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MILITARY SPECIFICATION

STEERING SYSTEM: AIRCRAFT, GENERAL REQUIREMENTS FOR

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 This specification covers the general requirements for aircraft steering systems.

2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on the date of invitation for bids or requests for proposal, form a part of this specification to the extent specified herein:

SPECIFICATIONS

Federal

QQ-C-320	Chromium Plating (Electrodeposited)
QQ-N-290	Nickel Plating (Electrodeposited)
QQ-P-416	Plating Cadmium (Electrodeposited)
QQ-Z-325	Zinc Coating, Electrodeposited, Requirements for

Military

MIL-D-1000	Drawings, Engineering and Associated Lists
MIL-S-4040	Solenoid, Electrical, General Specification for
MIL-W-5088	Wiring, Aircraft, Selection and Installation of
MIL-E-5400	Electronic Equipment, Airborne, General Specification for
MIL-H-5440	Hydraulic Systems, Aircraft, Types I and II, Design, Installation, and Data Requirements for
MIL-C-5503	Cylinders, Aeronautical, Hydraulic Actuating, General Requirements for
MIL-P-5518	Pneumatic Systems, Aircraft, Design, Installation, and Data Requirements for
MIL-V-5529	Valves, Hydraulic Directional Control
MIL-H-5606	Hydraulic Fluid, Petroleum Base, Aircraft, Missile and Ordnance

MIL-R-5757	Relays, Electrical (For Electronic and Communication Type Equipment), General Specification for
MIL-R-6106	Relays, Electric, Aerospace, General Specification for
MIL-P-8564	Pneumatic Systems Components, Aeronautical, General Specification for
MIL-A-8625	Anodic Coatings, for Aluminum and Aluminum Alloys
MIL-H-8775	Hydraulic System Components, Aircraft and Missiles, General Specification for
MIL-F-8785	Flying Qualities of Piloted Airplanes
MIL-A-8860	Airplane Strength and Rigidity, General Specification for
MIL-H-8890	Hydraulic Components, Type III (-65° to +450°F), General Specification for
MIL-H-8891	Hydraulic Systems, Manned Flight Vehicles, Type III, Design, Installation, and Data Requirements for
MIL-A-8892	Aircraft Strength and Rigidity, Vibration
MIL-T-10727	Tin Plating; Electrodeposited or Hot-Dipped, for Ferrous and Nonferrous Metals
MIL-V-27162	Valves, Servo Control, Electro-Hydraulic, General Specification for
MIL-C-38999	Connectors, Electrical, Circular, Miniature, High Density, Quick Disconnect, Environmental Resisting Removable Crimp Type Contacts, Reliability Assurance Program
MIL-W-81381	Wire, Electric, Polyimide-Insulated, Copper and Copper Alloy

STANDARDS

Military

MIL-STD-100	Engineering Drawing Practices
MIL-STD-129	Marking for Shipment and Storage
MIL-STD-130	Identification Marking of US Military Property
MIL-STD-143	Standards and Specifications, Order of Precedence for the Selection of
MIL-STD-203	Aircrew Station Controls and Displays: Assignment, Location and Actuation of, for Fixed Wing Aircraft
MIL-STD-461	Electromagnetic Interference Characteristics Requirements for Equipment
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of
MIL-STD-704	Electric Power, Aircraft, Characteristics and Utilization of
MIL-STD-794	Parts and Equipment, Procedures for Packaging and Packing of
MIL-STD-810	Environmental Test Methods
MIL-STD-831	Test Reports, Preparation of
MIL-STD-882	System Safety Program for Systems and Associated Subsystems and Equipment - Requirements for
MIL-STD-889	Dissimilar Metals
MIL-STD-1523	AGE Control of Age - Sensitive Elastomeric Materiel

(Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

3. REQUIREMENTS

3.1 Preproduction testing. This specification makes provisions for preproduction testing. The preproduction testing defined herein is the minimum testing requirement. Final design approval will be contingent upon successful completion of these tests and the tests specified in the detail specification including satisfactory demonstration on the intended aircraft.

3.1.1 Safety of flight. Safety of flight is the minimum level of successful testing required before release for first flight as specified in 4.3.2.

3.2 Selection of specifications and standards. Specifications and standards for necessary commodities and services not specified herein shall be selected in accordance with MIL-STD-143.

3.3 Materials. Materials used in the steering system components shall be of high quality, suitable for the purpose intended, and shall conform to applicable Government specifications.

3.3.1 Dissimilar metals. The use of dissimilar metals in contact, as defined in MIL-STD-889, shall be avoided. Where complete compliance proves impractical electrolytic action shall be minimized by plating or some other suitable method of dissimilar surface isolation.

3.3.2 Corrosion resistance. Corrosion prevention shall be provided by proper material selection and treatment. Protective treatment for hydraulic components shall be in accordance with MIL-H-8775.

3.4 Design and construction. Detail design and construction of the components and steering systems shall conform to the contractor prepared detail specification and the requirements specified herein. The components shall be suitably sealed against dust, dirt, and moisture to insure satisfactory operation in the aircraft environment. Where possible the external component parts shall be shaped to prevent water entrapment with gear extended. The useful life shall be specified in the detail specification and shall be equal to the aircraft design life. The type of system as defined in 6.3.1 and 6.3.2 shall be compatible with the configuration of the aircraft and shall be defined in the detailed specification.

3.4.1 Interface requirements. The steering system shall be designed to meet the interface requirements of the applicable aircraft including the following:

a. Aircraft directional control response characteristics

b. Aircraft hydraulic and mechanical installation

c. Dynamic characteristics including the tire(s), wheel(s), shock strut, and supporting structure

d. Dimensional and envelope interface

e. Aircraft operational environment.

3.4.2 System design requirements

3.4.2.1 Torque. The steering system shall be designed with sufficient output torque consistent with the aircraft ground maneuvering requirements and to permit turning the steered wheels through the full range without the aid of motion of the aircraft or engine thrust or auxiliary power. Unless a rational alternative is approved by the procuring activity, the steering capability shall be available throughout the design temperature range of the aircraft, and with the most critical combination of weight and center of gravity at engine idle thrust and a design coefficient of friction of 0.80 at the tire ground interface. The tires shall be inflated in accordance with applicable servicing instructions, and all brakes may be assumed to be released unless normal engine idle thrust is sufficiently high to cause motion.

3.4.2.2 Rate and ratio. The steering system shall provide a steering rate and ratio of steered wheel angle to control input displacement which will provide smooth handling at landing and takeoff speeds and minimize pilot induced oscillation. The system shall also give sufficient response at taxiing speeds to permit the necessary rate for small radius turns, parking, catapult spotting, and close quarters operation. The suitability of the selected steering rate and ratio shall be demonstrated by early taxi tests and results submitted to the procuring activity.

3.4.2.3 Powered steering angle. Unless otherwise approved by the procuring activity, all aircraft which require Class A steering systems (defined in 6.3.1) shall have full time steering authority designed to obtain the maximum tire cornering angle, with a pilot selected wide authority mode available to the authority limits as specified in 3.4.2.3.1 or 3.4.2.3.2 as applicable. This requirement is intended to provide more consistent aircraft directional control and to better utilize the available tire cornering forces. The maximum tire cornering angle shall be based upon the best available tire cornering data and shall be approved by the procuring activity.

3.4.2.3.1 Carrier based aircraft. Carrier based aircraft with nose wheel steering shall meet the powered steering angles as shown on figure 1.

3.4.2.3.2 Land based aircraft. Land based aircraft shall provide powered steering angles sufficient to enable a 180 degree turn on a runway width as defined in the aircraft detail specification.

3.4.2.4 Free swivel range. Provisions shall be incorporated on all land based aircraft to permit free swiveling to the limits of figure 1 consistent with the aircraft geometry. All carrier based aircraft shall be designed to permit 360° free swiveling. Any free swiveling range shall not require manual disconnect of any parts or linkages unless otherwise directed by the procuring activity. An automatic disconnect is permitted to turn the wheel beyond the power steering range however automatic re-engaging provisions shall be provided as the wheel re-enters the powered steering range.

3.4.2.5 Steered wheel centering. The steering system or the landing gear configuration shall provide wheel(s) centering before retraction. The following nose wheel centering features shall be provided for carrier-type nose wheel steering aircraft:

a. The nose wheel shall be steerable during the runout of an arrested landing.

b. The nose wheel shall remain centered unless commanded otherwise by the pilot during the roll back due to cable tension after arrestment.

Actuation of steering shall be possible regardless of arresting with position to enable steering during a field arrestment.

3.4.2.6 Input force limits. The control forces shall be in accordance with MIL-F-8785.

3.4.2.7 Dynamic stability and damping provisions. The steering system shall provide dynamic and damping stability to the nose landing gear for all ground speeds from zero to 1.3 V_{S1} (takeoff or landing configuration, whichever is greater) in accordance with MIL-A-8860. This shall be verified by analysis and test for all speed and vertical loading combinations of the nose landing gear, for the cases of steering power ON and with steering power failed or OFF, and for the extremes of the manufacturing tolerances for those parameters defined in the detail specification. The system shimmy stability requirements shall be determined by a non-linear dynamic analysis properly accounting for deadband, friction, wheel unbalance, and realistic damping characteristics. Excitation of the shimmy conditions shall include impulse, cyclic and initial displacements of the nose landing gear. The steering system shall provide sufficient damping to reduce the shimmy oscillation amplitude after three cycles to 1/4 or less of the original disturbance. If limit cycle is encountered,

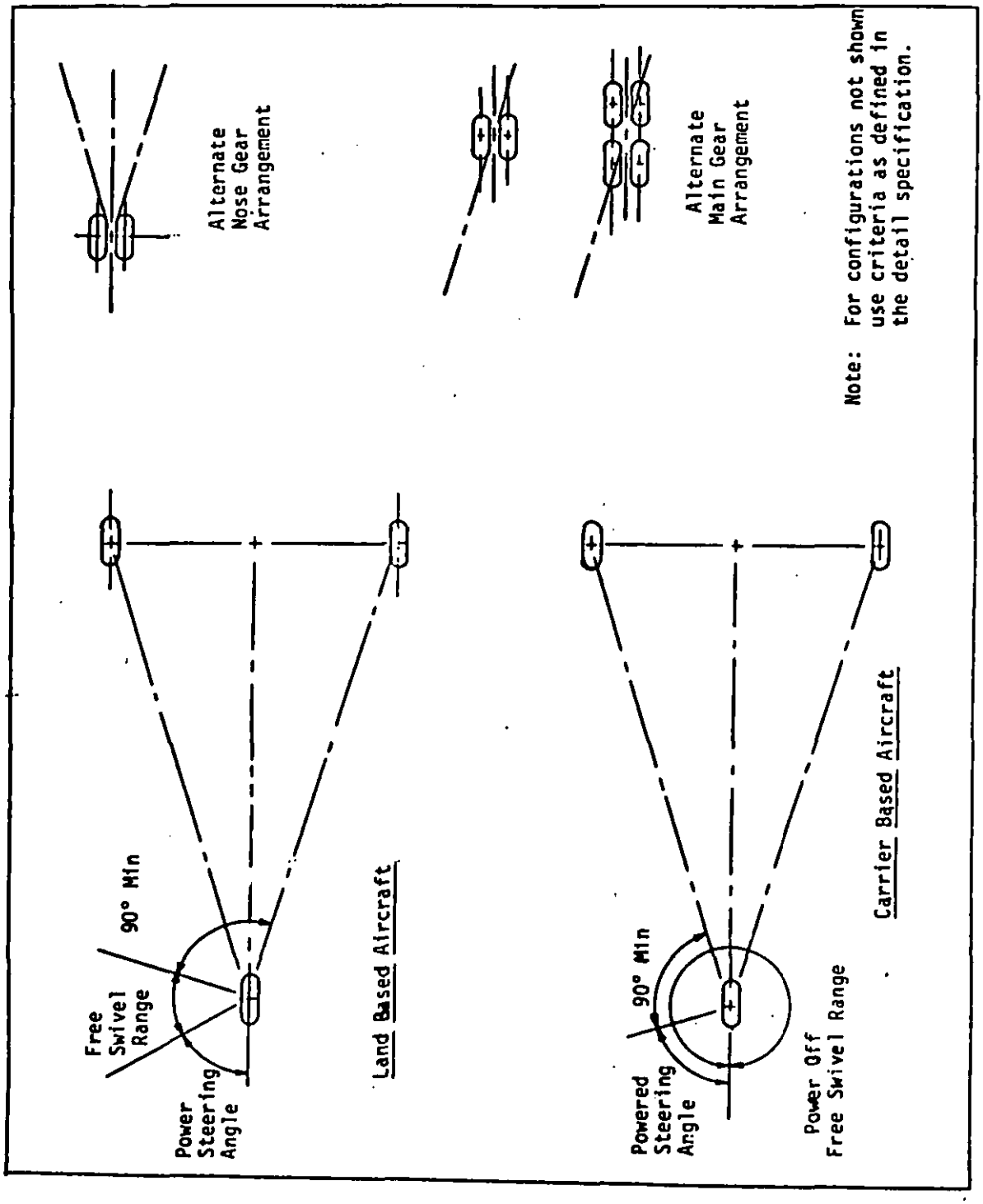

FIGURE 1. Powered Steering Angle - Free Swivel Range

the maximum amplitude is subject to approval by the procuring activity. The design component parameters used for the shimmy analysis shall be verified by demonstration laboratory tests. The system parameters used in the shimmy analysis shall be verified by ground vibration test on the aircraft in accordance with MIL-A-8892, prior to first flight. In the event the physical characteristics on the aircraft are different from those used in the shimmy analysis, the analysis shall be repeated for the corrected values. The analysis shall be continued to include freedom due to wear, with all surfaces worn to the maximum permissible amount and with the most adverse servicing of tires and shock absorbers permitted by aircraft technical publications. For these conditions the shimmy motion shall decay after three cycles to 1/3 or less of the original disturbance after the excitation cited above. For USAF aircraft, these damping requirements apply to the nose landing gear and to the main gear design criteria.

3.4.2.8 Cockpit controls. Cockpit controls including provisions for commanding the steered wheel position and a means for engaging or disengaging the steering system, if applicable, shall be provided in accordance with MIL-STD-203 as amended by this specification.

3.4.2.8.1 Cockpit controls - Class A control steering systems. Aircraft equipped with Class A control steering systems shall command the limited authority mode by rudder pedal position. The wide authority mode shall be commanded by a steering wheel on transport aircraft and with the rudder pedals on fighter/attack/carrier based aircraft with suitable switching arrangement and cockpit engagement status light subject to procuring activity approval. Provisions shall be made to rapidly disengage the Class A control steering system.

3.4.2.8.2 Cockpit controls - Class B control steering systems. Aircraft equipped with Class B control steering systems shall utilize the rudder pedal to command the steered wheel position and shall be engaged at the option of the pilot. On all stick controlled aircraft, a (press to engage, press to disengage, engage when depressed) switch shall be provided and shall have a steering engaged status light.

3.4.2.9 Steering control system. The steering system shall maintain the steered wheel at the commanded position or tire cornering force level as applicable for the system servo concept selected (defined in 6.3.3). A mechanical input and follow-up control linkage is preferred. Single channel electrical and electronic control systems shall not be used for steering systems (defined in 6.3.1).

3.4.2.10 Failure mode and malfunction effects. The system design failure mode, i.e. (fail operative, fail safe - inoperative), shall be compatible with aircraft requirement and as approved by the procuring activity. No single failure shall result in undesirable steering effects that cannot be overcome by normal and natural application of the steering cockpit controls. The system design failure

mode shall not require pilot interpretation and action to disengage the system upon failure. A malfunction of the steering control system shall not interfere with the required motion of the rudder pedals, flight controls or prevent shimmy stability. The steering system shall be so designed that steering system malfunction, such as a failed hydraulically open selector valve cannot result in turning the wheel(s) when off the ground or the gear is extended or retracted.

3.4.2.11 Emergency steering. An emergency steering system hydraulic power supply separate from the brake accumulator shall be provided, unless analysis indicates that the aircraft is adequately controllable in the event the normal steering system power supply is lost. Demonstration during contractor's flight test program shall consist of aircraft satisfactory handling performance with normal power lost.

3.4.2.12 Electromagnetic interference (EMI) compatibility. The performance of the steering system shall not be affected by EMI and shall comply with the requirements of MIL-STD-461 or as specified by the procuring activity.

3.4.3 Reliability. Quantitative reliability requirements shall be established for the steering system and its components consistent with the total aircraft system requirements. The reliability program shall be in accordance with the requirements of the applicable detail specification.

3.4.4 Maintainability. Quantitative maintainability requirements shall be established for the steering system and its components consistent with the total aircraft system requirements. The maintainability program shall be in accordance with the requirements of the applicable detail specification. The requirements shall apply to maintenance in the planned maintenance and support environment. Factors to be considered shall include time, rate, and costs of system and component maintenance.

3.4.4.1 Maintenance tools and equipment. The design shall be such as to accommodate, to the greatest extent, disassembly, reassembly, and service maintenance by use of tools and items of maintenance equipment normally available as commercial standard. Design requiring specially design maintenance tools and equipment shall be kept to a minimum.

3.4.4.2 Special support equipment. Special support equipment, if required, shall be designed in accordance with the requirements for the aircraft system and shall include flight-line fault isolation capability of line-replaceable items without breaking aircraft-wiring connections for electrical/electronic systems.

3.4.4.3 Lubrication. Lubrication shall be in accordance with normal maintenance practice.

3.4.5 Transportability. Any special transportability requirements shall be identified in the detail specification.

3.4.6 Safety. Safety requirements shall be established in accordance with MIL-STD-882 and shall be consistent with the total System Safety program.

3.4.7 Physical characteristics

3.4.7.1 Weight limits. The production weight limits of the steering system shall be specified in the detail component specification.

3.4.7.2 Dimensional envelope. The dimensional envelope with critical dimensional limitations shall be specified in the detail specification.

3.4.7.3 Strength. The structural strength of all steering components shall be such that, when installed, operation will not be impaired, and no part of the device or its mounting shall show evidence of permanent deformation or failure under the maximum imposed mechanical operating loads, accelerations, or wrench torque loads required for making connections.

3.4.8 Electrical-electronic requirements

3.4.8.1 Electronic components. All electronic assemblies shall be designed in accordance with MIL-E-5400. Special attention shall be given to the following: moisture-proofing of assemblies, including connectors; reducing susceptibility to moisture contamination; providing system component and tolerance compatibility throughout the extremes of the aircraft temperature environment and maintenance requirements; and tolerance to the electromagnetic interference environment.

3.4.8.2 Electric power requirements. When designed for electrical operation, the steering system shall conform to all applicable requirements for MIL-STD-704 and shall give specified performance from the power source configuration specified in the detail specification.

3.4.8.3 Relays. Relays when used in the steering system shall conform to the applicable requirements of MIL-R-6106 and MIL-R-5757.

3.4.8.4 Wiring. External wiring shall be installed in accordance with MIL-W-5088 and shall be of the type specified in MIL-W-81381. Internal wiring shall be compatible with accepted industry standards and the configuration.

3.4.8.5 Connectors. Component external connectors shall be in accordance with MIL-C-38999, threaded type with lock wire.

3.4.9 Hydraulic and pneumatic components

3.4.9.1 Hydraulic equipment-general. The steering system hydraulic components shall conform to the design requirements of MIL-H-8775 or MIL-H-8890 and MIL-H-5440 or MIL-H-8891 as applicable. Hydraulic cylinders shall conform to the requirements of MIL-C-5503.

3.4.9.2 Solenoid-operated control valves. Solenoid-operated control valves shall conform to the applicable requirements of MIL-V-5529. Design of the solenoid shall conform to the applicable requirements of MIL-S-4040, with the exception that solenoids employing multiple windings will be permitted.

3.4.9.3 Electro-hydraulic modulating valves. Electro-hydraulic modulating valves shall be designed in accordance with the applicable requirements of MIL-V-27162 and shall be suitable for the steering system environment with special emphasis upon contamination tolerance, stability with life and temperature, tolerance to service handling, and moisture sealing. Primary control steering systems using electro-hydraulic servo valves shall incorporate dual valves as a minimum. Hermetical connections in all exposed locations shall be required.

3.4.9.4 Pneumatic equipment. Pneumatic components shall conform to the applicable requirements of MIL-P-5518 and MIL-P-8564.

3.4.9.5 Hydraulic fluid. The steering system shall operate with MIL-H-5606 hydraulic fluid unless otherwise defined.

3.5 Performance

3.5.1 The steering system in conjunction with the aircraft brake and rudder systems shall provide, within the limits of the aircraft environment, a means of safely controlling the aircraft on the required runway length, width, surface and crosswind condition. The system performance shall apply to all landing surfaces and crosswind condition on which the aircraft is designed to operate. The steering system stable operating range shall be all ground velocities as specified in 3.4.2.7.

3.5.2 Service life and endurance. The steering system shall be designed to operate the design life of the aircraft. To demonstrate the system life, testing will be performed as specified in 4.5.3 or as approved by the procuring activity. Alternate or substitute cycling schedules may be submitted to the procuring activity for approval.

3.5.3 Environment. The equipment operational environment shall be as defined herein unless otherwise specified in the detail specification.

3.5.3.1 Operating temperatures. The components shall satisfactorily withstand operation at temperatures from -54° to +71°C (-65° to +160°F). Requirements for individual components which may be subjected to higher temperatures shall be specified in the detail specification.

3.5.3.2 Salt fog. The steering system shall operate satisfactorily when conditions are imposed which simulate the environment of sea coast regions as specified in 4.5.2.10.

3.5.3.3 Humidity. The steering system shall function satisfactorily in an environment of relative humidity up to 100 percent, including conditions in which condensation occurs in the form of water or frost.

3.5.3.4 Pressure. The steering system shall operate satisfactorily when subjected to pressure variations associated with altitude ranging from 1,300 feet below sea level to the maximum operational altitude of the aircraft.

3.5.3.5 Dust. The steering system shall operate satisfactorily under conditions consisting of blowing sand and dust particles as encountered in desert areas.

3.5.3.6 Explosive atmosphere. The steering system equipment shall not cause ignition of an explosive atmosphere when operated in such an atmosphere.

3.5.3.7 Acceleration. The steering system shall function properly when exposed to translational accelerations consistent with that encountered on the aircraft.

3.5.3.8 Acoustical noise. The steering system shall function properly when exposed to the acoustical environment encountered in the region on the aircraft where the hardware is mounted.

3.5.3.9 Vibration. The steering system shall function properly when exposed to vibration in addition to the acoustical noise which realistically will be encountered on the aircraft.

3.5.3.10 Shock. The steering system shall withstand any shock loading expected in operation, handling, or transportation. Unless otherwise determined, the components fastened rigidly to the landing gear shall be subjected to 50g's acceleration in all directions while operating.

3.5.3.11 Fungus. The steering system shall perform satisfactorily when exposed to fungus conditions as encountered in tropical climates.

3.6 Interchangeability. All parts having the same manufacturer's part number shall be directly and completely interchangeable with each other with respect to installation and performance. Changes in the manufacturer's part numbers shall be governed by the drawing number requirements of MIL-STD-100 or as otherwise specified.

3.7 Documentation. The following documentation of the steering system is required. Data preparation and delivery shall be in accordance with the contractual data submittal requirements.

3.7.1 Detail specification. A detail specification of the steering system shall be prepared to expand the requirements contained herein, to define specific performance and operating environments, and to provide any other specific requirements.

3.7.2 Preproduction test procedure. A document shall be prepared to fully define testing conditions, test equipment, and test procedures for component preproduction tests.

3.7.3 Performance analysis. The contractor shall provide an analysis of aircraft steering system performance under various aircraft-wind-runway-surface conditions. The method for analysis must be approved by the procuring activity. The initial analysis shall be prepared prior to flight test of the first unit. The final verification shall be during flight test evaluation of the system on the aircraft.

3.7.4 System failure mode effects analysis. The contractor shall provide an analysis to determine the effects of various system components failures and shall submit it prior to first flight. All single failure modes shall be considered.

3.7.4.1 System hazard analysis. Utilizing the system failure mode and effect analysis of 3.7.4 above, a hazard analysis in compliance with the system safety requirements shall be conducted.

3.7.5 Preproduction test report. A report shall be prepared as specified in 4.3.3.

3.8 Finishes and protection treatments

3.8.1 Aluminum alloy. Aluminum alloy external surfaces shall be anodized in accordance with MIL-A-8625, type II. Alternate protection treatments may be used if approved by the procuring activity and dictated by performance requirements.

3.8.2 Steel. Steel shall be of stainless composition or shall be cadmium plated in accordance with QQ-P-416, type II, class 1, or zinc plated in accordance with QQ-Z-325, type II, class 2. Tin plating in accordance with MIL-T-10727 or nickel plating in accordance with QQ-N-290 may be used in lieu of the above cadmium or zinc plating whenever galvanic corrosion is not introduced with metal contact. All chromium plating used on piston rods or sliding surfaces shall be in accordance with Type II of QQ-C-320. Alternate protective treatments may be used if approved by the procuring activity and dictated by performance requirements. Steel heat treated to strength levels higher than 180,000 psi shall be cadmium plated in accordance with MIL-STD-870, type II, class I: chromium plated in accordance with MIL-STD-1501, type II: or nickel plated in accordance with MIL-STD-868.

3.9 Identification of product. Equipment, assemblies, and parts shall be marked for identification in accordance with MIL-STD-130.

3.10 Workmanship. The steering system components shall be uniform in quality and free from irregularities, defects, or foreign matter which could adversely affect safety, performance, or durability.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the supplier may use his own or any other facilities suitable for performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Classification of inspections. The inspection of steering systems shall be classified as follows:

a. Preproduction tests (see 4.3)

b. Quality conformance test (see 4.4).

4.3 Preproduction tests. Preproduction tests shall consist of all the tests specified under 4.5.

4.3.1 Preproduction samples and tests. Unless otherwise approved by the procuring activity, the steering system tests shall be distributed as follows:

a. Test system No. 1:

(1) Examination of product
(2) Immersion altitude cycling
(3) Dust
(4) High and low temperature
(5) Endurance
(6) Vibration

b. Test system No. 2:

(1) Examination of product
(2) Immersion altitude cycling
(3) Internal leakage (hydraulic components)
(4) External leakage (hydraulic components)

(5) Pressure drop (hydraulic components)
(6) Proof pressure (hydraulic components)
(7) Electromagnetic interference
(8) Humidity
(9) Mechanical shock
(10) Temperature shock cycling
(11) Explosive atmosphere
(12) Acoustical noise
(13) Fungus
(14) Salt fog
(15) Acceleration
(16) Burst pressure.

c. Test system No. 3:

(1) Shimmy damping/control stability.

4.3.2 Safety of flight. Prior to release for first flight, the following minimum amount of preproduction testing shall be successfully completed on the steering system to establish an adequate level of safety.

a. Test system No. 1:

(1) Examination of product
(2) High and low temperature
(3) 25 percent of endurance tests
(4) Vibration

b. Test system No. 2:

(1) Examination of product
(2) Immersion altitude cycling
(3) Internal leakage
(4) External leakage
(5) Proof pressure
(6) Humidity
(7) Mechanical shock
(8) Explosive atmosphere.

c. Test system No. 3:

(1) Dynamic stability and damping.

4.3.3 Preproduction test report. A test report covering the results of the tests in 4.3.1 shall be prepared in accordance with MIL-STD-831.

4.4 Quality conformance tests. Quality conformance tests shall consist of the individual tests.

4.4.1 Individual tests. Each steering system component shall be subjected to the examination of product (4.5.1) and to component performance test as specified in the detail specification.

4.5 Test methods

4.5.1 Examination of product. Each complete steering system component shall be examined to determine compliance with the requirements of this specification and the detail specification with respect to materials, workmanship, dimensions, weight, and markings. Quality conformance inspection covering hydraulic components shall be in accordance with the quality conformance inspections specified in MIL-H-8775.

4.5.2 Environmental tests. Unless otherwise approved by the procuring activity, the steering system, components, including aircraft wiring and connectors, shall be operated and performance suitably monitored during all phases of the environmental tests without disturbing the installed connectors or the environment. The components shall operate satisfactorily under the conditions specified in the following tests. Unless otherwise specified, tests shall be performed at an ambient temperature of 25° ±10°C (77° ±18°F) and an ambient barometric pressure of 28 to 32 inches of mercury. When tests are performed at different ambient conditions, appropriate correction factors shall be applied to the flow and pressure readings.

4.5.2.1 High and low temperature. The steering system components shall be subjected to high and low temperature tests in accordance with MIL-STD-810, procedure I of Methods 501.1 and 502.1, respectively, except for components that are subjected to higher temperatures as specified in the detail specification.

4.5.2.2 Temperature shock cycling. The steering system components shall be subjected to 25 cycles of temperature shock in accordance with MIL-STD-810, Method 503.1, procedure I between the temperature limits of -54° to +71°C (-65° to +160°F) and at a rate of 100° per minute ambient temperature change or to the temperature environment specified in the detail specification. After the test, the components shall perform satisfactorily at room ambient temperature while warming up from -54°C (-65°F) to room ambient.

4.5.2.3 Mechanical shock. The steering system components shall be subjected to a mechanical shock test in accordance with MIL-STD-810, Method 516.2, procedures I and II.

4.5.2.4 Acoustical noise. The steering system components shall be subjected to an acoustical noise test in accordance with MIL-STD-810, Method 515.2, with test category as applicable to the installation on the aircraft.

4.5.2.5 Vibration. Unless otherwise specified in the detail specification, the steering system components shall be subjected to a vibration test in accordance with MIL-STD-810, Method 514.2 and as specified herein. Mounting (mechanical, electrical, and hydraulic) shall simulate aircraft installation. This test shall follow the successful completion of the safety of flight portion of the endurance test.

Note: An investigation shall be made to determine the magnitude of amplitudes, frequencies, and accelerations to which these units will be subjected. In cases where these values are higher than those specified herein, the higher values shall be used and specified in the detail specification.

4.5.2.6 Immersion altitude cycling. All gaskets, O-rings, or hermetically sealed components including appropriate aircraft wiring sections, connectors, hydraulic fittings, and tubing sections located in unsheltered or unpressurized areas shall be subjected to immersion in a 20 percent by volume salt water solution with the water evacuated to 70,000 feet pressure for 10 minutes and then reduced to ambient pressure at 100°F and 90 percent relative humidity. This procedure shall be repeated 10 times. The components shall perform satisfactorily subsequent to this test and may be weighed to prove no water has penetrated. The components shall be disassembled following completion of the component tests and checked for signs of mositure penetration and internal corrosion.

4.5.2.7 Humidity. All components, except those hermetically sealed, shall be subjected to a humidity test in accordance with MIL-STD-810, Method 507.1, procedure I, except those hermetically sealed.

4.5.2.8 Fungus. All components shall be subjected to a fungus test in accordance with MIL-STD-810, Method 508.1, procedure I unless documentation is provided which proves no fungus nutrients are used in the design.

4.5.2.9 Dust. All components not located in sheltered compartments as defined in the design specification shall be subjected to dust tests in accordance with MIL-STD-810, Method 510.1, procedure I and as specified herein. The unit shall be functionally checked after completion of the test.

4.5.2.10 Salt fog. The components with aircraft connectors installed shall be subjected to a salt fog test in accordance with MIL-STD-810, Method 509.1, procedure I. The component performance shall be checked in the salt fog environment for a minimum of 30 days with no corrosion or contamination permitted.

4.5.2.11 Explosive atmosphere. All components with unsealed contacts shall be subjected to an explosive atmosphere test in accordance with MIL-STD-810, Method 511.1, procedure I.

4.5.2.12 Acceleration. All components fastened rigidly to the landing gear structure shall be subjected to the translational accelerations specified in 3.5.3.7.

4.5.3 Endurance. The steering system, installed in the simulated hydraulic and electrical network, shall be subjected to the following tests. The entire system shall be mounted in a manner to simulate the actual loads and pressures experienced on the aircraft. The gear, if not available, may be suitably simulated, actuating controls and hydraulic system may be simulated. One preproduction sample of the aircraft steering system shall be subjected to complete cycling schedule as defined. The test apparatus shall duplicate loads that occur when the steering system is installed in the aircraft.

4.5.3.1 Cycling schedule. The following cycling shall be conducted on the total system to give a total of 100,000 cycles:

a. Full steering angle - Full load, 2,500 cycles
b. 50 percent steering angle - 50 percent rated load, 7,500 cycles
c. 10 degrees steering angle each side of the centerline - 25 percent rated load, 15,000 cycles.

The above schedule will be repeated four times. Hydraulically actuated systems shall be subjected to 5,000 ON-OFF cycles of full system pressure during each of the four phases of the endurance test. If the system incorporates a pressure selector valve, these cycles shall be actuated by the aircraft system valve.

The external leakage through glands shall not exceed one drop over 25 cycles of actuation, and there shall be no failure during this test. One change of seals may be made during the endurance test. Adjustment and lubrication may be made as needed. Accurate records shall be kept of the seal change, lubrication, and adjustments to facilitate outlining maintenance procedures.

4.5.3.2 Internal stop cycling. Systems configured with mechanical stops, either internal or external to the hydraulic actuator cylinder shall be subjected to a suitable number of impact loads in each direction as defined in the detail specification and approved by the procuring activity.

4.5.3.3 Relief load cycling. Systems incorporating a hydraulic relief valve(s) or equivalent, that limits torque loads during towing operation, shall be subjected to a suitable number of cycles that duplicate the towing condition as defined in the detailed specification and approved by the procuring activity.

4.5.3.4 Design steering rate and torque. Utilizing the simulated test rig from the endurance test, demonstrate the design steering rate and output torque under maximum aircraft loading.

4.5.4 Electromagnetic interference (EMI). EMI tests in accordance with MIL-STD-462 as applicable, shall be performed on the steering system installed in a simulated aircraft network.

4.5.5 Hydraulic tests. The test fluids and level of filtration specified in MIL-H-8775 shall apply for the following tests.

4.5.5.1 Proof pressure. The hydraulic components shall be subjected to proof pressure tests in accordance with MIL-H-8775.

4.5.5.2 External leakage. The hydraulic components shall be subjected to external leakage tests in accordance with MIL-H-8775.

4.5.5.3 Internal leakage. The hydraulic components shall be subjected to internal leakage tests in accordance with MIL-H-8775 paragraph entitled, Qualification of Production Tests.

4.5.5.4 Pressure drop. A pressure drop evaluation shall be conducted on hydraulic components in accordance with MIL-H-8775.

4.5.5.5 Burst pressure. The hydraulic components shall be subjected to burst pressure tests in accordance with MIL-H-8775.

4.5.6 Extreme tolerance analysis. The units used for preproduction component tests shall be physically measured and the performance determined. These measurements shall be compared with the proposed production tolerances. Based on performance of hydraulic leakage and electrical output exhibited during the component tests, the performance at the extremes shall be analytically determined. Performance at the extremes shall be within the limits identified in the detail specification.

4.5.7 Stability proof test. The steering shimmy damper system shall be subjected to dynamic testing to verify the analysis of 3.4.2.7 and to demonstrate system dynamic stability throughout the take-off and landing speeds range. The test shall be performed using appropriate landing gear assembly and damping system components designed to be used on the aircraft. The test procedure and schedule shall be approved by the procuring activity. Dynamometer simulation may be employed at the option of the airframe manufacturer or as required by the detail specification to more accurately determine system aircraft compatibility and system performance.

4.5.8 Flight tests. The steering system shall demonstrate aircraft compatibility by suitable flight testing.

5. PREPARATION FOR DELIVERY

5.1 Preservation, packing, and packaging. Components of the system shall be preserved, packaged, and packed in accordance with the appropriate level of MIL-STD-794. The level or levels required shall be specified in the detail specification.

5.2 Marking. All unit, intermediate and shipping containers shall be marked in accordance with MIL-STD-129. Marking of all containers shall include the date of manufacture and case date in accordance with MIL-STD-1523.

6. NOTES

6.1 Intended use. The steering system covered by this specification are the mechanisms used for directional control of aircraft during ground maneuvers.

6.2 Ordering data. Procurement documents should specify:

a. Title, number, and data of this specification

b. Where the preproduction testing is to be accomplished

c. Items of data to be furnished to the procuring activity (see 6.2.1).

6.2.1 Data. For the information of contractors and contracting officers, any of the data specified in (a) 6.2.2, 6.2.3, and 6.2.4, (b) applicable documents listed in section 2 of this specification, or (c) referenced lower-tier documents need not be prepared for the Government and shall not be furnished to the Government, unless specified in the contract or order. The data to be furnished shall be listed on DD Form 1423 (Contractor Data Requirements List), which shall be attached to and made a part of the contract or order.

6.2.2 Preproduction data. If preproduction samples are submitted to the procuring activity after test completion as defined in the detail specification, they should be accompanied by one complete set of manufacturer's drawings, the contractor's model specification, a parts list, and a complete test report showing the results of the contractor's tests.

6.2.3 Drawings and data list. Drawing, engineering and associated lists of the test equipment shall be in accordance with MIL-D-1000.

6.2.4 Verification data. A report shall be submitted verifying that components have met the design, test, calibration, and performance requirements of MIL-H-8775 and this specification.

6.3 Definitions

6.3.1 Class A steering system. A Class A steering system is one which is normally used and required for all low and high speed maneuvers such as landing, take-off, taxi and emergency situations such as control with blown tire(s) and is automatically powered when the aircraft is suitably loaded on the ground or is engaged at the option of the pilot with a press to engage, press to disengage switch as approved by the procuring activity.

6.3.2 Class B steering system. A Class B system is one which is used for taxi-parking-catapult spotting and is not required or used for landing or take-off operations and is engaged at the option of the pilot.

6.3.3 Servo control system concepts

6.3.3.1 Position command control system. A position command control system, controls the steered wheel to the position commanded by the pilot and is the type of control system currently used.

6.3.3.2 Cornering command control system. A cornering command control system controls the steered wheel to provide the tire cornering force requested by the pilot to the limit of the available tire-runway friction.

6.3.4 Limited authority mode. The limited authority mode is that mode of a steering system with a reduced steering authority angle to provide improved control by better utilization of the tire cornering characteristics during high speed operation.

6.3.5 Wide authority mode. The wide authority mode is that mode of a steering system with steering authority angles required for taxi, parking, or catapult spotting and is selected at the option of the pilot.

6.3.6 Powered steering angle. The powered steering angle (or steering authority) is the number of degrees the steered wheel is displaced right of left of the aircraft centerline while powered by the steering control system.

6.3.7 Cycle. A cycle is that movement from the center position to one extreme position returning past the center position to the opposite extreme, then returning to the center position.

6.3.8 Rated load. The rated load shall be the torque required in 3.4.2.1.

6.4 Asterisks are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

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Army - AV
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