**European Aviation Safety Agency**

# European Technical Standard Order

**Subject:** TRANSPORT AEROPLANE WHEELS AND WHEEL AND BRAKE ASSEMBLIES

**1 - Applicability**

This ETSO prescribes the minimum performance standard that transport category aeroplane wheels, and wheel and brake assemblies must meet to be identified with the applicable ETSO marking. Articles that are to be so identified on or after the date of this ETSO, must meet the requirements of Appendix 1 of this ETSO titled, "Minimum Performance Specification for Transport Aeroplane Wheels, Brakes, and Wheel and Brake Assemblies". Brakes and associated wheels are to be considered as an assembly for ETSO authorisation purposes.

**2 - Procedures**

2.1 - General

Applicable procedures are detailed in CS-ETSO Subpart A.

2.2 - Specific

2.2.1 - Data Requirements.

2.2.1.1 - In addition to the data specified in CS-ETSO Subpart A, the manufacturer must furnish one copy each of the following to the Agency:

2.2.1.2 - The applicable limitations pertaining to installation of wheels or wheel and brake assemblies on aeroplane(s), including the data requirements of paragraph 4.1 of Appendix 1 of this ETSO.

2.2.1.3 - The manufacturer's ETSO qualification test report.

2.2.2 - Data to be Furnished with Manufactured Articles.

2.2.2.1 - Prior to entry into service use, the manufacturer must make available to the Agency all applicable maintenance instructions and data necessary for continued airworthiness.

2.2.2.2 - The manufacturer must provide the applicable maintenance instructions and data necessary for continued airworthiness to each organisation or person receiving one or more articles manufactured under this ETSO. In addition, a note with the following statement must be included:

"The existence of ETSO approval of the article displaying the required marking does not automatically constitute the authority to install and use the article on an aeroplane. The conditions and tests required for ETSO 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 aeroplane to determine that the aeroplane operating conditions are within the ETSO standards. The article may be installed only if further evaluation by the user/installer documents an acceptable installation and the installation is approved by the Agency.

Additional requirements may be imposed based on aeroplane 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 ETSO, as well as any additional specific aeroplane requirements."

**3 - Technical Conditions**

3.1 - Basic

3.1.1 - Minimum Performance Standard

Appendix 1 to this ETSO.

3.1.2 - Environmental Standard

None.

3.1.3 - Computer Software

None

3.2 - Specific

None

**4 - Marking**

4.1 - General

In addition to the marking specified in CS-ETSO Subpart A paragraph 1.2; the following information shall be legibly and permanently marked on the major equipment components:

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

(ii) Hydraulic fluid type (this marking applies to hydraulic brakes only).

(iii) Serial Number.

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

4.2 - Specific

None.

**5 - Availability of Referenced Document**

See CS-ETSO Subpart A paragraph 3.

**APPENDIX 1: MINIMUM PERFORMANCE SPECIFICATION FOR TRANSPORT AEROPLANE WHEELS, BRAKES, AND WHEEL AND BRAKE ASSEMBLIES**

## CHAPTER 1
## INTRODUCTION.

### 1.1 PURPOSE AND SCOPE.

This Minimum Performance Specification defines the minimum performance standards for wheels, brakes, and wheel and brake assemblies to be used on aeroplanes certificated under CS-25. Compliance with this specification is not considered approval for installation on any transport aeroplane.

### 1.2 APPLICATION.

Compliance with this minimum specification by manufacturers, installers, and users 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 aeroplane operational characteristics and other external influences. Consequently, anticipated aeroplane braking performance should be verified by aeroplane testing.

### 1.3 COMPOSITION OF EQUIPMENT.

The words “equipment” or “brake assembly” or “wheel 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 brake assembly typically includes a backing plate, torque tube, cylinder assemblies, pressure plate, heat sink, and temperature sensor.

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 manufacturer.

### 1.4 DEFINITIONS AND ABBREVIATIONS.

#### 1.4.1 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.

#### 1.4.2 $BROP_{MAX}$ - Brake Rated Maximum Operating Pressure.

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

#### 1.4.3 $BRP_{MAX}$ - Brake Rated Maximum Pressure.

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

#### 1.4.4 $BRP_{RET}$ - Brake Rated Retraction Pressure.

$BRP_{RET}$ is the highest pressure at which full retraction of the piston(s) is assured.

#### 1.4.5 $BRPP_{MAX}$ - Brake Rated Maximum Parking Pressure.

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

1.4.6 BRWL - Brake Rated Wear Limit.

BRWL is the brake maximum wear limit to ensure compliance with paragraph 3.3.3, and, if applicable, paragraph 3.3.4 of this ETSO.

1.4.7 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.

1.4.8 $D_{DL}$ - Rated Design Landing Deceleration.

$D_{DL}$ is the minimum of the distance averaged decelerations demonstrated by the wheel, brake and tyre assembly during the 100 $KE_{DL}$ stops in paragraph 3.3.2.

1.4.9 $D_{RT}$ - Rated Accelerate-Stop Deceleration.

$D_{RT}$ is the minimum of the distance averaged decelerations demonstrated by the wheel, brake, and tyre assembly during the $KE_{RT}$ stops in paragraph 3.3.3.

1.4.10 $D_{SS}$ - Rated Most Severe Landing Stop Deceleration.

$D_{SS}$ is the distance averaged deceleration demonstrated by the wheel, brake and tyre assembly during the $KE_{SS}$ Stop in paragraph 3.3.4.

1.4.11 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.

1.4.12 $KE_{DL}$ - Wheel/Brake Rated Design Landing Stop Energy.

$KE_{DL}$ is the minimum energy absorbed by the wheel/brake/tyre assembly during every stop of the 100 stop design landing stop test. (paragraph 3.3.2).

1.4.13 $KE_{RT}$ - Wheel/Brake Rated Accelerate-Stop Energy.

$KE_{RT}$ is the energy absorbed by the wheel/brake/tyre assembly demonstrated in accordance with the accelerate-stop test in paragraph 3.3.3.

1.4.14 $KE_{SS}$ - Wheel/Brake Rated Most Severe Landing Stop Energy.

$KE_{SS}$ is the energy absorbed by the wheel/brake/tyre assembly demonstrated in accordance with paragraph 3.3.4.

1.4.15 L - Wheel Rated Radial Limit Load.

L is the wheel rated maximum radial limit load (paragraph 3.2.1).

1.4.16 R - Wheel Rated Tyre Loaded Radius.

R is the static radius at load "S" for the wheel rated tyre size at WRP. The static radius is defined as the minimum distance from the axle centreline to the tyre/ground contact interface.

1.4.17 S -Wheel Rated Static Load.

S is the maximum static load (Reference CS 25.731(b)).

1.4.18 $ST_R$ - Wheel/Brake Rated Structural Torque.

$ST_R$ is the maximum structural torque demonstrated (paragraph 3.3.5).

1.4.19 $TS_{BR}$ - Brake Rated Tyre Type(s) and Size(s).

$TS_{BR}$ is the tyre type(s) and size(s) used to achieve the $KE_{DL}$, $KE_{RT}$, and $KE_{SS}$ brake ratings. $TS_{BR}$ must be a tyre type and size approved for installation on the wheel ($TS_{WR}$).

1.4.20 $TS_{WR}$ - Wheel Rated Tyre Type(s) and Size(s).

$TS_{WR}$ is the wheel rated tyre type(s) and Size(s) defined for use and approved by the aeroplane manufacturer for installation on the wheel.

1.4.21 $TT_{BT}$ - Suitable Tyre for Brake Tests.

$TT_{BT}$ is the rated tyre type and size.

$TT_{BT}$ is the tyre 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 tyre type and size approved for installation on the wheel ($TS_{WR}$). The suitable tyre may be different for different tests.

1.4.22 $TT_{WT}$ - Suitable Tyre for Wheel Test.

$TT_{WT}$ is the wheel rated tyre type and size for wheel test.

$TT_{WT}$ is the tyre 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 tyre type and size approved for installation on the wheel ($TS_{WR}$). The suitable tyre may be different for different tests.

1.4.23 $V_{DL}$ - Wheel/Brake Design Landing Stop Speed.

$V_{DL}$ is the initial brakes-on speed for a design landing stop (paragraph 3.3.2).

1.4.24 $V_R$ - Aeroplane Maximum Rotation Speed.

1.4.25 $V_{RT}$ - Wheel/Brake Accelerate-Stop Speed.

$V_{RT}$ is the initial brakes-on speed used to demonstrate $KE_{RT}$ (paragraph 3.3.3).

1.4.26 $V_{SS}$ - Wheel/Brake Most Severe Landing Stop Speed.

$V_{SS}$ is the initial brakes-on speed used to demonstrate $KE_{SS}$ (paragraph 3.3.4).

1.4.27 WRP - Wheel Rated Inflation Pressure.

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

## CHAPTER 2
## GENERAL DESIGN SPECIFICATION.

### 2.1 AIRWORTHINESS.

As specified in CS 25.1529, the continued airworthiness of the aeroplane on which the equipment is to be installed must be considered. See paragraph 4 of this ETSO, titled "Data to be Furnished with Manufactured Articles."

### 2.2 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 paragraphs 2.4.5, 3.3.3.5 and 3.3.4.5.

### 2.3 DESIGN.

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

#### 2.3.1 Wheel Bearing Lubricant Retainers.

Wheel bearing lubricant retainers must retain the lubricant under all operating conditions, prevent the lubricant from reaching braking surfaces, and prevent foreign matter from entering the bearings.

#### 2.3.2 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 tyre deflates while the wheel is rolling.

#### 2.3.3 Adjustment.

The brake mechanism must be equipped with suitable adjustment devices to maintain appropriate running clearance when subjected to $BRP_{RET}$.

#### 2.3.4 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.

#### 2.3.5 Burst Prevention.

Means must be provided to prevent wheel failure and tyre burst that might result from over-pressurisation or from elevated brake temperatures. The means must take into account the pressure and the temperature gradients over the full operating range.

#### 2.3.6 Wheel Rim and Inflation Valve.

Tyre and Rim Association (Reference: Aircraft Year Book-Tyre and Rim Association Inc.) or, alternatively, The European Tyre and Rim Technical Organisation (Reference: Aircraft Tyre and Rim Data Book) approval of the rim dimensions and inflation valve is encouraged.

#### 2.3.7 Brake Piston Retention.

The brake must incorporate means to ensure that the actuation system does not allow hydraulic fluid to escape if the limits of piston travel are reached.

2.3.8 Wear Indicator.

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

2.3.9 Wheel Bearings.

Means should be incorporated to avoid mis-assembly of wheel bearings.

2.3.10 Fatigue.

The design of the wheel must incorporate techniques to improve fatigue resistance of critical areas of the wheel and minimise the effects of the expected corrosion and temperature environment. The wheel must include design provisions to minimise the probability of fatigue failures that could lead to flange separation or other wheel burst failures.

2.3.11 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.

2.4 CONSTRUCTION.

The suitability and durability of the materials used for components must be established on the basis of experience 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.

2.4.1 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.

2.4.2 Forgings.

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

2.4.3 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.

2.4.4 Environmental Protection.

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

2.4.5 Magnesium Parts.

Magnesium and alloys having magnesium as a major constituent must not be used on brakes or braked wheels.

**CHAPTER 3**
**MINIMUM PERFORMANCE UNDER STANDARD TEST CONDITIONS.**

3.1 INTRODUCTION.

The test conditions and performance criteria described in this chapter provide a laboratory means of demonstrating compliance with this ETSO minimum performance standard. The aeroplane manufacturer must define all relevant test parameter values.

3.2 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, roll-on-rim (if applicable) and overpressure test requirements.

For all tests, except the roll-on-rim test in paragraph 3.2.4, the wheel must be fitted with a suitable tyre, $TT_{WT}$, and wheel loads must be applied through the tyre. The ultimate load tests in paragraphs 3.2.1.3 and 3.2.2.3 provide for an alternative method of loading if it is not possible to conduct these tests with the tyre mounted.

3.2.1 Radial Load Test.

If the radial limit load of paragraph 3.2.2 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:

3.2.1.1 Test method.

With a suitable tyre, $TT_{WT}$, 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 aeroplane and is under the maximum radial limit load, L. Inflate the tyre 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 tyre 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 tyre were deflected to its maximum extent. 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.

3.2.1.2 Yield Load.

Apply to the wheel and tyre assembly a load not less than 1·15 times the maximum radial limit load, L, as determined under CS 25.471 through 25.511, as appropriate.

Determine the most critical wheel orientation with respect to the non-deflecting surface. Apply the load with the tyre loaded against the non-deflecting surface, and with the wheel rotated 90 degrees with respect to the most critical orientation. Repeat the loading with the wheel 180, 270, and 0 degrees 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 tyre occurs, then the tyre pressure may be increased an amount sufficient only to prevent bottoming.

Three successive loadings at the 0 degree position must not cause permanent set increments of increasing magnitude. The permanent set increment caused by the last loading at the 0 degree position may not exceed 5 percent of the deflection caused by that loading or ·005 inches (·125mm), 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. There must be no interference in any critical areas between the wheel and brake assembly, or between the most critical deflected tyre and brake (with fittings) up to limit load conditions, taking into account the axle flexibility. Lack of interference can be established by analyses and/or tests.

3.2.1.3 Ultimate Load.

Apply to the wheel used in the yield test in paragraph 3.2.1.2, and the tyre 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, as determined under CS 25.471 through 25.511, as appropriate.

Apply the load with the tyre and wheel against the non-deflecting surface and the wheel positioned at 0 degree orientation (paragraph 3.2.1.2). 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 tyre will not successfully maintain pressure or if bottoming of the tyre occurs, the tyre pressure may be increased. If bottoming of the tyre continues to occur with increased pressure, then a loading block that fits between the rim flanges and simulates the load transfer of the inflated tyre may be used. The arc of the wheel supported by the loading block must be no greater than 60 degrees.

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.

3.2.2 Combined Radial and Side Load Test.

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

3.2.2.1 Test Method.

With a suitable tyre, $TT_{WT}$, 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 aeroplane and is under the combined radial and side limit loads. Inflate the tyre to the pressure recommended for the maximum static load with gas and/or liquid.

If liquid inflation is used, liquid must be bled off to obtain the same tyre 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 tyre were deflected to its maximum extent. For the radial load component, load the wheel through its axle with load applied perpendicular to the flat non-deflecting surface. Apply the two loads simultaneously, increasing them either continuously or in increments no greater than 10 percent 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 tyre/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.

3.2.2.2 Combined Yield Load.

Apply to the wheel and tyre assembly radial and side loads not less than 1·15 times the respective ground limit loads, as determined under CS 25.485, 25.495, 25.497, and 25.499, as appropriate. If at a point of loading during the test bottoming of the tyre occurs, then the tyre 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 tyre loaded against the non-deflecting surface, and with the wheel rotated 90 degrees with respect to the most critical orientation. Repeat the loading with the wheel 180, 270, and 0 degrees 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 tyre only when it has been demonstrated that pressure will be lost due to the inability of a tyre bead to remain properly positioned under the load. The wheel must be tested for the most critical inboard and outboard side loads.

Three successive loadings at the 0 degree position must not cause permanent set increments of increasing magnitude. The permanent set increment caused by the last loadings at the 0 degree position must not exceed 5 percent of the deflection caused by the loading, or ·005 inches (·125mm), 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. There must be no interference in any critical areas between the wheel and brake assembly, or between the most critical deflected tyre and brake (with fittings) up to limit load conditions, taking into account the axle flexibility. Lack of interference can be established by analyses and/or tests.

3.2.2.3 Combined Ultimate Load.

Apply to the wheel, used in the yield test of paragraph 3.2.2.2, radial and side loads not less than 2 times for castings and 1·5 times for forgings, the respective ground limit loads as determined under JAR 25.485, 25.495, 25.497, and 25.499, as appropriate.

Apply these loads with a tyre and wheel against the non-deflecting surface and the wheel oriented at the 0 degree position (paragraph 3.2.2.2). 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 tyre will not successfully maintain pressure, or if bottoming of the tyre on the non-deflecting surface occurs, the tyre pressure may be increased. If bottoming of the tyre 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 tyre may be used. The arc of wheel supported by the loading block must be no greater than 60 degrees.

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.

3.2.3 Wheel Roll Test.

3.2.3.1 Test Method.

With a suitable tyre, $TT_{WT}$, 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 aeroplane and is under the Wheel Rated Static Load, S. During the roll test, the tyre pressure must not be less than 1·14 times the Wheel Rated Inflation Pressure, WRP, (0·10 to account for temperature rise and 0·04 to account for loaded tyre pressure). For side load conditions, the wheel axle must be yawed to the angle that will produce a wheel side load component equal to 0·15 S while the wheel is being roll tested.

3.2.3.2 Roll Test.

The wheel must be tested under the loads and for the distances shown in Table 3-1.

TABLE 3-1 Load Conditions and Roll Distances for Roll Test

| Load Conditions | Roll Distance Miles (km) |
|---|---|
| Wheel Rated Static Load, S | 2 000 (3 220) |
| Wheel Rated Static Load, S, plus a 0·15xS side load applied in the outboard direction | 100 (161) |
| Wheel Rated Static Load, S, plus a 0·15xS side load applied in the inboard direction | 100 (161) |

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.

3.2.4 Roll-on-Rim Test (not applicable to nose wheels).

The wheel assembly without a tyre must be tested at a speed of no less than 10 mph (4·6 m/s) under a load equal to the Wheel Rated Static Load, S. The test roll distance (in feet) must be determined as $0{\cdot}5V_R^2$ but need not exceed 15 000 feet (4 572 meters). The test axle angular orientation with the load surface must represent that of the aeroplane axle to the runway under the static load S.

The wheel assembly must support the load for the distance defined above. During the test, no fragmentation of the wheel is permitted; cracks are allowed.

3.2.5 Overpressure Test.

The wheel assembly, with a suitable tyre, $TT_{WT}$, installed, must be tested to demonstrate that it can withstand the application of 4·0 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-pressurisation protection device(s) to conduct this test (JAR 25.731(d)).

3.2.6 Diffusion Test.

A tubeless tyre and wheel assembly must hold its rated inflation pressure, WRP, for 24 hours with a pressure drop no greater than 5 percent. This test must be performed after the tyre growth has stabilised.

3.3 WHEEL AND BRAKE ASSEMBLY TESTS.

3.3.1 General.

3.3.1.1 The wheel and brake assembly, with a suitable tyre, $TT_{BT}$, installed, must be tested on a testing machine in accordance with the following, as well as paragraphs 3.3.2, 3.3.3, 3.3.5 and, if applicable, 3.3.4.

3.3.1.2 For tests detailed in paragraphs 3.3.2, 3.3.3, and 3.3.4, the test energies $KE_{DL}$, $KE_{RT}$, and $KE_{SS}$ and brake application speeds $V_{DL}$, $V_{RT}$, and $V_{SS}$ are as defined by the aeroplane manufacturer.

3.3.1.3 For tests detailed in paragraphs 3.3.2, 3.3.3, and 3.3.4, the initial brake application speed must be as close as practicable to, but not greater than, the speed established in accordance with paragraph 3.3.1.2, with the exception that marginal speed increases are allowed to compensate for brake pressure release permitted in paragraphs 3.3.3.4 and 3.3.4.4. An increase in the initial brake application speed is not a permissible method of accounting for a reduced (i.e., lower than ideal) dynamometer mass. This method is not permissible because, for a target test deceleration, a reduction in the energy absorption rate would result, and could produce performance different from that which would be achieved with the correct brake application speed. The energy to be absorbed during any stop must not be less than that established in accordance with paragraph 3.3.1.2. Additionally, forced air or other artificial cooling means are not permitted during these stops.

3.3.1.4 The brake assembly must be tested using the fluid (or other actuating means) specified for use with the brake on the aeroplane.

3.3.2 Design Landing Stop Test.

3.3.2.1 The wheel and brake assembly under test must complete 100 stops at the $KE_{DL}$ energy, each at the mean distance averaged deceleration, D, defined by the aeroplane manufacturer, but not less than 10 $ft/s^2$ (3·05 $m/s^2$). (See CS 25.735(f)(1)).

3.3.2.2 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 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 wheel/brake assembly parts must withstand the 100 $KE_{DL}$ stops without failure or impairment of operation.

3.3.3 Accelerate-Stop Test.

3.3.3.1 The wheel and brake assembly under test must complete the accelerate-stop test at the mean distance averaged deceleration, D, defined by the aeroplane manufacturer, but not less than 6 $ft/s^2$ (1·83 $m/s^2$). (See CS 25.735(f)(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 pressure consistent with the aeroplane's braking pressure limitations (e.g., tyre/runway drag capability based on substantiated data).

3.3.3.2 For the accelerate-stop test, the tyre, wheel, and brake assembly must be tested at $KE_{RT}$ for both a new brake and a fully worn brake.

a. A new brake is defined as a brake on which less than 5 percent 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.

3.3.3.3 At the time of brake application, the temperatures of the tyre, 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 aeroplane 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 temperature must be that resulting from the application of 10 percent $KE_{RT}$ to the tyre, wheel and brake assembly, initially at not less than normal ambient temperature (59°F/15°C).

3.3.3.4 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 tyre, 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.

3.3.3.5 Within 20 seconds of completion of the stop, or of the brake pressure release in accordance with paragraph 3.3.3.4, the brake pressure must be adjusted to the Brake Rated Maximum Parking Pressure, $BRPP_{MAX}$, and maintained for at least 3 minutes (CS 25.735(g)).

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

The time of initiation of tyre pressure release (e.g., by wheel fuse plug), if applicable, is to be recorded. The sequence of events described in paragraphs 3.3.3.4 and 3.3.3.5 is illustrated in figure 3-1.

3.3.4 Most Severe Landing Stop Test.

3.3.4.1 The wheel and brake assembly under test must complete the most severe landing braking condition expected on the aeroplane as defined by the aeroplane manufacturer. This test is not required if the testing required in paragraph 3.3.3 is more severe or the condition is shown to be extremely improbable by the aeroplane manufacturer.

This test establishes, if required, the maximum energy rating, $KE_{SS}$, of the wheel/brake assembly for landings under abnormal conditions using:

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

b. The maximum brake pressure consistent with an airline's braking pressure limitations (e.g., tyre/runway drag capability based on substantiated data).

3.3.4.2 For the most severe landing stop test, the tyre, wheel and brake assembly must be capable of absorbing the test energy, $KE_{SS}$, with a brake on which the usable wear range of the heat sink has already been fully consumed to BRWL (CS 25.735(f)(3)).

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.

3.3.4.3 At the time of brake application, the temperatures of the tyre, 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 the aeroplane may be dispatched from the ramp, plus a conservative estimate of heat sink temperature change during taxi, takeoff, and flight, as appropriate.

Alternatively, in the absence of a rational analysis, the starting heat sink temperature must be that resulting from the application of 5 percent $KE_{RT}$ to the tyre, wheel and brake assembly initially at not less than normal ambient temperature (59°F/15°C).

3.3.4.4 A full stop demonstration is not required for the most severe landing-stop test. The test brake pressure may be released at a test speed of up to 20 knots. In this case, the initial brakes-on speed must be adjusted such that the energy absorbed by the tyre, 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.

3.3.4.5 Within 20 seconds of completion of the stop, or of the brake pressure release in accordance with paragraph 3.3.4.4, the brake pressure must be adjusted to the Brake Rated Maximum Parking Pressure, $BRPP_{MAX}$, and maintained for at least 3 minutes.

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

The time of initiation of tyre pressure release (e.g., by wheel fuse plug), if applicable, is to be recorded. The sequence of events described in paragraphs 3.3.4.4 and 3.3.4.5 is illustrated in Figure 3-2.

3.3.5 Structural Torque Test.

The Wheel/Brake Rated Structural Torque, $ST_R$, is equal to the torque demonstrated in the test defined in 3.3.5.1.

3.3.5.1 Apply to the wheel, brake and tyre assembly, the radial load S and the drag load corresponding to the torque specified in paragraph 3.3.5.2 or 3.3.5.3, 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 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. A fully worn brake configuration, BRWL, must be used for this test. 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 aeroplane may be used for the structural torque test.

3.3.5.2 For landing gear with one wheel per landing gear strut, the torque is 1·2 (SxR).

3.3.5.3 For landing gear with more than one wheel per landing gear strut, the torque is 1·44 (SxR).

3.3.5.4 The wheel and brake assembly must support the loads without failure for at least 3 seconds.

3.4 BRAKE TESTS.

The brake assembly must be tested using the fluid (or other actuating means) specified for use with the brake on the aeroplane. It must be substantiated that standard production samples of the brake will pass the following tests:

3.4.1 Yield & Overpressure Test.

The brake must withstand a pressure equal to 1·5 times $BRP_{MAX}$ for at least 5 minutes without permanent deformation of the structural components under test.

The brake, with actuator piston(s) extended to simulate a maximum worn condition, must, for at least 3 seconds, withstand hydraulic pressure equal to 2·0 times the Brake Rated Maximum Pressure, $BRP_{MAX}$, available to the brakes. If necessary, piston extension must be adjusted to prevent contact with retention devices during this test.

3.4.2 Endurance Test.

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

The test must be conducted by subjecting the brake assembly to 100 000 cycles of an application of the average of the peak brake pressures needed in the design landing stop test (paragraph 3.3.2) and release to a pressure not exceeding the Brake Rated Retraction Pressure, BRPRET. The pistons must be adjusted so that 25 000 cycles are performed at each of the four positions where the pistons would be at rest when adjusted to nominally 25, 50, 75, and 100 percent of the wear limit, BRWL. The brake must then be subjected to 5 000 cycles of application of pressure to $BRP_{MAX}$ and release to $BRP_{RET}$ at the 100 percent wear limit.

Hydraulic brakes must meet the leakage requirements of paragraph 3.4.5 at the completion of the test.

3.4.3 Piston Retention.

The hydraulic pistons must be positively retained without leakage at 1·5 times $BRP_{MAX}$ for at least 10 seconds with the heat sink removed.

3.4.4 Extreme Temperature Soak Test.

The brake actuation system must comply with the dynamic leakage limits in paragraph 3.4.5.2 for the following tests.

Subject the brake to at least a 24-hour hot soak at the maximum piston housing fluid temperature experienced during a design landing stop test (paragraph 3.3.2), conducted without forced air cooling. While at the hot soak temperature, the brake must be subjected to the application of the average of the peak brake pressures required during the 100 design landing stops and release to a pressure not exceeding $BRP_{RET}$ for 1 000 cycles, followed by 25 cycles of $BROP_{MAX}$ and release to a pressure not exceeding $BRP_{RET}$.

The brake must then be cooled from the hot soak temperature to a cold soak temperature of -40°F (-40°C) and maintained at this temperature for at least 24 hours. While at the cold soak temperature, the brake must be subjected to the application of the average of the peak brake pressures required during the $KE_{DL}$ stops and release to a pressure not exceeding $BRP_{RET}$, for 25 cycles, followed by 5 cycles of $BROP_{MAX}$ and release to a pressure not exceeding $BRP_{RET}$.

3.4.5 Leakage Tests (Hydraulic Brakes).

3.4.5.1 Static Leakage Test.

The brake must be subjected to a pressure equal to 1·5 times $BRP_{MAX}$ for at least 5 minutes. The brake pressure must then be adjusted to an operating pressure of 5 psig (35 kPa) for at least 5 minutes. There must be no measurable leakage (less than one drop) during this test.

3.4.5.2 Dynamic Leakage Test.

The brake must be subjected to 25 applications of $BRP_{MAX}$, each followed by the release to a pressure not exceeding $BRP_{RET}$. Leakage at static seals must not exceed a trace. Leakage at moving seals must not exceed one drop of fluid per each 3 inches (76mm) of peripheral seal length.

**CHAPTER 4**

**DATA REQUIREMENTS.**

4.1 The manufacturer must provide the following data with any application for approval of equipment.

4.1.1 The following wheel and brake assembly ratings:

a. Wheel Ratings.

Wheel Rated Static Load, S,
Wheel Rated Inflation Pressure, WRP,
Wheel Rated Tyre Loaded Radius, R.
Wheel Rated Maximum Limit Load, L,
Wheel Rated Tyre Size, $TS_{WR}$.

b. Wheel/Brake and Brake Ratings.

Wheel/Brake Rated Design Landing Energy, $KE_{DL}$, and associated brakes-on-speed, $V_{DL}$,
Wheel/Brake Rated Accelerate-Stop Energy, $KE_{RT}$, and associated brakes-on-speed, $V_{RT}$,
Wheel/Brake Rated Most Severe Landing Stop Energy, $KE_{SS}$, and associated brakes-on-speed, $V_{SS}$ (if applicable),
Brake Rated Maximum Operating Pressure, $BROP_{MAX}$,
Brake Rated Maximum Pressure, BRPMAX,
Brake Rated Retraction Pressure, BRPRET,
Wheel/Brake Rated Structural Torque, STR,
Rated Design Landing Deceleration, DDL,
Rated Accelerate-Stop Deceleration, DRT,
Rated Most Severe Landing Stop Deceleration, DSS (if applicable),
Brake Rated Tyre Size,TSBR,
Brake Rated Wear Limit, BRWL.

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

4.1.3 Specification of hydraulic fluid used, as applicable.

4.1.4 One copy of the test report showing 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.

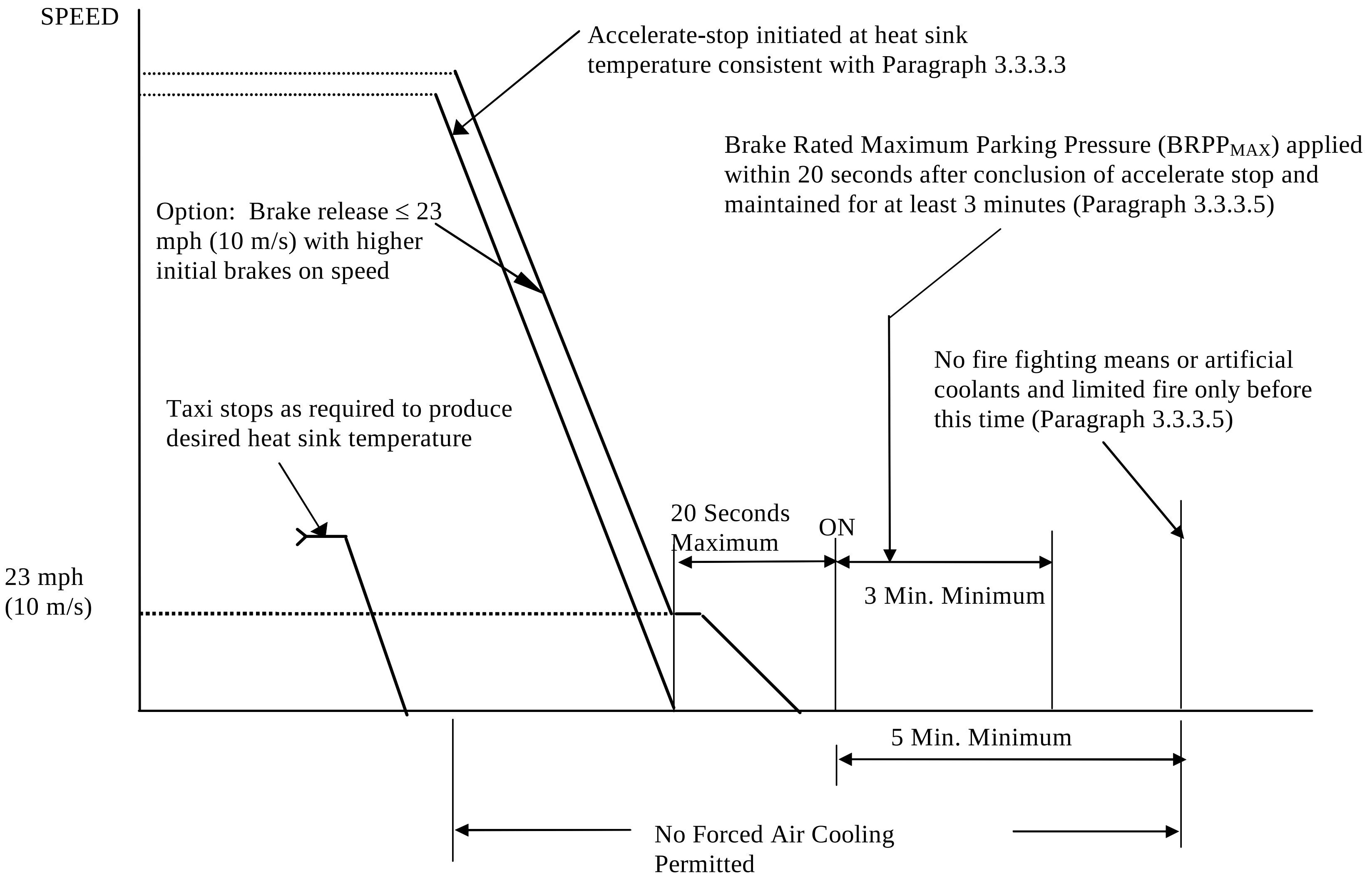


**Figure 3-1. Taxi, Accelerate-Stop, Park Test Sequence**

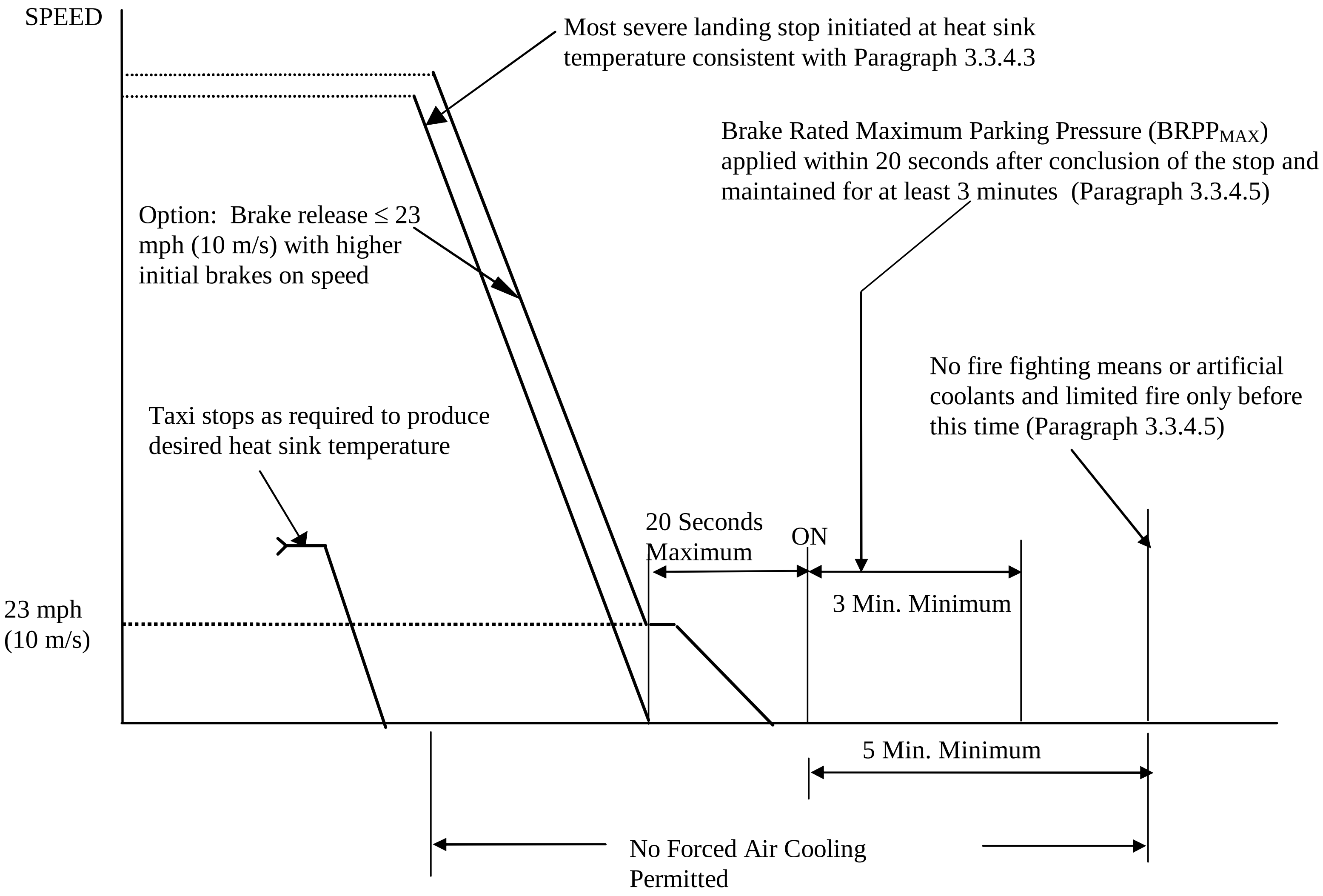


**Figure 3-2. Most Severe Landing-Stop, Park Test Sequence**