Title 14—AERONAUTICS AND SPACE

Chapter I—Federal Aviation Administration, Department of Transportation

[Docket No. 9193; Amdt. 37-28]

PART 37—TECHNICAL STANDARD ORDER AUTHORIZATIONS

Aircraft Wheels and Brakes

The purpose of this amendment to Part 37 of the Federal Aviation Regulations is to update the standards for aircraft wheels and brakes and to establish standards for small aircraft landing wheel brakes.

This amendment was proposed in Notice 68-24, issued on October 8, 1968 (33 F.R. 15344). Numerous comments were received in response to the notice. Based upon these comments and upon further review within the FAA, a number of changes have been made to the proposed rule. These changes and the FAA's disposition of the public comments are discussed hereinafter.

The marking requirements have been changed to require that the aircraft wheels and brakes be marked with the "part number" rather than the "drawing number". The part number is more meaningful with respect to the identification of a wheel or brake.

In response to comments, the design landing kinetic energy is now identified as "KE_{DL}" rather than "KE_{RT}". The proposal has also been changed to require only one copy of the manufacturers' equipment limitations. In addition, the proposed revision to the current TSO deleting the requirements that manufacturers must furnish the "maximum static load rating" and the "maximum limit load rating" has been withdrawn in response to various comments. The FAA agrees that the manufacturer should continue to furnish this information.

Various comments objected to the requirement in proposed § 37.172(c)(1) that the manufacturer submit to the FAA operating instructions and installation procedures for wheels and brakes. They indicate that such data would serve no useful purpose in approving wheels and brakes under the TSO system. Moreover, it was stated that operating instructions and installation procedures cannot be finalized until the equipment has been tested on the aircraft. It was not the intent of the proposal to require the manufacturer to submit procedures and instructions for installing and operating the wheels and brakes on a particular aircraft. The integration of the wheels and brakes in the aircraft is approved under the type certificate or supplement type certificate. The proposal has been changed to make it clear that the information required to be submitted is only the applicable limitations pertaining to the installation of the wheels and brakes on any aircraft.

One commentator recommended that a general statement be added to the design requirements of the FAA standard for wheels and brakes (herein referred to as Standard) requiring that each wheel/brake unit and its individual components be so designed as to prevent, to the maximum extent possible, an incorrect assembly or installation. While this recommendation goes beyond the scope of the notice, the FAA considers that it has merit and it will be given consideration in future rulemaking actions.

There was also a recommendation that a requirement should be added to the standard for a means to bleed the brake unless proven unnecessary. The FAA does not agree. While most existing brake system designs incorporate provisions for bleeding the system, such provisions are only for convenience in servicing the system. Bleeding provisions are not considered to be a part of the minimum performance standards for brakes.

One of the comments pointed out that, as proposed, the requirement concerning lubricant retainers should be revised to also require that lubricant retainers be suitable under specified normal operation and maximum temperature KE_{RT} conditions. The commentator stated that failure of the retainers could result in grease, thinned by hot temperature, running on to a hot brake assembly and starting a fire. The FAA agrees and this was the intention of the proposal. Therefore, to make this clear, the requirement has been changed to require that lubricant retainers retain the lubricant under all design maximum operating conditions.

A recommendation was made to delete the proposed requirement that water seals must be furnished unless the exposed materials in the wheels are corrosion resistant. The commentator indicated that other acceptable designs could maintain the necessery level of safety. The FAA agrees and proposed section 2(a)(4) has been changed accordingly.

Several comments maintain that explosion of wheel and tires can be prevented through the utilization of a regulator or thermal fuse. These comments recommended that the Standard be changed to require explosion prevention rather than requiring a means to minimize the probability of wheel and tire explosions. The FAA disagrees with these comments, since to its knowledge, there is no means presently available to prevent wheel and tire explosions. Another comment suggested limiting the applicability of the explosion requirement to wheels equipped with brakes that are retracted within the confines of the wings or fuselage. The FAA does not agree with this suggestion since wheel and tire explosions caused by elevated braking temperatures have occurred in both retracted and extended gear positions.

The rating requirements in proposed section 3 of the Standard have been changed to reference Parts 23, 27, and 23 as well as Part 25 of the Federal Aviation Regulations.

Comments were also received recommending that the Standard require the airframe manufacturer to supply the wheel manufacturer with the radial load limits for wheels. The FAA does not agree with this recommendation. While the manufacturer is not prohibited from securing information from the airframe manufacturer, there is no reason to require him to do so. However, the proposal has been changed to make it clear that the radial limit load must be determined under the regulations applicable to the aircraft.

One commentator recommended that the rating requirements in the Standard be revised to also specify the kinetic energy capacity rating, KE_{RT}, for Part 23 airplanes. The FAA disagrees. The rating is needed for Part 25 airplanes to permit compliance with § 121.177(a)(1). There is no similar requirement in the General Operating and Flight Rules of Part 91. Therefore, there is no need to require KE_{RT} to be specified for Part 23 airplanes.

In response to comments, a provision has been added to the Qualification Tests provisions of the Standard permitting the maximum radial load tests to be omitted if the radial limit in the combined radial and side load test is equal to or greater than the maximum radial limit load.

The test method provisions for the maximum radial load test and the combined radial and side load test have been corrected to require that the tire must be inflated to the pressure recommended for the "S" load rather than the "L" load. The proposals have also been revised, in response to a comment, to require that for the radial component, the axle must be loaded perpendicular to the nondeflecting surface with the tire restrained and for the side load component, the axle must be loaded parallel to the nondeflecting surface.

There was also a comment to the effect that the method of loading described in proposed paragraphs 4.1(a)(2) and 4.1(b)(2) is confusing. The FAA agrees and the statements in those paragraphs that: "The loadings must not cause permanent set increments of increasing magnitude." and "The permanent set increment caused by the last loading may not ex-

(As published in the Federal Register [35 F.R. 2477] on December 22, 1970)

ceed 5% of the deflection caused by that loading." have been changed to read "The successive loadings at the 0° position may not cause permanent set increments of increasing magnitude. The permanent set increment caused by the last loading at the 0° position may not exceed 5 percent of the deflection caused by that loading."

In response to a comment received, the ultimate load provisions of the wheel tests in proposed paragraphs 4.1(a)(3) and 4.1(b)(3) have been clarified to require application of a radial load "2 times the maximum radial limit load for castings and 1.5 times the maximum radial limit load for forgings." The proposed requirement of a radial load 2 times larger than the *L* load for castings and 1.5 times larger than the *L* load for forgings, if taken literally could result in factors of 3 and 2.5, respectively, and this was not the intent of the proposal.

One commentator questioned the procedure in paragraph 4.1 which would permit the use of a tube in a tubeless tire for the qualification tests. The commentator indicated that unless a tubeless tire can be shown to be superior in all considerations of load and use, a tube should be required at all times in service. The FAA, however, considers that it is reasonable and appropriate to permit the use of either a tube or tubeless tire in the qualification tests. These tests are concerned with the yield and ultimate loading of wheels, not tires.

As proposed, the test methods proposed in paragraphs 4.1(a)(1) and 4.1(b)(1) contain the statement that "Use of strain gauges or special coatings to show regions of high stress is desirable. "One comment recommended that this statement be changed to require a determination of the regions of high stress. The FAA does not agree. The purpose of the tests is to determine the yield and ultimate strength of the wheel. While locating regions of high stress is desirable, it is not essential for the qualification tests. To avoid any confusion, the proposed statement has been deleted from the final standard.

Another comment questioned the use of a 1.15 load factor in the combined yield load tests proposed in paragraph 4.1(b)(2). It was maintained that this load factor is normally used only with the wheel limit load and that the ground loads are determined from the critical load environment of a particular aircraft and are not necessarily limit loads. The FAA does not agree that the use of a 1.15 load factor with ground loads is incorrect. While it is true that the magnitude of these limit loads vary depending on the critical loading condition specified, the load factor is still applicable in demonstrating wheel yield load. In the current Standard this load factor is used with respect to both radial limit load and side load tests and is retained in the combined load test to ensure continued integrity of the wheel.

In response to a comment that it is unreasonable and unrealistic to apply the same combined yield load in both the inboard and outboard direction, the FAA has clarified that provision of proposed paragraph 4.1(b)(2) to now require that the wheel be tested for the most critical inboard and outboard loads.

One commentator questioned the basis and use in proposed paragraph 4.1(b) of "limit radial" and "limit side" loads in conjunction with the combined load limits. The commentator contends that L_R and L_S as used in past radial and side load tests where $L_S=40\%\ I_R$, were based on strut limit loads. This is not the case, however, the "limit radial" and "limit side" loads are based on the design ground loads specified in the regulations.

Several comments were received indicating the need for a roll test. It was pointed out that paragraph 4.1 does not contain the roll test needed to establish the static load rating "*S*" as required by the Standard. The FAA agrees that a roll test is necessary in order to establish the required "*S*" rating and a new paragraph 4.1(c) has been added which contains the same roll test that is required by the current TSO.

One comment stated that the wheel-brake system test should include the emergency brake fluid if it is different from the normal brake fluid. The FAA agrees. If a backup or emergency brake system utilizes an operating medium that is different from that used in the normal brake system, then the backup or emergency system should be tested with that medium. The Standard has been revised accordingly.

A comment was received recommending that proposed paragraph 4.2(a)(1)(i) be changed to require, for rotorcraft, that the most critical combination of takeoff weight and speed or landing weight and speed, whichever is the most critical, be used in calculating the kinetic energy level. The FAA considers that the takeoff weight will in all cases be the most critical weight. However, since rotorcraft do not have a V_1 speed, the requirement has been clarified by changing the word "speed" to "brake" application speed". This speed is the maximum speed at which the brakes can be applied and more appropriately defines the requirement.

One commentator questioned the use of KE_{RT} in proposed paragraph 4.2(a)(2). The commentator indicates that problems have been continually experienced in rejected takeoff approximating KE_{RT} in failing to stop the aircraft in the published distances. However, the FAA service records do not indicate a need for a higher KE_{RT} value and the commentator did not submit any data to support the statement.

One commentator contends that the brake requirements in the proposed Standard for Parts 23 and 25 airplanes are out-dated and do not represent the current state-of-the-art practice. Moreover, the commentator states that aircraft brakes certificated under Part 23 should meet the same requirements as those under Part 25. The FAA disagrees. The brake requirements proposed in Notice 68–24 are based on current industry standards for wheels and brakes. In addition, the performance characteristics and mode of operation of Parts 23 and 25 airplanes differ considerably, consequently their brake needs are different.

It was recommended that a provision be added to the proposed Standard stating that "The brakes need not be reusable after the accelerate-stop test to KE_{RT}. The FAA does not agree. Brakes must be usable upon completion of the accelerate-stop test to provide the capability of taxiing off the runway and this is required in the current TSO. Accordingly, the proposal is revised to make it consistent with the current Standard and to make it clear that brakes must be usable to taxi the aircraft off the runway after the accelerate-stop test to KE_{RT}.

Another comment contained a recommendation that the accelerate-stop (KE_{RT}) brake test be conducted on the same brakes that were used for the design landing stop (KE_{DL}) tests. The FAA does not agree with this recommendation. Service experience has not disclosed any problems concerning the inability of aircraft to meet published stopping distances because of noneffective braking on dry runways.

Two comments recommended that the leakage allowed during the endurance tests for the hydraulic brake-wheel assembly be changed to one drop of fluid per each 3 inches of peripheral seal length for each 25 cycles rather than 5 cc. The FAA does not agree. Although several methods of leakage measurements are available, the volumetric approach is the most consistent.

One commentator suggested that the proposed life cycle tests for hydraulic brakes are unnecessarily complicated and that 100,000 cycles of maximum brake operating pressure would adequately test the brake structure. The FAA does not agree. The proposed requirements have been accepted by the industry and effectively demonstrate the capacity of the brake/wheel assembly.

A suggestion was also made that a requirement should be added for parking with rated parking pressure for some definite period of time such as 30 minutes. While the FAA sees merit in this suggestion, it is beyond the scope of the notice. However, the FAA plans to consider this in future rulemaking.

A comment was also received stating that consideration must be given to uneven braking in an abort or loading (KE_{DL} or KE_{RT}) caused by maximum crosswind. Uneven braking use to keep the aircraft aligned on the runway will add considerably to the energy absorbed by the downwind gear, which also has added weight on it due to the heeling of the aircraft. In addition, the comment states that consideration must be taken during KE_{DL} or KE_{RT} testing for uneven braking on individual wheels due to malfunction or uneven antiskid operation on other wheels on dry pavement, to better simulate operation of the brake/wheel assembly in line operations. While the FAA agrees with the intent of the foregoing comment, it is of the opinion that the recommendation is more appropriate for an amendment to the airworthiness requirements for aircraft. The problem presented in this comment is one reason why the current airworthiness standards for aircraft require actual maximum KE acceleration and stop flight tests rather than relying on dynamometer test results for new or replacement brakes. With regard to uneven antiskid operation, the FAA considers that since certain operating rules provide a 1.66 factor on landing distance it adequately accounts for such operations.

In view of the vibration problems encountered on some of the newer airplanes, one comment suggested that the TSO Standard should incorporate a requirement for dynamic testing of the complete wheel/brake, strut/landing gear system. Also note should be taken of the amount of return pressure or back pressure in the hydraulic system that the brake will tolerate for a complete release of the brake when brakes are not applied. The FAA does not agree. Dynamic testing of a complete wheel/brake, strut/landing gear system, and the determination of the hydraulic system back pressure that the brake will tolerate for a complete release of the brake involve aircraft systems and parts other than the wheels and brakes. Thus, the tests are necessarily part of the installation of the wheel and brake assembly on an aircraft to be covered under the aircraft type certificate or supplemental type certificate.

Several comments pointed out that the proposed TSO Standard deletes certain requirements found in the current TSO concerning material, workmanship and construction, and requirements for castings. The FAA agrees that there is a need to retain the requirements concerning construction which includes requirements concerning castings and also protective treatment. This change merely makes TSO C-26b consistent with existing TSO C-26a. However, the FAA does not consider that special requirements concerning materials and workmanship as contained in current TSO C-26a are any longer necessary. Compliance with the proposed requirements will show suitability of materials and quality of workmanship.

Finally, the nomenclature for "*S*" and "*L*" loads in the rating requirements has been changed to agree with the nomenclature used for those loads in the Federal Aviation Regulations.

Other minor changes of an editorial or clarifying nature have been made. They are not substantive and do not impose an additional burden on any person.

In consideration of the foregoing, § 37.172 of the Federal Aviation Regulations is amended to read as hereinafter set forth, effective January 21, 1971.

§ 37.172 Aircraft wheels and brakes—TSO-C26b.

(a) *Applicability*. The TSO prescribes the minimum performance standards that aircraft landing wheels and brakes must meet in order to be identified with the applicable TSO marking. New models of such equipment which are to be so identified and which are manufactured on or after the effective date of this standard must meet the requirement of the Federal Aviation Administration Standard for Aircraft Wheels and Brakes set forth at the end of this section.

(b) *Marking*. In lieu of the marking requirements of § 37.7, the aircraft wheels and brakes must be legibly and permanently marked with the following information:

(1) Name of the manufacturer responsible for compliance.

(2) Serial number and part number.

(3) Applicable technical standard order (TSO) number.

(4) Size (this marking applies to wheels only).

All stamped, etched, or embossed markings must be located in noncritical areas.

(c) *Data requirements*. In addition to the data specified in § 37.5, the manufacturer must furnish to the Chief, Engineering and Manufacturing Division, Federal Aviation Administration, in the region in which the manufacturer is located (or, in the case of the Western Region, the Chief, Aircraft Engineering Division), the following technical data:

(1) 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 rejected takeoff kinetic energy in foot-pounds (KE_{RT}), design landing kinetic energy in foot-pounds (KE_{DL}), applicable speed as specified in paragraph 4.1(a)(1) of the FAA Standard for Aircraft Wheels and Brakes, type of hydraulic fluid used, and the weight of the wheel.

(2) One copy of the manufacturer's test report.

(3) One copy of the manufacturer's maintenance instructions.

(d) *Previously approved equipment*. Wheels and brakes approved prior to the effective date of this section may continue to be manufactured under the provisions of their original approval.

FEDERAL AVIATION ADMINISTRATION STANDARD FOR AIRCRAFT WHEELS AND BRAKES

1. *Purpose*. This document contains minimum performance standards for aircraft landing wheels and brakes.

2. *Design and Construction*—(a) *Design*—(1) *Lubricant retainers*. Lubricant retainers must retain lubricant under all maximum operating conditions, prevent 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 its retaining device from leaving the wheel if a tire should deflate while the wheel is rolling.

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

(4) *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.

(5) *Explosion prevention*. Unless determined to be unnecessary, means must be provided to minimize the probability of wheel and tire explosions which result from elevated brake temperatures.

(b) *Construction*—(1) *Castings*. Castings must be of high quality, clean, sound, and free from blowholes, porosity, or surface defects caused by inclusions, except that loose sand or entrapped gasses may be allowed when the serviceability of the casting has not been impaired.

(2) *Forgings*. Forgings must 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.

(3) *Rim surfaces*. The surface of the rim between bead seats must be free from defects which will be injurious to the inner tube. Holes which extend through a rim must be drilled out and filled with a flush plug. Other depressions in rim or bead seats which might injure the tube or casing must be filled with a hard surface permanent filler before applying the primer coat.

(4) *Rim joints*. Joints in the rim surface and joints between rim surfaces and demountable flanges must be smooth, close-fitting, and noninjurious to the inner tube while mounting the tire, or while in service.

(5) *Rivets and bolts*. When rivets are used, they must be well headed over, and rivets or 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.

(7) *Steel parts*. Wherever possible all steel parts, except braking surfaces and those parts fabricated from corrosion resistant steel, must be cadmium plated or zinc plated. Where cadmium or zinc plating cannot be applied, the surface must be thoroughly cleaned and suitably protected from corrosion.

(8) *Aluminum parts*. All aluminum alloy parts must be anodized or have equivalent protection from corrosion.

(9) *Magnesium parts*. All magnesium alloy parts must receive a suitable dichromate treatment or have equivalent protection from corrosion.

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

3. *Rating*. (a) Each wheel design and wheel-brake system design must be rated for the following:

(1) S=Maximum static load in pounds (ref. §§ 23.731(b), 25.731(b), 27.731(b), and 29.731(b) of this chapter).

(2) L=Maximum limit load in pounds (ref. §§ 23.731(c), 25.731(c), 27.731(c), and 29.731(c) of this chapter).

(b) Each wheel-brake system design must also be rated for the following:

(1) KE_{DL}=Kinetic energy capacity in foot-pounds per wheel-brake system at the design landing rate of absorption.

(2) KE_{RT}-Kinetic energy capacity in foot-pound per wheel-brake system at the rejected takeoff rate of absorption for wheel-brake systems of airplanes certificated under Part 25 of this chapter only.

4. *Qualification tests*—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 the yield and ultimate loads as follows:

(1) *Test method*. Mount the wheel with tire installed on its axle, and position it

against a flat nondeflecting surface. The wheel axle must have the same angular orientation to the nondeflecting surface that it will have to the runway when it is mounted on the aircraft and is under the maximum limit load. Inflate the tire to the pressure recommended for the *S* load with air or water. If water inflation is used, the water must be bled off during loading to approximate the same tire 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 tire was deflected to its maximum extent. Load the wheel through its axle perpendicular to the flat nondeflecting surface. Deflection readings must be taken at suitable points to indicate deflection and permanent set of the wheel rim at the bead seat.

(2) *Yield load.* Apply to the wheel a load, not less than 1.15 times the maximum radial limit load, determined under §§ 23.471 through 23.511, or §§ 25.471 through 25.511, or §§ 27.471 through 27.505, or §§ 29.471 through 29.511 of this chapter, as appropriate. Apply the load with the wheel positioned against the nondeflecting surface, and the valve hole positioned at 0° with respect to the line between the center of the wheel and the point of contact, then with the valve hole positioned 90°, 180°, and 270° from the nondeflecting surface, and finally twice again with the valve hole positioned at 0°. The 90° increments must be altered to other positions if the other positions are more critical. The successive loadings at the 0° position must not cause permanent set increments of increasing magnitude. The permanent set increment caused by the last loading at the 0° position may not exceed 5 percent of the deflection caused by that loading. 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 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 §§ 23.471 through 23.511, or §§ 25.471 through 25.511, or §§ 27.471 through 27.505, or §§ 39.471 through 39.511 of this chapter, as appropriate. Apply the load with the same wheel positioned against the nondeflecting surface and the valve hole positioned at 0° with respect to the line between the center of the wheel and the point of contact. The load must be sustained for 10 seconds. The bearing cones may be replaced with conical bushings, but the cups used in operation must be used for this loading. A tubeless tire may be replaced with a tire and tube.

(4) If the radial limit load in subparagraph (b) is equal to or greater than the maximum radial limit in subparagraphs (a) (2) and (3), the tests specified in subparagraphs (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 tire installed on its axle, and position it against a flat nondeflecting surface. The wheel axle must have the same angular orientation to the nondeflecting surface that it will have to the runway when it is mounted on the aircraft and is under the limit radial load. Inflate the tire to the pressure recommended for the maximum static load with air or water. If water inflation is used, the water must be bled off during loading to approximate the same tire 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 tire were deflected to its maximum extent. For the radial load component, load the wheel through its axle perpendicular to the flat nondeflecting surface. For the side load component, load the wheel through its axle parallel to the flat nondeflecting surface. The side load reaction must arise from the friction of the tire on the nondeflecting 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.

(2) *Yield load.* Apply to the wheel radial and side loads not less than 1.15 times the respective ground loads determined under § 23.485, or § 25.485, or § 27.485, or § 29.485 of this chapter, as appropriate. Apply these loads with wheel positioned against the nondeflecting surface and the valve hole positioned at 0° with respect to the center of the wheel and the point of contact, then with the valve hole positioned 90°, 180°, and 270° from the nondeflecting surface, and finally twice again with the valve hole positioned at 0°. The 90° increments must be altered to other positions if the other positions are more critical. The successive loadings at the 0° position must not cause permanent set increments of increasing magnitude. The permanent set increment caused by the last loading at the 0° position may not exceed 5 percent of the deflection caused by that loading. 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 leakage through the wheel or past the wheel seal, or interference in any critical areas. 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 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 § 23.485, or § 25.485, or § 27.485, or § 29.485 of this chapter, as appropriate. Apply these loads with the same wheel positioned against the nondeflecting surface and the valve hole positioned at 0° with respect to the center of the wheel and the point of contact. The load must be sustained for 10 seconds. The bearing cones may be replaced with conical bushings, but the cups used in operation must be used for this loading. A tubeless tire may be replaced with a tire and tube. The wheel must be tested for the most critical inboard and outboard side loads.

(c) *Maximum static load test.* Test the wheel for the maximum static load test as follows:

(1) *Test method.* Mount the wheel with the tire installed on its axle, and position it against a flat nondeflecting surface. The wheel axle must have the same angular orientation to the nondeflecting surface that it will have to the runway when it is mounted on the aircraft and is under the maximum limit load. Inflate the tire to the pressure recommended for the maximum limit load "*S*" with air. Load the wheel through its axle perpendicular to the flat nondeflecting surface.

(2) *Roll test.* Apply to the wheel a load not less than the maximum static load determined under §§ 23.471 through 23.511, or §§ 25.471 through 25.511, or §§ 27.471 through 27.505, or §§ 29.471 through 29.511 of this chapter, as appropriate. While loaded, roll the wheel 1,000 miles for airplanes and 250 miles for rotorcraft. At the end of the test the wheel shall be free of cracks and other types of failures.

(d) *Pressure test.* Pressure test the wheel in accordance with the following:

(1) *Burst test.* The wheel shall be hydrostatically tested, without failure, to a burst pressure that is not less than the inflation pressure at rated load "*S*" times a factor of 3.5 for airplanes and 3 for rotorcraft.

(2) *Static test.* The wheel and tubeless tire assembly shall be inflated to a pressure of 1.5 times the inflation pressure at rated load "*S*" and, when immersed in water, must show no signs of leakage as evidenced by bubbles.

(3) *Diffusion test.* The tubeless tire and wheel assembly must hold the normal deflection pressure for 24 hours with no greater pressure drop than 5 percent. This test must be performed after the tire growth has stabilized.

4.2 *Wheel brake system test.* A sample of a wheel-brake system design 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 system must be tested with the recommended operating medium (e.g., air, or an oil meeting recommended specifications).

(a) *Dynamic torque tests.* Test the wheel-brake system on a suitable inertia brake testing machine in accordance with the following:

(1) *Speed and weight values.* For airplanes, select either Method I or Method II below to calculate the kinetic energy level which a single wheel and brake system will be required to absorb. For rotorcraft, use Method I. Do not consider the decelerating effects of propeller reverse pitch, drag parachutes, and engine thrust reversers.

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

$$KE = 0.0444WV^2$$

Where:

KE = Kinetic energy per wheel-brake system in ft.-lbs. For the design landing test, KE will be subdesignated KE_{DL}, and for the rejected takeoff test, KE_{RT}.

W = Airplane weight per wheel-brake system in pounds. For the design landing test the design landing weight will be used.

V = Airplane speed in knots. For the dedesign landing test the speed will be V_{SO}, the power-off stalling speed of the airplane at sea level at the design landing weight and in the landing configuration.

For the rejected takeoff test, applicable only to airplanes certificated under Part 25 of this Chapter, the manufacturer must determine the most critical combination of takeoff weight and V_1 speed.

For rotorcraft, the manufacturer must calculate the most critical combination of takeoff weight and brake application speed to be used in the above equation.

(ii) *Method II.* The speed and weight values may be determined by other equations based on a rational analysis of the sequence of events expected to occur during operational landing at maximum landing weight. The analysis must include rational or conservative values for braking coefficients of friction between tire 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) The wheel-brake assembly must bring the inertia testing machine to a stop at the average deceleration rate, and for the number of repetitions, specified in the following table without failure, impairment of operation or replacement of parts except as permitted in subparagraph (3) below:

Category of the aircraft on which wheel-brake assembly will be used—

	Tests
Federal Aviation Regulations Part 25.	KE_{DL}: 100 design landing stops at 10 ft./sec.[2]
	KE_{RT}: 1 rejected takeoff stop at 6 ft./sec.[2]
Federal Aviation Regulations Part 23.	KE_{DL}: 35 design landing stops at 10 ft./sec.[2]
Federal Aviation Regulations Parts 27 and 29.	KE_{DL}: 20 design landing stops at 6 ft./sec.[2]

(3) *General conditions.* (i) During landing stop tests (KE_{DL}), one change of brake lining and attached discs is permissible. The remainder of the brake assembly parts must withstand the 100 KE_{DL} stops without failure or impairment of operation.

(ii) During the accelerate-stop tests (KE_{RT}) brake lining and bare discs may be new or used. No less than two landing stop tests must have been completed on the brake prior to this test. The brakes must be usable to taxi the aircraft off the runway after the accelerate-stop test to KE_{RT}.

(iii) As used in this subparagraph, "brake lining" is either individual blocks of wearing material or discs which have wearing material integrally bonded to them. "Bare discs" are plates or drums which do not have wearing material integrally bonded to them.

(b) *Brake structural torque test.* Apply the radial load *S* and a torque load specified in subparagraph (1) of (2) of this paragraph, 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 brake cable tension in the case of a nonhydraulic brake. If such pressure or tension is insufficient to prevent rotation, the friction surfaces may be clamped, bolted, or otherwise restrained, while applying the above 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 rolling radius of the tire 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 rolling radius of the tire under load *S*.

NOTE: The 1.44 factor contains an additional factor of 1.2 to account for occasions when the load of a wheel truck is distributed as much as 10 percent above its design distribution.

(c) *Burst pressure-hydraulic brakes.* The brake with actuator piston extended to simulate a maximum worn condition must withstand hydraulic pressure equal to the greatest of the following:

(1) For brake systems capable of developing only a limited pressure as in power operated brake systems, 2 times the maximum brake line pressure available to the brakes.

(2) Two times the highest pressure used in the tests required by paragraph 4.2(a)(2).

(3) For airplanes, 2 times the pressure required to resist a static torque of 0.55 *SR* with the brake at 70° where *S* is defined in paragraph (b) above.

(4) For rotorcraft, 2 times the pressure required to hold the rotorcraft on a 20° slope at design takeoff weight.

(d) *Endurance tests—hydraulic brakes.* The hydraulic brake-wheel assembly must be subjected to an endurance test during which the total leakage may not exceed 5 cc. 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-wheel assembly to—

(1) 100,000 cycles for airplanes, and 50,000 cycles for rotorcraft, of application and release of the average hydraulic pressure needed in the KE_{DL} tests specified in section 4.2(a)(2) except that manufacturers using Method II in conducting the tests specified in paragraph 4.2(a)(2) must subject the wheelbrake assembly to the average of the maximum pressures needed in those tests. The piston may be adjusted so that 25,000 cycles for airplanes, and 12,500 cycles for rotorcraft, are performed at each of the four positions where the piston would be at rest when adjusted for 25 percent, 50 percent, 75 percent, and 100 percent wear in the friction pads; and

(2) 5,000 cycles for airplanes, and 2,500 cycles for rotorcraft, of application and release of the greater of the following:

(i) The hydraulic pressure that is required to hold a static torque of 0.55 *SR* at 70° F. where *R* is the normal rolling radius;

(ii) The maximum hydraulic pressure used in conducting the dynamic brake tests of paragraph 4.2(a)(2); or

(iii) For brake systems capable of developing only a limited pressure, the maximum brake line pressure available to the brakes.

(NOTE that subparagraphs (c) and (d) of this paragraph require fluid pressure observations to be made during the dynamic torque tests.)

4.3 *Taxi and parking test.* Simulate on the inertia brake testing machine a landing at the maximum weight followed by a realistic roll, taxi stop and park, in accordance with the taxi speed and distance specified by the manufacturer.

(Secs. 313(a), 601, 603, Federal Aviation Act of 1958, 49 U.S.C. 1354(a), 1421, 1423; sec. 6(c), Department of Transportation Act, 49 U.S.C. 1655(c))

Issued in Washington, D.C., on December 15, 1970.

R. S. SLIFF,
Acting Director,
Flight Standards Service.

[F.R. Doc. 70-17156; Filed, Dec. 21, 1970; 8:45 a.m.]