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MILITARY SPECIFICATION

BRAKE CONTROL SYSTEMS, ANTISKID, AIRCRAFT WHEELS, GENERAL SPECIFICATION FOR

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

1. SCOPE

1.1 This specification covers the general requirements for aircraft antiskid brake control systems and their components.

2. APPLICABLE DOCUMENTS

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

SPECIFICATIONS

Federal

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

Military

MIL-S-4040	Solenoid, Electrical, General Specification for
MIL-W-5013	Wheel and Brake Assemblies; Aircraft
MIL-W-5088	Wiring, Aircraft, 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-P-5518	Pneumatic Systems, Aircraft; Design, Installation, and Data Requirements for
MIL-V-5529	Valves, Hydraulic Directional Control
MIL-R-5757	Relays, Electrical (For Electronic and Communication Type Equipment), General Specification for

FSC 1630

MIL-R-6106	Relays, Electric, Aerospace, General Specification for
MIL-V-7915	Valves; Hydraulic, Directional Control, Slide Selector
MIL-P-8564	Pneumatic System 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-H-8890	Hydraulic Components, Type III, (-65°F to +450°F), General Specification for
MIL-H-8891	Hydraulic Systems, Manned Flight Vehicles, Type III, Design, Installation, and Data Requirements for
MIL-T-10727	Tin Plating; Electrodeposited or Hot-Dipped, for Ferrous and Nonferrous Metals
MIL-C-26500	Connectors, General Purpose, Electrical, Miniature, Circular, Environment Resisting, Established Reliability, General Specification for
MIL-V-27162	Valves, Servo Control, Electro-hydraulic, General Specification for
MIL-G-81322	Grease, Aircraft, General Purpose Wide Temperature Range
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-461	Electromagnetic Interference Characteristics Requirements for Equipment
MIL-STD-470	Maintainability Program Requirements (For Systems and Equipments)
MIL-STD-471	Maintainability Demonstration
MIL-STD-704	Electric Power, Aircraft, Characteristics and Utilization of
MIL-STD-785	Reliability Program for Systems and Equipment, Development and Production
MIL-STD-790	Reliability Assurance Program for Electronic Parts Specifications
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

PUBLICATIONS

Air Force-Navy Aeronautical Bulletin

438	Age Controls of Age-Sensitive Elastomeric Items

(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. This specification makes provisions for preproduction testing. The preproduction testing contained herein is the minimum testing which will meet the preproduction requirements. Final 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. It shall be as identified in section 4 of this document.

3.2 Selection of specification and standards. Specifications and standards for all materials, parts, and customer certification and approval of processes and equipment, which are not specifically designated herein and which are necessary for the execution of this specification, shall be selected in accordance with procedures established by the procuring activity, except as provided in 3.2.1.

3.2.1 Standard parts. Standard parts (MS or AN) shall be used wherever they are suitable for the purpose and shall be identified on the drawings by their part numbers. Commercial utility parts, such as screws, bolts, nuts, cotter pins, etc, may be used provided they possess suitable properties and are replaceable by the standard parts without alteration, and provided the corresponding standard part numbers are referenced in the parts list, and if practicable, on the supplier's drawings. In the event there is no suitable corresponding standard part in effect on date of invitation for bids, commercial parts may be used provided they conform to all requirements of this specification. Parts shall be selected in accordance with MIL-STD-143.

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

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 is of prime importance and material selection shall be made accordingly.

3.4 Design and construction. Detail design and construction of the components and brake control 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. The useful life shall be as specified in the detail specification and shall be equal to the aircraft design useful life.

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

(a) Brake torque characteristics (in accordance with MIL-W-5013)

(b) The brake metering system and its components (including line sizes, etc)

(c) Expected flow requirements

(d) Strut dynamic characteristics

(e) Total aircraft stop performance requirements (in accordance with MIL-W-5013)

(f) Dimensional limits

(g) Various tire physical characteristics.

3.4.2 System features. The following are features which may be required for systems in addition to the basic skid control functions depending upon the aircraft configuration and landing distance requirements.

3.4.2.1 Touchdown protection. Where there is a reasonable possibility of applying brake pressure before wheel spin-up, the brake control system shall provide continuous release of brake pressure. Strut compression with wheel rotation override intelligence is normally employed to determine that the aircraft is on the ground, wheels are rotating, and the aircraft is ready for braking. In selecting touchdown protection, the probability of introducing additional failure modes and failure points should be considered.

3.4.2.2 Failure detection/failure mode. The failure detection circuit shall be of the "passive" type; that is, it will function to provide failure indication, visual or audio, without altering remaining skid control capability. The brake control system shall fail with "brake pressure as metered by the pilot," except for systems with four or more control valves, where the affected wheel shall be isolated. Pilot function shall not be required to deactivate the antiskid system in order to maintain brake metered pressure.

3.4.2.3 Cockpit warning light. A cockpit warning light, preferably mounted in a prominent location within the pilot's field of vision during the landing and braking phase of flight, shall be provided to indicate that there has been a system malfunction and the brake pressure is as metered.

3.4.2.4 Emergency operation. The brake control system shall function only on the normal braking system. The system shall not degrade braking capability when the aircraft is operated with any alternate or emergency brake system. This design requirement shall apply for the system turned off as well as on.

3.4.2.5 System integrity testing. If the antiskid system has a built-in self-monitoring test circuit, the pilot test monitoring procedure shall be identical for both ground and inflight system conditions. Normal braking shall be available when system testing is performed during taxiing or parking conditions.

3.4.3 Reliability. Quantitative reliability requirements shall be established for the brake control system and its components consistent with the weapon system requirements. The program shall be in accordance with MIL-STD-785 and MIL-STD-790. A failure mode and effect analysis shall be included in the data requirements.

3.4.4 Maintainability. Quantitative maintainability requirements shall be established for the brake control system and its components consistent with the weapon system requirements. The program shall be in accordance with MIL-STD-470, and the demonstration shall be consistent with MIL-STD-471. The requirements shall apply to maintenance in the planned maintenance and support environment. Factors to be considered shall include time, rate, complexity, 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 designed 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. The test equipment limits shall reflect the effect of brake-induced temperature levels of the wheel speed detectors and valves due to fluid temperature rise.

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.

3.4.7 Physical characteristics

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

3.4.7.2 Dimensional limitations. Critical dimensional limitations shall be specified in the detail specification.

3.4.7.3 Strength. The structural strength of all units of the brake control system shall be such that, when installed, operation will not be impaired, and no part of the device or its mounting shall show evidence of 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; 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 brake control system shall conform to all applicable requirements of MIL-STD-704, category B, and shall give specified performance from the power source configuration specified in the detail specification. During power interruption, as defined in MIL-STD-704, category B, the system shall revert to "brake pressure as metered by the pilot."

3.4.8.3 Relays. Relays used in the brake control 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-26500, threaded type with lock wire.

3.4.9 Hydraulic-pneumatic components

3.4.9.1 Hydraulic equipment - general. Hydraulic components shall conform to the applicable requirements of MIL-H-5440, MIL-H-8775, MIL-H-8890, and MIL-H-8891.

3.4.9.2 Solenoid-operated control valves. Solenoid-operated control valves shall conform to the applicable requirements of MIL-V-7915 or 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 Pressure-modulating valves. Pressure-modulating valves shall be designed in accordance with the applicable requirements of MIL-V-27162 and shall be suitable for the brake control system environment with special emphasis upon contamination tolerance, stability with life and temperature, tolerance to service handling, and moisture sealing.

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

3.4.10 Lubrication. Lubrication shall be in accordance with MIL-G-81322 with normal maintenance practice.

3.5 Performance

3.5.1 The brake control system in conjunction with the aircraft brake system shall provide, within the limits of the aircraft braking environment, a means of safely stopping the aircraft on the required runway length, width, and surface condition. The brake control system shall provide a means of controlling brake pressure to maintain wheel rotation within the required performance levels under all conditions other than tire hydroplaning. This requirement shall apply to all landing surfaces on which the aircraft is designed to operate. The system shall prevent tire flat-spotting and shall never permit a completely locked brake within the control speed range when the brake will respond to control. The control speed range shall be from maximum ground operation speed to the lowest speed compatible with ground handling, not to exceed 10 knots.

3.5.2 The brake control system shall not induce airframe dynamic instability, gear walking, gear chatter, etc. This will be demonstrated on the aircraft throughout the forecasted aircraft ground operation spectrum. The system shall be tuned for optimum performance on a wet runway, a dry surface, and combinations of wet and dry surfaces, considering both braking and cornering forces, throughout the control speed range. Since the total braking function involves more than the antiskid brake control system, total system performance shall be the responsibility of the airframe manufacturer.

3.5.3 Environment

3.5.3.1 Operating temperatures. The components shall satisfactorily withstand operation at temperatures from -54° to $+71^{\circ}C$ (-65° to $+160^{\circ}F$). 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 brake control system shall operate satisfactorily when conditions are imposed which duplicate the environment of sea coast regions.

3.5.3.3 Humidity. The brake control 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 brake control 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 brake control 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 brake control system equipment shall not cause ignition of an explosive atmosphere when operated in such an atmosphere.

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

3.5.3.8 Acoustical noise. The brake control 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 brake control system shall function properly when exposed to vibration in addition to acoustical noise which realistically will be encountered on the aircraft.

3.5.3.10 Shock. The brake control system shall withstand any shock loading expected in operation, handling, or transportation.

3.5.3.11 Fungus. The brake control 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 brake control 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 for each brake control system shall be prepared to incorporate 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 and compatibility analysis. An analysis of brake control system performance under various antiskid, aircraft (including wing lift), runway surface conditions, and various pilot metering valve pressures shall be prepared. The recommended method for analysis is described under 4.5.3.1. Any other method must be approved by the procuring activity. The initial analysis shall be prepared prior to flight test of the first unit. A final analysis shall be prepared at the conclusion of the flight test evaluation of the system and shall be based on flight test information.

3.7.4 System fault analysis. An analysis shall be conducted to determine the effects of various system part failures and submitted prior to first flight. All modes of failure shall be considered. Failures which cannot be adequately investigated by analysis alone shall be simulated by appropriate laboratory tests to allow preparation of a complete analysis. It shall be verified that operational checkout procedures can be developed to detect all failures.

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

3.8 Finishes and protective treatments

3.8.1 Aluminum alloy. Aluminum alloy external surfaces shall be anodized in accordance with MIL-A-8625, type II.

3.8.2 Steel. Steel shall be of stainless composition or shall be 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. Alternate protective treatments may be used if approved by the procuring activity and dictated by performance requirements.

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

3.10 Workmanship. The brake control system components shall be uniform in quality and free from irregularities, defects, or foreign matter which could adversely affect safety, performance, reliability, 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 brake control systems shall be classified as follows:

(a) Preproduction tests (see 4.3)

(b) Quality conformance tests (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. A minimum of two test samples consisting of all the components of the brake control system shall be used for the component tests as described under 4.5.2. The samples shall be subjected to the following tests:

(a) Test sample No. 1:

(1) Examination of product

(2) Immersion altitude cycling

(3) Dust

(4) High and low temperature

(5) Endurance

(6) Vibration

(b) Test sample No. 2:

(1) Examination of product

(2) Immersion altitude cycling

(3) Internal leakage (valve)

(4) External leakage (valve)

(5) Pressure drop (valve)

(6) Proof pressure (valve)

(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.

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 brake control systems and shall represent the safety of flight:

(a) Test sample No. 1:

(1) Examination of product

(2) Dust

(3) High and low temperature

(4) One-half (50 percent) of endurance tests

(5) Vibration

(b) Test sample No. 2:

(1) Examination of product

(2) Immersion altitude cycling

(3) Internal leakage

(4) External leakage

(5) Pressure drop

(6) Proof pressure

(7) Humidity

(8) Mechanical shock

(9) Explosive atmosphere.

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 brake control system shall be subjected to the examination of product (4.5.1) and to component performance tests as specified in the detail specification.

4.5 Test methods

4.5.1 Examination of product. Each complete brake control system 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.

4.5.2 Component tests. Unless specifically noted, all component tests shall be performed on a brake control system installed in a simulated aircraft hydraulic and electrical network, including production aircraft electrical and hydraulic connections. The system shall operate satisfactorily under the conditions specified in the following component tests. The degree of aircraft simulation shall be specified in the detail specification.

4.5.2.1 Environmental tests. The complete brake control system shall be operated and performance monitored during all phases of the environmental tests without disturbing the installed components or the environment. If the components are hermetically sealed, satisfactory completion of the immersion altitude cycling test will eliminate the requirement for performing the humidity, dust, salt fog, and explosive atmosphere tests.

4.5.2.1.1 High and low temperature. The brake control system shall be subjected to high and low temperature tests in accordance with MIL-STD-810, procedure I of methods 501 and 502, respectively, except for components that are subjected to higher temperatures as specified in the detail specification. The system shall be exercised as follows:

(a) High temperature - Wheel-speed-driven units for inertia or hubcap-driven alternating- or direct-current generators shall be accelerated from 0 to 10V to 0 at the maximum rate possible on the aircraft as specified in the detail specification. This shall be considered one cycle. For systems having no moving parts in the speed sensor, an appropriate signal simulation may be employed as approved by the procuring activity. The time between cycles shall be such as to allow completion of the performance of all functions in the system. Two and one-half percent of the total cycles specified in 4.5.2.2 shall be performed at high temperature.

(b) Low temperature - The acceleration and deceleration rates and velocities shall be the same as for the high temperature test. Two and one-half percent of the total number of cycles specified in 4.5.2.2 shall be required.

4.5.2.1.2 Temperature shock cycling. The brake control system components shall be subjected to 25 cycles of temperature shock in accordance with method 503, procedure I of MIL-STD-810 between the temperature limits of -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 -65°F to room ambient.

4.5.2.1.3 Mechanical shock. The brake control system components shall be subjected to a mechanical shock test in accordance with MIL-STD-810, method 516, procedures I and II.

4.5.2.1.4 Acoustical noise. The brake control system components shall be subjected to an acoustical noise test in accordance with MIL-STD-810, method 515, with test category as applicable to the installation on the aircraft.

4.5.2.1.5 Vibration. Unless otherwise specified in the detail specification, the brake control system components shall be subjected to a vibration test in accordance with MIL-STD-810, method 514 and as specified herein. Mounting (mechanical, electrical, and hydraulic) shall simulate aircraft installation. Wheel-driven units shall include an axle-hubcap simulation. 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.

4.5.2.1.6 Immersion altitude cycling. All gaskets, O-rings, or hermetically sealed components including appropriate aircraft wiring section, 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. This procedure shall be repeated 10 times. The components shall perform satisfactorily subsequent to the test and may be disassembled or weighed to prove no water has penetrated. The components shall be disassembled following completion of the component tests and checked for signs of moisture penetration and internal corrosion.

4.5.2.1.7 Humidity. All components, except those hermetically sealed, shall be subjected to a humidity test in accordance with method 507, procedure I of MIL-STD-810.

4.5.2.1.8 Fungus. All components shall be subjected to a fungus test in accordance with method 508, procedure I of MIL-STD-810 unless documentation is provided which proves no fungus nutrients are used in the design.

4.5.2.1.9 Dust. All components not located in sheltered compartments shall be subjected to dust tests in accordance with method 510, procedure I of MIL-STD-810 and as specified herein. The airframe manufacturer will determine whether or not a component is in a sheltered compartment. For wheel-driven-units, inertia devices or alternating- or direct-current generators shall be tested with the unit rotating at an equivalent wheel speed of 400 rpm or as specified in the detail specification. The unit shall be functionally checked after completion of the test.

4.5.2.1.10 Salt fog. The components with aircraft connectors installed shall be subjected to a salt fog test in accordance with method 509, procedure I of MIL-STD-810. The component performance shall be checked in the salt fog environment.

4.5.2.1.11 Explosive atmosphere. All components with unsealed contacts shall be subjected to an explosive atmosphere test in accordance with method 511, procedure I of MIL-STD-810.

4.5.2.1.12 Acceleration. All components fastened rigidly to the landing gear structure shall be subjected to translational accelerations of 50g in all principal directions while operating.

4.5.2.2 Endurance. The brake control system, installed in the simulated hydraulic and electrical network, shall be subjected to the following tests.

4.5.2.2.1 Transient cycling. The brake control system components shall be subjected to 20,000 power-on transient cycles of electrical and hydraulic pressure impulse cycles at the rates specified in the detail specification.

4.5.2.2.2 Skid cycling. The brake control system shall be cycled to give a total equivalent to the maximum number of and character of cycles per landing experienced during testing of the system on the aircraft, multiplied by the maximum anticipated landings in the life of the gear. If the maximum number of anticipated landings is not specified, the number 8,000 shall be used. The number of cycles required under this and all subsequent endurance test paragraphs for components to be subjected to service temperatures in excess of 71°C (160°F) may be reduced to reflect the adverse effects of the extreme temperature cycles which have been run previously. The cycles shall be run at room temperature to the oil temperature specified in the detail specification. For systems with wheel-speed detectors which do not have bearings, a suitable input system signal simulation, as approved by the airframe manufacturer, may be employed. For systems having wheel-speed detectors with internal bearings, the detectors shall be subjected to the tests specified in 4.5.2.2.3 and 4.5.2.2.4.

4.5.2.2.3 Maximum velocity test. Ten percent of the cycles defined in 4.5.2.2.2 shall be performed in the following manner. The wheel-speed detectors shall be accelerated from zero rpm to the rpm equivalent to velocity (V) (6.3.3 and 6.3.4) and then decelerated equivalent to the maximum deceleration rate experienced on the aircraft, as specified in the detail specification. This operation shall be considered to be one cycle. The time interval between accelerating and decelerating shall be sufficient to allow all internal parts of the wheel-driven components to perform their prescribed function, if applicable. A more rational duplication of takeoff and landing function may be considered, if applicable.

4.5.2.2.4 Medium velocity test. Eighty-five percent of the cycles specified in 4.5.2.2.2 shall be made in the following manner. The wheel-speed detector shall be accelerated from the equivalent wheel rpm for 0.25V or less to the equivalent wheel rpm for 0.5V and then decelerated to the equivalent wheel rpm for 0.25V or less. The acceleration and deceleration shall be specified in the detail specification, consistent with aircraft usage. This operation shall be considered to be one cycle. The time interval between acceleration and deceleration, and vice versa, shall be sufficient to allow all internal parts of the wheel-speed detectors to perform their prescribed function, if applicable. A more rational duplication of takeoff and landing function may be considered, if applicable.

4.5.2.3 Electromagnetic interference (EMI). EMI tests in accordance with MIL-STD-461 shall be performed on the brake control system installed in a simulated aircraft network.

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

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

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

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

4.5.2.4.4 Internal leakage. The hydraulic components shall be subjected to internal leakage tests in accordance with the paragraph entitled "Qualification or Preproduction Tests" of MIL-H-8775.

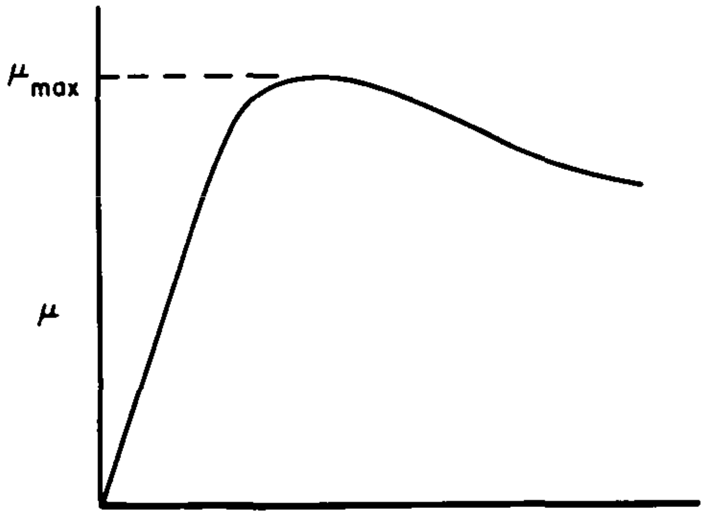
4.5.2.4.5 Pressure drop. A pressure drop evaluation shall be conducted on hydraulic components in accordance with MIL-H-8775.

4.5.2.5 Extreme tolerance analysis. The units used for preproduction component tests shall be physically measured and the electrical output 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.

4.5.3 Laboratory tests

4.5.3.1 Computer simulation. Tire, wheel, brake, and airframe dynamic characteristics and aircraft aerodynamic characteristics shall be included in a computer analysis in which the various component and system characteristics are simulated as accurately as possible utilizing available laboratory test data or in which actual system components (particularly antiskid electronic circuitry) are used. The characteristic variation of friction coefficient with tire or wheel slip as shown on figure 1 shall be considered, and the numerical values for this function shall be established in a rational manner based on the properties of the tire together with experimental data. It should be pointed out that wheel slip ratio is a response or resultant effect, and therefore, use of the tire slip is a preferable approach in the analysis.

4.5.3.1.1 The range for maximum available tire-to-surface friction coefficients to be analyzed shall be from .05 to the maximum available for a dry



μ = Instantaneous value of friction coefficient.

μ_{max} = Maximum available friction coefficient for the conditions being encountered.

FIGURE 1. Tire or Wheel Slip

surface, or the maxiumum which can be utilized by the brake's torque capability, whichever is least. The maximum friction coefficient for a dry surface may be computed from the following equation:

$$\mu \text{ Max dry} = .93 - 0.0011P$$

Where:

μ Max dry = Maximum available friction coefficient for a dry surface

P = Tire inflation pressure in psig

The results should include, but are not limited to, the variation of computed stopping efficiency and tire skid index throughout the range of maximum available coefficient of friction. Stopping distance efficiency, η in percent is defined as follows:

$$\eta = \frac{\text{minimum stopping distance}}{\text{actual stopping distance}} \times 100 \text{ (all wheels braked)}$$

or expressed symbolically

$$\eta = \frac{\dfrac{\dot{x}_o^2}{2\mu_{max} g}}{x} \times 100$$

where η = Stopping distance efficiency in percent

μ_{max} = Maximum available coefficient of friction

g = Acceleration of gravity

$\dot{x}_o$ = Initial aircraft forward velocity

x = Aircraft stopping distance computed from the analysis considering antiskid system operation.

(Alternately, the minimum stop distance can be computed on the brake maximum torque capability, if it produces a lesser braking force.)

The tire skid index is defined as the ratio of total work done in skidding to the total braking force work on the aircraft. Skid index in percent is defined as follows:

$$\sigma = \frac{W\ Skid}{W\ Braking\ \ Force} \times 100$$

where:

σ = Skid index in percent

WSkid = Total work done in skidding

$$W\ Skid = \int_0^{t_f} w_I \mu\ St\ \dot{x}\ dt$$

W Braking Force = Total braking force work

$$W\ Braking\ \ Force = \int_0^{t_f} w_I \mu\ \dot{x}\ dt$$

W_I = Instantaneous vertical ground reaction on the tire

μ = Instantaneous coefficient of friction

St = Instantaneous slip ratio at the tire-ground interface

$\dot{X}$ = Forward velocity of wheel axle

t_f = Time of braking stop

The value obtained for skid index indicates how the work done during braking is distributed between the tire and the brake, and therefore, is indicative of the tire wear to be expected and the cornering capability that can be achieved with the system.

The computer program shall include provision for varying the available maximum coefficient of friction during a single braking stop in order to simulate the effect of ice patches, puddles, and paint stripes on the runway.

4.5.3.2 Dynamometer testing. 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. The degree of use of aircraft hardware (hydraulic simulation, tire, wheel, brake, strut, etc) will improve aircraft simulation. Brake pressure efficiency, drag efficiency, and torque efficiency may be used for performance comparison.

4.5.4 Aircraft performance/compatibility tests. Aircraft performance/compatibility tests shall be conducted. The method of measuring performance efficiency and the level of system performance efficiency required shall be specified in the detail specification, depending upon the aircraft requirements. The following methods are available for brake control system evaluation.

4.5.4.1 Method I evaluation. Install instrumentation on the aircraft to measure the following, as a minimum: independent wheel speed, brake actuation pressure at the brakes, and pressure and signal to the control valve. Perform taxi and flight on wet, dry, and combinations of wet and dry surfaces to determine that: the wheels never fully lock-up, the aircraft brake control system performance is as required in the detail specification, and the aircraft has acceptable dynamic characteristics. As an additional part of the method I evaluation, determine the aircraft free roll or the unbraked deceleration characteristics.

4.5.4.2 Method II evaluation. For more sophisticated evaluation, conduct the following in addition to method I: install brake torque or strut drag instrumentation and suitably located accelerometers. In addition to the quantitative evaluations described above, determine drag or brake torque efficiency.

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 ANA Bulletin No. 438.

6. NOTES

6.1 Intended use. The antiskid brake control system covered by this specification is intended for use in conjunction with aircraft power brake systems.

6.2 Ordering data. Procurement documents should specify the following:

(a) Title, number, and date of this specification

(b) Submission of data (see 3.4.3 and 3.7).

6.3 Definitions unique to this specification

6.3.1 Individual wheel control. Individual wheel control refers to the feature where each braked wheel is controlled individually, as a function of its wheel speed.

6.3.2 Paired or grouped wheel control. The brake control system may be configured to control brake pressure to two or more brakes when any one of the braked wheels require skid control. Pairing or grouping of wheels is a function of landing gear arrangement, performance required, and aircraft directional stability required and should be defined in the detail specification.

6.3.3 Velocity (V). Velocity (V) denotes the maximum design system operating velocity and is the takeoff speed under maximum gross weight, standard hot day, 8,000 feet altitude, or as approved by the procuring activity.

6.3.4 Tire - loaded radius. The tire loaded radius is that distance from the axle center to the tire ground interface for all operating tire loads and procedures. The radius of rated tire deflection should be used in calculating the system operating velocity range.

6.3.5 Hermetically sealed unit. A hermetic seal refers to a seal that is suitably fused, brazed, and soldered to provide a positive barrier to air and moisture. (Reference: MIL-E-5400).

6.4 Definitions common to the antiskid industry

6.4.1 Antiskid system. The antiskid brake control system or system, as used in this specification, refers to the components normally supplied by the antiskid supplier, including but not limited to the following components: wheel-speed sensors, control valve(s), and control box.

6.4.2 Wheel braking system. The wheel braking system refers to all elements associated with the antiskid control system, which coupled together provide deceleration of the aircraft due to wheel brakes. The elements include but are not limited to antiskid control components and associated hydraulic installation, wheel(s), tire(s), and brake(s).

6.4.3 Antiskid control system operating environment. The antiskid control system operating environment is the environment which the antiskid control system feels in performing its function. The antiskid control operating environment includes the wheel braking system (see 6.4.2), the airframe elastic structure (including struts), the wheel dynamic loading tire elastic properties, runway friction levels available, runway roughness, and ambient and hydraulic fluid temperature.

6.4.4 Aircraft braking environment. The aircraft braking environment is that environment the aircraft experiences during the landing and braking phase of operations including: runway length/width/surface texture/slope/crown/contamination level, wind conditions, temperature/pressure, touchdown velocity and alignment, and touchdown point proficiency.

6.4.5 Friction

6.4.5.1 (μ) Coefficient of friction. The coefficient of friction in general terms is the ratio of drag force to the vertical force at the braked tire runway interface.

6.4.5.2 (μ_{max}) Coefficient of friction maximum instantaneous. μ max instantaneous coefficient of friction for a given tire runway condition is the maximum measured while driving the braked wheel toward a lockup. (μ slip)

6.4.5.3 (μ_e) Coefficient of friction effective. μ_e is the effective friction coefficient that results in the force increment applied by the braked wheels to the aircraft, which assists in aircraft deceleration.

6.4.6 Performance efficiency definitions. The following definitions are pictorially described on figure 2. Efficiency is measured over the full braking rollout. It should be noted that efficiencies determined by various methods are not necessarily directly comparable.

6.4.6.1 Pressure efficiency. Pressure efficiency is the ratio of the measured brake pressure integral to peak-to-peak straight line integral between the skid pressure levels from brake pressure time history instrumentation.

6.4.6.2 Drag efficiency. Drag efficiency is the ratio of measured drag integral on the strut(s) to the integral measured straight line between skid points taken from drag time histories. The skid point is the point of maximum drag.

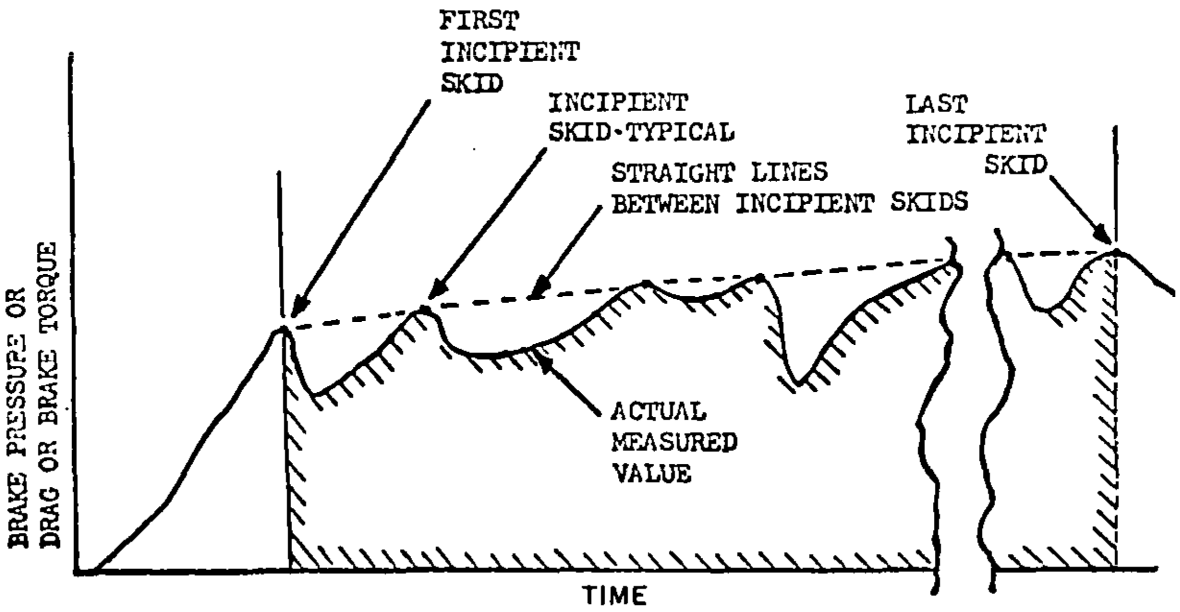


FIGURE 2. Performance Efficiency Description (See 6.4.6)

6.4.6.3 Torque efficiency. Torque efficiency is the ratio of measured brake torque integral to the integral of straight lines between peak torques taken from torque time history instrumentation.

6.4.6.4 Distance efficiency. See 4.5.3.1.1.

6.4.7 Slip ratio. Slip ratio is the ratio of reduction in wheel rotational velocity under the influence of braking forces to the equivalent free rolling rotational velocity of the unbraked wheel.

6.4.8 Incipient skid. Incipient skid is the point of wheel instability where brake torque exceeds resisting tire-runway friction torque and the wheel therefore begins a deceleration condition, where if continued would result in abrupt wheel lockup.

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

Custodians:
Army - AV
Navy - AS
Air Force - 11

Review activities:
Army - AV
Navy - AS
Air Force - 70

Preparing activity:
Air Force - 11

Project No. 1630-0041

SPECIFICATION ANALYSIS SHEET	Form Approved Budget Bureau No. 22-R255

INSTRUCTIONS: This sheet is to be filled out by personnel, either Government or contractor, involved in the use of the specification in procurement of products for ultimate use by the Department of Defense. This sheet is provided for obtaining information on the use of this specification which will insure that suitable products can be procured with a minimum amount of delay and at the least cost. Comments and the return of this form will be appreciated. Fold on lines on reverse side, staple in corner, and send to preparing activity. Comments and suggestions submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or serve to amend contractual requirements.

SPECIFICATION

ORGANIZATION

CITY AND STATE	CONTRACT NUMBER

MATERIAL PROCURED UNDER A

☐ DIRECT GOVERNMENT CONTRACT ☐ SUBCONTRACT

1. HAS ANY PART OF THE SPECIFICATION CREATED PROBLEMS OR REQUIRED INTERPRETATION IN PROCUREMENT USE?

   A. GIVE PARAGRAPH NUMBER AND WORDING.

   B. RECOMMENDATIONS FOR CORRECTING THE DEFICIENCIES

2. COMMENTS ON ANY SPECIFICATION REQUIREMENT CONSIDERED TOO RIGID

3. IS THE SPECIFICATION RESTRICTIVE?

   ☐ YES ☐ NO *(If "yes", in what way?)*

4. REMARKS *(Attach any pertinent data which may be of use in improving this specification. If there are additional papers, attach to form and place both in an envelope addressed to preparing activity)*

SUBMITTED BY *(Printed or typed name and activity - Optional)*	DATE

DD FORM 1 JAN 66 1426 REPLACES EDITION OF 1 OCT 64 WHICH MAY BE USED.

AFLC—WPAFB—OCT 67 2M