SOCIETY OF AUTOMOTIVE ENGINEERS, Inc.
485 LEXINGTON AVENUE
NEW YORK 17, N.Y.

AEROSPACE STANDARD

AS227 D

WHEELS AND BRAKES - MINIMUM REQUIREMENTS FOR CIVIL AIRCRAFT APPLICATIONS

Issued 8-1-50
Revised 4-15-63

1. PURPOSE: To specify minimum requirements for aircraft wheels and brakes for civil aircraft applications.

2. SCOPE: This specification covers minimum requirements for all aircraft wheels and brakes in a range of sizes to accommodate the standard sizes and types of tires.

3. GENERAL REQUIREMENTS:

3.1 Materials and Workmanship:

3.1.1 Materials: Materials shall be suitable for the purpose intended. All metals used in the construction of wheels and brakes shall be corrosion resistant unless suitably plated or treated to resist corrosion during stocking and normal service life. The use of dissimilar metals, especially brass, copper, or steel in contact with aluminum, magnesium, or alloys thereof, shall be avoided where practicable.

3.1.2 Workmanship: The workmanship and finish shall be in accordance with high grade aircraft wheel and brake manufacturing practices.

3.2 Identification: Each wheel and each brake assembly shall be plainly marked, in such a way that the marking will not be obliterated or effaced as a result of service usage, as follows:

a. Name of manufacturer responsible for compliance.
b. Serial number and date of manufacture (may be combined) on both wheel halves and demountable flanges.
c. Assembly number.

4. DETAIL REQUIREMENTS:

4.1 Design:

4.1.1 Brake Operating Medium: All brakes shall be designed and tested to operate with the medium (air, oil or other fluid) specified for the airplane on which the brakes are to be used.

4.1.2 Lubricant Retainers: Suitable retainers shall be provided to prevent lubricant from reaching the braking surfaces and to prevent foreign matter from entering the bearings.

4.1.3 Removable Flanges: All removable flanges shall be assembled onto the wheel in a manner that will prevent the removable flange and its retaining device from leaving the wheel if a tire should deflate while the wheel is rolling.

4.1.4 Adjustment: When necessary to insure safe performance, the brake mechanism shall be equipped with suitable adjustment devices.

4.1.5 Inflation Pressure Release: When wheel and/or tire explosion hazards are created as a result of brake heat, each wheel thus affected shall be equipped with an inflation pressure release device. Suitable tests, as agreed upon by the aircraft and wheel manufacturers, shall be conducted for the purpose of demonstrating satisfactory performance of the safety device.

4.2 Amphibian Applications:

4.2.1 Water Seal: Provision shall be made to seal the wheels of amphibious aircraft to prevent entrance of water into the wheel bearings or other portions of the wheel or brake where the presence of water might be detrimental. Unsealed brake assemblies will be permitted if all exposed materials therein are corrosion resistant or if the design is such that brake action and service life will not be impaired by the presence of sea water or fresh water.

4.3 Construction:

4.3.1 Casting Quality Control: The quality of magnesium and aluminum wheel castings shall be initially developed and subsequently maintained in accordance with the procedures stated in AS 586A. The same procedures shall apply to brake castings which function as primary landing-load carrying elements of the landing gear. When valid inspection procedures including samplings plans have prior approval of a U.S. Government Agency (Air Force, Navy, etc.), these procedures may be used in lieu of the procedures outlined above when authorized by FAA.

4.3.2 Forgings: Forgings shall be of uniform condition, free from blisters, fins, folds, seams, laps, cracks, segregation, and other defects. If strength and serviceability are not impaired, imperfections may be removed.

4.3.3 Rim Surfaces:

4.3.3.1 Wheel Rims for Tires and Tubes: The surface of the rim shall be free from defects which are injurious to the tire or tube. Depressions in the rim or bead seats which might injure the tube or casing shall be filled with a hard surface permanent filler before applying the primer coat.

4.3.3.2 Wheel Rims for Tubeless Tires: The surface of the rim shall be free from defects which may cause leakage of inflation pressure or which may damage the tire beads.

4.3.4 Rim Joints: Joints in the rim surface and joints between rim surfaces and demountable flanges shall be smooth, close-fitting, and non-injurious to the inner tube while mounting the tire or while in service.

4.3.5 Rivets and Bolts: When rivets are used, they shall be well headed over, and rivets or bolts coming in contact with the casing or tube shall be smooth enough not to damage the tube or casing during normal operation.

4.3.6 Bolts and Studs: When bolts and studs are used for fastening together sections of a wheel, the length of the threads for the nut extending into and bearing against the sections shall be held to a minimum; and there shall be sufficient unthreaded bearing area to carry the required load.

4.4 Protective Treatment:

4.4.1 Steel Parts: Wherever possible all steel parts, except braking surfaces and those parts fabricated from corrosion resistant steel, shall be cadmium plated or zinc plated. Where cadmium or zinc plating cannot be applied, the surface shall be thoroughly cleaned and suitably protected from corrosion.

4.4.2 Aluminum Parts: All aluminum alloy parts shall be anodized or have equivalent protection from corrosion.

4.4.3 Magnesium Parts: All magnesium alloy parts shall receive a suitable dichromate treatment or have equivalent protection from corrosion.

4.4.4 Bearing and Braking Surface: The bearings and braking surfaces shall be protected during the application of finish to the wheels and brakes.

4.4.5 Operating Cylinders: Prior to inspection tests, the cylinders shall be suitably cleaned to remove all metal particles and other foreign matter. The cylinder ports shall be suitably capped to prevent entrance of foreign matter.

5. QUALIFICATION TESTS:

5.1 Ratings: Each design of wheel or wheel-brake shall have the following ratings as applicable:

S = Maximum Static Load in lbs.
L = Maximum Limit Load in lbs.
KE_{ML} = Maximum Landing Kinetic Energy Capacity in ft. lbs.
KE_{RTO} = Maximum Rejected Take-off Kinetic Energy Capacity in ft. lbs.
V_{so} = Power off Stall Speed in mph (not applicable to Method II analysis per paragraph 5.3.7.1.2).

5.2 Tests Required: The ratings for wheel assemblies and brake assemblies shall be substantiated by the following tests as applicable:

(a) Wheel, Table I
(b) Brake, Table II

5.3 Test Methods:

5.3.1 Radial Load Test: The required limit load shall be determined by the airframe manufacturer from the ground load requirements of CAR, and shall be equal to the operating condition of maximum radial load reaction with side load equal to zero. If the critical combined load condition as defined under the combined load test, has a limit radial component in excess of the required limit radial load, the radial load test shall be omitted. This test shall be performed by applying the radial load to the wheel through a tire inflated to an initial pressure equal to the rated inflation pressure. Either air or water inflation may be used. If the tire is filled with water, the water shall be bled off during loading to approximate the same tire deflection that would result if air inflation were used and the inflation

5.3.1 Radial Load Test: (continued)
pressure shall not exceed the pressure at maximum tire deflection. The radial load shall be applied to the wheel by means of a straight axle passing through the hub. The tire shall be loaded directly against a flat, non-deflecting surface. Deflection and permanent set readings shall be taken at suitable points on the wheel to indicate deflections of the wheel rim at the bead seat. The use of strain gages or special coating to indicate regions of high stress is desirable. Wheels intended for tubeless tire mounting shall be tested in the same manner, unless otherwise specified. The required radial load tests are specified below.

5.3.1.1 Yield Radial Load Test: The wheel shall support the yield radial load applied consecutively at 0°, 90°, 180° and 270° followed by two more load applications at the 0° position. The 0° position shall be the initial load contact point which shall normally include the valve hole. The 90° increments shall be altered if other positions are more critical. The successive loadings at the 0° position shall not cause radial permanent set increments of increasing magnitude. The permanent set increment caused by the last loading (at the 0° position) shall not exceed 5% of the deflection caused by the last loading. There shall be no yielding of the wheel such as would result in loose bearing cups, air leakage, or interference in any critical clearance areas. The bearing cups and cones and rollers shall be used for this test.

5.3.1.2 Ultimate Radial Load Test: The ultimate load shall be applied at the 0° position of the same wheel on which the yield radial loads were applied. The wheel shall support the ultimate load for ten seconds. The bearing cones may be replaced with conical bushings, but the cups shall be used. A tubeless tire may be replaced with a tire and tube.

5.3.2 Combined Load Test: The combined load test shall be performed by applying the load to the wheel through a tire inflated to an initial pressure equal to the rated inflation pressure. Air or water inflation pressure may be used. If the tire is filled with water, the water shall be bled off during loading to approximate the same tire deflection that would result if air inflation were used and inflation shall not exceed the pressure at maximum tire deflection. Yield loads shall be applied in both inboard and outboard directions on the same wheel and at the ground angle and magnitude determined by the airframe manufacturer to demonstrate compliance with CAR. The required limit combined load components, both inboard and outboard, shall be determined by the airframe manufacturer and furnished to the wheel manufacturer. The wheel and tire assembly shall be mounted on a straight axle passing through the hub. The tire shall be loaded directly against a flat, non-deflecting surface. The loads shall be applied simultaneously, either continuously or in increments of approximately 10% of the specified values. Readings shall be taken at suitable points on the wheel to indicate deflections and permanent sets.

5.3.2.1 Yield Combined Load Test: The wheel shall support the components of the yield combined load applied consecutively at 0°, 90°, 180°, and 270° followed by two more load applications at the 0° position. The 0° position shall be the initial load contact point which shall normally include the valve hole. The 90° increments shall be altered if other positions are

5.3.2.1 Yield Combined Load Test: (continued) more critical. The successive loadings at the 0° position shall not cause permanent set increments of increasing magnitude. There shall be no yielding of the wheel such as would result in loose bearing cups, air leakage through the wheel or past the wheel seal, or interference in any critical clearance areas. The bearing cups and cones and rollers shall be used for this test. A tire and tube may be used when testing a tubeless wheel only when it has been demonstrated that pressure will be lost due to the inability of a tire bead to remain properly positioned when under load.

5.3.2.2 Ultimate Combined Load Test: The ultimate combined load shall be applied at the 0° position of the same wheel on which the respective yield combined load tests were performed. The ultimate load shall be sustained for ten seconds. The wheel shall be loaded in the most critical direction. The bearing cones may be replaced with conical bushings, but the cups shall be used. A tubeless tire may be replaced with a tire and tube.

5.3.3 Burst Test: The wheel shall be hydrostatically tested to a burst pressure, P, and shall withstand this test without failure.

$$P = pf$$

Where: p = Inflation pressure required for maximum static load (S)
f = Factor specified in Table I

5.3.4 Roll Test: Wheel with tire installed shall withstand, without failure or development of cracks, a roll life specified in Table I under a load not less than the maximum static rating 'S' of the wheel. For certain types of service, it may be desirable to subject the wheel to a roll test of greater duration than specified in Table I to assure longer service life. In such cases the exact condition of test should be determined by agreement between the aircraft and wheel manufacturer.

5.3.5 Tubeless Wheel Pressure Test:

5.3.5.1 Static Test: The tubeless tire and wheel assembly shall be inflated to a pressure of 1.5 times the rated inflation pressure and immersed in water. The rate of leakage, as evidenced by bubbles, shall not exceed four bubbles per second from the wheel.

5.3.5.2 Dynamic Pressure Test: The tubeless tire and wheel assembly shall be rolled under the load specified by the roll test for at least 25 miles with no pressure drop greater than 5%. Mileage accumulated during this test may be used in computing the total mileage in the roll test.

5.3.6 Alternate Tests: When the tests required by 5.2 (a) are not consistent with loads imposed on the airplane, equivalent alternate loads and tests may be evolved to the satisfaction of the airplane manufacturer.

5.3.7 Dynamic Torque Test:

5.3.7.1 Braking Capacity Calculations: Either of the following methods may be used to determine the energy capacity required of the wheel-brake system. (Refer to Table II).

5.3.7.1.1 Method I:

$$KE = .0334\ WV^2$$

Where: KE = Kinetic energy per wheel-brake system - ft. lbs.
W = Airplane weight applicable to wheel-brake system - lbs.
V = Speed, applicable - mph.

The aircraft manufacturer shall specify values for W and V.

5.3.7.1.1.1 Transport (CAR Part 4b)

(1) For the design landing energy stops:

W = design landing weight applicable to wheel-brake system.
V = V_{so} = Power-off stalling speed of the airplane at sea level at the design landing weight and the landing configuration.

(2) For the accelerate-stop condition, the energy shall be calculated for the most critical combination of take-off weight and V_1 speed as determined by the aircraft manufacturer.

5.3.7.1.1.2 Non-Transport (CAR Part 3)

(1) For the design landing energy stops, the energy shall be calculated in the same manner as for the Transport (CAR Part 4b) aircraft.

5.3.7.1.1.3 Rotorcraft (CAR Parts 6 and 7)

(1) For the design landing energy stops, the energy shall be calculated for the most critical combination of take-off weight and brake application speed as determined by the Rotorcraft manufacturer.

5.3.7.1.2 Method II: The wheel-brake system kinetic energy shall be based on a rational analysis of the sequence of events which are expected to occur during operational landings at design landing weight or rejected take-off stops at maximum weight. The analysis shall include rational or conservative values of braking coefficients of friction between tires and runway, aero-dynamic drag, propeller drag, or power plant forward thrust; and if more critical, the most adverse single engine or propeller malfunction which would result in a loss of drag credit for that engine or propeller. In addition, the analysis may include the effect of auxiliary deceleration devices which may be allowed in the field length certification test of the specific aircraft.

5.3.7.1.2.1 Transport (CAR Part 4b)

(1) The design landing energy stop analysis shall be based on the design landing weight per wheel-brake system and conservative values of airplane brake application speed for the airplane landing configuration.

(2) For the accelerate-stop condition, the energy shall be calculated for the most critical combination of take-off weight and V_1 speed as determined by the aircraft manufacturer.

5.3.7.1.2.2 Non-Transport (CAR Part 3)

(1) For the design landing energy stop analysis, the kinetic energy shall be calculated the same as for Transport (CAR Part 4b) aircraft.

5.3.7.2 Dynamometer Test: Dynamic torque tests shall be conducted on a suitable inertia brake testing machine. Kinetic energy, speed, deceleration, and torque will be as determined by Method I or Method II. Airworthiness shall be demonstrated by one wheel-brake system withstanding all of the dynamic torque tests specified for the applicable Method as shown in Table II and in accordance with 5.3.7.2.3. The test conditions are:

5.3.7.2.1 Method I:

(1) A flywheel inertia equivalent approximately equal to but not less than 99 per cent of the airplane weight per wheel-brake system for the applicable stop condition.

(2) A flywheel speed approximately equal to the aircraft speed used in the Method I calculation; however, the speed may be adjusted to develop the specified kinetic energy.

(3) A brake pressure shall be used during any one stop to develop the average deceleration rate shown in Table II.

5.3.7.2.2 Method II:

(1) A flywheel inertia equivalent capable of developing the determined kinetic energy when stopped from the aircraft brake application speed.

(2) Unless otherwise specified, brake pressure shall be used during any one stop of the design landing test to develop the average deceleration rate specified in Table II. During the accelerate-stop test, as required for Transport (CAR Part 4b) aircraft, a brake pressure shall be used to develop the deceleration necessary to meet the airplane speed-torque requirement as shown by the Method II analysis as specified by the aircraft manufacturer.

5.3.7.2.3 General:

(1) Landing Stops (A). One change of brake lining and attached discs is permissible in making the 100 normal energy stops. The remainder of the brake assembly parts shall withstand the 100 normal energy stops without failure or impairment of operation.

(2) Accelerate Stop (B). Linings and bare discs may be new or used. No less than two landing stops shall have been completed on this brake prior to this test.

(3) "Linings" mean either individual blocks of wearing material or discs which have wearing material integrally bonded to them.

(4) "Bare Discs" mean plates or drums which do not have wearing material integrally bonded to them.

5.3.8 Structural Torque Test: The test shall consist of the application of at least the rated static load (S) and a tangential torque load to the wheel. During this test, rotation of the wheel shall be resisted by a force transmitted through the brake or brakes by an application of at least maximum brake line pressure. If the wheel rotates or if prior testing indicates the wheel would rotate before development of the required torque load, the friction surfaces may be clamped, bolted, or otherwise restrained while applying at least maximum brake line pressure.

5.3.8.1 Single Wheel Landing Gear Units: The wheel-brake assembly shall withstand a torque load of 1.2 SR for at least 3 seconds without failure. R is the normal rolling radius of the tire under rated load (S).

5.3.8.2 Multiple Wheel Landing Gear Units: The wheel-brake assembly shall withstand a torque load of 1.44 SR for at least 3 seconds without failure. R is the normal loaded radius of the tire under rated load (S).

Note: The 1.44 factor includes an additional factor of 1.2 in recognition of landing gear configurations with a 60 per cent - 40 per cent wheel load component shall be at least 1.2 S when meeting the requirement of 5.3.8.2.

5.3.9 Burst Pressure: The brake with actuator piston extended to simulate a maximum worn condition shall withstand a pressure test as noted in Table II. Unless otherwise specified by the airframe manufacturer, the test pressure shall be the greatest of the following:

2.0 times maximum brake system pressure, assuming no malfunctions.

2.0 times maximum pressure required for Paragraph 5.3.7.2.

2.0 times pressure required for a static torque of 0.55 SR with brake at 70°F (fixed wing aircraft).

2.0 times pressure required to hold rotorcraft on a 20° slope.

5.3.10 Endurance: The brake shall be subjected to N_1 cycles of application and release pressure equal to normal operating pressure and N_2 cycles at a pressure equivalent to the maximum operating pressure as specified in Table II. Normal operating pressure shall be defined as - (1) the average pressure required to conduct the "A" portion of the dynamic brake tests of Table II if the stops are made with a constant pressure; or (2) the average of the maximum pressure required to conduct the "A" portion of the dynamic brake tests of Table II if the stops are made with a variable pressure to simulate predetermined torque-speed curves. The maximum operating pressure shall be defined as the greatest of - (1) the pressure required to develop a static torque of 0.55 SR (where S is the static rating and R the normal rolling radius) at 70°F temperature; or (2) the maximum pressure required to conduct the dynamic torque tests of Table II; or (3) the maximum brake line pressure available to the brakes. During this test, the minimum piston travel shall be no less than the maximum allowable piston travel prior to adjustments. The first portion of the test may be divided into four parts, such that $N_1/4$ cycles may be applied at each of four positions of brake piston travel conforming to 25 per cent, 50 per cent, 75 per cent, and 100 per cent travel, respectively. The total leakage during this test shall be limited to 5 c.c. No malfunction shall be evident during or upon completion of this test.

5.3.11 Taxi and Parking Test: At least one maximum weight landing test followed by a taxi roll, one taxi stop, and parking test, which realistically simulates normal airplane operation, shall be conducted on the dynamometer. The taxi speed and distance shall be obtained from the airplane manufacturer.

Prepared by
SAE Committee A-5, Aircraft Wheels,
Brakes, Skid Controls & Axles