

WHEELS AND BRAKES
MINIMUM REQUIREMENTS FOR CIVIL AIRCRAFT APPLICATIONS

Issued 8/1/50
Revised 2/1/59

1. PURPOSE: To specify minimum requirements for aircraft wheels and brakes for civil aircraft applications.
2. SCOPE: This specification covers minimum requirements for 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 as follows, and as applicable, in accordance with the ratings selected:

	Wheel	Brake
(a) Size	x	
(b) Serial number and date of manufacture	x	x
(c) Manufacturer's name and drawing number	x	x

Markings shall be of such character that they will not be obliterated or effaced as a result of service usage.
4. DETAIL REQUIREMENTS:
 - 4.1 Design:
 - 4.1.1 Brake Fluid: All hydraulic brakes shall be designed and tested to operate with hydraulic brake fluid or oil specified for the airplane on which the brakes are used.
 - 4.1.2 Lubricant Retainers: Suitable retainers shall be provided to prevent lubricant from reaching the braking surface 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.

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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 Radiographic Control: Castings shall be produced under radiographic control when a new foundry source is established, when new size or shape castings are made, or when a change is made in foundry technique. All subsequent inspection of production castings shall require inspection per AWP 586.
- 4.3.2 Castings: Castings shall be of high quality, clean, sound, and free from blowholes, porosity, or surface defects caused by inclusions, except that loose sand or entrapped gases may be allowed when the serviceability of the casting has not been impaired.
- 4.3.3 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.
- 4.3.4 Rim Surfaces: The surface of the rim between bead seats shall be free from defects which will be injurious to the inner tube. Holes which extend through a rim shall be drilled out and filled with a flush plug. Other depressions in 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.
- 4.3.5 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.
- 4.3.6 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.
- 4.3.7 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.

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- 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 = Maximum Kinetic Energy Capacity in ft-lbs at Design Landing Weight.
V_{so} = Minimum Stalling Speed in MPH, (not applicable to Method II analysis per paragraph 5.4.7.1(b)).

- 5.2 Tests Required: Except as qualified by 5.3, the ratings for wheel-brake assemblies shall be substantiated by the following tests as applicable.

- (a) Wheel loads, Table I
- (b) Brake Capacity, Table II

- 5.3 Exceptions - as noted:

- (a) Tail wheels need not be roll tested.

- 5.4 Test Methods:

- 5.4.1 Radial Load Test: This test shall consist of the application of a load equally on both sides of the wheel, to a straight axle passing through the hub, with the tire restrained against a flat non-deflecting surface so that the point of application of the resisting force is centered in the most critical location. In applying this load, the tire may be inflated with water to the specified pressure and the water gradually bled out as the load is increased so that the pressure in the completely deflected tire will equal that of the completely deflected air-inflated tire. A wheel being tested for use with tubeless tire may use conventional tire and tube for test under paragraph (b).

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- (a) A maximum radial limit load shall be determined by test by loading the wheel assembly to the yield radial load for three separate applications at the same point on the wheel. Successive loadings shall not cause radial permanent set increments of increasing magnitude, and permanent set increment caused by the third loading shall not exceed 5% of the total deflection under that load. Deflections and permanent set readings shall be taken at a suitable point on the wheel to indicate deflections of the wheel rim at the bead seat.

The wheel manufacturer shall select the limit load for which the wheel assembly will be rated.

- (b) After determining the maximum radial limit load, the load shall then be increased to at least the ultimate load. The wheel shall support the ultimate load for at least three seconds without failure.

5.4.2 Side Load Test: This test shall consist of the application of a load to the critical side of the wheel in a direction parallel to the axis of the wheel hub, to the side of the tire casing by means of a block which shall cover an arc of not more than 60 degrees and whose centroid shall fall on a point midway between the rim flange O.D. and the nominal tire O.D.

In applying this load, the wheel shall be restrained only by the axle. The tire may be inflated with water to any pressure, not exceeding the burst test pressure, necessary to accomplish the test. A wheel being tested for any use with tubeless tire may use conventional tire and tube for test under paragraph (b).

- (a) A side limit load of at least 40% of the maximum radial limit load shall be determined by test by loading the wheel assembly to the yield side load. The requirements for loading and permanent set shall be the same as outlined in paragraph 5.4.1.
- (b) After determining the side limit load, the load shall then be increased to at least the ultimate load. The wheel shall support the ultimate load for at least three seconds without failure.

5.4.3 Burst Test: The burst test load shall be applied to the wheel by means of hydrostatic pressure in the tire. The wheel shall be 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

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5.4.4 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.

5.4.5 Tubeless Wheel Pressure Test:

5.4.5.1 Static Test: The tubeless tire and wheel assembly shall be inflated to a pressure of 1.5 times the rated inflation pressure and, when immersed in water, shall show no signs of leakage as evidenced by bubbles.

5.4.5.2 Diffusion Test: The tubeless tire and wheel assembly shall hold the normal deflection pressure for 24 hours with no greater pressure drop than 5%. This test shall be performed after the tire growth has stabilized.

5.4.6 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.

5.4.7 Dynamic Torque Test:

5.4.7.1 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)

(a) Method I

$$K.E. = .0334 W V^2$$

WHERE:

K.E. = Kinetic energy per wheel-brake system - ft-lb
W = Weight, applicable to wheel-brake system - lbs
V = Speed, applicable - mph

(b) Method II

The wheel-brake system kinetic energy may be based on a rational analysis of the sequence of events, which are expected to occur during operational landing at design landing weight or takeoff at maximum weight. The analysis shall include rational or conservative values of airplane speed at which the brakes are applied, braking coefficients of friction between tires and runway, aerodynamic 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.

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- 5.4.7.2 Dynamometer Test: Dynamic torque tests shall be conducted on a suitable inertia brake-testing machine. Conduct wheel-brake tests at the conditions determined by Method I or II calculations and as specified in Table II. Tests may be conducted for the rated energy calculated by Method I and the one stop overload condition on energy calculated by Method II, or the combination may be reversed.
- 5.4.8 Structural Torque Test: The test shall consist of the application of a torque load tangentially to the wheel at radius (R), the normal rolling radius of the tire under rated static load (S). In applying this load, rotation of the wheel shall be prevented by a force transmitted through the brake, or brakes, but need not consist solely of the brake friction force. Wheel-brake assembly shall withstand either a torque load not less than 1.6 SR/B, where B is the number of identical brakes per wheel, for at least three seconds without failure, or 80% of this value without permanent set. If identical brakes are not used, the torque load shall be proportioned rationally between them.
- 5.4.9 Static Pressure: The brake, with the actuator piston extended to simulate a maximum worn condition, shall withstand a pressure test as noted in Table II. The maximum operating pressure is the pressure required to hold statically a torque of not less than .55 SR (as defined above) applied to the wheel, or the maximum pressure used in conducting dynamic tests, whichever is the greater. The pressure required for .55 SR shall be determined during these tests.
- 5.4.10 Endurance: The hydraulic brake shall be subjected to 100,000 cycles of application and release of pressure equal to normal operating pressure, as determined from Dynamic Torque Test, (reference Table II Brake Tests (A) condition) and 5,000 cycles at a pressure equivalent to the maximum operating pressure, as determined from Dynamic Torque Test (reference Table II Brake Test (B) condition). This test shall be conducted using a minimum clearance equivalent to the maximum clearance allowable between adjustments. The first portion of the test may be divided into four parts, such that 25,000 cycles may be applied at each of four positions of brake piston travel conforming to 25 percent, 50 percent, 75 percent, and 100 percent travel, respectively. There shall be no evidence of leakage or other malfunctioning during or upon completion of this test.
- 5.5 Desirable Features:
- 5.5.1 Taxi and Parking Test: It may be desirable to subject the brakes to taxi or parking tests. The exact conditions of test should be determined by the brake manufacturer and airframe manufacturer.
- 5.5.2 Roll Test: For certain types of service it may be desirable to subject the wheel to a roll test of greater than 1000 miles to increase service life. This change is considered desirable for wheels to be used in domestic air carrier type service. In such cases the exact conditions of test should be determined by agreement between the wheel manufacturer and the user.

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TABLE I
WHEEL TESTS

TYPE OF AIRCRAFT	RADIAL LOAD (Ref. 5.4.1)		SIDE LOAD (Ref. 5.4.2)		BURST (Ref. 5.4.3)	ROLL (Ref. 5.4.4) (Ref. 5.1)	TUBELESS INFLATION (Ref. 5.4.5)
	YIELD	ULTIMATE	YIELD	ULTIMATE			
Airplane	1.15 x Limit	2.0 x Limit (Castings) 1.5 x Limit (Forgings)	1.15 x Limit	2.0 x Limit (Castings) 1.5 x Limit (Forgings)	3.5 x Inflation Pressure at Rated Load	1000 mlie (Note 1) at Load 'S'	1.5 x Inflation Pressure at Rated Load
Rotorcraft	As Above	As Above	As Above	As Above	3 x Inflation Pressure at Rated Load	250 Mile (Note 1) at Load 'S'	As Above

Note 1 - Wheel being tested for use with tubeless tire may use conventional tires and tubes to demonstrate wheel fatigue life. However, a minimum of 25 miles shall be conducted using a tubeless tire, seals, valves, etc., to demonstrate suitability of the sealing arrangements.

At the conclusion of the 25 miles, the pressure drop shall not exceed 5% of inflation pressure. Test should be conducted on unit with stabilized (maximum tire growth) condition.