

Department of Transportation  
Federal Aviation Administration  
Aircraft Certification Service  
Washington, D.C.

**TSO-C26d**  
Effective  
Date: {XX/YY/ZZ}

# proposed Technical Standard Order

	<b>Subject</b>	<b>Aircraft Wheels, Brakes and Wheel/Brake Assemblies for Parts 23, 27 and 29 Aircraft</b>
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**1. PURPOSE.** This Technical Standard Order (TSO) tells persons seeking a TSO authorization (TSOA) or letter of TSO design approval (LODA), what minimum performance standards (MPS) their aircraft wheels, brakes and wheel/brake assemblies for small airplanes and rotorcraft must first meet in order to obtain approval and be identified with the applicable TSO marking.

**2. APPLICABILITY.**

**a.** This TSO is effective for new applications submitted after the effective date of this TSO. However, applications submitted against TSO-C26c, Aircraft Wheels and Wheel-Brake Assemblies, with Addendum I, dated May 18, 1984, may be accepted up to six months after the effective date of this TSO, in cases where we know that the applicant was working against the earlier MPS before the new change became effective.

**b.** Aircraft wheels, brakes and wheel/brake assemblies approved under a previous TSO authorizations may continue to be manufactured under the provisions of their original approval, as specified in Title 14 of the Code of Federal Regulations (14 CFR) 21 § 603(b).

**c.** However, major design changes to aircraft wheels, brakes and wheel/brake assemblies approved under TSO-C26c requires a new authorization under this TSO for 14 CFR parts 23, 27, and 29 applications and TSO-C135, Transport Airplane Wheels and Brake Assemblies, dated May 2, 2002, 14 CFR part 25 applications, per 14 CFR § 21.611(b).

**NOTE:** This proposed TSO **does not** provide a MPS for 14 CFR part 25, Transport Category Airplanes. For transport category airplanes, see TSO-135, Transport Airplane Wheels and Brake Assemblies, dated May 2, 2002.

**3. REQUIREMENTS.** New models of aircraft wheels, brakes and wheel/brake assemblies that are to be so identified and that are manufactured on or after the effective date of this TSO must meet the MPS in this TSO, APPENDIX 1, Minimum Performance Standard (MPS) for aircraft wheels, brakes and wheel/brake assemblies for small airplanes and rotorcraft. The MPS is based, in part, on the Society of Automotive Engineers (SAE), Aerospace Recommended Practice (ARP) 5381, Minimum Performance Recommendations for Part 23, 27, and 29 Aircraft Wheels, Brakes, and Wheel-Brake Assemblies, dated October 2000.

**a. Functional Qualification.** The required performance shall be demonstrated under the test conditions specified in APPENDIX 1 of this TSO.

**b. Deviations.** The FAA has provisions for using alternative or equivalent means of compliance to the criteria set forth in the MPS of this TSO. Applicants invoking these provisions shall demonstrate that an equivalent level of safety is maintained and shall apply for a deviation per 14 CFR § 21.609.

**4. MARKING.** Under 14 CFR § 21.607(d), articles manufactured under this TSO must be marked as follows:

**a.** In lieu of the marking specified in 14 CFR 21.607(d), the following information shall be legibly and permanently marked on the major equipment components:

(1) Name of the manufacturer responsible for compliance.

(2) Serial number.

(3) Part number.

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

(5) Rim size (this marking applies to wheels only).

(6) Hydraulic fluid specification (this marking applies to brakes only).

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

**c.** Due to the harsh environments where wheels and brakes operate, metal stamping, etching or permanently affixing a data plate with rivets or drive screws in a non-critical area is satisfactory. Laser marking is also acceptable if it can be read under 2X magnification. Ink stamping is allowed **only** if more permanent means are not possible.

**d.** At least one major component must be permanently and legibly marked with all of the information listed in Paragraph **a.** above, except for the following: the option in 14 CFR § 21.607(d)(2), where the name, type and part number must be used in lieu of the optional model number; and the option in 14 CFR § 21.607(d)(3), where the date of manufacture must be used in lieu of the optional serial number.

**e.** In addition to the requirements of 14 CFR § 21.607(d), each separate component that is easily removable (without hand tools), each interchangeable element, and each separate sub-assembly of the article that the manufacturer determines may be interchangeable must be permanently and legibly marked with at least the name of the manufacturer, manufacturer's subassembly part number, and the TSO number.

**5. APPLICATION DATA REQUIREMENTS.** Under 14 CFR § 21.605(a)(2), the manufacturer must furnish the Manager, Aircraft Certification Office (ACO), Federal Aviation Administration (FAA), responsible for the manufacturer's facilities, one copy each of the following technical data to support the FAA design and production approval:

**a.** Operating instructions and equipment limitations. The limitations shall be sufficient to describe the operational capability of the equipment. In particular, operational or installation limitations resulting from specific deviations granted must be described in detail.

**b.** Installation procedures and limitations. The limitations shall be sufficient to ensure that the wheels, brakes and wheel/brake assemblies, when installed according to the installation procedures, continue to meet the requirements of this TSO. The limitations shall identify any unique aspects of the installation. Finally, the limitations also shall include a note with the following statement:

“The conditions and tests required for TSO approval of this article are minimum performance standards. It is the responsibility of those installing this article either on or within a specific type or class of aircraft to determine that the aircraft installation conditions are within the TSO standards. TSO articles must have separate approval for installation in an aircraft. The article may be installed only if performed under 14 CFR part 43 or the applicable airworthiness requirements.”

**NOTE:** When applicable, identify the appliance as an incomplete system or a multi-use system and describe the functions that are intended to be provided by the appliance.

**c.** Schematic drawings, as applicable to the installation procedures.

**d.** Wiring diagrams, as applicable to the installation procedures.

**e.** List of the components, by part number, that make up the wheels, brakes and wheel/brake assemblies that comply with the standards prescribed in this TSO. Manufacturers should include vendor part number cross-references when applicable.

**f.** Instructions, in the form of a Component Maintenance Manual (CMM) containing information on the periodic maintenance, calibration and repair, for the continued airworthiness of installed wheels, brakes and wheel/brake assemblies, including recommended inspection intervals and service life. Details of deviations granted, as noted in paragraph **5.a** of this TSO, may also be described in the CMM.

**g.** Material and process specifications list.

**h.** The quality control system description required by 14 CFR §§ 21.605(a)(3) and 21.143(a) including functional test specifications to be used to test each production article to ensure compliance with this TSO.

- i. Manufacturer's TSO qualification test report.
- j. Nameplate drawing providing the information required by paragraph 4 of this TSO.

k. A list of all drawings and processes, including revision level, necessary to define the article's design. In the case of a minor change, any revisions to the drawing list need only be made available upon request.

**6. MANUFACTURER DATA REQUIREMENTS.** In addition to the data to be furnished directly to the FAA, each manufacturer must have available for review by the manager of the ACO responsible for the manufacturer's facilities the following technical data:

a. The functional qualification specifications to be used to qualify each production article to ensure compliance with this TSO.

b. Equipment calibration procedures.

c. Corrective maintenance procedures within 12 months after TSO authorization.

d. Schematic drawings.

e. Wiring diagrams.

f. Material and process specifications.

g. Additional requirements may be imposed based on aircraft specifications, wheel and brake design, and quality control specifications. In-service maintenance, modifications, and use of replacement components must be in compliance with the performance standards of this TSO, as well as any additional specific aircraft requirements.

**7. FURNISHED DATA REQUIREMENTS.**

a. One copy of the technical data and information specified in paragraphs 5.a through 5.f of this TSO and any other data or information necessary for the proper installation, certification and use and/or for continued airworthiness of the wheels, brakes and wheel/brake assemblies must accompany each article or multiple articles, if furnished to one source, i.e. operator, repair station, etc., manufactured under this TSO.

b. In addition, a note with the following statement must be included:

“The existence of TSO approval of the article displaying the required marking does not automatically constitute the authority to install and use the article on an airplane. The conditions and tests required for TSO approval of this article are minimum performance standards. It is the responsibility of those desiring to install this article either on or within a specific type or class of aircraft to determine that the aircraft operating conditions are within the capacity of the article demonstrated in accordance with

the TSO standards. The article may be installed only if further evaluation by the user/installer documents an acceptable installation and the Administrator approves the installation.”

**8. AVAILABILITY OF REFERENCED DOCUMENTS.**

a. Copies of SAE ARP5381 may be purchased from the Society of Automotive Engineers Inc., Department 331, 400 Commonwealth Drive, Warrendale, PA 15096-0001. Copies also can be obtained through the SAE Internet website at: [www.sae.org](http://www.sae.org).

b. You may buy copies of Federal Aviation Regulations 14 CFR part 21, Subpart O, from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402-9325. Copies also can be obtained from the Government Printing Office (GPO), electronic CFR Internet website at: [www.access.gpo.gov/ecfr/](http://www.access.gpo.gov/ecfr/).

c. Advisory Circular (AC) 20-110, Index of Aviation Technical Standard Orders, and AC 20-36, Index of Articles Certified under the Technical Standard Order System, may be obtained from the U.S. Department of Transportation, Subsequent Distribution Office, M-30 Ardmore East Business Center, 3341 Q 75th Avenue, Landover, MD 20785, Telephone (301) 322-4477 or FAX (301) 386-5394. Copies also may be obtained from the FAA Internet website at: [www.faa.gov/avr/air/airhome.htm](http://www.faa.gov/avr/air/airhome.htm) and select from the "Available Information" drop down list.

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**APPENDIX 1. MINIMUM PERFORMANCE STANDARD** for aircraft wheels, brakes and wheel/brake assemblies for small airplanes and rotorcraft.

**1. SCOPE:**

This Minimum Performance Standard (MPS) defines the testing required for wheels, brakes, and wheel/brake assemblies to be used on civil aircraft certified under 14 CFR parts 23, 27, and 29. Compliance with this standard does not constitute authorization for installation on an aircraft.

1.1 Applications:

Compliance with these minimum performance standards by manufacturers is required, as a means of assuring that the equipment will have the capability to satisfactorily perform its intended function(s).

**NOTE:** Aircraft operational characteristics and other external influences may affect performance capabilities. Consequently, anticipated aircraft braking performance should be verified by aircraft testing.

1.2 Composition of Equipment:

The words “equipment” or “brake assembly” or “wheel assembly” as used in this document include all components that form the entire unit. For example, a wheel assembly may include half hub(s), bearings, flange(s), drive keys, heat shields, brake disks, and fuse plugs. A brake assembly may include backing plate, torque tube, cylinder assemblies, pressure plate, and heat sink. It should not be inferred from this example that each wheel assembly and brake assembly will necessarily include all or only, the above example components. This will depend on the specific design chosen by the manufacturer.

**2. REFERENCES:**

2.1 Aircraft Year Book - Tire and Rim Association, Inc.

2.2 SAE ARP5381, Minimum Performance Recommendations for Part 23, 27, and 29 Aircraft Wheels, Brakes, and Wheel and Brake Assemblies, issued October 2000.

**3. DEFINITIONS AND ABBREVIATIONS:**

3.1 Wheel Rated Static Load, S:

S = Maximum Static Load (Reference 14 CFR §§ 23.731(a), 27.731(b), and 29.731(b)).

3.2 Wheel Rated Inflation Pressure, WRP:

WRP = Wheel Rated Inflation Pressure (wheel unloaded).

3.3 Wheel Rated Tire Loaded Radius, R:

R = Static Radius at load “S” for the wheel rated tire size at WRP. R is the minimum distance from the axle centerline to the ground.

3.4 Wheel Rated Maximum Radial Limit Load, L:

L = Maximum Radial Limit Load (Reference 14 CFR §§ 23.731(b), 27.731(c), and 29.731(c) of 14 CFR). L is the Wheel Rated Maximum Radial Limit Load (5.2.1).

3.5 Wheel Rated Tire Size(s),  $TS_{WR}$  :

$TS_{WR}$  = Wheel Rated Tire Size(s) approved for fit to the wheel.

3.6 Suitable Tire (for Wheel Test),  $TT_{WT}$  :

$TT_{WT}$  = Wheel Rated Tire Type(s) and Size(s) for Wheel Tests.  $TT_{WT}$  is that which has been determined as being the most appropriate to introduce loads and/or pressure to induce the most severe stresses. The suitable tire may be different for different tests.

3.7 Wheel /Brake Rated Structural Torque,  $ST_R$  :

$ST_R$  = Wheel/Brake Rated Structural Torque.  $ST_R$  is the maximum structural torque, demonstrated (5.3.4).

3.8 Wheel/Brake Rated Design Landing Energy,  $KE_{DL}$ :

$KE_{DL}$  = Wheel/Brake Rated Design Landing Energy.  $KE_{DL}$  is the energy to be absorbed by the wheel/brake/tire assembly during stops performed during the Design Landing Stop test (5.3.2).

3.9 Wheel/Brake Design Landing Speed,  $V_{DL}$ :

$V_{DL}$  = Wheel/Brake Design Landing Speed.  $V_{DL}$  is the initial braking speed for a Design Landing Stop (5.3.2).

3.10 Wheel/Brake Accelerate Stop Energy,  $KE_{RT}$  (for Commuter Category Aircraft):

$KE_{RT}$  = Wheel/Brake Accelerate Stop Energy.  $KE_{RT}$  is that energy which has been demonstrated in accordance with 5.3.3.

3.11 Wheel/Brake Accelerate Stop Speed,  $V_{RT}$  (for Commuter Category Aircraft):

$V_{RT}$  = Wheel/Brake Accelerate Stop Speed.  $V_{RT}$  is that initial brakes-on speed that has been demonstrated in accordance with 5.3.3.

3.12 Brake Rated Wear Limit, BRWL, if installed (for Commuter Category Aircraft):

BRWL = Brake maximum wear limit to ensure compliance with 5.3.3.

3.13 Airplane Maximum Rotation Speed,  $V_R$ :

$V_R$  = Airplane Maximum Rotation Speed.

3.14 Brake Rated Metered Operating Pressure,  $BROP_{max}$ :

$BROP$  = Brake Rated Metered Operating Pressure.  $BROP_{max}$  is the maximum operating pressure that is available to the brake from the metering device in normal operation.

3.15 Brake Rated Maximum Pressure,  $BRP_{max}$ :

$BRP_{max}$  = Brake Rated Maximum Pressure.  $BRP_{max}$  is the maximum pressure that the brake is designed to accommodate from the metering device.

3.16 Brake Rated Minimum Slope Pressure,  $BRSP_{20}$ :

$BRSP_{20}$  = Brake Rated Minimum Slope Pressure.  $BRSP_{20}$  is the minimum pressure required to hold the aircraft on a  $20^\circ$  slope at the aircraft design takeoff weight.

3.17 Brake Rated Retract Pressure,  $BRP_{RET}$  :

$BRP_{RET}$  = Brake Rated Retract Pressure.  $BRP_{RET}$  is the greatest pressure that brake piston retraction to the unpressurized position is assured.

3.18 Brake Rated Maximum Parking Pressure,  $BRPP_{max}$  :

$BRPP_{max}$  = Brake Rated Maximum Parking Pressure.  $BRPP_{max}$  is the maximum pressure that the brake is designed to accommodate from the parking valve.

3.19 Brake Rated Design Landing Pressure,  $BRP_{DL}$ :

$BRP_{DL}$  = Brake Rated Design Landing Pressure.  $BRP_{DL}$  is the average of the peak brake pressures required to accomplish the Design Landing Test.

3.20 Rated Design Landing Deceleration,  $D_{DL}$ :

$D_{DL}$  = Rated Design Landing Deceleration.  $D_{DL}$  is the minimum of the mean flywheel distance averaged deceleration values demonstrated during the 100  $KE_{DL}$  stops of 5.3.2.

3.21 Rated Accelerate Stop Deceleration,  $D_{RT}$  (for Commuter Category Aircraft):

$D_{RT}$  = Rated Accelerate Stop Deceleration.  $D_{RT}$  is the mean flywheel distance averaged deceleration that the wheel-tire and brake assembly will produce when absorbing  $KE_{RT}$ .

3.22 Distance Averaged Deceleration,  $D$ :

$D = ((\text{Initial brakes-on speed})^2 - (\text{Final brakes-on speed})^2) / (2 \times \text{braked flywheel distance})$ ).  $D$  is the distance-averaged deceleration to be used in all deceleration calculations.

3.23 Time, (s):

s = Measurement of time, in seconds.

3.24 Wheel/Brake Energy:

References to wheel/brake energy refer to the energy absorbed by the tire, wheel and brake assembly, unless specifically stated otherwise.

3.25 Brake Lining:

Brake lining is individual blocks of wearable material, discs that have wearable material integrally bonded to them, or discs that have wearable material as an integral part of the disc structure.

3.26 Heat Sink:

The heat sink is the part of the brake that is primarily responsible for absorbing kinetic energy during a stop. The heat sink typically consists of the stationary and rotating disc assemblies.

**4. GENERAL DESIGN SPECIFICATIONS:**

4.1 Design:

Unless shown to be unnecessary, the equipment shall comply with the following:

4.1.1 Bearing 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.

4.1.2 Removable Flanges: All removable flanges must be assembled onto the wheel in a manner that will prevent the removable flanges and retaining devices from leaving the wheel if a tire should deflate while the wheel is rolling.

4.1.3 Adjustment: When necessary to assure safe performance, the brake mechanism must be equipped with suitable adjustment devices.

4.1.4 Water Seal: Wheels intended for use on amphibious airplanes 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.

4.1.5 Burst Prevention: Unless determined to be unnecessary, means must be provided to minimize the probability of wheel and tire explosions that result from elevated brake temperatures.

4.1.6 Wheel Rim and Inflation Valve: The rim dimensions and standard inflation valves are available from the Tire and Rim Association and other standards organizations. (Reference: Aircraft Year Book - Tire and Rim Association Inc.).

4.1.7 Brake Piston Retention: Means shall be considered to prevent the actuation system from allowing hydraulic fluid to escape if the limits of piston travel are reached.

4.1.8 Wear Measurement/Indicator: If installed, a reliable method shall be provided for determining the heat sink wear.

4.1.9 Wheel Bearings: When the inboard and outboard bearings of a wheel are not fully interchangeable, consideration must be given to preclude mis-assembly of wheel bearings.

4.1.10 Fatigue: The design of the wheel should take into account techniques used to improve fatigue resistance of critical areas of the wheel and minimize the effect of the expected corrosion and temperature environment.

4.1.11 Dissimilar Metals: If dissimilar metals are used, adequate protection must be provided to prevent electrolytic action. In addition, the differential effect of thermal expansion should not unduly affect the static strength and fatigue life.

#### 4.2 Construction:

4.2.1 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 gases may be allowed when the serviceability is not impaired. Minor surface imperfections may be removed if strength and serviceability are not impaired.

4.2.2 Forgings: Forgings must be of uniform condition, free from blisters, fins, folds, seams, laps, cracks, segregation, and other imperfections. Minor surface imperfections may be removed if strength and serviceability are not impaired.

4.2.3 Rim Joints and Surfaces: Wheels designed for use with a tire and tube combination, shall be free from defects on the rim surface between bead seats that would be injurious to the tube or casing while mounting the tire or while in service. Rim surfaces, joints between rim surfaces, and/or demountable flanges shall be smooth, close fitting, and non-injurious to the tube while mounting the tire or while in service.

4.2.4 Rivets and Bolts: When rivets are used, they must be properly headed over, and rivets or bolts coming in contact with the casing or tube must be smooth to avoid damage to the tube or casing during normal operation.

4.2.5 Bolts and Studs: When bolts or studs are used for fastening together sections of a wheel or brake the length of the threads must be sufficient to fully engage the nut, including its locking feature, and there must be sufficient unthreaded bearing area to carry the required load.

4.2.6 Steel and Aluminum Parts: The corrosion protection system(s) should be compatible with the expected environment. All aluminum alloy parts must be anodized or have equivalent corrosion protection. This corrosion protection should include all holes and passages.

4.2.7 Magnesium Parts: All magnesium alloy parts should receive a suitable dichromate treatment or have equivalent protection from corrosion. This protection includes fuse plug holes, valve stem holes, and other passages.

4.2.8 Bearing and Braking Surfaces: The bearings and braking surfaces must be preserved during the application of finish to wheels and brakes.

## **5. MINIMUM PERFORMANCE UNDER STANDARD TEST CONDITIONS:**

### 5.1 Introduction:

The test conditions and performance criteria described in this section provide a laboratory means of obtaining TSO-C26d approval.

### 5.2 Wheel Tests:

To establish the ratings for a wheel, it shall be substantiated that standard production wheel samples will meet the following radial load, combined load, roll load and pressure test requirements.

For all tests the wheel shall be fitted with a suitable tire ( $TT_{WT}$ ) and wheel loads applied through the tire or appropriate loading block when applicable.

5.2.1 Radial Load Tests: If the radial limit load of 5.2.2 is equal to or greater than the radial limit load of this paragraph, the test specified in this paragraph may be omitted. Test the wheel for yield and ultimate loads as follows.

5.2.1.1 Test Method: Mount the wheel, with a suitable tire 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 airplane and is under maximum limit load (L). Inflate the tire to the pressure recommended for the Wheel Rated Static Load (S) with gas and/or liquid.

If liquid inflation is used, this must be bled off to obtain the same tire deflection that would result if gas inflation were used.

Liquid pressure should not exceed the pressure that would develop if gas inflation were used, and the tire 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.

5.2.1.2 Yield Load: Apply to the wheel a load not less than 1.15 times the maximum radial limit load (L) determined under 14 CFR §§ 23.471 through 23.511 or 14 CFR §§ 27.471 through 27.505, or 14 CFR §§ 29.471 through 29.511 as appropriate.

Determine the most critical wheel orientation with respect to the non-deflecting surface. Apply the load with the tire loaded against the non-deflecting surface, and with the wheel rotated 90° with respect to the most critical orientation. Repeat the loading with the most critical orientation positioned at 180°, 270° and 0° from the non-deflecting surface.

The bearing cups, cones, and rollers used in operation must be used for these loadings.

Three 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% of the deflection caused by that loading or 0.005 in (0.125 mm), whichever is greater. There must be no yielding of the wheel that results in loose bearing cups, gas or liquid leakage through the wheel or past the wheel seal, or interference in any critical areas.

5.2.1.3 Ultimate Load: Apply to the wheel a load not less than 2.0 times the maximum radial limit load (L) for castings and 1.5 times the maximum radial limit load (L) for forgings, determined under 14 CFR §§ 23.471 through 23.511 or 14 CFR §§ 27.471 through 27.505 or 14 CFR §§ 29.471 through 29.511 as appropriate.

Apply the load with the same wheel and tire loaded against the non-deflecting surface and most critical orientation positioned at 0° with respect to the line between the center of the wheel and the point of contact. The bearing cones may be replaced with conical bushings; however, 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 tire will not successfully maintain pressure or if bottoming of the tire on the non-deflecting surface occurs, the tire pressure may be increased. If bottoming of the tire continues to occur with the increased pressure, a loading block, which fits between the rim flanges and simulates the load transfer of the inflated tire, may be used. The arc of wheel supported by the loading block must be no greater than 60°.

The wheel must support the load without failure for at least 3 seconds. Abrupt loss of load carrying capability or fragmentation during test constitutes failure.

If the radial limit load in 5.2.2 is equal to or greater than the radial limit load in 5.2.1, the tests specified in 5.2.1 may be omitted.

5.2.2 Combined Radial and Side Load Test: Test the wheel for the yield and ultimate loads as follows:

5.2.2.1 Test Method: Mount the wheel, with a suitable tire 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 under the combined radial and side load. Inflate the tire to the pressure recommended for the maximum static load with gas and/or liquid.

If liquid inflation is used, this must be bled off to obtain the same tire deflection that would result if gas inflation were used.

Liquid pressure must not exceed the pressure that would develop if gas inflation were used and the tire 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 component should arise from the friction of the tire or the loading block on the non-deflecting surface.

Apply the two loads simultaneously, increasing them continuously or in increments no larger than 10% of the loads to be applied. (Applicable after 75% of the required loads has been reached.)

If it is impossible to generate the side load, due to friction limitations, it shall be permissible to increase the radial load, or apply a portion of the side load directly to the tire/wheel. In such circumstances it must be demonstrated that the moment resulting from the side load is no less severe than would otherwise have occurred.

Alternately, the 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.

5.2.2.2 Combined Yield Load: Apply to the wheel radial and side loads not less than 1.15 times the respective ground loads determined under 14 CFR §§ 23.485, 23.497, and 23.499, or 14 CFR §§ 27.485 and 27.497, or 14 CFR §§ 29.485 and 29.497 as appropriate.

Apply these loads with the tire loaded against the non-deflecting surface and the wheel with the most critical orientation positioned at 90° with respect to the line between the center of the wheel and the point of contact. Repeat the loading with the most critical orientation positioned at 180°, 270°, and 0° from the non-deflecting surface. The bearing cups, cones, and rollers used in operation must be used in this test.

A tire with a tube installed may be used when testing with a “tubeless” tire only after 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.

Three 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 must not exceed 5% of the deflection caused by that loading or 0.005 in (0.125 mm) whichever is greater. There must be no yielding of the wheel that would result in loose bearing cups, gas or liquid leakage through the wheel or past the wheel seal. There shall be no interference in any critical area between the wheel and brake assembly, or between the most critical deflected tire and brake (with fittings) up to limit load conditions, taking into account the axle flexibility. Lack of interference can be established by analysis and/or tests.

5.2.2.3 Combined Ultimate Load: Apply to the wheel radial and side load not less than 2.0 times for castings and 1.5 times for forgings the respective ground limit loads determined under 14 CFR §§ 23.485, 23.497, and 23.499, or 14 CFR §§ 27.485 and 27.497, or 14 CFR §§ 29.485 and 29.497 as appropriate.

Apply these loads with the same wheel, and tire loaded against the non-deflecting surface and the most critical orientation positioned at 0° with respect to the center of the wheel and the point of contact. The bearing cones may be replaced with conical bushings; however, 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 tire will not successfully maintain pressure; or if bottoming of the tire occurs, the tire pressure may be increased. If bottoming of the tire continues to occur with this increased pressure, a loading block that fits between the rim flanges and simulates the load transfer of the inflated tire may be used. The arc of wheel supported by the loading block must be no greater than 60°.

The wheel must support the load without failure for at least 3 seconds. Abrupt loss of load carrying capability or fragmentation during test constitutes failure.

### 5.2.3 Wheel Roll Test:

5.2.3.1 Test Method: Mount the wheel, with a suitable tire of proper fit installed, on its axle and position it against a flat non-deflecting surface or a flywheel. The angle of the wheel axle relative to the load surface must be representative of the orientation to the load surface that it will have to a flat runway when it is mounted on the aircraft and is under the maximum static load.

During the roll test the tire pressure shall be not less than 1.10 times wheel rated inflation pressure (WRP) for airplanes and 1.12 times wheel rated inflation pressure (WRP) for rotorcraft to account for temperature rise and loaded tire pressure factors.

The radial load must be applied to the wheel through the axle and perpendicular to the load surface.

The wheel must be tested under the maximum static load (S) for a distance of 1000 miles for 14 CFR part 23 aircraft and 500 miles for 14 CFR parts 27 and 29 rotorcraft.

At the end of the test the wheel must have no cracks, there must be no leakage through the wheel or past the wheel seal, and the bearing cups must not be loosened in the hubs.

5.2.3.2 Overpressure Test: The wheel must be tested to withstand without failure for at least 3 seconds application of an overpressure factor not less than 3.5 times the wheel rated inflation pressure (WRP). Plugs may be used at over inflation protection device locations to conduct this test.

5.2.3.3 Diffusion Test: The tubeless tire and wheel assembly must hold the wheel rated inflation pressure (WRP) for 24 hours with a pressure drop no greater than 5%. This test must be performed after the tire growth has stabilized.

### 5.3 Wheel and Brake Assembly Tests:

#### 5.3.1 General:

5.3.1.1 The wheel and brake assembly shall be tested, with a suitable tire ( $TT_{WT}$ ) fitted, on a testing machine in accordance with the following and 5.3.2.

5.3.1.2 For tests detailed in 5.3.2, the test energy ( $KE_{DL}$ ) and brake application speed ( $V_{DL}$ ) must comply with 14 CFR § 23.735 as appropriate, at a minimum (Higher energy and speed combinations may be specified which encompass compliance with applicable regulations.).

5.3.1.3 For tests detailed in 5.3.2 the initial brake application speed shall be as close as practicable to that established in accordance with 5.3.1.2.

5.3.1.4 The brake assembly must be tested using the operating medium specified for use on the aircraft.

#### 5.3.2 Design Landing Test:

5.3.2.1 The wheel/brake/tire assembly under test for 14 CFR part 23 aircraft must complete 100 design landing stops at a mean deceleration ( $D$ ) not less than  $10 \text{ ft/s}^2$  ( $3.05 \text{ m/s}^2$ ).

The wheel/brake/tire assembly under test for 14 CFR part 27 or 29 rotorcraft must complete 20 design landing stops at a mean deceleration not less than  $6 \text{ ft/s}^2$  ( $1.83 \text{ m/s}^2$ ).

The maximum brake pressure used for the 100-stop condition for airplane and the 20-stop condition for rotorcraft shall not be more than the brake rated metered operating pressure ( $BROP_{MAX}$ ).

5.3.2.2 During the 100 stop design-landing test ( $KE_{DL}$ ), for 14 CFR part 23 aircraft, one change of the individual or integrally bonded brake lining is permissible. For discs using integrally bonded wearable material one change is permitted, provided that the disc support structure is not intended for reuse. The remainder of the brake assembly parts must withstand the 100  $KE_{DL}$  stops without failure or impairment of operation. Change of carbon brake discs or carbon disc assemblies is not permissible. Tire changes are permissible to replace worn or deteriorated tires. Lining change is not permitted during the 20 stop test ( $KE_{DL}$ ) for 14 CFR part 27 and 29 rotorcraft.

#### 5.3.3 Accelerate Stop Test (for Commuter Category Aircraft):

5.3.3.1 A test shall be defined for Commuter Category aircraft brakes to meet the requirements of an accelerate-stop condition. The mean deceleration ( $D$ ) for this test shall not be less than  $6 \text{ ft/s}^2$  ( $1.83 \text{ m/s}^2$ ).

#### Guidance Material:

This test is recommended to encompass actual aircraft conditions for the wheel/brake assembly using:

a. The brake rated metered operating pressure ( $BROP_{MAX}$ ).

or

b. The maximum brake pressure consistent with the aircraft's scheduled braking pressure limitations taking account of the maximum predicted tire/runway friction coefficient based on substantiated data.

5.3.3.2 Three (3) 20 to 0 knot taxi stops applied within 10 minutes shall be followed by the accelerate stop of 5.3.3.3. The accelerate-stop of 5.3.3.3 must be initiated within 10 minutes after the conclusion of the last taxi stop. Deceleration for the taxi stops shall not be less than  $6 \text{ ft/s}^2$  ( $1.83 \text{ m/s}^2$ ). Heat sink temperatures shall be recorded prior to taxi and accelerate stops.

5.3.3.3 A full stop demonstration is not required for the brake accelerate-stop test. The test brake pressure may be released at a test machine speed of up to 20 knots. In this case the test parameters must be adjusted such that the energy absorbed by the tire, wheel and brake during the test is not less than the energy absorbed if the test had commenced at the specified speed and continued to zero ground speed.

5.3.3.4 Within 20 seconds of completion of the stop, or brake pressure release in accordance with 5.3.3.3, the brake pressure shall be adjusted to the brake rated maximum parking pressure ( $BRPP_{MAX}$ ) and maintained for 3 minutes.

No sustained fire that extends above the level of the highest point of the tire is allowed before 5 minutes have elapsed after application of parking brake pressure; until this time has elapsed neither fire fighting means nor artificial coolants shall be applied.

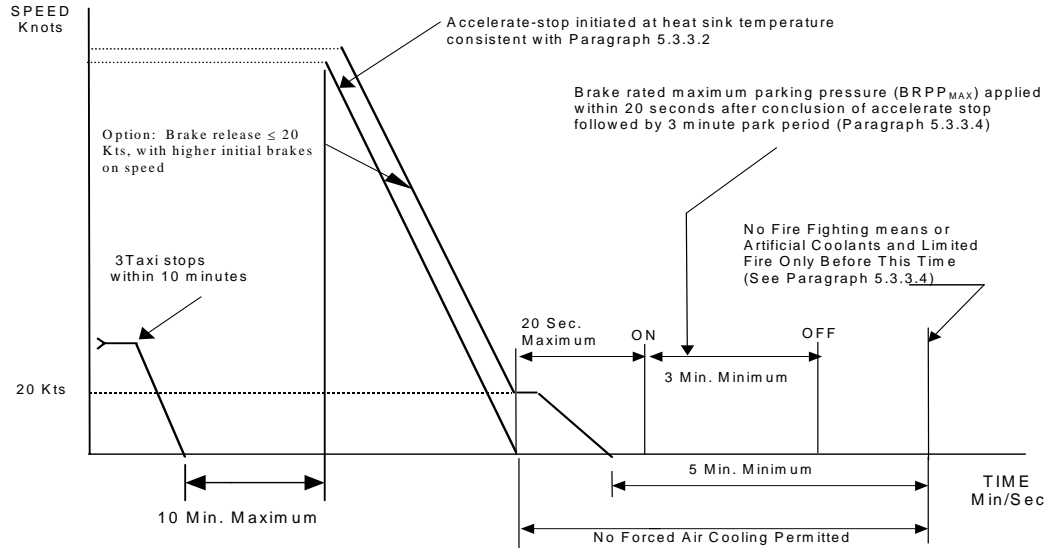
The time when the first fuse plug operates, if applicable, is to be recorded. The sequence of events described in 5.3.3.3 and 5.3.3.4. is illustrated in Figure 1.

#### 5.3.4 Structural Torque Test:

5.3.4.1 Apply wheel rated radial load (S) and the torque load specified in 5.3.4.2 or 5.3.4.3, 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 brake rated maximum pressure ( $BRP_{MAX}$ ), or equivalent. If such pressure or its equivalent is insufficient to prevent rotation, the friction surface may be clamped, bolted, or otherwise restrained while applying the pressure.

5.3.4.2 For landing gear with only one wheel per landing gear strut, the torque load is  $1.2 \times$  wheel rated radial load (S)  $\times$  wheel rated tire loaded radius (R).

5.3.4.3 For landing gear with multiple wheels per landing gear strut, the torque load is  $1.44 \times$  wheel rated radial load (S)  $\times$  wheel rated tire loaded radius (R).



**Figure 1 - Taxi, Accelerate-Stop, and Park Test Sequence for Commuter aircraft**

5.4 Brake Tests:

It shall be substantiated that standard production samples of the brake will meet the following tests:

5.4.1 Overpressure Test: The brake with actuator pistons extended to simulate a maximum worn condition must withstand hydraulic pressure for at least 3 seconds, equal to the following:

- a. For airplanes, 2.0 times the brake rated maximum pressure ( $BRP_{MAX}$ ).
- b. For rotor craft, 2.0 times the brake rated minimum slope pressure ( $BRSP_{20}$ ) or 2.0 times the brake rated maximum pressure ( $BRP_{MAX}$ ) whichever is greater.

5.4.2 Endurance Test: A brake assembly must be subjected to an endurance test during which malfunction may not occur. If desired, the heat sink components may be replaced by a reasonably representative dummy mass for this test.

For airplanes, the test must be conducted by subjecting the brake assembly to 100,000 cycles of application and release of the brake rated design landing pressure ( $BRP_{DL}$ ). The pistons shall be adjusted so that 25,000 cycles are performed at each of the four positions where the pistons would be at rest when adjusted for 25, 50, 75, and 100% of the wear limit. The brake shall also be subjected to 5000 cycles of the brake rated maximum pressure ( $BRP_{MAX}$ ).

For rotorcraft, 50,000 cycles of application and release of brake rated design landing pressure ( $BRP_{DL}$ ) are required with 12,500 cycles at each wear limit position. The brake should then be subjected to 2500 cycles of the brake rated maximum pressure ( $BRP_{MAX}$ ).

Leakage at static seals shall not exceed a trace. Leakage at moving seals shall not exceed one-drop per inch of peripheral length at each condition of wear limit or 5 cc total.

5.4.3 Piston Retention: If included in the design, positively retained hydraulic pistons shall be retained without leakage at 1.5 times brake rated maximum pressure ( $BRP_{MAX}$ ) for 10 seconds with the heat sink removed.

5.4.4 Leakage Tests (Hydraulic Brakes): The brake shall be subjected to an operating pressure equal to 1.5 times brake rated maximum pressure ( $BRP_{MAX}$ ) for 5 minutes. The brake pressure shall then be adjusted to an operating pressure of 5 psig (35 kPa) for 5 minutes. The leak shall be less than one drop per seal and there shall be no permanent set of the structural components during this test.

## 6. DATA REQUIREMENT:

### 6.1 Data Submitted:

For any application for approval of equipment, the manufacturer shall supply the following data:

#### 6.1.1 The following wheel and brake assembly ratings:

##### a. Wheel Ratings

Wheel Rated Static Load, S

Wheel Rated Inflation Pressure, WRP

Wheel Rated Tire Loaded Radius, R

Wheel Rated Maximum Radial Limit Load, L

Wheel Rated Tire Size(s),  $TS_{WR}$

##### b. Wheel/Brake and Brake Ratings

Wheel/Brake Rated Design Landing Energy,  $KE_{DL}$  & associated brakes on speed,  $V_{DL}$ .

Wheel/Brake Rated Accelerated Stop Energy,  $KE_{RT}$  & associated brakes on speed,  $V_{RT}$  (for Commuter Category Aircraft).

Brake Rated Metered Operating Pressure,  $BROP_{MAX}$ .

Brake Rated Maximum Pressure  $BRP_{MAX}$ .

Brake Rated Minimum Slope Pressure,  $BRSP_{20}$  (for Rotorcraft).

Brake Rated Retract Pressure,  $BRP_{RET}$ .

Brake Rated Maximum Parking Pressure  $BRPP_{MAX}$ .

Brake Rated Design Landing Pressure ,  $BRP_{DL}$ .

Brake Rated Wear Limit,  $BRWL$ , if installed (for Commuter Category Aircraft).

Wheel/Brake Rated Structural Torque,  $ST_R$ .

Rated Design Landing Deceleration,  $D_{DL}$ .

Rated Accelerate Stop Deceleration,  $D_{RT}$  (for Commuter Category Aircraft).

6.1.2 The weight of the wheel or brake, as applicable.

6.1.3 Type of hydraulic fluid used (for brakes).

6.1.4 One copy of the documentation to show compliance with the test requirements.

**NOTE:** When test results are being recorded for incorporation in the compliance test report, it is not sufficient to note merely that the specified performance was achieved. The actual numerical values obtained for each of the parameters tested must be recorded, except where tests are pass/fail in character.