cause ignition of an ambient-explosive-gaseous mixture with air when operating in such an atmosphere.

3.2.5.9 Vibration. The actuator shall operate as specified herein before and after being subjected to the vibration frequency range and amplitude shown in Figure 5.

3.2.6 Transportability. The actuator shall be sufficiently rugged to withstand handling and manipulation by unskilled personnel throughout shipping, inspection, installations, and service.

3.3 Design and construction.

3.3.1 Materials, processes, and parts. Selections of materials shall be made with special attention being given to the loads and environmental conditions. Attention also shall be given to reliability, repairability, and lightweight construction.



$G_f = 10$

$W_f = 0.053$

Figure 5. Combined Random and Sinusoidal Vibration Test for Gunfiring Environment

3.3.1.1 Metals. Metals shall be of the corrosion resisting type, or suitably protected to resist corrosion in all the environments required by this specification, when in storage or during normal service life. The use of dissimilar metals, especially brass, copper, or steel in contact with aluminum alloys shall be avoided wherever possible. Where such contacts are unavoidable, the metals shall be protected in a suitable manner. (See 3.3.1.9)

Titanium and titanium base alloys may be used in applications where their use is justified in terms of weight savings, improved performance, improved serviceability, and where adequacy of manufacturing methods can be demonstrated.

Magnesium shall not be used.

Steel - Steel shall not be used in major structural parts except as follows:

a. D6ac steel in accordance with FMS-1011 and heat treated and processed to 240,000 psi maximum in accordance with FPS-1029 may be used.

b. Other steels as listed in 16PR711 for heat treat to 200,000 psi maximum may be used. Only vacuum melted steels may be used at 180,000 psi and above.

c. Steels or heat treats other than those listed in a. and b. above shall not be used except with the specific written approval of Lockheed Martin Tactical Aircraft Systems (LMTAS).

3.3.1.2 Plastic parts. When plastics, synthetic rubber, and nonmetallic materials other than military approved articles are used, adequate proof of their suitability shall be submitted. The use of these parts shall be with proper consideration of resistance to the aircraft environment including the special problems of dimensional stability, aging characteristics, moisture absorption, and thermal embrittlement.

3.3.1.3 Protective treatment. Protective treatment of material shall be in accordance with FPS-3001. When materials are used in the construction of the actuator that are subject to deterioration when exposed to climatic and environmental conditions likely to occur during service usage, they shall be protected against such deterioration in a manner that will in no way prevent compliance with the performance requirements of this specification.

3.3.1.4 Finish. Finish shall be in accordance with FPS-3001 and requirements on SCD 16VK056001.

3.3.1.5 Corrosion resistance. The materials and finishes used in the construction of the actuator shall be corrosion resistant to the extent that the actuator shall remain free of corrosion and corrosion products, and that the actuator performance will not be affected by corrosion or corrosion products throughout the expected service life.

3.3.1.6 Fluid resistance. The materials and finishes used in the construction of the actuator shall resist exposure to the following fluids: MIL-A-8243, MIL-H-5606, MIL-L-7808, MIL-T-5624, TT-I-735 (use a 50 percent solution), MIL-C-38736.

3.3.1.7 Inspection of metals. All highly stressed parts shall be subjected to magnetic particle inspection in accordance with NDTS 2101 or fluorescent penetrant inspection in accordance with NDTS 1101 as applicable.

3.3.1.8 Castings. Castings shall be Class 2 (formerly Class IB) and be inspected per FPS-1001. Class 4 (formerly Class IIB) castings may be used subject to prior review and written approval by LMTAS.

3.3.1.9 Dissimilar metals. Insofar as practical, unless suitably protected against electrolytic corrosion, dissimilar metals as defined by MIL-STD-889 shall not be used in intimate contact with each other. (See 3.3.1.1)

3.3.1.10 Parts Standardization. Parts definitions are shown in MIL-STD-965. All parts included in the National Stock Classes (NSC) defined in MIL-STD-965 used in the design shall be selected from the Program Parts Selection List (PPSL) 16PP027. The use of parts that are not in 16PP027 require prior written approval by LMTAS.

3.3.2 Electromagnetic radiation. The electrical portion of the actuator shall meet the requirements of MIL-STD-461 as follows:

a. Test requirement CE03 except change frequency range to 5 MHz to 50 MHz. Data shall be collected from 0.014 MHz to 0.10 MHz for information purposes only.

b. Test requirement RE02

The actuator shall be designed to be bonded to airplane structure. The DC resistance of the bond from the actuator to airplane structure shall be 0.0025 ohm or less.

3.3.3 Nameplates and product marking.

3.3.3.1 Identification of product. Equipment, assemblies, and parts shall be marked for identification in accordance with MIL-STD-130 and FPS-3008. As a minimum, nameplates will contain the following information:

Configuration Item Identification Number (if applicable)
Part Number
LMTAS Specification Number
Design Activity Identification
Contract Number
National Stock Number

Serial Number

3.3.3.2 Motor data. Data pertaining to the motor which is included on a nameplate on the motor need not be duplicated on the actuator nameplate.

3.3.4 Workmanship. The workmanship employed in the manufacture of all parts and assemblies shall be of the highest quality. Particular attention shall be paid to neatness and thoroughness of soldering, wiring, impregnation of coils, marking of parts and assemblies, plating, painting, riveting, machine screw assemblage, welding and brazing, and freedom of parts from burrs and sharp edges.

3.3.5 Interchangeability. All parts having the same manufacturer's part number shall be functionally and dimensionally interchangeable per MIL-I-8500.

3.3.6 Safety. The actuator shall not present a hazard to personnel or flight safety during either normal operation or failure conditions. The actuator design shall limit or prevent the following hazards:

a. Actuator failure resulting in canopy free fall per 3.3.9.19.

b. Fire or release of toxic or noxious fumes during actuator overheat/overload.

c. Release of oil, grease, or other debris during normal operation or rapid decompression.

d. Failures in either the primary electro-mechanical actuation system or the manual drive system likely to cause the loss of the alternate method of opening the canopy.

3.3.7 Human performance/human engineering. The criteria and requirements of MIL-STD-1472 and AFSC DH 1-3 shall be applied to the design. In addition, the item design shall be such that the performance of any task required for maintenance of the item is within the capability of the 5th through 95th percentile Air Force personnel who have been selected appropriately and trained to perform the required task.

3.3.8 Electrical components and circuits.

3.3.8.1 Electric motors. Electric motors for electromechanical actuators shall be designed and tested in accordance with MIL-M-8609 for 28 VDC, direct-current motors.

3.3.8.1.1 Operating current and voltage. The actuator operating current shall not exceed 15 amperes except for momentary inrush at startup and for periods not to exceed two seconds during the high-load portion of the opening stroke as shown in Figure 4. In no case shall the actuator cause the aircraft-side 15 ampere circuit breaker to trip. The actuator shall meet all performance requirements of this specification, including operating time, when operating at any voltage from 16 VDC to 30 VDC.

3.3.8.1.2 Motor thermal protection. The actuator shall be provided with thermal protection which will automatically interrupt power to the actuator motor in the event of a stalled motor. The thermal protection shall be such that initial power interruption occurs prior to damage or degradation of the life characteristics of the actuator. Thermal protection shall automatically reset within 60 seconds after power interruption or shall require manual cycling of the canopy control switch to the "off" position to reset. If thermal protection is reset by cycling the canopy control switch, means shall be provided to ensure that repeated recycling does not cause thermal damage to the motor.

3.3.8.2 Motor nameplate. The electric motor shall have a separate nameplate with all identifying information.

3.3.8.3 Wiring and circuitry. All electrical wiring and components integral with the actuator shall be in accordance with MIL-W-5088, MIL-E-7080, and as specified herein.

a. All internal wire shall be color coded.

b. Connectors shall be as shown on the control drawing.

3.3.8.4 Electrical power characteristics. The actuator shall meet all specified requirements of MIL-STD-704 for the types of power specified herein, and shall give specified performance when supplied with electrical power having characteristics and limits as defined in MIL-STD-704, Category B, including battery operation, except as otherwise specified herein.

3.3.8.4.1 Steady-state and transient operation. The actuator shall provide specified performance when the prime power inputs are within the normal limits specified by MIL-STD-704. Under abnormal limits

specified by MIL-STD-704, the system shall remain safe, shall automatically recover to 100 percent performance, and shall remain unaffected in reliability.

3.3.8.4.2 Power requirements. The power requirements of the actuator shall be minimized to the greatest extent practical.

3.3.8.4.3 Power interruption. The actuator shall not be damaged by interruption (of any combination of power inputs) for any period of time (normal or abnormal). During power interruption, the equipment shall undergo an orderly shutdown. When power returns within the normal limits of MIL-STD-704, the equipment shall automatically resume normal operation.

3.3.8.5 Electrical potting. Potting of electrical components shall be avoided. However, if electrical potting is believed necessary by the supplier, the potting compound, its method of application, its use within the actuator, and the rationale for the requirement shall be subject to prior written approval by LMTAS.

3.3.8.6 Limit switches and actuation. Limit switches shall be integral with the actuator and in accordance with MIL-S-8805. The limit switch installation shall be capable of withstanding continuous overrunning without damage. Special care shall be exercised to protect switches from rough handling, moisture, dirt, grease, etc. The switch installation shall not require bending of switch levers for proper actuation. Special care shall be exercised in the design of the actuator to ensure accurate adjustment and repeatability of limit switch actuation points.

3.3.8.7 Actuator travel adjustment. The travel of the actuator output arm shall be permanently adjusted at the time of manufacture to the limits defined on the SCD and shall require no additional adjustment in service. Special care shall be exercised in the design of the actuator to ensure reliable repeatability of the actuator stroke.

3.3.9 Mechanical component requirements.

3.3.9.1 Foolproof assembly. The design shall incorporate features, where possible, to prevent incorrect assembly of parts and components.

3.3.9.2 Loose parts. All parts of an assembly shall be attached to the assembly. Adhesives, tapes, or other nonreusable attachments shall not be used.

3.3.9.3 Lubrication. The actuator shall be permanently lubricated at the time of manufacture for its useful life and shall require no additional lubrication in service. Lubrication shall be in accordance with MIL-STD-838 and only lubricants listed in MIL-HDBK-275 shall be used.

3.3.9.4 Pressure vents. If the actuator is likely to leak grease or oil as a result of pressure changes, pressure vents shall be incorporated to equalize pressure and prevent leakage.

3.3.9.5 Dimensional stability. All close-fitting metal parts shall be treated to minimize tendencies for dimensional change such as growth, warping, shrinking, etc.

3.3.9.6 Working fits and clearances. Clearances shall allow for differential thermal expansion and the effect of pressure variation.

3.3.9.7 Stress concentration. The design shall avoid the causes of stress concentration points such as poor basic proportions, sharp corner radii, and abrupt section changes.

3.3.9.8 Attachments. The attachment of parts in the actuator shall be as follows.

3.3.9.8.1 Screw threads. The MIL-S-8879 thread form shall be used on all components or parts in new design. On existing equipment, unmodified, MIL-S-7742 thread form may be used.

3.3.9.8.2 Alignment. Actuator components should not depend on the means of attachment for alignment between parts.

3.3.9.8.3 Snap rings. Snap rings shall not be used except with the written approval of LMTAS for the specific application.

3.3.9.8.4 Staking. Attachment by staking shall not be used except with the written approval of LMTAS for the specific application.

3.3.9.8.5 Securing. All means of attachment shall be positively locked either by self-locking features or with safety wire. Safety wire shall be applied in accordance with MS33540 and shall conform to MS20995. Spring pins or lockwashers shall not be used. Cotter pins shall be in accordance with MS24665.

3.3.9.9 Adjustment. Elements within the actuator requiring adjustment for their proper operation shall provide a locking and inspectable means of adjustment. The adjustment dimensions or

function requirement shall be called out on the engineering drawing with definite limits of acceptability established. Adjustment by means of bending, filing, cut and try, or any other means which rely on the discretion of the person making the adjustment will not be satisfactory.

3.3.9.10 Splines. American Standards Association ASA-B5.15 side fit Class 1 and 2 shall be used as a guide for the design and construction of straight or spherical splines.

3.3.9.11 Gears. Gear toothform, pressure angle, and backlash shall conform to gear industry standards.

3.3.9.12 Bearings. To minimize the probability of bearing failure, special attention shall be given to bearing selection and fitting. Special attention shall be directed to material selection, internal clearance, shaft and housing fit, alignment, sealing, lubrication, temperature, bearing class, and load capacity for each application. Bearings shall be per the American Bearing Manufacturer's Association (ABMA) Standards.

3.3.9.13 Rotational roughness. There shall be no rotational roughness or binding which causes perceptible changes to the smoothness of rotation as manifested in changes to the no-loading running friction when any part of the mechanism is operated by hand.

3.3.9.14 Cleaning. Units shall be cleaned thoroughly of loose parts, splattered or excess solder, metal chips, or other foreign material after assembly. Burrs and sharp edges as well as resin flash which might crumble shall be removed.

3.3.9.15 Inspections during assembly. Work instructions shall specifically address dimensions, features, or properties to be inspected during the assembly process. General statements to "Inspect" are not satisfactory.

3.3.9.16 Mechanical stops. Nonjamming mechanical stops shall be provided to limit the actuator overtravel to that shown on the specification control drawing. The actuator shall withstand impacts against these stops with the motor energized in either direction under the most severe conditions of load and no-load.

3.3.9.17 Overtravel. Overtravel of the actuator, incident to opening the motor circuit, shall be kept to a minimum consistent with practical considerations in the design of the braking device.

Overtravel shall be in accordance with the requirements on the control drawing.

3.3.9.18 Overriding loads. Overriding loads shall not cause sufficient overspeeding of the actuator during operation to cause failure or damage especially if driven into the mechanical stops. Overriding loads shall not increase the stopping distance beyond that allowed for normal operation.

3.3.9.19 Free-fall protection. The actuator shall be designed to preclude failures that result in free fall of the canopy. In the event of actuator failure, the minimum time for canopy closure from the full open position until the canopy frame rests on the sill of the aircraft fuselage shall not be less than four seconds for all combinations of loading conditions and whether the actuator is energized or deenergized.

3.4 Documentation. The following documentation shall apply as applicable.

a. Drawings
b. T.O.s/Test Manuals
c. Test plans, procedures, and results/reports

3.5 Logistics.

3.5.1 Maintenance. Maintenance considerations shall be as follows:

3.5.1.1 Accessibility. The design of the actuator shall provide ready access to test points or adjustments and for the replacement of parts. This requirement shall be applicable to both "on aircraft" and shop maintenance.

3.5.1.2 Maintenance environment. The design of the actuator shall provide for maintenance environments of any humidity, any form of precipitation, temperature from -65°F to 150°F, wind, sand, and dust. Emphasis shall be directed to "on-aircraft" maintenance by personnel wearing clothing appropriate for the environment.

3.5.1.3 Materials and processes. Maintenance materials or processes shall not require uncommon skill, support equipment (SE), special techniques, or long task time. For any maintenance material or process, consideration shall be given to its application in austere base operating environment.

3.5.1.4 Support equipment (SE) provisions. The overall support objective is minimum reliance on SE for ground testing, bench testing, installation, removal, repair, calibration, and overhaul of airborne equipment.

3.5.1.5 General requirements. Where SE is required, airborne equipment shall be designed to be compatible with the following to the maximum extent:

a. Use of common and standard hand tools for installation, removal, disassembly, assembly, and adjustment

b. Use of standard items of SE already in Air Force and/or Navy inventory to accomplish maintenance, handling, servicing, overhaul, and test functions

c. Requirements for special SE shall be kept to an absolute minimum. Such unique organizational and field level maintenance requirements which cannot be satisfied with standard or modified standard SE shall be fully justified by the manufacturer prior to proceeding with development of the affected airborne equipment.

3.5.1.6 Flight line requirements. Airborne equipment design shall be such that no flight line SE will be required for daily, preflight, postflight, or operational checkout.

3.5.1.7 Shop requirements. Airborne equipment design shall be compatible with standard SE for bench testing and calibration to the maximum extent. SE compatibility shall be such that airborne components may be installed in the airborne subsystem without the need for additional adjustment or test of the component of subsystem.

3.5.1.8 Depot requirements. During airborne equipment design, consideration shall be given to minimizing the requirements for depot type SE for repair and overhaul.

3.5.2 Supply. The item shall be configured to be compatible with deployable requirements of the air vehicle.

3.6 Precedence. This specification will be the governing document in respect to any conflict of requirements between this specification and requirements of other specifications, standards, or other documents referenced herein.

4. QUALITY ASSURANCE PROVISIONS

4.1 General. The actuator shall be inspected and tested in accordance with the requirements stated herein to demonstrate that it meets the requirements of this specification.

Prior to performing any test or verification required by this specification, all test specifications and procedures shall be approved by LMTAS. Unless otherwise specified in writing, no adjustment, repairs, or maintenance will be allowed during qualification tests or verification procedures. When conducting a test, a record will be kept containing the necessary test data for LMTAS to determine compliance with performance requirements. Test failures shall be documented, coordinated, and resolved via Test Failure and Resolution Report (TFRR).

a. Qualification by similarity: Formal qualification shall be accomplished by using test data from previously developed and qualified items when possible. When qualification by similarity is proposed, the test data from the earlier qualification shall be submitted with design data to substantiate that:

   (1) The equipment is to perform a similar function in the new application as it did in its earlier qualification.

   (2) The environment and operating limits are not more demanding or degrading than in the earlier operation.

   (3) The new item does not incorporate differences that would invalidate the criteria of 1 or 2.

   (4) The equipment operated satisfactorily in its earlier fighter application as indicated by its MTBF field failure data.

b. Methods of verification: Table III, the Verification Cross Reference Index (VCRI), provides a Section 4 method of verifying each Section 3 requirement. Verification shall be accomplished by inspection, analysis, demonstration or test, or a combination thereof as defined below:

   (1) Inspection. Inspection is defined as a visual verification that the item as manufactured conforms to the documentation to which it was designed.

TABLE III
VERIFICATION CROSS REFERENCE INDEX

NA - Not Applicable 2 - Analysis 4 - Test
1 - Inspection 3 - Demonstration

Section 3 Requirement Reference	Verification Methods					Section 4 Verification Requirements
	NA	1	2	3	4	
3. REQUIREMENTS	X					
3.1 Item definition	X					
3.1.1 Interface definition						
3.2 Characteristics	X					
3.2.1 Performance					X	4.2.4.2
3.2.1.1 Operation					X	4.2.4.2.1, 4.2.4.2.3
3.2.1.2 Normal operating torque					X	4.2.4.2.1
3.2.1.3 Normal operating time					X	4.2.4.2.1
3.2.1.4 Electrical duty cycle					X	4.2.4.2.5
3.2.1.5 Irreversibility					X	4.2.4.2.4
3.2.1.6 Position			X			4.1.b(2)
3.2.1.7 Free play					X	4.2.4.2.9
3.2.1.8 Endurance life					X	4.2.4.3.11
3.2.1.9 Limit load					X	4.2.4.2.4
3.2.1.10 Ultimate load					X	4.2.4.3.12
3.2.1.11 Maximum stall torque					X	4.2.4.2.2
3.2.1.12 Manual operation					X	4.2.4.2.10, 4.2.4.2.11, 4.2.4.2.12, 4.2.4.2.13

TABLE III
VERIFICATION CROSS REFERENCE INDEX

NA - Not Applicable 2 - Analysis 4 - Test
1 - Inspection 3 - Demonstration

Section 3 Requirement Reference	Verification Methods					Section 4 Verification Requirements
	NA	1	2	3	4	
3.2.2 Physical characteristics		X				4.1.b(1) 4.2.4.1
3.2.3 Reliability			X			4.1.b(2)
3.2.4 Maintainability			X			4.1.b(2)
3.2.4.1 Scheduled maintenance			X			4.1.b(2)
3.2.4.2 Reversibility restrictions			X			4.1.b(2)
3.2.5 Environmental conditions					X	4.2.4.3
3.2.5.1 Pressure					X	4.2.4.3.1
3.2.5.2 Temperature					X	4.2.4.3, 4.2.4.3.2, 4.2.4.3.3
3.2.5.3 Salt fog					X	4.2.4.3.4
3.2.5.4 Humidity					X	4.2.4.3.5
3.2.5.5 Sand and dust					X	4.2.4.3.6
3.2.5.6 Fungus					X	4.2.4.3.7
3.2.5.7 Acoustical noise					X	4.2.4.3.8
3.2.5.8 Explosive atmosphere (vapor-safe)					X	4.2.4.3.9
3.2.5.9 Vibration					X	4.2.4.3.10
3.2.6 Transportability		X				4.1.b(1)

TABLE III
VERIFICATION CROSS REFERENCE INDEX

NA - Not Applicable 2 - Analysis 4 - Test
1 - Inspection 3 - Demonstration

Section 3 Requirement Reference	Verification Methods					Section 4 Verification Requirements
	NA	1	2	3	4	
3.3 Design and construction	X					
3.3.1 Materials, processes and parts		X				4.1.b(1)
3.3.1.1 Metals		X				4.1.b(1)
3.3.1.2 Plastic parts		X				4.1.b(1)
3.3.1.3 Protective treatment		X				4.1.b(1)
3.3.1.4 Finish		X	X		X	4.1.b(1), 4.2.4.1, 4.2.4.3.14
3.3.1.5 Corrosion resistance			X		X	4.2.4.3.14
3.3.1.6 Fluid resistance			X		X	4.2.4.3.15
3.3.1.7 Inspection of metals		X				4.1.b(1)
3.3.1.8 Castings		X				4.1.b(1)
3.3.1.9 Dissimilar metals		X				4.1.b(1)
3.3.1.10 Standard parts		X				4.1.b(1)
3.3.2 Electromagnetic radiation					X	4.2.4.3.13
3.3.3 Nameplates and product marking	X					
3.3.3.1 Identification of product		X				4.1.b(1), 4.2.4.1

TABLE III
VERIFICATION CROSS REFERENCE INDEX

NA - Not Applicable 2 - Analysis 4 - Test
1 - Inspection 3 - Demonstration

Section 3 Requirement Reference	Verification Methods					Section 4 Verification Requirements
	NA	1	2	3	4	
3.3.3.2 Motor data		X				4.1.b(1), 4.2.4.1
3.3.4 Workmanship		X				4.1.b(1), 4.2.4.1
3.3.5 Interchangeability			X			4.1.b(2)
3.3.6 Safety			X			4.1.b(2)
3.3.7 Human performance/ human engineering			X			4.1.b(2)
3.3.8 Electrical components and circuits	X					
3.3.8.1 Electric motors					X	4.2.4.2.1
3.3.8.1.1 Operating current and voltage					X	4.2.4.2.1
3.3.8.1.2 Motor thermal protection					X	4.2.4.2.5, 4.2.4.2.6
3.3.8.2 Motor nameplate		X				4.1.b(1), 4.2.4.1
3.3.8.3 Wiring and circuitry		X				4.1.b(1)
3.3.8.4 Electrical power characteristics					X	4.2.4.2.1, 4.2.4.3
3.3.8.4.1 Steady-state and transient operation					X	4.2.4.2.14
3.3.8.4.2 Power requirements	X					
3.3.8.4.3 Power interruption					X	4.2.4.2.14
3.3.8.5 Electrical potting		X				4.1.b(1)
3.3.8.6 Limit switches and actuation					X	4.2.4.2.1

TABLE III
VERIFICATION CROSS REFERENCE INDEX

NA - Not Applicable 2 - Analysis 4 - Test
1 - Inspection 3 - Demonstration

Section 3 Requirement Reference	Verification Methods					Section 4 Verification Requirements
	NA	1	2	3	4	
3.3.8.7 Actuator travel adjustment		X				4.1.b(1)
3.3.9 Mechanical component requirements	X					
3.3.9.1 Foolproof assembly		X				4.1.b(1)
3.3.9.2 Loose parts		X				4.1.b(1)
3.3.9.3 Lubrication		X				4.1.b(1)
3.3.9.4 Pressure vents		X				4.1.b(1)
3.3.9.5 Dimensional stability		X				4.1.b(1)
3.3.9.6 Working fits and clearances		X				4.1.b(1)
3.3.9.7 Stress concentration			X			4.1.b(2)
3.3.9.8 Attachments	X					
3.3.9.8.1 Screw threads		X				4.1.b(1), 4.2.4.1
3.3.9.8.2 Alignment		X				4.1.b(1), 4.2.4.1
3.3.9.8.3 Snap rings		X				4.1.b(1), 4.2.4.1
3.3.9.8.4 Staking		X				4.1.b(1), 4.2.4.1
3.3.9.8.5 Securing		X				4.1.b(1), 4.2.4.1
3.3.9.9 Adjustment		X				4.1.b(1)
3.3.9.10 Splines		X				4.1.b(1)

TABLE III
VERIFICATION CROSS REFERENCE INDEX

NA - Not Applicable
1 - Inspection
2 - Analysis
3 - Demonstration
4 - Test

Section 3 Requirement Reference	Verification Methods					Section 4 Verification Requirements
	NA	1	2	3	4	
3.3.9.11 Gears		X				4.1.b(1)
3.3.9.12 Bearings		X				4.1.b(1)
3.3.9.13 Rotational roughness		X				4.1.b(1)
3.3.9.14 Cleaning		X				4.1.b(1)
3.3.9.15 Inspections during assembly		X				4.1.b(1)
3.3.9.16 Mechanical stops					X	4.2.4.2.7
3.3.9.17 Overtravel					X	4.2.4.2.1
3.3.9.18 Overriding loads					X	4.2.4.2.1, 4.2.4.2.3, 4.2.4.2.7
3.3.9.19 Free-fall protection					X	4.2.4.2.8
3.4 Documentation	X					
3.5 Logistics	X					
3.5.1 Maintenance	X					
3.5.1.1 Accessibility			X			4.1.b(2)
3.5.1.2 Maintenance environment			X			4.1.b(2)
3.5.1.3 Materials and processes			X			4.1.b(2)
3.5.1.4 Support equipment (SE) provisions			X			4.1.b(2)

TABLE III
VERIFICATION CROSS REFERENCE INDEX

NA - Not Applicable 2 - Analysis 4 - Test
1 - Inspection 3 - Demonstration

Section 3 Requirement Reference	Verification Methods					Section 4 Verification Requirements
	NA	1	2	3	4	
3.5.1.5 General requirements			X			4.1.b(2)
3.5.1.6 Flight line requirements			X			4.1.b(2)
3.5.1.7 Shop requirements			X			4.1.b(2)
3.5.1.8 Depot requirements			X			4.1.b(2)
3.5.2 Supply			X			4.1.b(2)
3.6 Precedence	X					

(2) Analysis. Analysis is defined as verification that a specification requirement has been met by technical evaluation of equations, charts, reduced data and/or representative data.

(3) Demonstration. Demonstration is defined as an uninstrumented test where success is determined by observation alone. Included in this category are tests that require simple quantitative measurements such as dimensions, time to perform tasks, etc.

(4) Tests. Test is defined as verification that a specification requirement is met by a thorough exercising of the application element under appropriate conditions in accordance with approved test procedures.

4.1.1 Responsibility for tests. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements and tests as specified herein. Except as otherwise specified in the contract or purchase order, the supplier may use his own or any other facilities suitable for the performance of the inspection requirements and tests specified herein unless disapproved by LMTAS or the Government. LMTAS reserves the right to monitor or witness all or any part of the qualification testing either at the vendor's facility or at any other laboratory. The LMTAS test representative's signature on the final report will attest to concurrence with test methods and results.

4.2 Quality conformance inspections.

4.2.1 General. The general conditions of testing are as follows.

4.2.1.1 Certification. Certification of satisfactory completion of qualification and safety-of-flight tests shall be submitted to LMTAS in accordance with the schedule required by the contract or purchase order. Failure to supply the test certification as required herein shall constitute cause for rejecting the vendor as a qualified source of supply for the 16VK056001 actuator and cause for rejecting components delivered under contract.

4.2.1.2 Test failures. Each incident wherein an actuator fails to meet the requirements of this specification shall be reported to LMTAS.

4.2.1.3 Investigation. The manufacturer shall conduct an investigation of each failure. The manufacturer shall conduct all structural investigations and examinations involving complete disassembly and the use of metallurgical, chemical, dimensional, penetrant, and other types of analyses as necessary in the exploration of the cause of failure. A written report of the specific data, causes, findings, and corrective action shall be submitted to LMTAS.

4.2.1.4 Rejection and retest. When components fail to meet the requirements of this specification, no item on hand or later produced will be accepted until the extent and cause of the failure are determined and corrected. After corrections have been made, all necessary tests shall be repeated. The extent of the retest shall be submitted to LMTAS for approval prior to the retest.

4.2.1.5 Test continuation. Pending the investigation of a test failure, individual tests may continue. However, acceptance of items on hand or later produced shall not be made until it is determined that the actuator meets all of the requirements of this specification.

4.2.1.6 Defects in items already accepted. If the investigation indicates that defects may exist in items already accepted, the supplier shall fully advise LMTAS of all defects likely to be found and the methods for correcting them.

4.2.2 Test conditions. Unless otherwise specified, all tests shall be conducted under the following conditions:

a. Ambient Air

Temperature - - - - - - -	23° ± 10°C (73° ± 18°F)
Relative humidity - - -	50 percent ± 30 percent
Pressure - - - - - - - -	Prevailing laboratory conditions

b. Tolerances - For convenience only; not a waiver of requirements.

Temperature - - - - - - -	±5°
Altitude - - - - - - - -	±5 percent in inches Hg
Power - - - - - - - - - -	±2 volt ac, ±1 volt dc,±5 CPS frequency
Vibration frequency - -	±2 percent or 0.5 CPS below 20 CPS, ±10 percent amplitude

c. Mounting. The actuator shall be mounted for testing in a manner similar to its mounting in the airplane.

d. Disposition of test specimens. All of the components used as test specimens shall be sent to LMTAS within six months after completion of the qualification tests unless otherwise directed.

4.2.3 Classification of tests. The classification of inspection and testing shall be as follows:

a. Acceptance tests - - - - - - - - See 4.2.3.1
b. Safety-of-flight tests - - - - - See 4.2.3.2
c. Qualification tests - - - - - - See 4.2.3.3
d. Reliability tests - - - - - - - See 4.2.5
e. Maintainability demonstrations - See 4.2.6

4.2.3.1 Acceptance tests. The acceptance tests shall consist of individual tests as follows:

a. Examination of Product - - - - - See 4.2.4.1
b. Functional tests consisting of the following:
(1) Operating time and repeatability - - See 4.2.4.2.1
(2) Maximum stall torque - - - - - - - - - See 4.2.4.2.2
(3) Mechanical stops impact test - - - - See 4.2.4.2.7
(4) Backlash - - - - - - - - - - - - - - - - See 4.2.4.2.9
(5) Manual input slippage - - - - - - - - See 4.2.4.2.10
(6) Manual input running torque - - - - See 4.2.4.2.11 and clutch slip torque
(7) Manual input aiding load test - - - See 4.2.4.2.12
(8) Manual input antibackdriving test - -See 4.2.4.2.13

Each actuator delivered under contract shall meet the requirements of this specification and the applicable drawings under the acceptance tests described herein.

4.2.3.2 Safety-of-flight tests. The safety-of-flight tests shall consist of tests in accordance with Table IV. Endurance testing accomplished in the safety-of-flight tests shall be applicable to the qualification tests. Certification of the completion of the safety-of-flight tests shall be submitted to LMTAS in accordance with 4.2.1.1 within seven days after completion of testing.

4.2.3.3 Qualification tests. The qualification tests shall consist of tests in accordance with Table V including safety-of-flight tests. Qualification testing shall be conducted on the same test

specimens used in the safety-of-flight tests. Certification of the completion of the qualification tests in Table V shall be submitted to LMTAS in accordance with 4.2.1.1 within 30 days after completion of testing.

4.2.4 Individual tests.

4.2.4.1 Examination of product. The actuator shall be inspected to demonstrate compliance with the requirements of this specification and the applicable drawings for the following:

a.	Test certification - - - - -	See 4.2.1.1
b.	Identification - - - - - - -	See 3.3.3.1, 3.3.3.2, and 3.3.8.2
c.	Weight - - - - - - - - - - -	See 3.2.2
d.	Mounting - - - - - - - - - -	See 16VK056001
e.	Interfaces & connectors - -	See 16VK056001
f.	Finish - - - - - - - - - - -	See 3.3.1.4 and 16VK056001
g.	Protective covers - - - - -	See 5.1
h.	Secure attachments - - - - -	See 3.3.9.8 and 16VK056001
i.	Workmanship - - - - - - - -	See 3.3.4
j.	Damage - - - - - - - - - - -	See 5.1

TABLE IV SAFETY-OF-FLIGHT TESTS

TEST	PARAGRAPH NO.	ORDER OF TESTING
Acceptance	4.2.3.1	1
Endurance	4.2.4.3.11	2
Altitude	4.2.4.3.1	3
High Temperature	4.2.4.3.2	4
Low Temperature	4.2.4.3.3	5
Humidity	4.2.4.3.5	6
Vibration	4.2.4.3.10	7
Explosive Atmosphere	4.2.4.3.9	8

TABLE V QUALIFICATION TESTS

TEST	PARAGRAPH NO.	PREFFERED ORDER OF TEST FOR SINGLE TEST ARTICLE *
Safety-of-flight	Table IV	1
Salt fog	4.2.4.3.4	2
Sand and dust	4.2.4.3.6	3
Verification of Finish Reqmts	4.2.4.3.14	4
Resistance to Fluids	4.2.4.3.15	5
Endurance	4.2.4.3.11	6
Reversibility test	4.2.4.2.3	7
Irreversibility/ limit load	4.2.4.2.4	8
Electrical duty cycle	4.2.4.2.5	9
Motor thermal protection	4.2.4.2.6	10
Mechanical stops impact	4.2.4.2.7	11
Maximum retract speed	4.2.4.2.8	12
Electric power transient testing	4.2.4.2.14	13
Electromagnetic radiation	4.2.4.3.13	14
Structural test (ultimate)	4.2.4.3.12	15
Fungus	4.2.4.3.7	16

*Order of testing and division of tests between separate environmental and endurance test articles subject to approval by LMTAS.

4.2.4.2 Functional tests. The actuator shall satisfy the following functional test requirements.

4.2.4.2.1 Operating time and repeatability. With loads per Figure 2 applied to the output arm, operate the actuator electrically through three complete cycles of opening and closing stroke at each of the following voltages: 16 VDC, and 20 VDC. Record operating time, actuator motor current, and the position of the output arm at the end of each opening and closing stroke. The actuator stroke shall be as shown on SCD 16VK056001. The variation in stroke angle shall not exceed ±0.5 degree. Operating time shall be in accordance with 3.2.1.3. Motor current shall be in accordance with 3.3.8.1.1.

4.2.4.2.2 Maximum stall torque. At approximately midstroke, operate the actuator electrically into a sudden stop in each direction. The maximum output torque at impact shall not exceed 11,000 in-lb.

4.2.4.2.3 Reversibility test. With nominal loads per Figure 2 applied and the actuator output arm in the fully closed position, operate the actuator in the open direction. At mid-stroke, instantaneously reverse the actuator direction and run into the fully closed position. Repeat 30 times. Repeat the test another 30 times with the actuator starting from the fully open position. Perform the tests of 4.2.4.2.1. There shall be no degradation of performance.

4.2.4.2.4 Irreversibility/limit load test. With the actuator at the full-open electrical limit position and deenergized, apply the limit opening load per Figure 4 to the output arm and maintain for 30 minutes. There shall be no rotation of the output arm during the test period and no distortion or permanent set of actuator components. The above test shall be repeated with the limit closing load per Figure 4. Perform the tests of 4.2.4.2.1. There shall be no degradation of performance.

4.2.4.2.5 Electrical duty cycle test. With nominal loads per Figure 2 applied to the output arm, operate the actuator continuously for one minute from the fully closed to the fully open position, reversing to fully closed, and reversing again as required. Wait three minutes and repeat the one minute operating cycle. Wait three minutes and repeat a third one minute operating cycle. The motor thermal protection device shall not function and no actuator damage or degradation of performance shall occur.

4.2.4.2.6 Motor thermal protection test. Thermal protection shall be verified by running the actuator into a mechanical stop at 28 VDC and maintaining power on the actuator until the thermal protection device functions. The time from shutdown until the actuator is again energized shall be monitored and shall not exceed 60 seconds. If thermal protection is reset by cycling the canopy control switch to "off", then the test shall be performed by recycling the canopy control switch 10 times in succession. Any evidence of smoke or toxic fumes during this test shall constitute a failure. Perform the tests of 4.2.4.2.1 after completion of the thermal protection test. There shall be no degradation in actuator performance.

4.2.4.2.7 Mechanical stops impact test. With the limit switches disabled and the actuator operating at 28 ± 0.5 VDC, the output arm shall be run into the down mechanical stop and the up mechanical stop with 250 applications in each direction and the motor shut off immediately after impact. An aiding moment of 1,300 in-lb shall be applied on the opening stroke, and no load shall be applied on the closing stroke. There shall be no jamming and no degradation in performance. For acceptance test the output arm shall be run into the mechanical stops five times in each direction with no load applied. There shall be no jamming and no degradation of performance.

4.2.4.2.8 Maximum retract speed with failed brake. Using the electric motor, move the actuator output arm to the fully open position. Deenergize the motor and disable the electromagnetic brake. Apply 85% of the closing limit load as shown in Figure 4. If the actuator backdrives, the time to travel 105 degrees in the closed direction shall not be less than four seconds. Repeat the test using the manual drive to move the actuator output arm to the open position.

4.2.4.2.9 Backlash. With the actuator mounted in a suitable fixture and the output arm in the canopy-closed position, apply ±100 in-lb torque to the output arm. Total relative motion shall not exceed 0.5 degrees for new units. Total relative motion shall not exceed 1.0 degree after one endurance life. After the second endurance life, no requirement is imposed.

4.2.4.2.10 Manual input slippage. With loads per Figure 2 applied to the output arm, operate the actuator electrically through one opening stroke and one closing stroke into the mechanical stops. Record the rotation angle of the manual input. Manual input travel shall not exceed six degrees.

4.2.4.2.11 Manual input running torque and clutch slip torque. Apply a closing load of 5,000 in-lb to the actuator output arm. Using a suitable adapter rotate the manual input shaft clockwise for opening stroke and measure the maximum opening running torque. Rotate the manual input shaft counterclockwise for closing stroke and measure the maximum closing running torque. Rotate the manual input shaft in the closed direction (CCW) until the down mechanical stop is contacted. Increase torque until the torque-limiting clutch slips, or to a maximum of 45 in-lb if no clutch is used. There shall be no damage to the actuator. The running torque shall not exceed 22 in-lb.

4.2.4.2.12 Manual input aiding load test. Apply the maximum closing load per Figure 2 to the actuator output arm. Rotate the manual input shaft several revolutions in the closing stroke direction (CCW) and release. The manual input drive shaft shall stop within one-quarter revolution.

4.2.4.2.13 Manual input antibackdriving test. With a 5,000 in-lb closing torque applied, rotate the manual input shaft in the opening direction (CW) gradually reducing the opening torque to zero. The input shaft shall not counterrotate (CCW) more than 45 degrees.

4.2.4.2.14 Electric power transient testing. All transient testing will be accomplished in the following manner. Normal steady-state voltage will be applied to the appropriate input; the voltage will then transition to the transient amplitude; remain at that amplitude for the specified duration; then transition back to the normal steady-state voltage. The maximum allowable transition time shall be 5.0 milliseconds.

4.2.4.2.14.1 Normal electric system operation. As a minimum, the actuator shall be tested to verify specified operation during and after application of the following normal electric system transients. This test does not relieve the vendor of the responsibility of the actuator having to operate anywhere within the DC normal transient curves 2 and 3 of Figure 9 in MIL-STD-704.

Amplitude (DC)	Duration
70 VDC	0.020 sec
60 VDC	0.040 sec
56 VDC	0.100 sec
44 VDC	0.006 sec
44 VDC	0.010 sec
44 VDC	0.030 sec

40 VDC	0.100 sec
22 VDC	0.500 sec
16 VDC	0.200 sec
14 VDC	0.070 sec
8 VDC	0.010 sec
8 VDC	0.020 sec
8 VDC	0.050 sec

4.2.4.2.14.2 Bus switching transients. The actuator shall be tested to verify that the equipment shall withstand the following bus switching transients without damage or loss of memory to the unit. The actuator does not have to provide specified performance during the transient, but must automatically resume operation after the transient.

Amplitude (DC)	Duration
6 VDC	0.050 sec
6 VDC	0.020 sec
6 VDC	0.010 sec
6 VDC	0.005 sec
4 VDC	0.050 sec
4 VDC	0.020 sec
4 VDC	0.010 sec
4 VDC	0.005 sec
0 VDC	0.050 sec
0 VDC	0.020 sec
0 VDC	0.010 sec
0 VDC	0.005 sec

4.2.4.2.14.3 Abnormal electric system operation. As a minimum, the actuator shall be tested to verify that the actuator automatically recovers after being subjected to the following transients. This test does not relieve the vendor of the responsibility of the actuator having to automatically recover after subjection to transients within the DC abnormal transient curves 1 and 4 of Figure 9 in MIL-STD-704.

Amplitude (DC)	Duration
80 VDC	0.050 sec
70 VDC	0.210 sec
50 VDC	0.900 sec
16 VDC	1.000 sec
10 VDC	0.500 sec
3 VDC	0.003 sec

3 VDC	0.200 sec
3 VDC	0.500 sec
0 VDC	0.003 sec
0 VDC	0.050 sec
0 VDC	0.200 sec
0 VDC	0.500 sec
0 VDC	7.000 sec

4.2.4.3 Environmental tests. A performance record shall be maintained for each environmental test. Before and after each environmental test the actuator shall meet the requirements of this specification when subjected to the following tests:

a. Examination of product - - - - See 4.2.4.1
b. Functional tests consisting of the following:

(1) Operating time and repeatability - - See 4.2.4.2.1
(2) Maximum stall torque - - - - - - - - See 4.2.4.2.2
(3) Mechanical stops impact test - - - - See 4.2.4.2.7
(4) Backlash - - - - - - - - - - - - - - - See 4.2.4.2.9
(5) Manual input slippage - - - - - - - See 4.2.4.2.10
(6) Manual input running torque - - - - See 4.2.4.2.11 and clutch slip torque
(7) Manual input aiding load test - - - See 4.2.4.2.12
(8) Manual input antibackdriving test - -See 4.2.4.2.13

In addition, the actuator shall meet the requirements of this specification during high and low temperature tests when subjected to a. and b. tests above and variation of electrical power in accordance with MIL-STD-704, Category B.

4.2.4.3.1 Altitude test. The actuator shall be tested in accordance with Method 500, Procedure II of MIL-STD-810, with the pressure during step 3 reduced to a pressure equivalent of 60,000 feet. Omit step 5 of procedure.

4.2.4.3.2 High temperature test. The actuator shall be tested in accordance with Method 501, Procedure I of MIL-STD-810, with the temperature in step 2 to be +203°F. In step 4, adjust temperature to +160°F.

4.2.4.3.3 Low temperature test. The actuator shall be tested in accordance with Method 502, Procedure I of MIL-STD-810, with temperature in step 2 to be -65°F and maintained for eight hours. In step 4, adjust temperature to -40°F.

4.2.4.3.4 Salt fog test. The actuator shall be tested in accordance with Method 509, Procedure I of MIL-STD-810 for 48 hours.

4.2.4.3.5 Humidity test. The actuator shall be tested in accordance with Method 507, Procedure I of MIL-STD-810.

4.2.4.3.6 Sand and dust test. The actuator shall be tested in accordance with Method 510, Procedure I of MIL-STD-810.

4.2.4.3.7 Fungus test. The actuator shall be tested in accordance with Method 508, Procedure I of MIL-STD-810. Certification that there are no fungus nutrient materials may be used in lieu of testing.

4.2.4.3.8 Acoustical noise test. No acoustical noise tests are required. The vibration tests of 4.2.4.3.10 will satisfy adequately quality assurance provisions for acoustical noise.

4.2.4.3.9 Explosive atmosphere (vapor-safe) test. The actuator shall be tested in accordance with Method 511, Procedure I of MIL-STD-810.

4.2.4.3.10 Vibration test. The actuator shall be tested in accordance with the requirements of 3.2.5.9. The vibration levels shall be applied sequentially along each of the three orthogonal axes of the actuator. The excitation shall be accomplished in two parts as follows:

a. The test time for the combined sine sweep and random excitation shall be one hour per axis. The sweep rate shall be as given in Method 514.1 of MIL-STD-810.

b. Six resonance dwells of five minutes each per axis as follows:

(1) One in each of the frequency bands corresponding to ±10 percent of the first four harmonics of the frequency. If no resonance is found in a frequency band, the dwell shall be at the center frequency of the band.

(2) Dwells in the frequency range from 440 to 1,000 Hz at the two most significant resonant frequencies.

The background random excitation is not required for the dwells.

4.2.4.3.11 Endurance test. The actuator shall be tested in accordance with the endurance life specified in 3.2.1.8. Before, during, and after this test, the actuator shall meet the requirements of this specification when subjected to the following tests:

a. Examination of product - - - - See 4.2.4.1
b. Functional tests - - - - - - - See 4.2.4.2

Endurance test shall be for two service lives of duty cycle loads, and for the fatigue damage equivalent of two service lives of wind gust/towing loads. The load spectrum for one service life is given in Table II. During full load, including low temperature operation, the actuator shall be tested to demonstrate compliance with the electrical voltage, frequency, and transient ranges of MIL-STD-704, Category B. The current, in-rush current, and watts shall be measured and recorded.

4.2.4.3.12 Structural test. The structural test shall consist of applying ultimate load to the output arm of the actuator. There shall be no failure of the actuator; however, no functional tests are required after ultimate load. Upon completion of the ultimate load test, the actuator shall be loaded in the closed direction until rupture occurs and that load recorded.

4.2.4.3.13 Electromagnetic radiation test. Test in accordance with MIL-STD-462 to verify requirements in 3.3.2.

4.2.4.3.14 Verification of finish requirements. Proof of compliance with FPS-3001 shall be accomplished by analysis of the materials and component finishes by LMTAS or neutral salt fog testing.

4.2.4.3.14.1 Verification by analysis. Materials and finishing systems may be approved by a design analysis by LMTAS. Drawings of sufficient detail to establish compliance with FPS-3001 showing material of construction, coatings, application techniques, dissimilar metals contact, etc. shall be presented by the vendor for verification and approval.

4.2.4.3.14.2 Verification by testing. Materials and finishing systems may be approved by exposure of the completed assembly to neutral salt fog testing per MIL-STD-810, Method 509, Procedure I for a period of not less than 500 hours. In addition to the failure criteria specified in paragraph 3.1.6 of MIL-STD-810, Method 509, any corrosion discoloration, change in characteristics, or

deterioration of the finish system shall be cause for rejection if determined to be significant by LMTAS. This verification requirement is in addition to the test requirement of 4.2.4.3.4.

4.2.4.3.15 Resistance to fluids. Resistance to fluids specified in 3.3.1.6 shall be verified by testing per the following procedure or by analysis of the component finishes by LMTAS. A test component or representative test coupon shall be immersed in each test fluid for a minimum of 24 hours at ambient temperature. Any degradation in performance or appearance, other than minor staining, is cause for rejection. If verification is by analysis, drawings of sufficient detail to establish compliance showing material of construction, coatings, application techniques, dissimilar metals contact, etc. shall be presented by the vendor for verification.

4.2.5 Reliability tests. Test data from the actuator qualification and development contract acceptance tests shall be utilized as fulfillment of the reliability test requirements. All failures during these tests shall be analyzed to determine failure cause, and corrective action shall be established and implemented to resolve all failures.

4.2.6 Maintainability demonstrations. Not applicable

5. PREPARATION FOR DELIVERY

Unless otherwise specified in the purchase order, preparation for delivery of the actuators for immediate use shall be in accordance with 16PP224 and the following:

5.1 Preservation and packaging. The actuators shall be preserved and packaged in accordance with the manufacturer's commercial practice to afford the minimum degree of protection necessary to prevent deterioration or damage during shipment under normal environmental conditions and commercial modes of transportation.

5.1.1 Protective covers. The actuators shall be shipped with protective covers on all open interfaces.

5.2 Intermediate packaging. The quantity of unit packages to be included in each intermediate package shall be at the option of the manufacturer and as governed by the limitations of the container being used.

5.3 Packing. Shipments that require overpacking for acceptance by the carrier shall be packed in exterior type shipping containers in a manner that will ensure safe transportation at the lowest rate to the point of delivery. Containers shall meet the requirements of the freight classification rules and regulations of the common carriers as applicable to the mode of transportation.

5.4 Marking. All containers shall be marked to indicate the purchase order number, part number, bill of lading number, case number, total number of pieces, and any special markings as required by carrier rules and regulations shall be applied.

5.5 Special handling, loading techniques, and devices. In the event special handling, loading techniques, and devices are required to protect the item during moving, storage, installation or removal, there shall be a suitable label or nameplate affixed to the item to delineate the necessary precautions.

6. NOTES

None.