AEROSPACE STANDARD

AS5714™ REV. A

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Superseding AS5714

Minimum Performance Standard for Parts 23, 27, and 29 Aircraft Wheels, Brakes, and Wheel and Brake Assemblies

RATIONALE

This document defines the minimum performance standard for TSO-C26e for wheels and brakes on Parts 23, 27, and 29 aircraft with either hydraulic or electric actuation. This also includes requirements for Accelerate-stop tests for Commuter category aircraft and jets over 6000 pounds.

AS5714A has been reaffirmed to comply with the SAE Five-Year Review policy.

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1. SCOPE

This SAE Aerospace Standard (AS) prescribes the Minimum Performance Standards (MPS) for wheel, brake, and wheel and brake assemblies to be used on aircraft certificated under 14 CFR Parts 23, 27, and 29.

Compliance with this specification is not considered approval for installation on any aircraft.

1.1 Application

Compliance with this minimum specification by the TSO applicant is required as a means of assuring that the equipment will have the capability to satisfactorily perform its intended function(s).

NOTE: Certain performance capabilities may be affected by aircraft operational characteristics and other external influences. 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” or “wheel and brake assembly” as used in this document, include all components that form part of the particular unit.

For example, a wheel assembly typically includes a hub or hubs, bearings, flanges, drive bars, heat shields, and fuse plugs. A hydraulically actuated brake assembly typically includes a backing plate, torque tube, cylinder assemblies, pressure plate, wear pin, heat sink, and other axle mounted components integral to the braking activity.

Also as an example, an electrically actuated brake assembly typically includes a backing plate, torque tube, electro-mechanical actuators, pressure plate, wear indicator, heat sink, and other axle mounted components integral to the braking activity.

It should not be inferred from these examples that each wheel assembly and brake assembly will necessarily include either all or any of the above example components; the actual assembly will depend on the specific design chosen by the TSO applicant.

For the purpose of this specification, the interface boundaries of the equipment are the wheel and brake attachments to the landing gear and the electrical connectors to the aircraft brake control system. The aircraft brake control system is a reference to any equipment related to the control of wheel braking that is not assembled to the brake on axle and provides either hydraulic energy to the hydraulic actuators or electrical energy to the Electro Mechanical Actuators (EMAs) and/or monitors sensors mounted in or on the brake assembly. This may also include hydraulic lines and fittings or wiring and connectors as applicable, if not integral to the brake.

2. REFERENCES

2.1 Applicable Documents

There are no referenced publications specified herein.

2.2 Definitions and Abbreviations

2.2.1 Wheel Definitions

2.2.1.1 L - WHEEL RATED RADIAL LIMIT LOAD

L is the wheel rated maximum radial limit load in 4.2.1.

2.2.1.2 S - WHEEL RATED STATIC LOAD

S is the maximum static load (see 14 CFR 23.731(a), 27.731(b), and 29.731(b)).

2.2.1.3 TS_{WR} - WHEEL RATED TIRE TYPE(S) AND SIZE(S)

TS_{WR} is the wheel rated tire type(s) and size(s) defined for use and approved for installation on the wheel, normally by the aircraft manufacturer.

2.2.1.4 TT_{WT} - SUITABLE TIRE FOR WHEEL TEST

TT_{WT} is the wheel rated tire type and size for wheel test. TT_{WT} is the tire type and size determined as being the most appropriate to introduce loads and/or pressure that would induce the most severe stresses in the wheel. TT_{WT} must be a tire type and size approved for installation on the wheel (TS_{WR}), normally by the aircraft manufacturer. The suitable tire may be different for different tests.

2.2.1.5 WRP - WHEEL RATED INFLATION PRESSURE

WRP is the wheel rated inflation pressure (wheel unloaded).

2.2.2 Hydraulically Actuated Brake Definitions

2.2.2.1 $BROP_{MAX}$ - BRAKE RATED MAXIMUM OPERATING PRESSURE

$BROP_{MAX}$ is the maximum design metered pressure that is available to the brake to meet aircraft stopping performance requirements.

2.2.2.2 BRP_{MAX} - BRAKE RATED MAXIMUM PRESSURE

BRP_{MAX} is the maximum pressure to which the brake is designed to be subjected (typically the nominal aircraft maximum system pressure).

2.2.2.3 BRP_{RET} - BRAKE RATED RETRACTION PRESSURE

BRP_{RET} is the pressure to which the brake inlet pressure must be reduced to cause full piston retraction after a brake is sufficiently pressurized to extend all pistons. Applicable only when adjustment means are provided.

2.2.2.4 $BRPP_{MAX}$ - BRAKE RATED MAXIMUM PARKING PRESSURE

$BRPP_{MAX}$ is the maximum parking pressure available to the brake

2.2.2.5 $BRSP_{10}$ - BRAKE RATED MINIMUM SLOPE PRESSURE

$BRSP_{10}$ = Brake Rated Minimum 10° Slope Pressure. $BRSP_{10}$ is the minimum pressure required to hold the rotorcraft applications on a 10° slope at the design takeoff weight.

2.2.2.6 $BRSP_{20}$ - BRAKE RATED MINIMUM 20° SLOPE PRESSURE

$BRSP_{20}$ is the minimum pressure required to hold the rotorcraft on a 20° slope at the design takeoff weight as used for the overpressure hydraulic brake tests of 4.4.1.

2.2.3 Electrically Actuated Brake Definitions

The maximum voltage, current and power ratings refer to the maximum values for voltage, current and power at the actuators in total for all the actuators in an individual brake on test.

2.2.3.1 BOP - BRAKE OFF POSITION

BOP is a retracted EMA position that permits free rotation of the wheel and brake assembly after a brake application and release cycle.

2.2.3.2 EMA - ELECTRO-MECHANICAL ACTUATOR

The EMA is a subassembly of the brake that converts electrical power to brake clamping force.

2.2.3.3 I_{BMAX} - MAXIMUM BRAKE CURRENT

I_{BMAX} is the maximum simultaneous current drawn by all the EMAs of the brake assembly in the most critical of the dynamic tests of 4.3.2 or 4.3.3 as determined by test or analysis of test results.

2.2.3.4 L_{BMAX} - MAXIMUM BRAKE LOAD

L_{BMAX} is the maximum clamping load the brake assembly is designed to generate with maximum brake control system command under normal conditions as established by analysis or test.

2.2.3.5 L_{DL} - BRAKE DESIGN LANDING LOAD

L_{DL} is the average of the 100 peak clamping loads generated in the brake assembly during the KE_{DL} stop test of 4.3.2 as determined by test or analysis of test results.

2.2.3.6 L_{LMT} - BRAKE LIMIT LOAD

L_{LMT} is the maximum clamping load the brake structure may be subjected to in its operation which would not result in permanent deformation that would prevent it from performing its intended function.

2.2.3.7 P_{BMAX} - MAXIMUM EMA BRAKE POWER

P_{BMAX} is the maximum simultaneous power drawn by all the EMAs of the brake assembly in the most critical of the dynamic tests of 4.3.2 or 4.3.3 as determined by test or analysis of test results.

2.2.3.8 PBC - PARKING BRAKE COMMAND

PBC is the configuration to which the EMAs are commanded following a high energy stop as normally defined by the aircraft manufacturer associated with the parking brake applications in 4.3.3.5.

2.2.3.9 V_{BMAX} - MAXIMUM EMA BRAKE VOLTAGE

V_{BMAX} is the maximum voltage applied to the brake assembly during the most critical of the dynamic tests of 4.3.2 or 4.3.3 as determined by test or analysis of test results.

2.2.3.10 $V_{10\ MIN}$ - BRAKE RATED MINIMUM SLOPE VOLTAGE

$V_{10\ MIN}$ is the minimum voltage required to hold the rotorcraft on a 10° slope at the maximum aircraft design takeoff weight.

2.2.3.11 $V_{20\ MIN}$ - BRAKE RATED MINIMUM SLOPE VOLTAGE

$V_{20\ MIN}$ is the minimum voltage required to hold the rotorcraft on a 20° slope at the maximum aircraft design takeoff weight as used for the brake tests of 4.4.1.

2.2.4 Common Definitions

These definitions apply to both Hydraulically Actuated and Electrically Actuated wheel and brake assemblies.

2.2.4.1 BRAKE LINING

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

2.2.4.2 BRWL - BRAKE RATED WEAR LIMIT

BRWL is the brake maximum wear limit to ensure compliance with 4.3.4.1 and 4.3.3.2 if applicable.

2.2.4.3 D - DISTANCE AVERAGED DECELERATION

D = ((Initial brakes-on speed) 2 - (Final brakes-on speed) 2)/(2 (braked flywheel distance)). D is the distance averaged deceleration to be used in all deceleration calculations.

2.2.4.4 D_{DL} - RATED DESIGN LANDING DECELERATION

D_{DL} is the minimum of the distance averaged decelerations demonstrated by the wheel/brake/tire assembly during the 100 KE_{DL} stops in 4.3.2.

2.2.4.5 D_{RT} - RATED ACCELERATE-STOP DECELERATION (FOR COMMUTER CATEGORY AIRCRAFT)

D_{RT} is the minimum of the distance averaged decelerations demonstrated by the wheel/brake/tire assembly during the KE_{RT} stops in 4.3.3.

2.2.4.6 V_{DL} - WHEEL/BRAKE DESIGN LANDING STOP SPEED

V_{DL} is the initial brakes-on speed for a design-landing stop in 4.3.2.

2.2.4.7 V_{RT} - WHEEL/BRAKE ACCELERATE-STOP SPEED

V_{RT} is the initial brakes-on speed used to demonstrate KE_{RT} in 4.3.3.

2.2.4.8 HEAT SINK

The heat sink is the mass of the brake that is primarily responsible for absorbing energy during a stop. For a typical brake, this would consist of the stationary and rotating disc assemblies.

2.2.4.9 KE_{DL} - WHEEL/BRAKE RATED DESIGN LANDING STOP ENERGY

KE_{DL} is the minimum energy absorbed by the wheel/brake/tire assembly during every stop of the 100 stop design landing stop test in 4.3.2.

2.2.4.10 KE_{RT} - WHEEL/BRAKE RATED ACCELERATE-STOP ENERGY (FOR COMMUTER CATEGORY AIRCRAFT)

KE_{RT} is the energy absorbed by the wheel/brake/tire assembly demonstrated in accordance with the accelerate-stop test in 4.3.3.

2.2.4.11 R - WHEEL RATED TIRE LOADED RADIUS

R is the static radius at load “S” for the wheel rated tire size at WRP. The static radius is defined as the minimum distance from the axle centerline to the tire/ground contact interface.

2.2.4.12 ST_R - WHEEL/BRAKE RATED STRUCTURAL TORQUE

ST_R is the maximum structural torque demonstrated in 4.3.4.

2.2.4.13 TS_{BR} - BRAKE RATED TIRE TYPE(S) AND SIZE(S)

TS_{BR} must be the tire type and size (approved for installation on the wheel (TS_{WR})) which transfers the most kinetic energy and torque into the brake during the design landing and rejected takeoff dynamic torque tests, if applicable.

2.2.4.14 TT_{BT} - SUITABLE TIRE FOR BRAKE TESTS

TT_{BT} is the rated tire type and size. TT_{BT} is the tire type and size that has been determined as being the most critical for brake performance and/or energy absorption tests. The TT_{BT} must be a tire type and size approved for installation on the wheel (TS_{WR}), normally by the aircraft manufacturer. The suitable tire may be different for different tests.

2.2.4.15 V_{DL} - WHEEL/BRAKE DESIGN LANDING STOP SPEED

V_{DL} is the initial brakes-on speed for a design landing stop in 4.3.2.

2.2.4.16 V_{RT} - WHEEL/BRAKE ACCELERATE-STOP SPEED (FOR COMMUTER CATEGORY AIRCRAFT)

V_{RT} is the initial brakes-on speed used to demonstrate KE_{RT} in 4.3.3 when applicable.

3. GENERAL DESIGN SPECIFICATIONS

3.1 Airworthiness

The continued airworthiness of the wheels (without brakes) and wheel and brake assemblies must be considered. Activities covering periodic maintenance, calibration, and repair, for the continued airworthiness of installed wheels and wheel and brake assemblies shall be defined in a Component Maintenance Manual per 5.1.7.

3.2 Fire Protection

Except for small parts (such as fasteners, seals, grommets, and small electrical parts) that would not contribute significantly to the propagation of a fire, all solid materials used must be self-extinguishing. See also 3.4.5 and 4.3.3.5.

3.3 Design

Unless shown to be unnecessary by test or analysis, the equipment must comply with the following:

3.3.1 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 lubricated cavity.

3.3.2 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 deflates while the wheel is rolling.

3.3.3 Water Seal

Wheels and brakes intended for use on amphibious aircraft and/or with electric brake actuation shall be sealed to prevent entrance of water and other contaminants 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.

3.3.4 Burst Prevention

For tubeless tire applications, means shall be provided to prevent wheel failure and tire burst that might result from over pressurization or from elevated brake temperatures if applicable. The means shall take into account the pressure and the temperature gradients over the full operating range.

3.3.5 Wheel Rim and Inflation Valve

Tire and Rim Association (refer to the *Aircraft Year Book*, by the Tire and Rim Association Inc.) or the European Tyre and Rim Technical Organization (reference: *Aircraft Tyre and Rim Data Book*) approval of the rim dimensions and inflation valve is encouraged.

3.3.6 Brake Piston Retention

Hydraulically actuated brakes with more than one rotating disk shall incorporate means to ensure that the actuation system does not allow hydraulic fluid to escape if the limits of piston travel are reached.

3.3.7 Wear Indicator

A reliable and readily visible method must be provided for determining when the heat sink is worn to its permissible limit.

3.3.8 Wheel Bearings

When the inboard and outboard bearings of a wheel are not fully interchangeable, consideration shall be given to avoid misassembly of wheel bearings.

3.3.9 Dissimilar Materials

When dissimilar materials are used in the construction and the galvanic potential between the materials indicate galvanic corrosion is likely, effective means to prevent the corrosion must be incorporated in the design. In addition, differential thermal expansion must not unduly affect the functioning, load capability, and the fatigue life of the components.

3.3.10 Brake Release and Wear Adjustment

When provided on hydraulically actuated brakes, the brake release and wear adjustment mechanism shall maintain appropriate running clearance when subjected to BRP_{RET}.

The electrically actuated brake assembly and its control system shall provide a suitable means to maintain an appropriate running clearance throughout the entire heat sink wear and thermal range when no braking is commanded.

3.3.11 Insulation Resistance

The equipment shall have an adequate insulation resistance level to ensure the design is robust to leakage current paths in accordance with established industry standards. The components shall be insulated from the external environment to avoid command current and feedback current signals, that in turn give unnecessary messages in the health monitoring system or flight deck monitors of the system.

3.3.12 Dielectric Strength

The equipment shall have a suitable dielectric withstanding capability for the voltages and voltage surges to which it will be subjected in accordance with established industry standards.

3.3.13 Bonding, Grounding, and Guarding

The equipment shall employ suitable electrical bonding, grounding and guarding techniques in its design to protect ground personnel, and the equipment, from fault currents, and from the potentially high voltages that may be present, in accordance with established industry standards.

3.4 Construction

The suitability and durability of the materials used for components must be established on the basis of similarity or tests. In addition, the materials must conform to approved specifications that ensure the strength and other properties are those that were assumed in the design.

3.4.1 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 serviceability is not impaired. Minor surface imperfections may be removed if the strength and serviceability are not impaired.

3.4.2 Forgings

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

3.4.3 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.

3.4.4 Environmental Protection

All the components used (including electrical wiring insulation) must be suitably protected against deterioration or loss of strength in service due to any environmental cause, such as weathering, corrosion, and abrasion.

3.4.5 Magnesium Parts

Magnesium and alloys having magnesium as a major constituent shall not be used on brakes or braked wheels for commuter category applications. Any such magnesium parts shall not contribute significantly to the propagation of a fire and have suitable corrosion protection including any fuse plug holes, valve stem holes, and other passages as applicable.

3.4.6 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.

3.4.7 Steel and Aluminum Parts

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

3.4.8 Bearing and Braking Surfaces

The bearings and braking surfaces must be preserved during the application of corrosion protection finishes to wheels and brakes.

4. MINIMUM PERFORMANCE UNDER STANDARD TEST CONDITIONS

4.1 Introduction

The test conditions and performance criteria provide a laboratory means of demonstrating compliance with this TSO MPS. The aircraft manufacturer normally defines the relevant test parameter values; however these may also be derived from published aircraft data for applicants for Supplemental Type Certificate (STC).

4.2 Wheel Tests

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

For all tests the wheel must be fitted with a suitable tire, TT_{WT}, and wheel loads must be applied through the tire. The ultimate load tests in 4.2.1.3 and 4.2.2.3 provide for an alternative method of loading if it is not possible to conduct these tests with the tire mounted.

4.2.1 Radial Load Test

If the radial limit load of 4.2.2 is equal to or greater than the radial limit load in this paragraph, the test specified in this paragraph may be omitted. Test the wheel for yield and ultimate loads as follows:

4.2.1.1 Test Method

With a suitable tire, TT_{WT}, installed, mount the wheel 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 a flat runway when it is mounted on an aircraft and is under the maximum radial limit load, L. Inflate the tire to the pressure recommended for the Wheel Rated Static Load, S, with gas and/or liquid. Plugs may be used in place of over pressurization protection device(s) to conduct this test.

If liquid inflation is used, liquid must be bled off to obtain the same tire deflection for each load case that would result if gas inflation were used. Load the wheel through its axle with the load applied 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.

4.2.1.2 Yield Load

Apply to the wheel and tire assembly a load not less than 1.15 times the maximum radial limit load, L. Refer to 14 CFR paragraphs 23.471 through 23.511, or 27.471 through 27.505, or 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 wheel 180°, 270°, and 0° from the most critical orientation. The bearing cups, cones, and rollers used in operation must be used for these loadings. If at a point of loading during the test bottoming of the tire occurs, then the tire pressure may be increased an amount sufficient only to prevent bottoming.

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 inch (0.127 mm), whichever is greater. There must be no yielding of the wheel such as would result in loose bearing cups, liquid or gas leakage through the wheel or past the wheel seal.

4.2.1.3 Ultimate Load

Apply to the wheel used in the yield test in 4.2.1.2, and the tire assembly, a load not less than 2 times the maximum radial limit load, L, for castings, and 1.5 times the maximum radial limit load, L, for forgings. Refer to 14 CFR paragraphs 23.471 through 23.511, or 27.471 through 27.505, or 29.471 through 29.511, as appropriate. If the same wheel test article is used for both the radial and combined load tests, all of the yield loads of 4.2.1.2 and 4.2.2.2 shall be completed before the ultimate loads tests of 4.2.1.3 or 4.2.2.3.

Apply the load with the tire and wheel against the non-deflecting surface and the wheel positioned at 0° orientation (see 4.2.1.2). 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 tire will not successfully maintain pressure or if bottoming of the tire occurs, the tire pressure may be increased. If tire will not hold pressure or if load cannot be successfully applied to the tire with increased pressure, then a loading block that fits between the rim flanges and simulates the load transfer of the inflated tire may be used. The arc of the 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 the test constitutes failure.

4.2.2 Combined Radial and Side Load Test

Test the wheel for the yield and ultimate loads as follows:

4.2.2.1 Test Method

With a suitable tire, TT_{WT}, installed, mount the wheel 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 a flat runway when it is mounted on an aircraft and is under the combined radial and side limit loads. Inflate the tire to the pressure recommended for the maximum static load with gas and/or liquid. Plugs may be used in place of over pressurization protection device(s) to conduct this test.

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

For the radial load component, load the wheel through its axle with load applied perpendicular to the flat non-deflecting surface. For the side load component, load the wheel and tire assembly 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 either continuously or in increments no greater than 10% of the total loads to be applied.

If it is impossible to generate the side load because of friction limitations, the radial load may be increased, or a portion of the side load may be applied 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.

Alternatively, the vector resultant of 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.

4.2.2.2 Combined Yield Load

Apply to the wheel and tire assembly radial and side loads not less than 1.15 times the respective ground limit loads. Refer to 14 CFR paragraphs 23.485, 23.497, and 23.499, or 27.485 and 27.497, or 29.485 and 29.497, as appropriate. If at a point of loading during the test bottoming of the tire occurs, then the tire pressure may be increased an amount sufficient only to prevent bottoming.

Determine the most critical wheel orientation with respect to the non-deflected 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 wheel 180°, 270°, and 0° from the most critical orientation. The bearing cups, cones, and rollers used in operation must be used in this test.

A tube may be used in a tubeless tire 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.

Three successive loadings at the 0° position must not cause permanent set increments of increasing magnitude. The permanent set increment caused by the last loadings at the 0° position must not exceed 5% of the deflection caused by the loading, or 0.005 inch (0.127 mm), whichever is greater. There must be no yielding of the wheel such as would result in loose bearing cups, gas or liquid leakage through the wheel or past the wheel seal.

4.2.2.3 Combined Ultimate Load

Apply to the wheel, used in the yield test of 4.2.2.2, radial and side loads not less than 2 times for castings and 1.5 times for forgings, the respective ground limit loads. Refer to 14 CFR paragraphs 23.485, 23.497, and 23.499, or 27.485 and 27.497, or 29.485 and 29.497, as appropriate.

Apply these loads with a tire and wheel against the non-deflecting surface and the wheel oriented at the 0° position (see 4.2.2.2). The bearing cones may be replaced with conical bushings, but the cups used in operation must be used for this loading.

If at any 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 this increased pressure, then 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 loads without failure for at least 3 seconds. Abrupt loss of load-carrying capability or fragmentation during the test constitutes failure.

4.2.3 Wheel Roll Test

4.2.3.1 Test Method

With a suitable tire, TT_{WT}, installed, mount the wheel 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 non-deflecting surface that it will have to a flat runway when it is mounted on an aircraft and is under the Wheel Rated Static Load, S. During the roll test the tire pressure shall be not less than 1.10 times wheel rated inflation pressure (WRP) to account for temperature rise and loaded tire pressure factors. The wheel must be tested under the maximum static load (S) for a distance of 1000 miles for Part 23 aircraft and 500 miles for Parts 27 and 29 rotorcraft.

At the end of the test, the wheel must not be cracked, there must be no leakage through the wheel or past the wheel seal(s), and the bearing cups must not be loose.

4.2.4 Overpressure Test

The wheel assembly, with a suitable tire, TT_{WT}, installed, must be tested to demonstrate that it can withstand the application of 3.5 times the wheel rated inflation pressure, WRP. The wheel must retain the pressure for at least 3 seconds. Abrupt loss of pressure containment capability or fragmentation during the test constitutes failure. Plugs may be used in place of over pressurization protection device(s) to conduct this test.

4.2.5 Diffusion Test

A tubeless tire and wheel assembly must hold its 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.

4.3 Wheel and Brake Assembly Tests

4.3.1 General

4.3.1.1 The wheel and brake assembly, with a suitable tire, TT_{BT}, installed, must be tested on a testing machine in accordance with the following, as well as 4.3.2, 4.3.4, 4.3.5, and, if applicable, 4.3.3.

4.3.1.2 For tests detailed in 4.3.2 and 4.3.3 the test energies KE_{DL} and KE_{RT}, and brake application speeds V_{DL} and V_{RT}, are normally defined by the aircraft manufacturer.

4.3.1.3 For tests detailed in 4.3.2 and 4.3.3, the initial brake application speed must be as close as practicable to the speed established in accordance with 4.3.1.2. If a lighter inertia is selected, the distance averaged deceleration shall be increased proportionately to achieve the distance averaged torque at the desired inertia. Marginal speed increases are also allowed to compensate for brake pressure release permitted in 4.3.3.4. The energy to be absorbed during any stop must not be less than that established in accordance with 4.3.1.2. Additionally, forced air or other artificial cooling means are not permitted during these stops.

4.3.1.4 Hydraulically actuated brakes must be tested using the fluid (or other actuating means) specified for use with the brake on the aircraft.

4.3.1.5 For brake stopping performance tests, electrically actuated brake assemblies must be tested using a control system and electrical power source providing representative characteristics of the actuating means to the EMAs, including limitations, specified for the aircraft braking system. I_{BMAX}, V_{BMAX} and P_{BMAX} shall not exceed the capabilities of the aircraft brake control system, I_{SMAX}, V_{SMAX} and P_{SMAX}, for which the equipment is intended. They must also be tested with any equipment which could affect any of the parameters recorded in Section 5. For example, if multiple brakes are actuated by a single electrical power source, then these brakes need to be connected to the power source during the brake tests.

4.3.1.6 For brake structural tests, the electrically actuated brake assemblies may be tested with an alternate control system to that required for the brake stopping performance tests. The control system must be capable of structurally loading the EMA load path and brake structure to the static values required by the test conditions.

4.3.2 Design Landing Stop Test

4.3.2.1 The wheel and brake assembly under test for Part 23 airplanes must complete 100 stops at the KE_{DL} energy, each at the mean distance averaged deceleration, D, normally defined by the aircraft manufacturer, but not less than 10 ft/s^2 (3.05 m/s^2).

The wheel and brake assembly under test for Part 27 or 29 rotorcraft must complete 20 stops at the KE_{DL} energy, each at the mean distance averaged deceleration, D, normally defined by the aircraft manufacturer, but not less than 6 ft/s^2 (1.83 m/s^2).

The maximum brake actuation force 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, ($BROP_{MAX}$).

4.3.2.2 During the design landing stop test, the disc support structure must not be changed if it is intended for reuse, or if the wearable material is integral to the structure of the disc. One change of individual blocks or integrally bonded wearable material is permitted for Part 23 airplanes. The remainder of the wheel/brake assembly parts must withstand the prescribed KE_{DL} stops without failure or impairment of operation. Tire changes are permissible to replace worn or deteriorated tires.

4.3.3 Accelerate-Stop Test for Commuter Category Aircraft and Jets Over 6000 Pounds

4.3.3.1 The wheel and brake assembly under test must complete the accelerate-stop test at the mean distance averaged deceleration, D, normally defined by the aircraft manufacturer, but not less than 6 ft/s^2 (1.83 m/s^2).

This test establishes the maximum accelerate-stop energy rating, KE_{RT}, of the wheel and brake assembly using:

a. The Brake Rated Maximum Operating Pressure, $BROP_{MAX}$; or

b. The maximum brake force consistent with the aircraft's braking actuation force limitations (for example, tire/runway drag capability based on substantiated data).

This test establishes the maximum accelerate-stop energy rating, KE_{RT}, of the wheel and brake assembly using the maximum brake current, voltage and power inputs consistent with the airplane's braking force limitations (tire/runway drag capability based on substantiated data).

4.3.3.2 For the accelerate-stop test, the tire, wheel, and brake assembly must be tested at KE_{RT} for a new brake, and recommended for fully worn brake.

NOTE: This test for a fully worn brake condition is not required by regulations for Part 23, 27, and 29 aircraft, but, it is strongly supported by industry as a safety enhancement, as required for Part 25 airplanes in TSO-C135a.

a. A new brake is defined as a brake on which less than 5% of the usable wear range of the heat sink has been consumed.

b. A worn brake is defined as a brake on which the usable wear range of the heat sink has already been fully consumed to BRWL.

The proportioning of wear through the brake for the various friction pairs for this test must be based on service wear experience or wear test data of an equivalent or similar brake. Either operationally worn or mechanically worn brake components may be used. If mechanically worn components are used, it must be shown that they can be expected to provide similar results to operationally worn components. The test brake must be subjected to a sufficient number and type of stops to ensure that the brake's performance is representative of in-service use; at least one of these stops, with the brake near the fully worn condition, must be a design landing stop.

4.3.3.3 At the time of brake application, the temperatures of the tire, wheel, and brake, particularly the heat sink, must, as closely as practicable, be representative of a typical in-service condition. Preheating by taxi stops is an acceptable means.

These temperatures must be based on a rational analysis of a braking cycle, taking into account a typical brake temperature at which an aircraft may be dispatched from the ramp, plus a conservative estimate of heat sink temperature change during subsequent taxiing and takeoff acceleration, as appropriate.

Alternatively, in the absence of a rational analysis, the starting heat sink and EMA temperatures, if applicable, must be that resulting from the application of 10% KE_{RT} to the tire, wheel and brake assembly, initially at not less than normal ambient temperature (59 °F/15 °C).

4.3.3.4 A full stop demonstration is not required for the accelerate-stop test. The test brake pressure may be released at a test speed of up to 23 mph (10 m/s). In this case, the initial brakes-on speed must be adjusted such that the energy absorbed by the tire, wheel and brake assembly 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.

4.3.3.5 Within 20 seconds of completion of the stop, or of the brake pressure release in accordance with 4.3.3.4, the brake pressure must be adjusted to the Brake Rated Maximum Parking Pressure, $BRPP_{MAX}$, or Parking Brake Command (PBC) as applicable and maintained for at least 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 pressure or brake clamping force as applicable; until this time has elapsed, neither firefighting means nor coolants may be applied.

The time of initiation of tire pressure release (for example, by wheel fuse plug), if applicable, is to be recorded. The sequence of events described in 4.3.3.4 and 4.3.3.5 is illustrated in Figure 1.

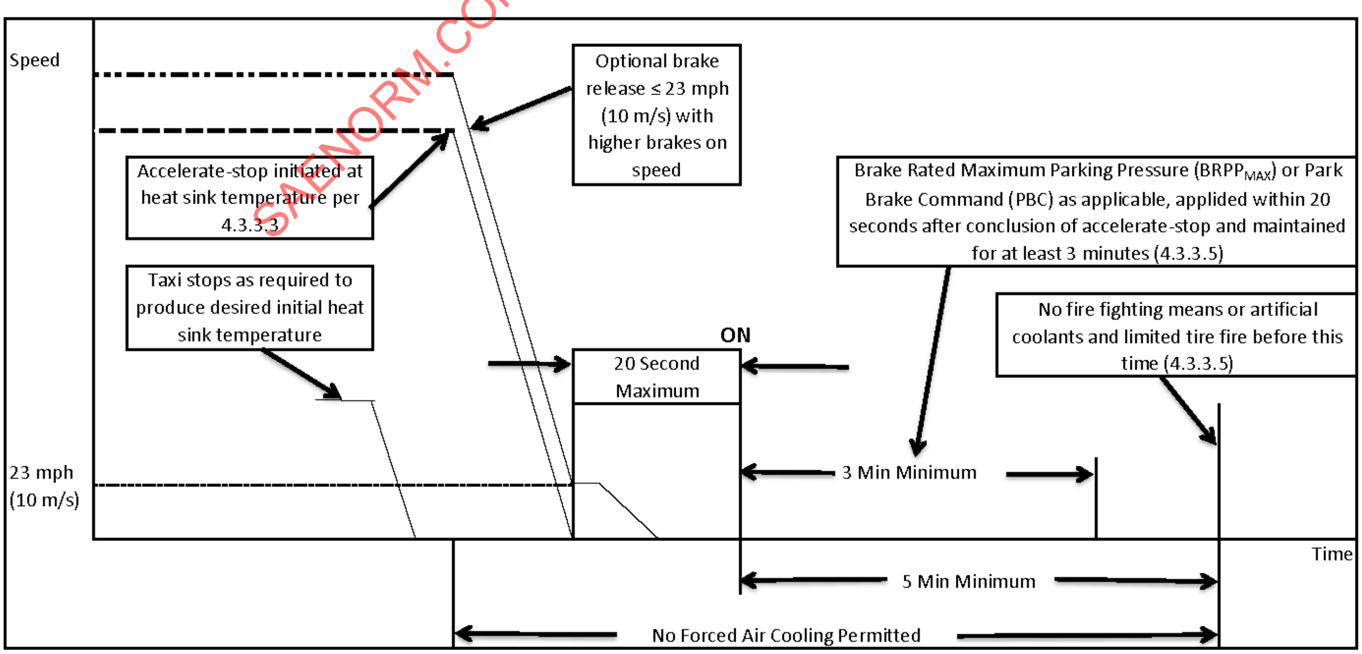

Figure 1 - Accelerate-stop and park test sequence for commuter category aircraft and jets over 6000 pounds

4.3.4 Structural Torque Test

The Wheel/Brake Rated Structural Torque, STR, is equal to the torque demonstrated in the test defined in 4.3.4.1.

IMPORTANT NOTE: The factors given in 4.3.4.2 and 4.3.4.3 WILL NOT be sufficient in every case to satisfy the installation requirements of the Braked Roll Conditions specified in 14 CFR 23.493(c), 27.493(c), and 29.493(c).

4.3.4.1 Apply to the wheel, brake and tire assembly, the radial load S and the drag load corresponding to the torque specified in 4.3.4.2 or 4.3.4.3, 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 the application of at least Brake Rated Maximum Operating Pressure, $BROP_{MAX}$, or L_{BMAX}, as applicable or their equivalent. If such pressure or its equivalent clamping force is insufficient to prevent rotation, the friction surface may be clamped, bolted, or otherwise restrained while applying the pressure. The most critical brake wear condition, including fully worn brake configuration, BRWL, shall be used for this test with regards to wheel and brake loads. The proportioning of wear through the brake for the various friction pairs for this test must be based on service wear experience of an equivalent or similar brake or test machine wear test data. Either operationally worn or mechanically worn brake components may be used. An actuating fluid other than that specified for use on the aircraft may be used for the structural torque test. The EMA may be cooled and/or restrained at the source of electromotive force generation after initial application of L_{BMAX} in lieu of maintaining application of electrical current throughout the test.

4.3.4.2 For landing gear with one wheel per landing gear strut, the torque is 1.2 (SxR).

4.3.4.3 For landing gear with more than one wheel per landing gear strut, the torque is 1.44 (SxR).

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

4.3.5 Wheel to Brake Clearance Test

There must be no interference in any critical areas between the wheel and brake assembly (with fittings) up to limit load conditions, taking into account the axle angular orientation. Lack of interference can be established by analyses and/or tests. Testing shall be conducted per the following methods:

4.3.5.1 Radial Limit Load Wheel and Brake Clearance Test

With a suitable tire, TT_{WT}, installed, mount the wheel and brake on a suitable 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 a flat runway when it is mounted on an aircraft and is under the maximum radial 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, liquid 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 was deflected to its maximum extent. Load the wheel through its axle with the load applied perpendicular to the flat, non-deflecting surface. Refer to 14 CFR paragraphs 23.471 through 23.511, or 27.471 through 27.505, or 29.471 through 29.511, as appropriate. If the radial limit load of 4.3.5.2 is equal or greater than the radial limit load specified in this paragraph, the test specified in this paragraph may be omitted.

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. If multiple critical orientations are determined, repeat the testing for each critical orientation. The bearing cups, cones, and rollers used in operation must be used for this loading. If at a point of loading during the test bottoming of the tire occurs, then the tire pressure may be increased an amount sufficient only to prevent bottoming.