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Aeroplane Wheels and Wheel-Brake Assemblies - Minimum Performance Standards

NOTE: THIS SPECIFICATION IS BASED ON FAA TSO C26c
THE TECHNICAL DIFFERENCES ARE UNDERLINED

A Applicability

1) Wheels and wheel brake assemblies fitted to aeroplanes certificated by the CAA to JAR-25 (Large Aeroplanes), or BCAR Section D.

B Marking

Wheels and wheel-brake assemblies must be legibly and permanently marked with the following information:

1) Name of Manufacturer responsible for compliance.

2) Serial Number or date of manufacture or both.

3) Part Number.

4) The CAA specification number.

5) Size (applies to wheels only).

All stamped, etched or embossed markings must be located in non-critical areas.

C Data Requirements

1) The manufacturer must supply the following data to the CAA Airworthiness Division.

i) One copy of the applicable limitations pertaining to installation of wheels and brakes on aircraft, including the weight of the brake assembly, maximum static load rating, maximum limit load rating, maximum accelerate-stop kinetic energy in foot-pounds (KERT), design landing kinetic energy in ft lbf (KEDL), accelerate-stop deceleration in ft/S^2, design landing stop deceleration in ft/S^2, type of hydraulic fluid used, and the weight of the wheel.

ii) One copy of the manufacturer's test reports.

2) Upon request of the CAA Airworthiness Division the manufacturer must furnish the applicable maintenance instructions.

The latest version of this document is available in electronic format at www.caa.co.uk, where you may also register for e-mail notification of amendments.

Printed copy is available from: TSO, PO Box 29, Norwich NR3 1GN www.tso.co.uk/bookshop
Telephone: 0870 600 5522 e-mail: book.orders@tso.co.uk Fax orders: 0870 600 5533

D Previously Approved Equipment

Wheels and wheel-brake assemblies approved prior to the first issue date of this specification may continue to be manufactured under the provisions of their original approval.

E Standard For Aeroplane Wheels And Wheel-brake Assemblies

E.1 Purpose

This document contains minimum performance standards for aeroplane landing wheels and wheel-brake assemblies.

E.2 Design and Construction

a) **Design**

1) **Lubricant Retainers** Lubricant retainers must retain the lubricant under all operating conditions, prevent the lubricant from reaching braking surfaces, and prevent foreign matter from entering the bearings.

2) **Removable Flanges** All removable flanges must be assembled onto the wheel in a manner that will prevent the removable flange and retaining device from leaving the wheel if a tyre should deflate while the wheel is rolling.

3) **Adjustment** When necessary to assure safe performance, the brake mechanism must be equipped with suitable adjustment devices.

3a) **Wear Indicator**

A reliable wear indicator positioned for easy inspection assessment shall be provided for determining that the wearable elements of the heat sink may no longer perform their intended functions.

4) **Wheel Bearings** When the inboard and outboard bearings of a wheel are not fully interchangeable, means shall be provided to preclude misassembly of bearings having similar external dimensions.

5) **Water Seal** Wheels intended for use on amphibious aircraft must be sealed to prevent entrance of water into the wheel bearings or other portions of the wheel or brake, unless the design is such that brake action and service life will not be impaired by the presence of sea water or fresh water.

6) **Wheel Disintegration and Tyre Bursting (Explosion)** Unless determined to be unnecessary, means must be provided to minimize the probability of wheel and tyre explosions which result from elevated brake temperatures.

7) **Fatigue** The design of the wheel shall be such that the probability of wheel flange separation or other failures resulting in sudden deflation are minimised.

NOTE: The desire effect is for failures to occur in a pre-determined section of the wheel assembly such that only gradual deflation results.

b) **Construction**

1) **Castings** Castings must be of a high quality, clean, sound, and free from blow-holes, 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.

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

3) **Rim Surfaces** For wheels designed for use with a tyre and inner tube combination, the surface of the rim between bead seats must be free from defects which would be injurious to the inner tube while mounting the tyre or while in service.

4) **Rim Joints** For wheels designed for use with a tyre and inner tube combination, joints in the rim surface and joints between rim surfaces and demountable flanges must be smooth, close fitting and non- injurious to the inner tube while mounting the tyre or while in service.

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

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 must be held to a minimum and there must be sufficient unthreaded bearing area to carry the required load. They should be sized to allow use of automatic torque wrenches during assembly.

7) **Steel Parts** All steel parts, except friction surfaces and those parts fabricated from corrosion-resistant steel must be cadmium plated or zinc plated or have equivalent protection from corrosion.

8) **Aluminium Parts** All aluminium alloy parts must be anodized or have equivalent protection from corrosion. This protection must include protection for fuse plug holes, valve stem holes, and other passages.

9) **Magnesium Parts** All magnesium alloy parts must receive a suitable dichromate treatment or have equivalent protection from corrosion. This protection must include protection for fuse plug holes, valve stem holes, and other passages.

10) **Bearing and Braking Surfaces** The bearings and braking surfaces must be protected during the application of finish to the wheels and brakes.

11) **Fatigue** The construction of the wheel must take into account techniques used to improve fatigue resistance of critical areas of the wheel.

12) **Dissimilar Metals** If dissimilar metals are used in the wheel construction, adequate protection must be provided to prevent electrolytic action when exposed to moisture. In addition, it must be shown that thermal expansion will not adversely effect the static strength and fatigue life of the wheel.

E.3 **Rating**

a) Each wheel design must be rated for the following:

1) S = Maximum static load in lbf (ref. para JAR 25.731(b)).

2) L = Maximum limit load in lbf (ref. para JAR 25.731(c)).

b) Each wheel-brake assembly design must be rated for the following:

1) KEDL = Kinetic energy capacity in ft lbf per wheel-brake assembly at the design landing rate of absorption.

2) KERT = Kinetic energy capacity in ft lbf per wheel-brake assembly at the maximum accelerate-stop rate of absorption for wheel-brake assemblies of aeroplanes certificated under JAR-25.

E.4 **Qualification Tests**

The aircraft wheels and wheel-brake assemblies must be tested as follows and the test data included in the applicant's test report.

E.4.1 **Wheel Tests** To establish the S and L ratings for a wheel, test a standard sample in accordance with the following radial, combined, and static load test:

a) **Maximum Radial Load Test** Test the wheel for yield and ultimate loads as follows:

1) **Test Method** Mount the wheel with a tyre of suitable type and fit installed, on its axle, and position it against a flat non-deflecting surface. The wheel axle must have the same angular orientation to the non-deflecting surface that it will have to the runway when it is mounted on the aircraft and is under the maximum limit load. Inflate the tyre to the pressure recommended for the S load with air or water. If water inflation is used, the water must be bled off to obtain the same tyre deflection that would result if air inflation were used. Water pressure may not exceed the pressure which would develop if air inflation were used and the tyre deflected to its maximum extent. Load the wheel through its axle perpendicular to the flat non-deflecting surface. Deflection readings must be taken at suitable points to indicate deflection and permanent set of the wheel rim at the bead seat.

NOTE: Under operating conditions the tyre pressure may increase significantly because of heating the contained gas (or water). In such cases, it should be accounted for in setting the conditions for the tests.

2) **Yield Load** Apply to the wheel a load not less than 1.15 times the maximum radial limit load determined under JAR 25.471 through 25.511. Apply the load with the wheel positioned against the non-deflecting surface, and the valve hole positioned at 90 degrees with respect to the line between the centre of the wheel and the point of contact, then with the valve hole positions 180 degrees, 270 degrees and 0 degrees from the non-deflecting surface. The 90 degree increments must be altered to other positions if the other positions are more critical. Three successive loadings at the 0 degree position may not cause permanent set increments of increasing magnitude. The permanent set increment caused by the last loading at the 0 degree position may not exceed 5 per cent of the deflection caused by that loading or 0.005 inches, whichever is greater. The bearing cups, cones, and rollers used in operation must be used for these loadings. There must be no yielding of the wheel such as would result in loose bearing cups, air, or water leakage through the wheel or past the wheel seal, or interference in any critical areas.

3) **Ultimate Load** Apply to the wheel a load, not less than 2 times the maximum radial limit load for castings and 1.5 times the maximum radial limit load for forgings, determined under JAR 25.471 through 25.511. Apply the load with the same wheel positioned against the non-deflecting surface and the valve hole positioned at 0 degrees with respect to the line between the centre of the wheel and the point of contact.

The wheel must be able to support the load without failure for at least 3 seconds. The bearing cones may be replaced with conical bushings, but the cups used in operation must be used for this loading. If at a point of loading during the test, it is shown that the tyre will not successfully maintain pressure or if bottoming of the tyre on the non-deflecting surface occurs, the tyre pressure may be increased to no more than 2 times the rated inflation pressure. If bottoming of the tyre continues to occur with this increased

pressure, a loading block which fits between the rim flanges and simulates the load transfer of the inflated tyre may be used. The arc of the wheel supported by the loading block must be no greater than 60 degrees.

4) If the radial limit load in paragraph 4.1 b) is equal to or greater than the maximum radial limit in paragraph 4.1 a) 2) and 3), the tests specified in paragraphs 4.1 a) 2) and 3) may be omitted.

b) **Combined Radial and Side Load Test** Test the wheel for the yield and ultimate loads as follows:

1) **Test Method** Mount the wheel, with a suitable tyre of proper fit installed, on its axle, and position it against a flat non-deflecting surface. The wheel axle must have the same angular orientation to the non-deflecting surface that it will have to the runway when it is mounted on the aircraft and is under the combined radial and side load. Inflate the tyre to the pressure recommended for the maximum static load with air or water. If water inflation is used, the water must be bled off to obtain the same tyre deflection that would result if air inflation were used. Water pressure may not exceed the pressure which would develop if air inflation were used and the tyre deflected to its maximum extent. For the radial load component, load the wheel through its axle perpendicular to the flat non-deflecting surface. For the side load component, load the wheel through its axle parallel to the flat non-deflecting surface. The side load reaction must arise from the friction of the tyre or the loading block on the non-deflecting surface. Apply the two loads simultaneously, increasing them either continuously or in increments no larger than 10 percent of the loads to be applied. Alternatively, a resultant load equivalent to the radial and side loads may be applied to the axle. Deflection readings must be taken at suitable points to indicate deflection and permanent set of the wheel rim at the bead seat.

NOTE: Under operating conditions the tyre pressure may increase significantly because of heating of the contained gas (or water). In such cases it should be accounted for in setting the condition for the test.

2) **Yield Load** Apply to the wheel radial and side loads not less than 1.15 times the respective ground loads determined under JAR 25.485, 25.495, 25.497, and 25.499.

Apply these loads with the wheel positioned against the non-deflecting surface and the valve hole positioned at 90 degrees with respect to the line between the centre of the wheel and the point of contact, then with valve hole positioned at 180 degrees, 270 degrees, and 0 degrees from the non-deflecting surface. The 90 degree increments must be altered to other positions if the other positions are more critical. Three successive loadings at the 0 degree position may not cause permanent set increments of increasing magnitude. The permanent set increment caused by the last loading at the 0 degree position may not exceed 5 percent of the deflection caused by that loading, or 0.005 inch, whichever is greater. The bearing cups, cones, and rollers used in operation must be used in this test. There must be no yielding of the wheel such as would result in loose bearing cups, air or water leakage through the wheel or past the wheel seal, or interference in any critical areas. A tyre 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 tyre bead to remain properly positioned under the load. The wheel must be tested for the most critical inboard and outboard side loads.

3) **Ultimate Load** Apply to the wheel radial and side loads not less than 2 times for castings and 1.5 times for forgings the respective ground loads determined under JAR 25.485, 25.495, 25.497, and 25.499.

Apply these loads with the same wheel positioned against the non-deflecting surface and the valve hole positioned at 0 degrees with respect to the centre of the wheel and the point of contact. The wheel must be able to support the load without failure for at least 3 seconds. The bearing cones may be replaced with conical bushings, but the cups used in operation must be used for this loading. If, at a point of loading during the test, it is shown that the tyre will not successfully maintain pressure or if bottoming of the tyre on the non-deflecting surface occurs, the tyre pressure may be increased to no more than 2 times the rated inflated pressure. If bottoming of the tyre continues to occur with this increased pressure, a loading block which fits between the rim flanges and simulates the load transfer of the inflated tyre may be used. The arc of wheel supported by the loading block must be no greater than 60 degrees.

c) **Maximum Static Load Test** Test the wheel for the maximum static load test as follows:

1) **Test Method** Mount the wheel, with a suitable tyre of proper fit installed, on its axle, and position it against a flat non-deflecting surface or a flywheel. The wheel axle must have the same angular orientation to the load surface that it will have to the runway when it is mounted on the aircraft and is under the maximum static load. Inflate the tyre to the pressure recommended for the maximum static load "S". The radial load must be applied to the wheel through the axle and perpendicular to the load surface. The side load, when required must be applied through the wheel axle and parallel to the load surface. For the side load, the wheel axle must be rotated or yawed to the angle which will produce a side load component equal to 0.15 "S" while the wheel is being roll tested.

NOTE: Under operating conditions the tyre pressure may increase significantly because of heating of the contained gas (or water). In such cases, it should be accounted for in setting the conditions for the tests.

2) **Roll Test** The wheel must be tested under the loads and for the distance shown in Table 1. At the end of the test there must be no cracks on the wheel and no leakage through the wheel or past the wheel seal, and the bearing cups may not be loosened in the hub.

Table I:

Category of Aircraft	Load Conditions	Roll Distance (Statute Miles)
JAR-25.....	Maximum static load "S"	2000
	Maximum static load, "S" plus 0.15 "S" side load applied in outboard direction	100
	Maximum static load "S" plus 0.15 "S" side load applied in inboard direction.	100

3) **Roll on Rim Test** The main wheel (nose wheels are excluded from this test) without a tyre must be tested at a speed not less than 10 mph under the loads and distance shown in Table II. The test axle angular orientation with the load surface must approximate that of the aeroplane axle to the runway under maximum static load. At the end of the test there may be cracks but no fragmentation of the wheel. (V = liftoff speed in knots TAS.)

Table II:

Categoryof Aircraft	Load Conditions	Roll Distance (need not exceed 15,000 ft)
JAR-25.....	Maximum static load "S"	$V^2 \times 0.5$

d) **Pressure Test** Pressure test the wheel in accordance with the following:-

1) **Overpressure Test** The wheel must be hydrostatically tested to withstand without failure for at least 3 seconds application of an overpressure factor not less than 4.0 times the rated inflation pressure determined by the applicant.

2) **Diffusion Test** The tubeless tyre and wheel assembly must hold the rated inflation pressure for 24 hours with no greater pressure drop than 5 percent. This test must be performed after the tyre growth has stabilized.

E.4.2 **Wheel-brake Assembly Test**

A sample of a wheel-brake assembly design, with a suitable tyre of proper fit installed, must meet the following tests to qualify the design for its kinetic energy ratings. The wheel of a wheel-brake assembly must be separately tested under paragraph 4.1. The wheel-brake assembly must be tested with the operating medium specified by the manufacturer.

a) **Dynamic Tests** Test the wheel-brake assembly on a suitable inertial brake testing machine in accordance with the following:

1) **Speed and Weight Values** Select either Method I or Method II below to calculate the kinetic energy level which a single wheel and wheel-brake assembly will be required to absorb.

i) **Method I** Calculate the kinetic energy level to be used in the brake testing machine by using the equation:

$$KE = \frac{0.0443\ WV^2}{N}$$

Where:

KE = Kinetic energy per wheel-brake assembly (ft lbf);

W = Design landing weight (lb);

V = Aeroplane speed in knots.

V must be not less than VSO the power-off stalling speed of the aircraft at sea level, at the design landing weight and the landing configuration. For the accelerate-stop tests applicable only to wheel-brake assemblies for aeroplanes certificated under JAR-25, the manufacturer must determine the most critical combination of take-off weight and speed.

N = Number of wheels with brakes.

ii) **Method II** The speed and weight values may be determined by other equations based on rational analysis of the sequence of events expected to occur during an accelerate-stop manoeuvre or an operational landing at maximum landing weight. The analysis must include rational or conservative values for braking coefficients of friction between the tyre and runway, aerodynamic drag, propeller drag, powerplant forward thrust and, if critical, loss of drag credit for the most adverse single-engine or propeller due to malfunction.

2) **Test Requirements** The wheel-brake assembly must bring the inertial testing machine to a stop at the average deceleration, and for the number of repetitions specified in Table III without failure, impairment of operation, or replacement of parts except as permitted in paragraph 4.2 a) 3).

Table III:

Category of Aircraft	Test
JAR-25……	KEDL 100 design landing stops at a deceleration selected by manufacturer but not less than 10 ft/S^2.
	KERT 1 accelerate-stop at a deceleration selected by manufacturer to be representative of the Flight Manual scheduled accelerate-stop data but not less than 6 ft/S^2.

3) **General Conditions** During landing stop tests (KEDL), one change of brake lining is permissible. The remainder of the brake assembly parts must withstand the 100 KEDL stops without failure or impairment of operation.

4) **Accelerate Stop Test (KERT)**

i) The brake wheel and tyre assembly must be capable of absorbing accelerate stop energy KERT throughout the entire defined usable wear range of the heat sink elements (as determined by the means provided to comply with E.2, 3a). Compliance must be shown by an accelerate stop test (KERT) carried out on a brake in which the usable wear range of the heat sink has been consumed by not less than 90%. For this test, allowance may be made for the decelerating effects of available power plant thrust reversers (or propeller reverse pitch). At the commencement of the test the temperature of the brake should be representative of the combined conditions:

1) Maximum permissible temperature for despatch from the ramp and

2) Energy input to the brake as a result of braking during taxying, up to the point of brakes release for take-off (see following note).

NOTE: For the purpose of this test an arbitrary value of 10 percent of KERT would be acceptable to the CAA. However the applicant may choose to submit a value based on a more rational analysis.

ii) The applicant shall define the tyre nominal loaded radius and the relative load rating and inflation pressure used for the tyre, wheel and brake assembly during the accelerate stop test.

iii) The applicant shall determine the amount of energy absorbed by the tyre and brake assembly individually during the accelerate stop test.

iv) After the Accelerate Stop Test the brake must continue to be functional for taxying and to allow the wheel to rotate freely with the brake selected off. There should be no failure which would result in fluid leakage or fire.

v) If so desired it will be permissible in performing the test, for the brake pressure to be released at a speed less than 10 knots in order to simulate a taxi roll sufficient to clear the runway, provided that the capability to have stopped the aircraft within the scheduled distance can be extrapolated from, the test record and also that at the end of such a taxi roll the brake is still capable of bringing the wheel to a stop from whatever taxying speed is used on the test machine.

b) **Brake Structural Torque Test** Apply load S and a torque load specified in paragraph 4.2 b) 1) or 2) as applicable, for at least 3 seconds. Rotation of the wheel must be resisted by a reaction force transmitted through the brake or brakes by an application of at least maximum brake line pressure or maximum brake cable tension in the case of a mechanically operated brake. If such pressure or tension is insufficient to prevent rotation, the friction surface may be clamped, bolted, or otherwise restrained while applying the pressure or tension.

1) For landing gears with only one wheel per landing gear strut, the torque load is 1.2 SR where R is the normal loaded radius of the tyre at rated inflation pressure under load S.

2) For landing gears with multiple wheels per landing gear strut, the torque load is 1.44 SR where R is the normal loaded radius of the tyre at rated inflation pressure under load S.

c) **Overpressure-hydraulic Brakes** The brake with actuator piston extended to simulate a maximum worn condition must withstand hydraulic pressure for at

least 3 seconds, equal to 2 times the maximum brake line pressure available to the brakes.

d) **Endurance Tests - Hydraulic Brakes** The hydraulic brake assembly must be subjected to an endurance test during which the total leakage may not exceed 5cc and no malfunction may occur during or upon completion of the test. Minimum piston travel during the test may not be less than the maximum allowable piston travel in operation. The tests must be conducted by subjecting the hydraulic brake assembly to:

1) 100,000 cycles, of application and release of the average hydraulic pressure needed in the KEDL tests specified in paragraph 4.2 a) 2) except that manufacturers using method II in conducting the tests specified in paragraph 4.2 a) 2) must subject the wheel-brake assembly to the average of the maximum pressures needed in those tests. The piston must be adjusted so that 25,000 cycles are performed at each of the four positions where the piston would be at rest when adjusted for 25, 50, 75, and 100 percent of the wear limit; and

2) 5,000 cycles at the maximum system pressure available to the brakes.